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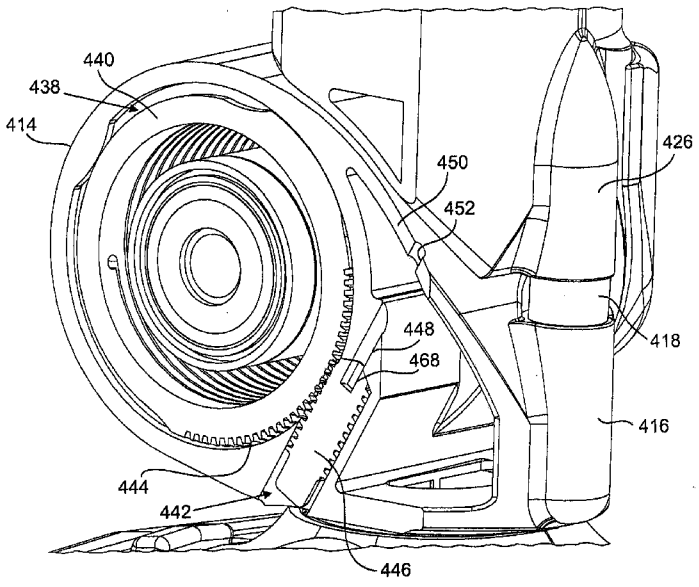
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[Continued on next page]

(54) Title: COUNTER BALANCE FOR COORDINATE MEASUREMENT DEVICE

FIG.9



(57) Abstract: A portable articulated arm coordinate measurement device is provided. The coordinate measurement device includes a base and an articulated arm portion having at least one arm segment. A biasing member is coupled on a first end to the base and on a second end to the articulated arm portion. The first end of the biasing member is movable between a first position and a second position. An adjuster is coupled between the base and the biasing member. The adjuster is coupled to move the first end of the biasing member from the first position to the second position.

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COUNTER BALANCE FOR COORDINATE MEASUREMENT DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of provisional application number 61/296,555 filed January 20, 2010, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates to a coordinate measuring machine, and more particularly to a portable articulated arm coordinate measuring machine having an adjustable counterbalance system.

[0003] Portable articulated arm coordinate measuring machines (AACMMs) have found widespread use in the manufacturing or production of parts where there is a need to rapidly and accurately verify the dimensions of the part during various stages of the manufacturing or production (e.g., machining) of the part. Portable AACMMs represent a vast improvement over known stationary or fixed, cost-intensive and relatively difficult to use measurement installations, particularly in the amount of time it takes to perform dimensional measurements of relatively complex parts. Typically, a user of a portable AACMM simply guides a probe along the surface of the part or object to be measured. The measurement data are then recorded and provided to the user. In some cases, the data are provided to the user in visual form, for example, three-dimensional (3-D) form on a computer screen. In other cases, the data are provided to the user in numeric form, for example when measuring the diameter of a hole, the text "Diameter = 1.0034" is displayed on a computer screen.

[0004] An example of a prior art portable articulated arm CMM is disclosed in commonly assigned U.S. Patent No. 5,402,582 ('582), which is incorporated herein by reference in its entirety. The '582 patent discloses a 3-D measuring system comprised of a manually-operated articulated arm CMM having a support base on one end and a measurement probe at the other end. Commonly assigned U.S. Patent No. 5,611,147 ('147), which is incorporated herein by reference in its entirety, discloses a similar articulated arm CMM. In the '147 patent, the articulated arm CMM includes a number of features including an additional rotational axis at the

probe end, thereby providing for an arm with either a two-two-two or a two-two-three axis configuration (the latter case being a seven axis arm).

[0005] The articulated arm may be of a variety of lengths, typically between two feet and four feet for example. To ease the use of the arm, a counter balance arrangement may be coupled to a fixed base to offset the torque applied by the weight of the articulated arm. The counter balance allows the articulated arm to be moved by the user with little effort and prevents the articulated arm from falling if released by the user. Unfortunately, in some circumstances the counter balance may apply too much, or too little torque due to differences in components, tolerances, configurations, and accessories of the articulated arm. As a result, rather than moving freely, the articulated arm may sag or resist movement depending on whether too little or too much counter balance is applied.

[0006] Accordingly, while existing articulated arms are suitable for their intended purposes what is needed is an AACMM having an improved adjustment and calibration of a counter balance for the articulated arm.

SUMMARY OF THE INVENTION

[0007] In accordance with an embodiment of the invention, a portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space is provided. The AACMM includes a base. A manually positionable articulated arm portion is provided having an opposed first end and second end, the arm portion being rotationally coupled to the base, the arm segment including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal. A measurement device is attached to the first end. An electronic circuit is provided for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device. A rotation assembly is coupled to the second end to the base, the rotation assembly having a first axis of rotation and a second axis of rotation substantially perpendicular to the first axis of rotation. Abiasing member is operably coupled between the rotation assembly and the second end to apply a force to the second end about the second axis of rotation the biasing member having at least one projection thereon. An adjuster having a

threaded portion is arranged to engage the at least one projection, wherein the force applied by the biasing member to the arm portion changes in response to movement of the adjuster.

[0008] In accordance with another embodiment of the invention, another AACMM is provided. The AACMM includes a base. A manually positionable articulated arm portion is provided having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal. A measurement device is attached to the first end. An electronic circuit is provided for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device. A biasing member is operably coupled between the base and the second end, the biasing member having at least one projection movable between a first position and a second position. An adjuster having a threaded portion is operably coupled between the base and the biasing member, wherein the threaded portion is engaged to the at least one projection to move the at least one projection between the first position to the second position.

[0009] In accordance with another embodiment of the invention, another AACMM for measuring coordinates of an object in space is provided. The AACMM includes a base. A manually positionable articulated arm portion is provided having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each arm segment including at least one position transducer for producing a position signal. A measurement device is attached to the first end. An electronic circuit is provided which receives the position signals from the transducers and provides data corresponding to a position of the measurement device. A rotation assembly is rotationally coupled to the second end to the base about a first axis of rotation and a second axis of rotation, the second axis of rotation being substantially perpendicular to the first axis of rotation. A biasing member is arranged within the rotation assembly and having a third end operably coupled to the second end, the biasing member having a fourth end opposite the third end, the fourth end being movable between a first position and a second position. An adjusting member is operably coupled for rotation to the base and operably coupled to the fourth end, wherein the fourth end moves between the first position and the second position in response to a rotation of the adjusting member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Referring now to the drawings, exemplary embodiments are shown which should not be construed to be limiting regarding the entire scope of the disclosure, and wherein the elements are numbered alike in several FIGS.:

[0011] FIG. 1, including FIGs. 1A and 1B, are perspective views of a portable articulated arm coordinate measuring machine (AACMM) having embodiments of various aspects of the present invention therewithin;

[0012] FIG. 2, including FIGS. 2A – 2D taken together, is a block diagram of electronics utilized as part of the AACMM of FIG. 1 in accordance with an embodiment;

[0013] FIG. 3, including FIGs. 3A and 3B taken together, is a block diagram describing detailed features of the electronic data processing system of FIG. 2 in accordance with an embodiment;

[0014] FIG. 4 is a partial perspective view of the AACMM of FIG. 1 in a first position;

[0015] FIG. 5 is a partial perspective view of the first bearing cartridge assembly of FIG. 1 in a second position;

[0016] FIG. 6 is a partial exploded perspective view of the first bearing cartridge assembly of FIG. 5;

[0017] FIG. 7 is another partial exploded perspective view of the first bearing cartridge assembly of FIG. 5;

[0018] FIG. 8 is a another partial perspective view of the first bearing cartridge assembly of FIG. 4 with a housing cover removed;

[0019] FIG. 9 is another partial perspective view partially in section of the first bearing cartridge assembly of FIG. 4;

[0020] FIG. 10 is a sectional view of a counter balance assembly for the first bearing cartridge assembly of FIG. 4;

[0021] FIG. 11 is an exploded view of the counter balance assembly of FIG. 9; and,

[0022] FIG. 12 is another embodiment of a counter balance assembly for the coordinate measurement device of FIG. 1.

DETAILED DESCRIPTION

[0023] Portable articulated arm coordinate measuring machines provide manufacturers and others with a convenient and flexible way to obtain high quality, high precision measurements of parts, components and objects. To provide this flexibility, the AACMM may have a multi-segmented arm having many degrees of freedom. Embodiments of the present invention provide advantages in offsetting the weight of the multi-segmented arm allowing the operator to make measurements with less effort and higher reliability. Embodiments of the present invention also provide advantages in providing a counter balance that is adjustable to compensate for differences in weights, tolerances and accessories associated with the multi-segmented arm.

[0024] FIGs. 1A and 1B illustrate, in perspective, a portable articulated arm coordinate measuring machine (AACMM) 100 according to various embodiments of the present invention, an articulated arm being one type of coordinate measuring machine. As shown in FIGs. 1A and 1B, the exemplary AACMM 100 may comprise a six or seven axis articulated measurement device having a measurement probe housing 102 coupled to an arm portion 104 of the AACMM 100 at one end. The arm portion 104 comprises a first arm segment 106 coupled to a second arm segment 108 by a first grouping of bearing cartridges 110 (e.g., two bearing cartridges). A second grouping of bearing cartridges 112 (e.g., two bearing cartridges) couples the second arm segment 108 to the measurement probe housing 102. A third grouping of bearing cartridges 114 (e.g., three bearing cartridges) couples the first arm segment 106 to a base 116 located at the other end of the arm portion 104 of the AACMM 100. Each grouping of bearing cartridges 110, 112, 114 provides for multiple axes of articulated movement. Also, the measurement probe housing 102 may comprise the shaft of the seventh axis portion of the AACMM 100 (e.g., a cartridge containing an encoder system that determines movement of the measurement device, for example a probe 118, in the seventh axis of the AACMM 100). In use of the AACMM 100, the base 116 is typically affixed to a work surface.

[0025] Each bearing cartridge within each bearing cartridge grouping 110, 112, 114 typically contains an encoder system (e.g., an optical angular encoder system). The encoder system (i.e., transducer) provides an indication of the position of the respective arm segments 106, 108 and corresponding bearing cartridge groupings 110, 112, 114 that all together provide an indication of the position of the probe 118 with respect to the base 116 (and, thus, the position of the object being measured by the AACMM 100 in a certain frame of reference – for example a local or global frame of reference). The arm segments 106, 108 may be made from a suitably rigid material such as but not limited to a carbon composite material for example. A portable AACMM 100 with six or seven axes of articulated movement (i.e., degrees of freedom) provides advantages in allowing the operator to position the probe 118 in a desired location within a 360° area about the base 116 while providing an arm portion 104 that may be easily handled by the operator. However, it should be appreciated that the illustration of an arm portion 104 having two arm segments 106, 108 is for exemplary purposes, and the claimed invention should not be so limited. An AACMM 100 may have any number of arm segments coupled together by bearing cartridges (and, thus, more or less than six or seven axes of articulated movement or degrees of freedom).

[0026] The probe 118 is detachably mounted to the measurement probe housing 102, which is connected to bearing cartridge grouping 112. A handle 126 is removable with respect to the measurement probe housing 102 by way of, for example, a quick-connect interface. The handle 126 may be replaced with another device (e.g., a laser line probe, a bar code reader), thereby providing advantages in allowing the operator to use different measurement devices with the same AACMM 100. In exemplary embodiments, the probe housing 102 houses a removable probe 118, which is a contacting measurement device and may have different tips 118 that physically contact the object to be measured, including, but not limited to: ball, touch-sensitive, curved and extension type probes. In other embodiments, the measurement is performed, for example, by a non-contacting device such as a laser line probe (LLP). In an embodiment, the handle 126 is replaced with the LLP using the quick-connect interface. Other types of measurement devices may replace the removable handle 126 to provide additional functionality. Examples of such measurement devices include, but are not limited to, one or more illumination lights, a temperature sensor, a thermal scanner, a bar code scanner, a projector, a paint sprayer, a camera, or the like, for example.

[0027] As shown in FIGs. 1A and 1B, the AACMM 100 includes the removable handle 126 that provides advantages in allowing accessories or functionality to be changed without removing the measurement probe housing 102 from the bearing cartridge grouping 112. As discussed in more detail below with respect to FIG. 2, the removable handle 126 may also include an electrical connector that allows electrical power and data to be exchanged with the handle 126 and the corresponding electronics located in the probe end.

[0028] In various embodiments, each grouping of bearing cartridges 110, 112, 114 allows the arm portion 104 of the AACMM 100 to move about multiple axes of rotation. As mentioned, each bearing cartridge grouping 110, 112, 114 includes corresponding encoder systems, such as optical angular encoders for example, that are each arranged coaxially with the corresponding axis of rotation of, e.g., the arm segments 106, 108. The optical encoder system detects rotational (swivel) or transverse (hinge) movement of, e.g., each one of the arm segments 106, 108 about the corresponding axis and transmits a signal to an electronic data processing system within the AACMM 100 as described in more detail herein below. Each individual raw encoder count is sent separately to the electronic data processing system as a signal where it is further processed into measurement data. No position calculator separate from the AACMM 100 itself (e.g., a serial box) is required, as disclosed in commonly assigned U.S. Patent No. 5,402,582 ('582).

[0029] The base 116 may include an attachment device or mounting device 120. The mounting device 120 allows the AACMM 100 to be removably mounted to a desired location, such as an inspection table, a machining center, a wall or the floor for example. In one embodiment, the base 116 includes a handle portion 122 that provides a convenient location for the operator to hold the base 116 as the AACMM 100 is being moved. In one embodiment, the base 116 further includes a movable cover portion 124 that folds down to reveal a user interface, such as a display screen.

[0030] In accordance with an embodiment, the base 116 of the portable AACMM 100 contains or houses an electronic data processing system that includes two primary components: a base processing system that processes the data from the various encoder systems within the AACMM 100 as well as data representing other arm parameters to support three-dimensional (3-D) positional calculations; and a user interface processing system that includes an on-board

operating system, a touch screen display, and resident application software that allows for relatively complete metrology functions to be implemented within the AACMM 100 without the need for connection to an external computer.

[0031] The electronic data processing system in the base 116 may communicate with the encoder systems, sensors, and other peripheral hardware located away from the base 116 (e.g., a LLP that can be mounted to the removable handle 126 on the AACMM 100). The electronics that support these peripheral hardware devices or features may be located in each of the bearing cartridge groupings 110, 112, 114 located within the portable AACMM 100.

[0032] FIG. 2 is a block diagram of electronics utilized in an AACMM 100 in accordance with an embodiment. The embodiment shown in FIG. 2 includes an electronic data processing system 210 including a base processor board 204 for implementing the base processing system, a user interface board 202, a base power board 206 for providing power, a Bluetooth module 232, and a base tilt board 208. The user interface board 202 includes a computer processor for executing application software to perform user interface, display, and other functions described herein.

[0033] As shown in FIG. 2, the electronic data processing system 210 is in communication with the aforementioned plurality of encoder systems via one or more arm buses 218. In the embodiment depicted in FIG. 2, each encoder system generates encoder data and includes: an encoder arm bus interface 214, an encoder digital signal processor (DSP) 216, an encoder read head interface 234, and a temperature sensor 212. Other devices, such as strain sensors, may be attached to the arm bus 218.

[0034] Also shown in FIG. 2 are probe end electronics 230 that are in communication with the arm bus 218. The probe end electronics 230 include a probe end DSP 228, a temperature sensor 212, a handle/LLP interface bus 240 that connects with the handle 126 or the LLP 242 via the quick-connect interface in an embodiment, and a probe interface 226. The quick-connect interface allows access by the handle 126 to the data bus, control lines, and power bus used by the LLP 242 and other accessories. In an embodiment, the probe end electronics 230 are located in the measurement probe housing 102 on the AACMM 100. In an embodiment, the handle 126 may be removed from the quick-connect interface and measurement may be performed by the

laser line probe (LLP) 242 communicating with the probe end electronics 230 of the AACMM 100 via the handle/LLP interface bus 240. In an embodiment, the electronic data processing system 210 is located in the base 116 of the AACMM 100, the probe end electronics 230 are located in the measurement probe housing 102 of the AACMM 100, and the encoder systems are located in the bearing cartridge pairs 110, 112, 114. The probe interface 226 may connect with the probe end DSP 228 by any suitable communications protocol, including commercially-available products from Maxim Integrated Products, Inc. that embody the 1-wire® communications protocol 236.

[0035] FIG. 3 is a block diagram describing detailed features of the electronic data processing system 210 of the AACMM 100 in accordance with an embodiment. In an embodiment, the electronic data processing system 210 is located in the base 116 of the AACMM 100 and includes the base processor board 204, the user interface board 202, a base power board 206, a Bluetooth module 232, and a base tilt module 208.

[0036] In an embodiment shown in FIG. 3, the base processor board 204 includes the various functional blocks illustrated therein. For example, a base processor function 302 is utilized to support the collection of measurement data from the AACMM 100 and receives raw arm data (e.g., encoder system data) via the arm bus 218 and a bus control module function 308. The memory function 304 stores programs and static arm configuration data. The base processor board 204 also includes an external hardware option port function 310 for communicating with any external hardware devices or accessories such as an LLP 242. A real time clock (RTC) and log 306, a battery pack interface (IF) 316, and a diagnostic port 318 are also included in the functionality in an embodiment of the base processor board 204 depicted in FIG. 3.

[0037] The base processor board 204 also manages all the wired and wireless data communication with external (host computer) and internal (display processor 202) devices. The base processor board 204 has the capability of communicating with an Ethernet network via an Ethernet function 320 (e.g., using a clock synchronization standard such as Institute of Electrical and Electronics Engineers (IEEE) 1588), with a wireless local area network (WLAN) via a LAN function 322, and with Bluetooth module 232 via a parallel to serial communications (PSC)

function 314. The base processor board 204 also includes a connection to a universal serial bus (USB) device 312.

[0038] The base processor board 204 transmits and collects raw measurement data (e.g., encoder system counts, temperature readings) for processing into measurement data without the need for any preprocessing, such as disclosed in the serial box of the aforementioned '582 patent. The base processor 204 sends the processed data to the display processor 328 on the user interface board 202 via an RS485 interface (IF) 326. In an embodiment, the base processor 204 also sends the raw measurement data to an external computer.

[0039] Turning now to the user interface board 202 in FIG. 3, the angle and positional data received by the base processor is utilized by applications executing on the display processor 328 to provide an autonomous metrology system within the AACMM 100. Applications may be executed on the display processor 328 to support functions such as, but not limited to: measurement of features, guidance and training graphics, remote diagnostics, temperature corrections, control of various operational features, connection to various networks, and display of measured objects. Along with the display processor 328 and a liquid crystal display (LCD) 338 (e.g., a touch screen LCD) user interface, the user interface board 202 includes several interface options including a secure digital (SD) card interface 330, a memory 332, a USB Host interface 334, a diagnostic port 336, a camera port 340, an audio/video interface 342, a dial-up/ cell modem 344 and a global positioning system (GPS) port 346.

[0040] The electronic data processing system 210 shown in FIG. 3 also includes a base power board 206 with an environmental recorder 362 for recording environmental data. The base power board 206 also provides power to the electronic data processing system 210 using an AC/DC converter 358 and a battery charger control 360. The base power board 206 communicates with the base processor board 204 using inter-integrated circuit (I2C) serial single ended bus 354 as well as via a DMA serial peripheral interface (DSPI) 356. The base power board 206 is connected to a tilt sensor and radio frequency identification (RFID) module 208 via an input/output (I/O) expansion function 364 implemented in the base power board 206.

[0041] Though shown as separate components, in other embodiments all or a subset of the components may be physically located in different locations and/or functions combined in

different manners than that shown in FIG. 3. For example, in one embodiment, the base processor board 204 and the user interface board 202 are combined into one physical board.

[0042] Referring now to FIGs. 4 – 11, an embodiment of AACMM 100 having an adjustable counter balance system is shown. The AACMM 100 includes a first rotation assembly 402 that includes a pair of bearing cartridges 402 disposed between the base 116 and the first arm segment 106. The first rotation assembly 402 is configured to rotate about a first axis 404 and a second axis 406. In one embodiment, the first axis 404 is substantially perpendicular to the second axis 406. The first axis 404 is defined by a rotary bearing cartridge 405 (FIG. 7) disposed within the base 116 that allows communications and power conduits to pass from the first arm segment 106 into the base 116.

[0043] The first rotation assembly 402 includes a first portion 408 and a second portion 410. The first portion 408 is fixed relative to the second axis 406. The first portion 408 includes a first housing member 412 and a second housing member 414. The second housing member 414 includes a projection 416 having a stop member 418. In the exemplary embodiment, the stop member 418 is an elastomeric material that dampens the impact of the second portion 410 when the first arm segment 106 is rotated to a position substantially co-linear with the first axis 404. As will be discussed in more detail herein, a counter balance assembly is at least partially positioned within the first portion 408.

[0044] The second housing member 414 includes a first opening 434 (FIG. 7) that is sized to receive a shaft 436. The second housing member 414 further includes a second opening 438 (FIG. 9) sized to receive a biasing member, such as torsion spring 440 for example. In the exemplary embodiment, the first opening 434 and second opening 438 are substantially co-linear. A third opening 442 is arranged in the second housing member 414 adjacent to the second opening 438. As will be discussed in more detail herein, the third opening 442 is disposed to intersect the second opening 438 to allow at least one projection 444 arranged on one end of the torsion spring 440 to engage a worm gear 446. In one embodiment, the at least one projection 444 includes a plurality of projections that form gear teeth. In the exemplary embodiment, the torsion spring 440 has 28 – 30 teeth disposed over an arc length of 140 degrees. In the exemplary embodiment, the worm gear 446 has single thread and a pitch diameter of

approximately 0.45 inches and a length of approximately 1 inch. The worm gear 446 is retained in position by the force applied by torsion spring 440.

[0045] It should be appreciated that while embodiments describe the gear teeth being disposed on the end of the torsion spring, the claimed invention should not be so limited. In one embodiment, the torsion spring is comprised of two counter wound torsion springs with gear teeth formed about a middle portion.

[0046] The gear teeth 444 are configured to rotate the end of the torsion spring 440 in response to the rotation of the worm gear 446. The gear teeth 444 and worm gear 446 cooperate to form an adjuster assembly for the torque applied to the first arm segment 106. It should be appreciated that the rotation of the worm gear 446 causes the end of the torsion spring 440 to move or rotate in a manner that results in a change in the torque being applied by the torsion spring 440.

[0047] In one embodiment, a first bore opening 448 extends from one end of the third opening 442. The first bore opening 448 is sized to receive a tool (not shown) that couples to rotate the worm gear 446. In another embodiment, the second housing member 414 includes a wall 450. In this embodiment, a second bore opening 452 is arranged co-linearly with the bore opening 448 to allow access of the tool to the worm gear 446.

[0048] The second portion 410 is disposed between the first portion 408 and the first arm segment 106. The second portion includes a third housing member 420 and a fourth housing member 422. The second portion 410 rotates about the second axis 406. A projection 424 having a surface 426 extends from the third housing member 420. The projection 424 is arranged such that the surface 426 contacts the stop member 418 when the first arm segment is rotated to a position substantially co-linear with the first axis 404 (the "initial position"). In the exemplary embodiment, the second portion 410 may rotate at least 165 degrees relative to the initial position. The section portion 410 further includes a tapered portion 428 that couples to the first arm segment 106. A projection 430 extends from the tapered portion 428. A bracket 432 is coupled to the projection 430. The bracket 432 is configured to support the second arm segment 108 when the first arm segment 106 and the second arm segment 108 are positioned in parallel.

[0049] The third housing 420 is coupled to a second shaft 454. The second shaft 454 has an outer portion 470, an intermediate portion 472 and an inner portion 474. The outer portion 470 has a diameter that is sized to engage and couple to the third housing 420. The outer portion 470 transitions to the intermediate portion 472 at a lip 476. In the exemplary embodiment, the lip 476 provides a stopping feature against which a corresponding feature on the third housing 420 contacts. The diameter of the intermediate portion is sized to receive the inner diameter of the torsion spring 440. The second shaft 454 tapers from the intermediate portion 472 to the inner portion 474. The inner portion 474 has a diameter that is less than the inner diameter of the torsion spring 440 to provide clearance to accommodate changes in the inner diameter of the torsion spring 440 as the first arm segment 106 is rotated.

[0050] The second shaft 454 has a substantially hollow interior portion that is disposed about the first shaft 436. The second shaft 454 is coupled to the first shaft 436 by a pair of bearings 456, 458, such as a ball bearing or a roller bearing for example. The bearings 456, 458 allow the rotation of the second portion 410 relative to the first portion 408 about the second axis 406. Additional components, such as spacers 478, collars 480 and washers 482 may also be included to provide the desired spacing and support of the assembly. In one embodiment, an optical encoder assembly 464 is coupled to the second shaft 454 and arranged to measure the rotational movement between the first shaft 436 and the second shaft 454.

[0051] The torsion spring 440 is disposed about the shafts 436, 454. In the exemplary embodiment, the torsion spring includes a first end 460 adjacent the worm gear 446 and a second end 462 coupled to the second portion 410. In the exemplary embodiment, the second end 462 is coupled to the fourth housing member 422 by at least one fastener 466 (FIG. 6). The fastener 466 couples the second end 462 to the second portion 410 such that when the first arm segment 106 is rotated about the second axis 406 a torque is applied to the first arm segment 106 by the torsion spring 440. The torsion spring 440 is selected to substantially counter balance the weight of the arm portion 104 when the arm segments 106, 108 are articulated to the desired position. In the exemplary embodiment, the torsion spring 440 is configured to provide a torque level that allows the first arm segment to remain at a desired angular position without sagging (e.g. moving downward under the force of gravity) or springing back (e.g. towards the initial position) when the operator releases the measurement device 102.

[0052] It should be appreciated that variations in the manufacturing processes of the components of the arm portion 104 may result in the torque produced by the torsion spring 440 being either too large (causing spring back) or too small (causing sagging). To compensate for the variations in components, the AACMM 100 includes an adjuster that provides means for changing the torque. In the exemplary embodiment, the adjustment of the torque is provided by rotating the worm gear 446 within the third opening 442 by inserting a tool through the first bore opening 448 and engaging a feature 468 on the end of the worm gear 446. The feature 468 may be any suitable feature appropriate to engage a tool such as but not limited to a straight slot, a Philips slot, a Frearson slot, a hexagon socket, an Allen socket, a star socket, or a Torx socket for example. By rotating the worm gear 446 clockwise or counter-clockwise, the first end 460 of the torsion spring 440 will be moved from a first position to a second position.

[0053] As the first end 460 is moved, the torque applied by the torsion spring 440 on the second portion 410 and thus the first arm segment 106 will increase or decrease. This provides advantages in adjusting the counter balancing torque to the components within a particular arm portion 104. In the exemplary embodiment, the torque may be adjusted from 0 ft-lb to 63 ft-lb over the range 70 degrees of rotation of the worm gear 446 and gear teeth 444 engagement. In one embodiment, the calibration of the torsion spring 440 is performed during the manufacturing assembly and a cap or plug (not shown) is inserted into the first bore opening 448 or second bore opening 452 to prevent tampering. In one embodiment, a set screw is used to lock the worm gear 446 to prevent movement.

[0054] Another embodiment of an adjuster assembly is shown in FIG. 12. In this embodiment, the second housing member 414 has a substantially hollow interior portion 484 defined by walls 450, 486 and 488. Arranged within the interior portion 484 is a threaded member 490, such as a threaded rod for example. The threaded member 490 is coupled for rotation between the walls 450, 486. The threaded member 490 may include a feature (not shown), similar to feature 486 for example, that allows the user to insert a tool to rotate the threaded member. A collar 492 is coupled to the threaded member 490. The collar 492 includes an internal thread that engages the threads of the threaded member 490 such that when the threaded member 490 is rotated, the collar 492 translates along the longitudinal axis of the threaded member 490. An arm 494 extends between the collar 492 and the torsion spring 440.

The arm 494 may be a separate member from or integral with the torsion spring 440. As such, when the collar translates along the threaded member, the first end 460 of the torsion spring 440 moves from a first position to a second position. As described above, the movement of the first end 460 allows the calibration of the torque output of the torsion spring 440 to provide the desired level of counter balance.

[0055] It should be appreciated that while embodiments of the invention describe an adjuster that is manually adjusted, the claimed invention should not be so limited. In one embodiment, a motor such as a stepper motor is coupled to rotate the adjuster. In one embodiment, the stepper motor is coupled with a controller that adjusts the torque of the torsion spring based on the position of the arm.

[0056] While the invention has been described with reference to example embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

CLAIMS

What is claimed is:

1. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion being rotationally coupled to the base, the arm segment including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device;

a rotation assembly coupling the second end to the base, the rotation assembly having a first axis of rotation and a second axis of rotation substantially perpendicular to the first axis of rotation;

a biasing member operably coupled between the rotation assembly and the second end to apply a force to the second end about the second axis of rotation the biasing member having at least one projection thereon; and

an adjuster having a threaded portion, the threaded portion being arranged to engage the at least one projection, wherein the force applied by the biasing member to the arm portion changes in response to movement of the adjuster.

2. The AACMM of claim 1 wherein:

the biasing member is a torsion spring; and

the force applies a first torque to the arm portion.

3. The AACMM of claim 2 wherein:

the at least one projection includes a plurality of gear teeth disposed on a third end; and

the adjuster is a worm gear engageably coupled to the plurality of gear teeth.

4. The AACMM of claim 3 wherein the worm gear is rotatably disposed within a housing, the housing being rotatably coupled to the base to rotate about the first axis of rotation.

5. The AACMM of claim 4 wherein the worm gear includes a feature on a fourth end sized to receive a tool, the worm gear rotating in response to an application of a second torque by the tool on the feature.

6. The AACMM of claim 5 wherein the housing includes a opening axially aligned with the worm gear and having a fifth end adjacent the feature, the opening being sized to receive the tool.

7. The AACMM of claim 6 wherein the torsion spring is coupled to the first end on a sixth end opposite the plurality of gear teeth.

8. The AACMM of claim 2 wherein:

the at least one projection is an arm coupled on a third end to the torsion spring; and

the adjuster includes a collar coupled between the threaded portion and the arm, wherein the collar moves the arm from a first position to a second position in response to a rotation of the adjuster.

9. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device;

a biasing member operably coupled between the base and the second end, the biasing member having at least one projection movable between a first position and a second position; and

an adjuster having a threaded portion operably coupled between the base and the biasing member, wherein the threaded portion is engaged to the at least one projection to move the at least one projection between the first position to the second position.

10. The AACMM of claim 9 wherein:

the adjuster is a worm gear; and

the at least one projection includes a plurality of gear teeth, the plurality of gear teeth being arranged to engage the worm gear.

11. The AACMM of claim 10 wherein the biasing member is a torsion spring.

12. The AACMM of claim 11 wherein the torsion spring applies a first torque on the articulatable arm when the plurality of gear teeth are in the first position and a second torque when the plurality of gear teeth are in the second position.

13. The AACMM of claim 12 further comprising a housing member coupled to the base, the housing member defining a first opening sized to receive and retain the worm gear and a second opening extending from the first opening and sized to receive a tool.

14. The AACMM of claim 9 wherein:

the adjuster includes a collar operably coupled to the threaded portion; and

the at least one projection is an arm coupled to the collar.

15. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each arm segment including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit which receives the position signals from the transducers and provides data corresponding to a position of the measurement device;

a rotation assembly rotationally coupling the second end to the base about a first axis of rotation and a second axis of rotation, the second axis of rotation being substantially perpendicular to the first axis of rotation;

a biasing member arranged within the rotation assembly and having a third end operably coupled to the second end, the biasing member having a fourth end opposite the third end, the fourth end being movable between a first position and a second position; and

an adjusting member operably coupled for rotation to the base and operably coupled to the fourth end, wherein the fourth end moves between the first position and the second position in response to a rotation of the adjusting member.

16. The AACMM of claim 15 wherein the rotation assembly further includes a housing, the housing defining a first opening sized to receive the adjusting member.

17. The AACMM of claim 16 wherein the biasing member is a torsion spring having a plurality of gear teeth on the fourth end, and the adjusting member is operably coupled to the gear teeth.

18. The AACMM of claim 17 wherein:

the adjusting member includes a worm screw portion; and

the housing includes a second opening extending from a fifth end of the first opening, the second opening sized to receive a tool.

19. The AACMM of claim 15 wherein the adjuster includes a threaded member and a collar disposed between the threaded member and the fourth end, the collar having a threaded portion engaged with the threaded member.

20. The AACMM of claim 19 further comprising an arm coupled between the collar and the fourth end, wherein the arm moves the fourth end between the first position and the second position in response to rotation of the threaded member.

AMENDED CLAIMS
received by the International Bureau on 16 June 2011 (16.06.2011)

CLAIMS:

1. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion being rotationally coupled to the base, the arm segment including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device;

a rotation assembly coupling the second end to the base, the rotation assembly having a first axis of rotation and a second axis of rotation substantially perpendicular to the first axis of rotation;

a biasing member operably coupled between the rotation assembly and the second end to apply a force to the second end about the second axis of rotation the biasing member having at least one projection thereon; and

an adjuster including a threaded portion having threads, the threads being arranged to engage the at least one projection, wherein the force applied by the biasing member to the arm portion changes in response to movement of the adjuster.

2. The AACMM of claim 1 wherein:

the biasing member is a torsion spring; and

the force applies a first torque to the arm portion.

3. The AACMM of claim 2 wherein:

the at least one projection includes a plurality of gear teeth disposed on a third end; and

the adjuster is a worm gear engageably coupled to the plurality of gear teeth.

4. The AACMM of claim 3 wherein the worm gear is rotatably disposed within a housing, the housing being rotatably coupled to the base to rotate about the first axis of rotation.

5. The AACMM of claim 4 wherein the worm gear includes a feature on a fourth end sized to receive a tool, the worm gear rotating in response to an application of a second torque by the tool on the feature.

6. The AACMM of claim 5 wherein the housing includes a opening axially aligned with the worm gear and having a fifth end adjacent the feature, the opening being sized to receive the tool.

7. The AACMM of claim 6 wherein the torsion spring is coupled to the first end on a sixth end opposite the plurality of gear teeth.

8. The AACMM of claim 2 wherein:

the at least one projection is an arm coupled on a third end to the torsion spring; and

the adjuster includes a collar coupled between the threaded portion and the arm, wherein the collar moves the arm from a first position to a second position in response to a rotation of the adjuster.

9. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each of the arm segments including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit for receiving the position signals from the transducers and for providing data corresponding to a position of the measurement device;

a biasing member operably coupled between the base and the second end, the biasing member having at least one projection movable between a first position and a second position; and

an adjuster having a threaded portion operably coupled for rotation between the base and the biasing member, wherein the threaded portion includes threads that are engaged to the at least one projection to move the at least one projection along the threads between the first position to the second position when the adjuster is rotated.

10. The AACMM of claim 9 wherein:

the adjuster is a worm gear; and

the at least one projection includes a plurality of gear teeth, the plurality of gear teeth being arranged to engage the worm gear.

11. The AACMM of claim 10 wherein the biasing member is a torsion spring.

12. The AACMM of claim 11 wherein the torsion spring applies a first torque on the articulatable arm when the plurality of gear teeth are in the first position and a second torque when the plurality of gear teeth are in the second position.

13. The AACMM of claim 12 further comprising a housing member coupled to the base, the housing member defining a first opening sized to receive and retain the worm gear and a second opening extending from the first opening and sized to receive a tool.

14. The AACMM of claim 9 wherein:

the adjuster includes a collar operably coupled to the threaded portion; and

the at least one projection is an arm coupled to the collar.

15. A portable articulated arm coordinate measurement device (AACMM) for measuring coordinates of an object in space, comprising:

a base;

a manually positionable articulated arm portion having an opposed first end and second end, the arm portion including a plurality of connected arm segments, each arm segment including at least one position transducer for producing a position signal;

a measurement device attached to the first end;

an electronic circuit which receives the position signals from the transducers and provides data corresponding to a position of the measurement device;

a rotation assembly rotationally coupling the second end to the base about a first axis of rotation and a second axis of rotation, the second axis of rotation being substantially perpendicular to the first axis of rotation;

a biasing member arranged within the rotation assembly and having a third end operably coupled to the second end, the biasing member having a fourth end opposite the third end, the fourth end having at least one projection integrally formed thereon, the fourth end being movable between a first position and a second position; and

an adjusting member having threads, the adjusting member being operably coupled for rotation to the base and operably coupled to engage the at least one projection with the threads, wherein the fourth end moves between the first position and the second position in response to a rotation of the adjusting member.

16. The AACMM of claim 15 wherein the rotation assembly further includes a housing, the housing defining a first opening sized to receive the adjusting member.

17. The AACMM of claim 16 wherein the biasing member is a torsion spring and the at least one projection is a plurality of gear teeth on the fourth end, and the adjusting member is operably coupled to the gear teeth.

18. The AACMM of claim 17 wherein:

the adjusting member includes a worm screw portion; and

the housing includes a second opening extending from a fifth end of the first opening, the second opening sized to receive a tool.

19. The AACMM of claim 15 wherein the adjuster includes a threaded member and a collar disposed between the threaded member and the fourth end, the collar having a threaded portion engaged with the threaded member.

20. The AACMM of claim 19 further comprising an arm coupled between the collar and the fourth end, wherein the arm moves the fourth end between the first position and the second position in response to rotation of the threaded member.

STATEMENT UNDER ARTICLE 19(1)

Applicant, by this Amendment, has amended claims 1, 9, 15 and 17 to clarify the claims by reciting that the adjuster includes a threaded portion with threads and that the projection engages the threads of the threaded portion.

In the Written Opinion, the Examiner stated that claims 1, 9 and 15 are not concise. Applicant respectfully disagrees. Independent claims 1, 9 and 15 clearly define the scope of the invention and the claimed limitations clearly and concisely define the inter-relationships between the elements. Applicant submits that claims 1, 9 and 15 are concise and proper.

In the Written Opinion, the Examiner objects to claims 1, 9 and 15 because they appear to relate effectively to the same subject-matter but with slightly different wording and level of detail. Applicant respectfully disagrees. While claims 1, 9 and 15 are directed to the same subject matter of the invention, the difference in the wording changes the scope of the claim. Applicant respectfully submits that independent claims 1, 9 and 15 are proper.

In the Written Opinion, the Examiner objected to claims 1, 9 and 15 since they comprise all of the features of either references D1 (US 2003/208919 hereinafter referred to as "D1") and D2 (WO 00/34733 hereinafter referred to as "D2"). Applicant respectfully disagrees.

The claims each recite that the adjusting member includes a threaded portion that engages a projection on the end of the biasing member. In contrast to the assertions of the Examiner, Applicant finds that D1 discloses a threaded screw (192) that moves laterally within a housing. The screw (192) has an end that is arranged to engage a pin 188 that extends from one side of the spring. Accordingly, Applicant respectfully submits that D1 does not disclose each and every element of the claim. Therefore, D1 cannot anticipate independent claims 1, 9 and 15.

With respect to D2, Applicant finds that D2 discloses a counter balance arrangement having a plurality of gears 221, 222, 223. A cable 225 is coupled to and extends from the end gear 223. The cable 225 extends through the inner diameter of a compression spring 224 and is captured on the end of the cable 225 by a nut or retainer 235 that connects with threads on the end of the cable 225. By rotating the gear 221, the operator causes a rotation of the gear 223 that either retracts or extends the cable 225. As a result of the movement of cable 225, the compression of the spring 224 may be changed. Applicant respectfully submits that D2 does not disclose an adjusting member having a threaded portion with threads that engage a projection on the spring. Accordingly, D2 does not disclose each and every element of the claims 1, 9 and 15 and therefore cannot be anticipatory.

The examiner further asserts that no inventive contribution is provided by any of claims 2-8, 10-14 and 16-20 since the features of the claims are disclosed in one or more of references, D1, D2, D3 (US 5,983,936 hereinafter referred to as "D3), D4 (US 4,537,233 hereinafter referred to as "D4") and D5 (US 3,485,167 hereinafter referred to as "D5"). Applicant respectfully disagrees.

Applicant finds that D3 discloses a torsion spring adjuster. The torsion spring 110 has a separate gear 90 mounted to one end. The gear and the torsion spring are two separate components (See Figure 2-3, Col. 4 Lns 40-55 "mounted to"). Accordingly, Applicant submits that D3 fails to overcome the deficiencies of D1 and D2 and namely this combination of references would not result in a portable articulated arm coordinate measurement device having an adjuster with threads that engage a projection from the spring to adjust the tension of the spring.

Applicant finds that D4 is directed to a torsion spring adjuster. The torsion spring 109 that is coupled to a shaft 118 that increases or decreases the tension in the spring when turned (Col. 3, Lns 60-65). Stub shaft 118 includes a support 120 for coil spring 109 and a slot 121 for end 122 and a series of toothed elements 123 designed to cooperate with a keeper element 124. In another embodiment, a bolt 47 is turned in one direction to draw with it the captive barrel nut and with end cap 19 that holds coil spring end 50 to increase or decrease tension on the coil spring 24. Accordingly, Applicant submits that D4 fails to overcome the deficiencies of D1, D2 and D3 and namely this combination of references would not result in a portable articulated arm coordinate measurement device having an adjuster with threads that engage a projection from the spring to adjust the tension of the spring.

With respect to D5, Applicant finds that D5 relates to a balancing mechanism. The balancing mechanism includes a torque lever 64. The lever 64 is provided with an axially extending hub 66 having a slot 68 also parallel with the axle 38. The slot receives the free end of the torsion spring 60 in such a manner that rotational movement of the torque lever will result in winding or unwinding of the spring about the axle. The torque lever is apertured as at 70 to receive the pivot bolt 28 which also passes through the spaced arms 29 of the connecting arm. As can be readily seen, vertical pivotal movement of the inner conduit 14 will result in rotation of the lever about the axle to cause winding or unwinding of the spring." (Col. 2, Lns 57-86). Accordingly, Applicant submits that D5 fails to overcome the deficiencies of D1, D2, D3 and D4 and namely this combination of references would not result in a portable articulated arm coordinate measurement device having an adjuster with threads that engage a projection from the spring to adjust the tension of the spring.

It is respectfully submitted that the claimed invention, as amended, is novel and involves an inventive step over the documents cited in the International Search Report. Further and favorable reconsideration of the subject application is hereby requested.

CONCLUSION

Applicant respectfully requests entry of the above amendment.

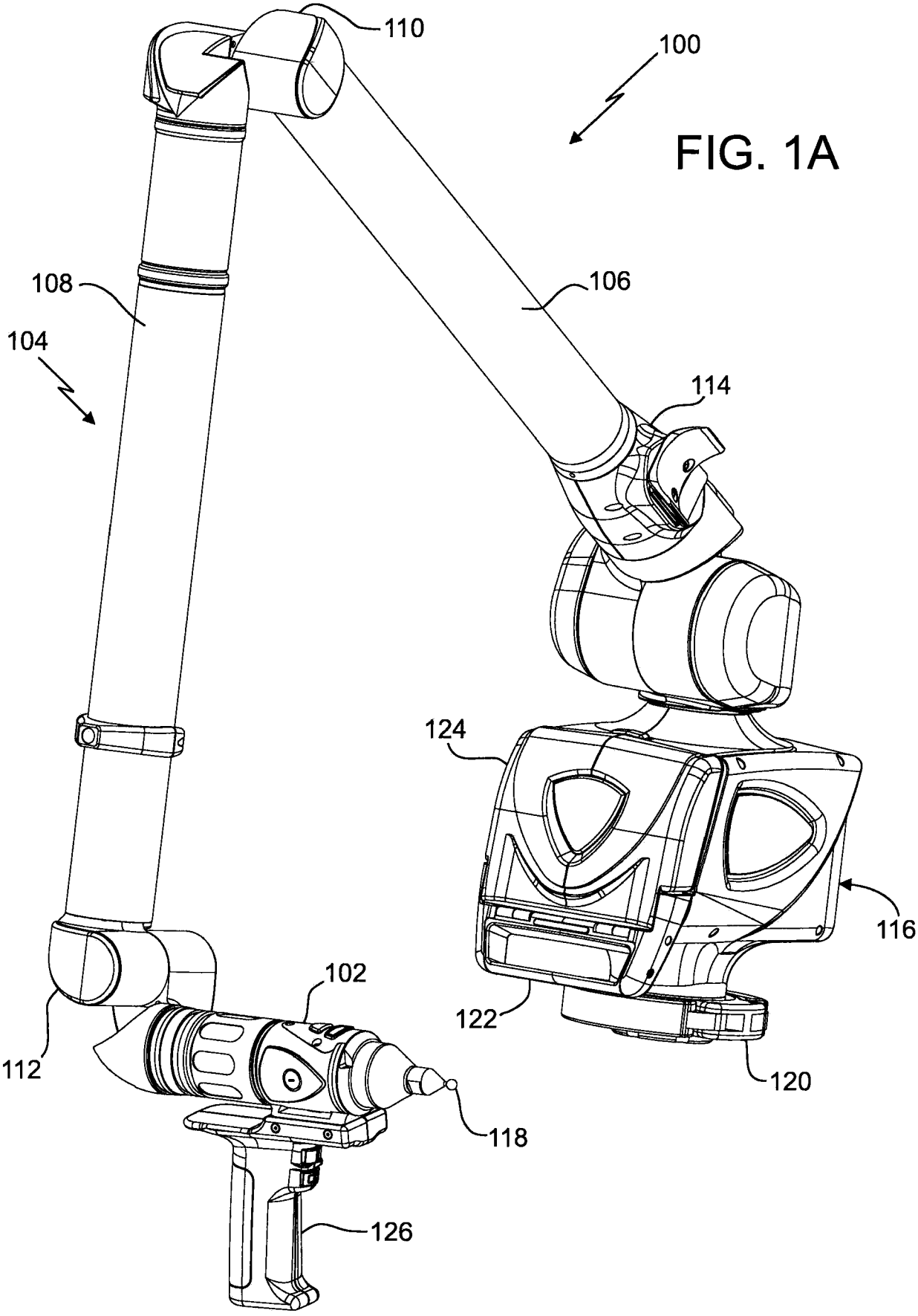


FIG. 1A

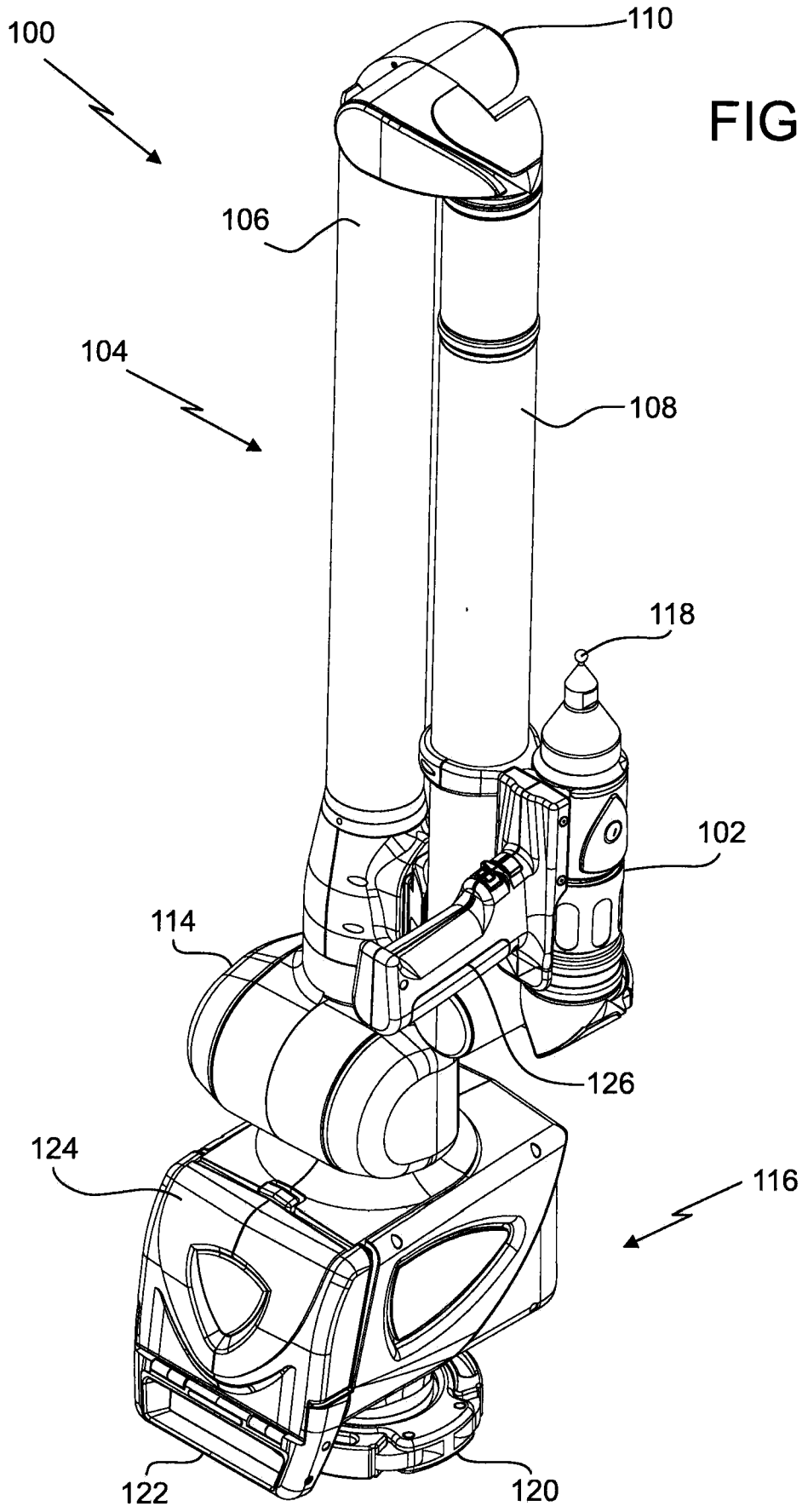
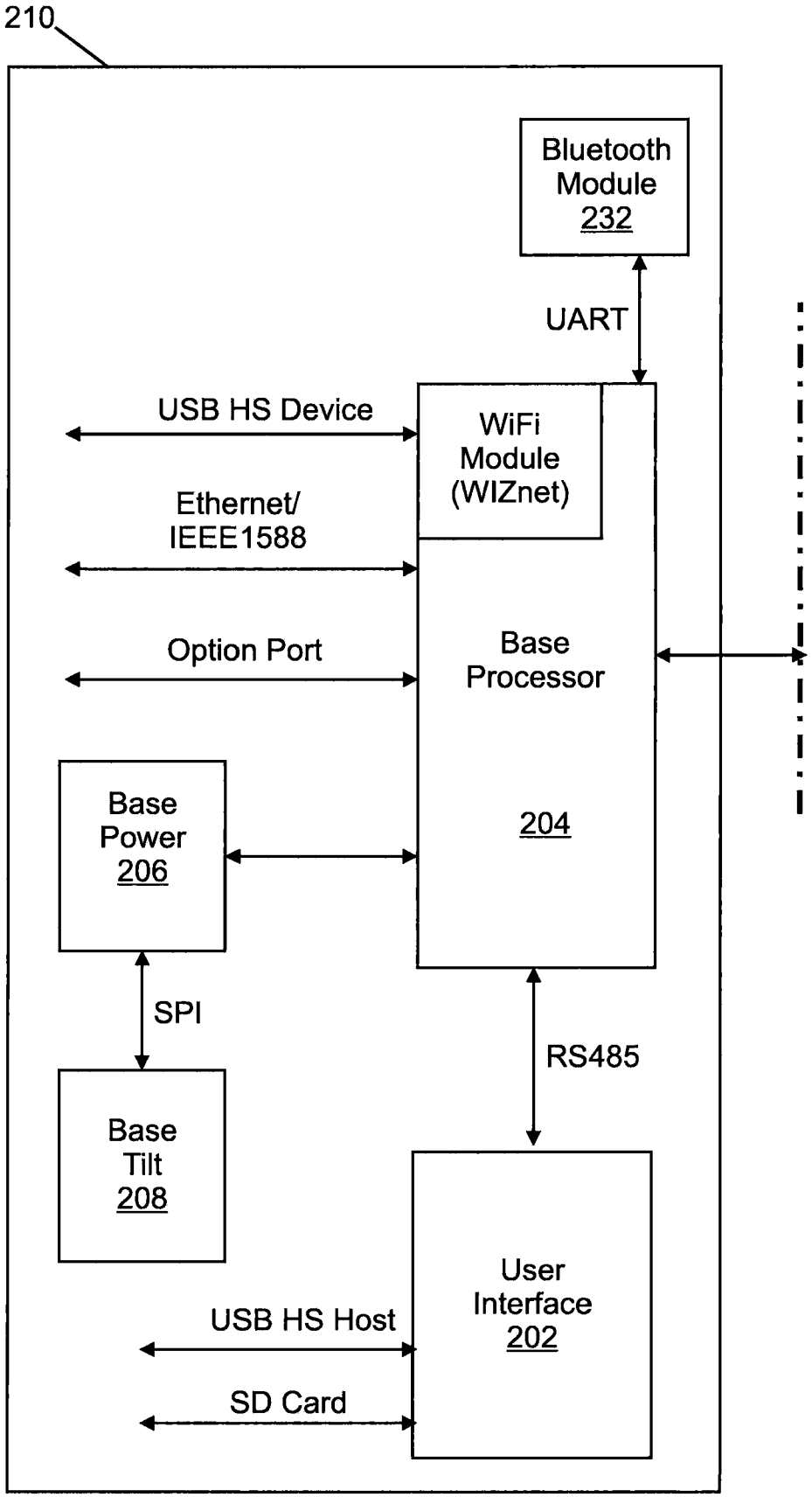


FIG. 1B

FIG. 2A


210
Bluetooth Module 232
UART
USB HS Device
WiFi Module (WIZnet)
Ethernet/ IEEE1588
Option Port
Base Processor
204
Base Power 206
SPI
RS485
Base Tilt 208
User Interface 202
USB HS Host
SD Card

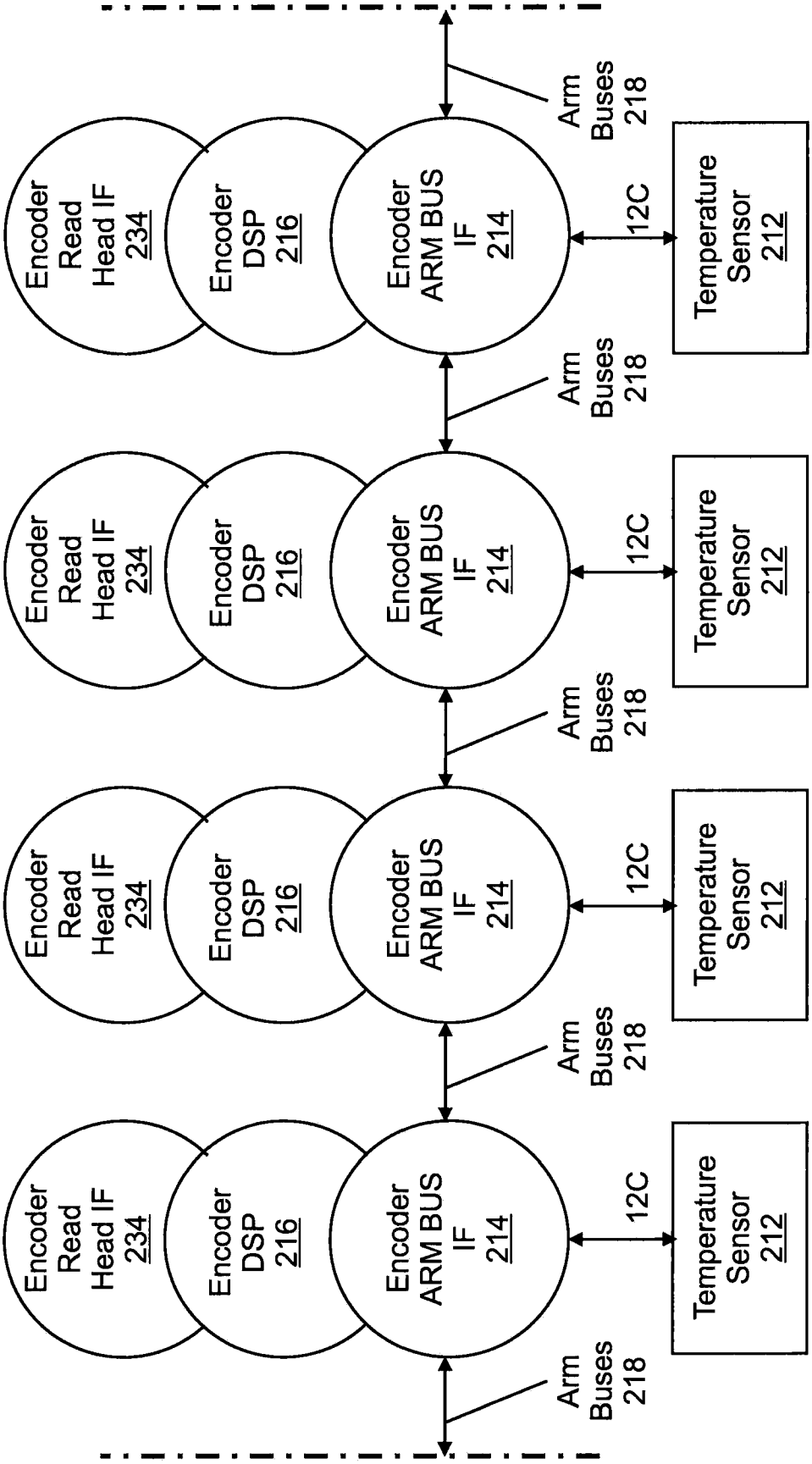

Encoder Read Head IF 234
Encoder DSP 216
Encoder ARM BUS IF 214
12C
Temperature Sensor 212
Arm Buses 218

FIG. 2B

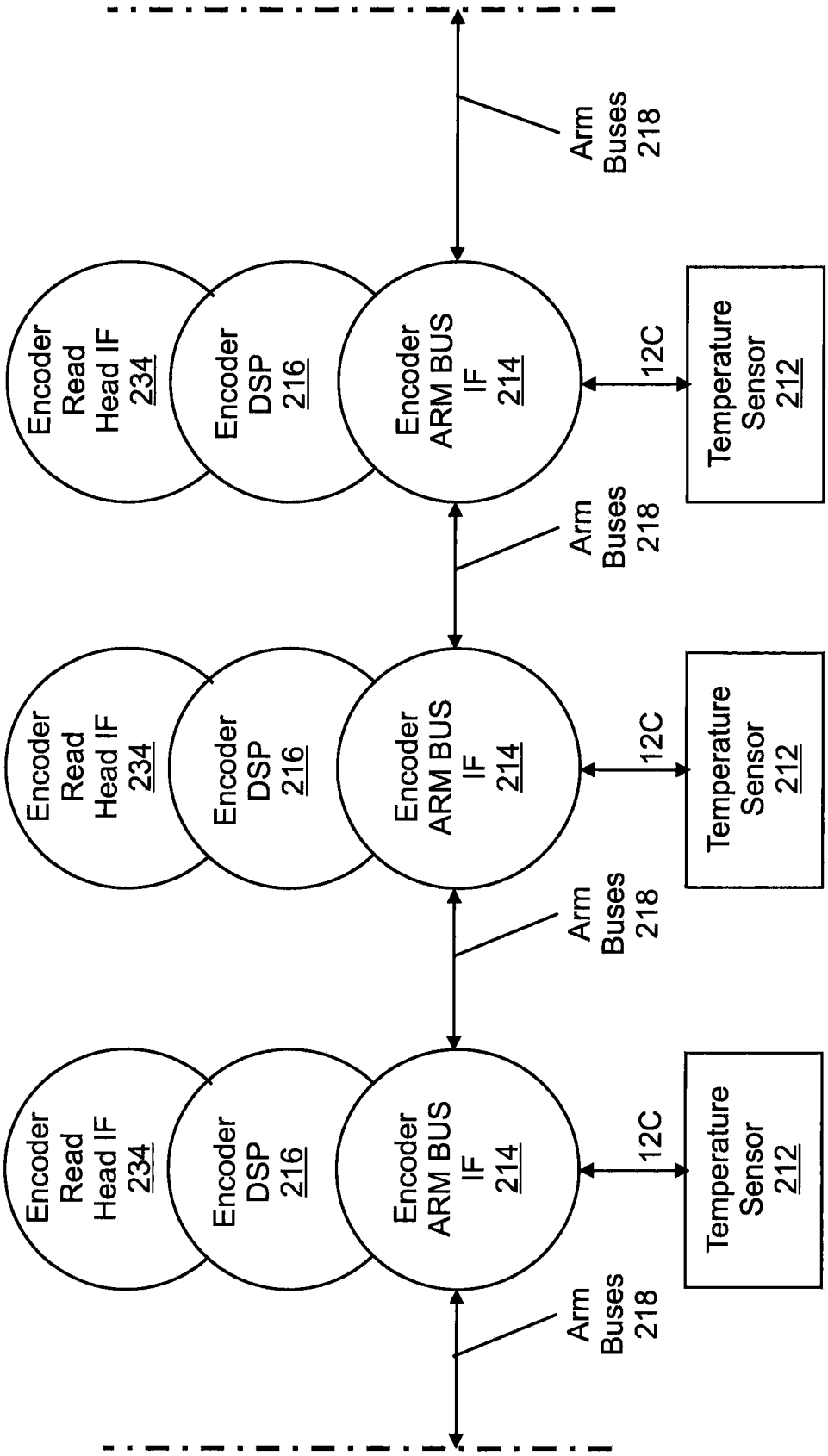
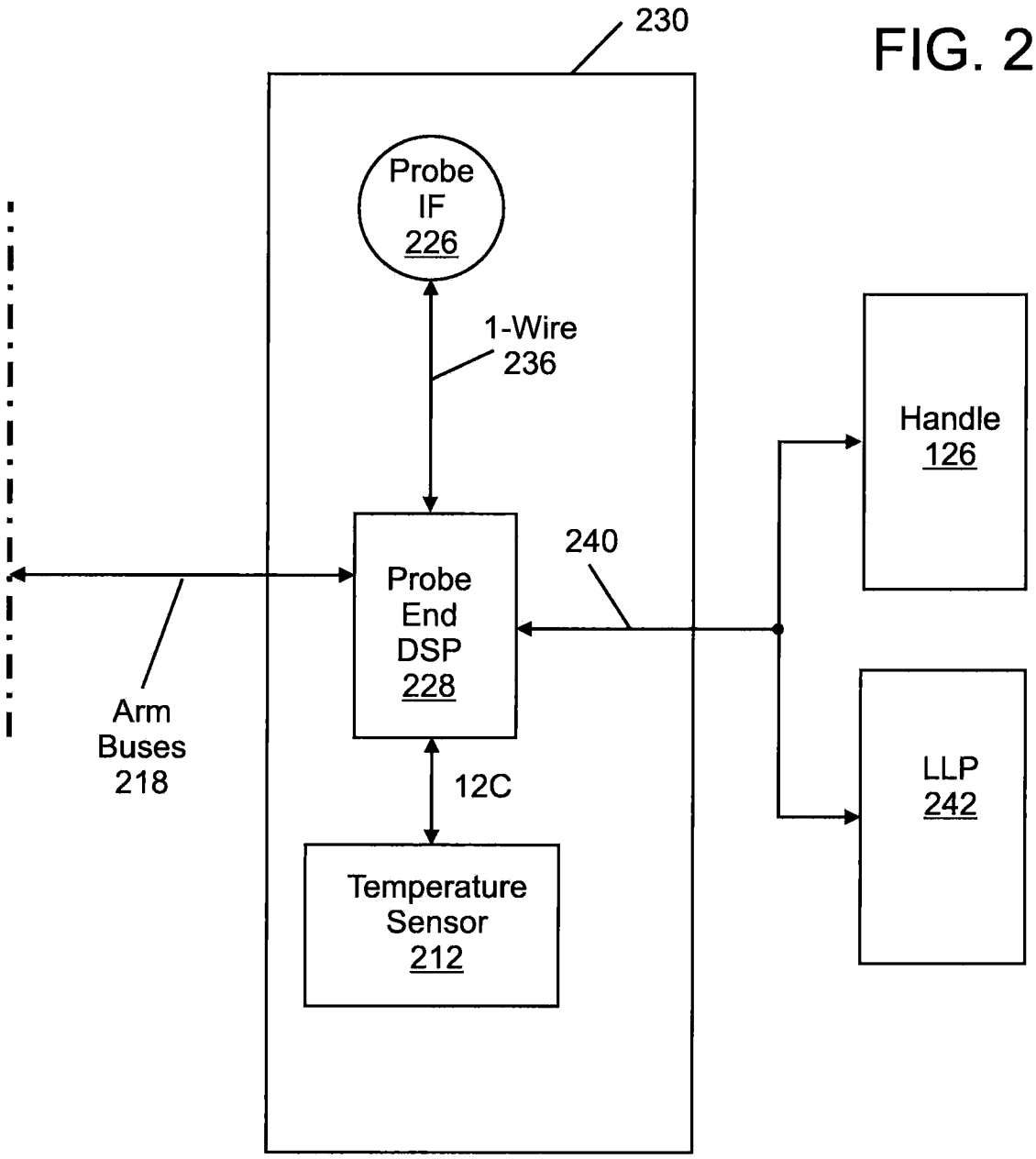

Arm Buses 218
Encoder Read Head IF 234
Encoder DSP 216
Encoder ARM BUS IF 214
12C
Temperature Sensor 212
Arm Buses 218
Encoder Read Head IF 234
Encoder DSP 216
Encoder ARM BUS IF 214
12C
Temperature Sensor 212
Arm Buses 218
Encoder Read Head IF 234
Encoder DSP 216
Encoder ARM BUS IF 214
12C
Temperature Sensor 212
Arm Buses 218

FIG. 2C

FIG. 2D


230
Probe
IF
226
1-Wire
236
Handle
126
240
Probe
End
DSP
228
Arm
Buses
218
12C
LLP
242
Temperature
Sensor
212

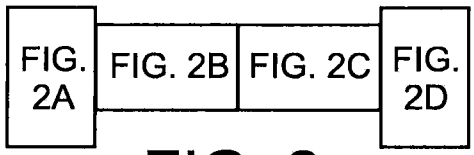
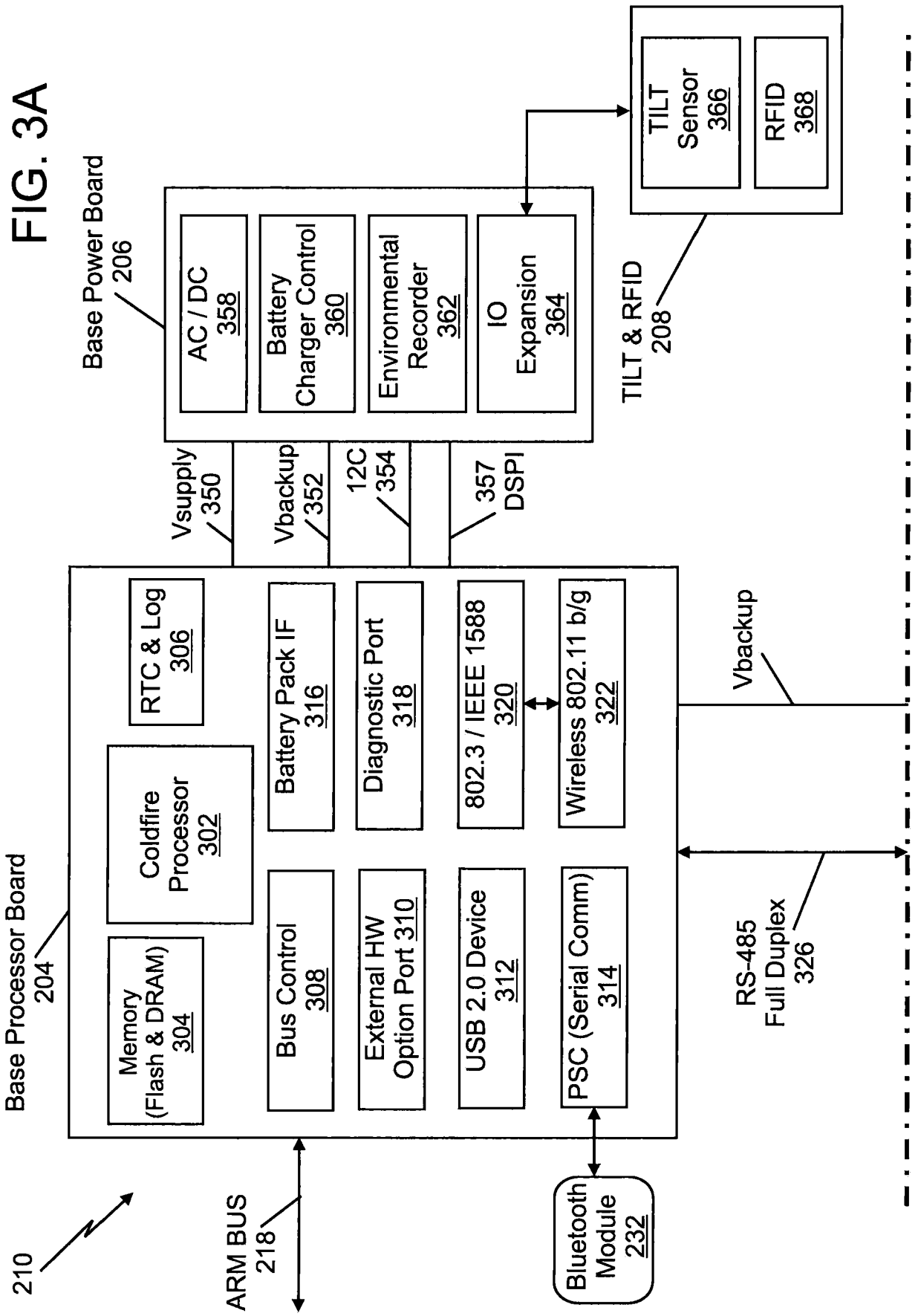

FIG. 2A
FIG. 2B
FIG. 2C
FIG. 2D

FIG. 2

FIG. 3A


Base Power Board
206
AC / DC
358
Battery
Charger Control
360
Environmental
Recorder
362
IO
Expansion
364
TILT
Sensor
366
RFID
368
TILT & RFID
208
Vsupply
350
Vbackup
352
12C
354
357
DSPI
Base Processor Board
204
Coldfire
Processor
302
RTC & Log
306
Memory
(Flash & DRAM)
304
Bus Control
308
Battery Pack IF
316
External HW
Option Port 310
Diagnostic Port
318
USB 2.0 Device
312
802.3 / IEEE 1588
320
PSC (Serial Comm)
314
Wireless 802.11 b/g
322
Vbackup
RS-485
Full Duplex
326
210
ARM BUS
218
Bluetooth
Module
232

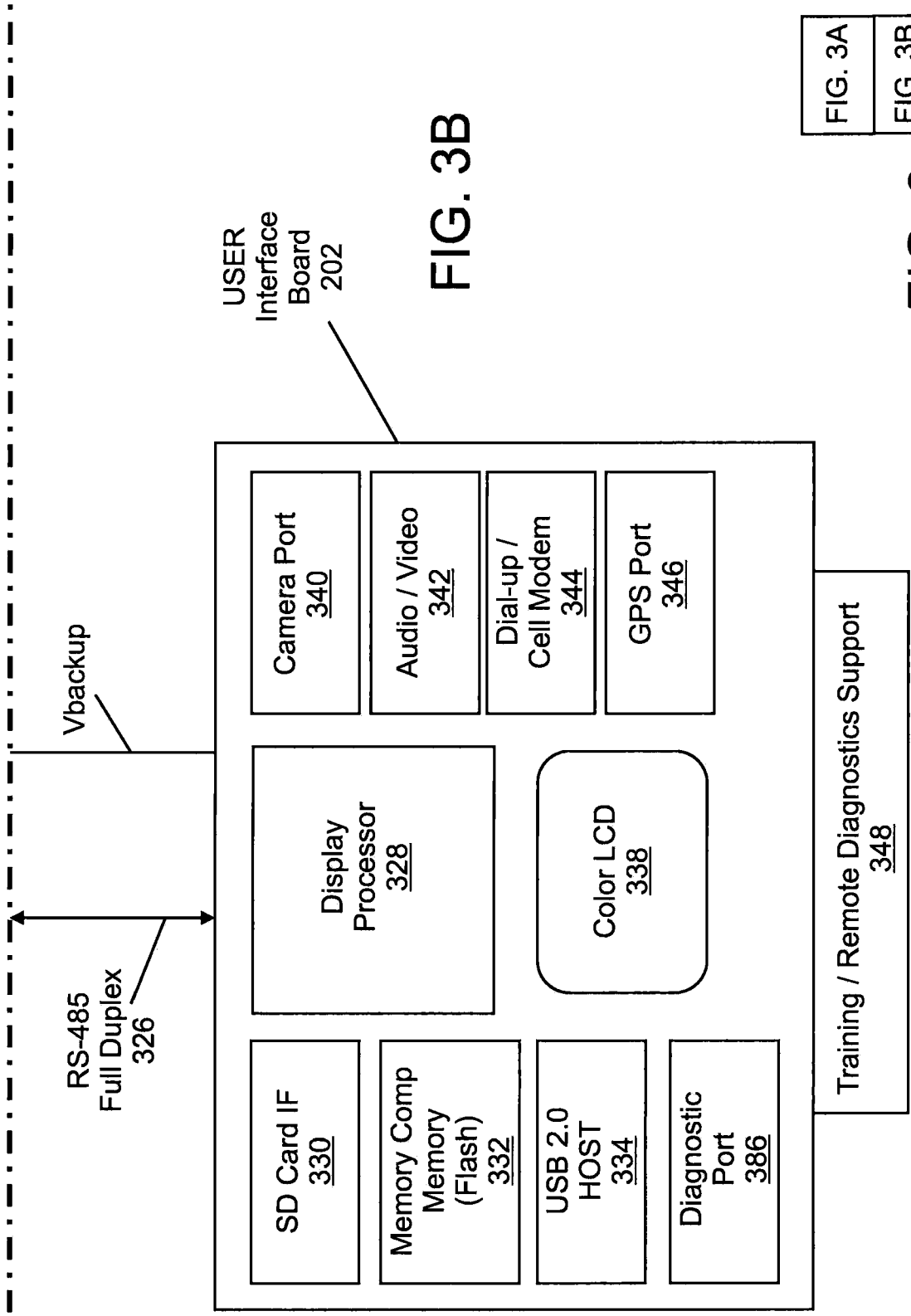


FIG. 3B

FIG. 3A
FIG. 3B

FIG. 3

FIG. 4

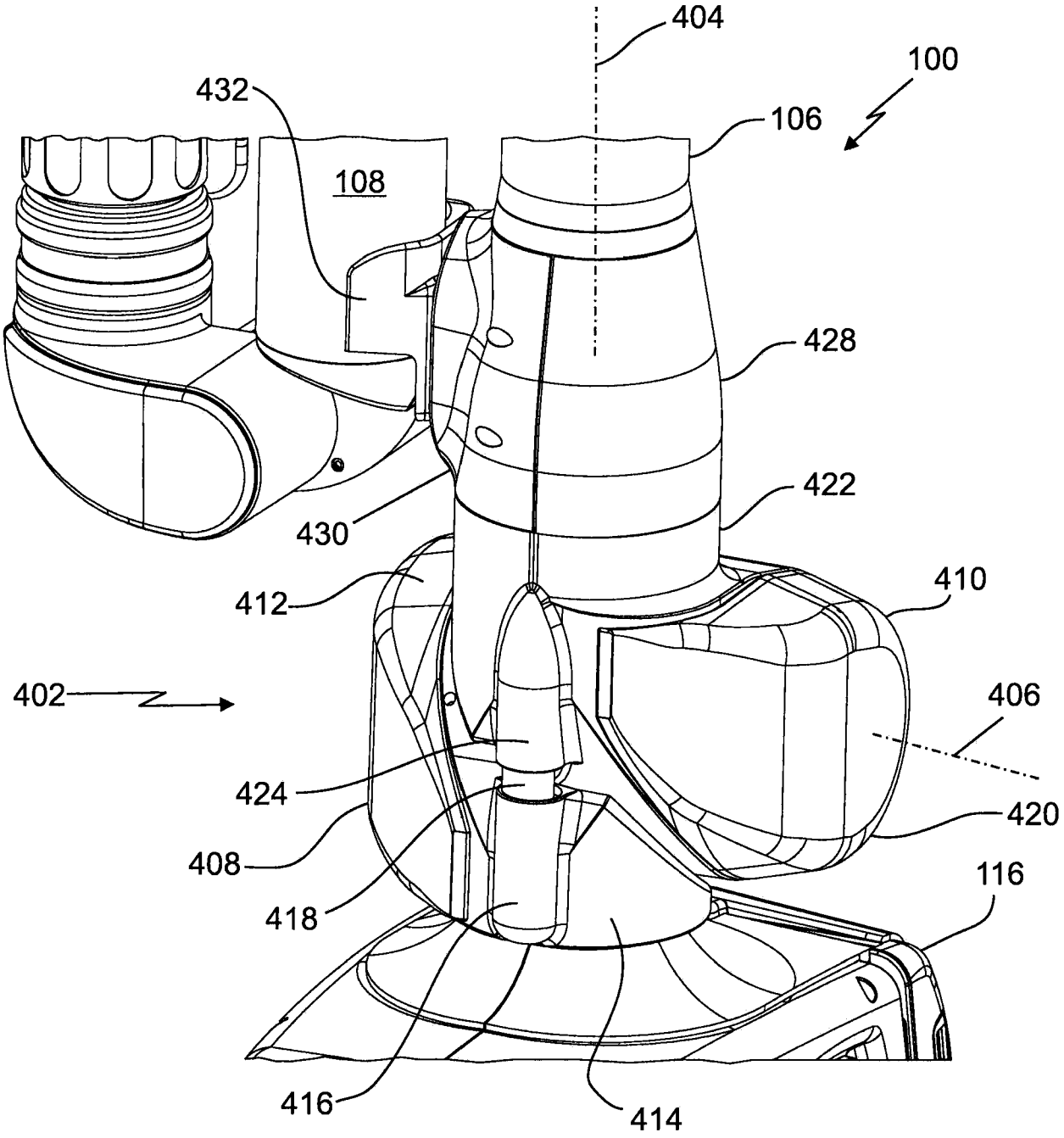
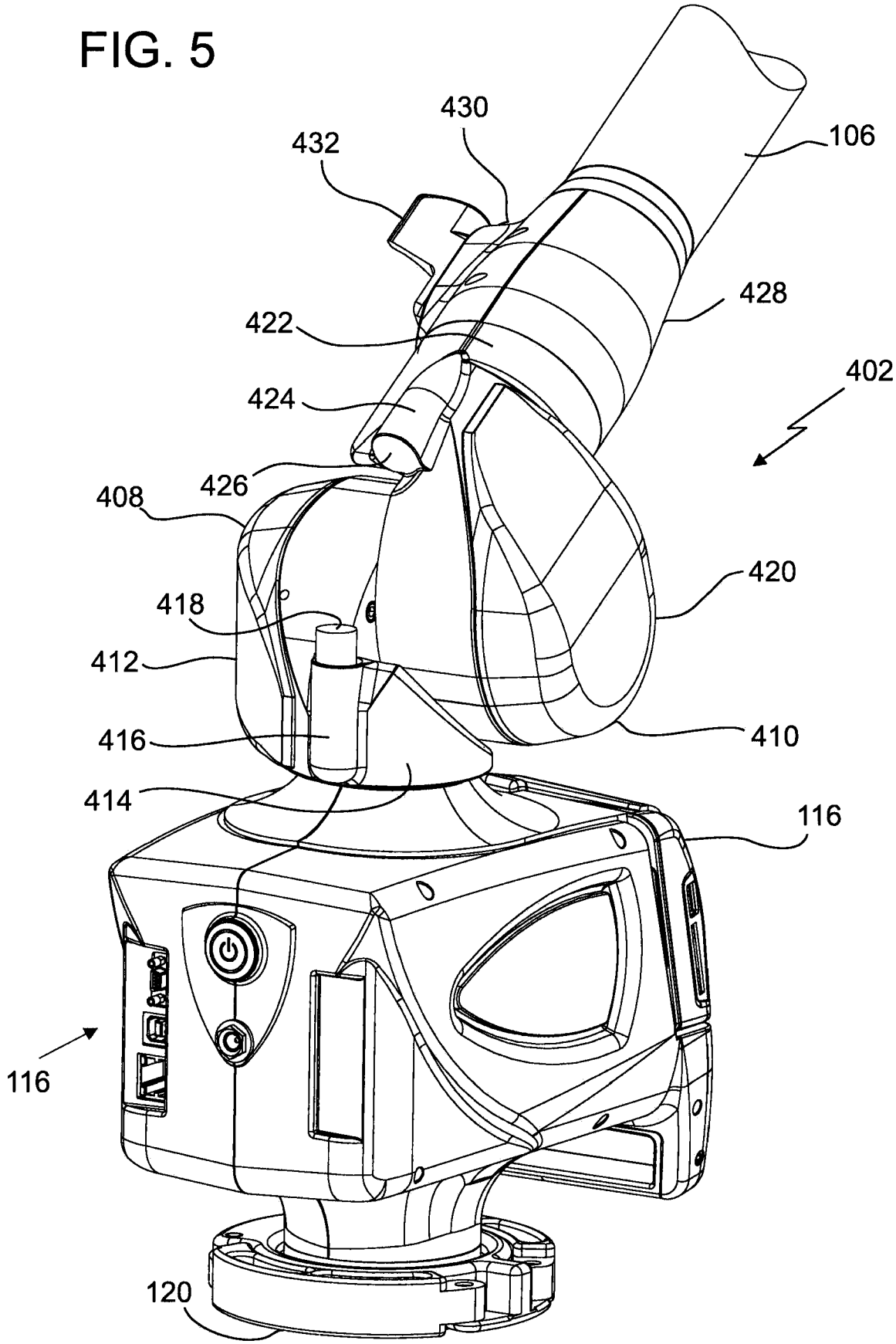

404
100
432
106
108
428
422
430
410
412
402
406
424
420
408
116
418
416
414

FIG. 5


430
432
106
428
422
402
424
426
408
420
418
412
410
416
414
116
116
120

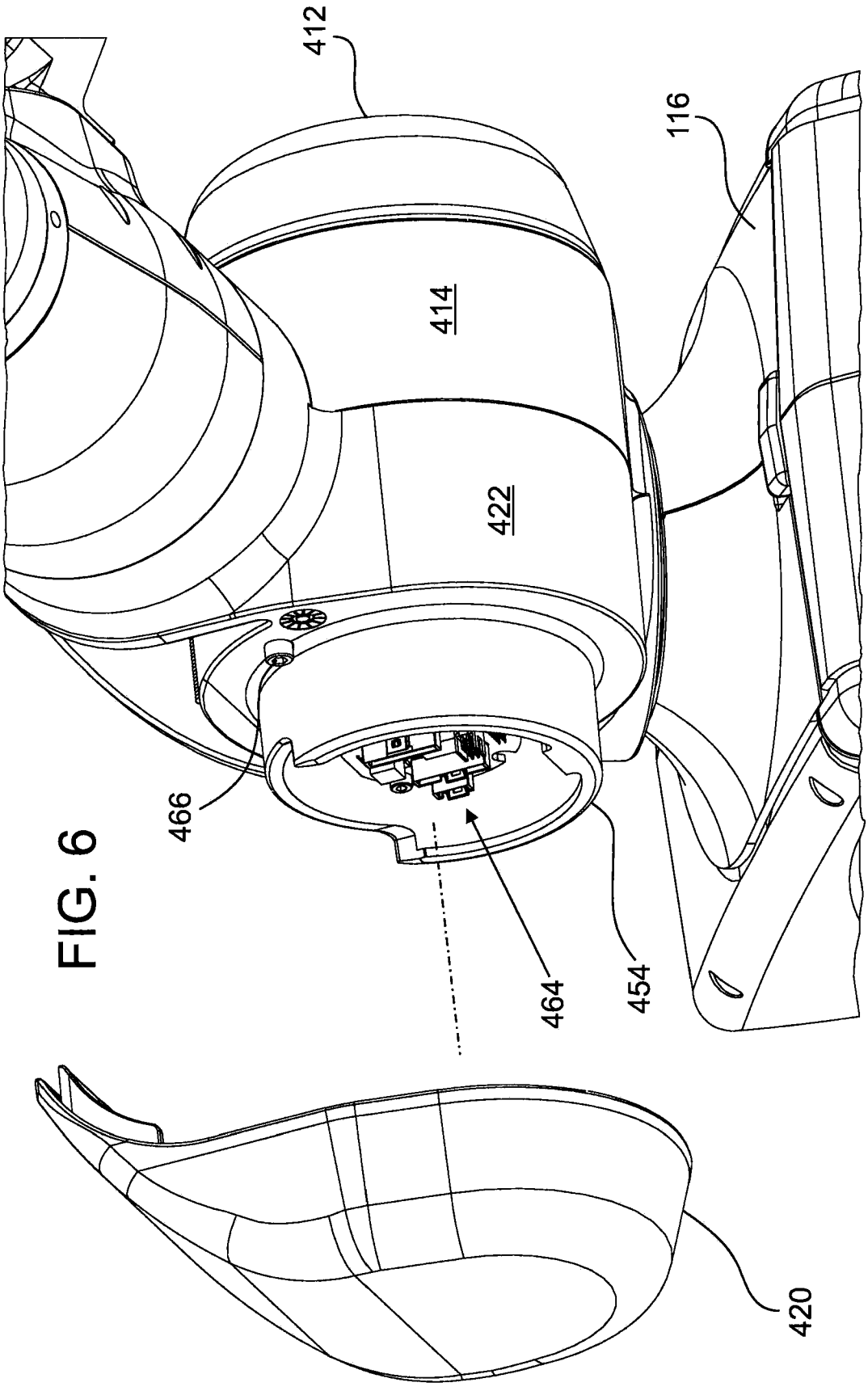


FIG. 6

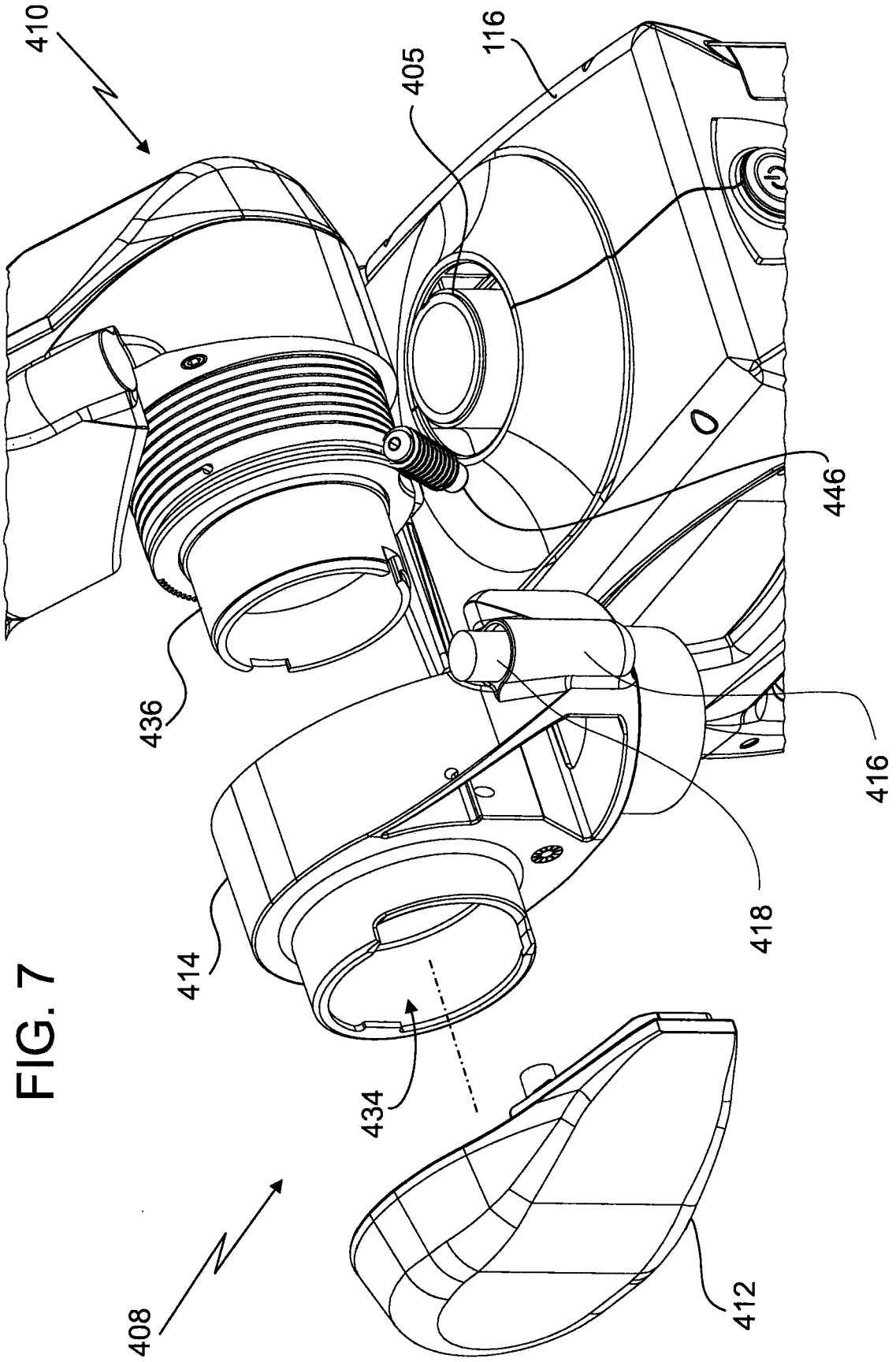


FIG. 7

FIG. 8

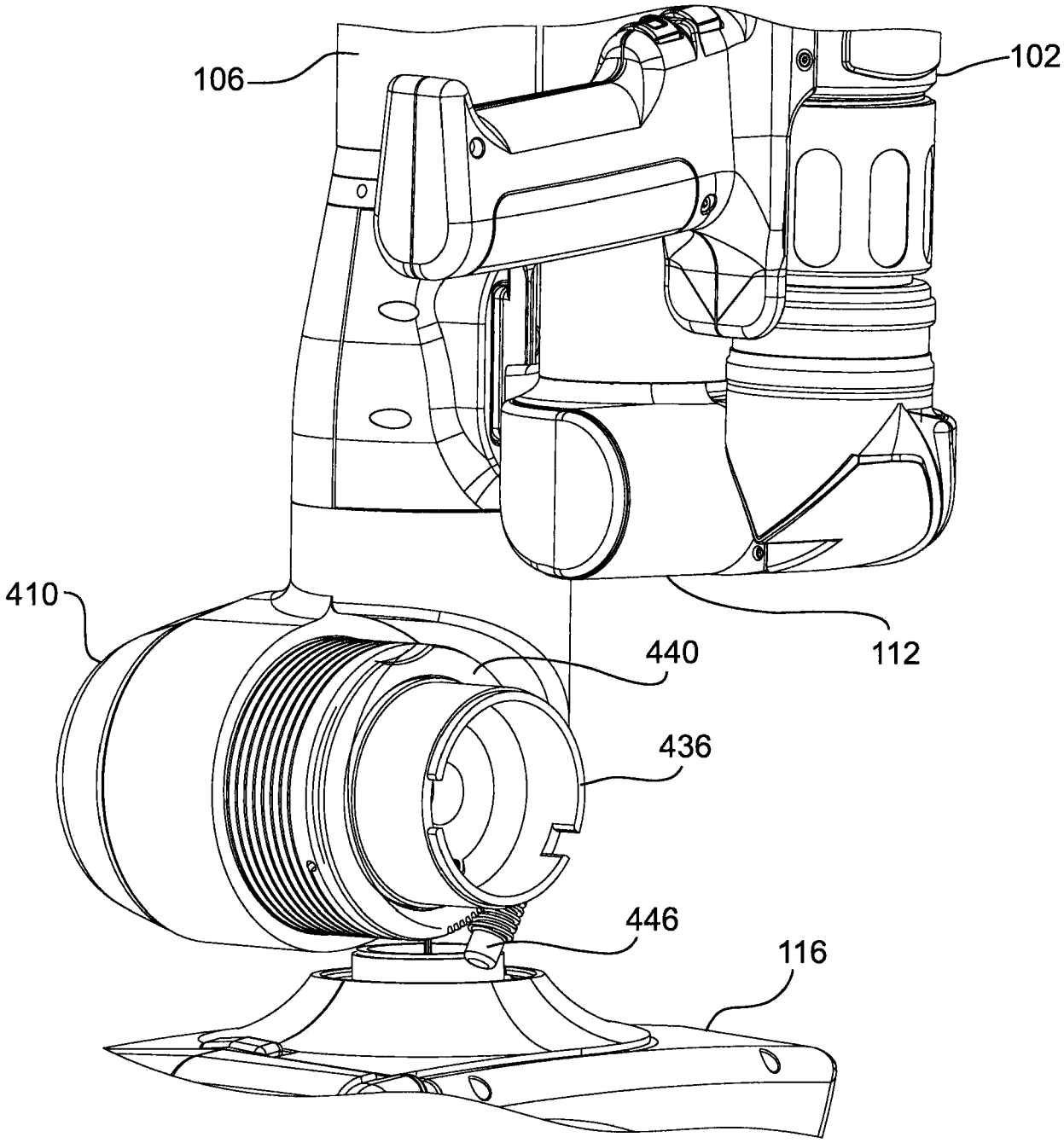


FIG.9

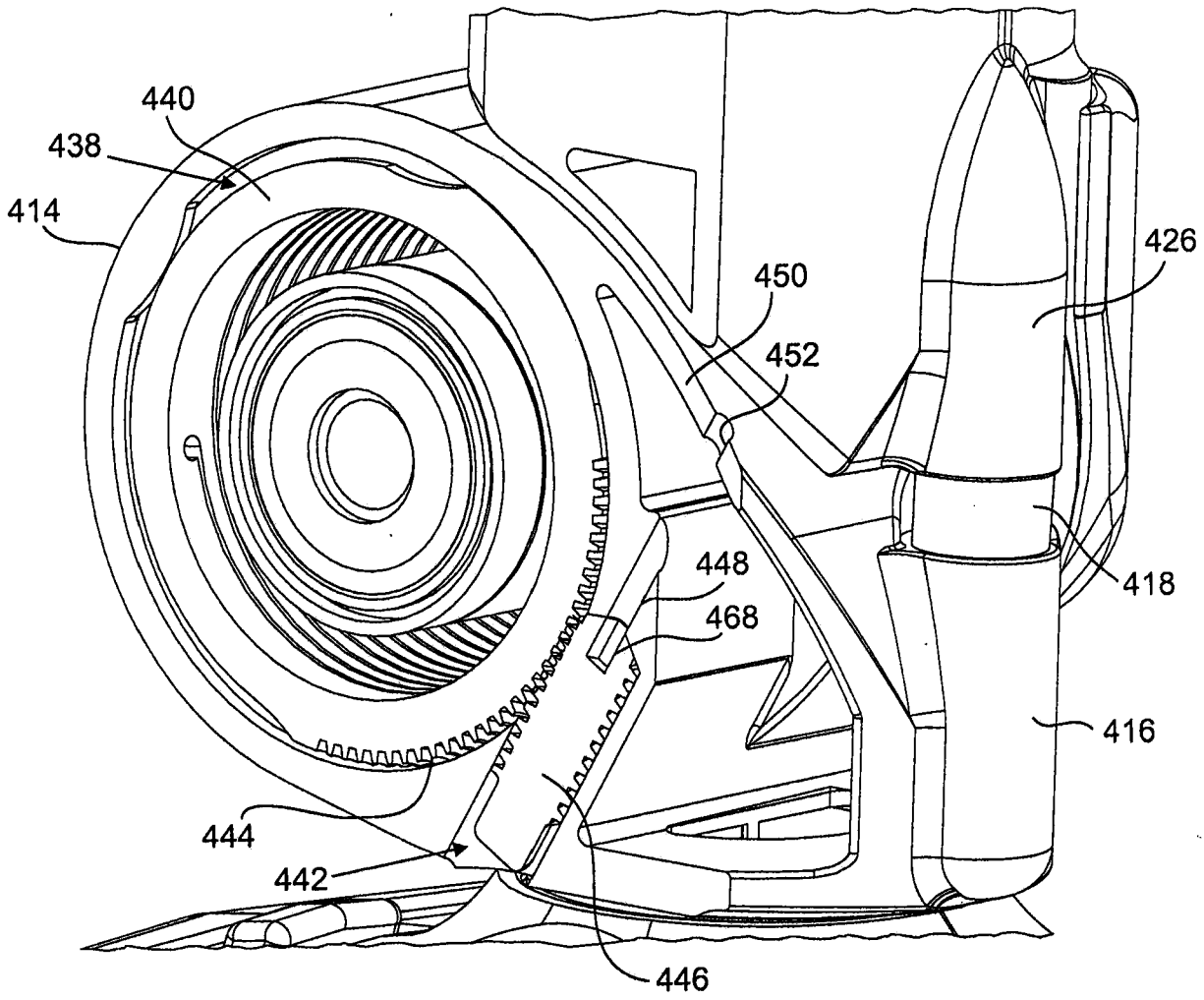


FIG.10

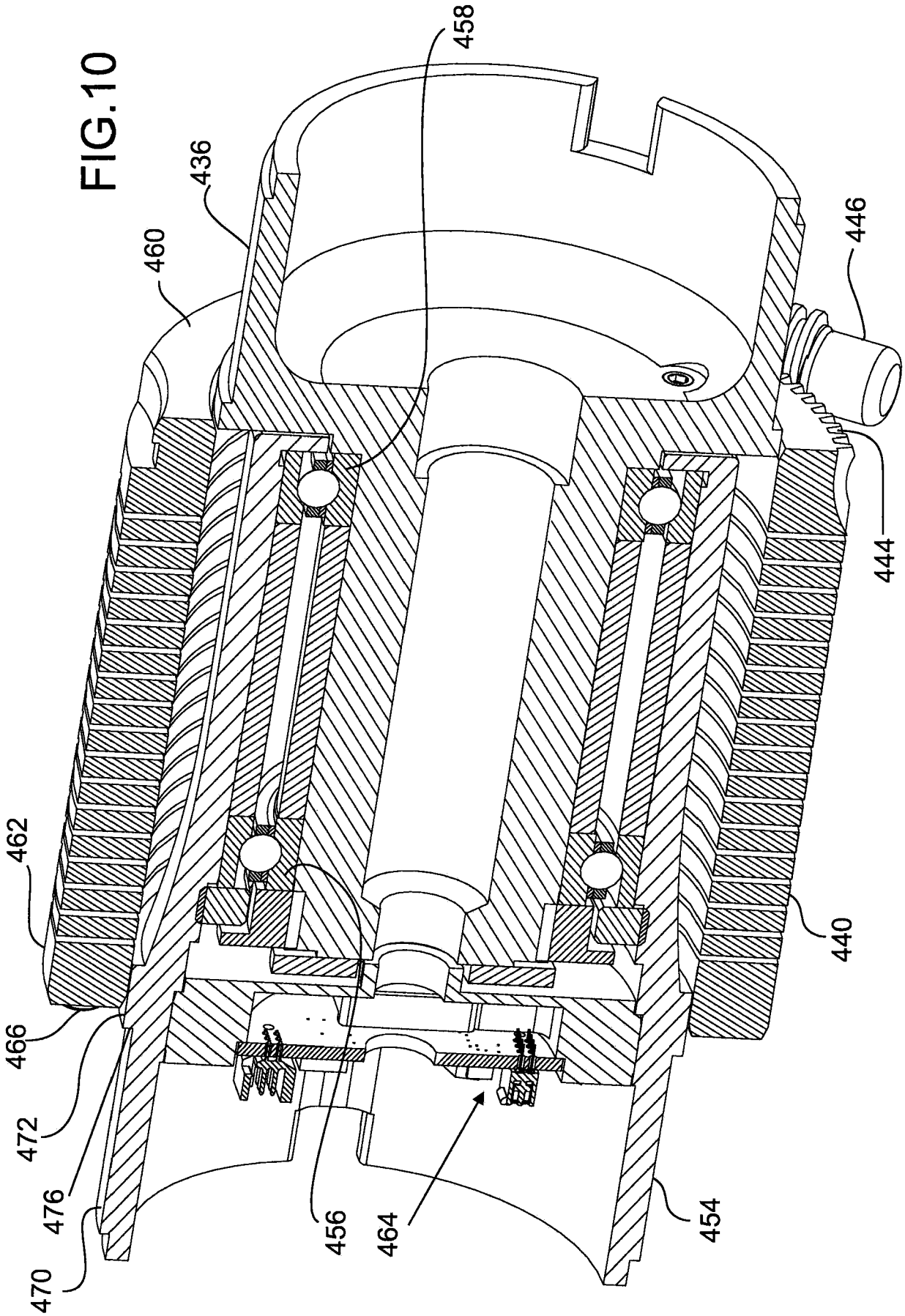
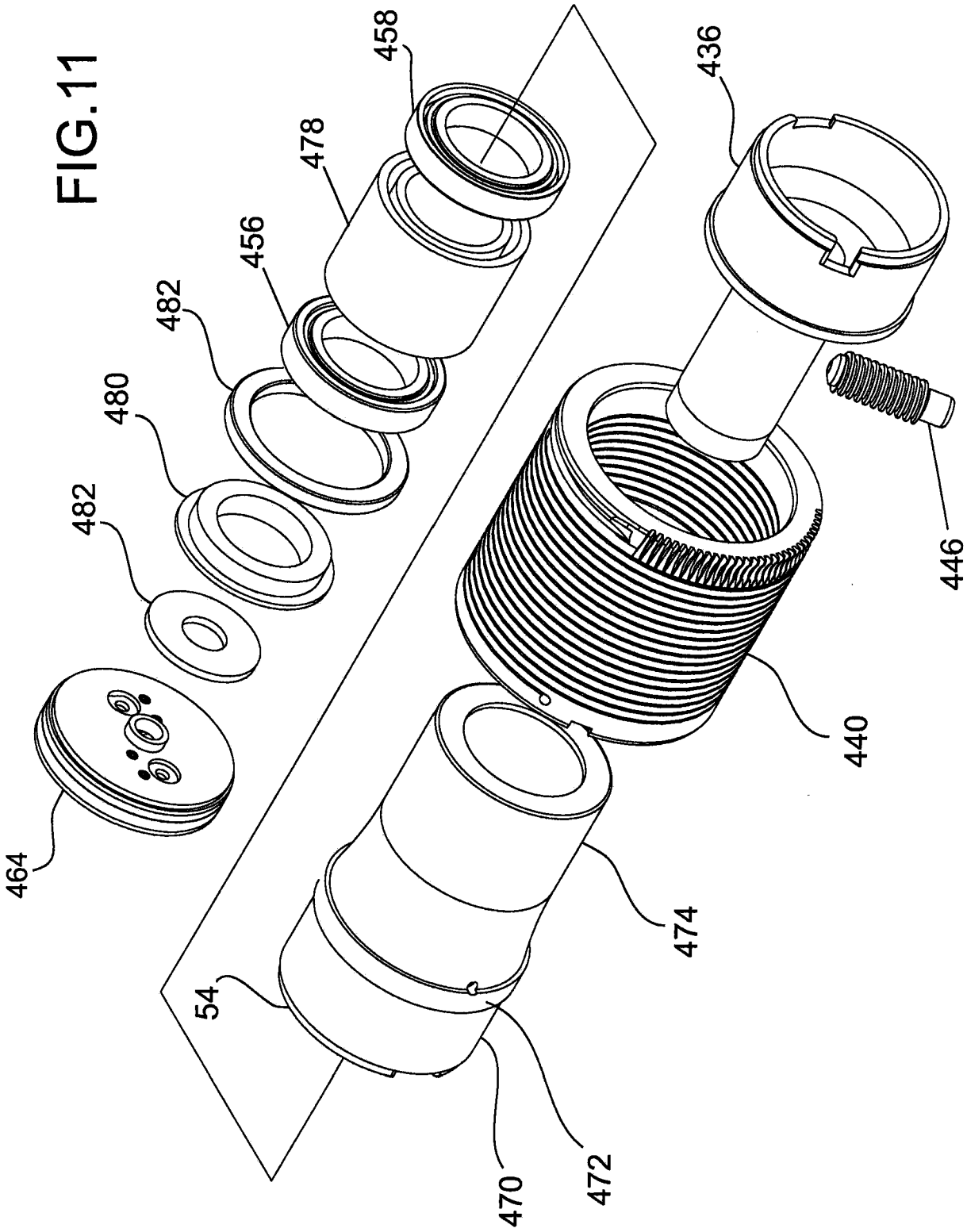


FIG.11



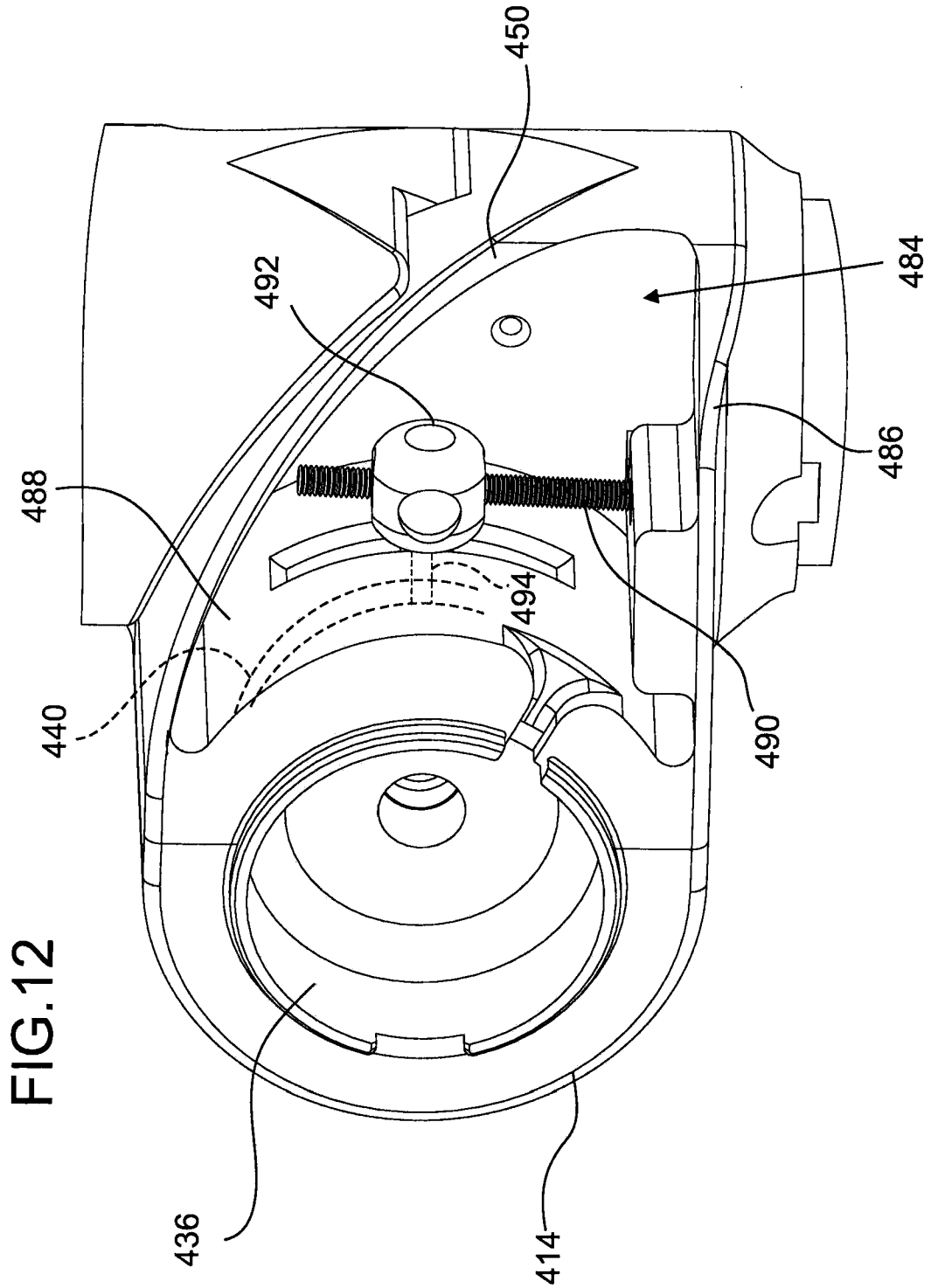


FIG.12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/021250

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01B5/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01B B23Q

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/208919 A1 (RAAB SIMON [US] ET AL) 13 November 2003 (2003-11-13) paragraph [0078] - paragraph [0110]; figures 1-3, 5 paragraph [0129] - paragraph [0130]; figures 16,27 -----	1-9, 14-20
X	WO 00/34733 A1 (FARO TECH INC [US]) 15 June 2000 (2000-06-15) page 1, line 3 - page 4, line 4; figures 1-5 page 5, line 6 - page 8, line 21 -----	1-20
X	US 5 983 936 A (SCHWIETERMAN MARK A [US] ET AL) 16 November 1999 (1999-11-16) the whole document -----	1-20

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

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 April 2011	18/04/2011

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

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/021250

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 537 233 A (VROONLAND EVART J [US] ET AL) 27 August 1985 (1985-08-27) the whole document	1-20
X	US 3 458 167 A (COOLEY CLAIBORN JR) 29 July 1969 (1969-07-29) the whole document	1-20

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2011/021250

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5983936 A	16-11-1999	NONE	
US 4537233 A	27-08-1985	NONE	
US 3458167 A	29-07-1969	NONE	