

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
10 December 2009 (10.12.2009)

PCT

(10) International Publication Number
WO 2009/148461 A1

(51) International Patent Classification:

F16H 13/04 (2006.01) F16H 15/40 (2006.01)
F16H 15/26 (2006.01)

(21) International Application Number:

PCT/US2008/066182

(22) International Filing Date:

6 June 2008 (06.06.2008)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: INFINITELY VARIABLE TRANSMISSIONS, CONTINUOUSLY VARIABLE TRANSMISSIONS, METHODS, ASSEMBLIES, SUBASSEMBLIES, AND COMPONENTS THEREFOR

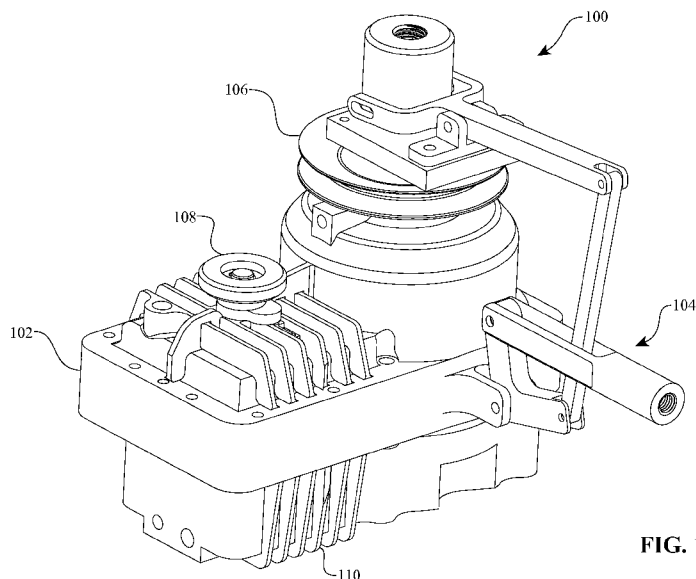


FIG. 1

(57) Abstract: Inventive embodiments are directed to components, subassemblies, systems, and/or methods for continuously and infinitely variable transmissions (IVT). In one embodiment, a variator is adapted to receive a control system that cooperates with a shift nut to actuate a ratio change in an IVT. In another embodiment, a neutral lock-out mechanism is adapted to cooperate with the variator to, among other things, disengage an output shaft from a variator. Various inventive mechanical couplings, such as an output engagement mechanism, are provided to facilitate a change in the ratio of an IVT for maintaining a powered zero operating condition. In one embodiment, the output engagement mechanism selectively couples an output member of the variator to a ratio adjuster of the variator. Embodiments of a ratio adjuster cooperate with other components of the IVT to support operation and/or functionality of the IVT. Among other things, user control interfaces for an IVT are disclosed.



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INFINITELY VARIABLE TRANSMISSIONS, CONTINUOUSLY VARIABLE
TRANSMISSIONS, METHODS, ASSEMBLIES, SUBASSEMBLIES, AND
COMPONENTS THEREFOR

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The field of the invention relates generally to transmissions, and more particularly the inventive embodiments related to continuously variable transmissions (CVTs) and infinitely variable transmissions (IVTs).

Description of the Related Art

[0002] In certain systems, power is characterized by torque and rotational speed. More specifically, power in these systems is generally defined as the product of torque and rotational speed. Typically, a transmission couples to a power input that provides an input torque at an input speed. The transmission also couples to a load that demands an output torque and output speed, which may differ from the input torque and the input speed. Typically, and generalizing, a prime mover provides the power input to the transmission, and a driven device or load receives the power output from the transmission. A primary function of the transmission is to modulate the power input in such a way to deliver a power output to the driven device at a desired ratio of input speed to output speed ("speed ratio").

[0003] Some mechanical drives include transmissions of the type known as stepped, discrete, or fixed ratio. These transmissions are configured to provide speed ratios that are discrete or stepped in a given speed ratio range. For example, such a transmission may provide for a speed ratio of 1:2, 1:1, or 2:1, but such a transmission cannot deliver intermediate speed ratios such as 1:1.5, 1:1.75, 1.5:1, or 1.75:1, for example. Other drives include a type of transmission generally known as a continuously variable transmission (or "CVT"), which includes a continuously variable variator. A CVT, in contrast to a stepped transmission, is configured to provide every fractional ratio in a given speed ratio range. For example, in the speed ratio range mentioned above, a

CVT is generally capable of delivering any desired speed ratio between 1:2 and 2:1, which would include speed ratios such as 1:1.9, 1:1.1, 1.3:1, 1.7:1, etc. Yet other drives employ an infinitely variable transmission (or "IVT"). An IVT, like a CVT, is capable of producing every speed ratio in a given ratio range. However, in contrast to a CVT, the IVT is configured to deliver a zero output speed (a "powered zero" state) with a steady input speed. Hence, given the definition of speed ratio as the ratio of input speed to output speed, the IVT is capable of delivering an infinite set of speed ratios, and consequently, the IVT is not limited to a given ratio range. It should be noted that some transmissions use a continuously variable variator coupled to other gearing and/or clutches in a split powered arrangement to produce IVT functionality. However, as used here, the term IVT is primarily understood as comprehending an infinitely variable variator which produces IVT functionality without being necessarily coupled to additional gearing and/or clutches.

[0004] The field of mechanical power transmission is cognizant of continuous or infinitely variable variators of several types. For example, one well known class of continuous variators is the belt-and-variable-radius-pulley variator. Other known variators include hydrostatic, toroidal, and cone-and-ring variators. In some cases, these variators couple to other gearing to provide IVT functionality. Some hydromechanical variators can provide infinite ratio variability without additional gearing. Some variators, continuously and/or infinitely variable, are classified as frictional or traction variators because they rely on dry friction or elastohydrodynamic traction, respectively, to transfer torque across the variator. One example of a traction variator is a ball variator in which spherical elements are clamped between torque transfer elements and a thin layer of elastohydrodynamic fluid serves as the torque transfer conduit between the spherical and the torque transfer elements. It is to this latter class of variators that the inventive embodiments disclosed here are most related.

[0005] There is a continuing need in the CVT/IVT industry for transmission and variator improvements in increasing efficiency and packaging flexibility, simplifying operation, and reducing cost, size, and complexity, among other things. The inventive embodiments of the CVT and/or IVT methods, systems, subassemblies, components, etc., disclosed below address some or all of the aspects of this need.

Summary of the Invention

[0006] The systems and methods herein described have several features, no single one of which is solely responsible for its desirable attributes. Without limiting the scope as expressed by the claims that follow, its more prominent features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description of Certain Inventive Embodiments" one will understand how the features of the system and methods provide several advantages over traditional systems and methods.

[0007] One aspect of the invention relates to a ball planetary infinitely variable transmission (IVT) having a shift rod driver and an output feedback rod. The output feedback rod is coupled to the shift rod driver. In one embodiment, the IVT includes a set of engagement pins that are configured to selectively couple to the output feedback rod.

[0008] Another aspect of the invention concerns a ball planetary infinitely variable transmission (IVT) having a throw-out bearing housing that is coupled to an output member of the IVT. The IVT can include a neutral fork arm that has a first end and a second end. The first end of the neutral fork arm is coupled to the throw-out bearing housing. In one embodiment, the IVT has a clevis member coupled to the second end of the neutral fork arm. The IVT can also include a knob coupled to the clevis member. The knob can be configured to be accessible from the exterior of the IVT.

[0009] Yet another aspect of the invention involves a variator for an infinitely variable transmission (IVT). The variator can include a group of power roller assemblies that are arranged angularly about a longitudinal axis of the transmission. The power roller assemblies are configured to tilt in operation. The variator can have a first traction ring in contact with the power rollers. The first traction ring is substantially non-rotatable. In one embodiment, the variator has a second traction ring in contact with the power rollers. The variator can also include a carrier that is adapted to transfer an input power to the power roller assemblies. In one embodiment, the variator has an output member operably coupled to the second traction ring. The output member is adapted to

translate along the longitudinal axis. The output member is also configured to engage and disengage selectively from the second traction ring.

[0010] One aspect of the invention concerns a transmission having a group of power roller assemblies. The power roller assemblies are arranged angularly about a longitudinal axis of the transmission. The power roller assemblies are configured to tilt during operation. In one embodiment, the transmission can have a first traction ring in contact with the power rollers. The transmission can include a second traction ring in contact with the power rollers. In one embodiment, the transmission has an idler in contact with the power rollers. The idler is adapted to translate with respect to the longitudinal axis. The transmission also has a shift rod sleeve operably coupled to the idler. The shift rod sleeve is configured to rotate with the idler. In some embodiments, the transmission has a shift rod driver arranged along the longitudinal axis. The shift rod driver is operably coupled to the shift rod sleeve. The transmission can include an output feedback rod coupled to the shift rod driver. The transmission can also include an output engagement mechanism operably coupled to the output feedback rod. The output engagement mechanism is configured to rotate with the second traction ring.

[0011] Another aspect of the invention relates to a neutral lock-out mechanism for a transmission. The neutral lock-out mechanism has a throw-out bearing housing operably coupled to an output member of the transmission. In one embodiment, the neutral lock-out mechanism has a neutral fork arm having a first end and a second end. The first end is coupled to the throw-out bearing housing. The neutral lock-out mechanism can have a clevis member coupled to the second end. The neutral lock-out mechanism can also have a knob coupled to the clevis member. The knob can be configured to be accessible from the exterior of the transmission.

[0012] Yet one more aspect of the invention addresses an output shaft assembly for a transmission. The output shaft assembly has an output shaft that has a flange end and a splined end. The output shaft adapted to translate axially. In one embodiment, the output shaft has a throw-out bearing housing operably coupled to the output shaft. In some embodiments, an axial translation of the throw-out bearing corresponds to an axial translation of the output shaft.

[0013] In another aspect, the invention concerns a control system for an infinitely variable transmission (IVT). The control system has a shift rod driver and an output feedback rod coupled to the shift rod driver. In one embodiment, the control system has a control interface housing operably coupled to the shift rod driver. The control interface housing is configured to translate axially. The control system can also have an output member configured to be selectively coupled to the output feedback rod.

[0014] Another aspect of the invention relates to a method of controlling an infinitely variable transmission (IVT). In one embodiment, the method includes providing a ratio adjuster coupled to the IVT. The ratio adjuster is configured to actuate a change in transmission ratio of the IVT. The ratio adjuster has a shift rod driver and an output feedback rod coupled to the shift rod driver. The ratio adjuster also has a shift rod sleeve operably coupled to the output feedback rod. In one embodiment, the method includes sensing a position of the ratio adjuster of the IVT. The position corresponds to a desired transmission output speed of zero. The method can include coupling operably an output member of the IVT to the ratio adjuster. The method can also include actuating the ratio adjuster to maintain a zero output speed of the IVT.

[0015] One aspect of the invention relates to a method of controlling an infinitely variable transmission (IVT) having a ratio adjuster and a ball planetary variator. The method includes commanding an IVT output speed of zero. In one embodiment, the method includes sensing the IVT output speed via a mechanical coupling. The mechanical coupling can be configured to couple to both the ratio adjuster and the variator. The method can also include adjusting the mechanical coupling to maintain the IVT output speed at zero.

[0016] Another aspect of the invention addresses a ratio adjuster for an infinitely variable transmission (IVT) having a variator. The ratio adjuster has a shift rod driver and an output feedback rod coupled to the shift rod driver. In one embodiment, the ratio adjuster has a shift rod sleeve operably coupled to the output feedback rod. The shift rod sleeve is arranged radially outward of, and coaxially with, the output feedback rod. The shift rod sleeve is coupled to the variator.

[0017] One more aspect of the invention concerns a control interface apparatus for a control system having a shift rod driver and a user interface. The control

interface apparatus includes a housing having a central bore and an adjustment member coupled to the central bore. In one embodiment, the control interface apparatus includes a first threaded portion located on the central bore. The first threaded portion adapted to receive a threaded portion of the shift rod driver. The control interface apparatus also includes a second threaded portion on the central bore. The second threaded portion is adapted to receive the adjustment member.

[0018] Yet another aspect of the invention involves an output engagement mechanism for an infinitely variable transmission (IVT). The output engagement mechanism has a housing and an output member operably coupled to the IVT. The output member is operably coupled to the housing. The output engagement mechanism can include an output feedback rod selectively coupled to the housing. The output feedback rod operably couples to the housing at an output speed of the IVT substantially equal to zero. In one embodiment, the output engagement mechanism includes a group of engagement pins operably coupled to the housing. The engagement pins are arranged angularly about, and extending radially from, a longitudinal axis of the output feedback rod. The output engagement mechanism also includes a groups of springs operably coupled to the engagement pins.

[0019] Another aspect of the invention relates to a housing assembly for an output engagement mechanism having a first generally cylindrical housing. The first generally cylindrical housing has a first central bore, a first end, and a second end. The housing assembly includes a set of flat surfaces formed on an exterior perimeter of the cylindrical housing. The housing assembly also includes a first set of channels formed on the first end. The channels extend radially outward from the central bore. In one embodiment, the housing assembly includes a retaining cap coupled to the first end of the cylindrical housing. The retaining cap has a second set of channels configured to substantially align with the first set of channels.

[0020] Yet one more aspect of the invention addresses a shift rod driver having a substantially cylindrical rod having a first end and a second end. The shift rod driver has a reaction flange configured on the first end and a first threaded portion formed on the second end. The shift rod driver also has a second threaded portion formed on the first end.

[0021] Another aspect of the invention relates to a shift rod member having a substantially cylindrical body with a first end and a second end. The first end has a threaded bore. The shift rod member has a set of engagement surfaces formed on the outer periphery of the cylindrical body. The engagement surfaces can be located in proximity to the second end. The shift rod member also has a bearing flange formed on the outer periphery of the cylindrical body. The bearing flange can be located between the threaded bore and the engagement surfaces.

[0022] Yet another aspect of the invention involves a shift rod sleeve for a control system of an infinitely variable transmission (IVT). The shift rod sleeve has a substantially cylindrical body having a first central bore and a second central bore. The first central bore is arranged on a first end of the cylindrical body, and the second central bore is arranged on a second end of the cylindrical body. The first central bore has a different diameter than the second central bore. The shift rod sleeve also has an end cup extending from the second end of the cylindrical body. The end cup can be configured to couple to an output engagement rod of the control system. The end cup has a cup threaded portion. The shift rod sleeve also has a reaction face formed on an interior surface of the end cup.

[0023] In another aspect, the invention concerns a carrier nut for an infinitely variable transmission (IVT). The carrier nut has a substantially cylindrical body having a central bore formed with a threaded portion. The threaded portion is configured to couple to a main shaft of the IVT. The carrier nut has a first reaction surface formed on a face of one end of the cylindrical body. The carrier nut can have a second reaction surface formed on the outer periphery of the cylindrical body. The carrier nut can also have a shoulder configured on the outer circumference of the cylindrical body. The shoulder is adapted to support a bearing of the IVT.

[0024] Another aspect of the invention relates to a housing for a transmission. The housing can have an upper housing member with a flange surface having a first group of fastening holes. The housing includes a first set of cooling fins extending outwardly and inwardly from a main cavity of the upper housing member. In one embodiment, the housing includes a piloting shoulder adapted to align and support a control mechanism of the transmission. The housing also includes an intermediate plate

coupled to the upper housing member. In one embodiment, the housing includes a lower housing member having a flange surface with a second group of fastening holes. The flange surface configured to couple to the intermediate plate. The lower housing member can also include a second group of cooling fins extending outwardly and inwardly from a main cavity of the lower housing member. The lower housing member can also include a support hub located on the interior of the main cavity of the lower housing member. The support hub has a number of grooves and shoulders.

BRIEF DESCRIPTION OF THE FIGURES

[0025] Figure 1 is a perspective view of a transmission that uses an infinitely variable variator (IVT) in accordance with inventive embodiments disclosed herein.

[0026] Figure 2 is a cross-sectional view of the transmission of Figure 1.

[0027] Figure 3 is a second cross-sectional view of the transmission of Figure 1.

[0028] Figure 4 is a partially exploded assembly view of the transmission of Figure 1.

[0029] Figure 5 is a cross-sectional view of an IVT that can be used with the transmission of Figure 1.

[0030] Figure 6 is an exploded assembly view of certain components of the IVT of Figure 5.

[0031] Figure 7A is a perspective view of certain components a neutral lock-out device that can be used with the transmission of Figure 1.

[0032] Figure 7B is a perspective view of an exemplary manual neutral knob that can be used with the neutral lock-out device of Figure 7A.

[0033] Figure 7C is a perspective view of an exemplary switch cam that can be used with the neutral lock-out device of Figure 7A.

[0034] Figure 7D is a perspective view of an exemplary switch that can be used with the neutral lock-out device of Figure 7A.

[0035] Figure 8A is a perspective view of certain components of an output shaft assembly that can be used in the transmission of Figure 1.

[0036] Figure 8B is a cross-sectional view of the output shaft assembly of Figure 8A.

[0037] Figure 9A is a perspective view of an output coupling that can be used with the IVT of Figure 5.

[0038] Figure 9B is a perspective view of the output coupling of Figure 9A.

[0039] Figure 9C is a cross-sectional view of the output coupling of Figure 9A.

[0040] Figure 10A is a cross-sectional view of certain components of a control system that can be used with the IVT of Figure 5.

[0041] Figure 10B is a Detail A view of the control system of Figure 10A.

[0042] Figure 10C is a Detail B view of the control system of Figure 10A.

[0043] Figure 10D is a cross-sectional view of certain components of the control system of Figure 10A.

[0044] Figure 11A is a perspective view of an exemplary control interface mechanism housing that can be used with the control system of Figure 10A.

[0045] Figure 11B is a cross-sectional view of the control interface mechanism housing of Figure 11A.

[0046] Figure 12A is an exploded assembly view of certain components of an output engagement mechanism that can be used with the control system of Figure 10A.

[0047] Figure 12B is a cross-sectional view of the components of the output engagement mechanism of Figure 12A.

[0048] Figure 13A is a perspective view of an output engagement mechanism housing that can be used with the output engagement mechanism of Figure 12A.

[0049] Figure 13B is a cross-sectional view of the output engagement mechanism housing of Figure 13A.

[0050] Figure 13C is another perspective view of the output engagement mechanism housing of Figure 13A.

[0051] Figure 13D is a perspective view of an output engagement mechanism cap that can be used with the output engagement mechanism of Figure 12A.

[0052] Figure 13E is a perspective view of an engagement pin that can be used with the output engagement mechanism of Figure 12A.

[0053] Figure 13F is a cross-sectional view of the engagement pin of Figure 13E.

[0054] Figure 14 is a perspective view of a shift rod driver that can be used with the control system of Figure 10A.

[0055] Figure 15A is a perspective view of an output feedback rod that can be used with the control system of Figure 10A.

[0056] Figure 15B is a cross-sectional view of the output feedback rod of Figure 15A.

[0057] Figure 15C is a Detail C view of the shift rod member of Figure 15A.

[0058] Figure 15D is a cross-sectional view of another embodiment of the output feedback rod of Figure 15A.

[0059] Figure 16A is a perspective view of a shift rod sleeve that can be used with the control system of Figure 10A.

[0060] Figure 16B is a cross-sectional view of the shift rod sleeve of Figure 16A.

[0061] Figure 17A is a perspective view of a cap that can be used with the control system of Figure 10A.

[0062] Figure 17B is a cross-sectional view of the cap of Figure 17A.

[0063] Figure 18 is a perspective view of a shift rod nut that can be used in the control system of Figure 10A.

[0064] Figure 19A is a perspective view of a carrier nut that can be used with the IVT of Figure 5.

[0065] Figure 19B is a cross-sectional view of the carrier nut of Figure 19A.

[0066] Figure 20A is a top elevational view of a main shaft that can be used with the IVT of Figure 5.

[0067] Figure 20B is side elevational view of the main shaft of Figure 20A.

[0068] Figure 20C is a cross-sectional view of the main shaft of Figure 20A.

[0069] Figure 20D is a Detail D view of the main shaft of Figure 20A.

[0070] Figure 20E is a Detail E view of the main shaft of Figure 20A.

[0071] Figure 21 is an exploded assembly view of a housing that can be used with the transmission of Figure 1.

[0072] Figure 22A is a perspective view of the lower housing member of the housing assembly of Figure 21.

[0073] Figure 22B is a cross-sectional, perspective view of the lower housing member of Figure 22A.

[0074] Figure 22C is a Detail F view of the lower housing member of Figure 22B.

[0075] Figure 23A is a perspective view of an upper housing member of the housing assembly of Figure 21.

[0076] Figure 23B is a cross-sectional, perspective view of the upper housing member of Figure 23A.

DETAILED DESCRIPTION OF CERTAIN INVENTIVE EMBODIMENTS

[0077] The preferred embodiments will now be described with reference to the accompanying figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be interpreted in any limited or restrictive manner simply because it is being utilized in conjunction with a detailed description of certain specific embodiments of the invention. Furthermore, embodiments of the invention may include several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to practicing the inventions herein described. The CVT/IVT embodiments described here are generally related to transmissions and variators disclosed in United States Patents 6,241,636, 6,419,608, 6,689,012, 7,011,600, and U.S. patent applications 11/243,484 and 11/543,311. The entire disclosure of each of these patents and applications is hereby incorporated herein by reference.

[0078] As used here, the terms “operationally connected,” “operationally coupled”, “operationally linked”, “operably connected”, “operably coupled”, “operably linked,” and like terms, refer to a relationship (mechanical, linkage, coupling, etc.) between elements whereby operation of one element results in a corresponding, following, or simultaneous operation or actuation of a second element. It is noted that in using said terms to describe inventive embodiments, specific structures or mechanisms that link or couple the elements are typically described. However, unless otherwise specifically stated, when one of said terms is used, the term indicates that the actual linkage or coupling may take a variety of forms, which in certain instances will be obvious to a person of ordinary skill in the relevant technology.

[0079] For description purposes, the term “radial” is used here to indicate a direction or position that is perpendicular relative to a longitudinal axis of a transmission or variator. The term “axial” as used here refers to a direction or position along an axis

that is parallel to a main or longitudinal axis of a transmission or variator. For clarity and conciseness, at times similar components labeled similarly (for example, control piston 582A and control piston 582B) will be referred to collectively by a single label (for example, control pistons 582).

[0080] Referring to **Figures 1-4**, in one embodiment an infinitely variable transmission (IVT) 100 includes a housing assembly 102 adapted to cooperate with a control assembly 104. The IVT 100 can be coupled to a power input with an input pulley 106, for example. Among other things, the housing assembly 102 encloses most of the components of the IVT 100 and provides structural support for mounting the IVT 100 to, for instance, a vehicle frame or other components in the drivetrain such as a gearbox, differential, or axle. In some embodiments, the IVT 100 includes a manual neutral knob assembly 108 that can couple to certain components that are inside the housing assembly 102. The manual neutral knob assembly 108 can provide an interface to allow manual disconnection between the input pulley 106 and a driven device, such as a driven axle on a lawn tractor. In one embodiment, a number of cooling fins 110 are formed on the housing assembly 102. The cooling fins 110 can aid in thermal management of the IVT 100.

[0081] Turning now to **Figure 2** more specifically, in one embodiment of the IVT 100 the housing assembly 102 encloses a variator 200 that can be operably coupled to the input pulley 106 and to an output shaft 210. In some embodiments, the housing assembly 102 supports a neutral fork arm 220 which can couple to the manual neutral knob assembly 108. The manual neutral knob assembly 108 can be connected to a clevis member 222, for example. A holding spring 224 can be coupled to the clevis member 222. In one embodiment, adjustment of the manual neutral knob assembly 108, typically by rotation to a predetermined angular position, translates the clevis member 222 and energizes the holding spring 224, whereby adjustment of the manual neutral knob assembly 108 results in movement of the neutral fork arm 220 about a pivot 223. In some embodiments, the neutral fork arm 220 couples to a throw-out bearing housing 226, which throw-out bearing housing 226 is configured to engage and disengage the output shaft 210. An axial thrust bearing 211 and a needle roller bearing 212 can be provided to support, among other things, certain components of the variator 200.

[0082] In one embodiment, the IVT 100 includes a control interface mechanism 230 to facilitate adjustment of the speed ratio of the IVT 100. In some embodiments, the control interface mechanism 230 can be coupled to a ratio adjuster 240 that couples to certain components of the variator 200. As shown in **Figure 3**, in one embodiment the control interface mechanism 230 can be coupled to a control linkage 310, which control linkage 310 can be supported on the housing 102 at a pivot 312, and which control linkage 310 couples additionally, in one embodiment, to a coupling member 314. The coupling member 314 is preferably adapted to interact with a user control interface such as a foot pedal or a hand lever (not shown) for communicating adjustments in transmission ratio from a user (or, alternatively or additionally, an automated or a semi-automated command system) to the IVT 100. In one embodiment of the control linkage 310, the coupling member 314 couples to a pivot 315 arranged on one end of a pivot lever 316. An intermediate linkage 318 couples to the pivot lever 316 at a pivot 317. Translation of the coupling member 314 tends to rotate the pivot lever 316 around the pivot 312 and, thereby, tends to translate the control linkage 318. In some embodiments, the control linkage 318 couples to a shift fork 320 at a pivot 319. The shift fork 320 couples to the control interface mechanism 230. The shift fork 320 can couple to a pivot 321, which in one embodiment is supported by a ground member 330. The ground member 330 can be attached to, for example, the vehicle chassis.

[0083] Turning now to **Figure 4**, in one embodiment of the IVT 100, the housing assembly 102 can include an upper housing member 102A, an intermediate plate 102C, and a lower housing member 102B. The housing members 102A, 102B, and 102C are coupled in a suitable manner, such as with bolts, screws, or clamps. The variator 200 can be positioned on the interior of the housing assembly 102 and towards one side thereby creating an internal volume to provide, for instance, a reservoir for lubricant. In some embodiments, a housing cap 410, a flange seal 412, and a shaft seal 414 couple to the upper housing member 102A. The housing cap 410 can seal the IVT 100. The variator 200 can be provided with a number of springs, for example coil springs 202, which can couple the variator to the upper housing member 102A. The coil springs 202 can facilitate the provision of a preload on components of the variator 202.

[0084] Referring now to **Figure 5**, in one embodiment a variator 200 is configured to receive input power from a pulley 106 on a main shaft 510. The main shaft 510 can be attached to a carrier 512 with a carrier clamp 514. Power is transferred to the carrier 512, which facilitates the infinitely variable ratio range. IVT functionality allows delivery of a zero output speed (a “powered zero” condition) with a non-zero input speed of a power delivery device. The carrier 512 provides support to a number of power roller assemblies 502, among other things. The carrier clamp 514 is configured to receive a support bearing 515A. In some embodiments, the bearing 515A can operably couple the variator 200 and the housing assembly 102. An exemplary power roller assembly 502 is described in United States patent application 11/543,311, the entire disclosure of which is hereby incorporated herein by reference. In one embodiment, a traction ring 516 couples to a clamp force generator assembly 518. The clamp force generator assembly 518 can include a reaction member 520 and a number of load cam rollers 522. In some embodiments, the reaction member 520 couples to the upper housing member 102A with, for example, dowel pins and coil springs 202. The variator 200 can be configured to have an output traction ring 524 in contact with the power roller assembly 502. The output traction ring 524 can couple to a second axial force generator mechanism that includes a number of load cam rollers 522 and to a reaction member 526. The reaction member 526 can attach to an output member 528 with, for instance, dowel pins, so that relative motion between the two members is prevented. In other embodiments, the coupling between the reaction member 526 and the output member 528 can be a frictional coupling.

[0085] Referring now to **Figure 5** and **Figure 6**, in one embodiment of the variator 200, a ratio adjuster 240 can be arranged coaxially and radially inward of the main shaft 510. The ratio adjuster 240 can couple to an idler assembly 504. An adjustment of the ratio adjuster 240 tends to translate axially the idler assembly 504, thereby adjusting the speed ratio of the IVT 100. In some embodiments, the ratio adjuster 240 can couple to an output engagement mechanism 530. Under certain operating conditions, such as powered zero, the output member 528 can be operably coupled to the ratio adjuster 240. In one embodiment, the ratio adjuster 240 is supported radially along the central axis of the variator 200 by bearings 540 and 542, which can be

coupled to the main shaft 510. The ratio adjuster 240 can be additionally supported by a bearing 544 that is received and supported by the output member 528 in a bore 545.

[0086] Turning to **Figure 2** and **Figure 6**, in one embodiment of the variator 200, the output shaft 210 is coupled to the output member 528 with, for example, a number of dowels 611. The dowels 611 can be arranged angularly about, and substantially coaxial with, the main axis of the IVT 100. The output shaft 210 and the output member 528 can be rigidly linked during operation. The throw-out bearing housing 226 can be coupled to the output shaft 210 with, for instance, a radial ball bearing 227. The throw-out bearing housing 226 can be radially supported in the housing assembly 102 and constrained from rotation with at least two dowels 612. The dowels 612 can also couple to the neutral fork arm 220. The neutral fork arm 220 can be used to translate axially the throw-out bearing housing 226 thereby selectively engaging and disengaging the output shaft 210 from the output member 528.

[0087] Passing now to **Figure 7A**, in one embodiment of the IVT 100, a neutral lock out mechanism 700 can be coupled to the variator 200. The neutral lock out mechanism 700 can include a throw-out bearing housing 226 coupled to one end of a neutral fork arm 220. The neutral fork arm 220 can be supported at a pivot 223 with a bracket 730. The clevis member 222 can be connected to the neutral fork arm 220 at pivot 722. The neutral knob assembly 108 can include, in one embodiment, a knob 710 and a switch cam 712. The neutral knob assembly 108 can couple to one end of the clevis member 222. In some embodiments, a spring 224 can cooperate with the clevis member 222. One end of the spring 224 couples to the clevis member 222 while the other end of the spring 224 couples to the housing 102. In some embodiments, a kill switch 720 couples to the switch cam 712 thereby allowing the activation of the neutral lock out mechanism 700 to be communicated to, for example, the electrical system of a vehicle. During operation of the IVT 100, the neutral lock out mechanism 700 is inactive and therefore the neutral throw-out bearing housing 226 is positioned to allow engagement of the output shaft 210 with the output member 528. During certain operating conditions, it is desirable to decouple the variator 200 from the output shaft 210. The neutral lock out mechanism 700 can be used for this purpose. The neutral knob assembly 108 can be adjusted to a predetermined position by pulling the knob 710 away

from the housing 102 and rotating the knob 710 through an arc of, for example, about 90 degrees. This action translates the clevis member 222, compresses the spring 224 between the housing 102 and the clevis member 222, and pivots the neutral fork arm 220, thereby axially translating the throw-out bearing housing 226.

[0088] Turning to **Figure 7B** through **Figure 7D**, in one embodiment the neutral knob 710 can be a substantially cylindrical body formed with a central bore 711. The central bore 711 can be adapted to receive one end of the clevis member 222. The neutral knob 710 can have a shoulder 713 that extends from the main body. The shoulder 713 can be adapted to mate with the switch cam 712. In one embodiment, the switch cam 712 includes a main bore 716 and a number of guide bores 717. The guide bores 717 can facilitate the selective coupling of the switch cam 712 to a housing member such as housing member 102A via a number of dowel pins (not shown). The body of the switch cam 712 can have a switch cam extension 715 adapted to couple to the kill switch 720. In one embodiment, the kill switch 720 includes a switch button 721 supported in a housing 722. A number of fastener holes 723 can be provided in the housing 722 to facilitate, for example, attaching the kill switch 720 to the chassis of a vehicle.

[0089] Referring now to, **Figures 8A** and **8B**, in one embodiment an output shaft 210 is adapted to cooperate with the neutral throw-out bearing housing 226. A ball bearing 227 can be supported in the neutral throw-out bearing housing 226. The ball bearing 227 can be supported by the output shaft 210 on a bearing seat 818. A snap ring 811A can be inserted in a snap ring groove 820; the snap ring 811A is suitably adapted to secure bearing race 810. Likewise, a snap ring 811B can be provided to secure a bearing race of the bearing 227 in the neutral throw-out bearing housing 226. In one embodiment, the output shaft 210 has a splined end 824 and a flange end 816. The flange end 816 can include a number of holes 610 adapted to receive, for example, the dowels 611. The output shaft 210 can be provided with a seal surface 822 adapted to receive a shaft seal, for example. The end 816 can include a counter bore 812 to provide clearance for certain components of the ratio adjuster 240.

[0090] Turning to **Figures 9A-9C**, in one embodiment the output member 528 can be a generally hollow cylindrical body with an output member end 911A and an output member end 911B. The output member end 911A is adapted to couple to the axial

force reaction member 526. The output member end 911B is adapted to couple to the output shaft 210. In some embodiments, a number of dowel bores 910 are formed on the output member end 911A. The dowel bores 910 are adapted to constrain a number of dowels 611. The dowels 611 can couple the output member 528 to the axial force reaction member 526. In some implementations, a number of drain holes 912 can be arranged radially on the outer circumference of the output member 528. The drain holes 912 facilitate the drainage of lubricant from the interior of the variator 200. Focusing now on the output member end 911B, a shoulder 914 can be provided to mate with the axial thrust bearing 211 (see, for example, Figure 2). In some embodiments, a flange surface 916 is provided with bores 915 to receive a number of dowels 611. The flange surface 916 can mate with the output shaft 210. A cylindrical shoulder 917 can extend from the flange surface 916 to provide support for the needle roller bearing 212 (see, for example, Figure 2). Among other things, the shoulder 914 and the shoulder 917 support the variator 200 in the housing assembly 102. The inner bore of the output member 528 is substantially cylindrical and can have, for example, a number of flat spring reaction surfaces 920 that can be configured to mate with an output engagement mechanism 530 (see, for example, Figure 5).

[0091] Referring to **Figure 10A, 10B, 10C, and 10D** now, a control system 1000 that can be adapted to cooperate with the variator 200 will be described. In one embodiment, the control system 1000 includes a control interface mechanism 230, a ratio adjuster 240, and an output engagement mechanism 530. In some embodiments, the ratio adjuster 240 includes a shift rod subassembly 1001 and a shaft subassembly 1002. In one embodiment, the shift rod subassembly 1001 includes a shift rod driver 1001A and an output feedback rod 1001B. The shift rod driver 1001A and the output feedback rod 1001B can be coupled with threads 1003, for example. Once assembled, the shift rod driver 1001A and the output feedback rod 1001B form a substantially rigid shift rod subassembly 1001. The shaft subassembly 1002 can be arranged radially outward of and coaxially with the shift rod subassembly 1001. In some embodiments, the shaft subassembly 1002 includes a shift rod sleeve 1002A coupled to a cap 1002B. The shift rod sleeve 1002A can be configured to adapt to a shift nut 1006. The shift nut 1006 can be retained on or by the shift rod sleeve 1002A with, for example, a snap ring 1007. The

shift nut 1006 can be further coupled to the idler assembly 504 (See, for example, Figure 5). The shaft subassembly 1002 is supported on the shift rod subassembly 1001 with, for example, bearings 1004 and 1005. The bearings 1004 and 1005 can be, for example, needle roller bearings and can be constrained between the shift rod subassembly 1001 and the shaft subassembly 1002.

[0092] Referring now to **Figures 10A, 11A and 11B**, in one embodiment a control interface mechanism housing 1100 is a substantially cylindrical body with a central bore 1102 having two portions of different diameters. One portion of the central bore 1102 is threaded with, for example, a straight thread 1106. The threaded portion 1106 can be adapted to receive adjustment members 1020 and 1021. The adjustment members 1020 and 1021 constrain certain parts of the ratio adjuster 240 during operation. The central bore 1102 can include a second threaded portion having, for example, an acme thread 1108. The acme thread 1108 can be configured to mate with a threaded portion of the shift rod driver 1001A. The control interface mechanism housing 1100 can include tapped holes 1104A and 1104B to connect to, for example, the shift fork 320 with fasteners such as bolts or screws (not shown).

[0093] Turning now to **Figures 12A and 12B**, in one embodiment the output engagement mechanism 530 can be a mechanical coupling configured to facilitate a selective connection between, for example, the output member 528 and the ratio adjuster 240. In some embodiments, the output engagement mechanism 530 rotates with, for example, the output member 528. In one embodiment, the output engagement mechanism 530 includes a generally cylindrical housing 1200 coupled to a retaining cap 1202. The engagement mechanism housing 1200 and the retaining cap 1202 enclose a number of springs 1008 and pins 1010. In the illustrated embodiment, four pins 1010 and four springs 1008 are arranged angularly about the central axis of the housing 1200. The output engagement mechanism 530 is configured to cooperate with the variator 200. In one embodiment, the output engagement mechanism 530 surrounds certain components of the ratio adjuster 240. Under certain operating conditions, such as powered zero, the output engagement mechanism 530 can couple to certain components of the ratio adjuster 240, for example, the output feedback rod 1001B. In some implementations, the output

engagement mechanism 530 turns the output feedback rod 1001B thereby shifting the variator 200.

[0094] Turning to **Figures 13A-13F**, in one embodiment the housing 1200 includes a generally cylindrical body with a central bore 1302. One end of the housing 1200 can include a shoulder 1310. The shoulder 1310 can facilitate the radial and axial alignment of the bearing 515B (see Figure 5). In some embodiments, a number of flat surfaces 1312 can be arranged on the outer circumference of the housing 1200. The flat surfaces 1312 generally cooperate with the spring reaction surfaces 920 formed on the inner bore of output member 528 (see, for example, Figure 9A). A number of holes 1314 provide clearance for fasteners that secure the housing 1200 to both the retaining cap 1202 and the output member 528 with, for example, bolts. A number of counter bores 1316 can be formed in the housing 1200 to provide clearance to, for example, bolt heads (not shown). The central bore 1302 is generally sized to provide clearance for certain components of the ratio adjuster 240. The housing 1200 can additionally include a number of channels 1318 and reaction surfaces 1320 formed on the end of the housing 1200 that is opposite to the end of the housing 1200 having the shoulder 1310. The channels 1318 can be arranged to support the pins 1010. Similarly, the retaining cap 1202 is a generally cylindrical disk with a central bore 1303 that can provide clearance for certain components of the ratio adjuster 240. A number of holes 1315 can be provided on the retaining cap 1202 and adapted to cooperate with the holes 1314. A number of channels 1319 are configured on one face of the retaining cap 1202. The channels 1319 are substantially similar to the channels 1318 and are adapted to receive the pins 1010. The retaining cap includes a number of reaction surfaces 1321, which are adapted to mate with the pins 1010. The pins 1010 can be generally hollow cylindrical bodies with an inner counter bore 1334. The pins 1010 include a number of external reaction surfaces 1330 adapted to mate with, for instance, the reaction surfaces 1320 and 1321. Each inner bore 1334 is adapted to receive a spring 1008 (see, for example, Figure 12B). The springs 1008 are configured to press the pins 1010 against the reaction surfaces 1320 and 1321. The pins 1010 can couple to certain components of the ratio adjuster 240 with an engagement shoulder 1332 that extends from the reaction surface 1330 of the pin 1010. In one embodiment, the reaction surfaces 1320 and 1321 are

configured to prevent the engagement shoulder 1332 from contacting the ratio adjuster 240 during certain operating conditions, namely conditions with non-zero output speed, for example.

[0095] Passing now to **Figures 14-18**, in one embodiment a shift rod driver 1001A includes a generally cylindrical rod 1410 formed with a reaction flange 1412 on one end and a fastening thread 1003 on the other end. A screw lead 1414 can be an acme thread, for example, adapted to cooperate with the acme thread 1108 provided in the control interface housing 1100 (see, for example, Figure 11A). The reaction flange 1412 can be configured to cooperate with the control interface housing 1100 and the adjustment members 1020 and 1021 (see, for example, Figure 10A). The fastening thread 1003 couples the shift rod driver 1001A to the output feedback rod 1001B. In one embodiment, the output feedback rod 1001B can be a substantially cylindrical body provided with a threaded bore 1510 on one end, a bearing flange 1514, and a number of engagement surfaces 1512. The bearing flange 1514 includes reaction surfaces 1516 and 1518. The reaction surfaces 1516 and 1518 are adapted to cooperate with, for example, needle bearings 1004 and 1005, respectively. The engagement surfaces 1512 can be adapted to cooperate with the output engagement mechanism 530 and the engagement shoulder 1332 on the pin 1010. A number of profiled ramps 1520A and 1520B can be formed on the output feedback rod 1001B. Preferably, the profiled ramps 1520 are adapted to guide and capture the engagement shoulders 1332. In some embodiments, a number of engagement surfaces 1530 can be formed on the output feedback rod 1001B. The engagement surfaces 1530 can be substantially similar in function to the engagement surfaces 1512. A number of profiled ramps 1532A and 1532B can be arranged to cooperate with the engagement shoulders 1332 for guiding and capturing the pins 1010.

[0096] Turning to **Figures 16A-17B**, in one embodiment, the shift rod sleeve 1002A can be a generally hollow cylindrical body having a first bore 1730 and a second bore 1732. The shift rod sleeve 1002A can be operationally coupled to the variator 200, and more specifically to the idler assembly 504. The two bores 1730 and 1732 are configured to provide clearance for the shift rod driver 1001A and the output feedback rod 1001B. The shift rod sleeve 1002A can be formed with a cup end 1702, which is adapted to enclose a number of needle bearings 1004 and 1005. The cup end 1702

includes threads 1710 configured to mate with the threads 1610 of the retaining cap 1002B. The reaction face 1712 can support the bearing 1004, for example. A reaction face 1620 can be provided on one end of the retaining cap 1002B. The reaction face 1620 can support the bearing 1005 (see, for example, Figure 10B). In some embodiments, the shift rod sleeve 1002A can include a surface 1720 and a shoulder 1721 adapted to receive, for example, the inner bore 1830 of a shift nut 1006. The shift nut 1006 can be secured to the shift rod sleeve 1002A by a snap ring 1007 (see, for example, Figure 10A) received in a groove 1722. In one embodiment, the retaining cap 1002B can be a generally cylindrical disk with a central bore 1614. Threads 1610 can be provided on the outer circumference of the cylindrical disk to mate with the cup end 1702. The retaining cap 1002B can further include a number of counter bores 1612, which are adapted to receive a tool, for example pliers, for fastening the cap to the shift rod sleeve 1002A.

[0097] Referring now to **Figure 18**, in one embodiment the shift nut 1006 can be a generally rectangular body with a central bore 1830 adapted to mate with, for example, the surface 1720 and the shoulder 1721 of the shift rod sleeve 1002A. Shoulders 1832 and 1833 are configured to adapt to the idler assembly 504; hence, during operation, in one embodiment the shift nut 1006 rotates and translates with the idler assembly 504. The shift nut 1006 couples to the shift rod sleeve 1002A.

[0098] During operation of the IVT 100, a zero output speed condition or powered zero condition may be desired. The command for a zero output speed can be transmitted to the IVT 100 by the control linkage 310 (see, for example, Figure 3). In one embodiment of the variator 200, the zero output speed condition generally corresponds to an arrangement wherein the axis of rotation of the power rollers of the power roller assembly 502 has a tilt angle substantially equal to zero relative to the longitudinal axis of the variator 200. The tilt angle of the power roller assembly 502 generally corresponds to an axial translation of the idler assembly 504. Consequently, the zero output speed condition corresponds to a particular axial position of the idler assembly 504. Typically, the engagement surfaces 1512 of the output feedback rod 1001B align with the engagement pins 1010 during the zero output speed condition. The engagement pins 1010 couple the shift rod assembly 1001 to the output member 528,

consequently a change in output speed can be communicated to the ratio adjuster 240. The coupling of the threads 1108 to the threads 1414 result in the conversion of the rotational input from the output member 528 into an axial translation of the shift rod assembly 1001. The shift rod assembly 1001 can have a minimal degree of allowable rotational and axial travel with respect to the control interface mechanism housing 1100. The amount of allowable rotational and axial travel can be adjusted with the adjustment members 1020 and 1021. The adjustment members 1020 and 1021 define the allowable axial travel of shift rod assembly 1001 with respect to the control interface mechanism housing 1100. The axial translation of the shift rod assembly 1001 axially translates the idler assembly 504 thereby tilting the power roller assemblies 502 to achieve an adjustment of speed ratio of the variator 200, for instance to bring the output speed to zero. Preferably, during the zero output speed condition, the control interface mechanism housing 1100 is substantially stationary and the axial movement of the shift rod assembly 1001 is substantially undetectable to the user of the IVT 100. For example, a user would not notice the IVT 100 shifting to maintain the zero output speed condition. The length of the engagement surfaces 1512 defines the ratio range around a zero speed for which the engagement pins 1010 affect the speed ratio of the variator 200. When the user shifts the shift rod assembly 1001 substantially away from a zero speed ratio such that the engagement surfaces 1512 are not aligned with the engagement pins 1010, the engagement pins do not contact the output feedback rod 1001B.

[0099] Turning now to **Figures 19A-19B** and referring again to **Figure 5**, in one embodiment a carrier clamp 514 includes a generally cylindrical body with a central bore. A number of holes 1912 can be provided to, among other things, facilitate the delivery of lubricant, such as transmission fluid, to the central axis of the variator 200. The carrier clamp 514 includes a threaded portion 1910 formed on the central bore to couple the carrier clamp 514 to the main shaft 510. Among other things, the carrier clamp 514 operationally couples the main shaft 510 to the carrier 512. The central bore can be further provided with a groove 915, which can be adapted to receive, for example, an o-ring. In one embodiment, the carrier clamp 514 includes a reaction surface 1916 on one end. The reaction surface 1916 is configured to couple to the carrier 512. A shoulder 1932 and a reaction surface 1930 can be provided to support the bearing 515A

that axially supports the carrier 512. The carrier clamp 514 can include a groove 1934 for receiving a snap ring that aids in retaining the bearing 515A. A number of flats 1920 can be formed on the outer circumference of the carrier clamp 514. The flats 1920 can facilitate the mounting of the carrier clamp 514 onto the main shaft 510.

[0100] Passing now to **Figures 20A-20E** and still referencing Figure 5, in one embodiment the main shaft 510 can be a generally cylindrical body having a first central bore 2010 and a second central bore 2012. In some embodiments, the central bores 2010 and 2012 are adapted to receive a number of support bearings, such as bearings 540 and 542, which are configured to support certain components of the ratio adjuster 240. The main shaft 510 can include a number of slots 2014 that are adapted to receive the shift nut 1006 (see, for example, Figure 3). In one embodiment, the slots 2014 provide axial clearance for the shift nut 1006. The main shaft 510 can include a slot 2016 having a crescent shape to receive, for example, a key that can couple the input pulley 106 to the main shaft 510. A number of lubrication holes 2020 can be formed on one end of the main shaft 510. In this embodiment, two lubrication holes 2020 are provided on the main shaft 510 and are configured to align with the lubrication holes 1912 on the carrier clamp 514. A seal groove 2030 can be provided on one end of the main shaft 510. In one embodiment, the main shaft 510 includes a bearing support shoulder 2032 that can be located in the first central bore 2010. The bearing support shoulder 2032 can be configured to couple to the bearing 542, for example. During operation, lubricant can be directed along the inner bore of the main shaft 510. The seal groove 2030 can retain a shaft seal, for example, to prevent leakage of lubricant from the inner bore of the main shaft 510.

[0101] Referring specifically to **Figures 20D** and **20E**, in one embodiment the main shaft 510 includes a number of knurls 2040A and 2040B. The knurls 2040A and 2040B can be configured to facilitate the rigid coupling of the main shaft 510 to the carrier 512. One end of the main shaft 510 can include a set of threads 2042 to engage the carrier clamp 514. A snap ring groove 2041 can be formed on the other end of the main shaft 510. The groove 2041 is configured to receive a snap ring for axially securing the carrier 512. A bearing surface 2044 can be provided on the main shaft 510 for

supporting the bearing 515B. Snap ring grooves 2043 and 2046 receive, for example, snap rings that can axially retain the support bearing 515B.

[0102] Passing now to **Figure 21**, in one embodiment the housing assembly 102 includes an upper housing member 102A, an intermediate plate 102C, and a lower housing member 102B. The upper housing member 102A can include a number of holes 2132 for receiving fasteners such as bolts. Likewise, a number of holes 2122 and 2112 can be provided on the intermediate plate 102C and the lower housing member 102B, respectively. The holes 2132, 2122, and 2112 can be arranged on flange surfaces 2130, 2120, and 2110, respectively. The flange surfaces 2130, 2120, and 2110 can generally extend around the perimeter of the respective housing assembly members 102B, 102C, and 102A, and provide a base for, among other things, sealing the IVT 100. A groove 2124 can be provided on the intermediate plate 102C to receive an o-ring (not shown). A bracket 2126 can further be provided on the intermediate plate 102C. The bracket 2126 is configured to support the pivot lever 316. The cooling fins 110A can be formed on the external surface of the housing member 102A. Likewise, the cooling fins 110B can be formed on the external surface of the housing member 102B. A number of internal cooling fins 110C can further be provided on the interior surface of the lower housing member 102B.

[0103] Turning now to **Figures 22A-22C**, in one embodiment the lower housing member 102B can include a support hub 2210. The support hub 2210 can be formed on the interior surface of the lower housing member 102B. The support hub 2210 is adapted to cooperate with the output shaft 210 and the neutral throw-out bearing housing 226. A seal surface 2220 can be provided to receive, for example, a shaft seal. A shoulder 2222 can be provided that supports the bearing 211. Likewise, a shoulder 2224 can be provided to support the bearing 212. A number of grooves 2226 can be formed on the support hub 2210 to retain the dowels 612 of the throw-out bearing housing 226. A clearance bore 2202 can be provided on the lower housing member 102B. The output shaft 210 extends from the IVT 100 at the clearance bore 2202. A drain hole 2204 allows for removal of lubricant from the housing assembly 102. A number of through bores 2206 can be provided on the lower housing member 102B and can be adapted to mount the IVT 100 to a vehicle structure.

[0104] Referring now to **Figures 23A** and **23B**, in one embodiment the upper housing member 102A can include a number of dowel bores 2302 arranged on the internal cavity of the housing member 102A. The dowel bores 2302 can be configured to couple to certain components of the variator 200. In particular, the dowel bores 2302 can receive dowels that couple to the axial force generator assembly 518. A shoulder 2304 can support a snap ring, for example, that retains the bearing 515A. The cooling fins 110A can be formed on the exterior of the housing member 102A, while the cooling fins 110D can be formed on the interior of the housing member 102A. A through bore 2306 and a number of guide bores 2308 can be provided to cooperate with and/or receive the manual neutral knob assembly 108. A lubricant port 2310 can be formed on the exterior of the upper housing member 102A and is configured to receive a hydraulic fitting to supply lubricant to the IVT 100. A piloting shoulder 2312 and a number of threaded bores 2314 can be provided to receive the housing cap 410 (see, for example, Figure 4).

[0105] The foregoing description details certain embodiments of the invention. It will be appreciated, however, that no matter how detailed the foregoing appears in text, the invention can be practiced in many ways. As is also stated above, it should be noted that the use of particular terminology when describing certain features or aspects of the invention should not be taken to imply that the terminology is being re-defined herein to be restricted to including any specific characteristics of the features or aspects of the invention with which that terminology is associated.

WHAT IS CLAIMED IS:

1. A ball planetary infinitely variable transmission (IVT) comprising:
 - a shift rod driver;
 - an output feedback rod coupled to the shift rod driver; and
 - a plurality of engagement pins configured to selectively couple to the output feedback rod.
2. The IVT of Claim 1, further comprising a control interface housing operably coupled to the shift rod driver.
3. The IVT of Claim 1, wherein the output feedback rod comprises a plurality of flats and ramps adapted to cooperate with at least one of the engagement pins.
4. A ball planetary infinitely variable transmission (IVT) comprising:
 - a throw-out bearing housing coupled to an output member of the IVT;
 - a neutral fork arm having a first end and a second end, the first end coupled to the throw-out bearing housing;
 - a clevis member coupled to the second end; and
 - a knob coupled to the clevis member, the knob configured to be accessible from the exterior of the IVT.
5. The IVT of Claim 4, further comprising a holding spring coupled to the clevis member.
6. The IVT of Claim 4, wherein the knob is configured to move the clevis member.
7. The IVT of Claim 4, further comprising a switch cam coupled to the knob.
8. A variator for an infinitely variable transmission (IVT), the variator comprising:
 - a plurality of power roller assemblies arranged angularly about a longitudinal axis of the transmission, the power roller assemblies configured to tilt in operation;
 - a first traction ring in contact with the power rollers, the first traction ring substantially non-rotatable;
 - a second traction ring in contact with the power rollers;

a carrier adapted to transfer an input power to the power roller assemblies;
and

an output member operably coupled to the second traction ring, the output member adapted to translate along the longitudinal axis, the output member configured to engage and disengage selectively from the second traction ring.

9. The variator of Claim 8, further comprising a ratio adjuster operably coupled to the output member.

10. The variator of Claim 9, wherein the ratio adjuster comprises a rotatable member and a substantially non-rotatable member.

11. The variator of Claim 10, wherein the substantially non-rotatable member is adapted to selectively engage the output member during operation.

12. A transmission comprising:

a plurality of power roller assemblies arranged angularly about a longitudinal axis of the transmission, the power roller assemblies configured to tilt during operation;;

a first traction ring in contact with the power rollers;

a second traction ring in contact with the power rollers; and

an idler in contact with the power rollers, the idler adapted to translate with respect to the longitudinal axis;

a shift rod sleeve operably coupled to the idler, the shift rod sleeve configured to rotate with the idler;

a shift rod driver arranged along the longitudinal axis, the shift rod driver operably coupled to the shift rod sleeve;

an output feedback rod coupled to the shift rod driver; and

an output engagement mechanism operably coupled to the output feedback rod, wherein the output engagement mechanism is configured to rotate with the second traction ring.

13. The transmission of Claim 12, further comprising a control interface housing operably coupled to the shift rod driver.

14. The transmission of Claim 12, wherein the output engagement mechanism is configured to selectively couple to the output feedback rod during operation of the transmission.

15. The transmission of Claim 12, wherein a speed of rotation of the output engagement mechanism facilitates an axial translation of the shift rod sleeve.

16. A neutral lock-out mechanism for a transmission, the neutral lock-out mechanism comprising:

a throw-out bearing housing operably coupled to an output member of the transmission;

a neutral fork arm having a first end and a second end, the first end coupled to the throw-out bearing housing;

a clevis member coupled to the second end; and

a knob coupled to the clevis member, the knob configured to be accessible from the exterior of the transmission.

17. The neutral lock-out mechanism of Claim 16, further comprising a holding spring coupled to the clevis member.

18. The neutral lock-out mechanism of Claim 16, further comprising a switch cam coupled to the knob.

19. The neutral lock-out mechanism of Claim 16, wherein a movement of the knob corresponds to a translation of the throw-out bearing housing.

20. An output shaft assembly for a transmission, the output shaft assembly comprising:

an output shaft having a flange end and a splined end, the output shaft adapted to translate axially; and

a throw-out bearing housing operably coupled to the output shaft;

wherein an axial translation of the throw-out bearing corresponds to an axial translation of the output shaft.

21. The output shaft assembly of Claim 20, wherein the throw-out bearing housing is substantially non-rotatable.

22. The output shaft assembly of Claim 20, wherein the flange end is configured to selectively engage an output member of the transmission.

23. A control system for an infinitely variable transmission (IVT), the control system comprising:

- a shift rod driver;
- an output feedback rod coupled to the shift rod driver;
- a control interface housing operably coupled to the shift rod driver, the control interface housing configured to translate axially; and
- an output member configured to be selectively coupled to the output feedback rod.

24. The control system of Claim 23, further comprising an adjustment member coupled to the control interface housing, the adjustment member configured to cooperate with the shift rod driver.

25. The control system of Claim 23, further comprising an output engagement mechanism having a plurality of pins, the output engagement mechanism coupled to the output member, the output engagement mechanism selectively coupled to the output feedback rod.

26. The control system of Claim 25, wherein the output engagement mechanism comprises a spring coupled to each of the pins.

27. A method of controlling an infinitely variable transmission (IVT) comprising:

- providing a ratio adjuster coupled to the IVT, the ratio adjuster configured to actuate a change in transmission ratio of the IVT, wherein the ratio adjuster comprises:

- a shift rod driver;
 - an output feedback rod coupled to the shift rod driver; and
 - a shift rod sleeve operably coupled to the output feedback rod;
- sensing a position of the ratio adjuster of the IVT, said position corresponding to a desired transmission output speed of zero;
- coupling operably an output member of the IVT to the ratio adjuster; and
 - actuating the ratio adjuster to maintain a zero output speed of the IVT.

28. The method of Claim 27, wherein coupling operably an output member comprises providing an output engagement mechanism coupled to the output member of the IVT.

29. The method of Claim 27, wherein actuating the ratio adjuster comprises rotating the output feedback rod.

30. The method of Claim 28, wherein actuating the ratio adjuster comprises axially translating the shift rod sleeve.

31. A method of controlling an infinitely variable transmission (IVT) having a ratio adjuster and a ball planetary variator, the method comprising:

commanding an IVT output speed of zero;

sensing the IVT output speed via a mechanical coupling, the mechanical coupling configured to couple to both the ratio adjuster and the variator; and

adjusting the mechanical coupling to maintain the IVT output speed at zero.

32. The method of Claim 31, wherein commanding an IVT output speed comprises translating a control interface housing axially, wherein the control interface housing is operably coupled to the mechanical coupling.

33. The method of Claim 31, wherein adjusting the mechanical coupling comprises activating an output engagement mechanism coupled to the IVT.

34. The method of Claim 33, wherein activating an output engagement mechanism comprises selectively coupling the output engagement mechanism to an output member of the IVT.

35. A ratio adjuster for an infinitely variable transmission (IVT) having a variator, the ratio adjuster comprising:

a shift rod driver;

an output feedback rod coupled to the shift rod driver; and

a shift rod sleeve operably coupled to the output feedback rod, the shift rod sleeve arranged radially outward of, and coaxially with, the output feedback rod, wherein the shift rod sleeve is coupled to the variator.

36. The ratio adjuster of Claim 35, further comprising a shift nut coupled to the shift rod sleeve.

37. The ratio adjuster of Claim 35, wherein the shift rod sleeve is rotatable about a longitudinal axis of the IVT.

38. The ratio adjuster of Claim 35, wherein the shift rod sleeve is adapted to translate axially.

39. A control interface apparatus for a control system having a shift rod driver and a user interface, the control interface apparatus comprising:

a housing having a central bore;

an adjustment member coupled to the central bore;

a first threaded portion located on the central bore, the first threaded portion adapted to receive a threaded portion of the shift rod driver; and

a second threaded portion on the central bore, the second threaded portion adapted to receive the adjustment member.

40. The control interface apparatus of Claim 39, further comprising a second adjustment member coupled to the central bore.

41. The control interface apparatus of Claim 40, wherein the housing is substantially cylindrical.

42. The control interface apparatus of Claim 39, further comprising means for coupling to a user interface.

43. An output engagement mechanism for an infinitely variable transmission (IVT), the output engagement mechanism comprising:

a housing;

an output member operably coupled to the IVT, wherein the output member is operably coupled to the housing;

an output feedback rod selectively coupled to the housing, wherein the output feedback rod operably couples to the housing at an output speed of the IVT substantially equal to zero;

a plurality of engagement pins operably coupled to the housing, the engagement pins arranged angularly about, and extending radially from, a longitudinal axis of the output feedback rod; and

a plurality of springs operably coupled to the engagement pins.

44. The output engagement mechanism of Claim 43, wherein each of the engagement pins comprise an engagement shoulder extending from a first end of the engagement pin.

45. The output engagement mechanism of Claim 44, wherein the output feedback rod comprises an elongated body having a plurality of engagement surfaces on a portion of the body.

46. The output engagement mechanism of Claim 45, wherein each of the engagement pins is configured to selectively couple to at least one of the engagement surfaces.

47. A housing assembly for an output engagement mechanism, the housing comprising:

a first generally cylindrical housing having a first central bore, a first end, and a second end;

a plurality of flat surfaces formed on an exterior perimeter of the cylindrical housing;

a first plurality of channels formed on the first end, the channels extending radially outward from the central bore; and

a retaining cap coupled to the first end of the cylindrical housing, the retaining cap having a second plurality of channels configured to substantially align with the first plurality of channels.

48. The housing assembly of Claim 47, further comprising a plurality of reaction surfaces located radially inward of each of the channels.

49. The housing assembly of Claim 48, wherein the cylindrical housing comprises a first plurality of reaction surfaces located in proximity to the first central bore.

50. The housing assembly of Claim 49, wherein the retaining cap comprises a second generally cylindrical body having a second central bore, the retaining cap comprising a second plurality of reaction surfaces located in proximity to the second central bore.

51. A shift rod driver comprising:

a substantially cylindrical rod having a first end and a second end;

a reaction flange configured on the first end;
a first threaded portion formed on the second end; and
a second threaded portion formed on the first end.

52. The shift rod driver of Claim 51, wherein the first threaded portion is adapted to receive an output feedback rod of the control system.

53. The shift rod driver of Claim 51, wherein the second threaded portion is adapted to couple to a plurality of mating threads of a control interface housing of the control system.

54. A shift rod member comprising:

a substantially cylindrical body having a first end and a second end, wherein the first end has a threaded bore;

a plurality of engagement surfaces formed on the outer periphery of the cylindrical body, the engagement surfaces located in proximity to the second end; and

a bearing flange formed on the outer periphery of the cylindrical body, the bearing flange located between the threaded bore and the engagement surfaces.

55. The shift rod member of Claim 54, wherein the engagement surfaces comprise profiled ramps.

56. The shift rod member of Claim 55, wherein the profiled ramps extend radially outward from the cylindrical body.

57. The shift rod member of Claim 55, wherein the profiled ramps extend radially inward on the cylindrical body.

58. A shift rod sleeve for a control system of an infinitely variable transmission (IVT), the shift rod sleeve comprising:

a substantially cylindrical body having a first central bore and a second central bore, wherein the first central bore is arranged on a first end of the cylindrical body, and the second central bore is arranged on a second end of the cylindrical body, wherein the first central bore has a different diameter than the second central bore;

an end cup extending from the second end of the cylindrical body, the end cup configured to couple to an output engagement rod of the control system, the end cup having a cup threaded portion; and

a reaction face formed on an interior surface of the end cup.

59. The shift rod sleeve of Claim 58, further comprising a groove formed on the first end of the cylindrical body, the groove adapted to receive a snap ring of the IVT.

60. The shift rod sleeve of Claim 59, wherein the end cup comprises a reaction face.

61. A carrier nut for an infinitely variable transmission (IVT), the carrier nut comprising:

a substantially cylindrical body having a central bore formed with a threaded portion, said threaded portion configured to couple to a main shaft of the IVT;

a first reaction surface formed on a face of one end of the cylindrical body;
a second reaction surface formed on the outer periphery of the cylindrical body; and

a shoulder configured on the outer circumference of the cylindrical body, the shoulder adapted to support a bearing of the IVT.

62. The carrier nut of Claim 61, further comprising a lubricant delivery hole configured to intersect the central bore.

63. The carrier nut of Claim 61, further comprising means for fastening the cylindrical body to the main shaft via a tool.

64. A housing for a transmission, the housing comprising:

an upper housing member comprising:

a flange surface having a first plurality of fastening holes;

a first plurality of cooling fins extending outwardly and inwardly from a main cavity of the upper housing member;

a piloting shoulder adapted to align and support a control mechanism of the transmission;

an intermediate plate coupled to the upper housing member;

a lower housing member comprising:

a flange surface having a second plurality of fastening holes, the flange surface configured to couple to the intermediate plate;

a second plurality of cooling fins extending outwardly and inwardly from a main cavity of the lower housing member; and

a support hub located on the interior of the main cavity of the lower housing member, the support hub having a plurality of grooves and shoulders.

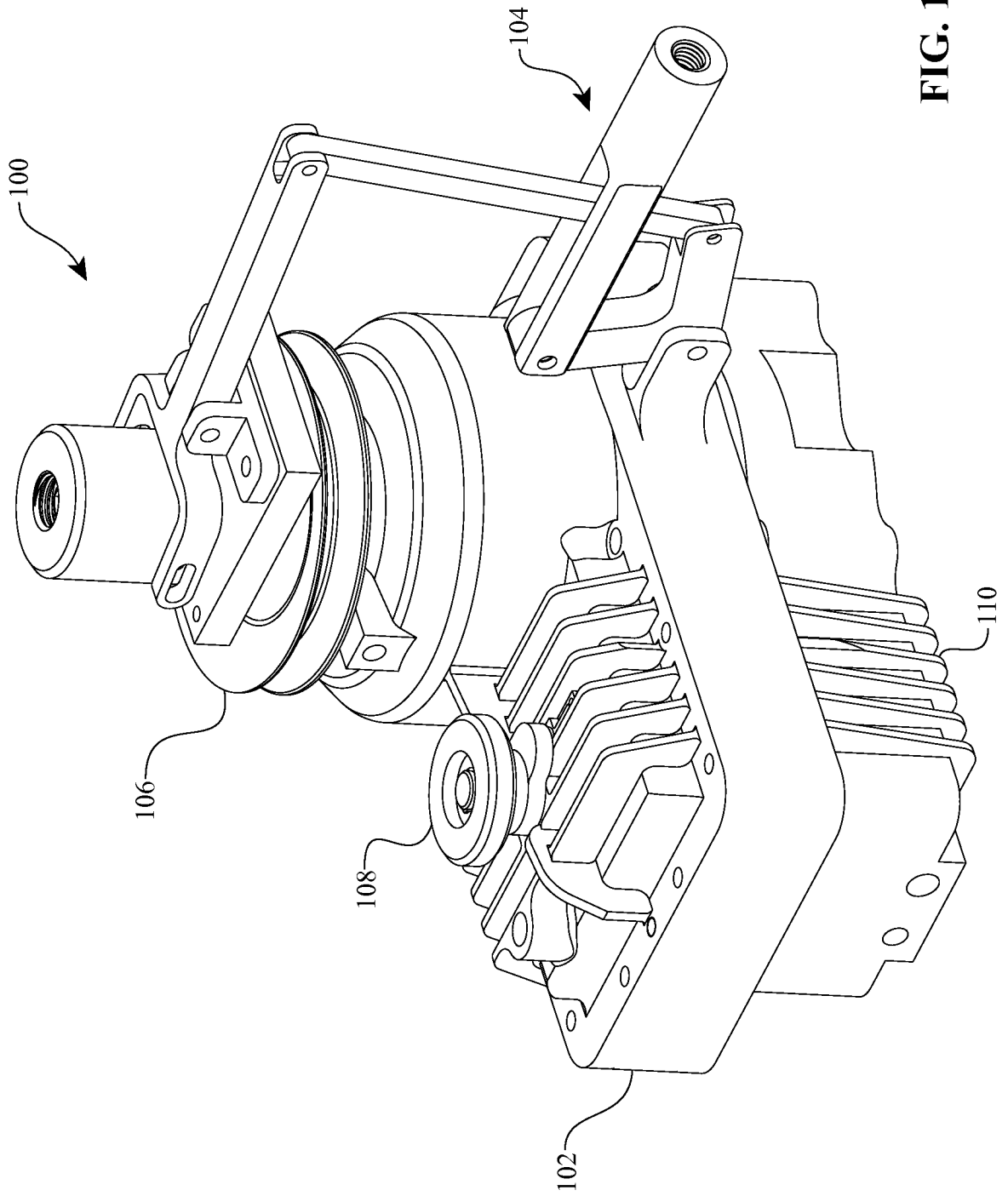
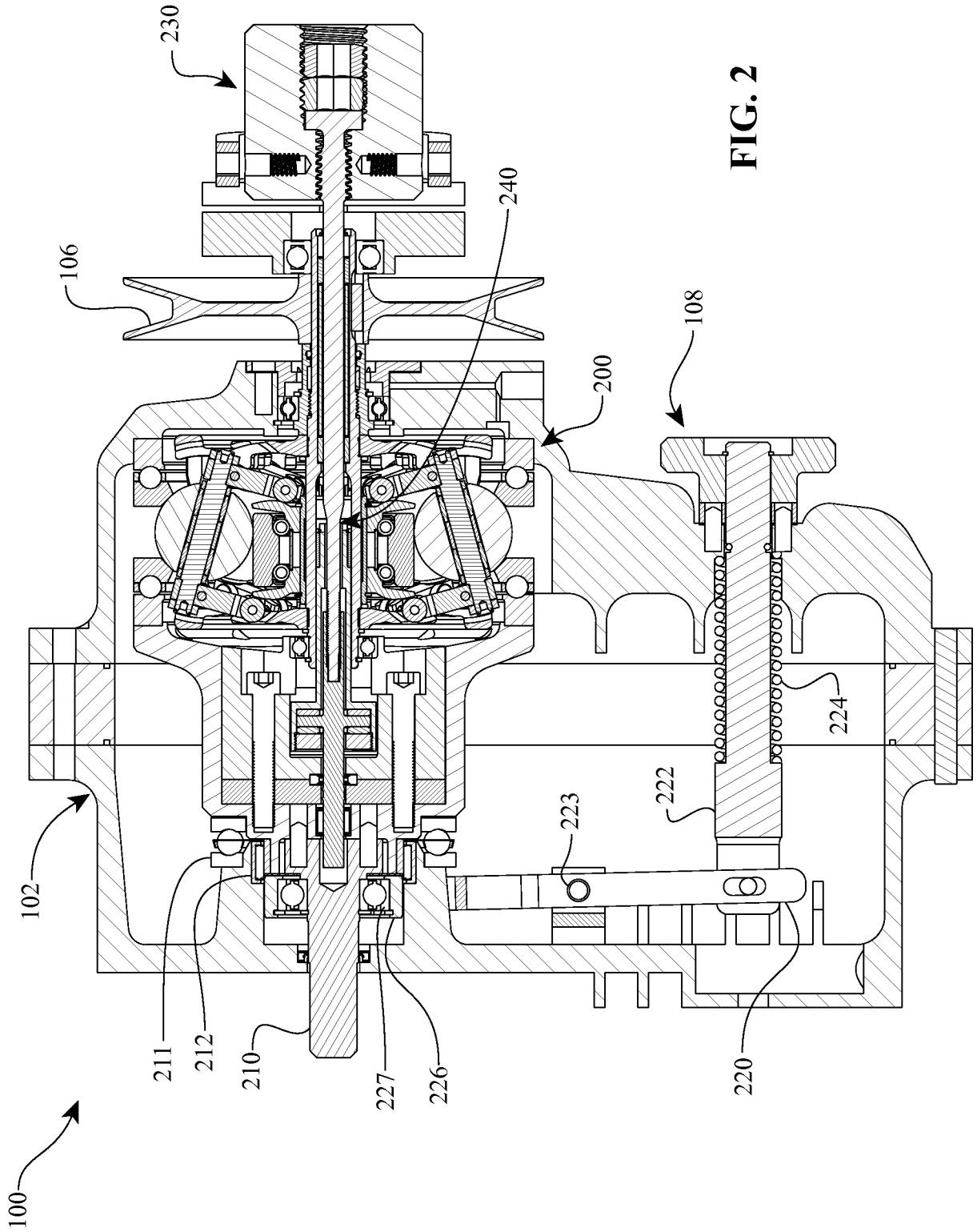


FIG. 1



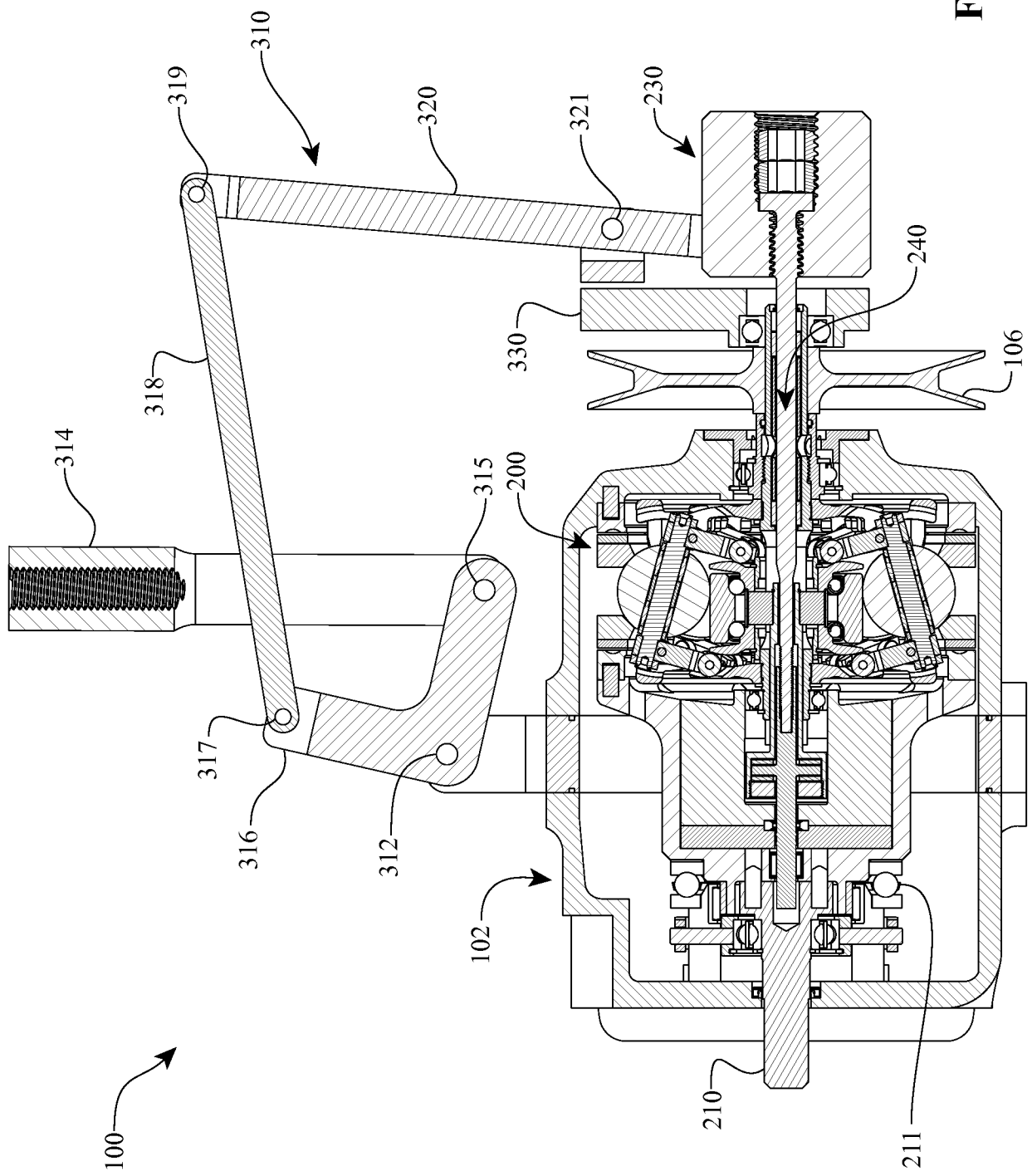


FIG. 3

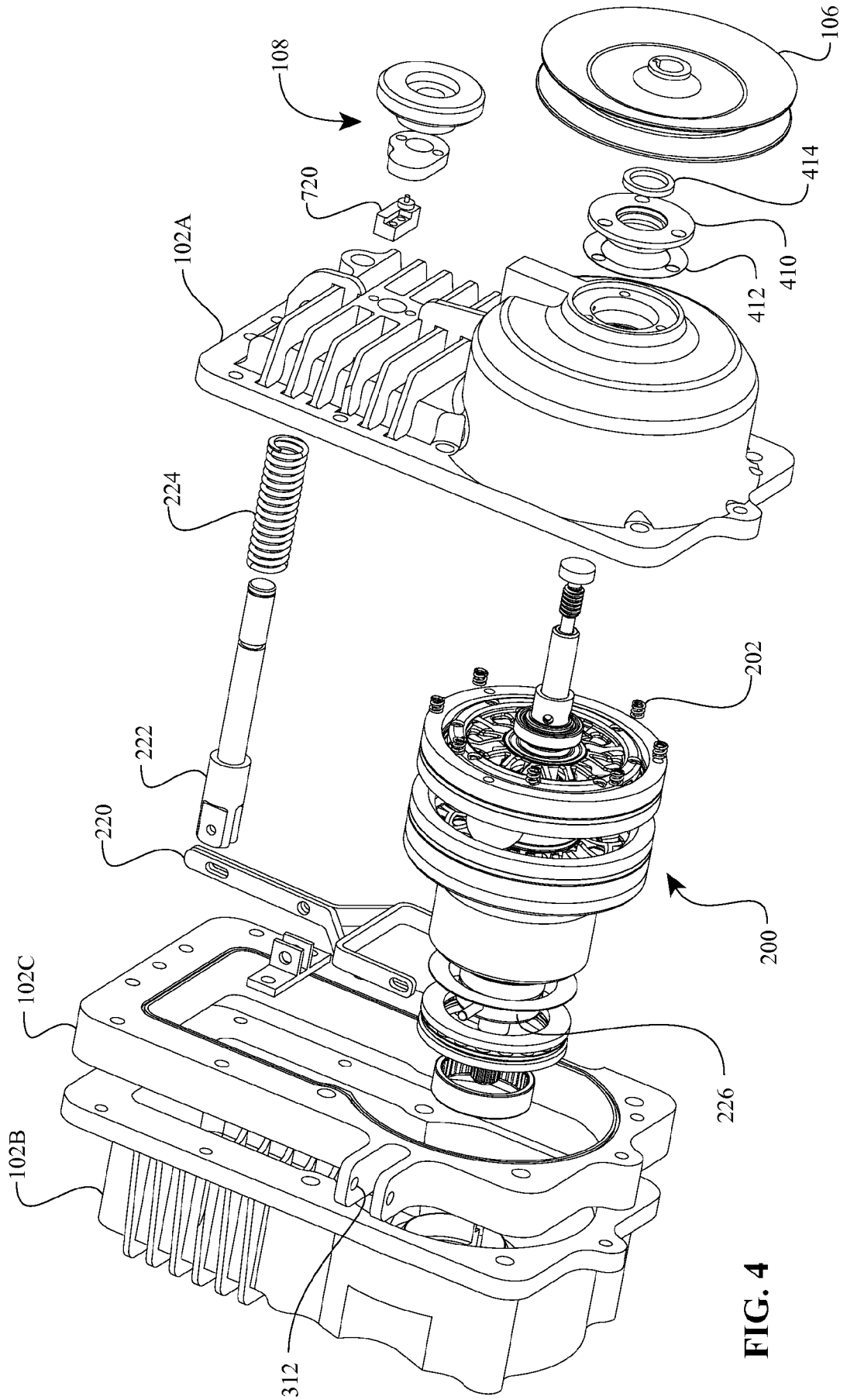


FIG. 4

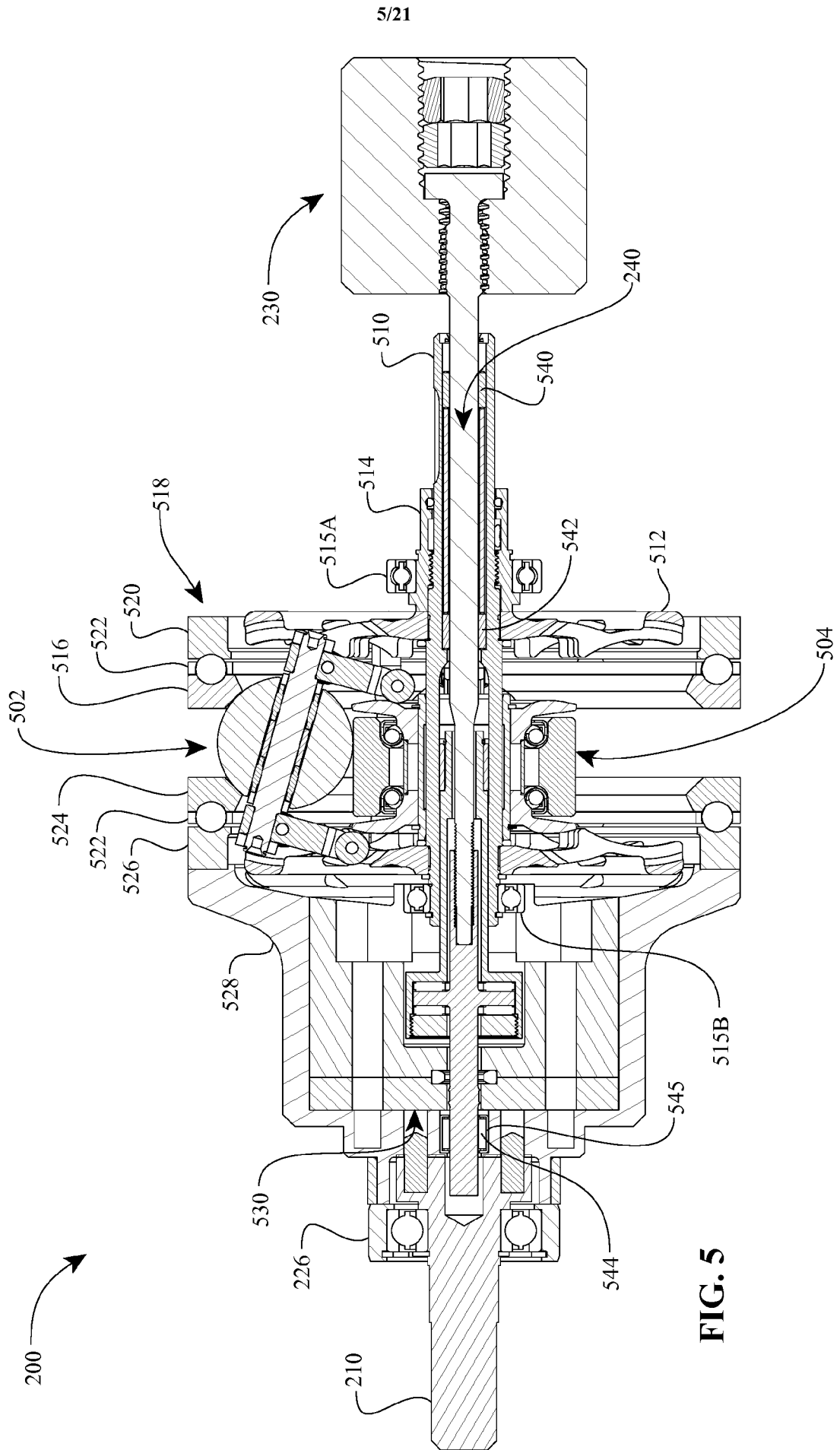


FIG. 5

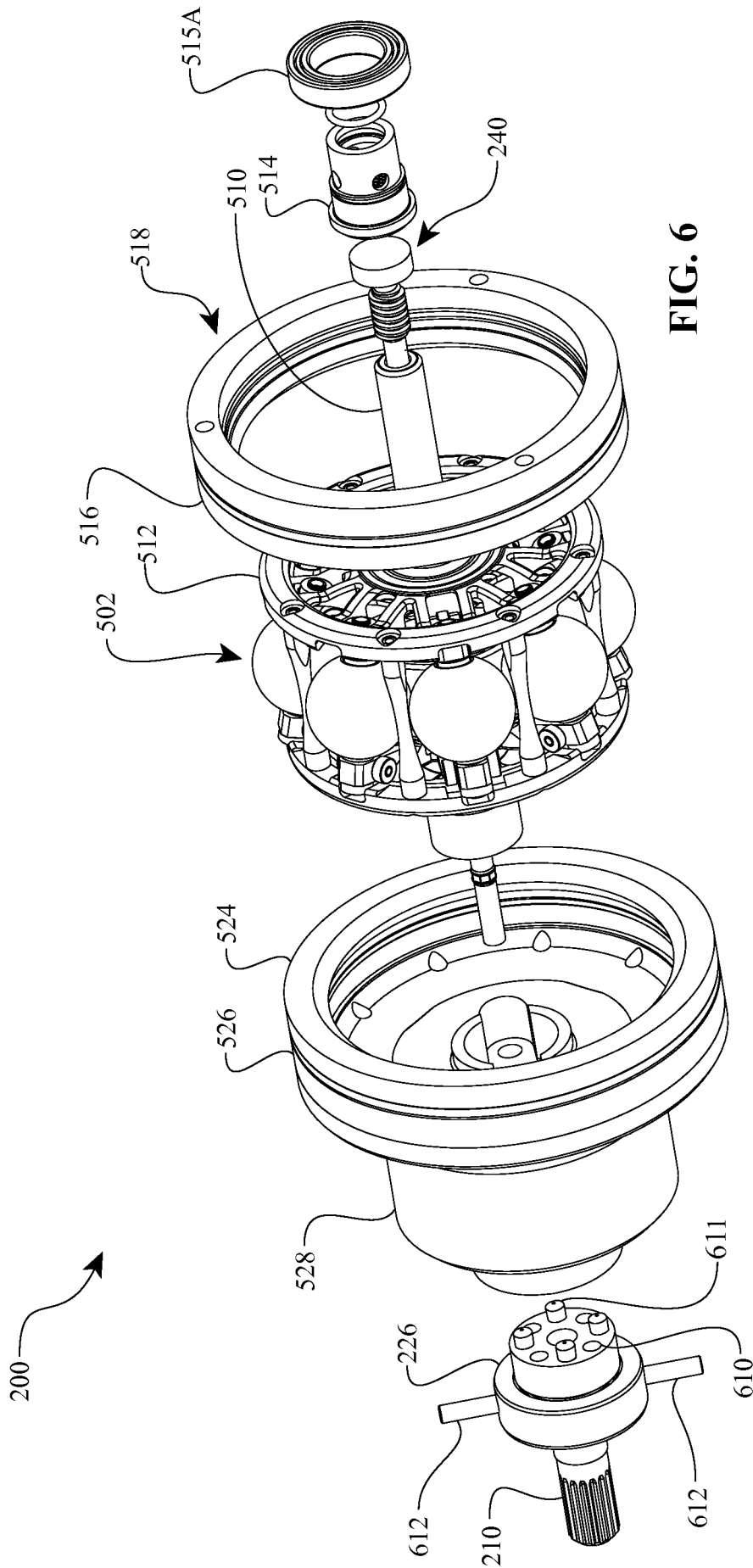
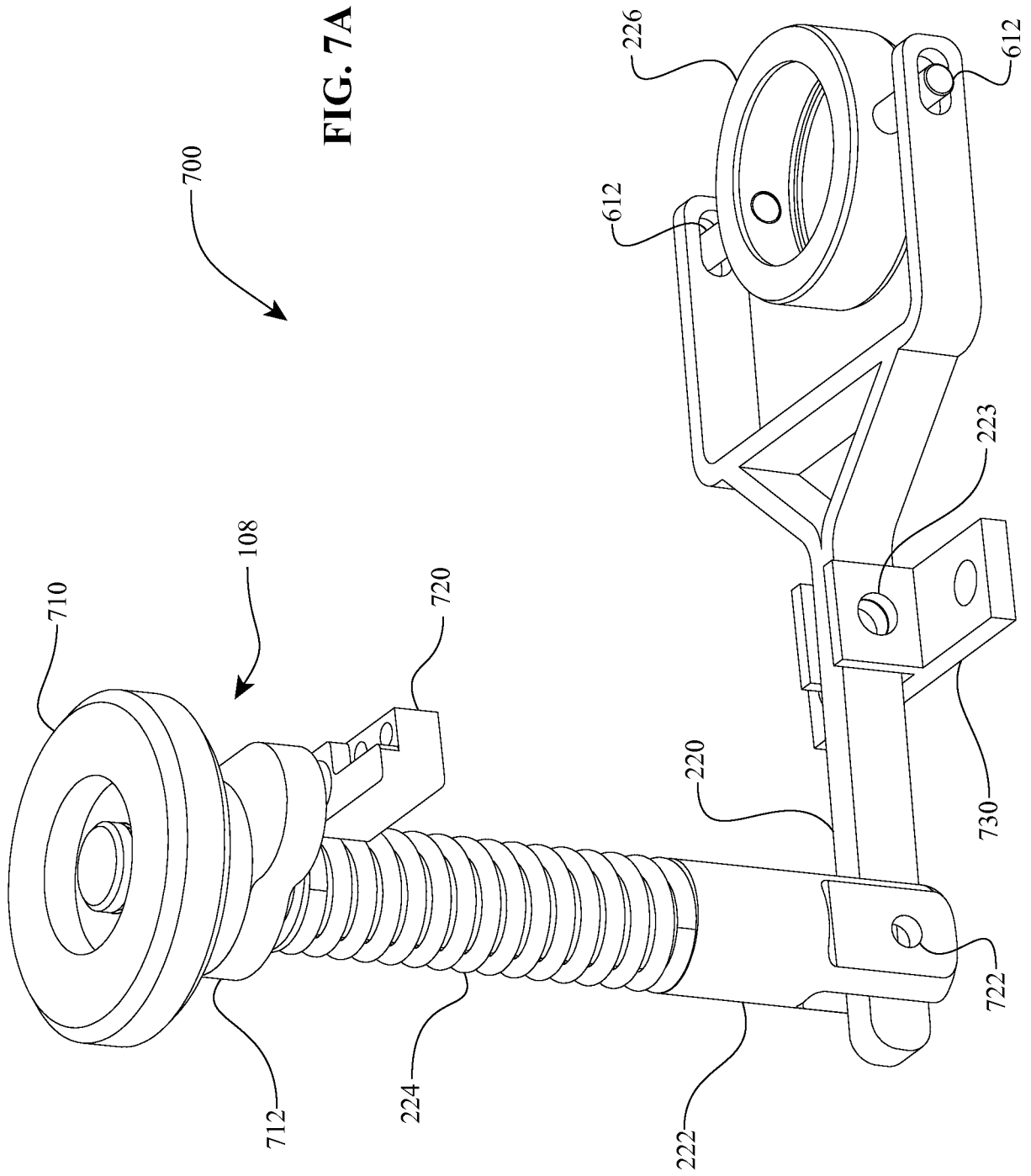


FIG. 6



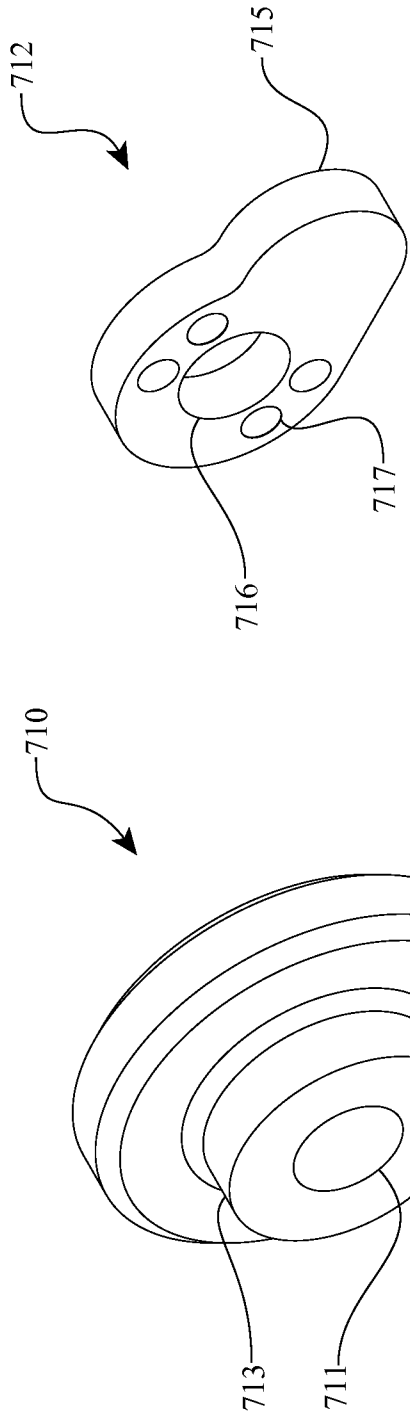


FIG. 7C

FIG. 7B

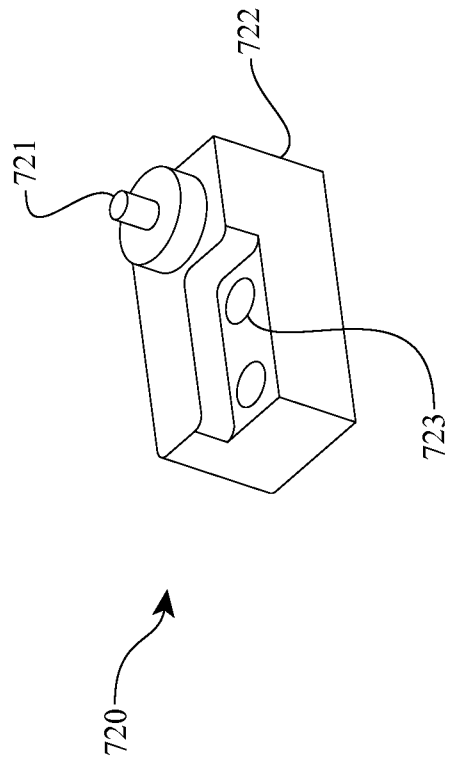


FIG. 7D

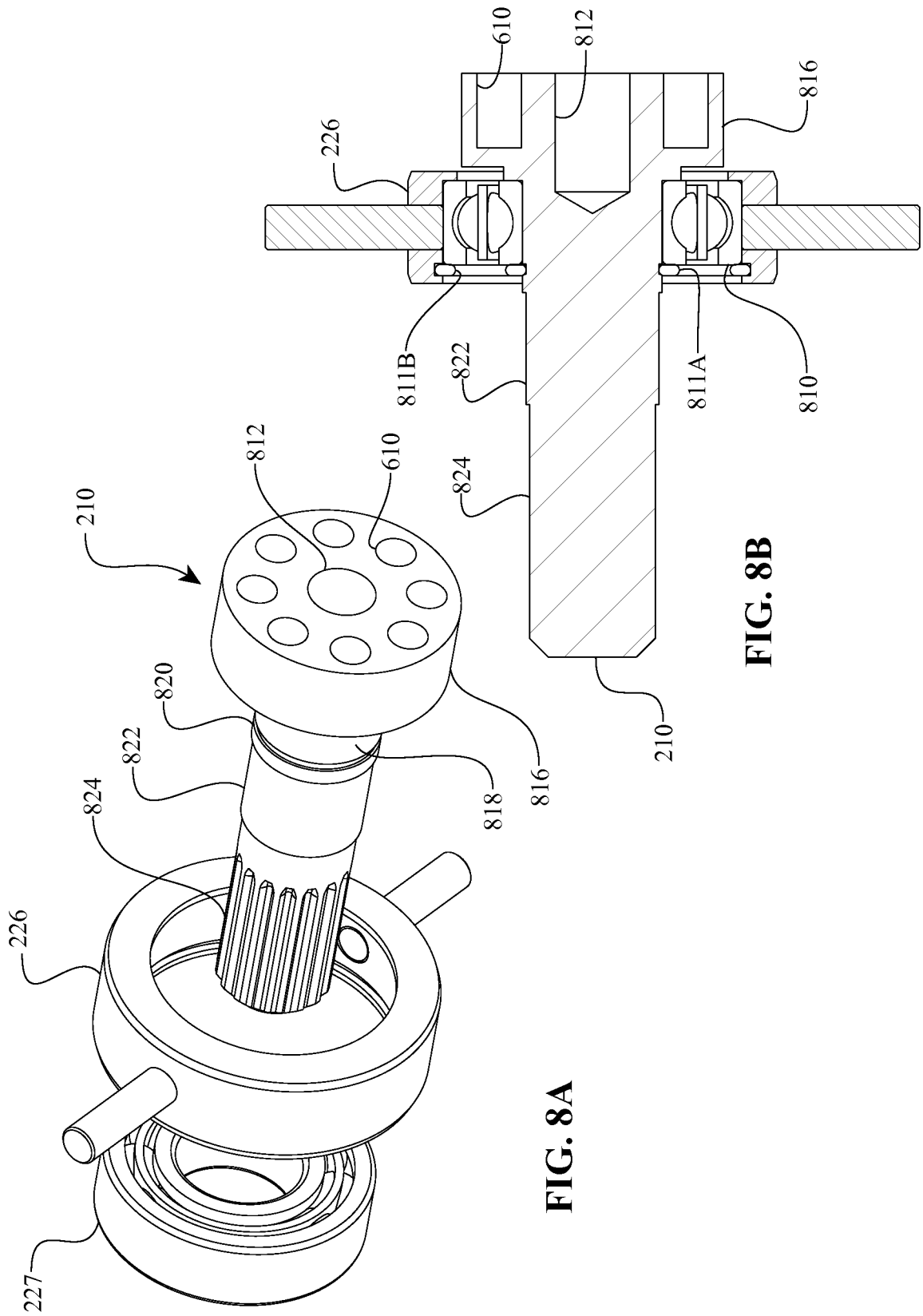


FIG. 8A

FIG. 8B

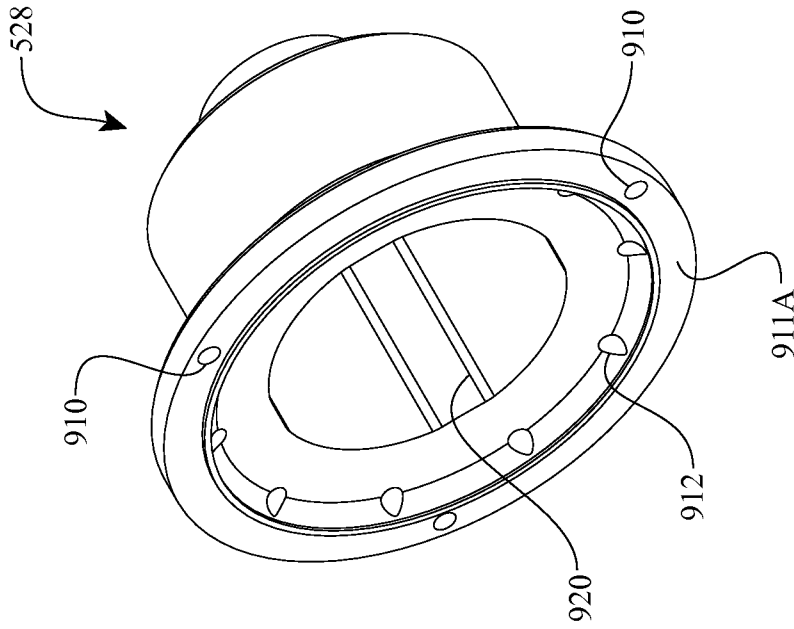


FIG. 9A

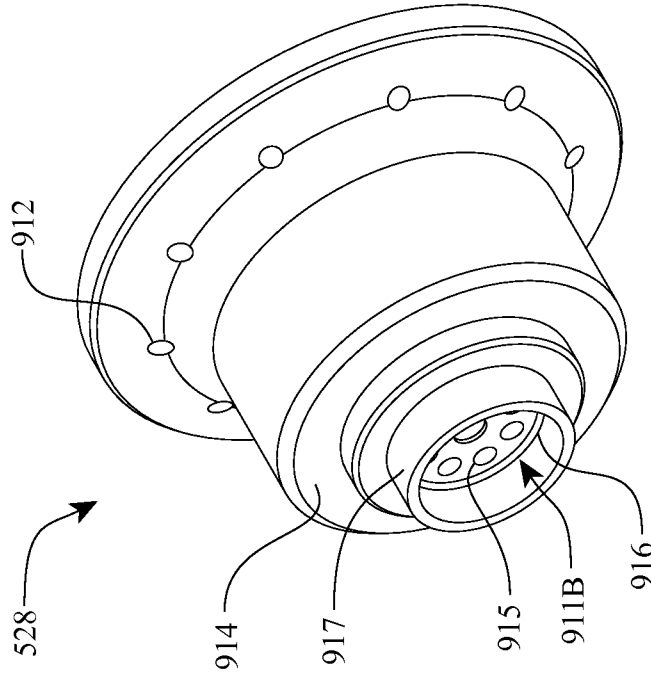


FIG. 9B

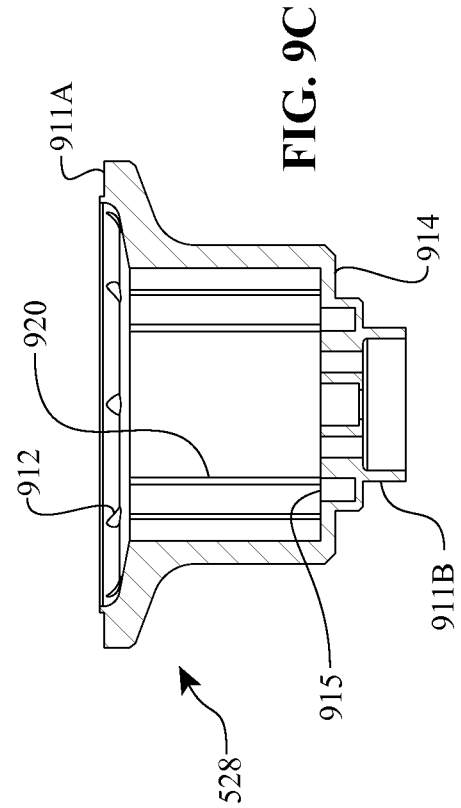
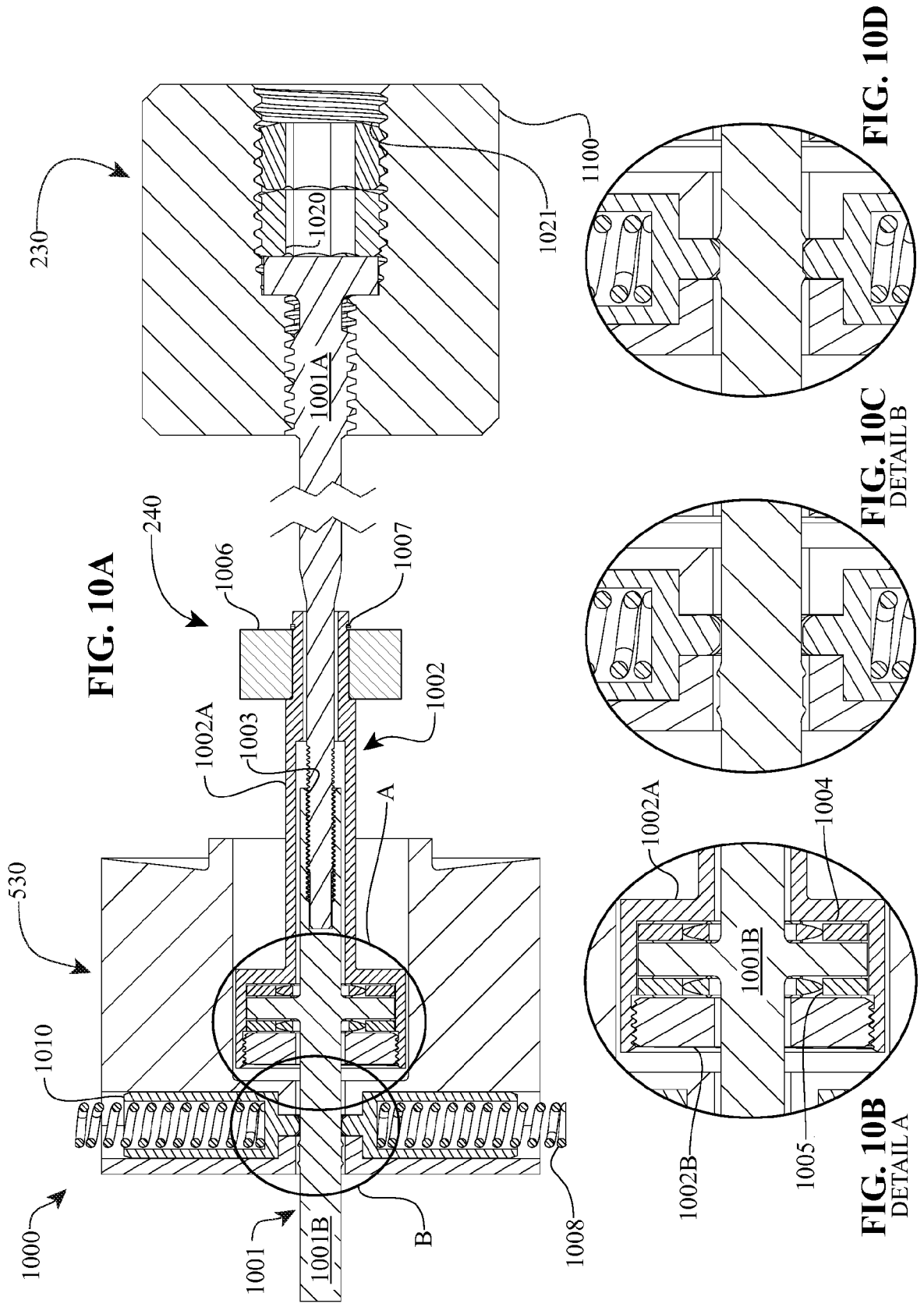


FIG. 9C



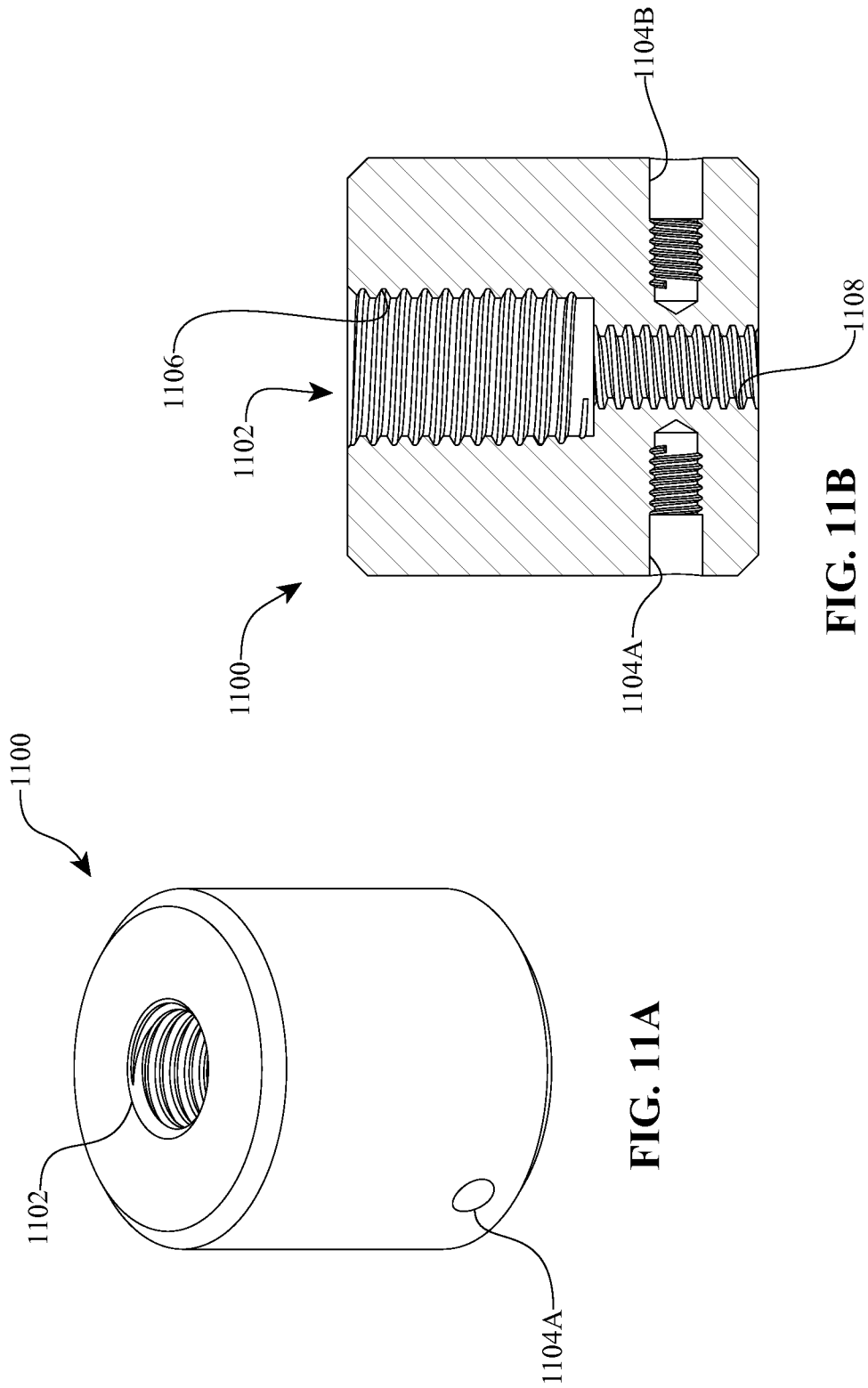


FIG. 11A

FIG. 11B

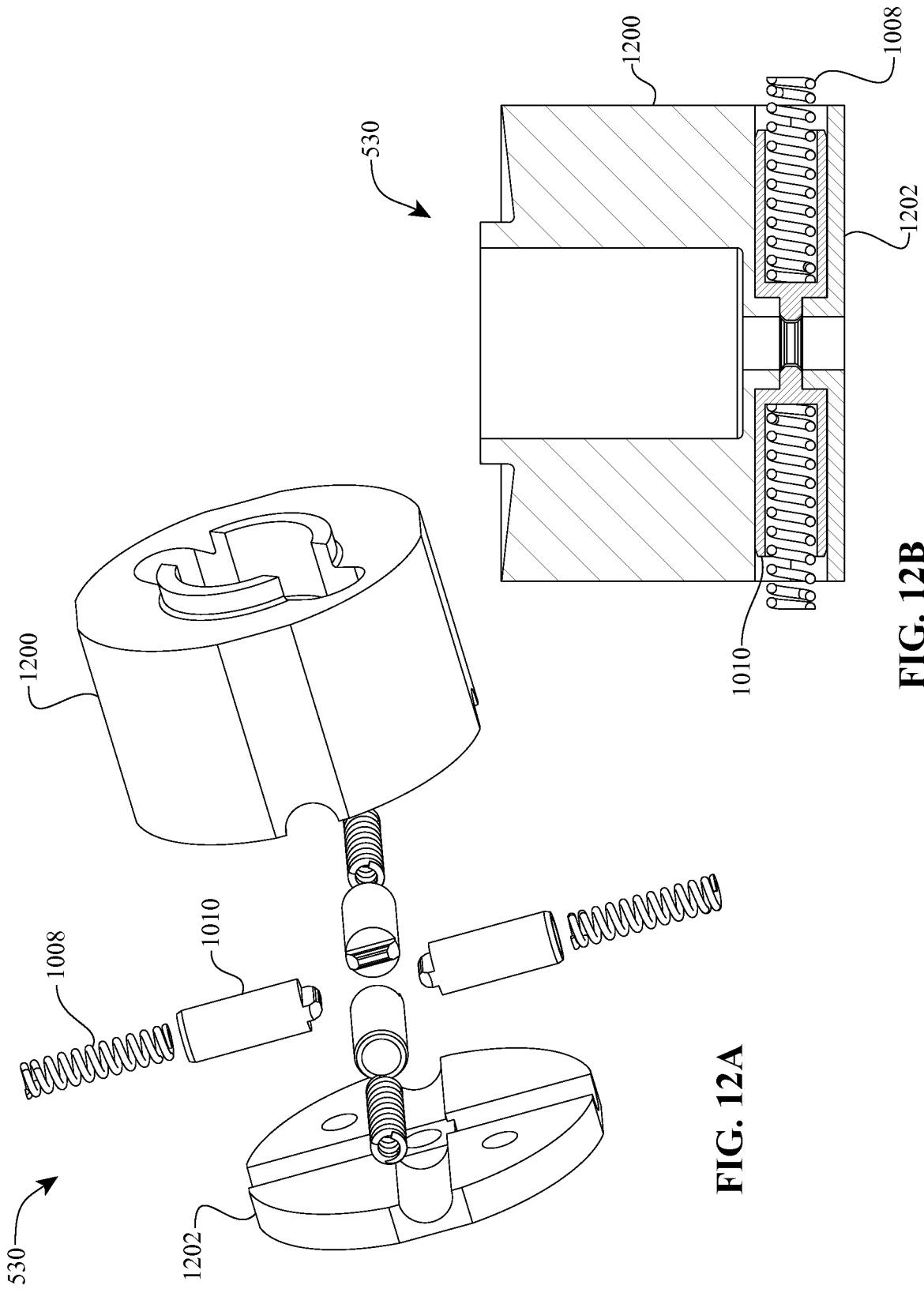


FIG. 12A

FIG. 12B

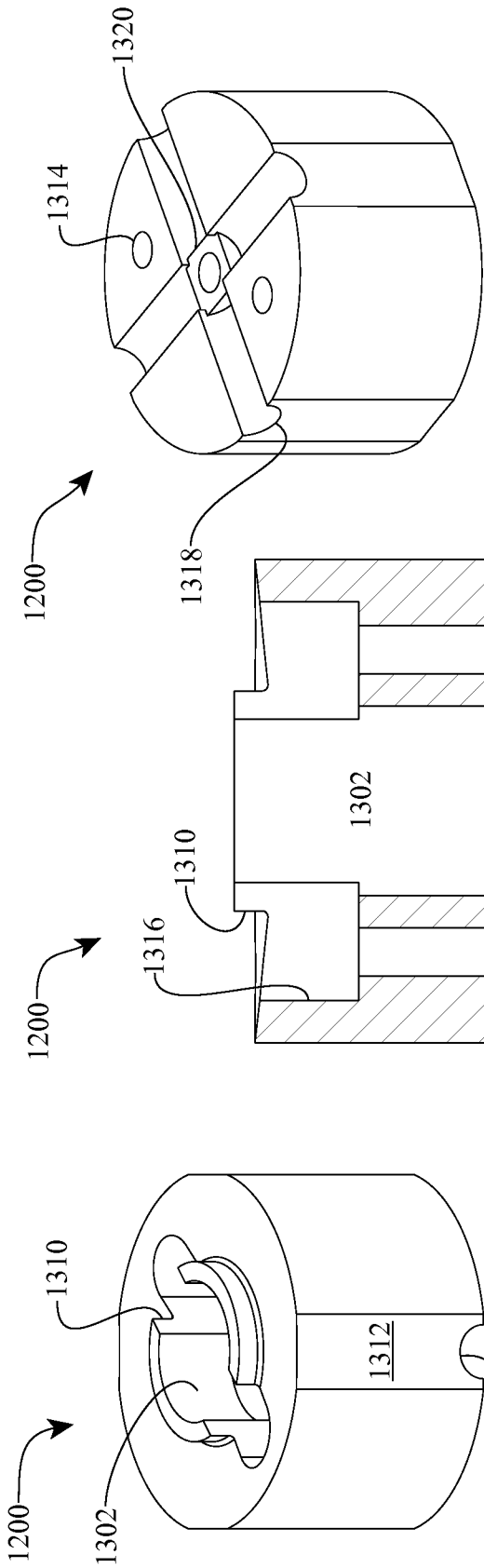


FIG. 13C

FIG. 13B

FIG. 13A

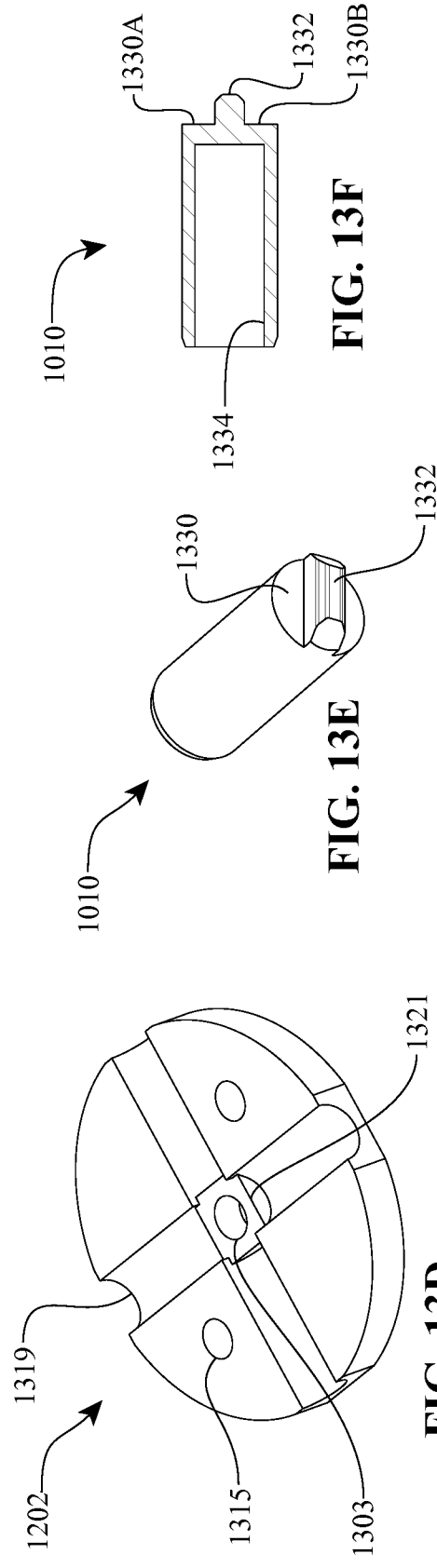
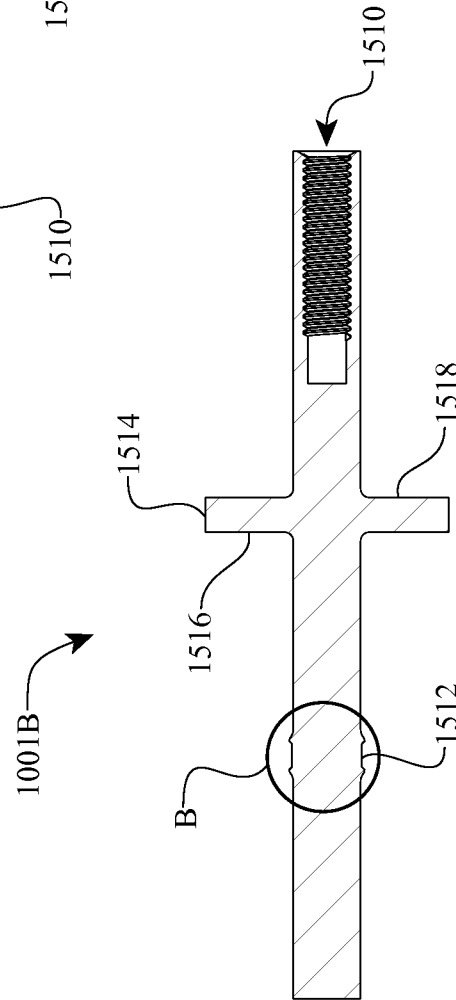
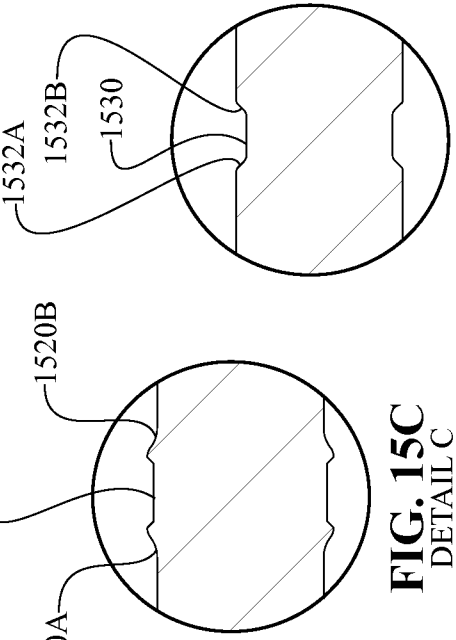
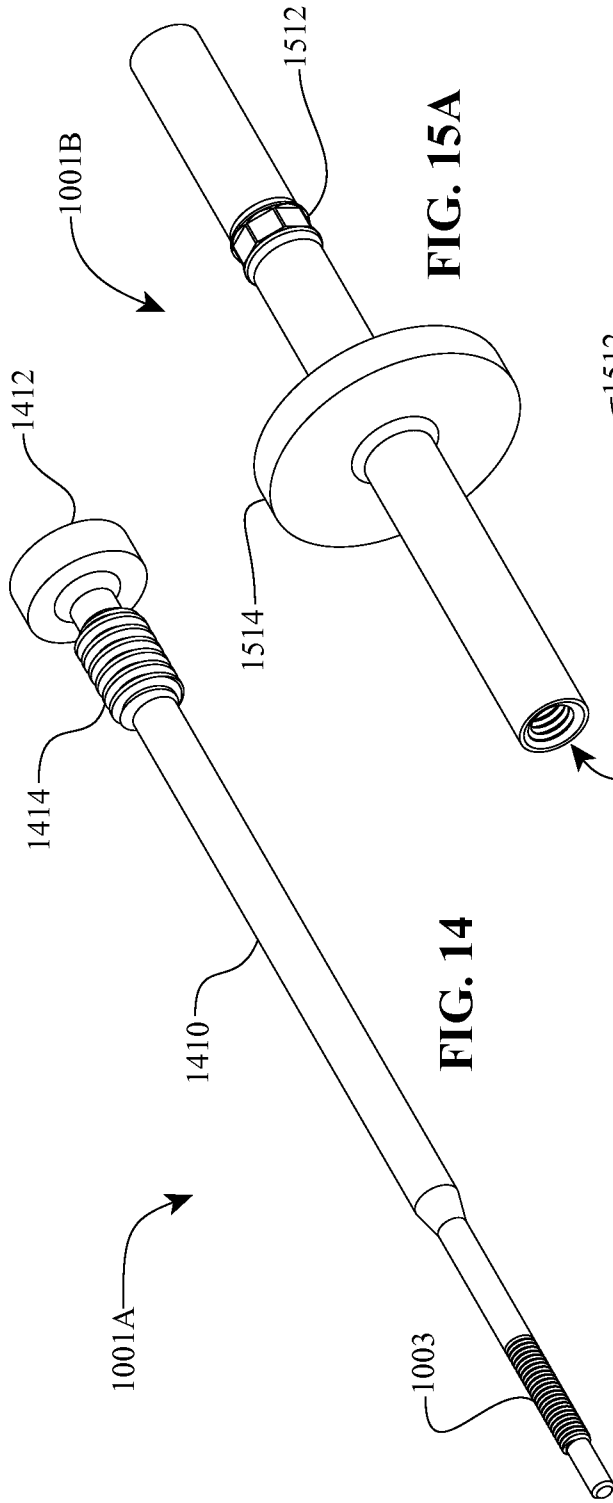
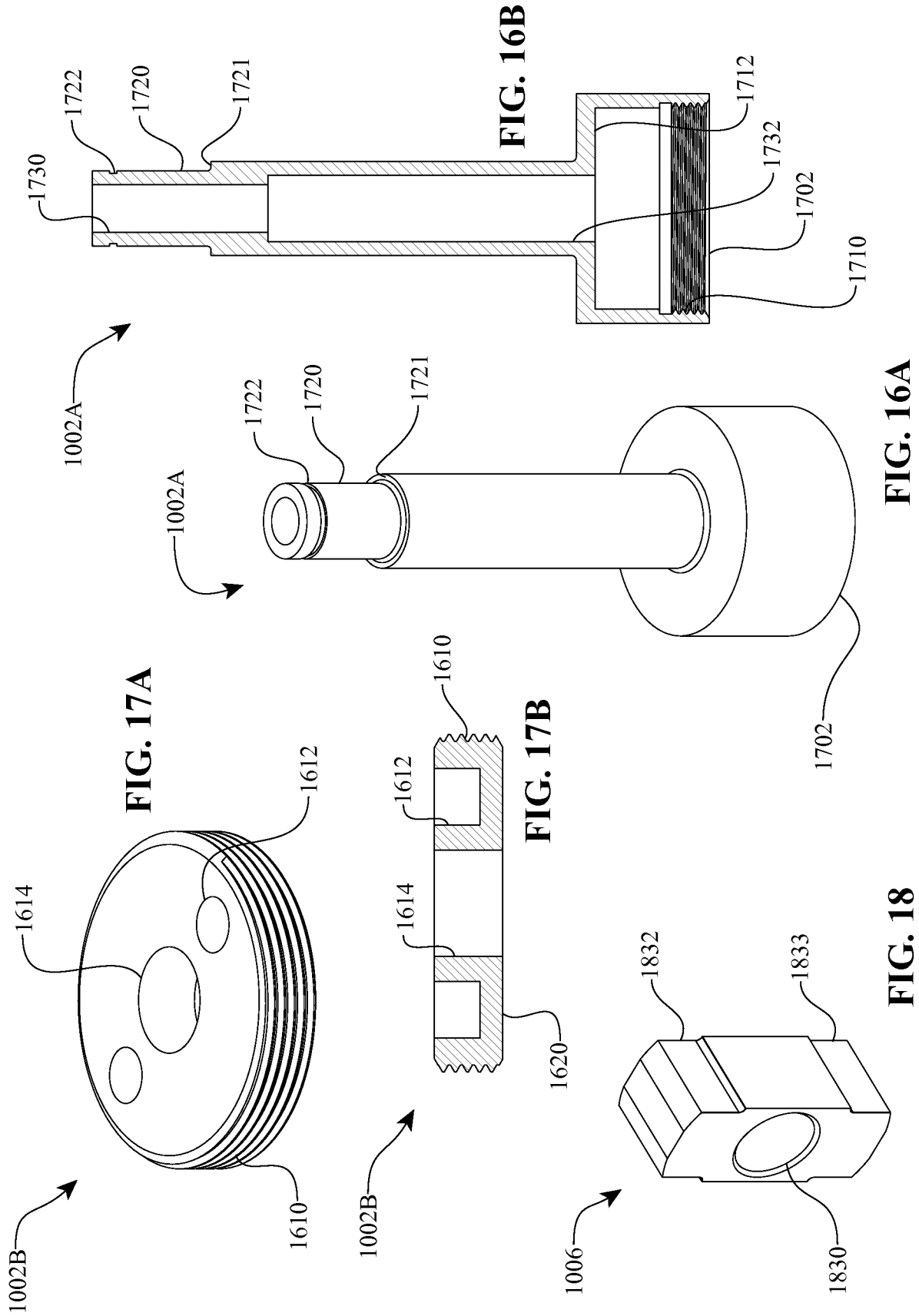


FIG. 13D

FIG. 13E

FIG. 13F





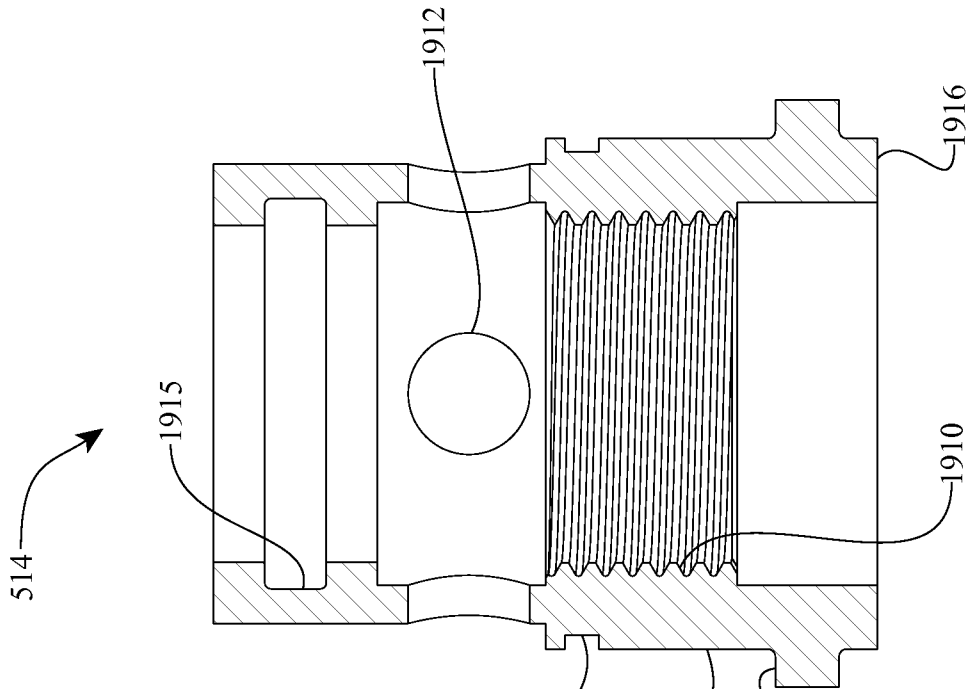


FIG. 19B

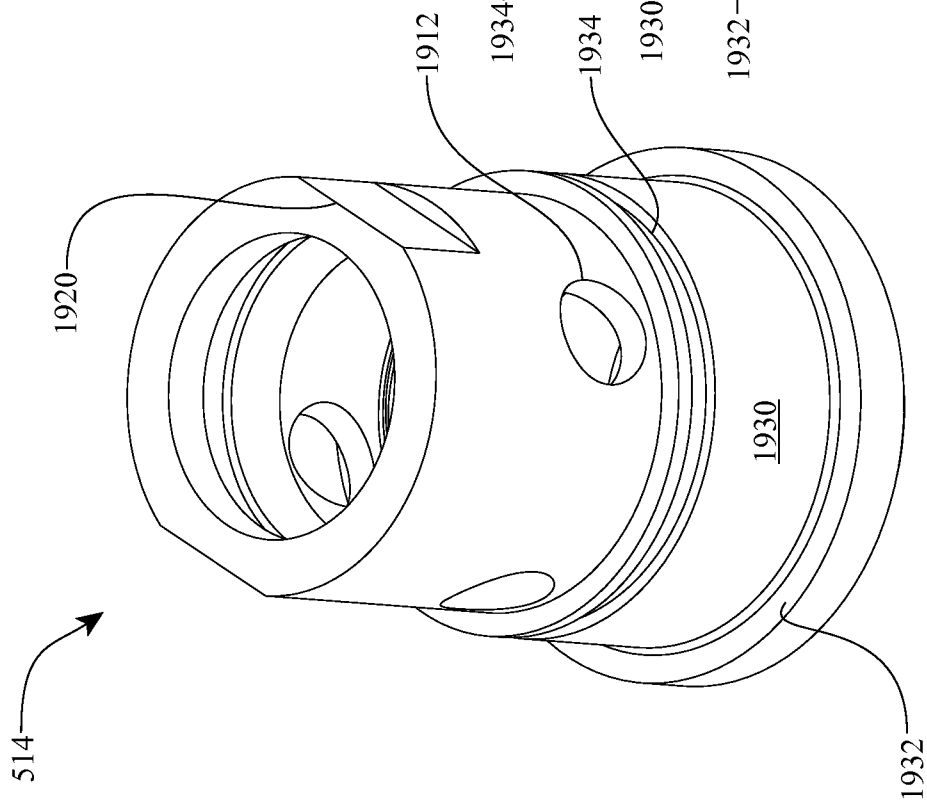


FIG. 19A

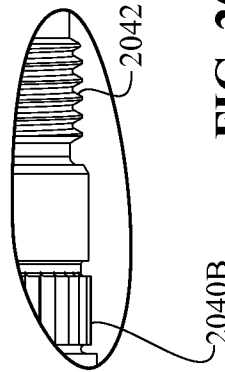
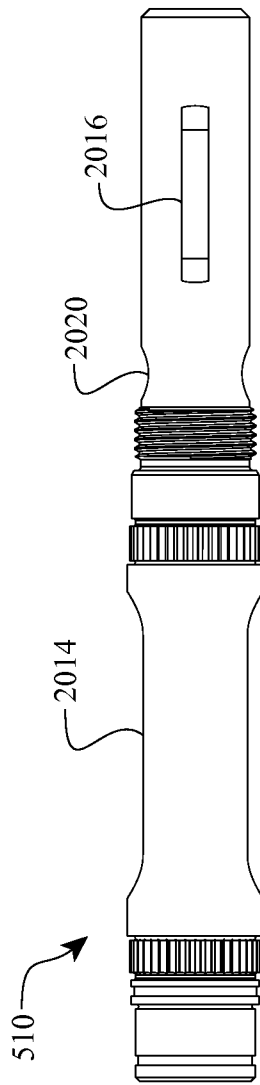
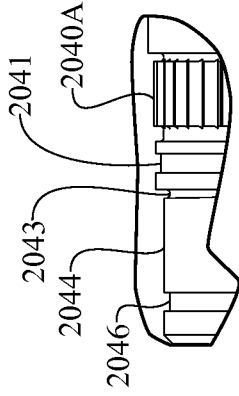
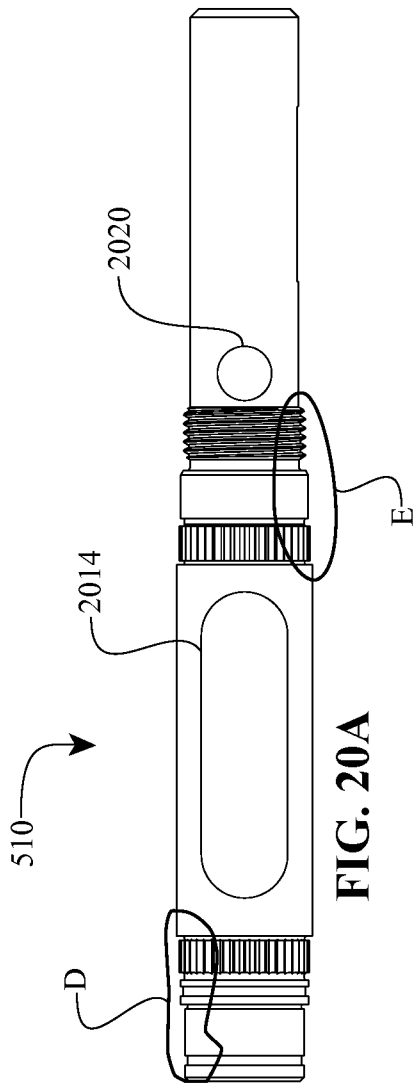
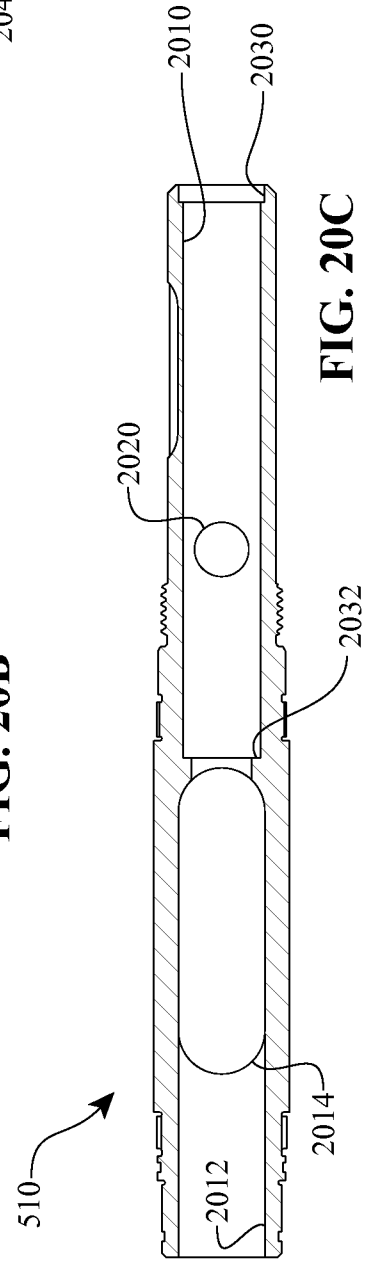


FIG. 20B



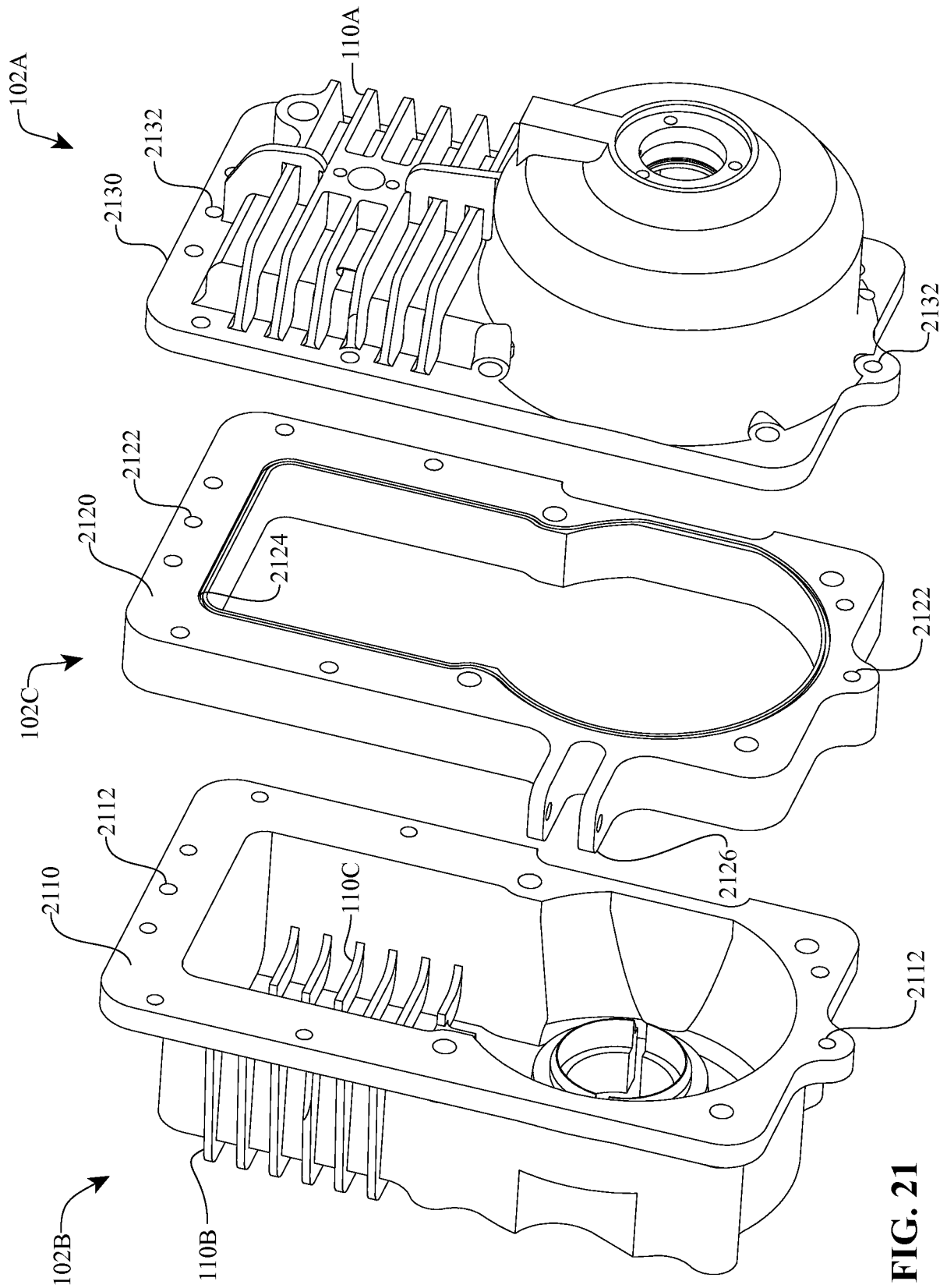


FIG. 21

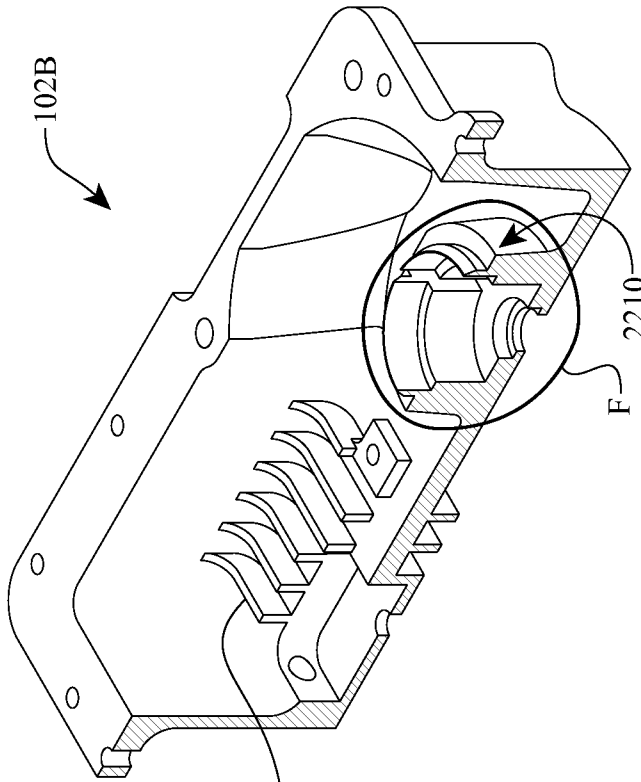


FIG. 22B

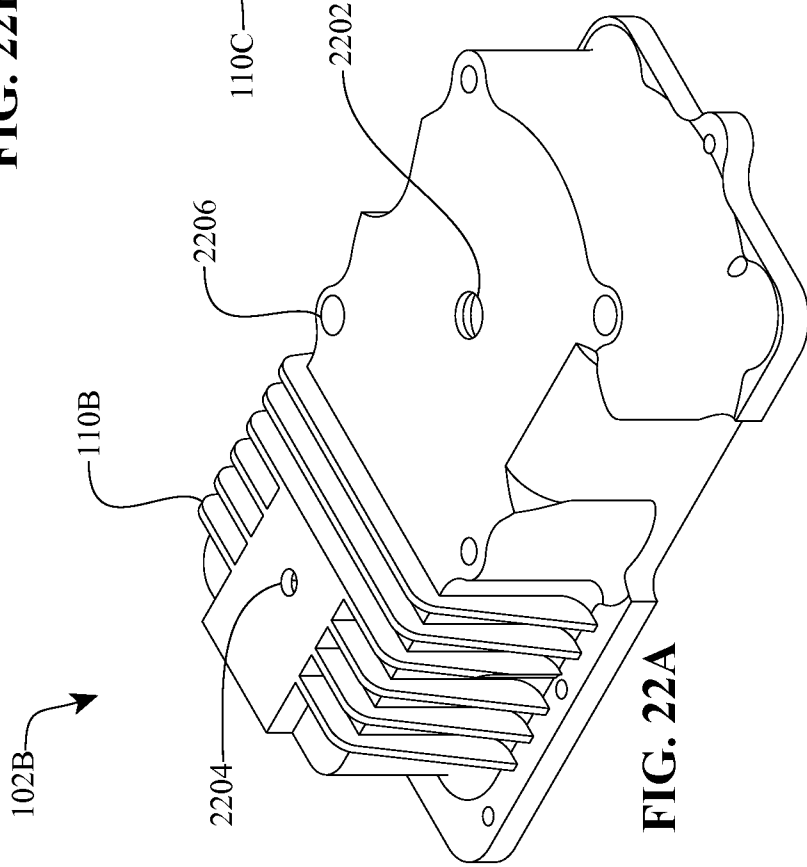


FIG. 22A

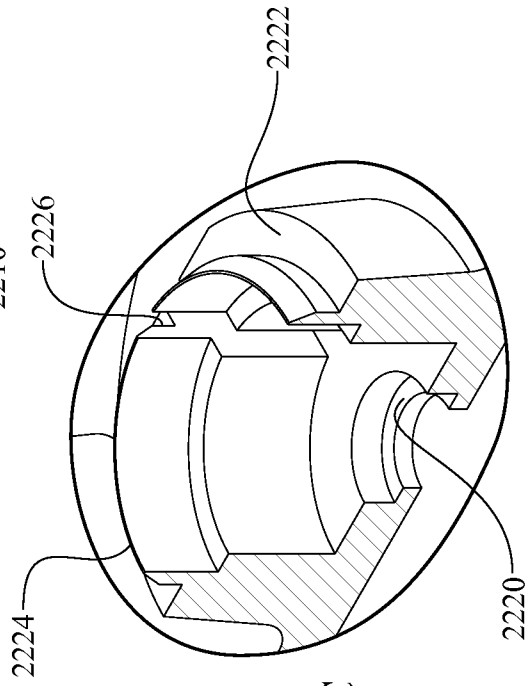
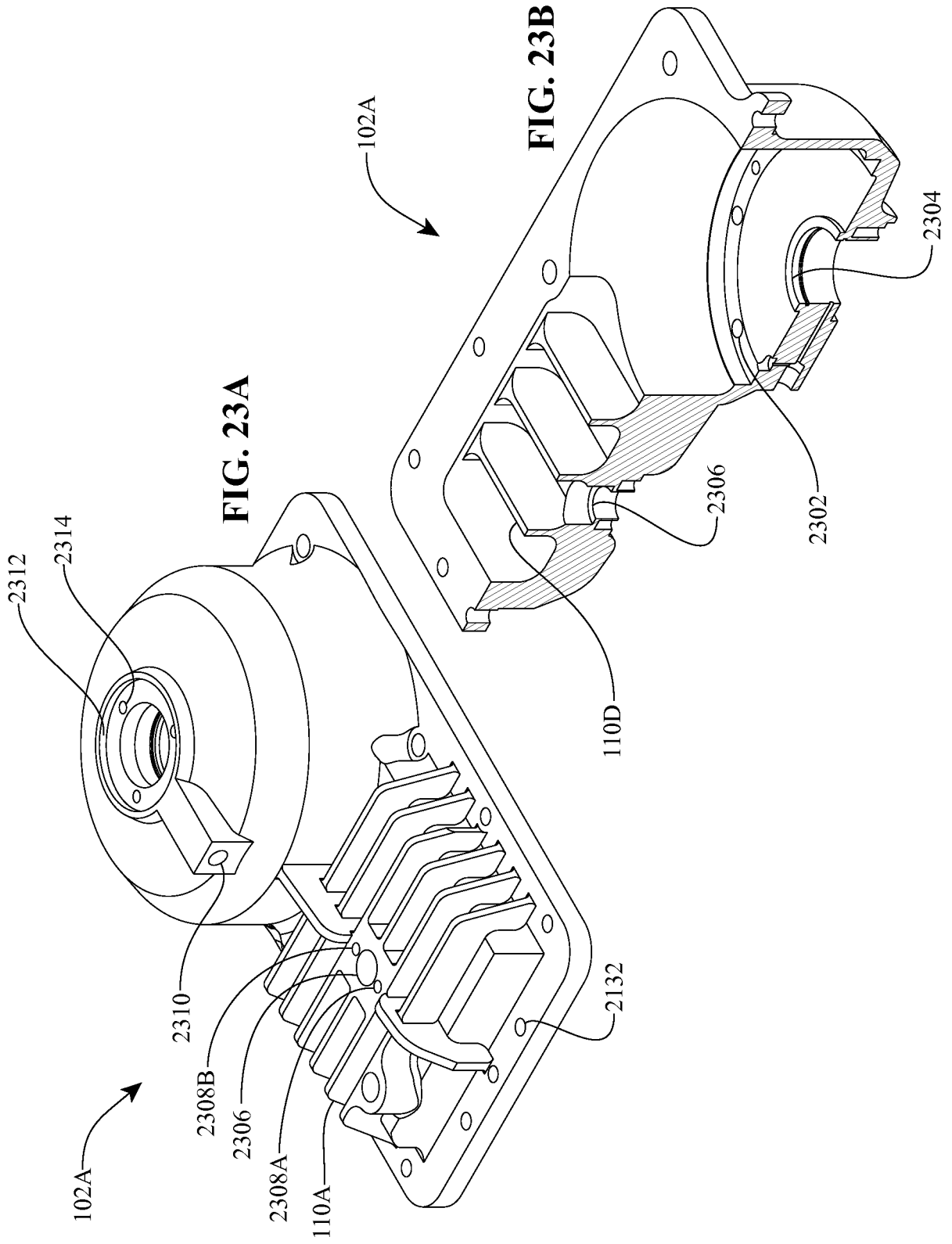


FIG. 22C
DETAIL F



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2008/066182

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16H 13/04; 15/26, 15/28, 15/40 (2008.04)

USPC - 476/36, 38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - F16H 13/04; 15/00, 15/26, 15/28, 15/40 (2008.04)

USPC - 476/36, 38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2,597,849 A (ALFREDEEN) 27 May 1952 (27.05.1952) entire document	1-3
--		-----
Y		12-15, 23-26, 43-46
X	US 3,820,416 A (KRAUS) 28 June 1974 (28.06.1974) entire document	4-7
X	US 4,345,486 A (OLESEN) 24 August 1982 (24.08.1982) entire document	35-42
--		-----
Y		23-26, 43-46
Y	US 2007/0155580 A1 (NICHOLS et al) 05 July 2007 (05.07.2007) entire document	12-15
A	US 2007/0049450 A1 (MILLER) 01 March 2007 (01.03.2007) entire document	1-7, 12-15, 23-26, 35-46, 51-57

 Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

26 November 2008

Date of mailing of the international search report

09 DEC 2008

Name and mailing address of the ISA/US

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Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2008/066182

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-7, 12-15, 23-26, 35-46, 51-57

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-7, 12-15, 23-26, 35-46, 51-57, a ball planetary infinitely variable transmission (IVT) comprising: a shift rod driver; an output feedback rod coupled to the shift rod driver; and a plurality of engagement pins configured to selectively couple to the output feedback rod.

Group II, claims 8-11, a variator for an infinitely variable transmission (IVT), the variator comprising: a plurality of power roller assemblies arranged angularly about a longitudinal axis of the transmission, the power roller assemblies configured to tilt in operation; a first traction ring in contact with the power rollers, the first traction ring substantially non-rotatable; a second traction ring in contact with the power rollers; a carrier adapted to transfer an input power to the power roller assemblies; and an output member operably coupled to the second traction ring, the output member adapted to translate along the longitudinal axis, the output member configured to engage and disengage selectively from the second traction ring.

Group III, claims 16-19 a neutral lock-out mechanism for a transmission, the neutral lock-out mechanism comprising: a throw-out bearing housing operably coupled to an output member of the transmission; a neutral fork arm having a first end and a second end, the first end coupled to the throw-out bearing housing; a clevis member coupled to the second end; and a knob coupled to the clevis member, the knob configured to be accessible from the exterior of the transmission.

Group IV, claims 20-22, 27-30 an output shaft assembly for a transmission, the output shaft assembly comprising: an output shaft having a flange end and a splined end, the output shaft adapted to translate axially; and a throw-out bearing housing operably coupled to the output shaft; wherein an axial translation of the throw-out bearing corresponds to an axial translation of the output shaft.

Group V, claims 31-34 a method of controlling an infinitely variable transmission (IVT) having a ratio adjuster and a baH planetary variator, the method comprising: commanding an IVT output speed of zero; sensing the IVT output speed via a mechanical coupling, the mechanical coupling configured to couple to both the ratio adjuster and the variator; and adjusting the mechanical coupling to maintain the IVT output speed at zero.

Group VI, claims 47-50, a housing assembly for an output engagement mechanism, the housing comprising: a first generally cylindrical housing having a first central bore, a first end, and a second end; a plurality of flat surfaces formed on an exterior perimeter of the cylindrical housing; a first plurality of channels formed on the first end, the channels extending radially outward from the central bore; and a retaining cap coupled to the first end of the cylindrical housing, the retaining cap having a second plurality of channels configured to substantially align with the first plurality of channels.

Group VII, claims 58-60, a shift rod sleeve for a control system of an infinitely variable transmission (IVT), the shift rod sleeve comprising: a substantially cylindrical body having a first central bore and a second central bore, wherein the first central bore is arranged on a first end of the cylindrical body, and the second central bore is arranged on a second end of the cylindrical body, wherein the first central bore has a different diameter than the second central bore; an end cup extending from the second end of the cylindrical body, the end cup configured to couple to an output engagement rod of the control system, the end cup having a cup threaded portion; and a reaction face formed on an interior surface of the end cup.

Group VIII, claims 61-63 A carrier nut for an infinitely variable transmission (IVT), the carrier nut comprising: a substantially cylindrical body having a central bore formed with a threaded portion, said threaded portion configured to couple to a main shaft of the IVT; a first reaction surface formed on a face of one end of the cylindrical body; a second reaction surface formed on the outer periphery of the cylindrical body; and a shoulder configured on the outer circumference of the cylindrical body, the shoulder adapted to support a bearing of the IVT.

Group IX, claims 64 a housing for a transmission, the housing comprising: an upper housing member comprising: a flange surface having a first plurality of fastening holes; a first plurality of cooling fins extending outwardly and inwardly from a main cavity of the upper housing member; a piloting shoulder adapted to align and support a control mechanism of the transmission; an intermediate plate coupled to the upper housing member; a lower housing member comprising: a flange surface having a second plurality of fastening holes, the flange surface configured to couple to the intermediate plate; a second plurality of cooling fins extending outwardly and inwardly from a main cavity of the lower housing member; and a support hub located on the interior of the main cavity of the lower housing member, the support hub having a plurality of grooves and shoulders.

The inventions listed as Groups I-IX do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of Group I, a shift rod driver; an output feedback rod coupled to the shift rod driver; and a plurality of engagement pins configured to selectively couple to the output feedback rod, is not present in Groups II-IX; the special technical feature of Group II, a plurality of power roller assemblies arranged angularly about a longitudinal axis of the transmission, the power roller assemblies configured to tilt in operation; a first traction ring in contact with the power rollers, is not present in Groups I, III- IX; the special technical feature of Group III, a neutral fork arm having a first end and a second end and a knob coupled to the clevis member, the knob configured to be accessible from the exterior of the transmission, is not present in Groups I, II, IV, V and/or VI; the special technical feature of Group IV, a flange end and a splined end, the output shaft adapted to translate axially; and a throw-out bearing housing operably coupled to the output shaft, is not present in Groups I, II, III, V and/or VI; the special technical feature of Group V, an IVT output speed of zero; sensing the IVT output speed via a mechanical coupling, the mechanical coupling configured to couple to both the ratio adjuster and the variator; and adjusting the mechanical coupling to maintain the IVT output speed at zero, is not present in Groups I, II, III, V and/or VI; the special technical feature of Group VI, a retaining cap coupled to the first end of the cylindrical housing, the retaining cap having a second plurality of channels configured to substantially align with the first plurality of channels, is not present in Groups I, II, III, IV and/or V-IX; the special technical feature of Group VII, an end cup extending from the second end of the cylindrical body, the end cup configured to couple to an output engagement rod of the control system is not present in groups I-VI or VII and IX, the special technical feature of Group VIII a substantially cylindrical body having a central bore formed with a threaded portion is not in ; and the special technical feature of Group IX first plurality of cooling fins extending outwardly and inwardly from a main cavity of the upper housing member; a piloting shoulder adapted to align and support a control mechanism of the transmission; an intermediate plate coupled to the upper housing member; a lower housing member comprising: a flange surface having a second plurality of fastening holes is not present in Groups I-VIII

Since none of the special technical features of the Groups I-IX inventions is found in more than one of the inventions, unity of invention is lacking.