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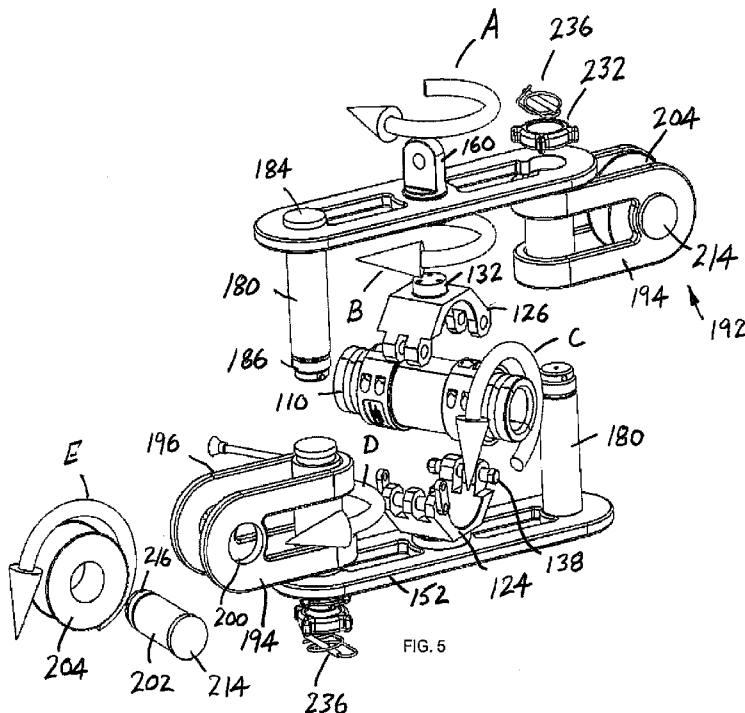
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[Continued on next page]

(54) Title: SUSPENSION SYSTEM ESPECIALLY FOR UNDERWATER CABLE



(57) Abstract: A suspension system receives an associated cable. The suspension system includes first and second mount arms disposed in spaced relation that receive a collar assembly having first and second collar members dimensioned to circumferentially enclose around the associated cable in a first assembled position, and a second open position, where the first and second collar members do not circumferentially enclose the associated cable. Sheave mount assemblies are provided along the interconnecting posts and various degrees of freedom are incorporated into the modular assembly.

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SUSPENSION SYSTEM ESPECIALLY FOR UNDERWATER CABLE

Background

[0001] This application hereby expressly incorporates herein by reference and claims the priority benefit of US provisional application Serial No. 61/737,288, filed December 14, 2012.

[0002] The present exemplary embodiment relates to high-strength cable attachments for dynamic applications, and finds particular use in connection with wide-tow and/or high-load seismic surveys. For example, the present disclosure finds particular application in conjunction with mid-span cable attachments and for connecting paravanes, compressors and floats, lines, and light packages to cable spans, and will be described with particular reference thereto. However, it is to be appreciated that the present exemplary embodiments are also amenable to other like applications.

[0003] For example, today's three-dimensional (3D) seismic operators tow sixteen (16) or more streamers to provide large amounts of data to meet the demands required in connection with seismic mapping. As a result, a need exists for lead-in line protection for the cable, and a low profile, full strength seismic lead termination design that can effectively grip a towed cable. In particular, the termination must be able to be installed mid-span at any location on the lead-in and be conveniently designed so the termination can be wound on to a cable drum.

[0004] The assignee of the present application presently sells a commercial unit known as a Dyna-Hanger Suspension System (DHSS). The DHSS is a reliable cable attachment point for seismic streamers, paravanes, surface and subsurface floats, cable compressors, and other instances requiring mid-span termination. The commercially available DHSS provides for two degrees of freedom with respect to the cable axis. Particularly, a collar assembly can rotate 360° around the cable to provide a first degree of freedom, and a pair of trunnion-mounted arms articulate fore and aft to provide a second degree of freedom. As a result, the lead-in can rotate and the arms of the DHSS can become aligned with the load. When stored on deck, the collar assembly of the DHSS is removed to allow the housing and rods to be reeled directly on to a cable drum.

[0005] Although the DHSS has met with commercial success, there are continued needs for improvement. For example, ease of assembly/disassembly, an increased number of degrees of freedom, modularity, subassemblies, reliability, strength, ease of manufacture and efficiency of manufacture, limiting the number of tools required for assembly and disassembly, reduced drag, adaptability to different configurations, reduced cost, etc. are just some of the desired needs, although it will be recognized that this list is not deemed to be limiting or exhaustive.

Brief Description

[0006] A suspension system includes first and second mount arms disposed in spaced relation and receiving an associated cable. A collar assembly having first and second collar members is dimensioned to circumferentially enclose around the associated cable in a first assembled position, and the first and second collar members do not circumferentially enclose the associated cable in a second open position.

[0007] The first and second collar members are pivotally mounted to the first and second mount arms, respectively.

[0008] In one embodiment, the first and second collar members are identical.

[0009] The first and second collar members include overlapping fingers having openings extending therethrough for receiving pins to circumferentially and axially join the first and second collar members together.

[0010] The collar assembly receives a housing having first and second housing members adapted to receive the associated cable therethrough, and dimensioned for relative rotation between the collar assembly and the housing.

[0011] The collar assembly and housing are configured to preclude relative axial movement therebetween when assembled on the associated cable.

[0012] The suspension system further includes at least one post joining the first and second mount arms together.

[0013] The at least one post includes a flange at a first end secured to the first mount arm, and in a preferred arrangement the flange is welded to the first mount arm.

[0014] The at least one post has a threaded second end secured to the second mount arm via a threaded nut.

[0015] The suspension system further includes a float attachment joined to at least one of the first and second mount arms, where the float attachment is configured and mounted for rotation relative to the at least one mount arm.

[0016] The suspension system further includes at least one sheave assembly secured to at least one of the first and second mount arms.

[0017] The at least one sheave assembly includes a sheave assembly having a rotatable sheave secured to the first and second mount arms.

[0018] The rotatable sheave is received over a post joining the first and second mount arms together.

[0019] The rotatable sheave mount of the at least one sheave assembly includes a generally U-shaped flange having first and second portions extending outwardly from a bight region dimensioned for receipt around the post joining the first and second mount arms together.

[0020] The flange is configured for rotation relative to the post.

[0021] A shaft extends between the first and second portions of the flange for rotatably receiving the sheave thereon.

[0022] A threaded nut is received on one end of the shaft and/or post, and a retention pin is received through the shaft and/or post outboard of the threaded nut to retain the nut.

[0023] The retention pin includes a flat edge to prevent rotation of the pin.

[0024] The retention pin includes a detent to preclude inadvertent removal of the pin.

[0025] The threaded nut includes enlarged external lugs to facilitate finger tightening/loosening.

[0026] A first sheave assembly includes a rotatable sheave that rotates about a first axis and a second sheave assembly includes a rotatable sheave that rotates about a second axis different from the first axis, e.g., where the first and second axes are spaced apart, and in one embodiment the axes are parallel and in another embodiment the axes are perpendicular.

[0027] In still another embodiment, an opening in the flange temporarily receives a pin to hold the flange relative to the post while the flange is mounted to a shaft

extending between the first and second portions of the flange for rotatably receiving the sheave thereon.

[0028] Primary benefits of the present disclosure include a reduced cost to manufacture.

[0029] Another advantage resides in the use of common components to reduce inventory.

[0030] Still another advantage resides in the ease of assembly.

[0031] Still other benefits and advantages will become apparent upon reading and understanding the following detailed description.

Brief Description of the Drawings

[0032] Figure 1 is a perspective view of one embodiment of the subject suspension system.

[0033] Figure 2 is an exploded view of the embodiment of Figure 1.

[0034] Figures 3A-3D are views of different types of rotating sheave mount pins.

[0035] Figure 4 is a perspective view of another embodiment of a suspension system bearing many similarities to Figure 1.

[0036] Figure 5 is an exploded view of the embodiment of Figure 4.

[0037] Figure 6 is a partially assembled view of portions of the embodiment of Figure 4.

[0038] Figure 7 is a partially assembled view of other portions of the embodiment of Figure 4.

[0039] Figure 8 is a perspective view illustrating other portions of the embodiment of Figure 4.

[0040] Figure 9 is a perspective view illustrating still further portions of the embodiment of Figure 4.

[0041] Figure 10 is an elevational view of yet another embodiment.

[0042] Figure 11 is a partially assembled and partially exploded view of the embodiment of Figure 10.

[0043] Figures 12-14 are views of still another modified embodiment.

[0044] Figures 15 – 17 illustrate details of a sheave mounting assembly.

[0045] Figures 18 – 20 are enlarged views of the collar assembly and quick release pin therefor.

[0046] Figures 21 – 23 are views of a subassembly of a mounting arm, float or buoy attachment, and post arrangement.

[0047] Figures 24 – 25 are views of the subassembly of the mounting arm and post arrangement without a float attachment.

[0048] Figures 26 – 28 are views of still another rotating sheave mount flange.

[0049] Figures 29 and 30 are exploded and assembled views of another embodiment of the present disclosure.

[0050] Figure 31 is an enlarged view of a fastening nut and pin arrangement used to assemble components.

Detailed Description

[0051] With reference to Figures 1 and 2, there is shown an exemplary embodiment of a suspension system 100. More particularly, there is an interior housing or sleeve 110 that is received around an associated cable (not shown) and the housing is received over a limited longitudinal extent of the cable, preferably a mid-span location. The structure of the cable and bending strain relief support structure are known to those skilled in the art, and further details of same may be found in commonly owned PCT/2013/068316, filed November 4, 2013, the details of which are incorporated herein by reference.

[0052] A collar assembly 120 includes first and second collar members 122, 124. As illustrated, the collar members 122, 124 are preferably identical to simplify manufacture and interchangeability, particularly during assembly, disassembly, and/or replacement. Each collar member 122, 124 has a central body portion 126 and a series of axially spaced flanges or fingers 128 at opposed edges that include aligned openings 130 extending axially therethrough. In addition, a projection or boss 132 extends outwardly from an external surface of the collar, opposite from the curved inner surface 134. In this manner, the collar members 122, 124 are oriented so that the curved surfaces 134 are received in a recess 136 formed in an external surface of the housing 110. The fingers 128 from the respective collar members 122, 124 are interleaved so that

openings 130 are aligned with one another and adapted to receive a fastener connecting pin 138 (Figures 5 and 7). For example, a connecting fastener/pin 138 may be received along one edge of the mating collar members in a first position in order to form a hinge that is open and partially circumscribes the outer perimeter of the housing 110. Once the cable and housing are positioned in the collar members 122, 124, the opposite edges of the collar members are then brought into alignment and a connector pin 138 received therein to complete the circumferential capture of the cable and housing within the collar assembly 120. It will be appreciated, however, and as perhaps best illustrated in Figure 5, that the collar assembly 120 is closed around the cable/housing 110 yet still permits the cable/housing to rotate relative to the collar assembly.

[0053] The suspension system 100 further includes first and second mounting arms 150, 152. Again, for ease of manufacture, assembly//disassembly, and/or replacement, the mounting arms 150, 152 are preferably identical structures, although this need not necessarily be the case. Each mounting arm 150, 152 preferably has first and second openings 154, 156 disposed adjacent first and second ends. In addition, and as evident by comparing Figures 2 and 5, the remainder of the mounting arms 150, 152 may adopt slightly different configurations such as the solid conformation of Figure 2 and a slotted arrangement of Figure 5. Providing the slots in the embodiment of Figure 5, for example, reduces the overall weight of the system without impacting functionality or strength of the mounting arms.

[0054] A free-to-rotate float attachment 160 is preferably secured with a retaining ring 162 provided on the first mounting arm 150. An inner surface (not shown) of the float attachment 160 receives the boss 132 from the first collar member 122, while the other mounting arm 152 includes a plug 164 having a recessed inner surface adapted to receive the boss 132 from the lower collar member 124. When used, the float attachment 160 provides a convenient attachment point along with a desired degree of freedom (i.e., the float attachment 162 rotate relative to the support arm. Likewise, the bosses 132 of the collar members allow the collar assembly 120 and enclosed cable/housing 110 to also pivot or rotate relative to the first and second mounting arms 150, 152.

[0055] The mounting arms 150, 152 are maintained in spaced, parallel relation by first and second posts 180, 182. Opposite ends 184, 186 of each post are received in a respective opening 154, 156 in the mounting arms 150, 152. In one preferred arrangement, the first end 184 of each post 180, 182 is secured such as through a welding operation to the mounting arm. The second end 186 is threaded and cooperates with a retaining nut 188 (see Figure 2). In the embodiment of Figures 1 and 2, the external surface of the posts 180, 182 serve as a bearing surface associated with first and second rotating sheave mounts 190, 192. Each sheave mount 190, 192 includes a generally U-shaped flange having first and second arms 194, 196 interconnected along a bight region 198. Outer ends of the arms 194, 196 have aligned openings 200 passing therethrough that receive a pin 202 that serves as a support shaft for the rotating sheave 204. A central opening 206 in the sheave is aligned with the openings 200 in the first and second arms 194, 196 of the U-shaped flange and suitably dimensioned to receive the pin 202 therethrough.

[0056] Different embodiments of pins or shafts 202 are shown in Figures 3A-3D. Axially spaced grooves 210 provided to segregate the central bearing portion of the shaft from the support ends 212 of the pin 202. In this manner, under a predetermined load, the central bearing portion with separate from the remainder of the pin due to the reduced cross-sectional diameter in the regions of the grooves. A first end of the pin 202 includes an enlarged shoulder 214 that limit axial insertion of the pin through the aligned openings in the flange and the sheave. A second end has a tapered nose 216 that helps to insert the pin through the aligned openings. In addition, triangular-shaped detent 218 deflect inwardly as the pin 202 is passed through the openings, and the detent 218 flexes outwardly into the position shown in Figures 3A and 3B once the pin is fully inserted. A finger receiving hole 220 facilitates an outward pull force that retracts the detents 218 when the pins are in the mounted relation and disassembly is desired. Also, this arrangement will not lose strength by having features only on non-load bearing sides of the pin. Alternatively, Figures 3C and 3D includes an opening 222 that receives a cotter pin or other suitable fastener for preventing inadvertent removal of the pin 202.

[0057] Figures 4 -9 illustrate an embodiment substantially similar to that of Figure 1. One primary difference is that the support arms 150, 152 include openings to make the structures lightweight and allow for the passage of fluid. In this manner, less drag is exerted by the suspension system. Likewise, the U-shaped flanges of the sheave mounts also include openings 230 that generally serve these same purposes, i.e., make the structures lightweight, allow for the passage of fluid, and exert less drag on the suspension system. The nut 232 at the end of each post is also modified to include enlarged finger-engaging projections 234 that allow the nut to be manually installed and removed on the threaded end of the post 180. Once installed, a cross pin 236 is inserted through a small diameter opening in the post 180 to retain the nut 232 in place.

[0058] The various degrees of freedom of movement are exemplified in Figures 5 – 7. Particularly, the float attachment 160 can rotate relative to the support arm 150 (or support arm 152 if it is provided with a float attachment) as represented by reference arrow A. Likewise, the collar assembly 120 can rotate about boss 132 as represented by reference arrow B. Further, the housing 110 can rotate relative to the collar assembly 120 as represented by reference arrow C. Still further, reference arrow D represents relative rotation of the U-shape flange of the sheave mount rotating relative to post 180. Moreover, the sheave 204 can rotate around pin 202 as represented by reference arrow E.

[0059] Figure 6 also illustrates a sleeve 236 provided in the bight region of the U-shape flange of the sheave assembly. The sleeve 236 is dimensioned for receipt over the external surface of the post 180 and distributes the bearing forces due to relative rotation over the enlarged surface area of the post.

[0060] More particularly illustrated in Figure 7 quick release arrangement of the collar assembly 120. Pin 250 hold one side of the collar members 124, 126 together via the openings 130 in the interleaved fingers 128. Further, one of a pair of pins 238 is shown in figure 7 which has a length to pass through 2-1/2 of the interleaved fingers. An outer end of the pin 238 includes a link 240 that has an opening adapted to receive the elongated stem of the quick release pin 254. Thus, removal of the pin 254 allows the individual pins 238 to be subsequently accessed whereby removal allows rotation about pin 250 of one collar member relative to the other collar member.

[0061] Figure 11 illustrates an alternative mounting of the right-hand sheave 204. Typically, the upper and lower spacer blocks 242 position the sheave 204 approximately mid-height along the post 180. In this manner, the right-hand sheave rotates about an axis defined by the post 180 while the left-hand sheave rotates about pin 202, in which sheave mount also rotates relative to pin 180 as described above.

[0062] In the arrangement of Figure 12, both the right-hand and left-hand sheave mounts are similar to the right-hand sheave mount of Figure 11, i.e., the sheave 204 disposed between spacer blocks 242 rotate about the post 180. Additional details are also illustrated in Figures 13 – 14.

[0063] Figures 15 – 17 illustrate the inclusion of sleeve 240 in the right portion of the U-shaped sheave flange. This arrangement still provides for easy assembly and disassembly of the individual components of the suspension system.

[0064] Figures 18 – 20 are provided to show additional clarifying details of the collar assembly 120. Similarly, Figures 21 – 25 show enlarged details of the support arm 150 with a rotatable float mount 160 (Figures 21 – 23) or without the float mount (Figures 24 – 25).

[0065] Figures 26 – 28 illustrate a modified U-shaped flange associated with a rotating sheave mount. This arrangement allows for installation of the sheave mount assembly after the mount arms have been secured together. Particularly, small openings 280 receive a pin (not shown) that temporarily holds the U-shaped flange around the post during assembly. In this manner, the support arms 150, 152 can be secured together via the posts 180. Subsequently, the U-shaped flange is received around the post 180, and a temporary pin inserted through the aligned openings 280. This holds the flange in place while assembly of the rotating sheave 204 and its support pin 202 is completed.

[0066] Figures 29 and 30 illustrate exploded and assembled views of a slightly modified embodiment, particular details of which are illustrated in Figure 31. Specifically, the retention pins 300 associated with each of nuts 302 is modified to include a detent 304 at one end which prevents inadvertent removal of the pin and retains the nut in place. Also, the opposite end of the pin 300 preferably has a D-shape which allows the pin to lay flat against the nut along the flat surface 306.

[0067] Most components are made of high-grade stainless steel and intended to be reused for many deployments and retrievals. It will be appreciated, however, that other materials may be used if deemed acceptable for use in the harsh marine environment. The various embodiments are lightweight, provided openings for the passage of fluid therethrough, which improves drag characteristics of the suspension system. Many the components are interchangeable so that the same nuts and retaining pins can be used for securing different components together.

[0068] This written description uses examples to describe the disclosure, including the best mode, and also to enable any person skilled in the art to make and use the disclosure. The patentable scope of the disclosure is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims. Moreover, this disclosure is intended to seek protection for a combination of components and/or steps and a combination of claims as originally presented for examination, as well as seek potential protection for other combinations of components and/or steps and combinations of claims during prosecution.

We claim:

1. A suspension system receiving an associated cable, the suspension system comprising:
first and second mount arms disposed in spaced relation;
a collar assembly having first and second collar members dimensioned to circumferentially enclose around the associated cable in a first assembled position, and a second open position, where the first and second collar members do not circumferentially enclose the associated cable.
2. The suspension system of claim 1 wherein the first and second collar members are pivotally mounted to the first and second mount arms, respectively.
3. The suspension system of either of claims 1 or 2 wherein the first and second collar members are identical.
4. The suspension system of any one of claims 1-3 wherein the first and second collar members include overlapping fingers having openings extending therethrough for receiving pins to circumferentially and axially join the first and second collar members together.
5. The suspension system of any one of claims 1-4 wherein the collar assembly receives a housing having first and second housing members adapted to receive the associated cable therethrough, and dimensioned for relative rotation between the collar assembly and the housing.
6. The suspension system of any one of claims 1-5 wherein the collar assembly and housing are configured to preclude relative axial movement therebetween when assembled on the associated cable.

7. The suspension system of any one of claims 1-6 further comprising at least one post joining the first and second mount arms together.
8. The suspension system of claim 7 wherein the at least one post includes a flange at a first end welded to the first mount arm.
9. The suspension system of either of claims 7 or 8 wherein the at least one post has a threaded second end secured to the second mount arm via a threaded nut.
10. The suspension system of any one of claims 1-9 further comprising a float attachment joined to at least one of the first and second mount arms, the float attachment configured and mounted for rotation relative to the at least one mount arm.
11. The suspension system of any one of claims 1-10 further comprising at least one sheave assembly secured to at least one of the first and second mount arms.
12. The suspension system of claim 11 wherein the at least one sheave assembly includes a sheave assembly having a rotatable sheave secured to the first and second mount arms.
13. The suspension system of claim 12 wherein the rotatable sheave is received over a post joining the first and second mount arms together.
14. The suspension system of any one of claims 11-13 wherein the at least one sheave assembly includes a rotatable sheave mount secured to the first and second mount arms, and configured for movement relative thereto.
15. The suspension system of any one of claims 11-14 wherein the rotatable sheave mount of the at least one sheave assembly includes a generally U-shaped flange having first and second portions extending outwardly from a bight region

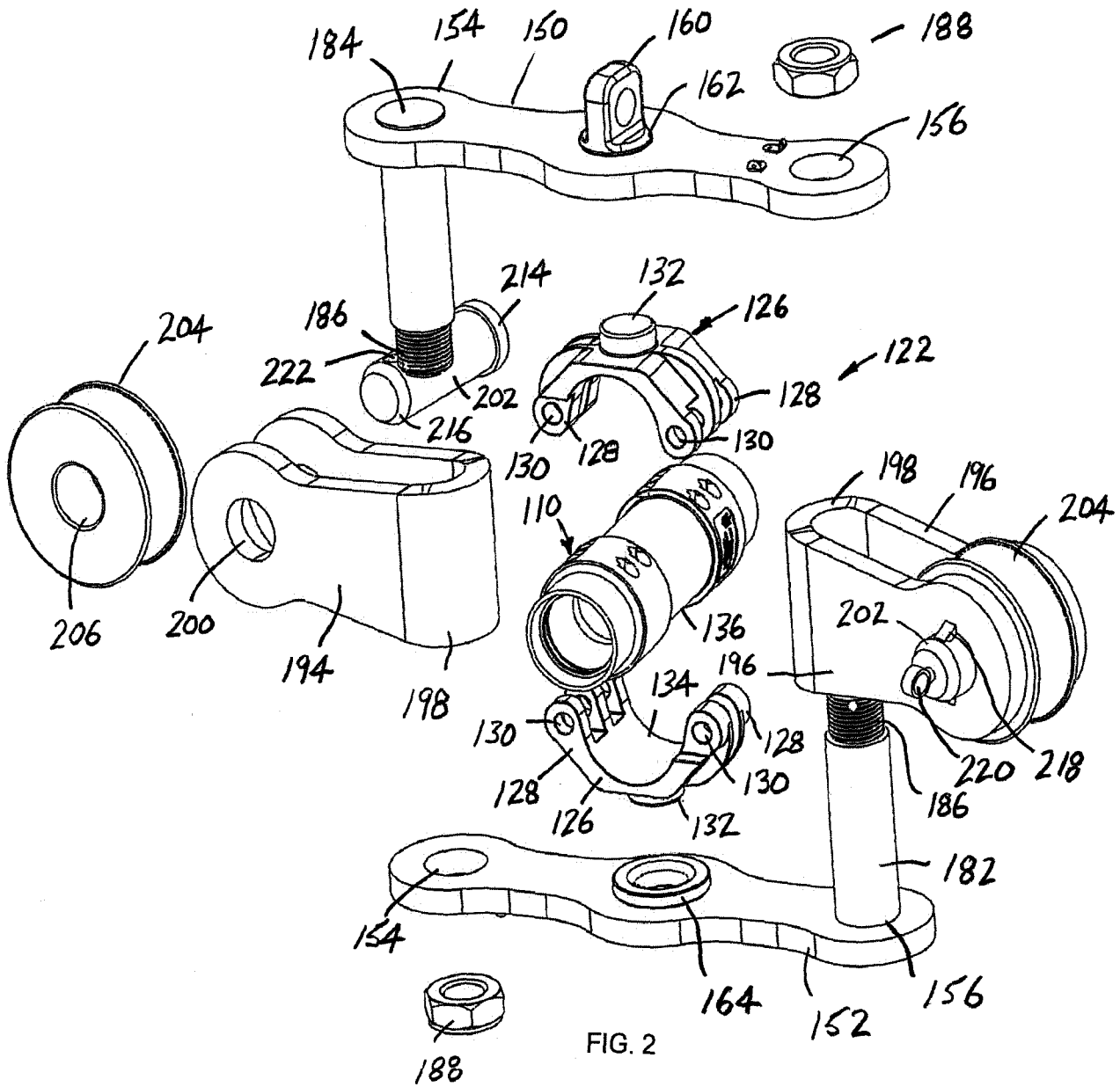
dimensioned for receipt around a post joining the first and second mount arms together.

16. The suspension system of claim 15 wherein the flange is configured for rotation relative to the post.
17. The suspension system of either of claims 15 or 16 further comprising a shaft extending between the first and second portions of the flange for rotatably receiving the sheave thereon.
18. The suspension system of any one of claims 11-17 wherein the at least one sheave assembly includes a rotatable sheave mount secured to the first and second mount arms, and configured for movement relative thereto.
19. The suspension system of any one of claims 11-18 wherein the rotatable sheave mount of the at least one sheave assembly includes a generally U-shaped flange having first and second portions extending outwardly from a bight region dimensioned for receipt around a post joining the first and second mount arms together.
20. The suspension system of any one of claims 15-19 wherein the flange is configured for rotation relative to the post.
21. The suspension system of any one of claims 15-20 further comprising a shaft extending between the first and second portions of the flange for rotatably receiving the sheave thereon.
22. The suspension system of any one of claims 17-21 further comprising a threaded nut received on one end of the shaft, and a retention pin received through the shaft outboard of the threaded nut to retain the nut.

23. The suspension system of claim 22 wherein the retention pin includes a flat edge to prevent rotation of the pin.
24. The suspension system of either of claims 22 or 23 wherein retention pin includes a detent to limit inadvertent removal of the pin.
25. The suspension system of either of claims 22 or 24 wherein the threaded nut includes enlarged external lugs to facilitate finger tightening/loosening.
26. The suspension system of claim 22 wherein a first sheave assembly includes a rotatable sheave that rotates about a first axis and a second sheave assembly includes a rotatable sheave that rotates about a second axis different from the first axis.
27. The suspension system of claim 26 wherein the first and second axes are perpendicular to each other.
28. The suspension system of any one of claims 19-27 wherein the flange includes an opening for temporarily receiving a pin to hold the flange relative to the post while the flange is mounted to a shaft extending between the first and second portions of the flange for rotatably receiving the sheave thereon.
29. The suspension system of any one of claims 19-28 wherein the post is secured by a threaded nut which is retained by a retention pin that extends through the post outboard of the nut.
30. A method of suspending a cable comprising:
mounting the cable in a housing surrounded by a two-piece collar assembly;
positioning the collar assembly with the cable received therein between first and second suspension arms;
incorporating at least one rotatable sheave assembly between the first and second suspension arms; and

securing the first and second suspension arms together.

31. The method of claim 30 further comprising permitting relative rotation of the at least one sheave assembly relative to the first and second suspension arms.
32. The method of either of claims 30 or 31 further comprising providing a float attachment and mounting the float attachment to at least one of the first and second suspension arms while permitting rotation relative thereto.
33. The method of any one of claims 30-32 further comprising allowing the collar assembly to rotate relative to the housing.



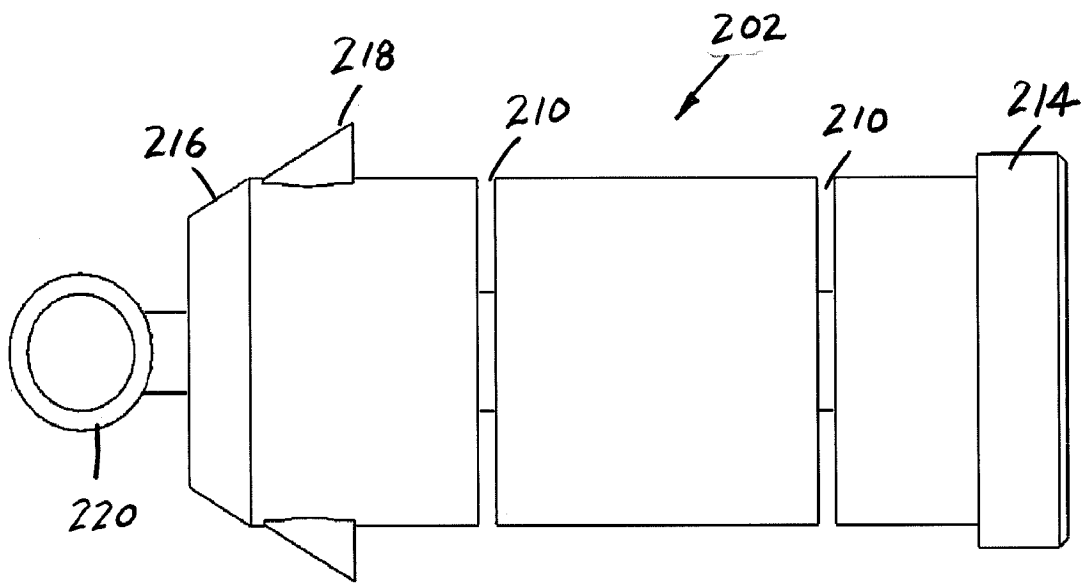


FIG 3A

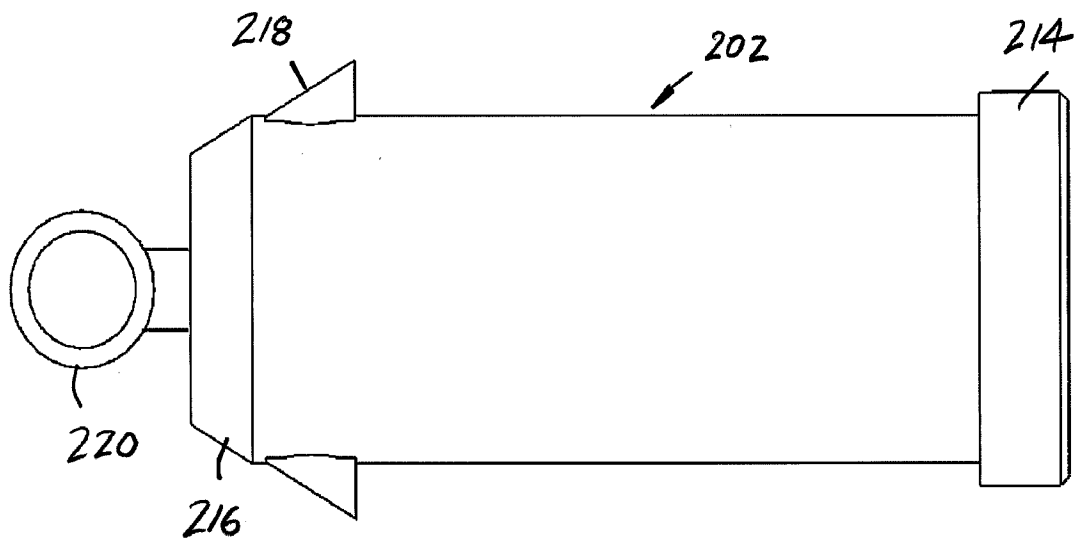


FIG. 3B

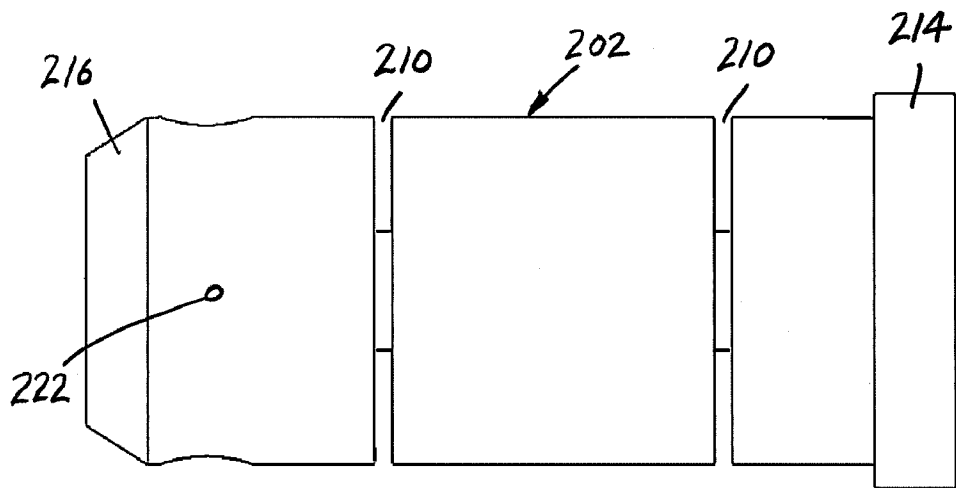


FIG. 3C

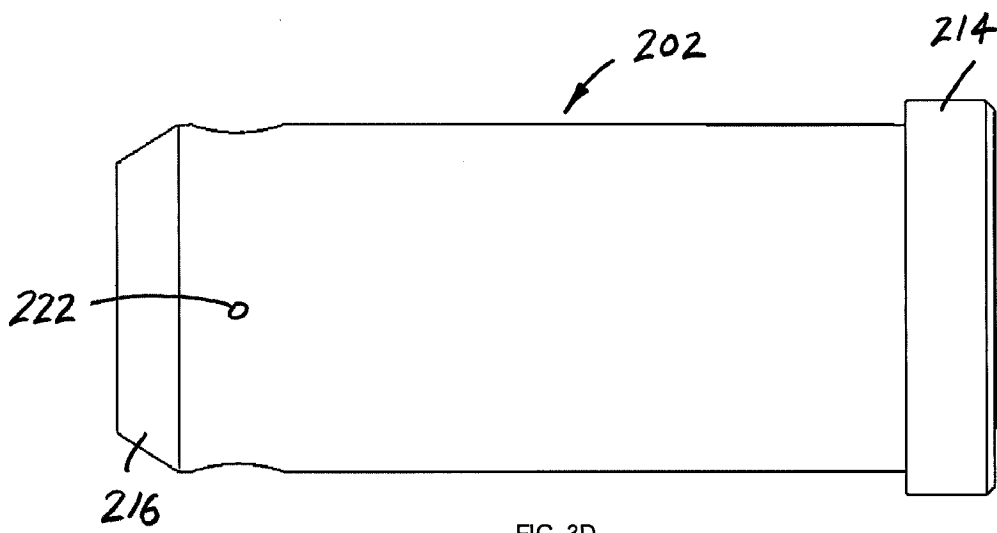
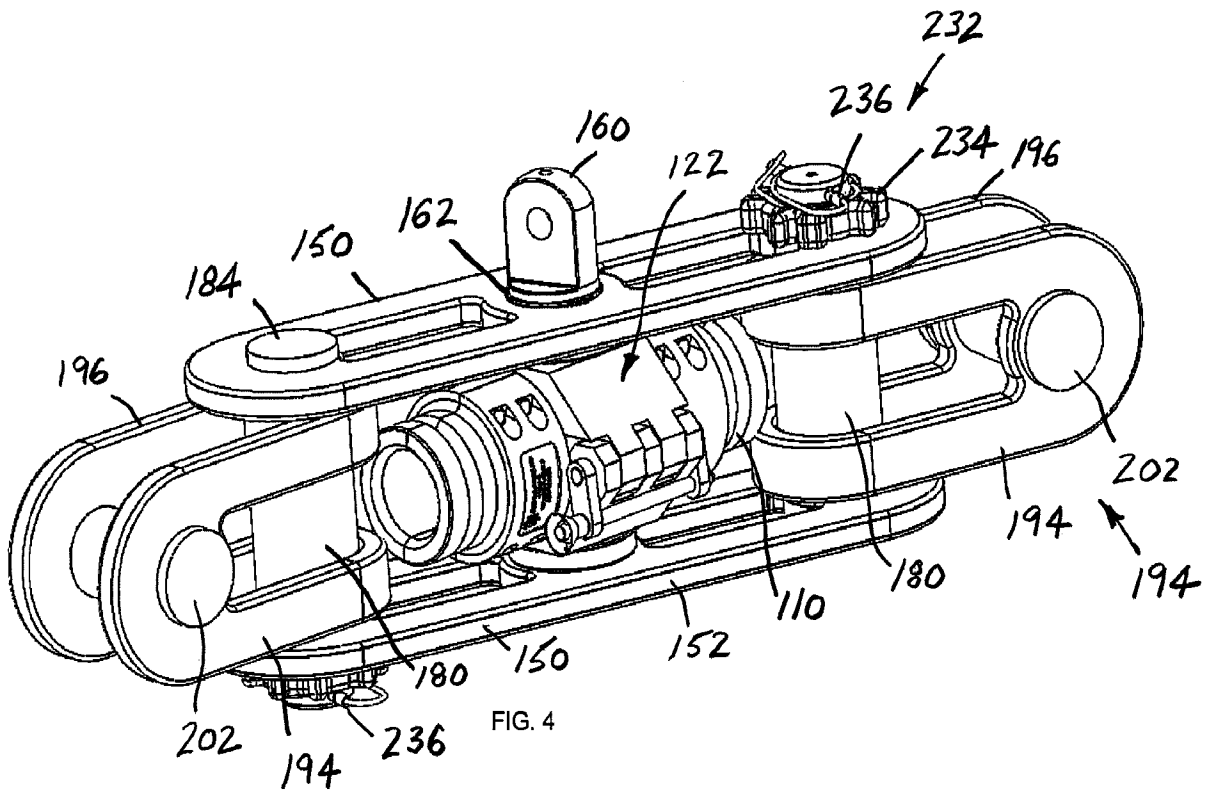


FIG. 3D



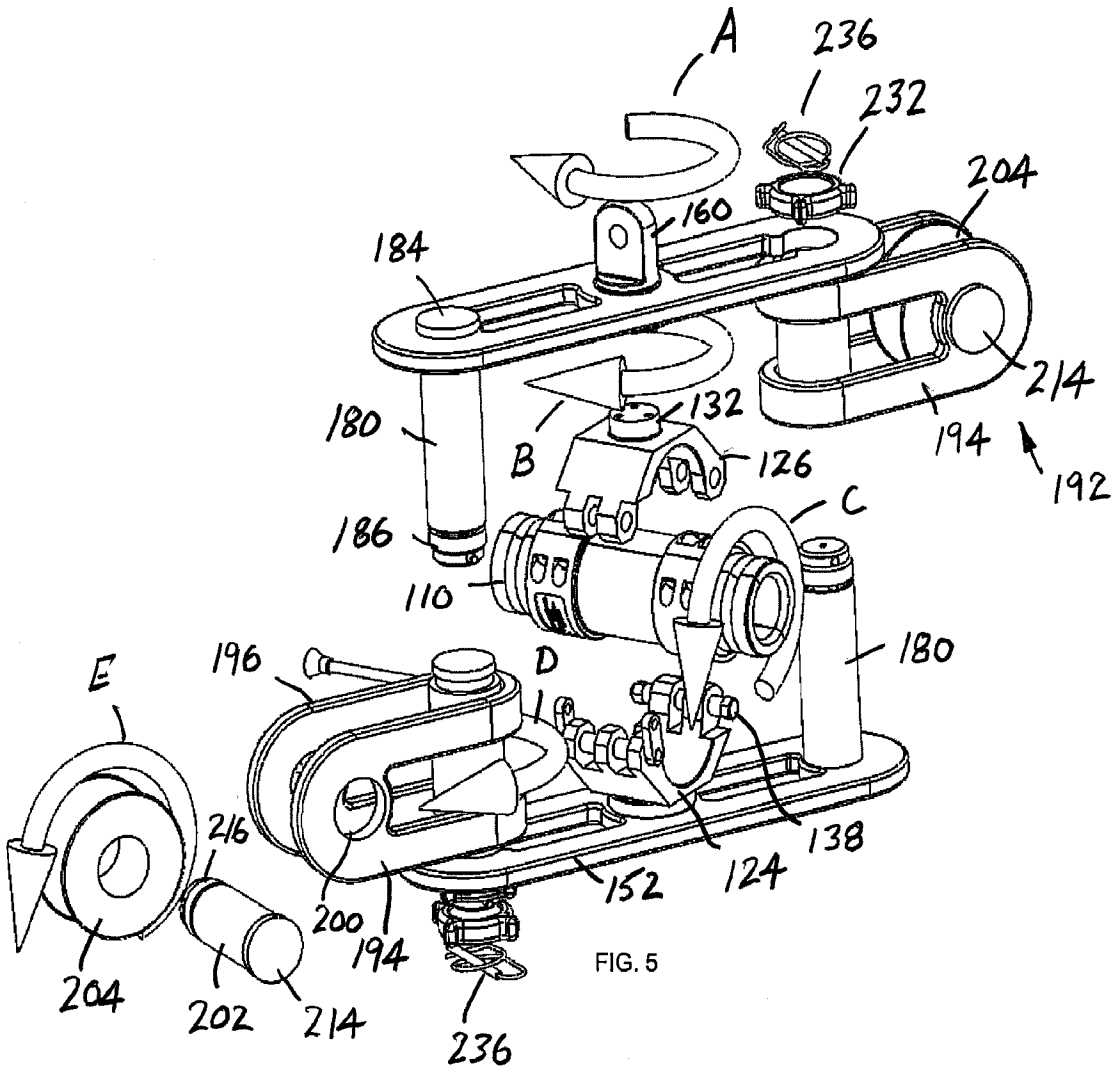
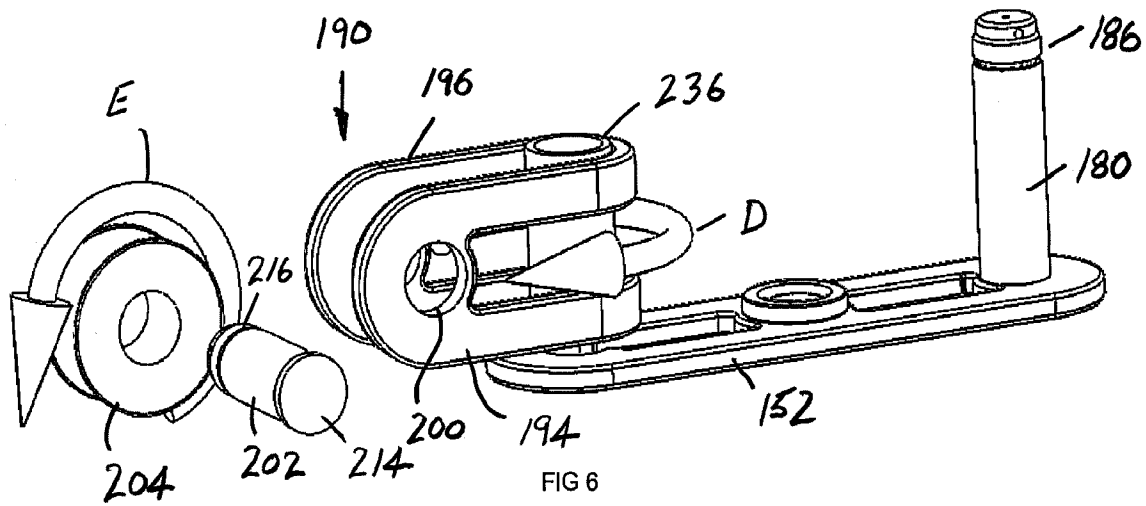


FIG. 5



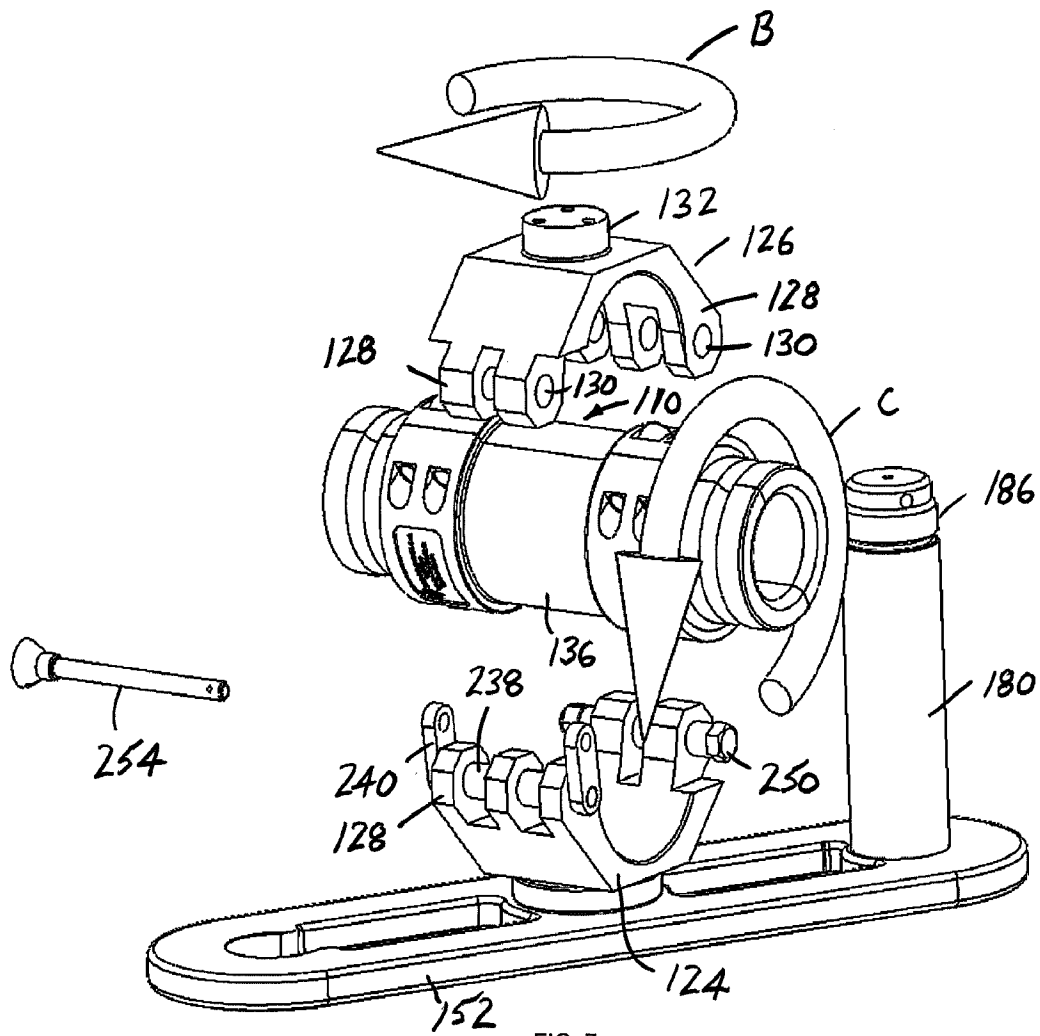


FIG. 7

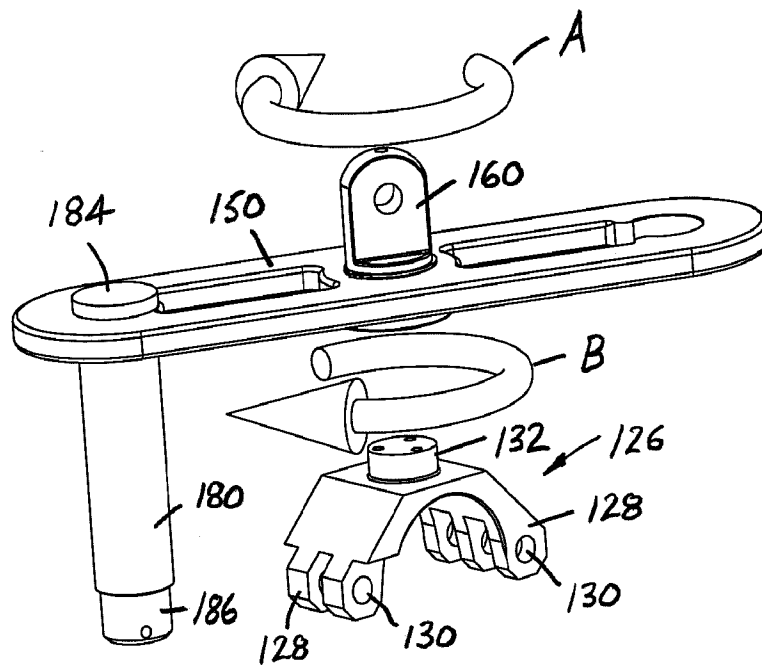


FIG. 8

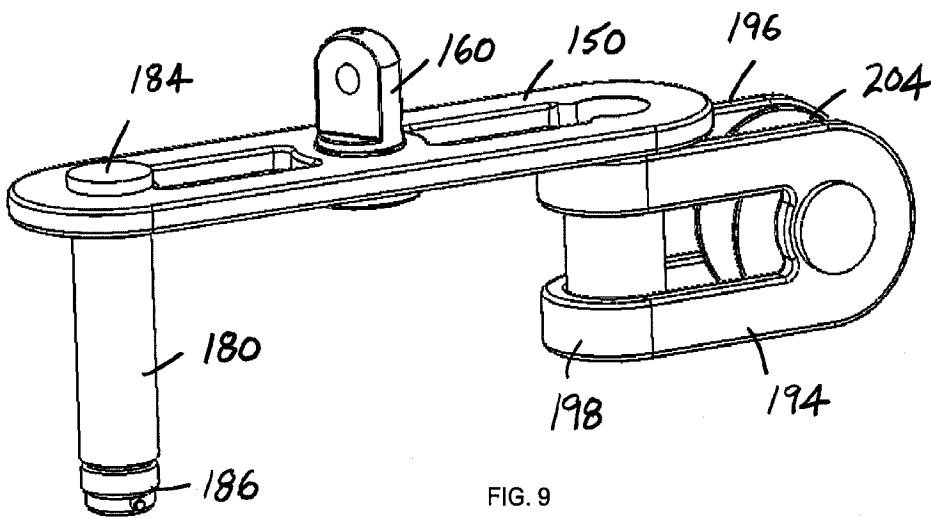


FIG. 9

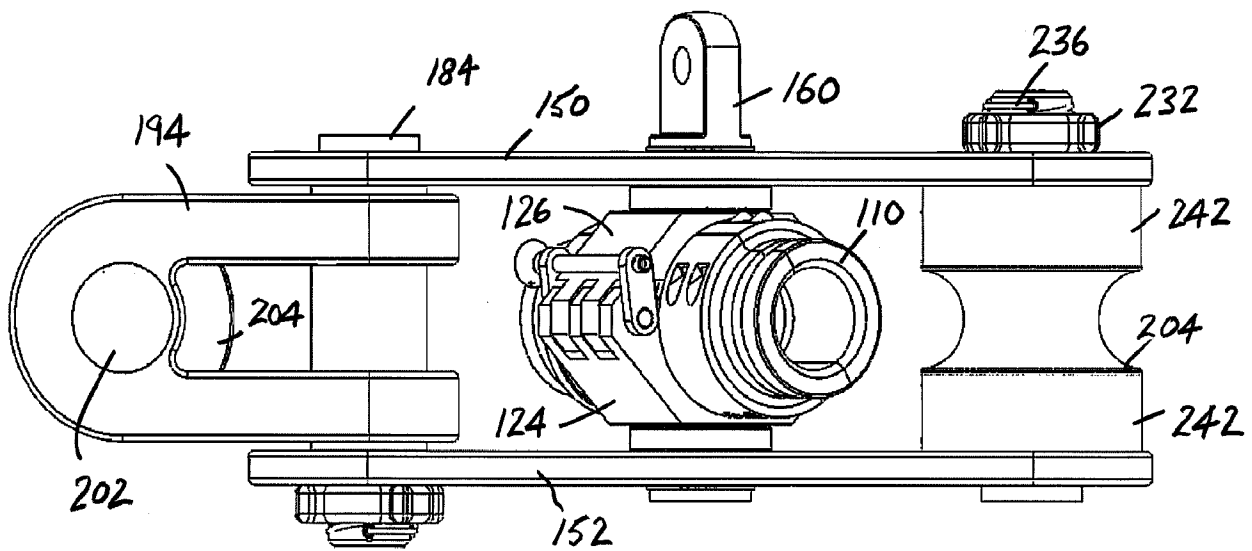


FIG. 10

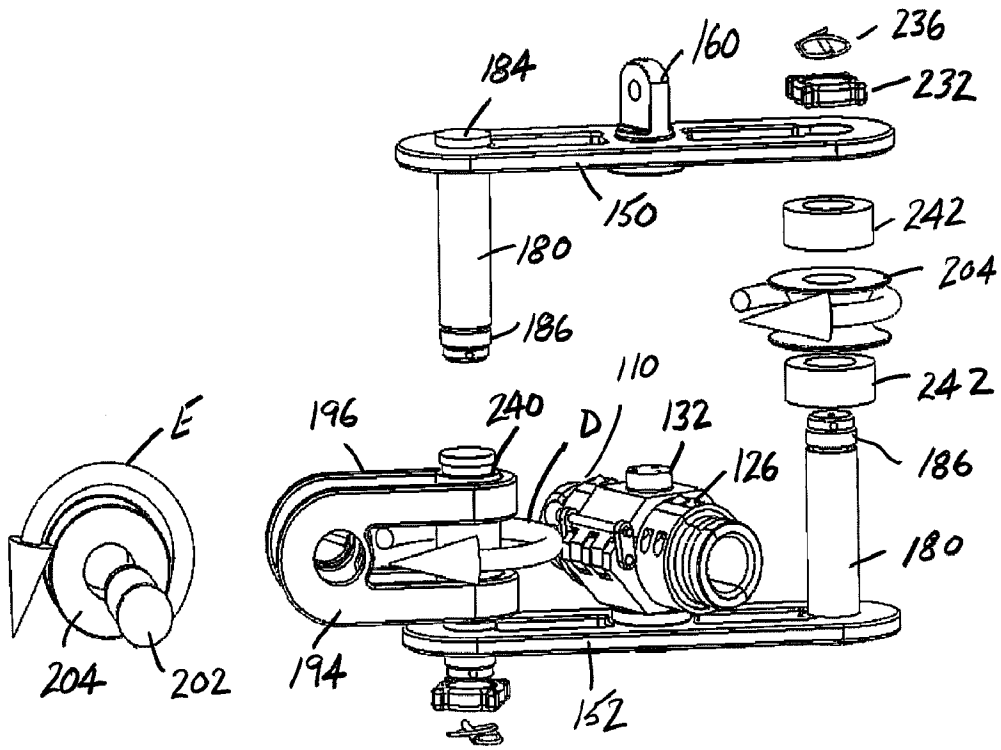


FIG. 11

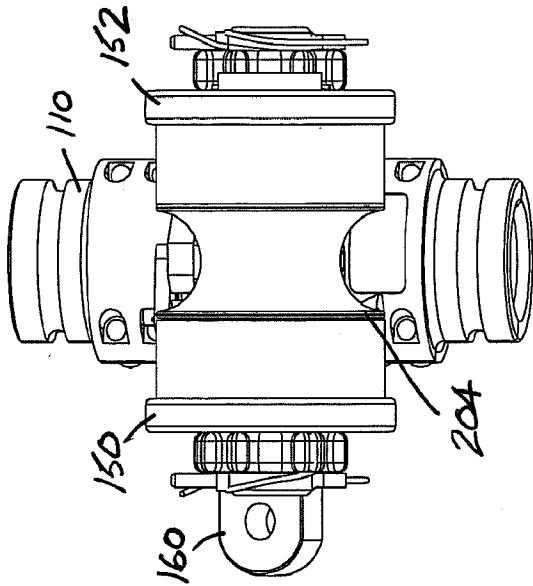


FIG. 14

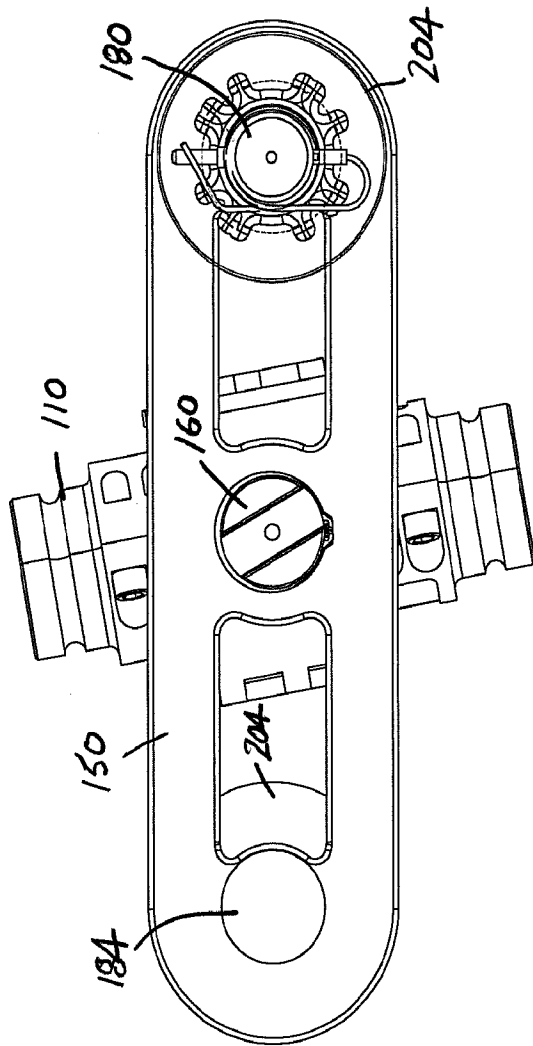


FIG. 13

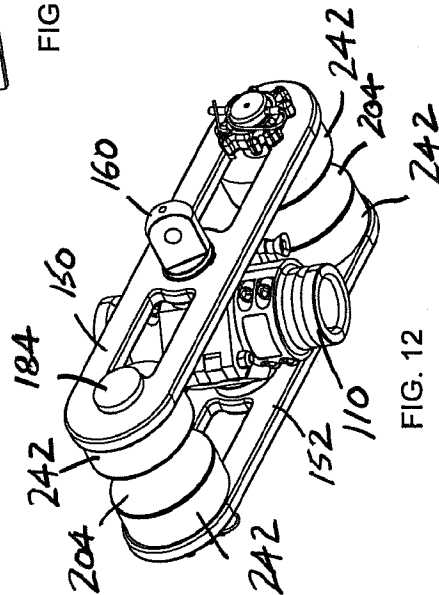


FIG. 12

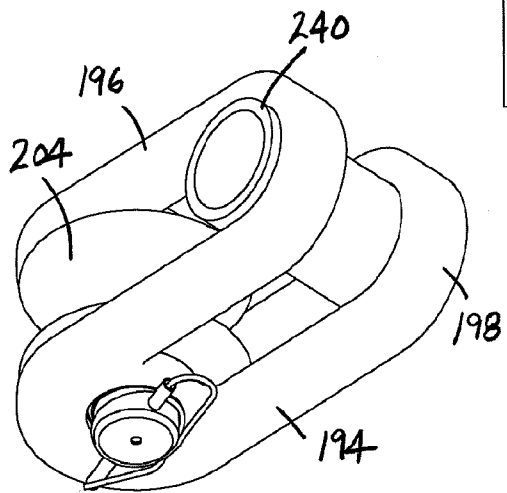


FIG. 15

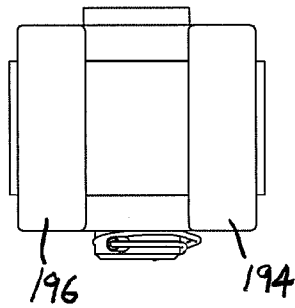


FIG. 16

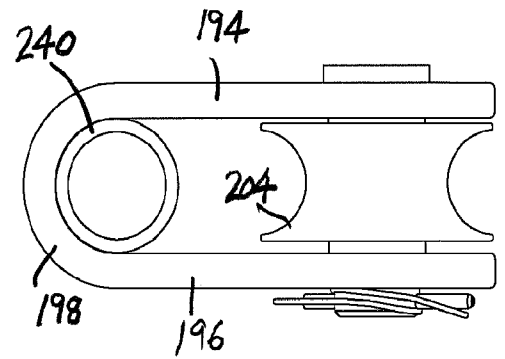
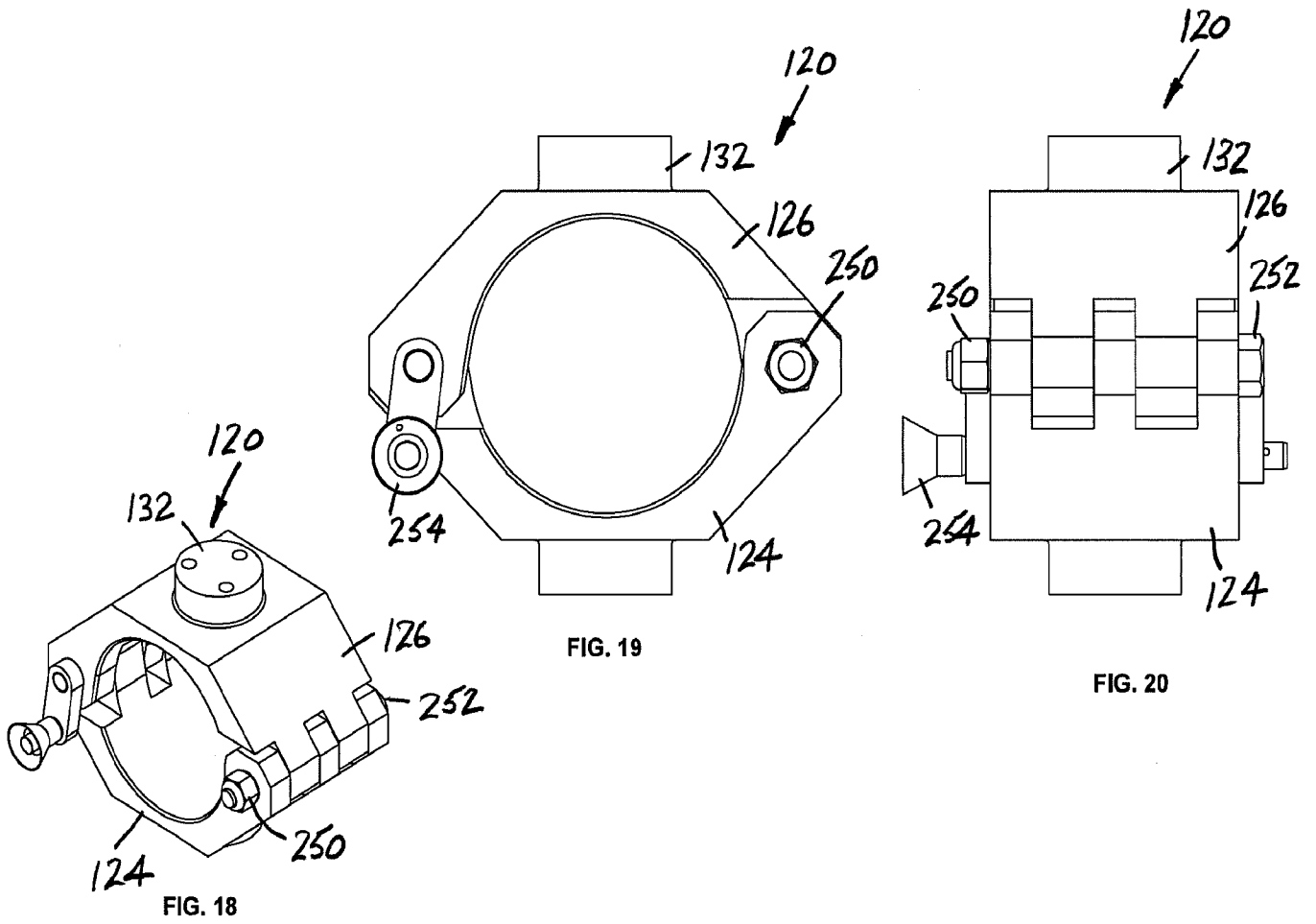


FIG. 17



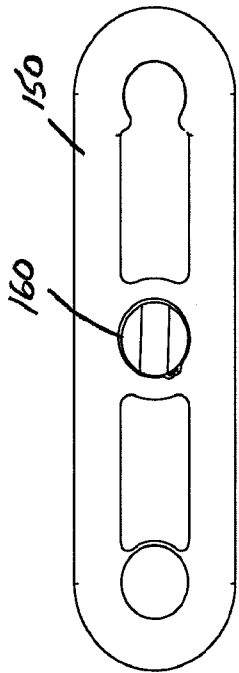


FIG. 23

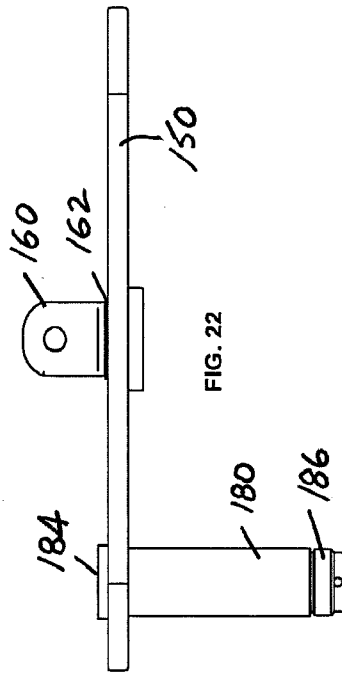


FIG. 22

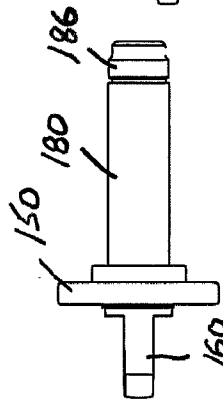


FIG. 24

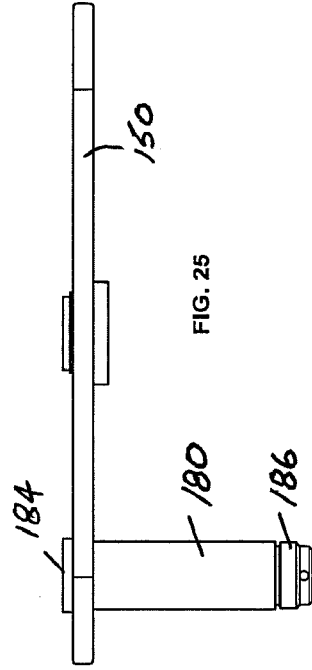


FIG. 25

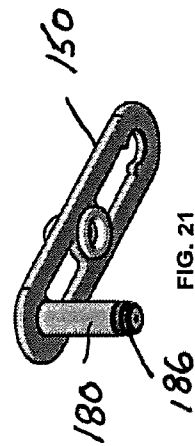
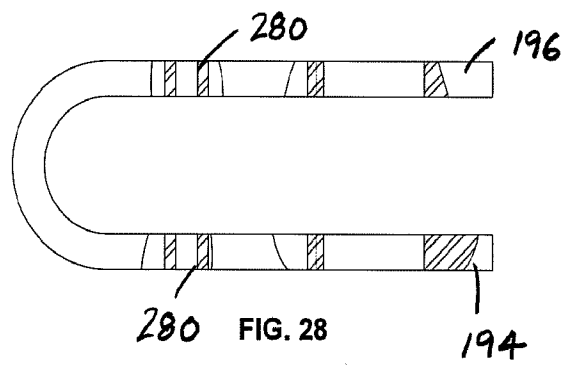
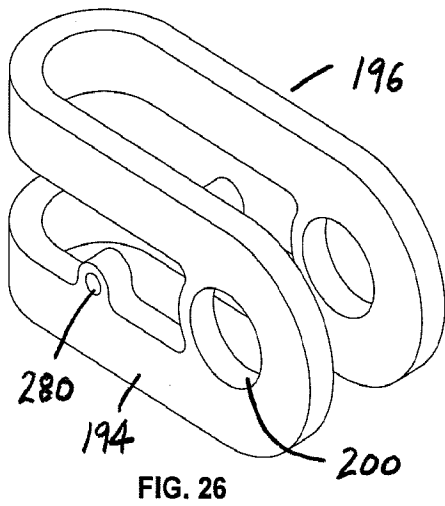
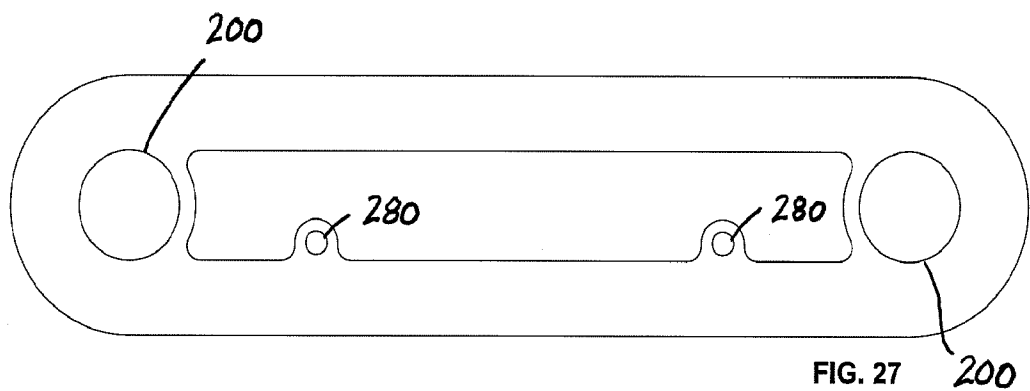


FIG. 21



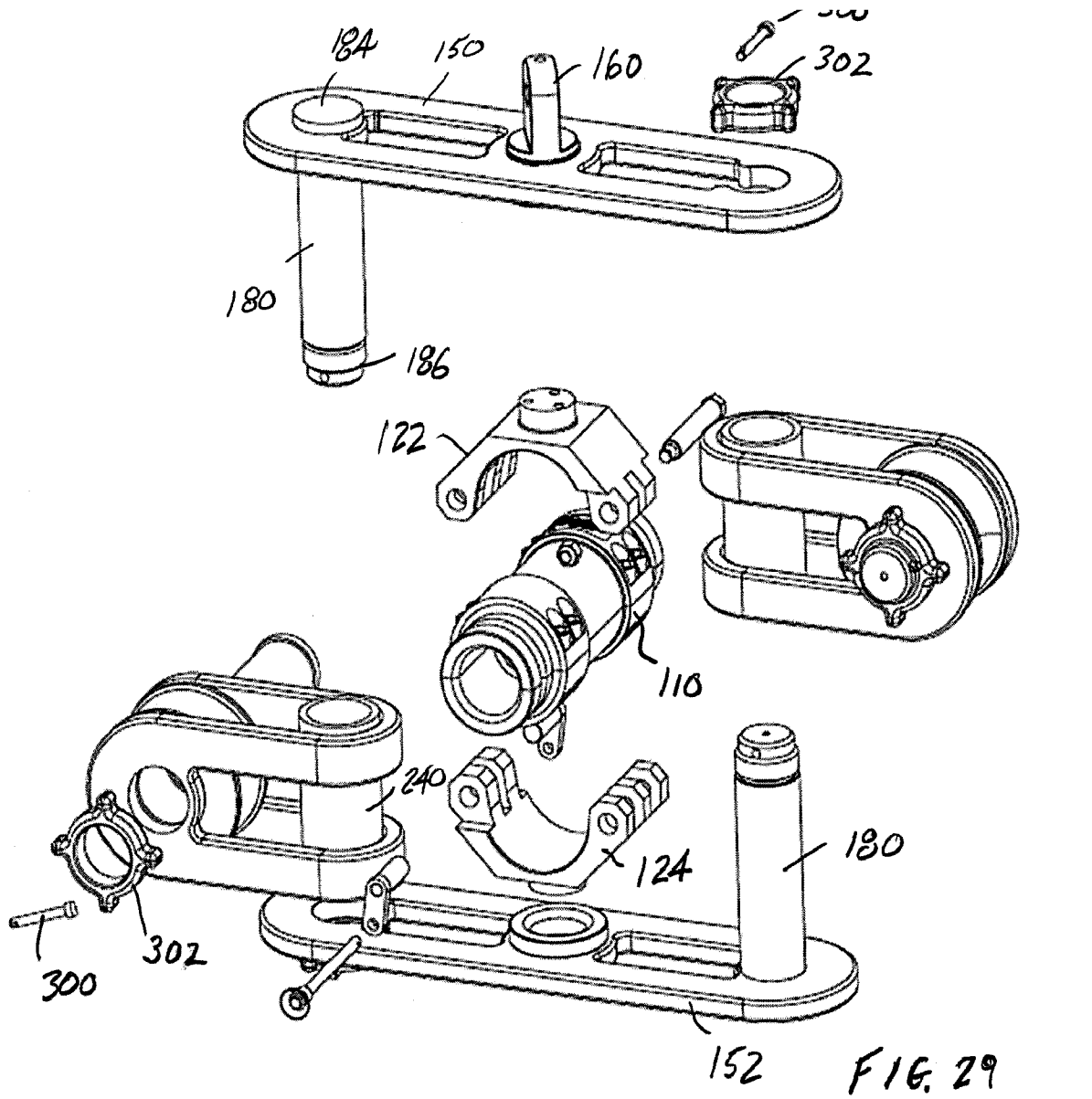


FIG. 29

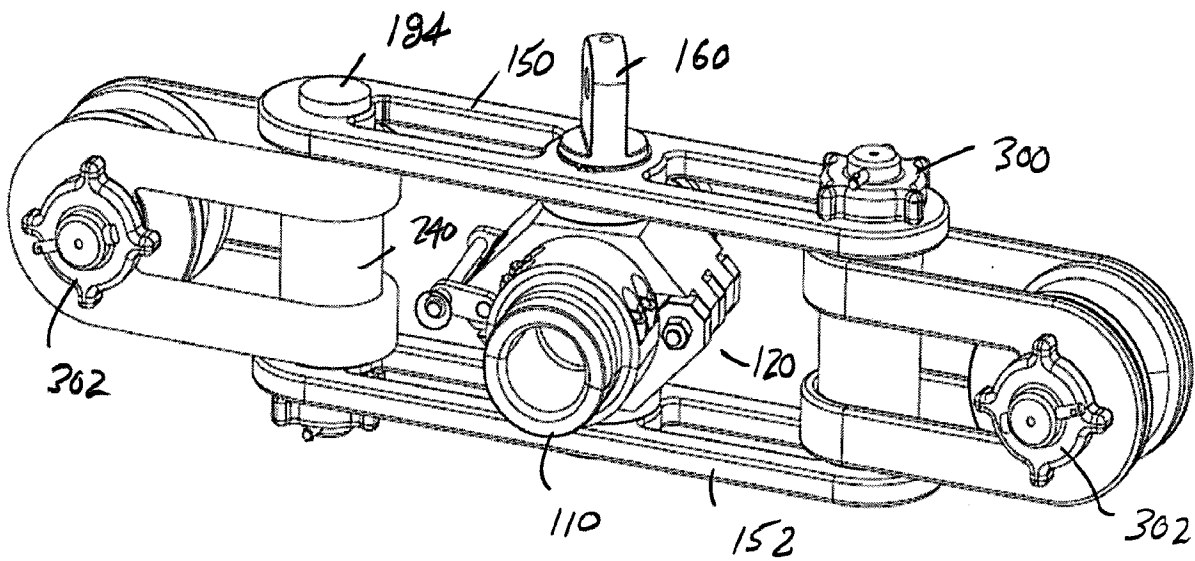


FIG. 30

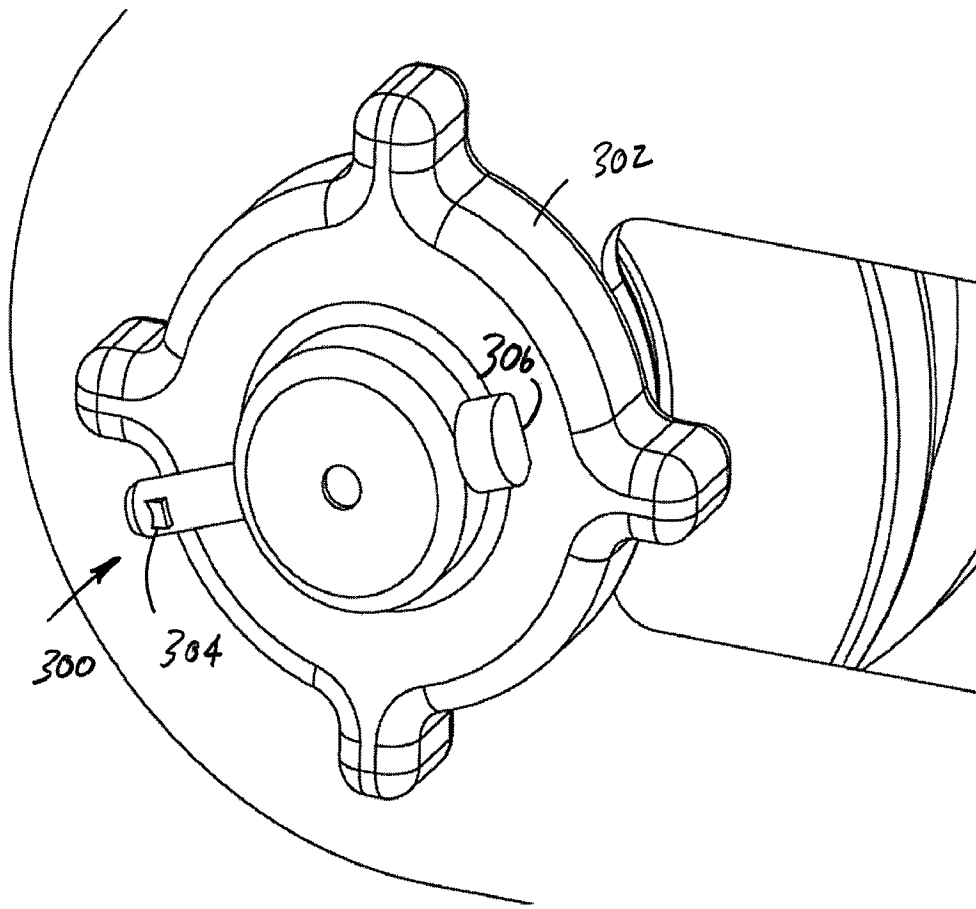


FIG. 31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/075454

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - B63B 21/66; F16G 11/00 (2014.01)
 USPC - 403/314
 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) - B63B 21/56, 21/66; F16G 11/00 (2014.01)
 USPC - 114/243, 244, 249; 248/231.51, 231.61; 254/134.3R, 134.3SC; 367/16, 17, 18; 403/309, 312, 314; 405/166, 173

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 CPC - B63B 21/20, 21/56, 21/66; F16G 11/00 (2014.02)

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,010,273 A (METZLER, JR.) 04 January 2000 (04.01.2000) entire document	1-3
-		-----
Y		30-32
Y	GB 2 223 732 A (HYSTAD) 18 April 1990 (18.04.1990) entire document	30-32
A	US 5,197,716 A (ZIBILICH, JR. et al) 30 March 1993 (30.03.1993) entire document	1-3, 30-32
A	US 6,350,077 B1 (PALMQUIST) 26 February 2002 (26.02.2002) entire document	1-3, 30-32
A	WO 2012/022757 A1 (HARTLAND) 23 February 2012 (23.02.2012) entire document	1-3, 30-32

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 04 April 2014	Date of mailing of the international search report 23 APR 2014
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/075454

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.: 4-29, 33
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:

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.:

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.