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**(54) RISER TENSIONER SYSTEM FOR OFF SHORE OIL PLATFORMS AND PETROLEUM
PRODUCTION PROCESSES**

STEIGROHRSPANNERSYSTEM FÜR OFFSHORE-ÖLPLATTFORMEN UND
ERDÖLHERSTELLUNGSVERFAHREN

SYSTÈME DE TENSIONNEUR DE TUBE PROLONGATEUR POUR PLATEFORMES DE PÉTROLE
OFFSHORE ET PROCÉDÉS DE PRODUCTION DE PÉTROLE

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(56) References cited:

WO-A1-98/55355

US-A- 3 958 840

US-A- 4 883 387

US-A1- 2005 147 473

US-B1- 6 431 284

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Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of petroleum production. The invention relates to the field of underwater petroleum production and petroleum wells and offshore platforms. More particularly the invention relates to the field of riser tensioner systems.

BACKGROUND OF THE INVENTION

[0002] There is a need for riser tensioner systems which are economically manufacturable, provide beneficial performance and robust lifetimes. There is a need for improved riser tensioner systems and a method of economically providing riser tensioner systems. There is a need for a robust riser tensioner system and method of making. There is a need for economic and high performance riser tensioner system bearings and methods for making high performance riser tensioner system bearings. U.S. Patent No. 6,431,284B1 discloses a gimbaled table riser support system that is for a spar type floating platform having risers passing vertically through the center well of a spar hull, there is provided apparatus for supporting the risers from a gimbaled table supported. U.S. Patent No. 4,883,387A discloses an apparatus for tensioning a riser that is for a tensioner system for a riser of a subsea production well. It has a plurality of at least three tensioners are each pivotally secured to both a lower surface of the production platform and to a tensioner. PCT Patent Publication WO 98/55355A1 discloses a load and deflection measurement system for elastomeric bearings. U.S. Patent Publication No. 2005/147473 discloses a riser tensioner with shrouded rods. U.S. Patent No. 3,958,840 discloses a flexible bearing having reinforcements.

SUMMARY OF THE INVENTION

[0003] According to the present invention there is provided a riser tensioner system. The riser tensioner system includes a fluid cylinder, the fluid cylinder for applying a force on a riser from a platform foundation. The fluid cylinder has a first riser end and a distal second foundation end. The platform is a tension leg platform. The riser tensioner system includes a cylinder riser bearing, the cylinder riser bearing having a first riser side nonelastomeric bearing member and a distal second cylinder side nonelastomeric bearing member. The first riser side nonelastomeric bearing member and the distal second cylinder side nonelastomeric bearing member are vulcanized mold bonded together with a mold cured elastomer intermediate containing a plurality of nonelastomer interleaved shims. The mold cured elastomer intermediate being bonded between the nonelastomer interleaved shims and having a cylinder riser bearing elastomer first bonding surface positioned proximate to the first riser

side nonelastomeric bearing member and a cylinder riser bearing elastomer second bonding surface positioned proximate to the distal second cylinder side nonelastomeric bearing member. The riser tensioner system includes a cylinder foundation bearing, the cylinder foundation bearing having a first foundation side nonelastomeric bearing member and a distal second cylinder side nonelastomeric bearing member. The first foundation side nonelastomeric bearing member and the distal second cylinder side nonelastomeric bearing member are vulcanized mold bonded together with a second mold cured elastomer intermediate containing a plurality of nonelastomer interleaved shims. The second mold cured elastomer intermediate being bonded between the nonelastomer interleaved shims and having a cylinder foundation bearing elastomer first bonding surface positioned proximate to the first foundation side nonelastomeric bearing member and a cylinder foundation bearing elastomer second bonding surface positioned proximate to the distal second cylinder side nonelastomeric bearing member. The cylinder riser bearing provides for the connecting of the fluid cylinder to the riser with the first riser side nonelastomeric bearing member for connecting to the riser and the distal second cylinder side nonelastomeric bearing member grounded to the fluid cylinder. The cylinder foundation bearing provides for the connecting of the fluid cylinder to the platform foundation with the first foundation side nonelastomeric bearing member for connecting to a platform foundation and the distal second cylinder side nonelastomeric bearing member grounded to the fluid cylinder. Wherein a force is applied between the riser and a platform foundation through the cylinder foundation bearing and the cylinder riser bearing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004]

FIG. 1 illustrates an off shore petroleum well site with a platform including a riser tensioner system.

FIG. 2-2A illustrates a riser tensioner system and method of making a system with fluid cylinders and bearings.

FIG. 3-3A illustrates a riser tensioner system and method of making a system with fluid cylinders and bearings.

FIG. 4 illustrates a riser tensioner system bearing.

FIG. 5 illustrates a riser tensioner system bearing.

FIG. 6 illustrates a method of making a riser tensioner system bearing.

FIG. 7 illustrates a riser tensioner system bearing.

FIG. 8 illustrates a riser tensioner system bearing.

FIG. 9 illustrates a riser tensioner system bearing.

FIG. 10 illustrates a riser tensioner system bearing with an elastomer intermediate.

FIG. 11 illustrates a method of making a riser tensioner system bearing.

FIG. 12 illustrates a riser tensioner system bearing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0005] Reference will now be made in detail to embodiments of a riser tensioning system, examples of which are illustrated in the accompanying drawings.

[0006] FIG. 1 illustrates a tension leg platform for use in petroleum production, such as in off shore location with the platform on top of the water with the petroleum well drilled in the earth below the water. FIG. 1 illustrates platform foundation 10 for use in producing petroleum. Preferably, platform foundation 10 is secured to the ocean floor 11 by a plurality of tendons 12. A plurality of risers 14 extend between the individual wells in template 16 and a deck foundation 18 of platform foundation 10. Riser 14 and platform foundation 10 are flexibly connected to permit relative motion between riser 14 and platform foundation 10 that occurs because of wave action on the platform foundation 10, and that riser 14 rises up from the ocean floor 11. FIG. 2 illustrates a top 22 of a riser 14 with lower end 24 threaded to connect with a riser joint in a conventional manner.

[0007] A collar tensioner ring 40 on the riser 14 provides for the connection of riser tensioners 38. Riser tensioners 38 of the riser tensioner system 100 are preferably riser tensioners 38 comprised of a fluid cylinder 102 which contain working fluids such as gas and/or liquid and provides a force between the movable foundation of platform foundation 10 and the riser 14.

[0008] Preferably, with the riser tensioner system 100 fluid cylinders 102 are connected to the deck foundation 18 by elastomeric bearings 110 with movement provided between the fluid cylinders 102 and deck foundation 18 as the arms 37 of fluid cylinders 102 extend and retract to maintain a uniform tension on riser 14. Elastomeric bearings 110 also connect the ends of arms 37 to tensioner ring 40 to permit motion between riser tensioners 38 and tensioner ring 40.

[0009] Riser tensioners 38, acting through the elastomeric bearings 110 and the tensioner ring 40 of the riser 14 provide a continuous upward tension on riser 14 despite relative movement of deck foundation 18. The application of continuous upward tension on riser 14 eliminates the threat of buckling, crimping or otherwise damaging the riser 14.

[0010] In an embodiment the invention includes a method of making a riser tensioner system 100. The method preferably includes providing a fluid cylinder 102, the fluid cylinder 102 for applying a force on a riser 14. The riser 14 is preferably a fluid conduit for drilling and/or extraction of petroleum products from underwater. The fluid cylinder 102 preferably has a first riser end 102a and a distal second foundation end 102b, also known as first fluid cylinder member 102a and a second fluid cylinder member 102b, respectively. The method preferably includes providing a riser tensioner system 100 cylinder riser bearing 110a, the cylinder riser bearing 110a having a first riser side nonelastomeric bearing member 112a

and a distal second cylinder side nonelastomeric bearing member 114a. Preferably, the first riser side nonelastomeric bearing member 112a and the distal second cylinder side nonelastomeric bearing member 114a are vulcanized mold bonded together with a mold cured elastomer intermediate 116 containing a plurality of nonelastomer interleaved shims 118 with the mold cured elastomer intermediate 116 bonded between the nonelastomer interleaved shims 118. The mold cured elastomer intermediate 116 preferably, has a cylinder riser bearing elastomer first bonding surface 120a with the first riser side nonelastomeric bearing member 112a and a cylinder riser bearing elastomer second bonding surface 122a with the distal second cylinder side nonelastomeric bearing member 114a.

[0011] The method preferably includes providing a riser tensioner system 100 cylinder foundation bearing 110b. The cylinder foundation bearing 110b has a first foundation side nonelastomeric bearing member 112b and a distal second cylinder side nonelastomeric bearing member 114b. The first foundation side nonelastomeric bearing member 112b and the distal second cylinder side nonelastomeric bearing member 114b vulcanized mold bonded together with a second mold cured elastomer intermediate 116 containing a plurality of nonelastomer interleaved shims 118. The second mold cured elastomer intermediate 116 bonded between the nonelastomer interleaved shims 118. The second mold cured elastomer intermediate 116 has a cylinder foundation bearing elastomer first bonding surface 120b with the first foundation side nonelastomeric bearing member 112b and a cylinder foundation bearing elastomer second bonding surface 122b with the distal second cylinder side nonelastomeric bearing member 114b.

[0012] The method preferably includes disposing the cylinder riser bearing 110a between the fluid cylinder 102 and the riser 14 with the first riser side nonelastomeric bearing member 112a proximate the riser 14 and the distal second cylinder side nonelastomeric bearing member 114a proximate the fluid cylinder 102. The method preferably includes disposing the cylinder foundation bearing 110b between the fluid cylinder 102 and a platform foundation 10 with the first foundation side nonelastomeric bearing member 112b proximate the platform foundation 10 and the distal second cylinder side nonelastomeric bearing member 114b proximate the fluid cylinder 102, wherein the force is applied between the riser 14 and the platform foundation 10 through the cylinder foundation bearing 110b and the cylinder riser bearing 110a.

[0013] Preferably, the cylinder riser bearing elastomer first bonding surface 120a comprises a spherical shell segment bonding surface.

[0014] Preferably, the cylinder riser bearing elastomer second bonding surface 122a comprises a spherical shell segment bonding surface.

[0015] Preferably, the cylinder foundation bearing elastomer first bonding surface 120b comprises a spher-

ical shell segment bonding surface.

[0016] Preferably, the cylinder foundation bearing elastomer second bonding surface 122b comprises a spherical shell segment bonding surface.

[0017] Preferably, the fluid cylinder 102 includes a cylinder fluid seal 124 for containing a working fluid within the fluid cylinder 102 while providing for relative motion between a first fluid cylinder member 102a and a second fluid cylinder member 102b, with the cylinder fluid seal 124 having a maximum cylinder fluid seal 124 operational moment (SOM). The maximum cylinder fluid seal 124 SOM is the maximum operational moment that may be applied to cylinder fluid seal 124 during riser tensioner system 100 operation while the cylinder fluid seal 124 can continue its operation without being sacrificed.

[0018] Preferably, the cylinder riser bearing 110a has a cylinder riser bearing cocking moment (RBCM) wherein the cylinder riser bearing 110a inhibits an application of a cylinder RBCM proximate the cylinder fluid seal 124 maximum cylinder fluid seal 124 SOM. Preferably, the cylinder RBCM is substantially less than the maximum cylinder fluid seal 124 SOM and does not exceed or approach the SOM during operation and use of the fluid cylinder 102 and elastomeric bearing 110. Preferably RBCM has a value less than SOM, where SOM has a range between about 0.5 SOM and 0.1 SOM. Preferably $RBCM < 0.5 \text{ SOM}$, $RBCM < 0.35 \text{ SOM}$, $RBCM < 0.21 \text{ SOM}$, or $RBCM < 0.13 \text{ SOM}$. However, it is most preferred if $RBCM \leq 0.1 \text{ SOM}$. Preferably, the elastomeric bearing 110 has a substantially constant stiffness in an operational cocking direction.

[0019] Preferably, the cylinder foundation bearing 110b has a cylinder foundation bearing 110b cocking moment (FBCM) wherein the cylinder foundation bearing 110b inhibits an application of a cylinder foundation bearing 110b FBCM proximate the cylinder fluid seal 124 maximum cylinder fluid seal 124 SOM. Preferably, the cylinder foundation bearing 110b FBCM is substantially less than the maximum cylinder fluid seal 124 SOM and does not exceed or approach the SOM during operation and use of the fluid cylinder 102 and elastomeric bearing 110. Preferably FBCM has a value less than SOM, where SOM has a range between about 0.5 SOM and 0.1 SOM. Preferably, $FBCM < 0.5 \text{ SOM}$, $FBCM < 0.35 \text{ SOM}$, $FBCM < 0.21 \text{ SOM}$, or $FBCM < 0.13 \text{ SOM}$. However, it is most preferred if $FBCM \leq 0.1 \text{ SOM}$. Preferably, the elastomeric bearing 110 has a substantially constant stiffness in an operational cocking direction.

[0020] Preferably, the cylinder riser bearing 110a elastomer first bonding surface 120a comprises a spherical shell segment bonding surface with a radius RCRFS and the cylinder riser bearing 110a elastomer second bonding surface 122a comprises a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS > RCRSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRFS and greater than RCRSS to a small radius spherical shell

segment having a radius less than the large radius spherical shell segment radius and greater than RCRSS. FIG.2 illustrates a riser tensioner system 100 with bearings 110 having cylinder riser bearing 110a elastomer first bonding surface 120a with a spherical shell segment bonding surface with a radius RCRFS and the cylinder riser bearing 110a elastomer second bonding surface 122a with a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS > RCRSS$. FIG. 4 illustrates bearings 110 with a central aperture 130, with the central aperture 130 through the bearing member 112a, the elastomer 116, the nonelastomer interleaved shims 118 and the bearing member 114a, to provide a reach through attachment of fluid cylinder 102 to the bearing member 114a such as illustrated in FIG. 2 with the riser 14 pulled upward by the fluid cylinder 102 to maintain riser tension.

[0021] Preferably, the cylinder riser bearing 110a elastomer first bonding surface 120a comprises a spherical shell segment bonding surface with a radius RCRFS and the cylinder riser bearing 110a elastomer second bonding surface 122a comprises a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS < RCRSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRSS and greater than RCRFS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCRFS. FIG.3 illustrates a riser tensioner system 100 with bearings 110 having cylinder riser bearing 110a elastomer first bonding surface 120a with a spherical shell segment bonding surface with a radius RCRFS and the cylinder riser bearing 110a elastomer second bonding surface 122a with a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS < RCRSS$. FIG. 5 illustrates bearings 110 without a central aperture 130 and without a reach through attachment of fluid cylinder 102 to the bearing member 114a such as illustrated in FIG. 3 with the riser 14 pushed upward by the fluid cylinder 102 to maintain riser tension.

[0022] Preferably, the cylinder foundation bearing 110b elastomer first bonding surface 120b comprises a spherical shell segment bonding surface with a radius RCFFS and the cylinder foundation bearing 110b elastomer second bonding surface 122b comprises a spherical shell segment bonding surface with a radius RCFSS, with $RCFFS > RCFSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCFFS and greater than RCFSS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCFSS. FIG.2 illustrates a riser tensioner system 100 with bearings 110 having cylinder riser bearing 110b elastomer first bonding surface 120b with a spherical shell segment bonding surface with a radius RCFFS and the cylinder riser bearing 110b elastomer second bonding surface 122b with a spherical shell segment bonding surface with a radius

RCFSS, with $RCFFS > RCFSS$.

[0023] Preferably, the cylinder foundation bearing 110b elastomer first bonding surface 120b comprises a spherical shell segment bonding surface with a radius $RCFFS$ and the cylinder foundation bearing 110b elastomer second bonding surface 122b comprises a spherical shell segment bonding surface with a radius $RCFSS$, with $RCFFS < RCFSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than $RCFSS$ and greater than $RCFFS$ to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than $RCFFS$. FIG. 3 illustrates bearing 110 with cylinder foundation bearing 110b elastomer first bonding surface 120b having spherical shell segment bonding surface with radius $RCFFS$ and the cylinder foundation bearing 110b elastomer second bonding surface 122b having spherical shell segment bonding surface with radius $RCFSS$, with $RCFFS < RCFSS$, with the fluid cylinder 102 pushing up on the riser 14.

[0024] A riser tensioner system 100 preferably includes a fluid cylinder 102 for applying a force on a riser 14 from a platform foundation 10. The riser 14 is preferably a fluid conduit for drilling and/or extraction of petroleum products from underwater. The fluid cylinder 102 preferably has a first riser end 102a and a distal second foundation end 102b. The riser tensioner system 100 preferably includes a cylinder riser bearing 110a, the cylinder riser bearing 110a having a first riser side nonelastomeric bearing member 112a and a distal second cylinder side nonelastomeric bearing member 114a, the first riser side nonelastomeric bearing member 112a and the distal second cylinder side nonelastomeric bearing member 114a vulcanized mold bonded together with a mold cured elastomer intermediate 116 containing a plurality of nonelastomer interleaved shims 118 with the mold cured elastomer intermediate 116 bonded between the nonelastomer interleaved shims 118 and having a cylinder riser bearing 110a elastomer first bonding surface 120a with the first riser side nonelastomeric bearing member and a cylinder riser bearing 110a elastomer second bonding surface 122a with the distal second cylinder side nonelastomeric bearing member.

[0025] The riser tensioner system 100 preferably includes a cylinder foundation bearing 110b, the cylinder foundation bearing 110b having a first foundation side nonelastomeric bearing member 112b and a distal second cylinder side nonelastomeric bearing member 114b, the first foundation side nonelastomeric bearing member and the distal second cylinder side nonelastomeric bearing member vulcanized mold bonded together with a second mold cured elastomer intermediate 116 containing a plurality of nonelastomer interleaved shims 118 with the mold cured elastomer intermediate bonded between the nonelastomer interleaved shims 118 and having a cylinder foundation bearing 110b elastomer first bonding surface 120b with the first foundation side nonelastomeric

ic bearing member and a cylinder foundation bearing 110b elastomer second bonding surface 122b with the distal second cylinder side nonelastomeric bearing member.

[0026] The cylinder riser bearing 110 provides for the connecting of the fluid cylinder 102 to a riser 14 with the first riser side nonelastomeric bearing member for connecting to the riser 14 and the distal second cylinder side nonelastomeric bearing member grounded to the fluid cylinder 102. The cylinder foundation bearing 110 provides for the connecting of the fluid cylinder 102 to a platform foundation 10 with the first foundation side nonelastomeric bearing member 112b for connecting to the platform foundation 10 and the distal second cylinder side nonelastomeric bearing member grounded to the fluid cylinder 102, wherein a force is applied between the connected riser 14 and the platform foundation 10 through the cylinder foundation bearing 110b and the cylinder riser bearing 110a.

[0027] Preferably, the cylinder riser bearing 110a elastomer first bonding surface 120a is comprised of a spherical shell segment bonding surface.

[0028] Preferably, the cylinder riser bearing 110a elastomer second bonding surface 122a is comprised of a spherical shell segment bonding surface.

[0029] Preferably, the cylinder foundation bearing 110b elastomer first bonding surface 120b is comprised of a spherical shell segment bonding surface.

[0030] Preferably, the cylinder foundation bearing 110b elastomer second bonding surface 122b is comprised of a spherical shell segment bonding surface.

[0031] Preferably, the fluid cylinder 102 includes a cylinder fluid seal 124 for containing fluid within the fluid cylinder 102 while providing for relative motion between first fluid cylinder member 102a and second fluid cylinder member 102b, with the cylinder fluid seal 124 having a maximum cylinder fluid seal 124 operational moment (SOM). As stated before, maximum cylinder fluid seal 124 SOM is the maximum operational moment that is to be applied to the cylinder fluid seal 124 during riser tensioner system 100 operation.

[0032] Preferably, the cylinder riser bearing 110a has a cylinder riser bearing 110a cocking moment (RBCM) wherein the cylinder riser bearing 110a inhibits an application of a cylinder riser bearing 110a RBCM proximate the cylinder fluid seal 124 maximum cylinder fluid seal 124 SOM. Preferably, the cylinder riser bearing 110a RBCM is substantially less than the SOM and does not exceed or approach the SOM during operation and use of the fluid cylinder 102 and elastomeric bearing 110. Preferably, RBCM has a value less than SOM, where SOM has a range between about 0.5 SOM and 0.1 SOM. Preferably, $RBCM < 0.5 \text{ SOM}$, $RBCM < 0.35 \text{ SOM}$, $RBCM < 0.21 \text{ SOM}$, or $RBCM < 0.13 \text{ SOM}$. However, most preferably $RBCM \leq 0.1 \text{ SOM}$. Preferably, the elastomeric bearing 110 has a substantially constant stiffness in an operational cocking direction.

[0033] Preferably, the cylinder foundation bearing

110b has a cylinder foundation bearing 110b cocking moment (FBCM) wherein the cylinder foundation bearing 110b inhibits an application of a cylinder foundation bearing 110b FBCM proximate the cylinder fluid seal 124 maximum cylinder fluid seal 124 operational moment (SOM). Preferably, cylinder foundation bearing 110b FBCM is substantially less than the SOM and does not exceed or approach the SOM during operation and use of the fluid cylinder 102 and bearing 110. Preferably, FBCM has a value less than SOM, where SOM has a range between about 0.5 SOM and 0.1 SOM. Preferably, $FBCM < 0.5 \text{ SOM}$, $FBCM < 0.35 \text{ SOM}$, $FBCM < 0.21 \text{ SOM}$, or $FBCM < 0.13 \text{ SOM}$. However, most preferably $FBCM \leq 0.1 \text{ SOM}$. Preferably, the bearing 110 has a substantially constant stiffness in an operational cocking direction.

[0034] Preferably, the cylinder riser bearing 110a elastomer first bonding surface 120a comprises the spherical shell segment bonding surface with radius RCRFS and the cylinder riser bearing 110a elastomer second bonding surface 122a comprises the spherical shell segment bonding surface with radius RCRSS, with $RCRFS > RCRSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRFS and greater than RCRSS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCRSS.

[0035] Preferably, the cylinder foundation bearing 110b elastomer first bonding surface 120b comprises the spherical shell segment bonding surface with radius RCFFS and the cylinder foundation bearing 110b elastomer second bonding surface 122b comprises the spherical shell segment bonding surface with radius RCFSS, with $RCFFS > RCFSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCFFS and greater than RCFSS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCFSS.

[0036] An elastomeric bearing 110 preferably provides for the transferring a tensioning force from a fluid cylinder 102 to a riser 14, preferably with the riser 14 comprising a fluid conduit for drilling and/or extraction of petroleum products from underwater. The elastomeric bearing 110 preferably has the first side nonelastomeric bearing member 112a, 112b and distal second fluid cylinder side nonelastomeric bearing member 114a, 114b, the first side nonelastomeric bearing member 112a, 112b, and the distal second fluid cylinder side nonelastomeric bearing member 114a, 114b, vulcanized mold bonded together with mold cured elastomer intermediate 116 containing the nonelastomer interleaved shims 118 with the mold cured elastomer intermediate 116 bonded between the nonelastomer interleaved shims 118 and having bearing elastomer first bonding surface 120a, 120b, with the first side nonelastomeric bearing member 112a, 112b, and bearing elastomer second bonding surface 122a, 122b with the distal second cylinder side nonelastomeric bear-

ing member 114a, 114b. The elastomeric bearing 110 preferably has a substantially constant stiffness in an operational cocking direction wherein the elastomeric bearing 110 inhibits the application of an elastomeric bearing cocking moment to cylinder fluid seal 124 of the fluid cylinder 102.

[0037] Preferably, the elastomeric bearing 110 elastomer first bonding surface 120a, 120b comprises the spherical shell segment bonding surface.

[0038] Preferably, the elastomer second bonding surface 122a, 122b comprises the spherical shell segment bonding surface.

[0039] The elastomeric bearing 110 is used with the fluid cylinder 102. Preferably, the cylinder fluid seal 124 contains a fluid within the fluid cylinder 102 while providing for relative motion between first fluid cylinder member 102a and second fluid cylinder member 102b, with the cylinder fluid seal 124 having a maximum cylinder fluid seal operational moment (SOM). As stated before, maximum cylinder fluid seal 124 SOM is the maximum operational moment that may be applied to cylinder fluid seal 124 during riser tensioner system 100 operation. Elastomeric bearing 110 has an inhibiting elastomeric bearing 110 cocking moment (RBCM). For this case, RBCM preferably has a value less than SOM, where SOM has a range between about 0.35 SOM and 0.1 SOM. Preferably, $RBCM < 0.35 \text{ SOM}$, $RBCM < 0.21 \text{ SOM}$, or $RBCM < 0.13 \text{ SOM}$. However, most preferably $RBCM \leq 0.1 \text{ SOM}$.

[0040] Preferably, the bearing elastomer first bonding surface 120a, 120b comprises the spherical shell segment bonding surface with radius RCRFS and the bearing elastomer second bonding surface 122a, 122b comprises the spherical shell segment bonding surface with radius RCRSS, with $RCRFS > RCRSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRFS and greater than RCRSS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCRSS.

[0041] Preferably, the bearing elastomer first bonding surface 120a, 120b comprises the spherical shell segment bonding surface with radius RCRFS and the bearing elastomer second bonding surface 122a, 122b comprises the spherical shell segment bonding surface with radius RCRSS, with $RCRFS < RCRSS$. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRSS and greater than RCRFS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCRFS.

[0042] A method of making elastomeric bearings 110 preferably includes providing a first side nonelastomeric bearing member 112a, 112b. The method preferably includes providing a second fluid cylinder side nonelastomeric bearing member 114a, 114b. The method prefer-

ably includes providing a plurality of nonelastomer interleave shims 118. The method preferably includes disposing the first side nonelastomeric bearing member 112a, 112b, the second fluid cylinder side nonelastomeric bearing member 114a, 114b, and the nonelastomer interleave shims 118 in a mold 140 with the nonelastomer interleave shims 118 oriented between a bearing elastomer first bonding surface 120a, 120b of the first side nonelastomeric bearing member 112a, 112b and a second distal bonding surface 122a, 122b of the second cylinder side nonelastomeric bearing member 114a, 114b. The method preferably includes bonding an elastomer 116 to the bearing elastomer first bonding surface 120a, 120b of the first side nonelastomeric bearing member 112a, 112b and the second distal bonding surface 122a, 122b of the second cylinder side nonelastomeric bearing member 114a, 114b and the oriented nonelastomer interleave shims 118, to provide an elastomeric bearing 110 having a substantially constant stiffness in an operational cocking direction of the first side nonelastomeric bearing member 112a, 112b relative to the second cylinder side nonelastomeric bearing member 114a, 114b. Preferably, the mold 140 includes a sprue 142 for the application of an elastomeric molding pressure to the elastomer 116 bonded to the nonelastomeric components of the bearing 110 with a vulcanizing heat applied to the elastomer mold and the elastomer to provide an elastomeric bearing 110 with the vulcanized mold bonded elastomer intermediate 116 with oriented nonelastomer interleaved shims 118.

[0043] Preferably, the elastomeric bearing first bonding surface 120a, 120b is comprised of the spherical shell segment bonding surface.

[0044] Preferably, the elastomeric second bonding surface 122a, 122b is comprised of the spherical shell segment bonding surface.

[0045] Preferably, the bearing 110 is used with the fluid cylinder 102, with the riser tensioner fluid cylinder fluid seal 124 containing a fluid within fluid cylinder 102 while providing for relative motion between the first fluid cylinder member 102' and the second fluid cylinder member 102", with the cylinder fluid seal 124 having the maximum cylinder seal operational moment (SOM). As stated before, maximum cylinder fluid seal 124 SOM is the maximum operational moment that may be applied to cylinder fluid seal 124 during riser tensioner system 100 operation. Elastomeric bearing 110 has an inhibited bearing cocking moment RBCM. For this case, RBCM preferably has a value less than SOM, where SOM has a range between about 0.35 SOM and 0.1 SOM. Preferably, RBCM < 0.35 SOM, RBCM < 0.21 SOM, or RBCM < 0.13 SOM. However, most preferably RBCM ≤ 0.1 SOM.

[0046] Preferably, the bearing first bonding surface 120a comprises the spherical shell segment bonding surface with radius RCRFS and the bearing second bonding surface 122a comprises the spherical shell segment bonding surface with radius RCRSS, with RCRFS > RCRSS. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical

shell segment having a radius less than RCRFS and greater than RCRSS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCRSS.

[0047] Preferably, the bearing first bonding surface 120b comprises the spherical shell segment bonding surface with radius RCFFS and the bearing second bonding surface 122b comprises the spherical shell segment bonding surface with radius RCFSS, with RCFFS < RCFSS. Preferably, the nonelastomer interleaved shims 118 progress from a large radius spherical shell segment having a radius less than RCRSS and greater than RCRFS to a small radius spherical shell segment having a radius less than the large radius spherical shell segment radius and greater than RCFFS.

[0048] FIG. 1 shows a riser tensioner system 100 with a platform above the water bottom and utilizing a riser tensioner system 100. FIG. 2-2A show a riser tensioner system 100 with the fluid cylinders 102 pulling upward on the riser 14 through the riser tensioner system bearings 110. FIG. 3-3A show a riser tensioner system 100 with the fluid cylinders 102 pushing upward on the riser 14 with the riser tensioner system bearings 110. FIG. 4 shows a riser tensioner system bearing 110 with a central aperture. FIG. 5 shows a riser tensioner system bearing 110. FIG. 6 shows a method of molding a riser tensioner system bearing 110 such as the one shown in FIG. 5. FIG. 7 shows views of a riser tensioner system bearing 110 including a cross section A-A and the controlled cocking motion that the riser tensioner system bearing 110 provides. FIG. 8 shows a riser tensioner system bearing 110 with two oriented nonelastomer bonded shims 118. FIG. 9 shows a riser tensioner system bearing. FIG. 10 shows a cross-section of riser tensioner system bearing 110 such as the one in FIG. 9. In FIG. 10 the nonelastomeric bearing member has an elastomer molding sprue conduit 145 for the mold transferring of elastomer 116. FIG. 11 shows the molding of a riser tensioner system bearing 110 such as the one in FIG. 10 with an elastomer molding sprue conduit 145 in communication with the mold sprue 142. FIG. 12 shows a riser tensioner system bearing 110 that provides a long projected service life while inhibiting side loads to a fluid cylinder seal 124 with an inhibiting cocking stiffness.

[0049] Thus, it is intended that the invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents. It is intended that the scope of differing terms or phrases in the claims may be fulfilled by the same or different structure(s) or step(s).

Claims

1. A riser tensioner system (100), said riser tensioner system (100) including:

a fluid cylinder (102), said fluid cylinder (102) for

applying a force on a riser (14) from a force on a platform foundation, said fluid cylinder (102) having a first riser end (102a) and a distal second foundation end (102b), the riser tensioner system (100) **characterized by:**

the platform being a tension leg platform, and by

a cylinder riser bearing (110a), said cylinder riser bearing (110a) having a first riser side nonelastomeric bearing member (112a) and a distal second cylinder side nonelastomeric bearing member (114a), said first riser side nonelastomeric bearing member (112a) and said distal second cylinder side nonelastomeric bearing member (114a) vulcanized mold bonded together with a mold cured elastomer intermediate (116) containing a plurality of nonelastomer interleaved shims (118), said mold cured elastomer intermediate (116) bonded between said nonelastomer interleaved shims (118) and having a cylinder riser bearing (110a) elastomer first bonding surface (120a) positioned proximate to said first riser side nonelastomeric bearing member (112a) and a cylinder riser bearing (110a) elastomer second bonding surface (122a) positioned proximate to said distal second cylinder side nonelastomeric bearing member (114a);

a cylinder foundation bearing (110b), said cylinder foundation bearing (110b) having a first foundation side nonelastomeric bearing member (112b) and a distal second cylinder side nonelastomeric bearing member (114b), said first foundation side nonelastomeric bearing member (112b) and said distal second cylinder side nonelastomeric bearing member (114b) vulcanized mold bonded together with a second mold cured elastomer intermediate (116) containing a plurality of nonelastomer interleaved shims (118), said second mold cured elastomer intermediate (116) bonded between said nonelastomer interleaved shims (118) and having a cylinder foundation bearing (110b) elastomer first bonding surface (120a) positioned proximate to said first foundation side nonelastomeric bearing member (112b) and a cylinder foundation bearing (110b) elastomer second bonding surface (122a) positioned proximate to said distal second cylinder side nonelastomeric bearing member (114b);

said cylinder riser bearing (110a) for connecting said fluid cylinder (102) to said riser (14) with said first riser side nonelastomeric

bearing member (112a) connecting to said riser (14) and said distal second cylinder side nonelastomeric bearing member (114a) grounded to said fluid cylinder (102); and

said cylinder foundation bearing (110b) for connecting said fluid cylinder (102) to said platform foundation (10) with said first foundation side nonelastomeric bearing member (112b) connecting to said platform foundation (10) and said distal second cylinder side nonelastomeric bearing member (114b) grounded to said fluid cylinder (102), wherein a force is applied between said riser (14) and a platform foundation (10) through said cylinder foundation bearing (110b) and said cylinder riser bearing (110a).

2. The riser tensioner system (100) of claim 1 wherein said cylinder riser bearing (110a) elastomer first bonding surface (120a) comprises a spherical shell segment bonding surface.
3. The riser tensioner system (100) of claim 1 wherein said cylinder riser bearing (110a) elastomer second bonding surface (122a) comprises a spherical shell segment bonding surface.
4. The riser tensioner system (100) of claim 1 wherein said cylinder foundation bearing (110b) elastomer first bonding surface (120a) comprises a spherical shell segment bonding surface.
5. The riser tensioner system (100) of claim 1 wherein said cylinder foundation bearing (110b) elastomer second bonding surface (122a) comprises a spherical shell segment bonding surface.
6. The riser tensioner system (100) of claim 1 wherein said fluid cylinder (102) includes a cylinder fluid seal (124) for containing fluid within said fluid cylinder (102) while providing for relative motion between a first fluid cylinder member (102a) and a second fluid cylinder member (102b), with said cylinder fluid seal (124) having a maximum cylinder fluid seal operational moment (SOM).
7. The riser tensioner system (100) of claim 6 with said cylinder riser bearing (110a) having a cylinder riser bearing (110a) cocking moment wherein said cylinder riser bearing (110a) inhibits an application of a cylinder riser bearing (110a) cocking moment proximate said cylinder fluid seal (124) maximum cylinder fluid SOM.
8. The riser tensioner system (100) of claim 6 with said cylinder foundation bearing (110b) having a cylinder foundation bearing (110b) cocking moment wherein

said cylinder foundation bearing (110b) inhibits an application of a cylinder foundation bearing (110b) cocking moment proximate said cylinder fluid seal (124) maximum cylinder fluid SOM.

9. The riser tensioner system (100) of claim 1 wherein said cylinder riser bearing (110a) elastomer first bonding surface (120a) of comprises a spherical shell segment bonding surface with a radius RCRFS and said cylinder riser bearing (110a) elastomer second bonding surface (122a) comprises a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS > RCRSS$. 5
10. The riser tensioner system (100) of claim 1 wherein said cylinder riser bearing (110a) elastomer first bonding surface (120a) of comprises a spherical shell segment bonding surface with a radius RCRFS and said cylinder riser bearing (110a) elastomer second bonding surface (122a) comprises a spherical shell segment bonding surface with a radius RCRSS, with $RCRFS < RCRSS$. 10
11. The riser tensioner system (100) of claim 1 wherein said cylinder foundation bearing (110b) elastomer first bonding surface (120a) comprises a spherical shell segment bonding surface with a radius RCFSS and said cylinder foundation bearing (110b) elastomer second bonding surface (122a) comprises a spherical shell segment bonding surface with a radius RCFSS, with $RCFSS > RCFSS$. 15
12. The riser tensioner system (100) of claim 1 wherein said cylinder foundation bearing elastomer first bonding surface (120b) comprises a spherical shell segment bonding surface with a radius RCFSS and said cylinder foundation bearing (110b) elastomer second bonding surface (122b) comprises a spherical shell segment bonding surface with a radius RCFSS, with $RCFSS < RCFSS$. 20

Patentansprüche

1. Ein Steigrohrspannersystem (100), wobei das Steigrohrspannersystem (100) Folgendes umfasst: 25
 - einen Fluidzylinder (102), wobei der Fluidzylinder (102) zum Anwenden einer Kraft auf ein Steigrohr (14) von einer Kraft auf einer Plattformbasis dient, wobei der Fluidzylinder (102) ein erstes Steigrohrende (102a) und ein distales, zweites Basisende (102b) aufweist, wobei das Steigrohrspannersystem (100) **dadurch gekennzeichnet ist, dass** die Plattform eine TLP (Tension Leg Platform) ist, und es **gekennzeichnet ist durch** ein Zylindersteigrohrlager (110a), wobei das Zylindersteigrohrlager (110a) 30

ein erstes, steigrohrseitiges, nicht elastomeres Lagerelement (112a) und ein distales, zweites, zylinderseitiges, nicht elastomeres Lagerelement (114a) aufweist, wobei das erste, steigrohrseitige, nicht elastomere Lagerelement (112a) und das distale, zweite, zylinderseitige, nicht elastomere Lagerelement (114a) mit einem formgehärteten, elastomeren Zwischenstück (116), das eine Vielzahl von nicht elastomeren, verschachtelten Scheiben (118) enthält, mittels einer vulkanisierten Form miteinander verbunden sind, wobei das formgehärtete, elastomere Zwischenstück (116) zwischen den nicht elastomeren, verschachtelten Scheiben (118) verbunden ist und eine elastomere, erste Verbindungsfläche (120a) des Zylindersteigrohrlagers (110a), die nahe dem ersten, steigrohrseitigen, nicht elastomeren Lagerelement (112a) positioniert ist, und eine elastomere, zweite Verbindungsfläche (122a) des Zylindersteigrohrlagers (110a), die nahe dem distalen, zweiten, zylinderseitigen, nicht elastomeren Lagerelement (114a) positioniert ist, aufweist; 35

ein Zylinderbasislager (110b), wobei das Zylinderbasislager (110b) ein erstes, basisseitiges, nicht elastomeres Lagerelement (112b) und ein distales, zweites, zylinderseitiges, nicht elastomeres Lagerelement (114b) aufweist, wobei das erste, basisseitige, nicht elastomere Lagerelement (112b) und das distale, zweite, zylinderseitige, nicht elastomere Lagerelement (114b) mit einem zweiten, formgehärteten, elastomeren Zwischenstück (116), das eine Vielzahl von nicht elastomeren, verschachtelten Scheiben (118) enthält, mittels einer vulkanisierten Form miteinander verbunden sind, wobei das zweite, formgehärtete, elastomere Zwischenstück (116) zwischen den nicht elastomeren, verschachtelten Scheiben (118) verbunden ist und eine elastomere, erste Verbindungsfläche (120a) des Zylinderbasislagers (110b), die nahe dem ersten, basisseitigen, nicht elastomeren Lagerelement (112b) positioniert ist, und eine elastomere, zweite Verbindungsfläche (122a) des Zylinderbasislagers (110b), die nahe dem distalen, zweiten, zylinderseitigen, nicht elastomeren Lagerelement (114b) positioniert ist, aufweist; 40

wobei das Zylindersteigrohrlager (110a) zum Verknüpfen des Fluidzylinders (102) mit dem Steigrohr (14) dient, wobei das erste, steigrohrseitige, nicht elastomere Lagerelement (112a) mit dem Steigrohr (14) verknüpft ist und das distale, zweite, zylinderseitige, nicht elastomere Lagerelement (114a) mit dem Fluidzylinder (102) verankert ist; und 45

wobei das Zylinderbasislager (110b) zum Verknüpfen des Fluidzylinders (102) mit der Platt-

- formbasis (10) dient, wobei das erste, basisseitige, nicht elastomere Lagerelement (112b) mit der Plattformbasis (10) verknüpft ist und das distale, zweite, zylinderseitige, nicht elastomere Lagerelement (114b) mit dem Fluidzylinder (102) verankert ist, wobei über das Zylinderbasislager (110b) und das Zylindersteigrohrlager (110a) eine Kraft zwischen dem Steigrohr (14) und einer Plattformbasis (10) angewendet wird.
2. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche beinhaltet.
 3. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, zweite Verbindungsfläche (122a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche beinhaltet.
 4. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120a) des Zylinderbasislagers (110b) eine Kugelschalensegmentverbindungsfläche beinhaltet.
 5. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, zweite Verbindungsfläche (122a) des Zylinderbasislagers (110b) eine Kugelschalensegmentverbindungsfläche beinhaltet.
 6. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei der Fluidzylinder (102) eine Zylinderfluiddichtung (124) zum Halten von Fluid innerhalb des Fluidzylinders (102) während des Bereitstellens einer relativen Bewegung zwischen einem ersten Fluidzylinderelement (102a) und einem zweiten Fluidzylinderelement (102b) aufweist, wobei die Zylinderfluiddichtung (124) ein Maximalzylinderfluiddichtungsbetriebsmoment (Maximalzylinderfluid-SOM) aufweist.
 7. Steigrohrspannersystem (100) gemäß Anspruch 6, wobei das Zylindersteigrohrlager (110a) ein Spannungsmoment des Zylindersteigrohrlagers (110a) aufweist, wobei das Zylindersteigrohrlager (110a) eine Anwendung eines Spannungsmoments des Zylindersteigrohrlagers (110a) nahe dem Maximalzylinderfluiddichtungs-SOM der Zylinderfluiddichtung (124) verhindert.
 8. Steigrohrspannersystem (100) gemäß Anspruch 6, wobei das Zylinderbasislager (110b) ein Spannungsmoment des Zylinderbasislagers (110b) aufweist, wobei das Zylinderbasislager (110b) eine Anwendung eines Spannungsmoments des Zylinderbasislagers (110b) nahe dem Maximalzylinderfluiddichtungs-
- SOM der Zylinderfluiddichtung (124) verhindert.
9. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCRFS beinhaltet und wobei die elastomere, zweite Verbindungsfläche (122a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCRSS beinhaltet, wobei $RCRFS > RCRSS$.
 10. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCRFS beinhaltet und wobei die elastomere, zweite Verbindungsfläche (122a) des Zylindersteigrohrlagers (110a) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCRSS beinhaltet, wobei $RCRFS < RCRSS$.
 11. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120a) des Zylinderbasislagers (110b) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCFFS beinhaltet und wobei die elastomere, zweite Verbindungsfläche (122a) des Zylinderbasislagers (110b) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCFSS beinhaltet, wobei $RCFFS > RCFSS$.
 12. Steigrohrspannersystem (100) gemäß Anspruch 1, wobei die elastomere, erste Verbindungsfläche (120b) des Zylinderbasislagers eine Kugelschalensegmentverbindungsfläche mit einem Radius RCFFS beinhaltet und wobei die elastomere, zweite Verbindungsfläche (122b) des Zylinderbasislagers (110b) eine Kugelschalensegmentverbindungsfläche mit einem Radius RCFSS beinhaltet, wobei $RCFFS < RCFSS$.
- ### Revendications
1. Un système de tensionneur de tube prolongateur (100), ledit système de tensionneur de tube prolongateur (100) incluant :
 - un cylindre à fluide (102), ledit cylindre à fluide (102) pour appliquer une force sur un tube prolongateur (14) à partir d'une force sur une fondation de plateforme, ledit cylindre à fluide (102) ayant une première extrémité de tube prolongateur (102a) et une deuxième extrémité de fondation distale (102b), le système de tensionneur de tube prolongateur (100) étant **caractérisé par** :

le fait que la plateforme est une plateforme à câbles tendus, et par un palier de tube prolongateur de cylindre (110a), ledit palier de tube prolongateur de cylindre (110a) ayant un premier élément de palier non élastomère côté tube prolongateur (112a) et un deuxième élément de palier non élastomère côté cylindre distal (114a), ledit premier élément de palier non élastomère côté tube prolongateur (112a) et ledit deuxième élément de palier non élastomère côté cylindre distal (114a) étant liés ensemble par moule vulcanisé avec un intermédiaire élastomère durci en moule (116) contenant une pluralité de cales entrelacées non élastomères (118), ledit intermédiaire élastomère durci en moule (116) étant lié entre lesdites cales entrelacées non élastomères (118) et ayant une première surface de liaison élastomère (120a) de palier de tube prolongateur de cylindre (110a) positionnée à proximité dudit premier élément de palier non élastomère côté tube prolongateur (112a) et une deuxième surface de liaison élastomère (122a) de palier de tube prolongateur de cylindre (110a) positionnée à proximité dudit deuxième élément de palier non élastomère côté cylindre distal (114a) ; un palier de fondation de cylindre (110b), ledit palier de fondation de cylindre (110b) ayant un premier élément de palier non élastomère côté fondation (112b) et un deuxième élément de palier non élastomère côté cylindre distal (114b), ledit premier élément de palier non élastomère côté fondation (112b) et ledit deuxième élément de palier non élastomère côté cylindre distal (114b) étant liés ensemble par moule vulcanisé avec un deuxième intermédiaire élastomère durci en moule (116) contenant une pluralité de cales entrelacées non élastomères (118), ledit deuxième intermédiaire élastomère durci en moule (116) étant lié entre lesdites cales entrelacées non élastomères (118) et ayant une première surface de liaison élastomère (120a) de palier de fondation de cylindre (110b) positionnée à proximité dudit premier élément de palier non élastomère côté fondation (112b) et une deuxième surface de liaison élastomère (122a) de palier de fondation de cylindre (110b) positionnée à proximité dudit deuxième élément de palier non élastomère côté cylindre distal (114b) ; ledit palier de tube prolongateur de cylindre (110a) pour raccorder ledit cylindre à fluide (102) audit tube prolongateur (14), ledit premier élément de palier non élastomère côté

tube prolongateur (112a) se raccordant audit tube prolongateur (14) et ledit deuxième élément de palier non élastomère côté cylindre distal (114a) étant mis à la terre sur ledit cylindre à fluide (102) ; et ledit palier de fondation de cylindre (110b) pour raccorder ledit cylindre à fluide (102) à ladite fondation de plateforme (10), ledit premier élément de palier non élastomère côté fondation (112b) se raccordant à ladite fondation de plateforme (10) et ledit deuxième élément de palier non élastomère côté cylindre distal (114b) étant mis à la terre sur ledit cylindre à fluide (102), où une force est appliquée entre ledit tube prolongateur (14) et une fondation de plateforme (10) à travers ledit palier de fondation de cylindre (110b) et ledit palier de tube prolongateur de cylindre (110a).

2. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique.
3. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite deuxième surface de liaison élastomère (122a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique.
4. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120a) de palier de fondation de cylindre (110b) comprend une surface de liaison de segment de coque sphérique.
5. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite deuxième surface de liaison élastomère (122a) de palier de fondation de cylindre (110b) comprend une surface de liaison de segment de coque sphérique.
6. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ledit cylindre à fluide (102) inclut un joint de fluide de cylindre (124) pour contenir du fluide à l'intérieur dudit cylindre à fluide (102) tout en assurant un mouvement relatif entre un premier élément de cylindre à fluide (102a) et un deuxième élément de cylindre à fluide (102b), ledit joint de fluide de cylindre (124) ayant un moment opérationnel de joint (SOM) de fluide de cylindre maximal.
7. Le système de tensionneur de tube prolongateur (100) de la revendication 6, ledit palier de tube prolongateur de cylindre (110a) ayant un moment d'ar-

mement de palier de tube prolongateur de cylindre (110a) où ledit palier de tube prolongateur de cylindre (110a) empêche une application d'un moment d'armement de palier de tube prolongateur de cylindre (110a) à proximité dudit SOM de joint de fluide de cylindre maximal de joint de fluide de cylindre (124).

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8. Le système de tensionneur de tube prolongateur (100) de la revendication 6, ledit palier de fondation de cylindre (110b) ayant un moment d'armement de palier de fondation de cylindre (110b) où ledit palier de fondation de cylindre (110b) empêche une application d'un moment d'armement de palier de fondation de cylindre (110b) à proximité dudit SOM de joint de fluide de cylindre maximal de joint de fluide de cylindre (124).

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9. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique avec un rayon RCRFS et ladite deuxième surface de liaison élastomère (122a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique avec un rayon RCRSS, avec $RCRFS > RCRSS$.

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10. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique avec un rayon RCRFS et ladite deuxième surface de liaison élastomère (122a) de palier de tube prolongateur de cylindre (110a) comprend une surface de liaison de segment de coque sphérique avec un rayon RCRSS, avec $RCRFS < RCRSS$.

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11. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120a) de palier de fondation de cylindre (110b) comprend une surface de liaison de segment de coque sphérique avec un rayon RCFFS et ladite deuxième surface de liaison élastomère (122a) de palier de fondation de cylindre (110b) comprend une surface de liaison de segment de coque sphérique avec un rayon RCFSS, avec $RCFFS > RCFSS$.

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12. Le système de tensionneur de tube prolongateur (100) de la revendication 1 où ladite première surface de liaison élastomère (120b) de palier de fondation de cylindre comprend une surface de liaison de segment de coque sphérique avec un rayon RCRFS et ladite deuxième surface de liaison élastomère (122b) de palier de fondation de cylindre (110b) com-

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prend une surface de liaison de segment de coque sphérique avec un rayon RCFSS, avec $RCFFS < RCFSS$.

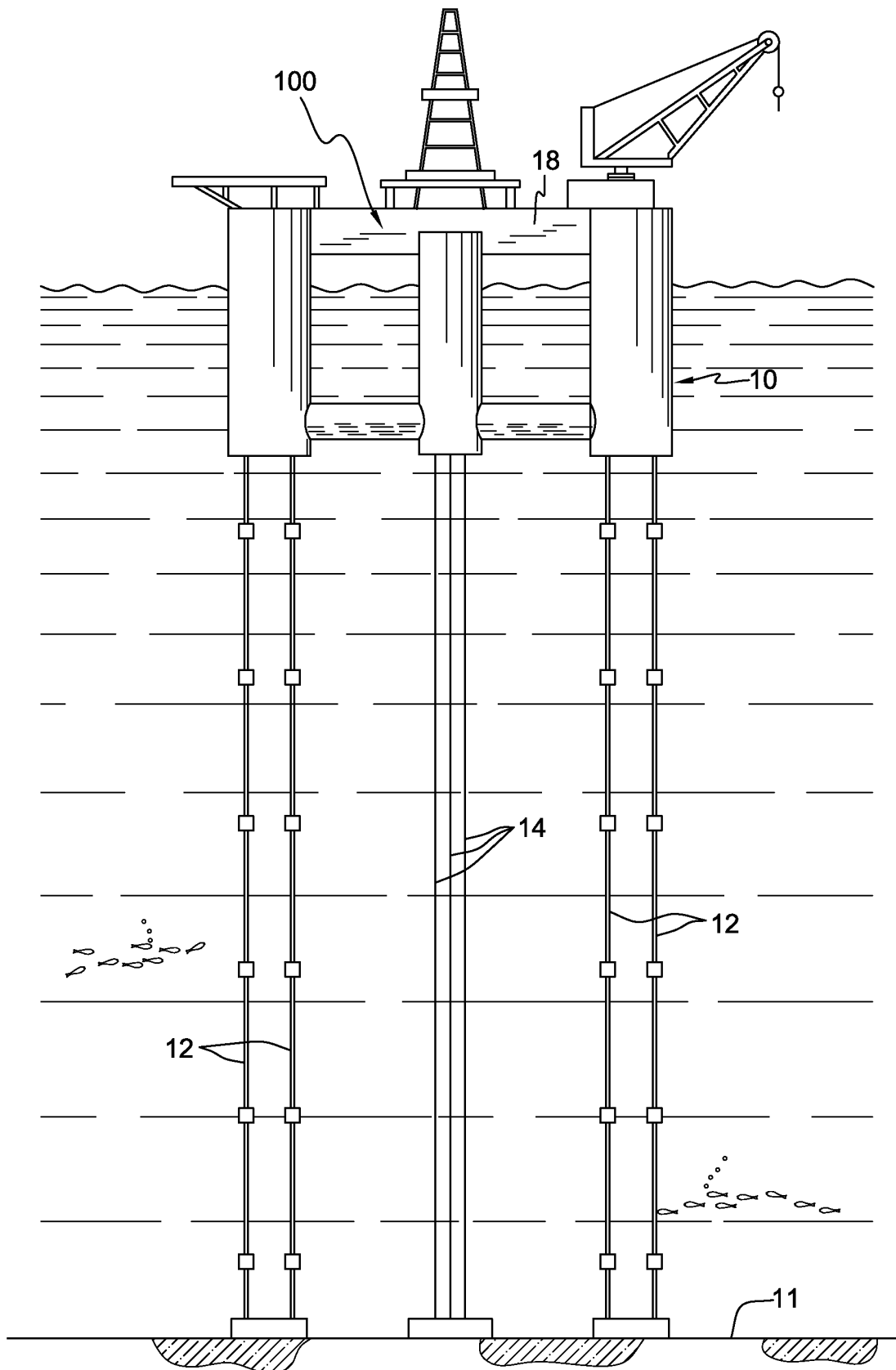


FIG. 1

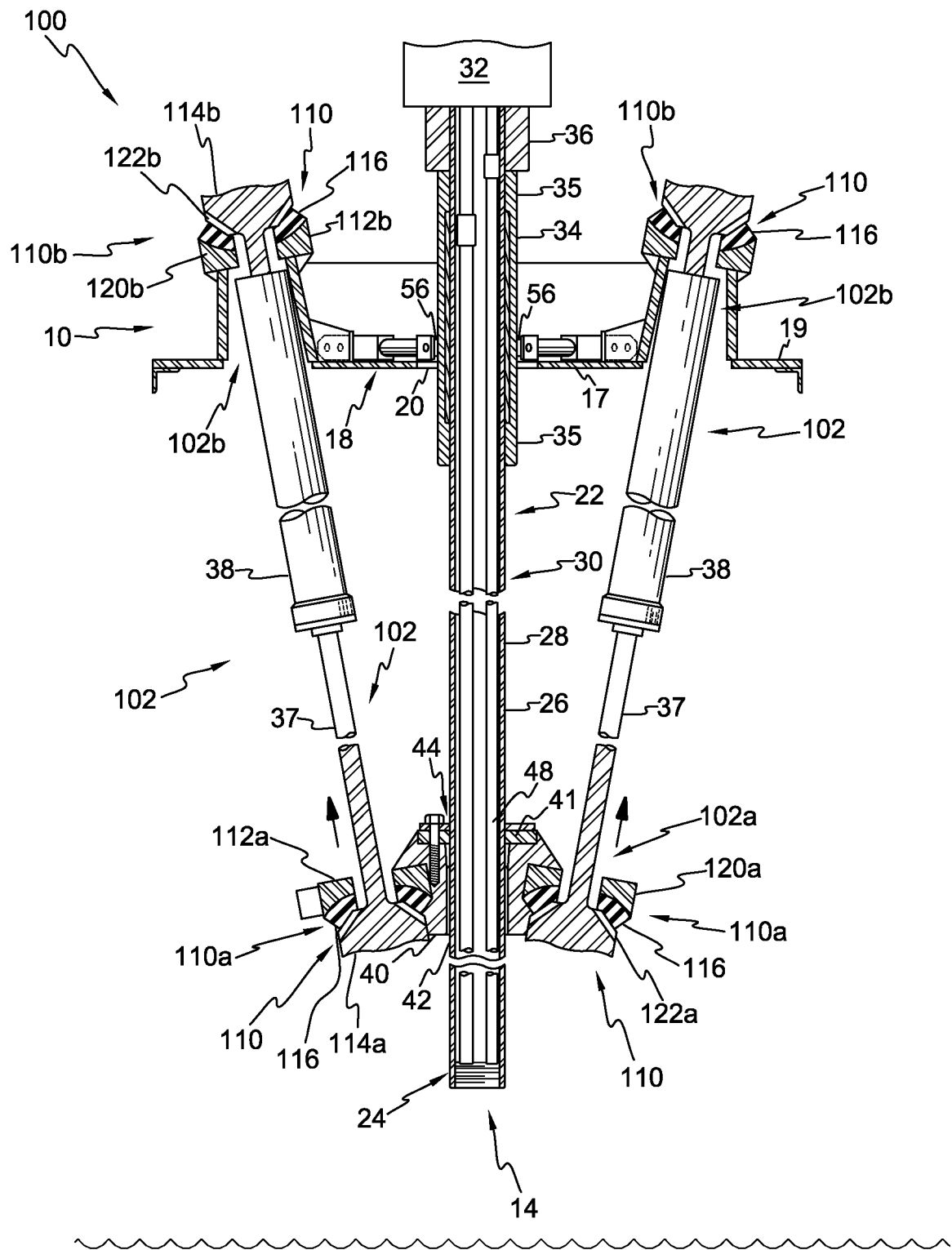


FIG. 2

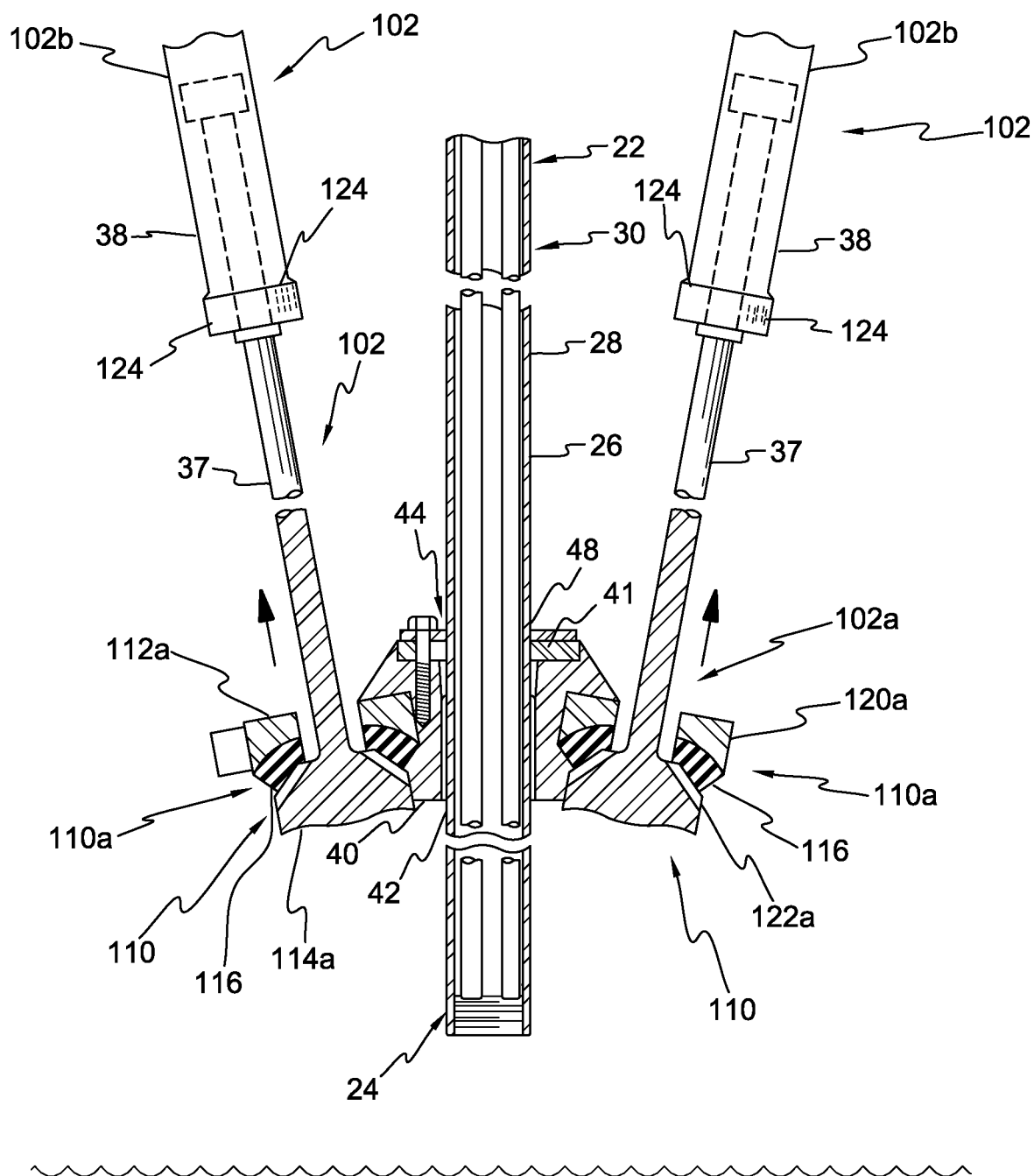


FIG. 2A

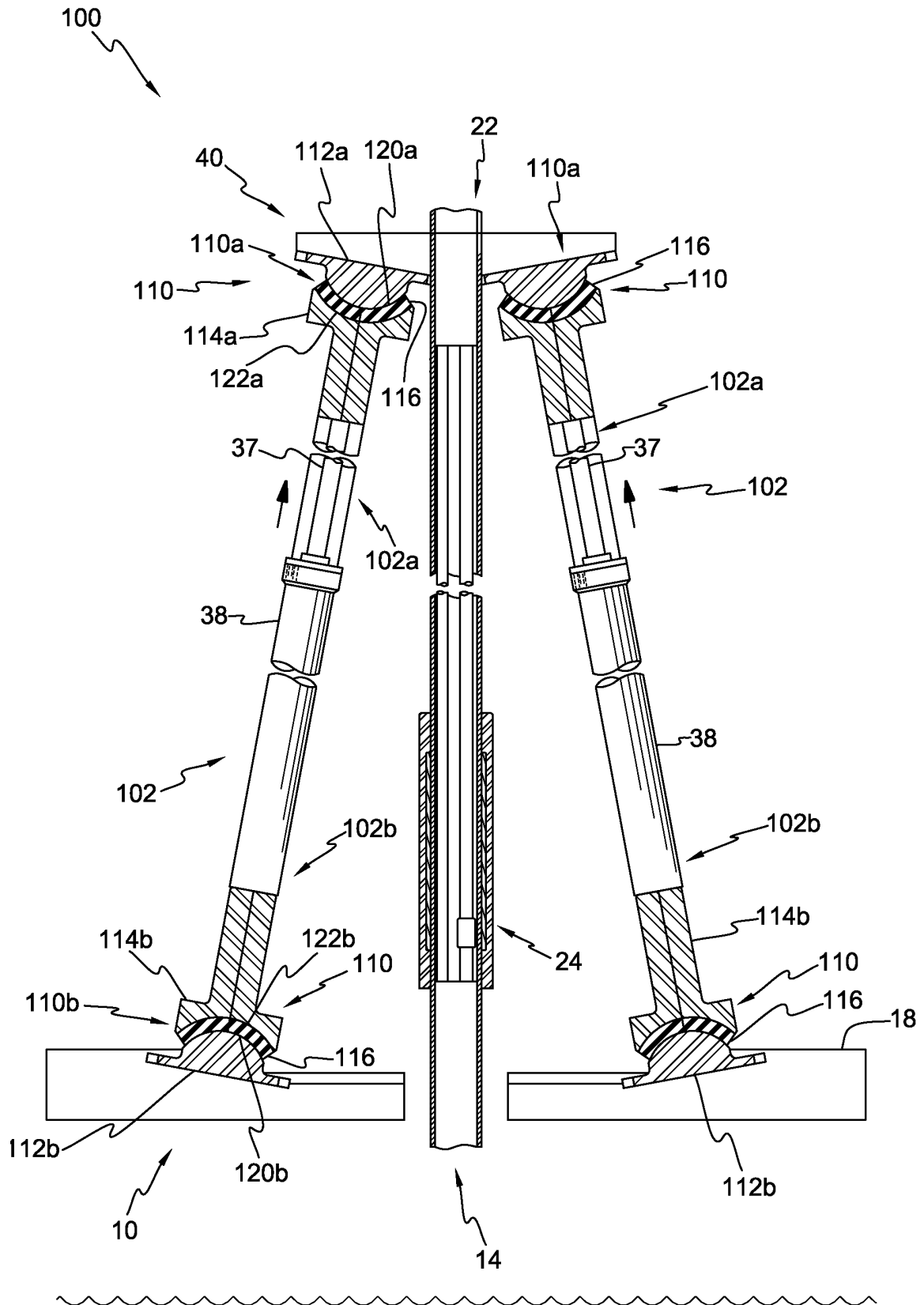


FIG. 3

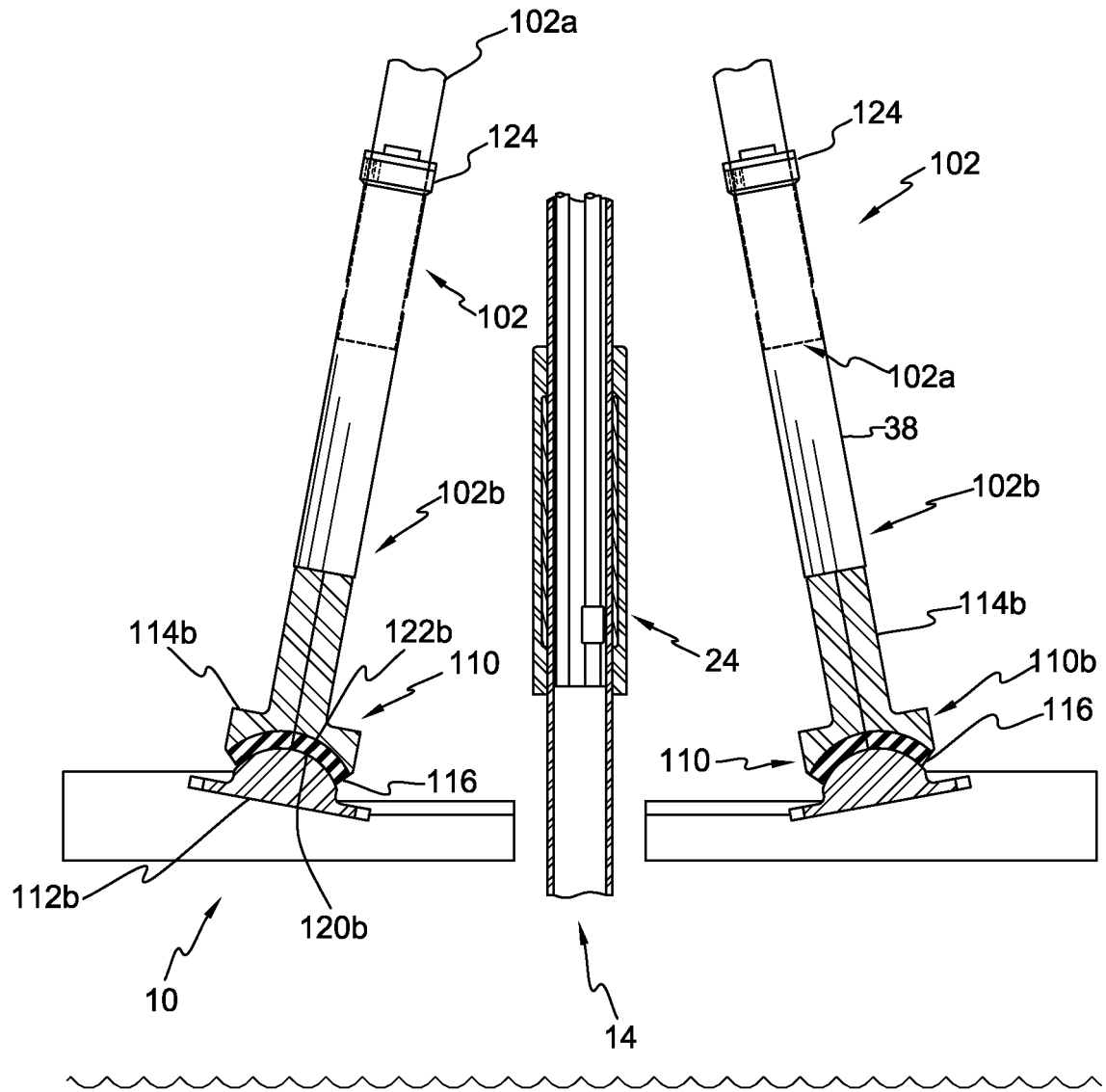


FIG. 3A

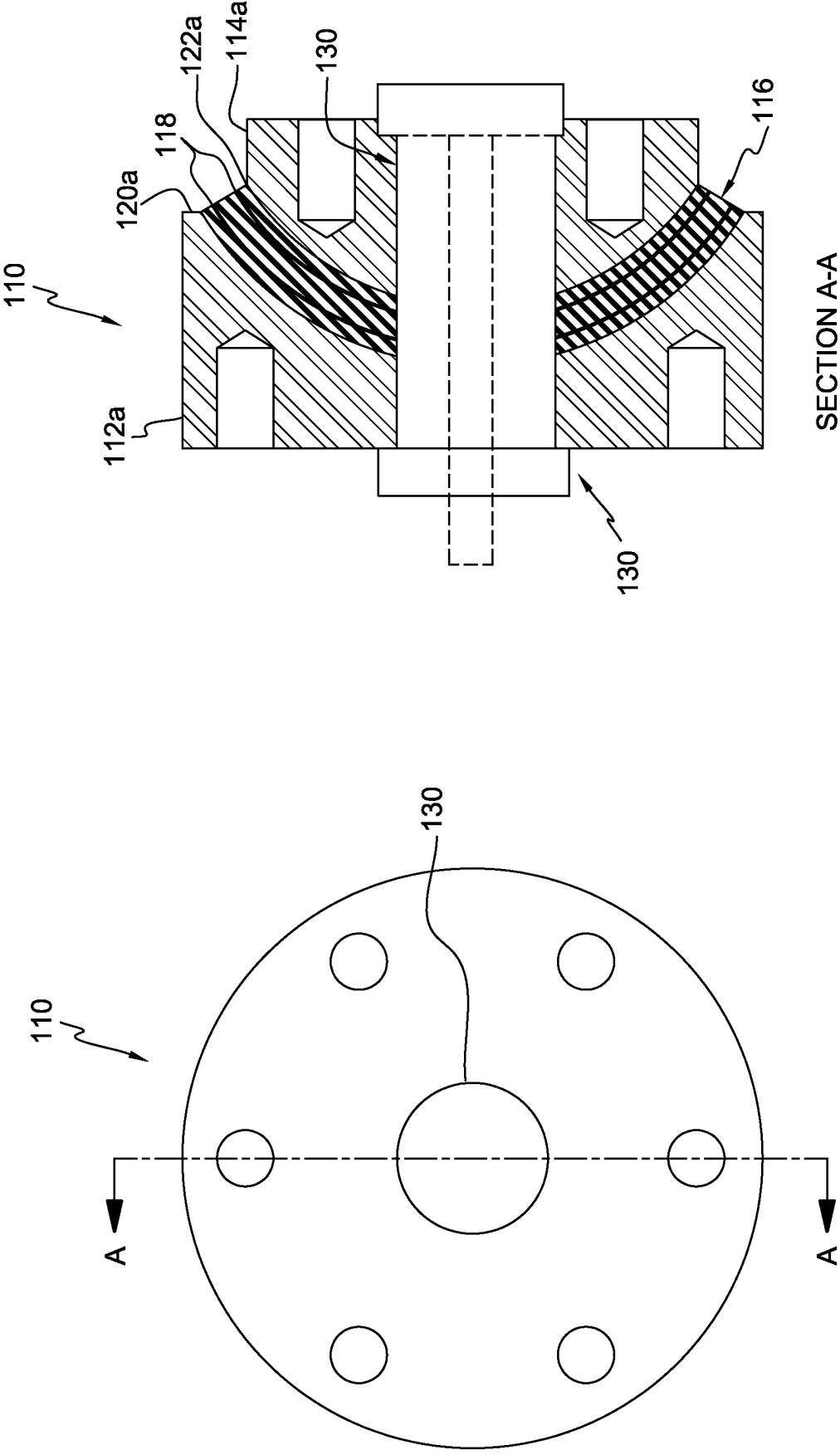
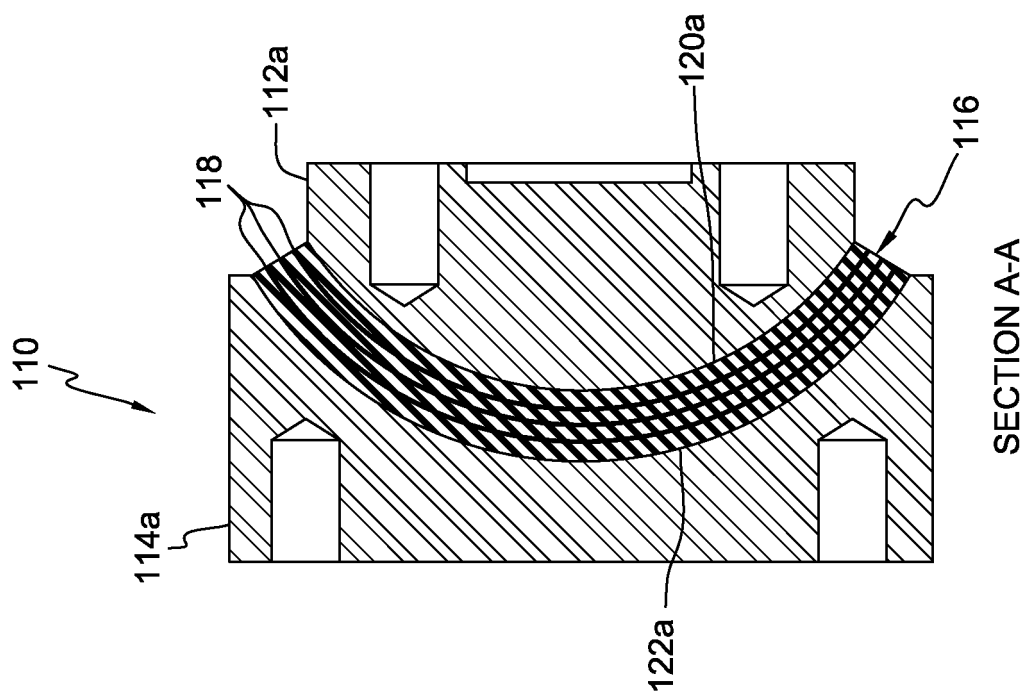


FIG. 4



SECTION A-A

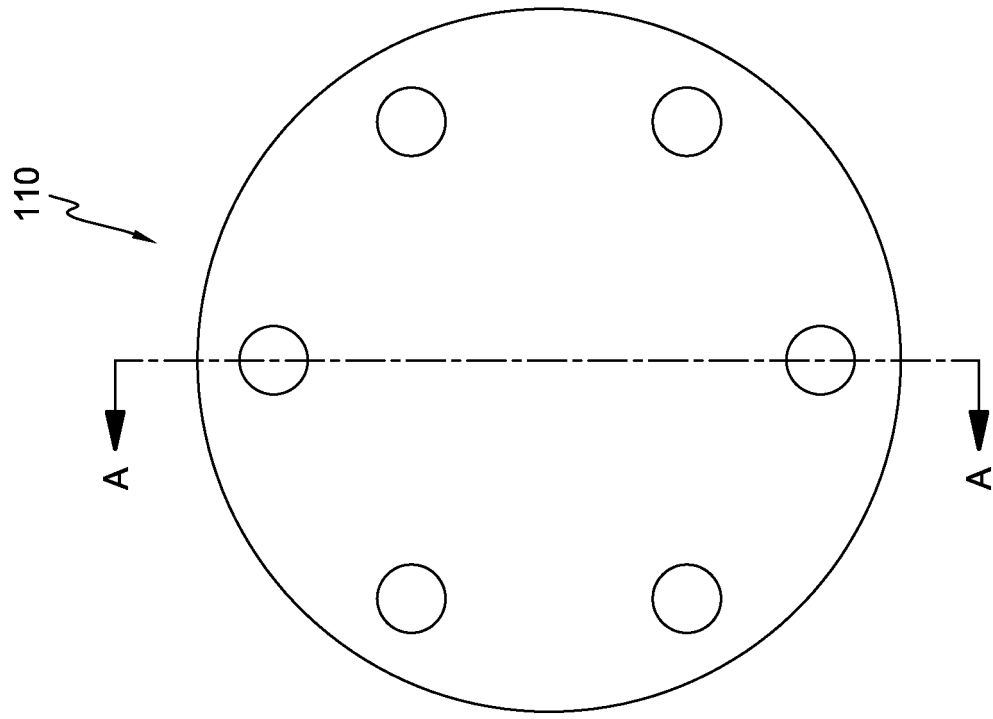


FIG. 5

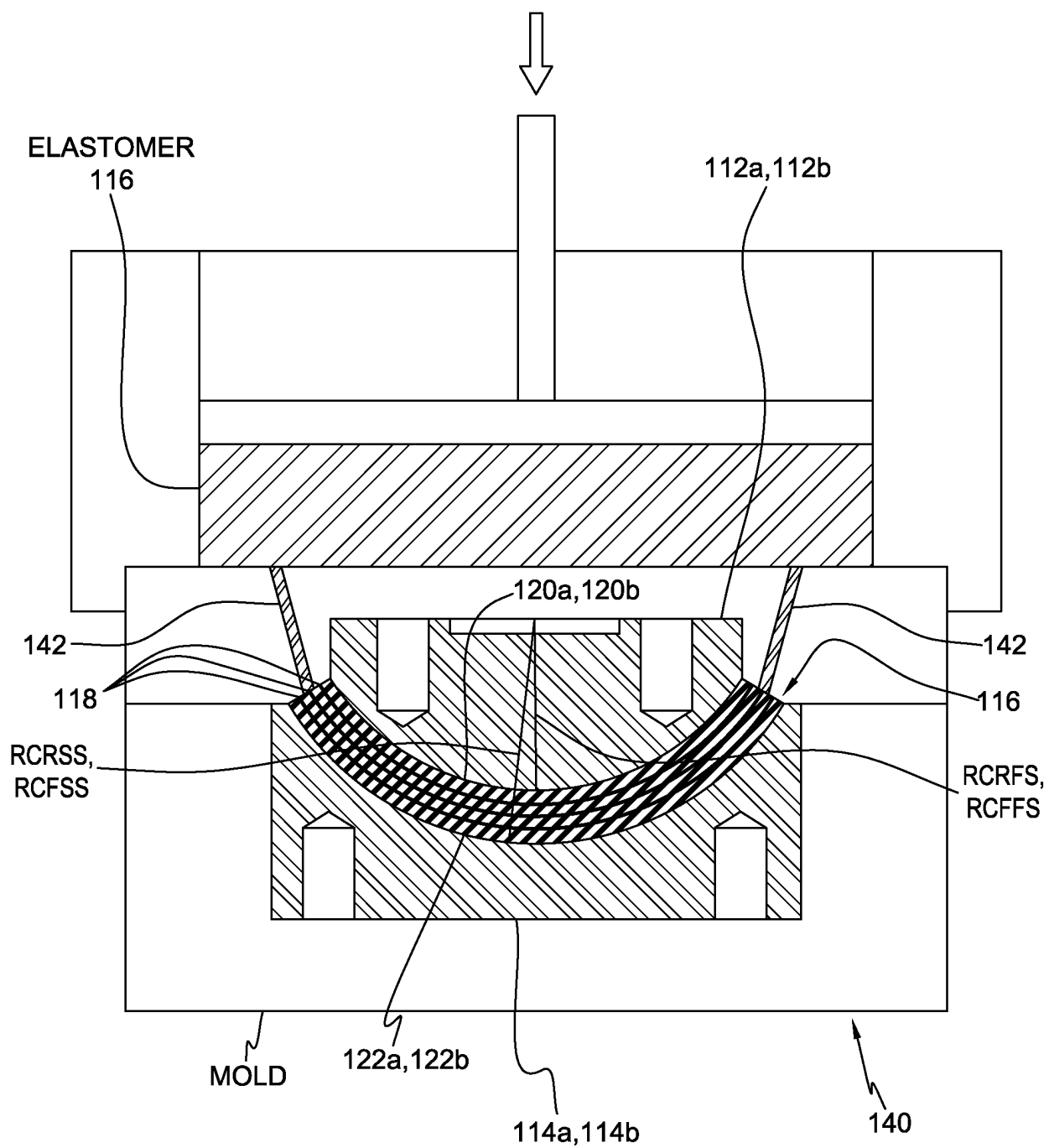
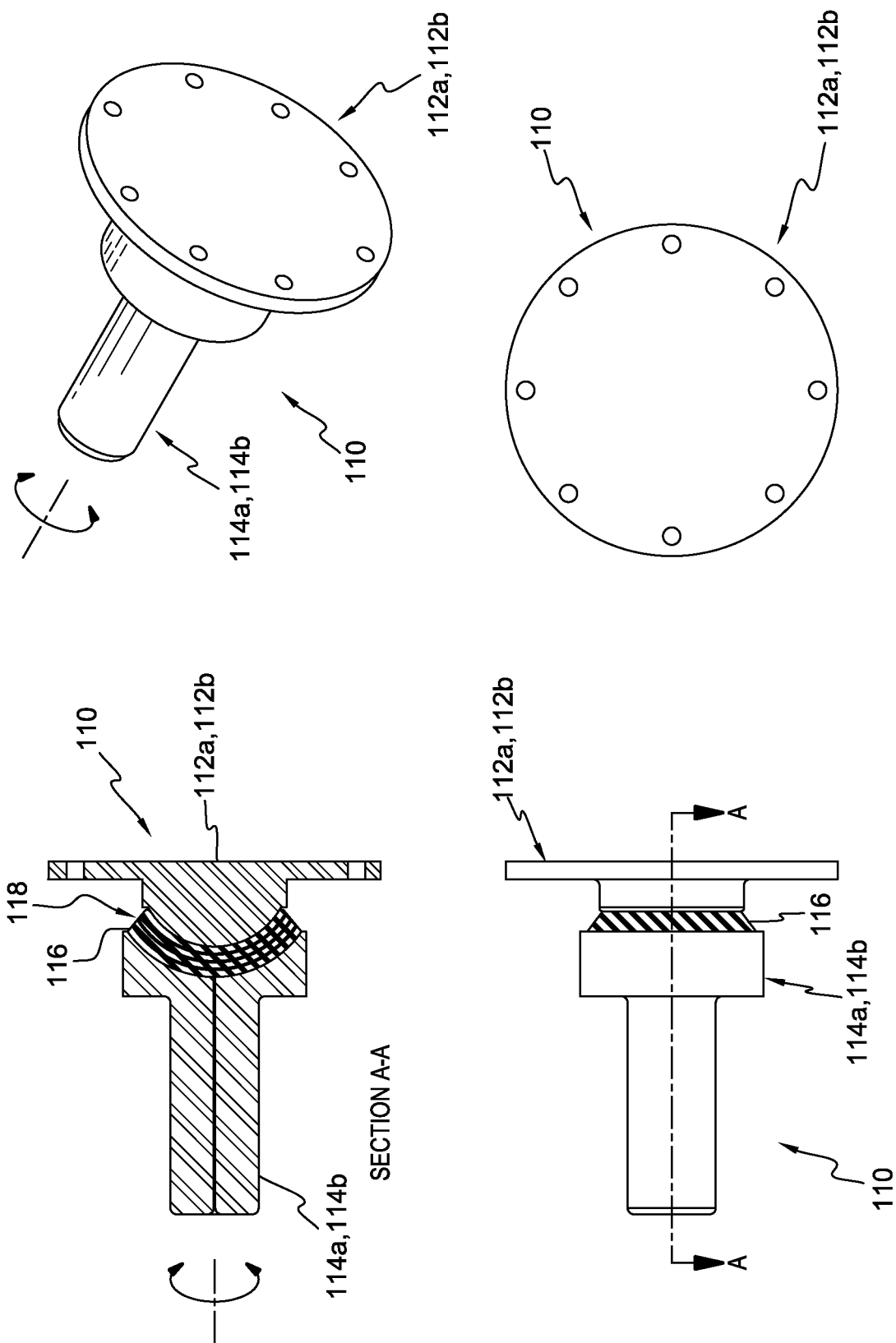


FIG. 6



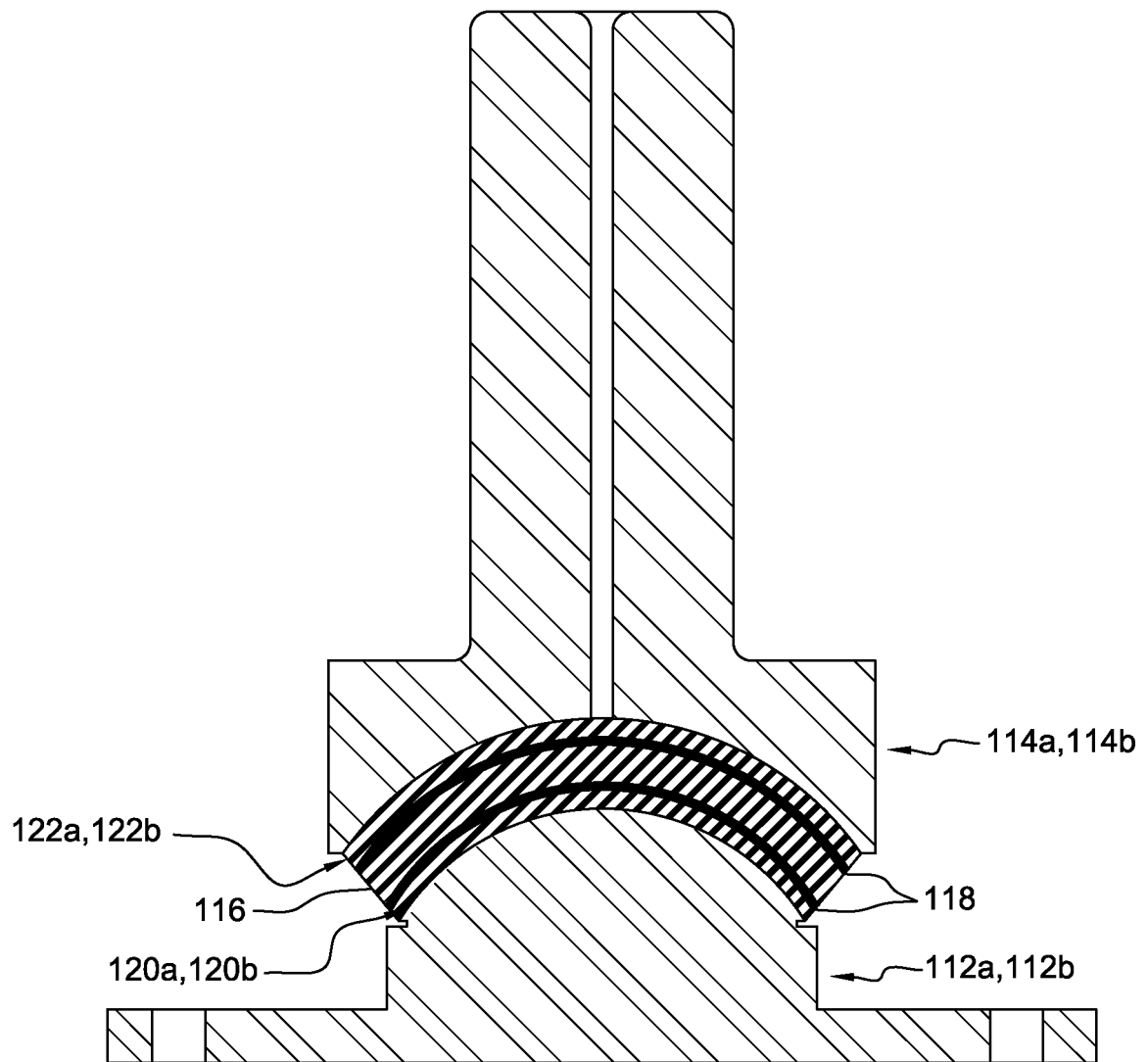


FIG. 8

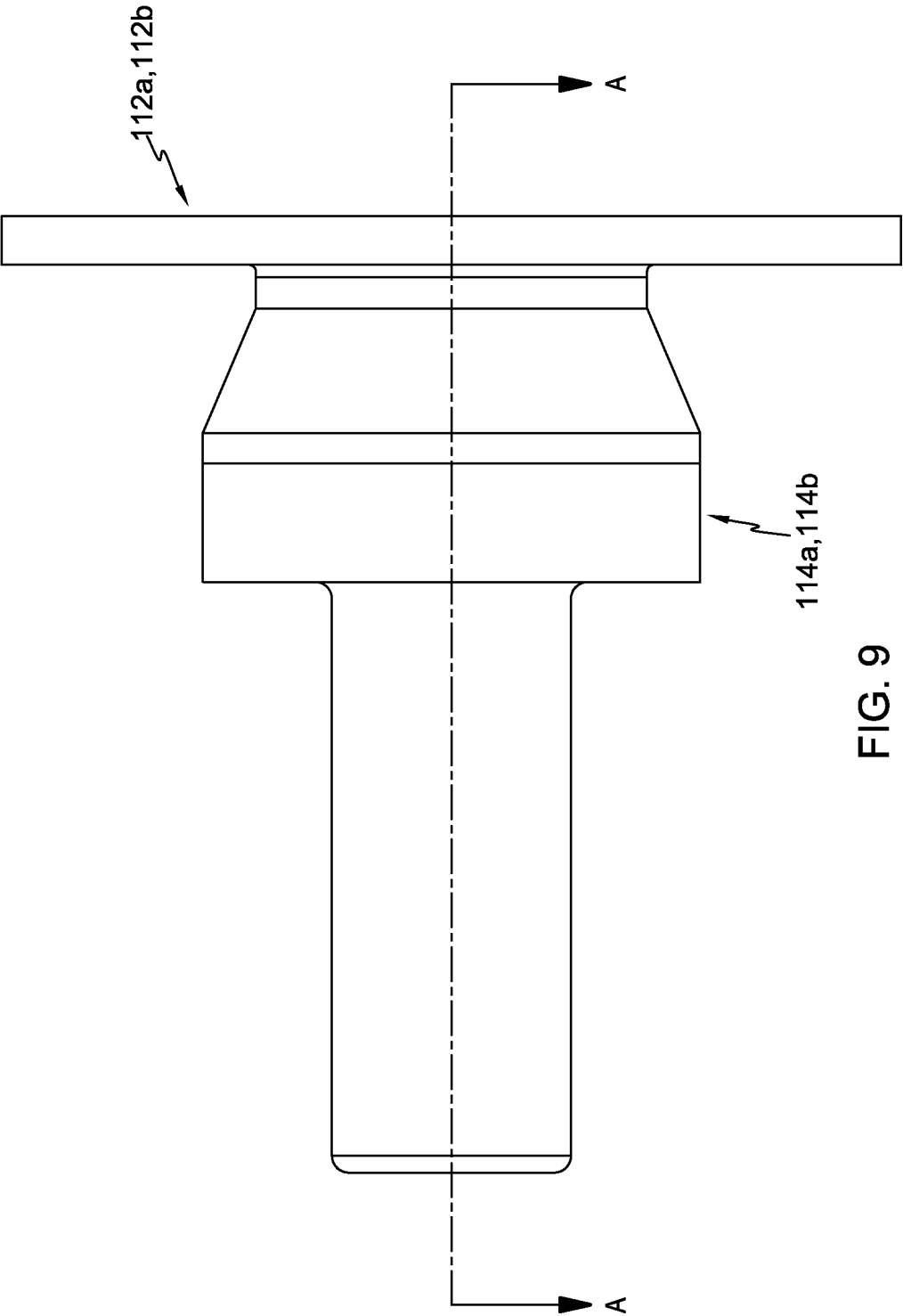


FIG. 9

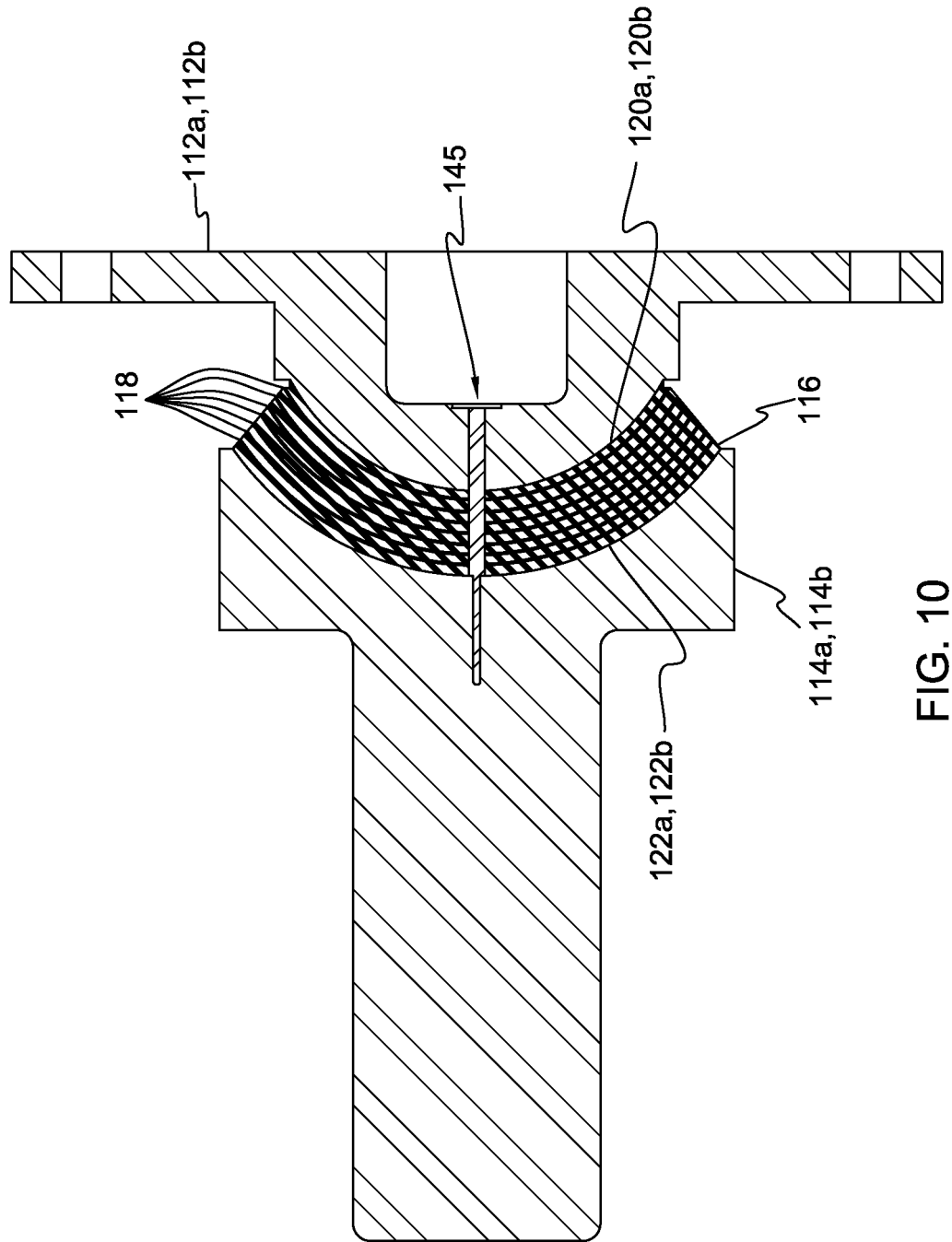


FIG. 10

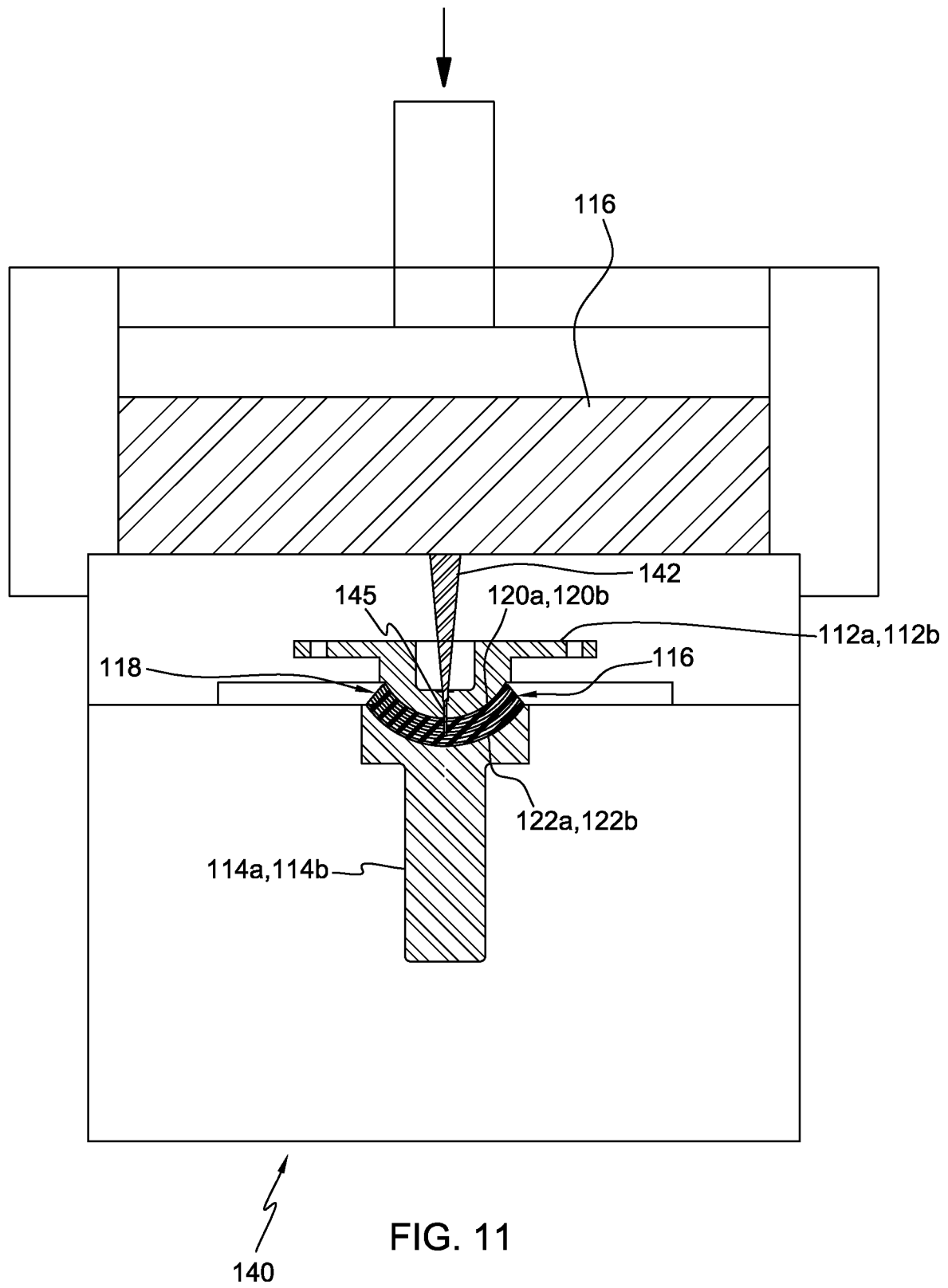


FIG. 11

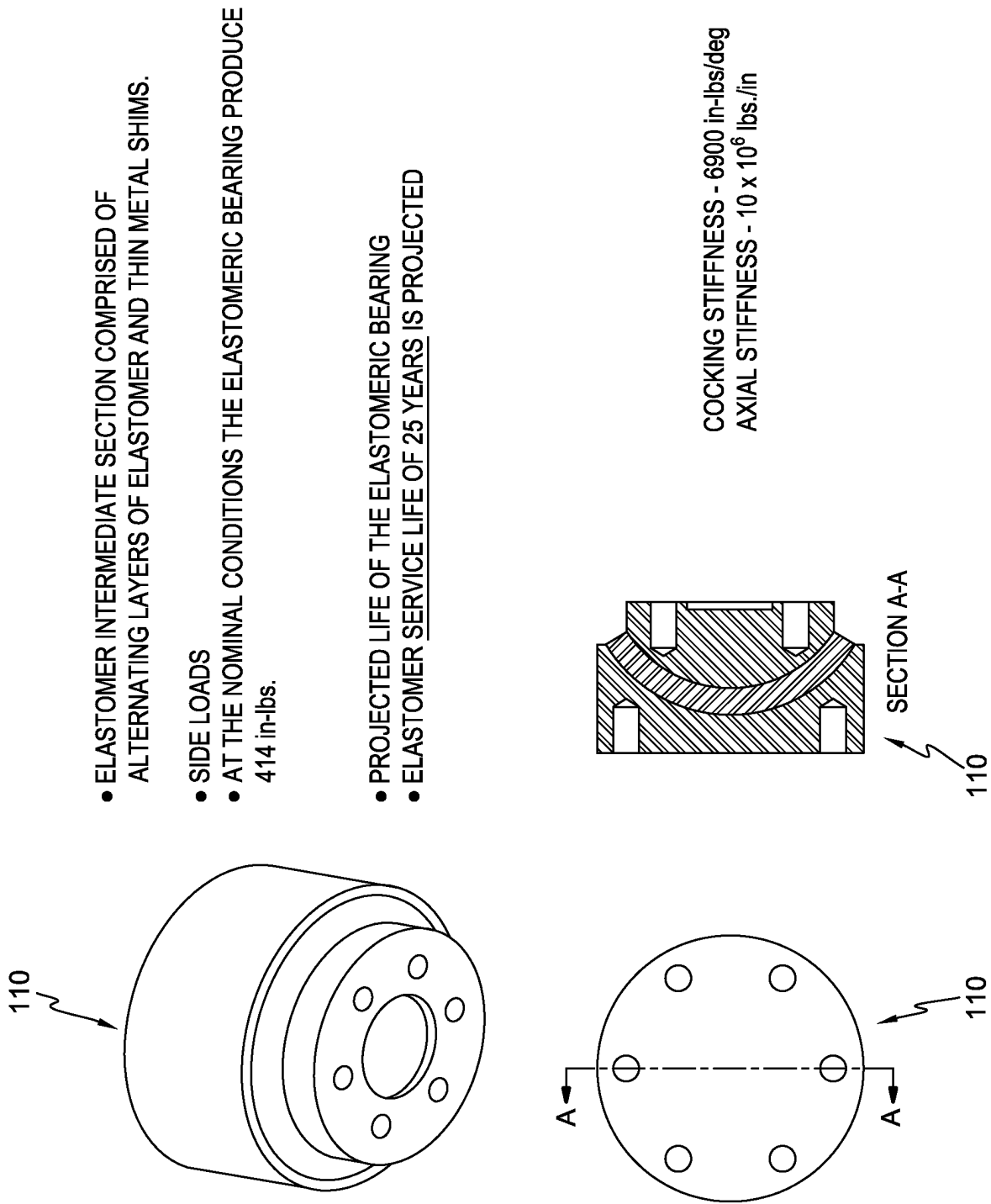


FIG. 12

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6431284 B1 [0002]
- US 4883387 A [0002]
- WO 9855355 A1 [0002]
- US 2005147473 A [0002]
- US 3958840 A [0002]