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(73) Proprietor: **Aker Solutions AS
1325 Lysaker (NO)**

(72) Inventors:
• **TANDBERG, Geir
3408 Tranby (NO)**
• **HALDORSEN, Henrik Dishington
1389 Heggedal (NO)**

• **MØGEDAL, Øystein
1388 Borgen (NO)**
• **HAVSTEIN, Kent
3132 Husøysund (NO)**
• **ERIKSEN, Bård Meling
0464 Oslo (NO)**

(74) Representative: **HGF
HGF Limited
1 City Walk
Leeds LS11 9DX (GB)**

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EP 4 172 460 B1

Description

TECHNICAL FIELD

[0001] This disclosure concerns an actuator, such as a subsea actuator for actuating a subsea valve; and associated methods, such as methods of actuating and/or overriding valves.

BACKGROUND

[0002] In the oil/gas industry, wellheads are typically at least partly controlled using Subsea Control Modules ("SCMs"), such as where an SCM controls a Xmas Tree ("XMT") associated with a production wellhead. The SCM provides well control functions, particularly during the production phase of subsea oil/gas production. The SCM contains electronics for performing a variety of functions, often including: processing communications signals, conditioning electrical power supplies, providing status information; and distributing signals and power to/from control valves, pressure/temperature sensors, and the like.

[0003] XMTs typically have various fluid barriers for controlling fluid, pressure, flow in the well. Periodically XMTs may require maintenance, inspection, etc. Often temporary barriers are placed using bores below the XMT. These bores are typically dedicated for such temporary use and access via these bores is only enabled when particular valves are open to allow such access. The valves are typically gate valves operable between a closed position, where the bore (below the XMT) is closed.

[0004] EP2165100 discloses a valve actuator comprising a screw member coupled to a valve stem and a sleeve such that rotation of the sleeve causes translation of the valve stem. The sleeve has a first end that is rotatably coupled to a housing that is fixably coupled to a valve body and a second end that projects out of the housing. The valve stem is partially disposed within the sleeve and extends into the valve body. A transmission is coupled to the housing and engaged with the sleeve. A motor is coupled to the transmission so that operation of the motor causes rotation of the sleeve.

[0005] WO 2019/141595 relates to a subsea electric actuator operating a linear valve, the actuator comprising a roller-screw for translating a rotational movement of a motor to a linear movement of a gate rod operating the valve.

[0006] The subject matter of at least some examples of the present disclosure may be directed to overcoming, or at least reducing the effects of, one or more of the problems of the prior art, such as may be described above.

Summary

[0007] According to a first aspect there is provided an

actuator as defined in the appended claims. The actuator comprises an electrically-operable actuator. The actuator may be for operating a valve. The actuator comprises a subsea actuator, such as a subsea electrical actuator for providing a subsea electrical actuation of the valve. The actuator comprises a screw assembly. The screw assembly comprises a roller screw. The screw assembly comprises a threaded part, such as a female threaded part (e.g. a nut), for receiving the screw. The screw assembly comprises a roller screw assembly. The roller screw assembly comprises a roller screw and a roller nut. The actuator comprises a housing for the screw assembly. The actuator comprises an axial stop for preventing axial movement relative to the housing of one of the screw and the threaded part. The actuator comprises a primary drive for providing a rotational movement to the screw assembly in a normal mode of operation. The screw assembly is for converting the rotational movement to an axial movement of a valve member relative to the housing. The actuator comprises an override for operating the actuator in an override mode of operation. The override is configured to release at least one of the screw and the threaded part for axial movement relative to the housing. The actuator may be configured to be overridden by release of at least a portion of the screw assembly. The portion for release in override may be otherwise fixed or restrained in normal operation of the actuator. The actuator may be configured for override by release of the entire screw assembly, such as release of the screw assembly relative to a housing of the actuator.

[0008] The screw assembly may comprise a longitudinal member for axial movement along a central axis of the longitudinal member. The longitudinal member may comprise the screw of the screw assembly. The screw of the screw assembly may be a spindle. The longitudinal member may comprise a solid member. The longitudinal member may comprise a rigid, solid rod. The screw assembly may comprise a transmission for transferring drive to or from the longitudinal member. A threaded part assembly, such as a roller nut assembly, may comprise the transmission. The roller nut assembly may comprise a plurality of rollers for transmitting drive between the screw and the roller nut of the roller screw assembly. The transmission may convert a rotational motion of the screw to a longitudinal motion of the threaded part. Alternatively the transmission may convert a rotational motion of the threaded part to a longitudinal motion of the screw.

[0009] The screw assembly may be operable by converting rotational movement or torque, such as from a motor (e.g. electric), to axial movement or force. The axial movement or force may be relative between the longitudinal member of the screw and the transmission. For example operation of the screw may provide an axial movement of the threaded part relative to the screw. The axial movement may comprise linear movement. The screw assembly may define a linear actuator. The actuator may comprise the motor. The motor may comprise the primary drive for operating the actuator in the normal

mode of operation.

[0010] The screw assembly may be operable to axially drive the valve between positions. The screw assembly may be operable to selectively drive the valve cyclically between open and closed positions. For example, the screw assembly may be operable to push a valve member to an open position and to pull the valve member to a closed position. The screw assembly may comprise a push member. The push member may comprise a push rod. The push rod may comprise a hollow push rod. Accordingly, the push member may comprise a push tube.

[0011] The valve may comprise a valve member, such as a valve rod or stem. The valve stem may extend through a stem seal. In at least some examples, the valve assembly may comprise a bonnet, the bonnet housing the stem seal through which the valve stem may extend. The valve may comprise a bore-sealing member, the bore-sealing member being configured to sealingly occlude access via a bore. The bore may be for providing access below a XMT, such as when a XMT is removed, damaged, being inspected or repaired, etc. The valve may comprise a seat for the bore-sealing member. The bore-sealing member may comprise a gate. The valve stem may be perpendicular to the bore, with the valve stem being axially movable along its axis perpendicular to the bore. Accordingly, the bore-sealing member may be movable transversely into and out of the bore to respectively close and open the bore (e.g. for access via the bore).

[0012] At least one of the screw and the threaded part of the screw assembly may be operatively associated with the valve member. For example, the threaded part may be connected to the valve member such that axial movement of the threaded part axially moves the valve member. In other examples, the screw may be connected to the valve member, such that axial movement of the screw axially moves the valve member. The screw or the threaded part may be connected to the push member. The portion of the screw assembly connected to the valve member (e.g. via the push member) may be an axially movable member of the screw assembly. The other portion of the screw assembly may be an axially stationary member of the screw assembly, at least during normal or primary operation of the actuator. For example, the threaded part may be the axially movable member and the screw may be the axially stationary member (or vice versa). The push member may be configured to push the valve stem. The push member may be configured to pull the valve stem. The push member may be attached to the valve stem.

[0013] The actuator may comprise a housing. The housing may be configured to maintain an axial position of the axially stationary member of the screw assembly. For example, the housing may comprise an axial stop for maintaining the axial position of the screw. The axial stop may prevent axial movement of the axially stationary member in a first and/or a second axial direction. In at

least some examples, the housing may prevent axial movement in both axial directions. The axial directions may be parallel with the longitudinal axis of the screw. The housing may limit or prevent movement of the axially stationary member during normal operation of the actuator. Accordingly, in at least some examples, the actuator may be normally operable to actively rotate, such as driven by the motor, the screw to axially displace the threaded part, thereby axially displacing the valve member associated with the threaded part.

[0014] The actuator may comprise a bearings assembly comprising a bearings casing containing bearings. The bearings may support at least a portion of the screw assembly. For example, the bearings may support the screw. The bearings may comprise contact angle bearings. The bearings may provide a high degree of axial stiffness. The bearings may provide a high axial load carrying capacity. The bearings may provide accommodate high speeds and rapid accelerations; and offer high running accuracy. The bearings may provide a safe radial and axial support. The bearings may provide an extremely precise axial guidance of the longitudinal member (e.g. the screw).

[0015] The bearings assembly may comprise a bearing sleeve. The bearing sleeve may be configured to transfer loads. The bearings sleeve may be configured to keep the bearings pre-loaded.

[0016] In at least some examples, the housing may at least partially seal the actuator. For example, the housing may seal an interior of the actuator from an exterior of the actuator. The housing may comprise a cylinder, with the axial movement being along an axis parallel to a central longitudinal axis of the cylinder.

[0017] The screw may be electrically operable. The screw may be electrically operable by selectively supplying electrical power to a motor for driving the transmission. For example, an electric motor may be associated with the screw of the screw assembly. Rotation of the screw (e.g. at or towards a first end of the screw) may force the threaded part to move axially, parallel to a central longitudinal axis of the screw. The screw may comprise a spline, such as a screwthread. The threaded part may comprise an interface/s for engaging the screw, such as an interengaging complementary profile. The threaded part may comprise a screwthread/s for engaging the screw. The threaded part may comprise a threaded part assembly.

[0018] The actuator may be configured to provide an alternative drive to the valve member. The actuator may be configured to move the valve member in an event of a failure of the screw assembly or a component thereof, or of the primary drive thereto. The actuator may be configured to move the valve member in an event of the screw assembly becoming stuck.

[0019] The actuator may comprise an override. The override may be configured to allow operation of the valve without requiring transmission of drive from the primary drive. The primary drive may comprise the drive normally

used to operate the screw. The override may be configured to release at least one of the screw and the threaded part of the screw assembly. In at least some examples, the override may be configured to enable movement of the screw assembly in unison. The override may be configured to enable movement of the screw assembly as a single unit. For example, the override may be configured to enable axial movement of the screw and the threaded part together. The override may be configured to move, such as translate, the entire screw assembly. The override may be configured to move the screw assembly without causing or requiring relative movement between the screw and the threaded part. The override may be configured to allow axial movement of the portion of the screw assembly that is normally axially stationary during normal operation of the actuator. For example, where the screw is normally stationary, the override may be configured to allow axial movement of the screw during the override mode of operation.

[0020] In at least some examples, the override comprises a release mechanism. The release mechanism may be configured to allow a movement of at least one of the screw and/or the threaded part. The movement may comprise an axial movement. The movement may comprise a movement not otherwise possible without or prior to the operation of the override. The release mechanism may be configured to allow axial movement of the axially stationary member, upon activation of the override. For example, activation of the override, operating the release mechanism, may allow axial movement of the screw not normally possible during normal operation of the actuator.

[0021] The override may comprise a releasable stop. The releasable stop may comprise an axial stop defining or limiting axial movement in at least one direction for at least one of the screw and/or threaded part. The releasable stop may define or limit an axial position of the axially stationary member. The axial stop may comprise a shoulder. The axial stop may comprise a bearing shoulder. Operation of the override to release the releasable stop may allow movement of the stationary member of the screw assembly not otherwise possible without or prior to the operation of the override. For example, in normal operation of the actuator the screw may be axially stationary, with driven rotation of the screw consequently driving axial movement of the threaded part. When the actuator override is activated, operation of the actuator in override mode may allow axial movement of the screw. Accordingly, in at least some examples, the override may allow axial movement of both the screw and the threaded part, such as in tandem or unison.

[0022] In at least some examples, the releasable stop may comprise a backplate, or at least a portion thereof. The method of override may comprise a release of at least a portion of the backplate. The portion of the backplate may be connected to or associated with the portion of the screw assembly. The release mechanism may comprise a weakness, such as a predefined weakness.

The actuator may be reconfigurable from a normal mode of operation to an override mode of operation upon activation or rupturing of the predefined weakness.

[0023] The release mechanism may be configured to release the bearing assembly for axial movement. The bearing assembly may normally be axially fixed or limited, such as by the axial stop. Accordingly, operation of the override may allow axial movement of the bearing assembly, such as jointly with the longitudinal member. In at least some examples, the override is configured to release the bearings casing for axial movement. Accordingly, the bearings casing may be axially movable, such as with the screw, upon activation of the override. The bearings casing may be axially stationary during normal operation, such as being stopped by the axial stop.

[0024] The release mechanism may be configured to release the longitudinal member from the bearing assembly. For example, the release mechanism may be configured to allow the longitudinal member to move longitudinally relative to the bearing assembly in the override mode. The longitudinal member may be axially immovable relative to the bearings assembly during normal operation of the actuator.

[0025] The release mechanism may comprise an external release interface. The external release interface may be external of the actuator housing, such as a cylinder containing the actuator. The release mechanism may comprise a release member. The release mechanism may comprise an external release member. The external release member may comprise an external sleeve, such as located on an exterior of the actuator housing. Accordingly, the release mechanism may be operated externally of the actuator. The release mechanism may normally be locked in position, such as by a mechanical lock. In at least some examples, the mechanical lock comprises a shear pin. The mechanical lock may be for limiting or preventing movement of the release member, such as in normal use of the actuator. The shear pin may be disassociated with the screw assembly. The shear pin may be isolated from forces associated with the screw assembly. For example, forces associated with the screw assembly or bearings therefore may be isolated from the shear pin. Accordingly, the shear pin may be prevented from shearing due to movement or force associated with the normal operation of the screw assembly. The shear pin may be sheared by a movement or force applied to an external portion of the actuator. For example, the shear pin may be, optionally may only be, sheared by a force applied externally to the release member.

[0026] Different examples may comprise different release mechanisms. In at least some examples, reconfiguration of the actuator from the normal mode of operation to the override mode of operation may comprise an irreversible process, or at least only reversible by a resetting and/or retrieval of at least a portion of the actuator. For example, the actuator may be reconfigurable to the override mode of operation by activation or

rupturing of the predefined weakness. The predefined weakness may comprise a shear pin, rupture disc and/or a portion of another member, such as a predefined thinning or narrowing (e.g. of a portion of the backplate). In other examples, the reconfiguration of the actuator from the normal mode of operation to the override mode of operation may be reversible.

[0027] The actuator may be configured for bidirectional operation by the override tool. The actuator may be configured to activate and/or deactivate by the override tool. For example, the actuator may be configured to both open and close the valve with the override tool.

[0028] The actuator may comprise a retainer. The retainer may comprise or be associated with the axial stop. In at least some examples, the retainer retains the axial stop axially during normal operation of the actuator. Activation of the release mechanism may comprise a transverse movement of the axial stop or a member associated therewith. The transverse movement may be of the retainer. The retainer may comprise a ring, such as a lock ring. The lock ring may comprise a split lock ring. The retainer may comprise a pretension when assembled in the actuator. For example, the retainer may comprise a transverse, such as radial, pretension when assembled in the actuator. The pretension may assist in maintaining the retainer in its normal retaining position during normal operation of the actuator. Alternatively, the pretension may assist in releasing the retainer from its normal position when the release mechanism is activated. The retainer may normally be locked in position during normal operation of the actuator. The override may release the retainer.

[0029] The release mechanism may be configured to release the bearing assembly for axial movement. The bearing assembly may normally be axially fixed or limited, such as by the axial stop. Accordingly, operation of the override may allow axial movement of the bearing assembly, such as jointly with the longitudinal member. In at least some examples, the override is configured to release the bearings casing for axial movement. Accordingly, the bearings casing may be axially movable, such as with the screw, upon activation of the override. The bearings casing may be axially stationary during normal operation, such as being stopped by the axial stop.

[0030] The override may not comprise a bypass, such as a bypass for bypassing one or more of the screw and/or the threaded part. In at least some examples, the override utilises at least some functionality of the screw assembly to operate the valve member. The override may utilise a same connection of the screw assembly to the valve member for operating the valve assembly in override mode as the connection of the screw assembly to the valve member for operating the valve assembly in normal or primary operation, such without or prior to operation of the override. The override may allow operation of the same push member for pushing and/or pulling the valve member as in normal or primary operation of the actuator. The override may be configured to utilise the

interface between the screw and the threaded part of the screw assembly. The override may be configured to utilise the interface between the screw and the threaded part of the screw assembly to directly transmit force and/or movement in a same direction or mode. For example, the override may allow a transfer of an axial force and/or axial movement between the screw and the threaded part (e.g. axially pushing/pulling the screw may axially push/pull the threaded part via the spline interface/s therebetween). Additionally, or alternatively, the override may be configured to rotate the screw and/or the threaded part. Accordingly, the actuator may not comprise or require an additional or alternative connection.

[0031] The actuator may comprise an interface for an override tool. The override tool interface may comprise an external interface. The external interface may be axially external to the actuator. For example, where the actuator housing comprises a cylinder, the override tool interface may be provided at or through an axial end of the cylinder. The override tool interface may be positioned with the screw assembly located between the override tool interface and the valve member. The override tool interface may be configured to transmit torque and/or axial force to at least a portion of the screw assembly to move the valve member. The override tool interface may comprise a torque interface to allow clockwise and/or counter-clockwise torque to be applied to at least a portion of the screw assembly to move the valve member. The override tool interface may be configured to drive the at least a portion of the screw assembly axially in a first direction to push the valve member. Additionally, or alternatively, the override tool interface may be configured to drive the at least a portion of the screw assembly axially in a second direction to pull the valve member. The override tool interface may be configured to drive the at least a portion of the screw assembly axially to open the valve member. Additionally, or alternatively, the override tool interface may be configured to drive the at least a portion of the screw assembly rotationally to open the valve member.

[0032] The override tool may comprise an alternative drive. The alternative drive may comprise an electric drive, such as an alternative electric motor. Additionally or alternatively, the alternative drive may comprise a hydraulic drive.

[0033] The override tool may be operated remotely. The override tool may comprise or may be operated by a ROV. Additionally, or alternatively, the override tool may be operated manually. In at least some examples the actuator may be configured for override operation by a plurality of override tools. For example, the actuator may be configured to be operated by a ROV override tool in a first override operation; and operated manually in a second override operation (e.g. if the first override operation was unsuccessful; or if subsequently the first override operation was desired to be reversed).

[0034] The actuator may comprise a rotational stop for

at least one of the screw and the threaded part. The rotational stop may prevent or at least limit rotation of the axially-movable member, at least during normal operation of the actuator. Accordingly, the rotational stop may provide for conversion of relative rotation between the screw and the threaded part to axial movement. The axial movement may therefore may be pure, non-rotational linear movement in the axial direction. The rotational stop may comprise at least one anti-rotation pin. The actuator may comprise a guide member for guiding axial movement of the threaded part and/or the screw. For example, the guide member may comprise a pin in an axial channel. The axial channel may be provided in or associated with the housing; and the guide pin provided in or associated with the threaded part. Alternatively, the axial channel may be provided in or associated with the threaded part

[0035] The actuator may comprise an underwater or subsea actuator. The actuator may comprise a subsea electrical actuator for providing a subsea electrical actuation.

[0036] The valve may comprise a subsea valve. The valve may comprise a linear valve, such as a gate valve. The valve may be for selectively providing access via a bore below a XMT. The valve may be normally closed, such as during normal operation of the XMT. The valve may be selectively openable by operation of the actuator.

[0037] The screw assembly may comprise a planetary screw assembly, such as a planetary roller screw assembly. The screw assembly may comprise a non-recirculating screw assembly. The lack of axial movement of the screw may not move axially relative to the threaded part. The screw assembly may comprise an inverted screw assembly, such as an inverted roller screw assembly. The screw assembly may comprise a reverse screw assembly, such as a reverse roller screw assembly.

[0038] The screw may comprise a recirculating screw, such as a recirculating roller screw. The rollers may move axially within the nut. The rollers may be reset, such as after one orbit about the screw.

[0039] The actuator may be configured for high-precision. The actuator may be configured for high-speed. The actuator may be configured for heavy-load applications. The actuator may be configured for long-life applications. The actuator may be configured for heavy-use applications.

[0040] In at least some examples, the actuator is used as a subsea actuator to provide an axial force to an element. The actuator may be used to operate one or more valves, such as a gate valve/s. The valve may form part of a XMT, such as a vertical XMT. The XMT may comprise an Enhanced Vertical Deepwater Tree. The actuator may be used in an all-electric application, such as an all-electric XMT, Wellhead, SCM or the like.

[0041] According to a further aspect, there is provided an apparatus comprising the actuator of any other aspect, example, embodiment or claim. The apparatus may comprise a subsea apparatus for the oil/gas industry. The

apparatus may comprise a wellhead apparatus for controlling access to a hydrocarbon wellbore. The apparatus may comprise a subsea valve. The apparatus may comprise a subsea control module ("SCM"). The apparatus may comprise a subsea electronics module ("SEM").

[0042] According to a further aspect, there is provided a method of actuation. The method may comprise providing the actuator of any other example, embodiment, claim or aspect. The method may comprise a method of subsea or underwater actuation. The method may comprise providing the actuation in the apparatus of any other aspect, example, embodiment or claim.

[0043] The method may comprise providing a subsea electrical actuator for actuating a valve, the actuator comprising a screw assembly comprising a screw and a threaded part. The screw may comprises a roller screw and the threaded part may comprise a nut. The method may comprise using an axial stop of the actuator to prevent axial movement of one of the screw and the threaded part, the axial movement being relative to a housing for the screw assembly. The method may comprise providing a rotational movement to the screw assembly in a normal mode of operation with a primary drive. The method may comprise using the screw assembly to convert the rotational movement to an axial movement of a valve member relative to the housing. The method may comprise using an override to operate the actuator in an override mode of operation. The method may comprise releasing at least one of the screw and the threaded part for axial movement relative to the housing. The method may comprise axially moving at least one of the screw and the threaded part to move the valve member. The method may comprise axially moving the screw assembly as in unison, as a single unit, to move the valve member.

[0044] The method may comprise releasing the axial stop to release at least one of the screw and the threaded part for axial movement relative to the housing, with the axial stop comprising a shoulder preventing the axial movement of at least one of the screw and the threaded part in normal operation of the actuator. The method may comprise overriding an electric motor that is used to operate the actuator in the normal mode of operation. The method may comprise using an alternative drive to operate the actuator in the override mode of operation.

[0045] The method may comprise operating a valve of a wellhead apparatus for controlling access to a hydrocarbon wellbore.

[0046] According to a further aspect there is provided an apparatus designed and/or manufactured according to the method of any other aspect, example, embodiment or claim.

[0047] According to a further aspect there are provided at least some examples of an oil/gas apparatus comprising the apparatus of any other aspect, example, embodiment or claim. The oil/gas apparatus may comprise wellhead apparatus, such as a manifold.

[0048] Another aspect of the present disclosure pro-

vides a computer program comprising instructions arranged, when executed, to implement a method in accordance with any other aspect, example, claim or embodiment. A further aspect provides machine-readable storage storing such a program. The storage may be non-transitory. In at least some examples, the computer program may be for controlling the actuator and/or the override thereof.

[0049] According to an aspect of the invention, there is provided computer software which, when executed by a processing means, is arranged to perform a method according to any other aspect, example, claim or embodiment. The computer software may be stored on a computer readable medium. The computer software may be tangibly stored on a computer readable medium. The computer readable medium may be non-transitory. For example, the computer software may be configured to control the actuator and/or the override thereof.

[0050] The invention includes one or more corresponding aspects, embodiments or features in isolation or in various combinations whether or not specifically stated (including claimed) in that combination or in isolation. For example, it will readily be appreciated that features recited as optional with respect to the first aspect may be additionally applicable with respect to the other aspects without the need to explicitly and unnecessarily list those various combinations and permutations here (e.g. the apparatus of one aspect may comprise features of any other aspect). Optional features as recited in respect of a method may be additionally applicable to an apparatus or device; and vice versa. The apparatus or device of one aspect, example, embodiment or claim may be configured to perform a feature of a method of any aspect, example, embodiment or claim. In addition, corresponding means for performing one or more of the discussed functions are also within the present disclosure. It will also be appreciated that features associated with one of the screw and the threaded part may also be associated with the other of the screw and the threaded part. For example, where examples or features are disclosed in combination with the screw it will be appreciated that those features may apply equally to the threaded part, and vice versa. In at least some examples, the roles of the screw and the threaded part may be inverted (e.g. the threaded part may be axially stationery and the screw axially movable, in normal operation, to axially move the valve member with the screw).

[0051] It will be appreciated that one or more embodiments/aspects may be useful in at least providing a subsea actuation.

[0052] The above summary is intended to be merely exemplary and non-limiting.

[0053] Various respective aspects and features of the present disclosure are defined in the appended claims.

[0054] It may be an aim of certain embodiments of the present disclosure to solve, mitigate or obviate, at least partly, at least one of the problems and/or disadvantages associated with the prior art. Certain embodiments or

examples may aim to provide at least one of the advantages described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0055] These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross-sectional diagram of an assembled subsea actuator and associated valve in a normal mode of operation;

Figure 2 shows the Fig. 1 subsea actuator in an override mode of operation;

Figure 3 shows a detailed view of a portion of the actuator of Figure 1;

Figure 4 shows a detailed view of a portion of the actuator of Figure 2;

Figure 5 is a flowchart showing a method of operating the actuator of Figure 1;

Figure 6 is a subsea actuator generally similar to that shown in Figure 1, in a normal mode of operation, also showing an override tool spaced from the actuator;

Figure 7 shows the actuator of Figure 6 showing the override tool in a first engaged position;

Figure 8 shows the actuator of Figure 6 with the override tool having sheared a shear pin of the actuator;

Figure 9 shows the actuator of Figure 6, with the override tool having partially moved a valve member associated with the actuator;

Figure 10 shows the actuator of Figure 6, with the override tool having fully moved the valve member, from a closed position of Figure 6 to an open position of Figure 10;

Figure 11 shows a detail view of the configuration of the actuator and override tool of Figure 6;

Figure 12 shows a detail view of the configuration of the actuator and override tool of Figure 7;

Figure 13 shows a detail view of the configuration of the actuator and override tool of Figure 8;

Figure 14 shows a detail view of the configuration of the actuator and override tool of Figure 9;

Figure 15 is a subsea actuator generally similar to that shown in Figure 6, in a normal mode of operation, also showing a release tool spaced from the actuator;

Figure 15a is a detail view of a portion of Figure 15;

Figure 16 shows the actuator of Figure 15 with the release tool moved into a first engaging position;

Figure 16a shows a corresponding detail view of Figure 16;

Figure 17 shows the actuator of Figure 15 after operation of the release tool;

Figure 18 shows the actuator of Figure 17, also showing an override tool spaced from the actuator;

Figure 19 shows the actuator of Figure 18, with the

override tool engaged with the actuator in a first position;

Figure 20 shows the actuator of Figure 10, with a stem of the override tool advanced to engage an interface of the actuator;

Figure 21 shows the actuator of Figure 21 with the actuator being operated by the override tool to open a valve; and

Figure 22 shows the actuator of Figure 21, with the valve operated by the override tool, via the actuator, to the fully open position.

DETAILED DESCRIPTION OF THE DRAWINGS

[0056] Referring first to Figure 1, there is shown an actuator 10 according to the present disclosure. Here, the actuator 10 comprises an electrically-operable subsea actuator 10 for providing a subsea electrical actuation of a valve 16. The actuator 10 comprises a screw assembly 18, here in the form of a roller screw assembly. The screw assembly 18 comprises a screw 20 and a threaded part 22. Here, the roller screw assembly 18 comprises a roller screw 20 and a roller nut 22. The actuator 10 comprises a housing 24 for the roller screw assembly 18; and an axial stop 26 for preventing axial movement relative to the housing 24 of one of the roller screw 20 and the roller nut 22. The actuator 10 comprises a primary drive for providing a rotational movement to the roller screw assembly 18 in a normal mode of operation. The roller screw assembly 18 converts the rotational movement to an axial movement of a valve member 14 relative to the housing 24. The actuator 10 comprises an override 28 for operating the actuator 10 in an override 28 mode of operation (as shown in Figures 2 and 4). The override 28 is configured to release at least one of the roller screw 20 and the roller nut 22 for axial movement relative to the housing 24. In the example shown, the override 28 releases the roller screw 20 for axial movement in the override 28 mode.

[0057] The roller screw 20 of the roller screw assembly 18 here comprises a longitudinal member in the form of a rigid, solid threaded rod. The roller nut 22 assembly comprises a plurality of rollers for transmitting drive between the screw 20 and the roller nut 22 of the roller screw assembly 18. The transmission converts a rotational motion of the roller screw 20 to a longitudinal motion of the roller nut 22. In other examples (not shown) the roles of the roller nut 22 and the roller screw 20 may be reversed, with the transmission converting a rotational motion of the roller nut 22 to a longitudinal motion of the roller screw 20.

[0058] The roller screw assembly 18 is operable by converting rotational movement or torque, such as from a motor (e.g. electric), to axial movement or force. The axial movement or force is relative between the roller screw 20 of the roller screw 20 and the transmission. Accordingly, operation of the roller screw 20 provides an axial movement of the roller nut 22 relative to the roller screw 20. The

axial movement here comprises linear movement (e.g. of the roller nut 22 from right to left, or left to right, as shown in Figures 1 and 2). Here, the roller screw assembly 18 defines a linear actuator. The actuator 10 comprises a motor, which is the primary drive for operating the actuator 10 in the normal mode of operation, as shown in Figures 1 and 3.

[0059] The roller screw assembly 18 is operable to selectively axially drive the valve 16 cyclically between open and closed positions. For example, the roller screw assembly 18 is operable to push the valve member 14 to an open position (as shown in Figure 1) and to pull the valve member 14 to a closed position (similar to the position of the valve member 114 shown in a closed configuration of Figure 6). The roller screw assembly 18 comprises a push tube 30.

[0060] The valve 16 here has a valve rod or stem 12. The valve stem 12 extends through a stem seal 32 housed in a bonnet 34. The valve member 14 comprises a bore-sealing member, the bore-sealing member being configured to sealingly occlude access via a bore 36. The bore 36 here is for providing access below a XMT (not shown), such as when a XMT is removed, damaged, being inspected or repaired, etc. The valve 16 comprises a seat 38 for the bore-sealing member. As shown here, the valve 16 is a gate valve. The valve stem 12 is perpendicular to the bore 36, with the valve stem 12 being axially movable along its axis perpendicular to the bore 36. Accordingly, the bore-sealing member 14 is movable transversely into and out of the bore 36 to respectively close and open the bore 36 (e.g. for access via the bore 36).

[0061] At least one of the screw and the roller nut 22 of the roller screw assembly 18 is operatively associated with the valve member 14. Here, the roller nut 22 is connected to the valve member 14 such that axial movement of the roller nut 22 axially moves the valve member 14. In other examples (not shown), the screw is connected to the valve member 14, such that axial movement of the screw axially moves the valve member 14. The roller nut 22 is connected to the push tube 30, the roller nut 22 being the axially movable member of the roller screw assembly 18 in the normal mode of operation (as shown in Figures 1 and 3). The roller screw 20 is the axially stationary member of the roller screw assembly 18 as shown here, at least during normal or primary operation of the actuator 10. The push tube 30 is configured to push the valve stem 12 and also to pull the valve stem 12, with the push tube 30 here being attached to the valve stem 12.

[0062] The actuator 10 comprises a housing 24 configured to maintain an axial position of the axially stationary member of the roller screw assembly 18. Here, the housing 24 comprises the axial stop 26 for maintaining the axial position of the roller screw 20, the axial stop 26 preventing axial movement of the axially stationary roller screw in a first axial direction - to the right, towards the valve 16, as shown in Figure 1. Here, a backplate 40 at the rear of the housing 24 prevents axial movement of

the roller screw 20 in a second axial direction - to the left, away from the valve 16, as shown in Figure 1. The axial directions are parallel with the longitudinal axis of the roller screw 20. The housing 24 limits or prevents axial movement of the roller screw 20 during normal operation of the actuator 10. Accordingly, here, the actuator 10 is normally operable to actively rotate, driven by the motor, the roller screw 20 to axially displace the roller nut 22, thereby axially displacing the valve member 14 associated with the roller nut 22.

[0063] The actuator 10 comprises a bearings assembly 42 comprising a bearings casing 44 containing contact angle bearings 46 for supporting the roller screw 20. The bearings 46 provide a high degree of axial stiffness, high axial load carrying capacity; accommodate high speeds and rapid accelerations; and offer high running accuracy. The bearings 46 provide a safe radial and axial support and an extremely precise axial guidance of the roller screw 20.

[0064] Here, the housing 24 seals the actuator 10, with an interior of the actuator 10 sealed from an exterior of the actuator 10. The housing 24 here comprises a cylinder, with the axial movement of the roller nut 22 being along an axis parallel to a central longitudinal axis of the cylinder.

[0065] The roller screw 20 is electrically operable. The roller screw 20 is electrically operable by selectively supplying electrical power to the motor for driving the transmission. Here, the electric motor is associated with the screw 20 of the roller screw assembly 18. Rotation of the screw 20 (e.g. at or towards a first end of the screw) forces the roller nut 22 to move axially, parallel to the central longitudinal axis of the screw assembly 18. The screw 20 has a screwthread, with the roller nut 22 comprising an interengaging complementary screwthread profile for engaging the roller screw 20.

[0066] The actuator 10 here is configured to provide an alternative drive to the valve member 14. The actuator 10 is configured to move the valve member 14 in an event of a failure of the roller screw assembly 18 or a component thereof, or of the primary drive thereto. For example, the actuator 10 is configured to move the valve member 14 in an event of the roller screw assembly 18 becoming stuck.

[0067] The actuator 10 comprises an override 28 configured to allow operation of the valve 16 without requiring transmission of drive from the primary drive (motor) normally used to operate the roller screw 20. The override 28 is configured to release the roller screw 20. In at least some examples, the override 28 is configured to enable movement of the roller screw assembly 18 in unison. For example, the override 28 is configured to enable axial movement of the roller screw 20 and the roller nut 22 together. The override 28 is configured to allow axial movement of the portion of the roller screw assembly 18 that is normally axially stationary during normal operation of the actuator 10. For example, where the roller screw 20 is normally axially stationary in the normal mode of operation as shown in Figure 1, the override allows the roller screw 20 to move axially in the override mode of

operation, as shown in Figures 2 and 4.

[0068] Here, the override 28 comprises a release mechanism 50 configured to allow axial movement of the roller screw 20 that is not otherwise possible without or prior to the operation of the override 28. The release mechanism 50 is configured to allow axial movement of the roller screw 20 not normally possible during normal operation of the actuator 10, upon activation of the override 28, as shown in Figures 1-4.

[0069] The override 28 here comprises a releasable axial stop 26 defining or limiting axial movement in at least one direction for the roller screw 20. Here, the axial stop 26 comprises a bearing shoulder. Operation of the override 28 to release the releasable stop allows movement of the stationary member of the roller screw assembly 18 not otherwise possible without or prior to the operation of the override 28. In normal operation of the actuator 10 the roller screw 20 is axially stationary, with driven rotation of the roller screw 20 consequently driving axial movement of the roller nut 22. As shown in Figures 2 and 4, when the actuator override 28 is activated, operation of the actuator 10 in override 28 mode allows axial movement of the roller screw 20. Accordingly, here, the override 28 may allow axial movement of both the roller screw 20 and the roller nut 22, such as in tandem or unison.

[0070] The release mechanism 50 is configured to release the bearing assembly 42 for axial movement, the bearing assembly 42 normally being axially fixed or limited by the axial stop 26 in the form of the bearing shoulder. Accordingly, operation of the override 28 allows axial movement of the bearing assembly 42 jointly with the roller screw 20. Here, the override 28 is configured to release the bearings casing 44 for axial movement with the roller screw 20, upon activation of the override 28. As shown in Figures 1 and 3, the bearings casing is axially stationary during normal operation, being stopped by the axial stop 26.

[0071] In other examples, the release mechanism 50 releases the roller screw 20 from the bearing assembly 42. For example, the release mechanism 50 in such examples is configured to allow the roller screw 20 to move longitudinally relative to the bearing assembly 42 in the override 28 mode. The roller screw 20 is axially immovable relative to the bearings assembly during normal operation of the actuator 10.

[0072] The release mechanism 50 here comprises an external release interface, external of the actuator housing 24. The release mechanism 50 comprises an external release sleeve 52 located on an exterior of the actuator 10 housing 24. Accordingly, the release mechanism 50 is operated externally of the actuator 10. The release mechanism 50 is normally be locked in position, by a mechanical lock, comprising a shear pin 54 here for limiting or preventing movement of the external release sleeve 52 in normal use of the actuator 10. The shear pin is disassociated with the roller screw assembly 18, being isolated from forces associated with the roller screw

assembly 18. Here, forces associated with the roller screw assembly 18 and bearings 46 therefor are isolated from the shear pin 54 by one or more bearings/balls 56 providing an interface between the external release sleeve 52 and the roller screw assembly 18 and bearings 46 therefor. Accordingly, the shear pin 54 here is prevented from shearing due to movement or force associated with the normal operation of the roller screw assembly 18. The shear pin 54 is only sheared by a movement or force applied externally to the external release sleeve 52. The bearings/balls 56 provide for a low axial friction (rolling) for sliding movement during release of the external release sleeve 52, whilst providing a rigid or stiff radial connection between the external release sleeve 52 and the roller screw assembly 18.

[0073] Here the actuator 10 comprises a retainer 58 associated with the axial stop 26, the retainer 58 retaining the axial stop 26 axially during normal operation of the actuator 10. Activation of the release mechanism 50 entails a transverse movement of the retainer 58. here, the retainer 58 comprises a split lock ring. The retainer 58 comprises a pretension when assembled in the actuator 10. Here, the retainer 58 comprises a transverse, radial, pretension when assembled in the actuator 10. The pretension assists in releasing the retainer 58 from its normal position when the release mechanism 50 is activated. The retainer 58 is normally locked in position during normal operation of the actuator 10, with the override 28 releasing the retainer 58. As can be seen in Figures 3 and 4, when the external release sleeve 52 is released (moved from the left in Figure 3 to the right in Figure 4), a cavity 60 is progressed to the axial position of the bearings/balls 56, allowing the bearings/balls to be pushed radially outwards with the retainer 58, thereby releasing the axial stop 26 for axial movement in the override mode as shown in Figure 4. An offset angle 62 assists transverse release of the retainer 58.

[0074] Here, the override 28 does not comprise a bypass, such as a bypass for bypassing one or more of the roller screw 20 and/or the roller nut 22. The override 28 utilises at least some functionality of the roller screw assembly 18 to operate the valve member 14 in the override mode of operation. The override 28 here utilises a same connection of the roller screw assembly 18 to the valve member 14 for operating the valve 16 assembly in the override mode as the connection of the roller screw assembly 18 to the valve member 14 for operating the valve 16 assembly in normal or primary operation prior to operation of the override 28. The override 28 allows operation of the same push tube 30 for pushing and pulling the valve member 14 as in normal or primary operation of the actuator 10. The override 28 is configured to utilise the interface between the roller screw 20 and the roller nut 22 of the roller screw assembly 18 to directly transmit force and/or movement in a same direction or mode. For example, the override 28 allows a transfer of an axial force and/or axial movement between the roller screw 20 and the roller nut 22 (e.g. axially

pushing/pulling the roller screw 20 axially pushes/pulls the roller nut 22 via the threaded interface/s therebetween). Additionally, the override 28 is configured to rotate the roller screw 20. Accordingly, the actuator 10 does not comprise or require an additional or alternative connection between the roller screw assembly and the valve member.

[0075] The actuator 10 comprises an external interface 70 for an override tool (not shown) axially external to the actuator 10. Here, where the actuator housing 24 comprises a cylinder, the override tool interface 70 is provided at or through an axial end of the cylinder. The override tool interface 70 is positioned with the roller screw assembly 18 located between the override tool interface 70 and the valve member 14. The override tool interface 70 is configured to transmit torque and/or axial force to the roller screw 20 to move the valve member 14. The override tool interface 70 comprises a torque interface to allow clockwise and/or counter-clockwise torque to be applied to the roller screw 20 to move the valve member 14. The override tool interface 70 is configured to drive the roller screw 20 axially in the first direction to push the valve member 14. Additionally, the override tool interface 70 is configured to drive the roller screw 20 axially in the second direction to pull the valve member 14. The override tool interface 70 is configured to drive the roller screw 20 axially to open and close the valve member 14. Additionally, the override tool interface 70 is configured to drive the at least a portion of the roller screw assembly 18 rotationally to open and close the valve member 14. Here, it will be appreciated that the roller screw 20 has been axially and rotationally drive from the position of Figure 1 to the position of Figure 2, thereby axially moving the roller screw 20 relative to the roller nut 22. It will be appreciated that the roller screw 20 may be driven further (e.g. to the right in Figure 2). Thereafter it may be possible to close the valve 16 by driving the roller screw assembly 18 in an opposite direction (e.g. to the left from the position as shown in Figure 2) to pull the valve member 14 closed (to the left from the position as shown in Figure 2). The override tool (not shown, but may be generally similar to that 190 shown in Figure 6) comprises an alternative drive, such as a hydraulic drive.

[0076] The override tool is operated remotely, by a ROV. In at least some examples the actuator 10 is configured for override operation by a plurality of override tools, such as by a ROV override tool in a first override operation; and operated manually in a second override operation (e.g. if the first override operation was unsuccessful; or if subsequently the first override operation was desired to be reversed).

[0077] Here, the actuator 10 comprises a rotational stop 80 for the roller nut 22 to prevent or at least limit rotation of the roller nut 22, during normal and override operation of the actuator 10. Accordingly, the rotational stop 80 helps provide for the conversion of relative rotation between the roller screw 20 and the roller nut 22 to axial movement. The axial movement here is therefore

pure, non-rotational linear movement in the axial direction. The rotational stop 80 here comprises a plurality of anti-rotation pins associated with the roller nut 22, received in axial guide channels 82 associated with the housing 24.

[0078] In at least some examples, the actuator 10 is used as a subsea actuator 10 to provide an axial force to an element. The actuator 10 is used to operate one or more valves 16, such as gate valves 16. The valve 16 may form part of a XMT, such as a vertical XMT. The XMT comprises an Enhanced Vertical Deepwater Tree. The actuator 10 is used in an all-electric application, such as an all-electric XMT, Wellhead, SCM or the like.

[0079] Here, the actuator 10 comprises a subsea electrical actuator 10 for providing a subsea electrical actuation. The valve 16 comprises a subsea gate valve 16 for selectively providing access via the bore 36 below a XMT. The valve 16 is normally closed, such as during normal operation of the XMT. The valve 16 is selectively openable by operation of the actuator 10. Here, the roller screw assembly 18 comprises a planetary roller screw assembly 18. The actuator 10 is configured for high-precision. The actuator 10 is configured for high-speed. The actuator 10 is configured for heavy-load applications. The actuator 10 is configured for long-life applications. The actuator 10 is configured for heavy-use applications. It will be appreciated that the actuator 10 for the valve 16 shown here forms part of a subsea wellhead apparatus for controlling access to a hydrocarbon wellbore.

[0080] Figure 5 depicts a method of operation of the actuator 10 of Figures 1 to 4. The method comprises providing the actuator 10 of Figure 1 for subsea actuation of the valve 16. The method comprises using the axial stop 26 of the actuator 10 to prevent axial movement of the roller screw 20, the axial movement being relative to the housing 24 for the roller screw assembly 18. The method comprises providing the rotational movement to the roller screw assembly 18 in the normal mode of operation with the primary drive (electric motor). The method comprises using the roller screw assembly 18 to convert the rotational movement to the axial movement of the valve member 14 relative to the housing 24. The method comprises using the override 28 to operate the actuator 10 in the override 28 mode of operation. The method comprises releasing the roller screw 20 for axial movement relative to the housing 24. The method comprises axially moving the roller screw 20 to move the valve member 14 in the override mode of operation.

[0081] The method comprises releasing the axial stop 26 to release the roller screw 20 for axial movement relative to the housing 24, with the axial stop 26 comprising the shoulder preventing the axial movement of the roller screw 20 in normal operation of the actuator 10. The method comprises overriding the electric motor that is used to operate the actuator 10 in the normal mode of operation. The method comprises using an alternative drive to operate the actuator 10 in the override 28 mode of

operation. The method comprises operating the valve 16 of the wellhead apparatus for controlling access to a hydrocarbon wellbore.

[0082] It will be appreciated that in an unlikely circumstance that a portion of the actuator 10 fails, the override 28 may enable operation of the valve 16.

[0083] Figure 6 shows a further embodiment of an actuator 110 generally similar to that shown in Figures 1 to 4. The actuator 110 of Figure 6 shares features common to the embodiment of Figure 1, with those features represented by reference numerals incremented by 100. For example, the actuator 100 comprises a roller screw assembly 118 with a roller screw 120 and a roller nut 122. Not all features common to both embodiments are repeated here to maintain brevity and clarity. Operation of the actuators 10, 110 is generally similar, with override possible by an override tool.

[0084] As well as the actuator 110, an example override tool 190 is also depicted in Figure 6. The override tool 190 is configured to engage with the override tool interface 170 at the axial end of the cylinder, as shown in the transition from Figure 6 to Figure 7. In Figure 7, the override tool 190 is shown here with a pair of arms 192a, 192b positioned around an exterior of the cylindrical actuator housing 124. Each of the override tool arms 192a, 192b comprises an inner protrusion 193a, 193b for engaging the external release sleeve 152 of the actuator 110. As shown in Figure 7 the override tool has been slid over the housing 120 (towards the right) from the positions of Figure 6. It will be appreciated that the protrusions 192a, 192b can be positioned beyond the external release sleeve 152 due to flexion of the override tool arms 192a, 192b as the protrusions 193a, 193b ride over the external release sleeve 152. In other examples, the protrusions 193a, 193b may be positioned beyond the external sleeve 152 (to the right as shown in Figure 7) by rotating the override tool arms 192a, 192b to align with castellations or gaps in the external release sleeve 152 before rotating to align the protrusions 193a, 193b with corresponding protrusions on the external release sleeve 152. It will also be appreciated that in other embodiments the override tool may comprise more or less arms for engaging the external release sleeve 152. For example, in other embodiments, there may be a single arm; or the override tool 190 may comprise a sleeve extending fully around the external release sleeve 152. It will also be appreciated that in addition to, or instead of, arms for pulling, an override tool may have a sleeve or arms for pushing the external release sleeve, such as the external release sleeve 52 shown in Figure 1.

[0085] With the override tool 190 positioned as shown in Figure 7, the external release sleeve 152 can be operated - here by pulling on the arms 192a, 192b. It will be appreciated that the arms 192a, 192b can be controlled to operate the sleeve 152 by applying a force such as from a cylinder or piston. For example, here pressurisation of a chamber 194 (shown here as an annular chamber) can force movement of a piston 195 to force

the arms 192a, 192b to operate the sleeve 152. The piston 195 here divides a volume defined by an override tool cylinder 191 into two chambers 194, 198. As shown in the transition between Figures 7 and 8, the shear pin 154 is configured to shear at a force exerted by the arms 192a, 192b of the override tool 190 - pulling the release sleeve 152 to the left as shown in Figure 8 to shear the pin 154 (whereas the sleeve 52 can be pushed to the right in the transition between Figures 1 and 2, and Figures 3 and 4, to shear the shear pin 54). It will be appreciated that the override tool 190 can be hydraulically operated, such as by supplying or pressurising hydraulic fluid in/into the chamber 194 to move the external release sleeve 152 to shear the shear pin 154. It will also be appreciated that other activation methods can be used to shear the shear pin 154, such as pressurisation of other chambers (e.g. in some embodiments an inner override tool chamber 196 may be pressurisable) or other actuation means, such as electrically-operated or even manual. A detailed view of the shearing of the shear pin can be seen in Figures 12 through 13. In the embodiment shown here, the external release sleeve 152 comprises a cavity 160 that becomes aligned to release the axial stop 126 as illustrated in Figures 13 through 14.

[0086] With the external release sleeve 152 released by the override tool 190, as shown in Figure 8 (and Figure 13), the axial stop 126 can be released, similarly as for the actuator 10 of Figure 4. The cavity 160 is progressed to the axial position of the bearings/balls 156, allowing the bearings/balls to be pushed radially outwards with the retainer 158, thereby releasing the axial stop 126 for axial movement of the roller screw assembly 118 in the override mode as shown in Figure 4. Here, an angle 162 on the axial stop 126 supports transverse release of the retainer 58. The angle 162 is configured to assist in transverse movement of the retainer 158 away from the axial stop 126 when the retainer is urged in an axial direction - the axial direction being that of the actuator 110, with the transverse direction here being perpendicular thereto. The angle is not a right-angle; here the angle 162 is defined by a face of the axial stop 126 that is inclined rearwards (to the left in Figure 13) by a few degrees. Accordingly, the angle 162 is a small acute angle of a few degrees to a radial transverse access of the actuator 110; and defines an obtuse opening of a few degrees more than 90 degrees between a side face (e.g. cylindrical outer side wall) of the axial stop 126. It will be appreciated that in other embodiments other configurations of interface between the axial stop 126 and the retainer 158 may be provided. For example, the retainer 158 may comprise an offset angle to assist transverse movement of the retainer 158 resultant from an axial force applied (such as by the axial stop 126). With the cavity 160 aligned with the bearings/balls 156, the bearings/balls 156 are freed to move radially outwards into the cavity 160, such as when urged by the retainer 158 - and depicted in the transition from Figure 13 to Figure 14. Accordingly, when the retainer 158 is urged radially out-

wards via the angle 162 by an axial force urging the axial stop 126, the retainer 158 is no longer prevented from radial movement by the external release sleeve 152 (via the bearings/balls 156) in the override configuration of Figure 13 and Figure 14 (and Figures 8 through 10), contrary to the normal operation configuration of the actuator 110 of Figure 11 (and Figure 7). Accordingly, the retainer 158 can be released by the override tool 190, freeing the axial stop 126, thus allowing axial movement of the roller screw assembly 118 as shown in Figures 9, 10 and 13. It will be appreciated that the axial stop 126 and/or the retainer 158 can be circumferential (e.g. rings here). Although only a single set of bearings/balls 156 is shown in the cross-section in the figures, it will be appreciated that multiple sets (e.g. three) may be spaced circumferentially around the actuator 110.

[0087] As shown here in Figure 8, once the external release sleeve 152 has been actuated to shear the shear pin 154, further movement of the external release sleeve 152 is limited. For example, further movement here is prevented from the position shown in Figure 8 (e.g. by a stop or shoulder 197, such as associated with the back-plate 140 or housing 124). Accordingly, further pressurisation of the chamber 194 here does not move the arms 192a, 192b or external release 152 further from the position of Figure 8. As shown from the transition from Figure 8 to Figure 9, further pressurisation of the chamber 194 causes the piston 195 to move (further) relative to the override tool cylinder housing 191. The piston 195 is connected to a tool stem 199 that is connected to and engages the actuator override tool interface 170. Accordingly, as shown in Figure 9, axial movement of the piston 195 causes axial movement of the tool stem 199, here a stem rod, and actuation of the actuator 110 via the actuator override tool interface 170, as described in detail below.

[0088] With the axial stop 126 released as described above and shown in Figure 13, the roller screw assembly 118 is no longer prevented from axial movement as a unit. In the example shown here, the bearing assembly 142, including the bearing casing 144, is freed for axial movement by the actuation of the external release sleeve 152. The application of force from the actuator tool 190, here via the override tool interface 170 and the tool stem 199 driven by the piston 195, drives the entire roller screw assembly 118, including the bearing assembly 142, axially. Accordingly, even in an event of failure of the roller screw assembly 118 or component thereof, the override tool 190 can be utilised to operate the valve member 114. The valve member 114 can be operated between the closed position (e.g. Figure 8) and the open configuration (e.g. Figure 10). It will be appreciated that the embodiment shown in Figures 8 to 10 has the roller screw assembly 118 being pushed in unison as a single unit to move the valve member 114 to the open position. Accordingly it is only necessary for the override tool 190 to contact the override tool interface 170 to push the roller screw assembly 118; and not necessarily grip

the override tool interface 170. However, it will also be appreciated that where the override tool 190 engages the override tool interface 170 to grip the override tool interface 170, the roller screw assembly 118 may additionally be pulled (e.g. to close the valve by pulling the valve member 114 from the position of Figure 10 to the position of Figure 8). Likewise, in at least some examples, it will also be appreciated that the override tool 190 may engage the override tool interface 170 to apply torque to the override tool interface 170. Accordingly, in at least some examples, the override tool 190 may be used to rotate the roller screw assembly 118, or a component thereof (such as the roller screw). Such rotation may be used to axially move at least a component of the roller screw assembly 118, or assist therein.

[0089] Figure 15 shows a further embodiment of an actuator 210 generally similar to that 110 shown in Figures 6 to 14. The actuator 210 of Figure 6 shares features common to the embodiment 110 of Figure 6, with those features represented by reference numerals incremented by 100. For example, the actuator 200 comprises a roller screw assembly 218 with a roller screw 220 and a roller nut 222. Not all features common to both embodiments are repeated here to maintain brevity and clarity. Operation of the actuators 110, 210 is generally similar, with override possible by an override tool.

[0090] The example 210 shown here does not comprise an external release sleeve, in contrast to that 152 of Figure 6. As shown in Figure 15, and in detail in Figure 15a, the actuator 210 here is configured for release of the bearings assembly 210 by releasing an axial stop, here the backplate 240. Accordingly, similar to the previous examples of overriding the actuator 210 (as shown here, also comprised in an actuator linear drive module (ALDM)), the method of override involves the release of the roller screw assembly 218 by releasing the bearing assembly 242. The backplate 240 has a predefined weakness in the form of an undercut 241, as shown in detail in Figure 15a. It will be appreciated that the undercut 241 extends around the entire circumference of the backplate 240 in the example shown; although in other examples partial undercuts, or multiple discrete undercuts may be used. As shown in Figure 15a, the undercut is supported - here with a pair of half-rings 243 extending around in the annular space provided by the undercut 241. The backplate 240 here has a guide groove 245. The guide groove 245 assists in positioning a release tool 247, shown here as a core bit. As shown in Figure 16, and in detail in Figure 16a, an inner wall 249 of the ROV bucket also assists in guiding and supporting the release tool 247. The release tool 247 can be used to free the bearings assembly 242 by releasing the backplate 240 - shown in Figure 16 by rotating the core bit of the release tool 247 to cut into the backplate 240, guided by the guide groove 245. As shown here, the bearing assembly 242 has a bearings sleeve 244 configured to transfer loads and keep the bearings 246 pre-loaded.

[0091] As shown in Figure 17, the core bit of the release

tool 247 only needs to penetrate the backplate 240 to the undercut 241. Although shown here as having an inner diameter corresponding to the core bit of the release tool 247 (and the groove guide 245), it will be appreciated that in other examples, the undercut 241 may extend into a smaller diameter - such as to allow for additional tolerance in the positioning and/or cutting of the core bit of the release tool 247. Once the backplate 240 has been cut by the core bit of the release tool 247 as far as the undercut 241, the bearings assembly 242 is released relative to the housing 224 - together with an inner portion of the backplate 240 that is still attached to the bearing assembly 242.

[0092] Once the release tool 247 has released the bearing assembly 242, as shown in the configuration of Figure 17, the actuator 210 is in a generally similar configuration to that shown in Figures 2 and 8 - with the roller screw assembly 218 able to move axially as a unit together with the bearing assembly 242. With the backplate 240 released as described above and shown in Figure 16, the roller screw assembly 218 is no longer prevented from axial movement as a unit. In the example shown here, the bearing assembly 242, including the bearing sleeve 244, is freed for axial movement by the cutting of the backplate 240. It will be noted here that where the axial stop 226 normally prevents axial movement of the bearings assembly 242 (and roller screw assembly 218), the valve-side axial stop 226 is connected to the backplate 240 such that release of the central portion of the backplate 240 also releases the axial stop 226 at the other end of the bearings assembly 218. Accordingly, as shown sequentially in Figure 18 through Figure 22, an override tool 290 can be used to engage the external interface 270 of the actuator 210 to control the valve 216 with the actuator 210. As shown in Figure 19, the override tool 290 has a tool stem 299 that can be extended to engage the external interface 270, as shown in Figure 20 - with the actuator 210 and override tool 290 in generally similar positions to that shown in Figure 8.

[0093] Accordingly, pressurisation of the chamber 294 causes the piston 295 connected to the tool stem 299 to move relative to the override tool cylinder housing 291. As shown in the transition from Figure 20 to Figure 21, axial movement of the piston 295 (to the right as shown) causes axial movement of the tool stem 299, here a stem rod, and actuation of the actuator 210 via the actuator override tool interface 270.

[0094] The application of force from the actuator tool 290, here via the override tool interface 270 and the tool stem 299 driven by the piston 295, drives the entire roller screw assembly 218, including the bearing assembly 242, along with the central portion of the backplate 240, axially. Accordingly, even in an event of failure of the roller screw assembly 218 or component or control thereof, the override tool 290 can be utilised to operate the valve 216. The valve member 214 can be operated between the closed position (e.g. Figure 16) and the open

configuration (e.g. Figure 22). It will be appreciated that the embodiment shown in Figures 18 to 22 has the roller screw assembly 218 being pushed in unison as a single unit to move the valve member 214 to the open position. Accordingly it is only necessary for the override tool 290 to contact the override tool interface 270 to push the roller screw assembly 218. However, here, it will also be appreciated that the override tool 290 can engage the override tool interface 270 to grip the override tool interface 270, such that the roller screw assembly 218 can also be pulled (e.g. to close the valve 216 by pulling the valve member 214 from the position of Figure 22 to the position of Figure 16).

[0095] The applicant hereby discloses in isolation each individual feature described herein and any combination of two or more such features, to the extent that such features or combinations are capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein, and without limitation to the scope of the claims.

[0096] The applicant indicates that aspects of the present invention may consist of any such individual feature or combination of features. It should be understood that the embodiments described herein are merely exemplary and that various modifications may be made thereto without departing from the scope of the invention. For example it will be appreciated that although shown here as a screw comprising continuous screwthread, in other examples the longitudinal member of the roller screw assembly may comprise an interface or profile for inter-engagement (e.g. screwthread/s, spline/s) at only one or more portions of the longitudinal member (e.g. one or more axial zones).

Claims

1. A subsea electrical actuator for providing a subsea electrical actuation of a valve, the actuator comprising:

a screw assembly comprising a screw and a threaded part for receiving the screw;
 a housing for the screw assembly;
 an axial stop for preventing axial movement relative to the housing of at least one of the screw and the threaded part;
 a primary drive for providing a rotational movement to the screw assembly in a normal mode of operation, the screw assembly converting the rotational movement to an axial movement of a valve member relative to the housing;
 an override for operating the actuator in an override mode of operation, the override being configured to release at least one of the screw and the threaded part for axial movement relative to

the housing and wherein the screw comprises a roller screw and the threaded part comprises a roller nut; and the override is configured to release the axial stop to release at least one of the roller screw and the roller nut for axial movement relative to the housing.

2. The actuator of claim 1, wherein the axial stop comprises a shoulder, the shoulder preventing the axial movement of at least one of the screw and the threaded part in normal operation of the actuator, optionally wherein the axial stop comprises a backplate, the backplate preventing the axial movement of at least one of the screw and the threaded part in normal operation of the actuator.
3. The actuator of any preceding claim, wherein the actuator comprises a bearings assembly for supporting a portion of the screw assembly; and the override is configured to release a portion of the bearings assembly for axial movement in the override mode of operation.
4. The actuator of any preceding claim, wherein it is the screw that is prevented from moving axially relative to the housing by the axial stop and the threaded part converts the rotational movement to axial movement, preferably wherein the threaded part is prevented from rotating relative to the housing with axial movement of the threaded part relative to the housing being guided by a guide member; and the threaded part is connected via a push tube to the valve member, axial movement of the threaded part axially moving the valve member.
5. The actuator of any preceding claim, wherein the override is configured to allow an alternative drive to operate the screw assembly to move the valve member relative to the housing, the alternative drive being alternative to the primary drive, preferably wherein the actuator comprises an external interface for allowing the alternative drive to be connected externally to the screw assembly.
6. The actuator of any preceding claim, wherein the override is configured to allow axial movement in both axial directions in the override mode, such as pushing and pulling, of the valve member.
7. The actuator of any preceding claim, wherein the override is configured to allow rotation of at least one of the screw and the threaded part.
8. The actuator of any preceding claim, wherein the override is configured to allow an application of torque to at least one of the screw and the threaded part to drive rotation of at least one of the screw and the threaded part.

9. The actuator of any preceding claim, wherein the override comprises a release mechanism, the axial stop defining a releasable member of the release mechanism, the release mechanism further comprising an external release member, the external release member being accessible at an exterior of the actuator, preferably wherein the external release member comprises a sliding external sleeve, the sleeve being locked during normal operation to prevent sliding movement of the sleeve and becoming unlocked during the override mode, more preferably the override comprising a shear pin, wherein the sliding external sleeve is unlocked for the override mode by applying a force to the external sliding sleeve to shear the shear pin.

10. The actuator of any preceding claim, the actuator further comprising a retainer, the retainer being associated with the axial stop; wherein the retainer is configured to move transversely upon activation of the override to release the axial stop, the transverse movement being transverse to the direction of axial movement of the valve member.

11. The actuator of any preceding claim, wherein the override comprises a predefined weakness, the predefined weakness configured to reconfigure the actuator from a normal mode of operation to an override mode of operation upon activation or rupturing of the predefined weakness.

12. An apparatus comprising the actuator of any preceding claim, optionally wherein the apparatus comprises a wellhead apparatus for accessing a hydrocarbon wellbore.

13. A method of subsea electrical actuation, the method comprising:

providing a subsea electrical actuator for actuating a valve, the actuator comprising a screw assembly comprising a screw and a threaded part;
using an axial stop of the actuator to prevent axial movement of one of the screw and the threaded part, the axial movement being relative to a housing for the screw assembly;
providing a rotational movement to the screw assembly in a normal mode of operation with a primary drive,
using the screw assembly to convert the rotational movement to an axial movement of a valve member relative to the housing;
using an override to operate the actuator in an override mode of operation, wherein the override releases at least one of the screw and the threaded part for axial movement relative to the housing, and at least one of the screw and the

threaded part is axially moved to move the valve member.

14. The method of claim 13, wherein the method comprises:

releasing the axial stop to release at least one of the screw and the threaded part for axial movement relative to the housing, with the axial stop comprising a shoulder preventing the axial movement of at least one of the screw and the threaded part in normal operation of the actuator; and
overriding an electric motor to operate the actuator in the normal mode of operation, using an alternative drive to operate the actuator in the override mode of operation.

15. The method of claim 13 or 14, wherein the method comprises operating a valve of a wellhead apparatus for controlling access to a hydrocarbon wellbore, preferably wherein the method comprises activating a release mechanism to reconfigure the actuator to an override mode of operation, even more preferably wherein the method comprises utilising a predefined weakness to reconfigure the actuator for override operation.

Patentansprüche

1. Elektrischer Unterwasseraktuator zum Bereitstellen einer elektrischen Unterwasserbetätigung eines Ventils, der Aktuator umfassend:

eine Schraubenanordnung, umfassend eine Schraube und ein Gewindeteil zum Aufnehmen der Schraube;
ein Gehäuse für die Schraubenanordnung;
einen axialen Anschlag zum Verhindern einer axialen Bewegung relativ zu dem Gehäuse von mindestens einem des Schrauben- und des Gewindeteils;
einen Primär Antrieb zum Erzeugen einer Drehbewegung für die Schraubenanordnung in einem Normalbetriebsmodus, wobei die Schraubenanordnung die Drehbewegung in eine axiale Bewegung eines Ventilelements relativ zu dem Gehäuse umwandelt;
eine Übersteuerung zum Betreiben des Aktuators in einem Übersteuerungsbetriebsmodus, wobei die Übersteuerung konfiguriert ist, um mindestens eine der Schraube und des Gewindeteils für eine axiale Bewegung relativ zu dem Gehäuse zu lösen, und wobei die Schraube einen Planetenrollengewindetrieb und das Gewindeteil eine Rollennutter umfasst; und die Übersteuerung konfiguriert ist, um den axialen

- Anschlag zu lösen, um mindestens einen des Planetenrollengewindetriebs und der Rollennutter für eine axiale Bewegung relativ zu dem Gehäuse zu lösen.
2. Aktuator nach Anspruch 1, wobei der axiale Anschlag eine Schulter umfasst, wobei die Schulter die axiale Bewegung von mindestens einem der Schraube und des Gewindeteils in einem Normalbetrieb des Aktuators verhindert, optional wobei der axiale Anschlag eine Rückplatte umfasst, wobei die Rückplatte die axiale Bewegung von mindestens einem der Schraube und des Gewindeteils in einem Normalbetrieb des Aktuators verhindert.
 3. Aktuator nach einem der vorstehenden Ansprüche, wobei der Aktuator eine Lageranordnung zum Stützen eines Abschnitts der Schraubenanordnung umfasst; und die Übersteuerung konfiguriert ist, um einen Abschnitt der Lageranordnung für eine axiale Bewegung in dem Übersteuerungsbetriebsmodus zu lösen.
 4. Aktuator nach einem der vorstehenden Ansprüche, wobei es die Schraube ist, die durch den axialen Anschlag gehindert wird, sich relativ zu dem Gehäuse axial zu bewegen, und das Gewindeteil die Drehbewegung in eine axiale Bewegung umwandelt, vorzugsweise wobei das Gewindeteil an einer Drehung relativ zu dem Gehäuse gehindert wird und die axiale Bewegung des Gewindeteils relativ zu dem Gehäuse durch ein Führungselement geführt wird; und das Gewindeteil über ein Schubrohr mit dem Ventilelement verbunden ist, wobei eine axiale Bewegung des Gewindeteils das Ventilelement axial bewegt.
 5. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung konfiguriert ist, um einem alternativen Antrieb zu ermöglichen, die Schraubenanordnung zu betätigen, um das Ventilelement relativ zu dem Gehäuse zu bewegen, wobei der alternative Antrieb eine Alternative zu dem primären Antrieb ist, vorzugsweise wobei der Aktuator eine externe Schnittstelle zum Ermöglichen, dass der alternative Antrieb mit der Schraubenanordnung extern verbunden wird, umfasst.
 6. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung konfiguriert ist, um eine axiale Bewegung des Ventilelements in beide axialen Richtungen in dem Übersteuerungsmodus, wie Drücken und Ziehen, zu ermöglichen.
 7. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung konfiguriert ist, um eine Drehung von mindestens einem der Schraube und des Gewindeteils zu ermöglichen.
 8. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung konfiguriert ist, um eine Anwendung von Drehmoment auf mindestens eines der Schraube und des Gewindeteils zu ermöglichen, um die Drehung von mindestens einem der Schraube und des Gewindeteils anzutreiben.
 9. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung einen Freigabemechanismus umfasst, wobei der axiale Anschlag ein lösbares Element des Freigabemechanismus definiert, der Freigabemechanismus ferner umfassend ein externes Freigabeelement, wobei das externe Freigabeelement von einem Außenbereich des Aktuators zugänglich ist, vorzugsweise wobei das externe Freigabeelement eine gleitende externe Hülse umfasst, wobei die Hülse während eines Normalbetriebs verriegelt ist, um eine Gleitbewegung der Hülse zu verhindern, und während des Übersteuerungsmodus entriegelt wird, mehr bevorzugt wobei die Übersteuerung einen Scherstift umfasst, wobei die gleitende externe Hülse für den Übersteuerungsmodus durch Anwenden einer Kraft auf die externe Gleithülse entriegelt wird, um den Scherstift abzusichern.
 10. Aktuator nach einem der vorstehenden Ansprüche, der Aktuator ferner umfassend eine Halterung, wobei die Halterung an den axialen Anschlag angeschlossen ist; wobei der Halter konfiguriert ist, um sich bei Aktivierung der Übersteuerung quer zu bewegen, um den axialen Anschlag zu lösen, wobei die Querbewegung quer zu der Richtung der axialen Bewegung des Ventilelements ist.
 11. Aktuator nach einem der vorstehenden Ansprüche, wobei die Übersteuerung eine vordefinierte Schwäche umfasst, wobei die vordefinierte Schwäche konfiguriert ist, um den Aktuator von einem Normalbetriebsmodus in einen Übersteuerungsbetriebsmodus bei Aktivierung oder Unterbrechung der vordefinierten Schwäche neu zu konfigurieren.
 12. Vorrichtung, umfassend den Aktuator nach einem der vorstehenden Ansprüche, optional wobei die Vorrichtung eine Bohrlochkopfvorrichtung für den Zugang zu einem Kohlenwasserstoffbohrloch umfasst.
 13. Verfahren zum elektrischen Betätigen unter Wasser, das Verfahren umfassend:

Bereitstellen eines elektrischen Unterwasseraktuators zum Betätigen eines Ventils, der Aktuator umfassend eine Schraubenanordnung, umfassend eine Schraube und ein Gewindeteil; Verwenden eines axialen Anschlags des Aktuators, um eine axiale Bewegung eines der

- Schraube oder des Gewindeteils zu verhindern, wobei die axiale Bewegung relativ zu einem Gehäuse für die Schraubenanordnung ist; Bereitstellen einer Drehbewegung der Schraubenanordnung in einem Normalbetrieb mit einem Primärtrieb, 5
Verwenden der Schraubenanordnung, um die Drehbewegung in eine axiale Bewegung eines Ventilelements relativ zu dem Gehäuse umzuwandeln; 10
Verwenden einer Übersteuerung, um den Aktuator in einem Übersteuerungsbetriebsmodus zu betreiben, wobei die Übersteuerung mindestens eines der Schraube und des Gewindeteils für eine axiale Bewegung relativ zu dem Gehäuse löst und mindestens eines der Schraube und des Gewindeteils axial bewegt wird, um das Ventilelement zu bewegen. 15
- 14.** Verfahren nach Anspruch 13, wobei das Verfahren umfasst: 20
- Lösen des axialen Anschlags, um mindestens eines der Schraube und des Gewindeteils für eine axiale Bewegung relativ zu dem Gehäuse zu lösen, wobei der axiale Anschlag eine Schulter umfasst, die die axiale Bewegung mindestens eines der Schraube und des Gewindeteils in einem Normalbetrieb des Aktuators verhindert; und 25
Übersteuern eines Elektromotors, um den Aktuator in dem Normalbetriebsmodus zu betreiben, Verwenden eines alternativen Antriebs zum Betreiben des Aktuators in dem Übersteuerungsbetriebsmodus. 30
- 15.** Verfahren nach Anspruch 13 oder 14, wobei das Verfahren das Betätigen eines Ventils einer Bohrlochkopfvorrichtung zum Steuern des Zugangs zu einem Kohlenwasserstoffbohrloch umfasst, vorzugsweise wobei das Verfahren das Aktivieren eines Lösungsmechanismus umfasst, um den Aktuator in einen Übersteuerungsbetriebsmodus neu zu konfigurieren, noch mehr bevorzugt wobei das Verfahren das Verwenden einer vordefinierten Schwäche umfasst, um den Aktuator für den Übersteuerungsbetriebsmodus neu zu konfigurieren. 35
- Revendications** 40
- 1.** Actionneur électrique sous-marin destiné à fournir un actionnement électrique sous-marin d'une vanne, l'actionneur comprenant : 45
- un ensemble vis comprenant une vis et une partie filetée pour recevoir la vis ;
un boîtier pour l'ensemble vis ;
- une butée axiale pour empêcher le mouvement axial par rapport au boîtier d'au moins l'une parmi la vis et la partie filetée ;
un entraînement primaire destiné à fournir un mouvement de rotation à l'ensemble vis dans un mode de fonctionnement normal, l'ensemble vis convertissant le mouvement de rotation en un mouvement axial d'un élément de vanne par rapport au boîtier ;
un surpassement pour faire fonctionner l'actionneur dans un mode de fonctionnement de surpassement, le surpassement étant configuré pour libérer au moins l'une parmi la vis et la partie filetée pour un mouvement axial par rapport au boîtier et dans lequel la vis comprend une vis à rouleaux et la partie filetée comprend un écrou à rouleaux ; et le surpassement est configuré pour libérer la butée axiale afin de libérer au moins l'une parmi la vis à rouleaux et l'écrou à rouleaux pour un mouvement axial par rapport au boîtier. 50
- 2.** Actionneur selon la revendication 1, dans lequel la butée axiale comprend un épaulement, l'épaulement empêchant le mouvement axial d'au moins l'une parmi la vis et la partie filetée en fonctionnement normal de l'actionneur, éventuellement dans lequel la butée axiale comprend une plaque arrière, la plaque arrière empêchant le mouvement axial d'au moins l'une parmi la vis et la partie filetée en fonctionnement normal de l'actionneur. 55
- 3.** Actionneur selon l'une quelconque revendication précédente, dans lequel l'actionneur comprend un ensemble de paliers pour supporter une portion de l'ensemble vis ; et le surpassement est configuré pour libérer une portion de l'ensemble de paliers pour un mouvement axial dans le mode de fonctionnement de surpassement.
- 4.** Actionneur selon l'une quelconque revendication précédente, dans lequel c'est la vis qui est empêchée de se déplacer axialement par rapport au boîtier par la butée axiale et la partie filetée convertit le mouvement de rotation en mouvement axial, de préférence dans lequel la partie filetée est empêchée de tourner par rapport au boîtier avec le mouvement axial de la partie filetée par rapport au boîtier étant guidé par un élément de guidage ; et la partie filetée est reliée par le biais d'un tube de poussée à l'élément de vanne, le mouvement axial de la partie filetée déplaçant axialement l'élément de vanne.
- 5.** Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement est configurée pour permettre à un entraînement alternatif de faire fonctionner l'ensemble vis afin de déplacer l'élément de vanne par rapport au boîtier, l'entraîne-

ment alternatif étant alternatif à l'entraînement primaire, de préférence dans lequel l'actionneur comprend une interface externe pour permettre à l'entraînement alternatif d'être relié à l'extérieur de l'ensemble vis.

6. Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement est configuré pour permettre un mouvement axial dans les deux directions axiales en mode de surpassement, tel que la poussée et la traction, de l'élément de vanne.
7. Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement est configuré pour permettre la rotation d'au moins l'une parmi la vis et la partie filetée.
8. Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement est configuré pour permettre une application d'un couple à au moins l'une parmi la vis et la partie filetée afin d'entraîner la rotation d'au moins l'une parmi la vis et la partie filetée.
9. Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement comprend un mécanisme de libération, la butée axiale définissant un élément libérable du mécanisme de libération, le mécanisme de libération comprenant en outre un élément de libération externe, l'élément de libération externe étant accessible à l'extérieur de l'actionneur, de préférence dans lequel l'élément de libération externe comprend un manchon externe coulissant, le manchon étant verrouillé durant un fonctionnement normal pour empêcher le mouvement de coulissement du manchon et devenant déverrouillé durant le mode de surpassement, plus préférentiellement le surpassement comprenant une goupille de cisaillement, dans lequel le manchon externe coulissant est déverrouillé pour le mode de surpassement par l'application d'une force au manchon externe coulissant pour cisainer la goupille de cisaillement.
10. Actionneur selon l'une quelconque revendication précédente, l'actionneur comprenant en outre un dispositif de retenue, le dispositif de retenue étant associé à la butée axiale ; dans lequel le dispositif de retenue est configuré pour se déplacer transversalement lors de l'activation du surpassement pour libérer la butée axiale, le mouvement transversal étant transversal à la direction du mouvement axial de l'élément de vanne.
11. Actionneur selon l'une quelconque revendication précédente, dans lequel le surpassement comprend une faiblesse prédéfinie, la faiblesse prédéfinie étant

configurée pour reconfigurer l'actionneur d'un mode de fonctionnement normal à un mode de fonctionnement de surpassement lors de l'activation ou la rupture de la faiblesse prédéfinie.

12. Appareil comprenant l'actionneur selon l'une quelconque revendication précédente, éventuellement dans lequel l'appareil comprend un appareil de tête de puits pour accéder à un puits de forage d'hydrocarbures.

13. Procédé d'actionnement électrique sous-marin, le procédé comprenant :

la fourniture d'un actionneur électrique sous-marin destiné à actionner une vanne, l'actionneur comprenant un ensemble vis comprenant une vis et une partie filetée ;

l'utilisation d'une butée axiale de l'actionneur pour empêcher le mouvement axial de l'une parmi la vis et la partie filetée, le mouvement axial étant relatif à un boîtier pour l'ensemble de vis ;

la fourniture d'un mouvement de rotation à l'ensemble vis dans un mode de fonctionnement normal avec un entraînement primaire,

l'utilisation de l'ensemble vis pour convertir le mouvement de rotation en un mouvement axial d'un élément de vanne par rapport au boîtier ;

l'utilisation d'un surpassement pour faire fonctionner l'actionneur dans un mode de surpassement, dans lequel le surpassement libère au moins l'une parmi la vis et la partie filetée pour un mouvement axial par rapport au boîtier, et au moins l'une parmi la vis et la partie filetée est déplacée axialement pour déplacer l'élément de vanne.

14. Procédé selon la revendication 13, dans lequel le procédé comprend :

la libération de la butée axiale pour libérer au moins l'une parmi la vis et la partie filetée pour un mouvement axial par rapport au boîtier, la butée axiale comprenant un épaulement empêchant le mouvement axial d'au moins l'une parmi la vis et la partie filetée en fonctionnement normal de l'actionneur ; et

le surpassement d'un moteur électrique pour faire fonctionner l'actionneur dans le mode de fonctionnement normal, en utilisant un système d'entraînement alternatif pour faire fonctionner l'actionneur dans le mode de fonctionnement de surpassement.

15. Procédé selon la revendication 13 ou 14, dans lequel le procédé comprend le fonctionnement d'une vanne d'un appareil de tête de puits pour contrôler l'accès à

un puits de forage d'hydrocarbures, de préférence dans lequel le procédé comprend l'activation d'un mécanisme de libération pour reconfigurer l'actionneur en mode de fonctionnement de surpassement, encore plus préférablement dans lequel le procédé 5 comprend l'utilisation d'une faiblesse prédéfinie pour reconfigurer l'actionneur pour un fonctionnement de surpassement.

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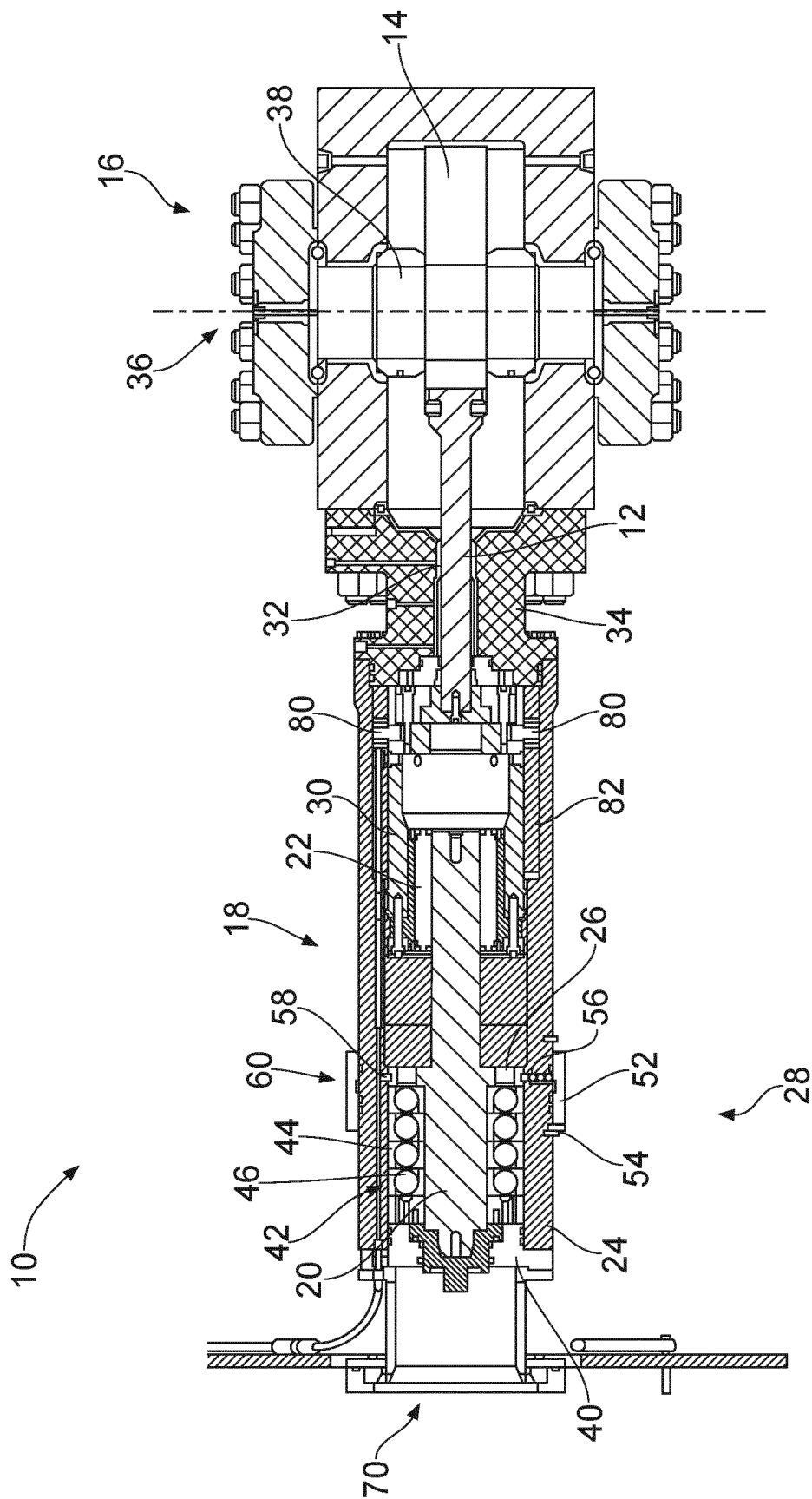


FIG. 1

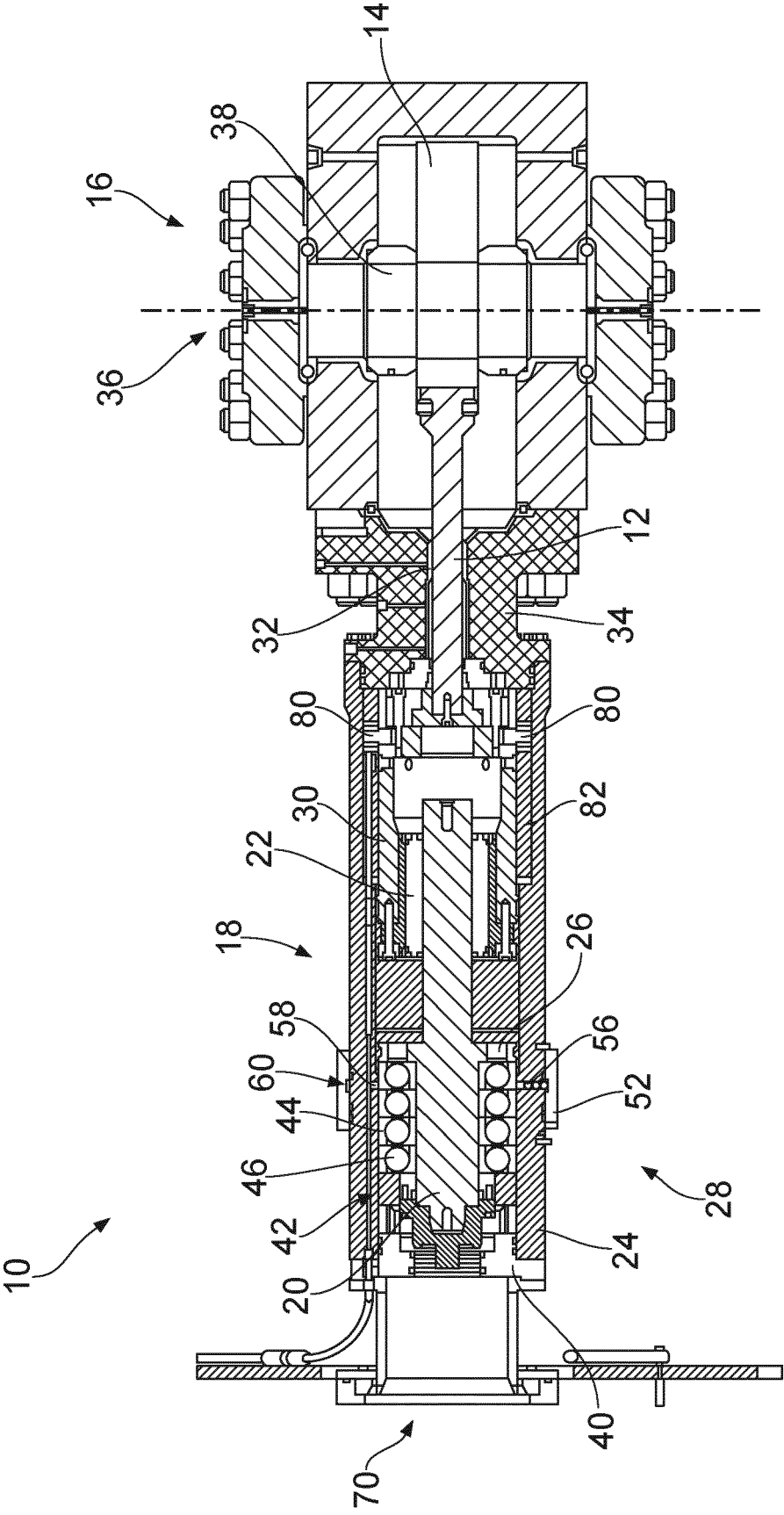


FIG. 2

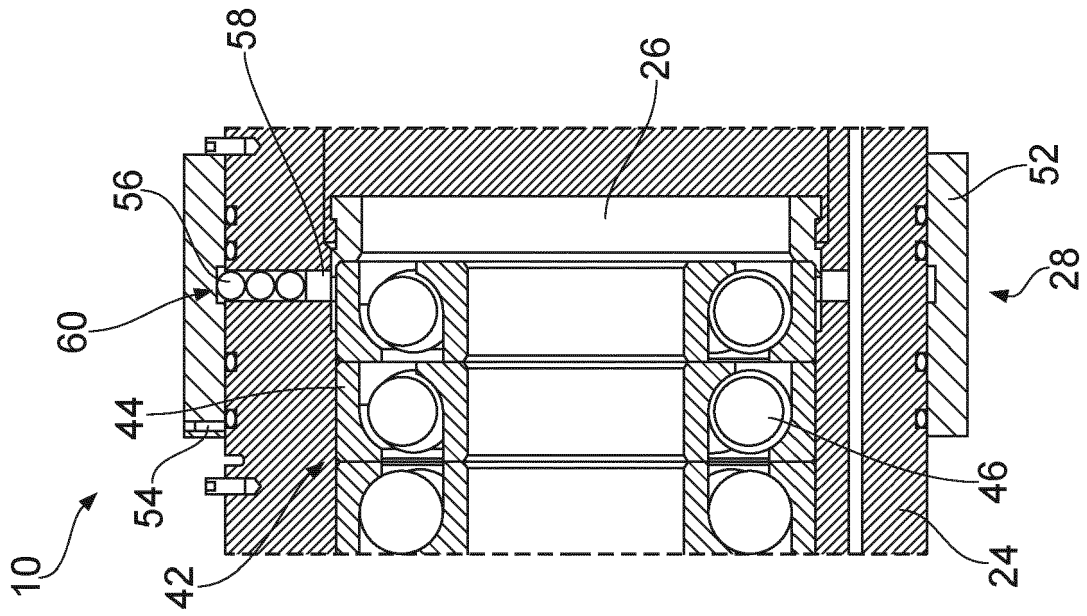


FIG. 4

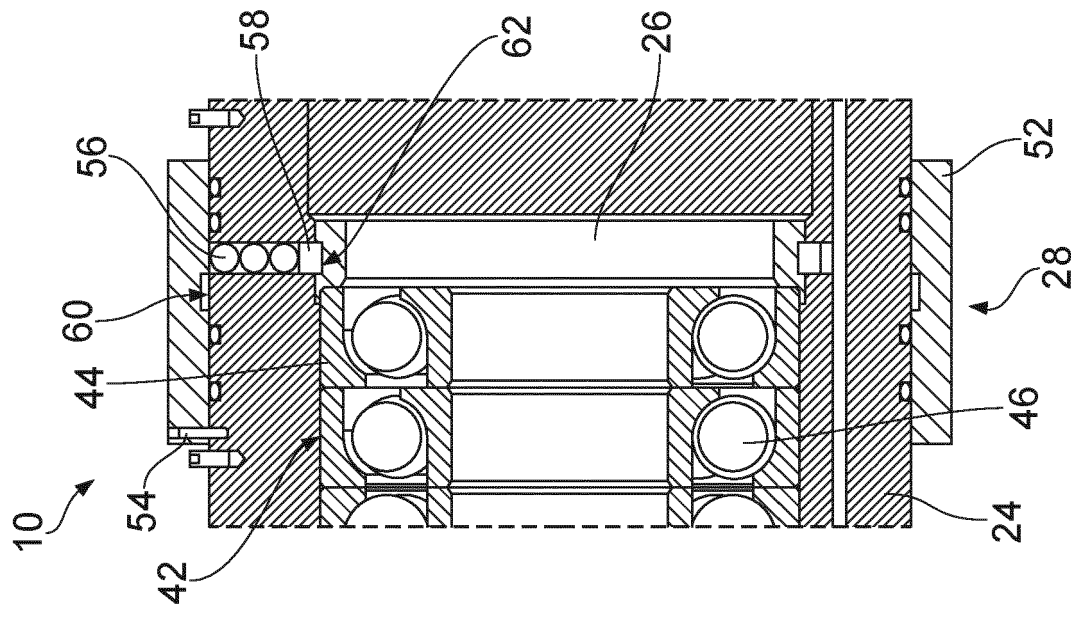


FIG. 3

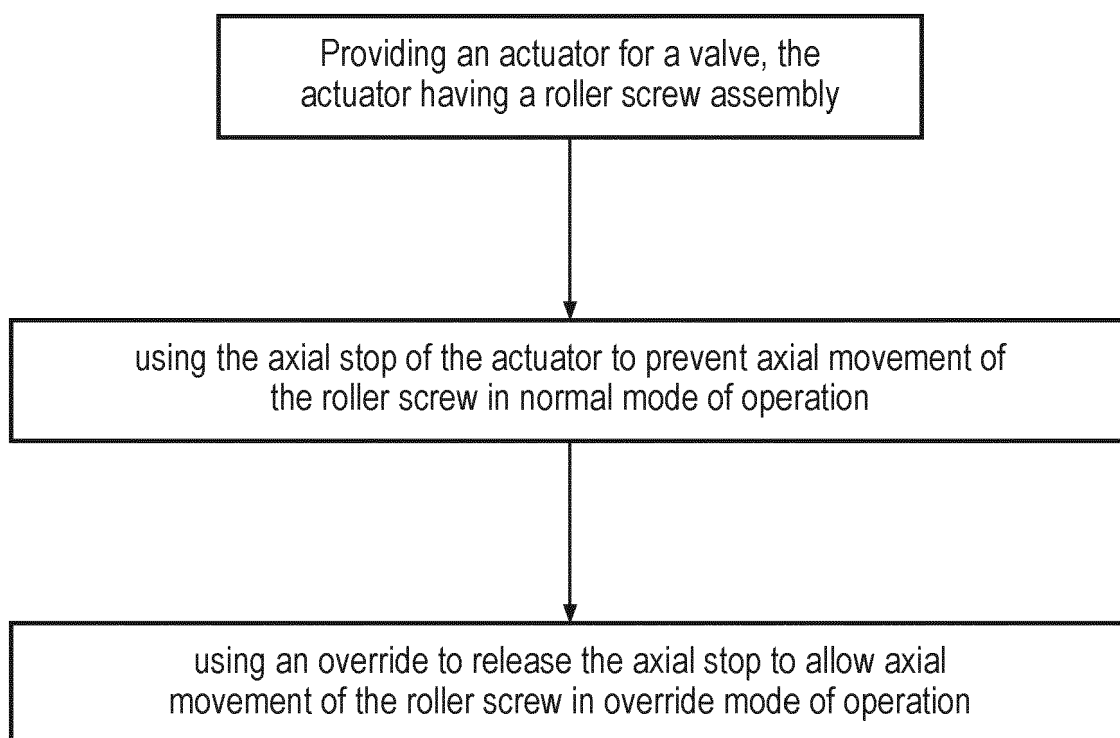


FIG. 5

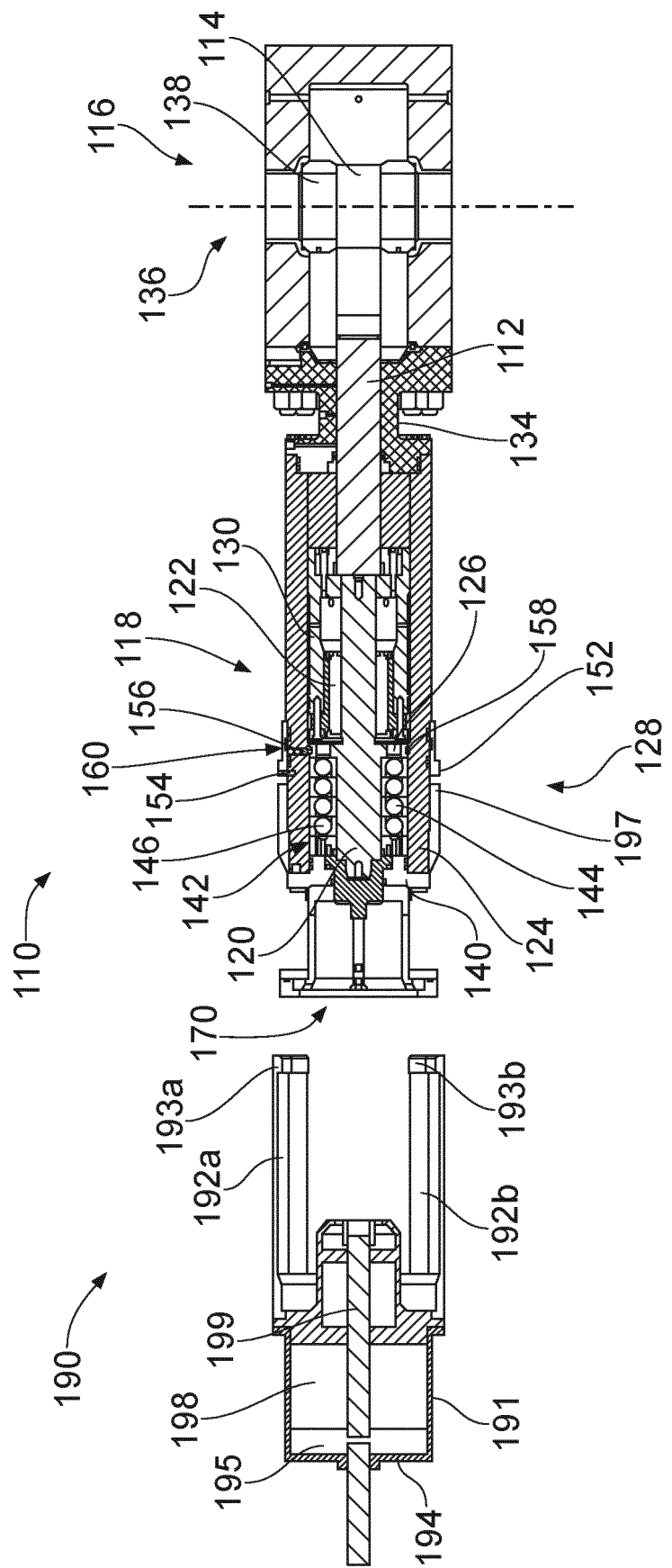


FIG. 6

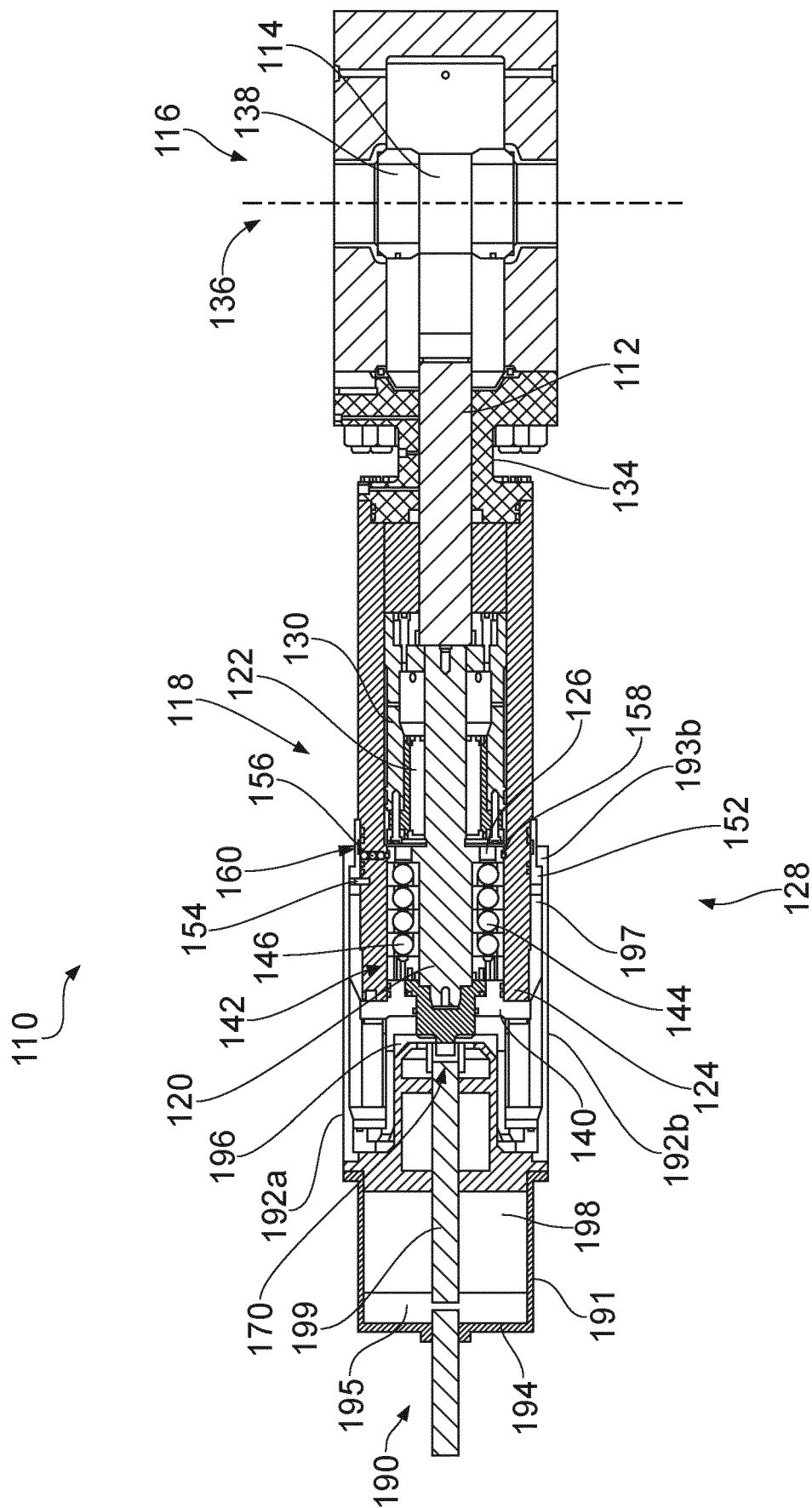
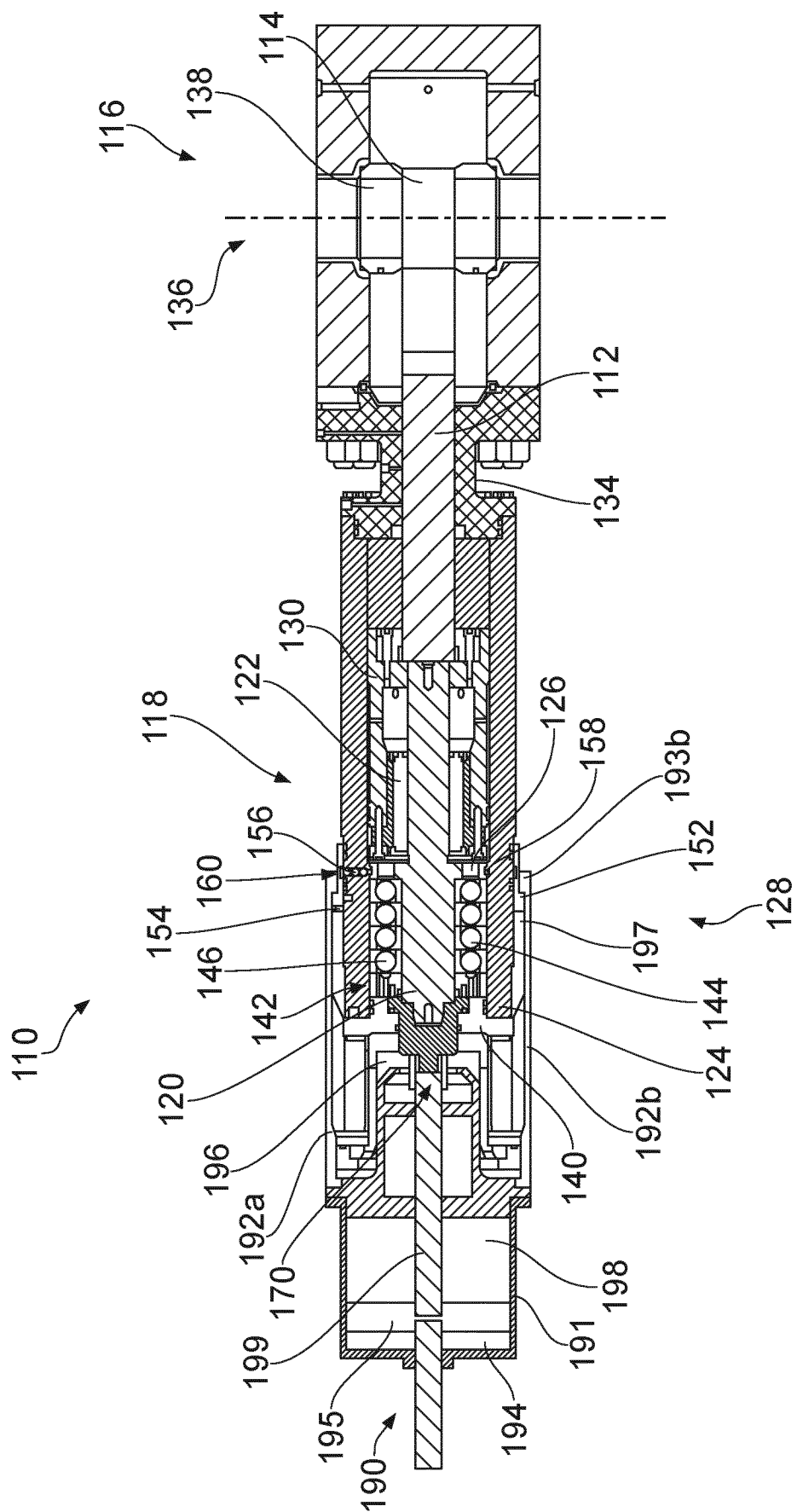


FIG. 7


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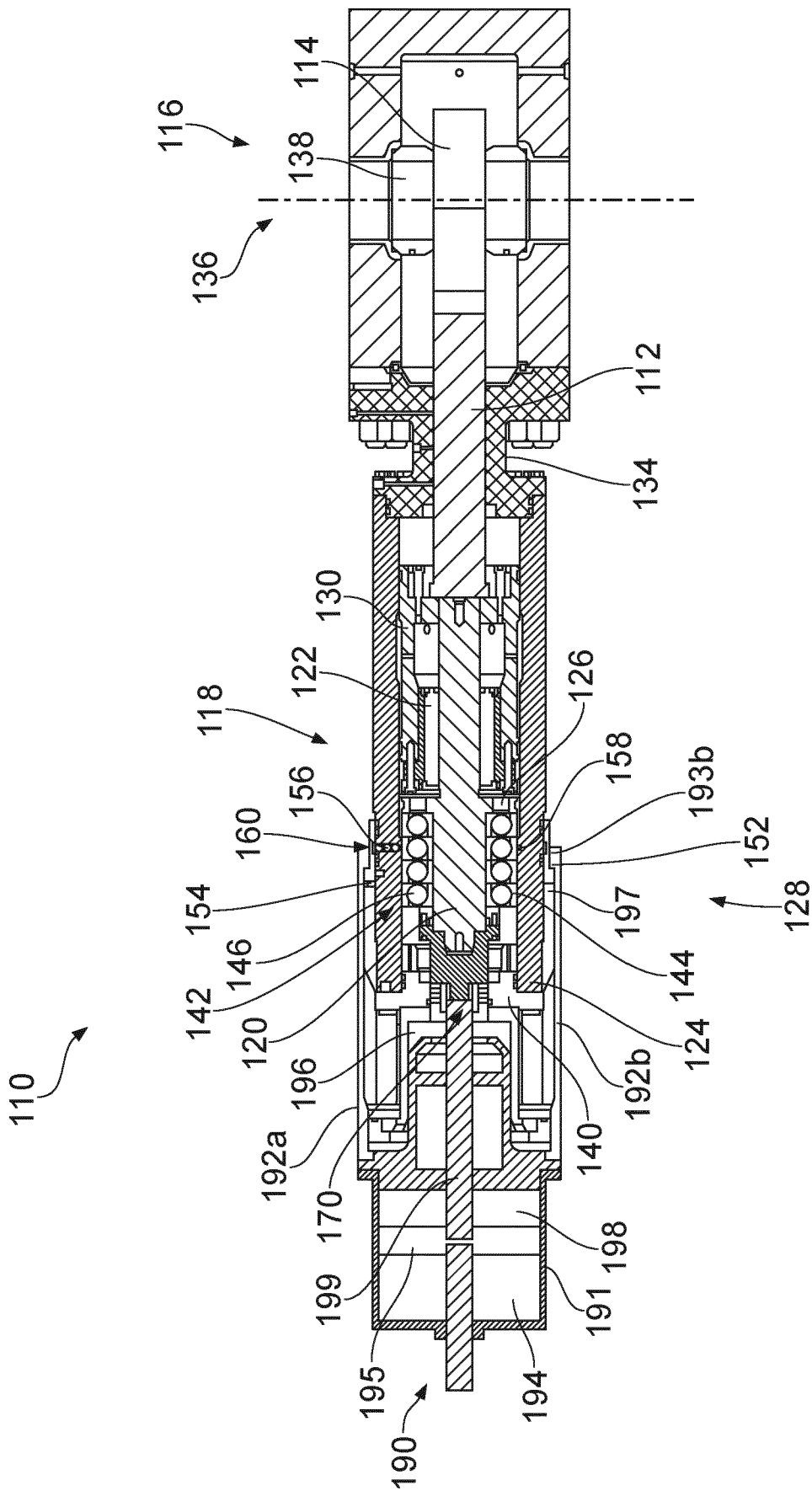


FIG. 9

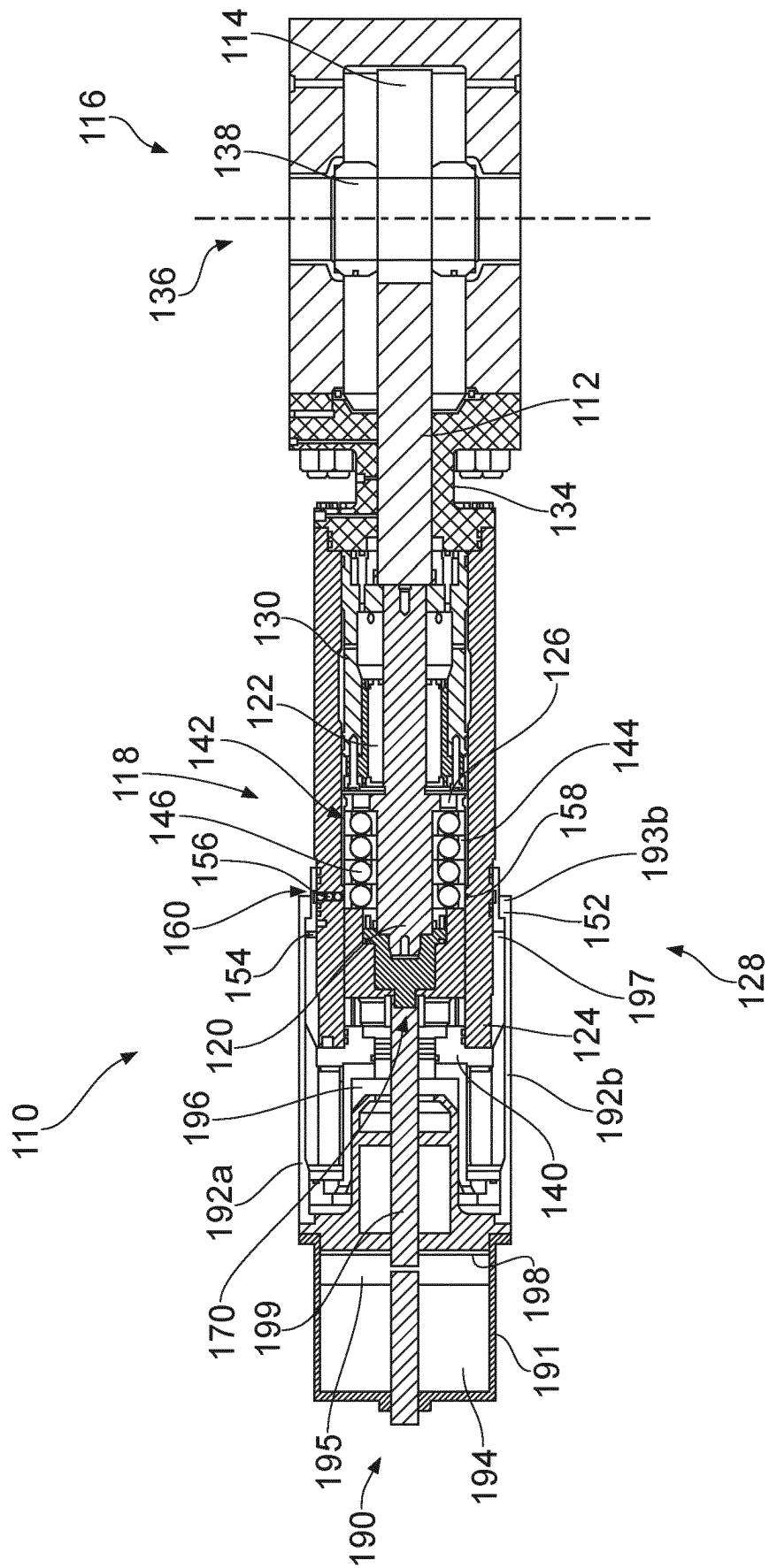


FIG. 10

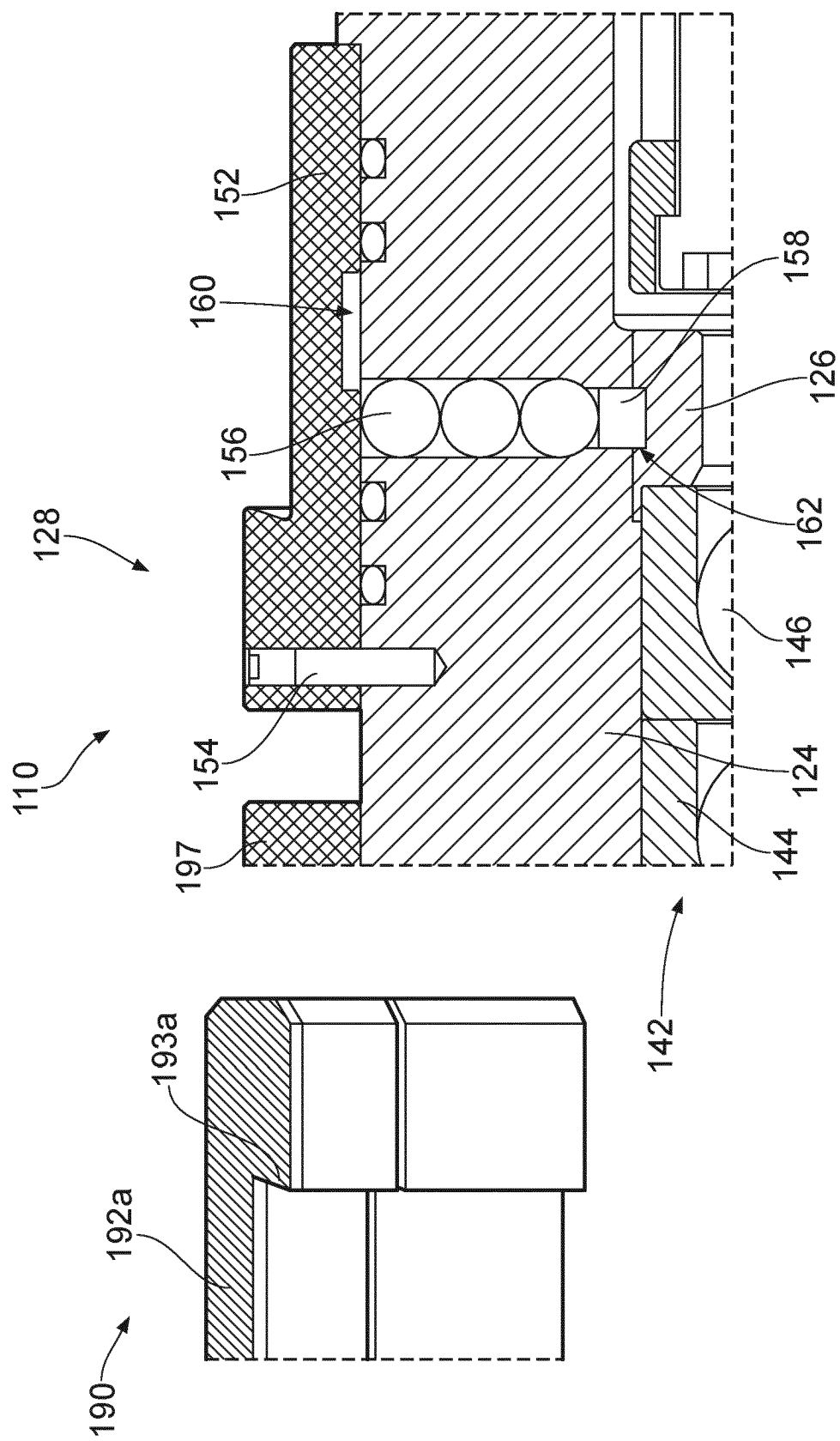


FIG. 11

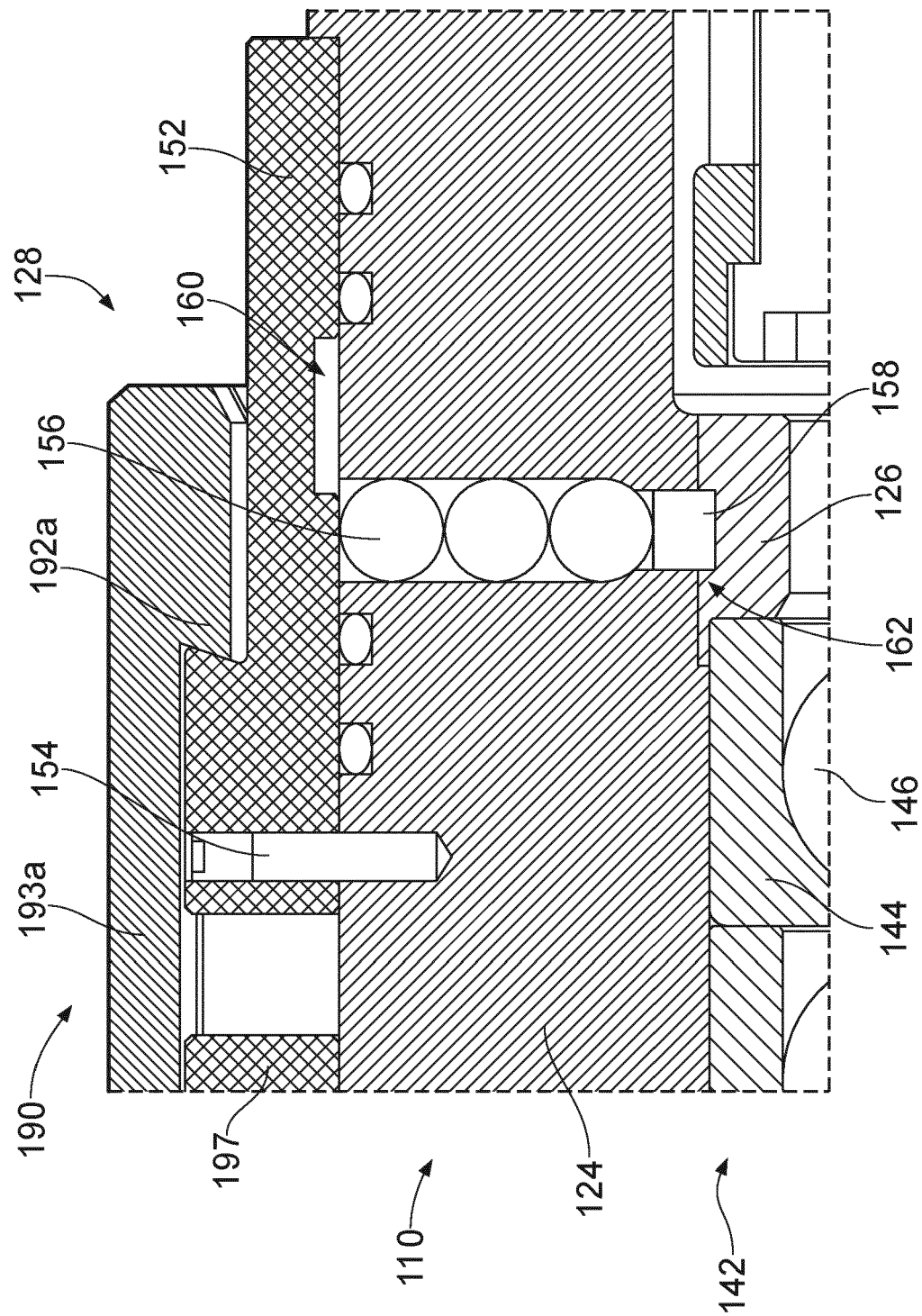


FIG. 12

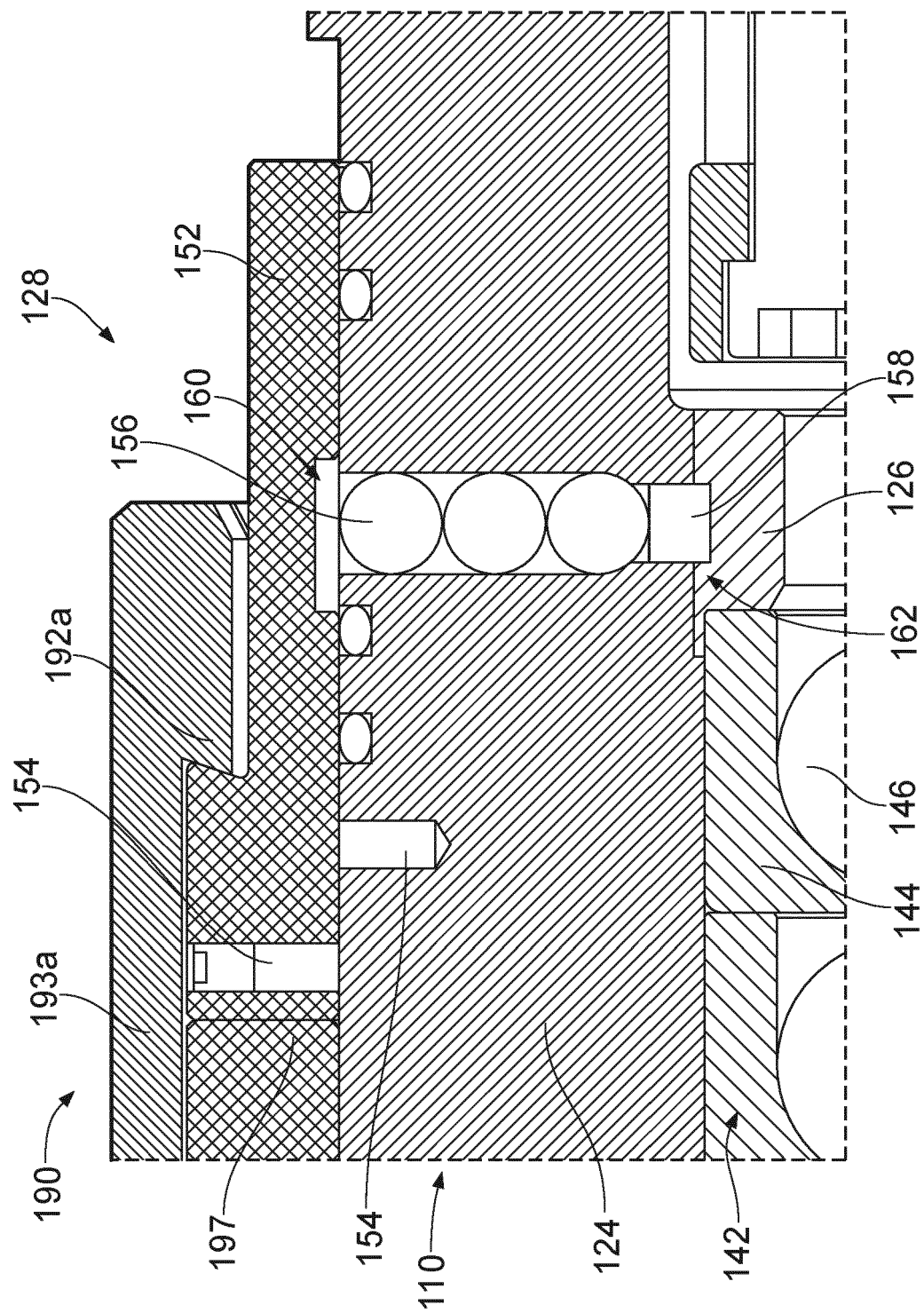


FIG. 13

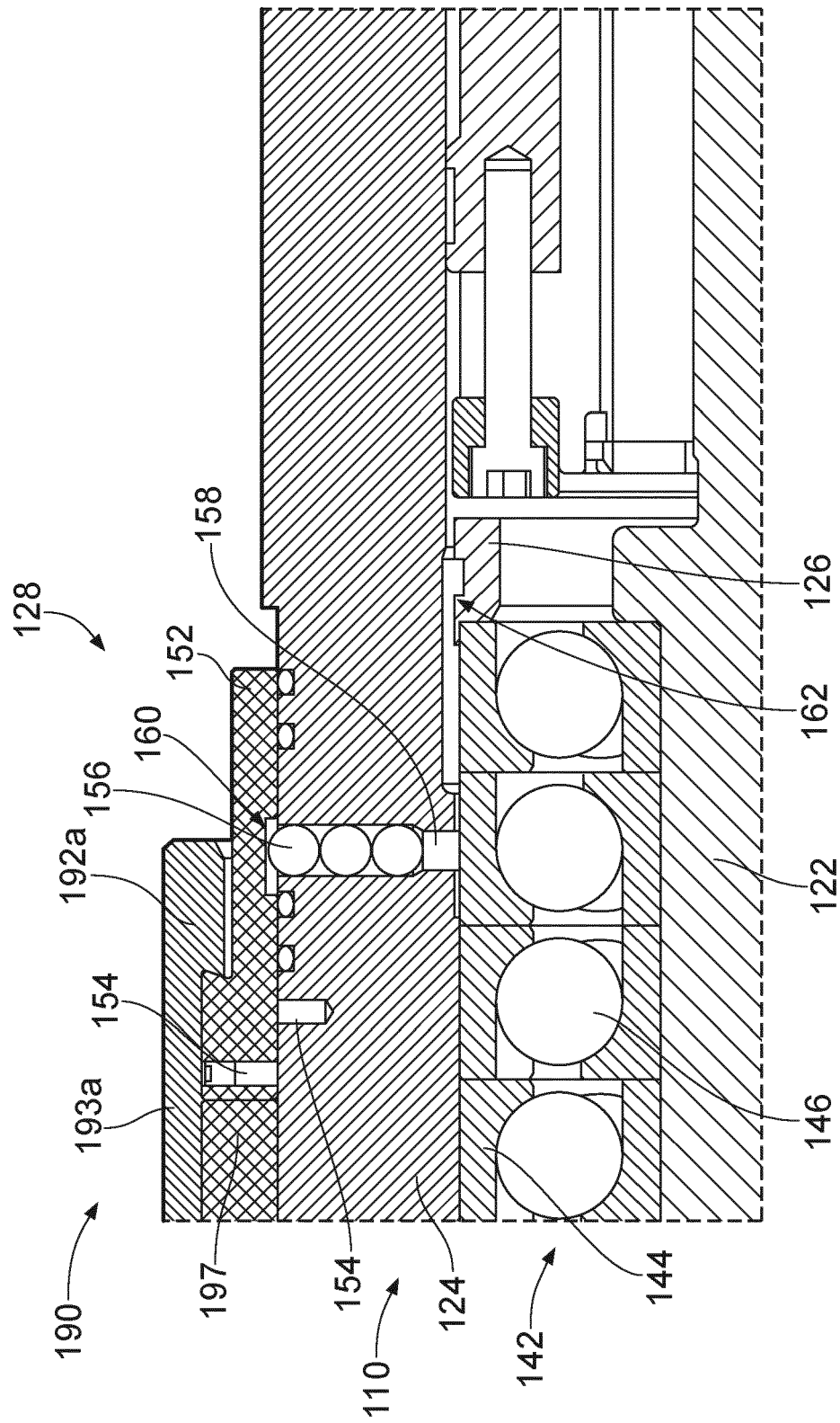


FIG. 14

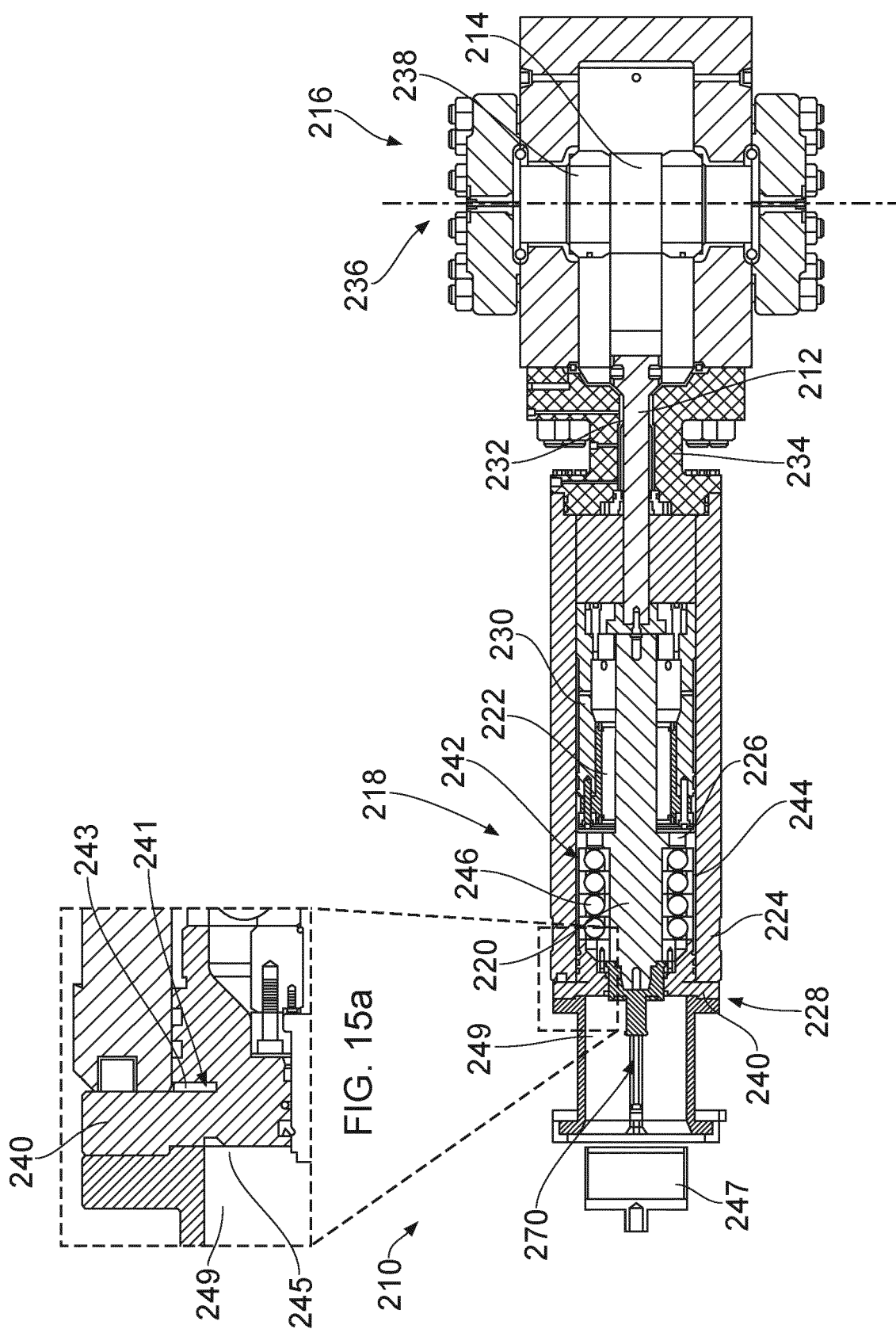


FIG. 15

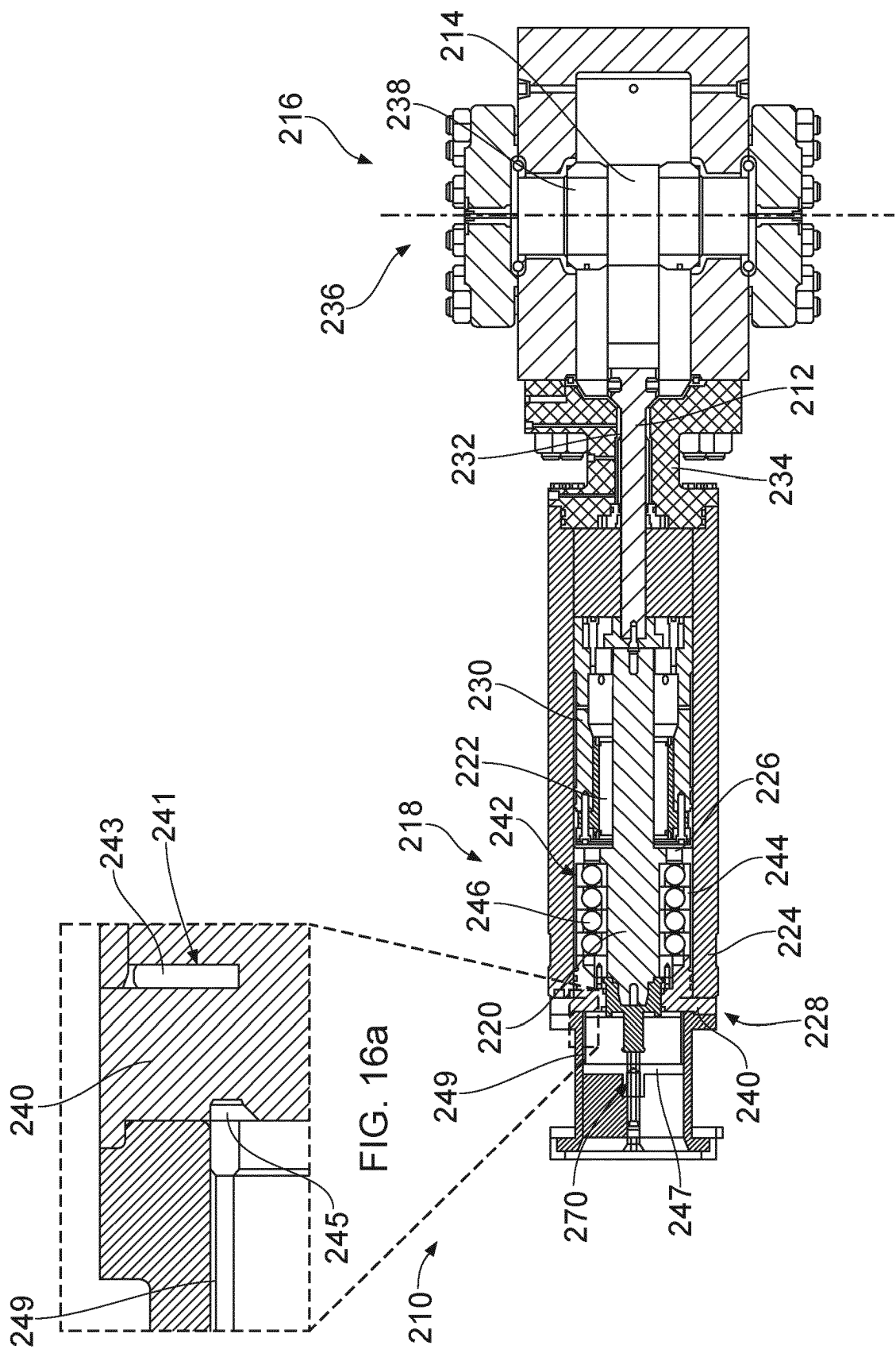


FIG. 16

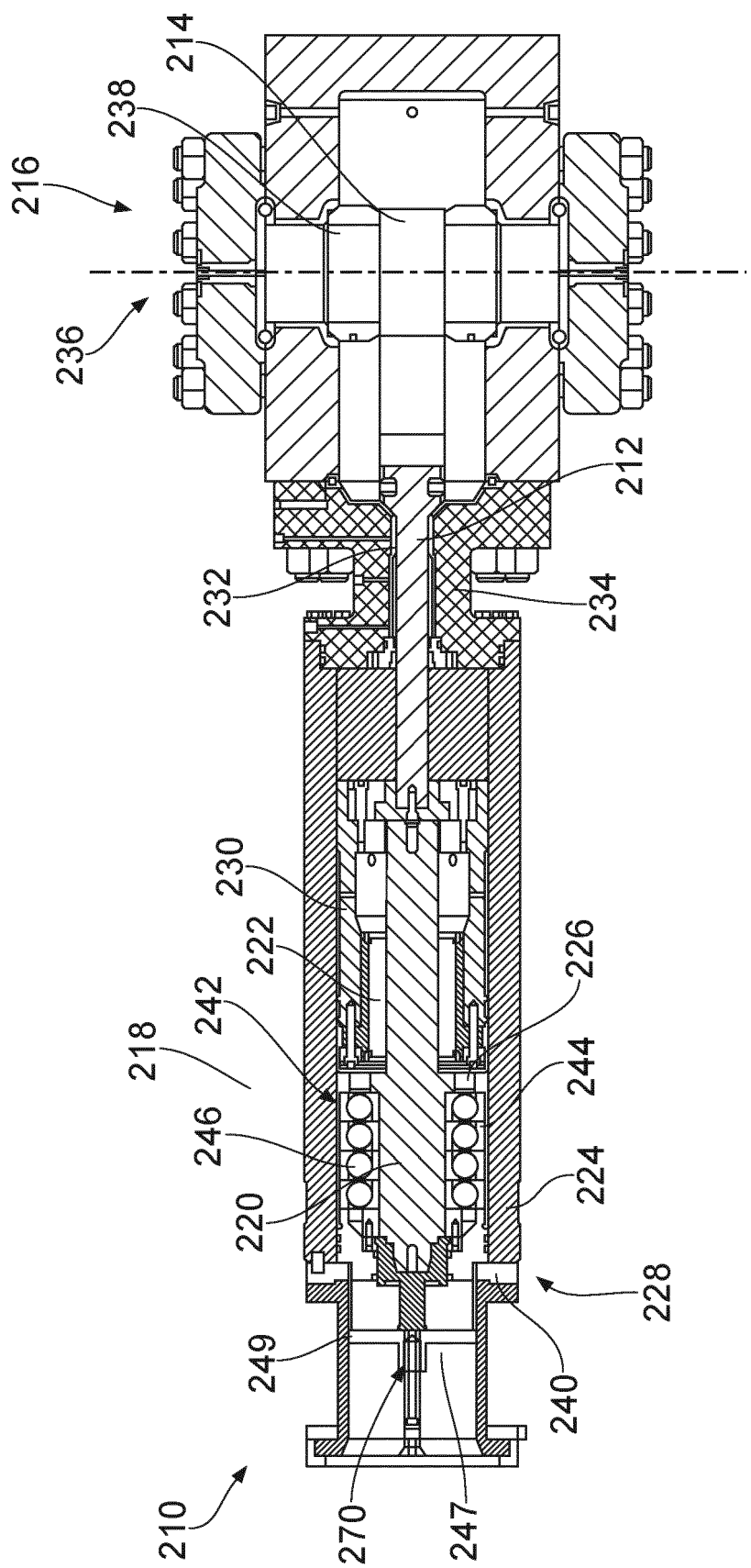
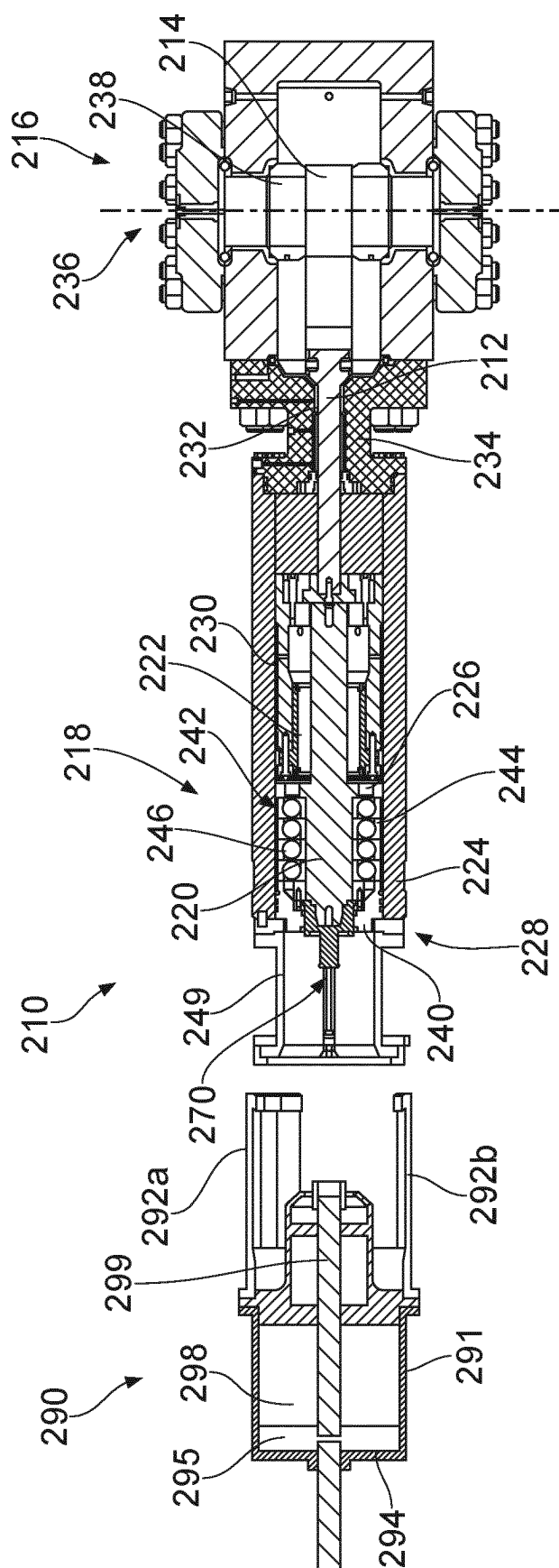


FIG. 17



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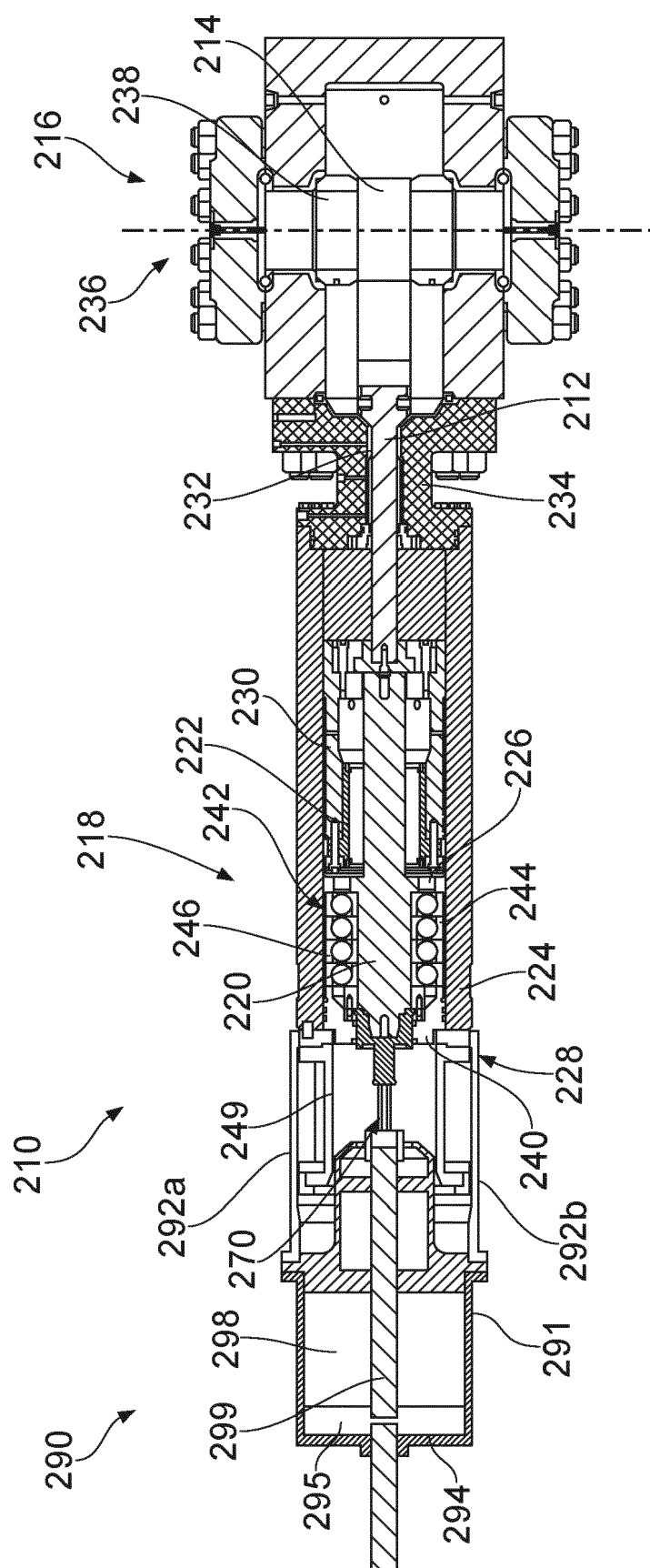


FIG. 19

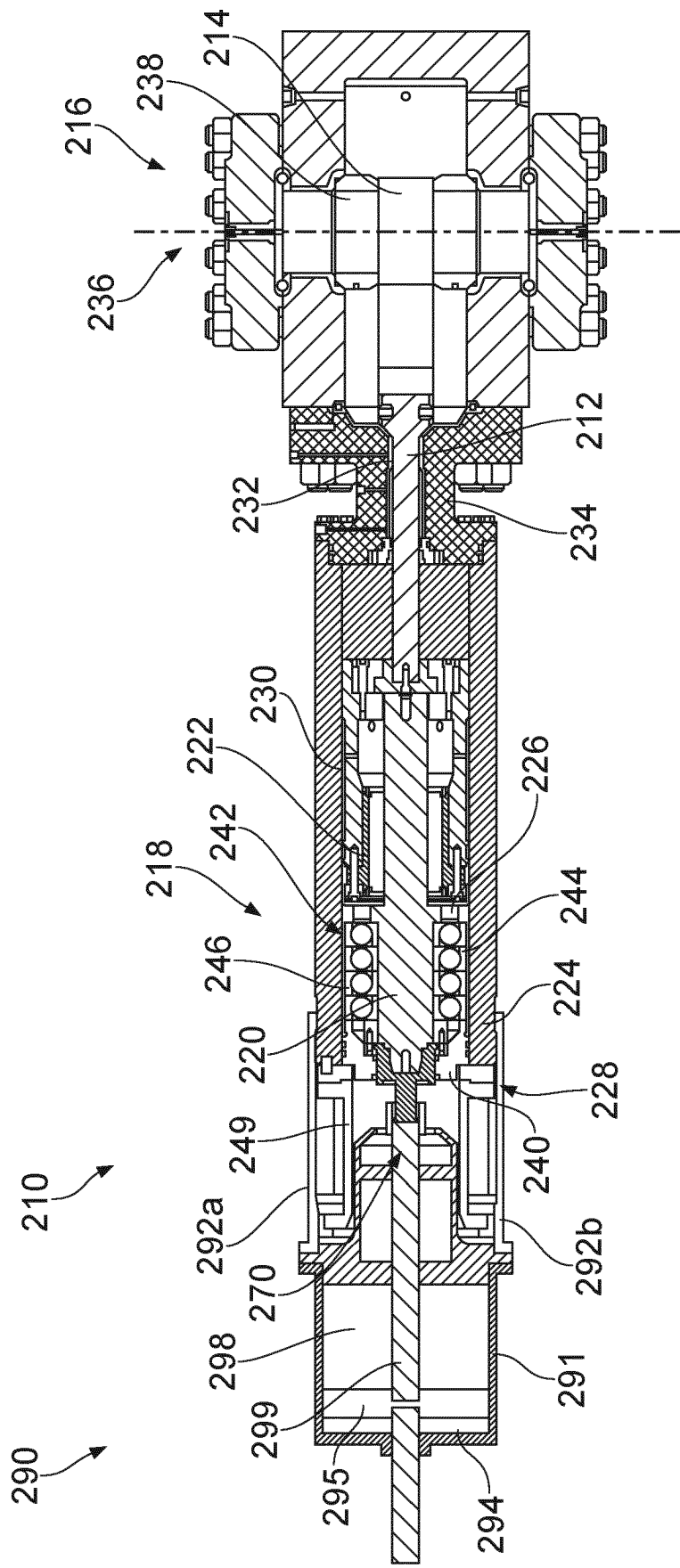


FIG. 20

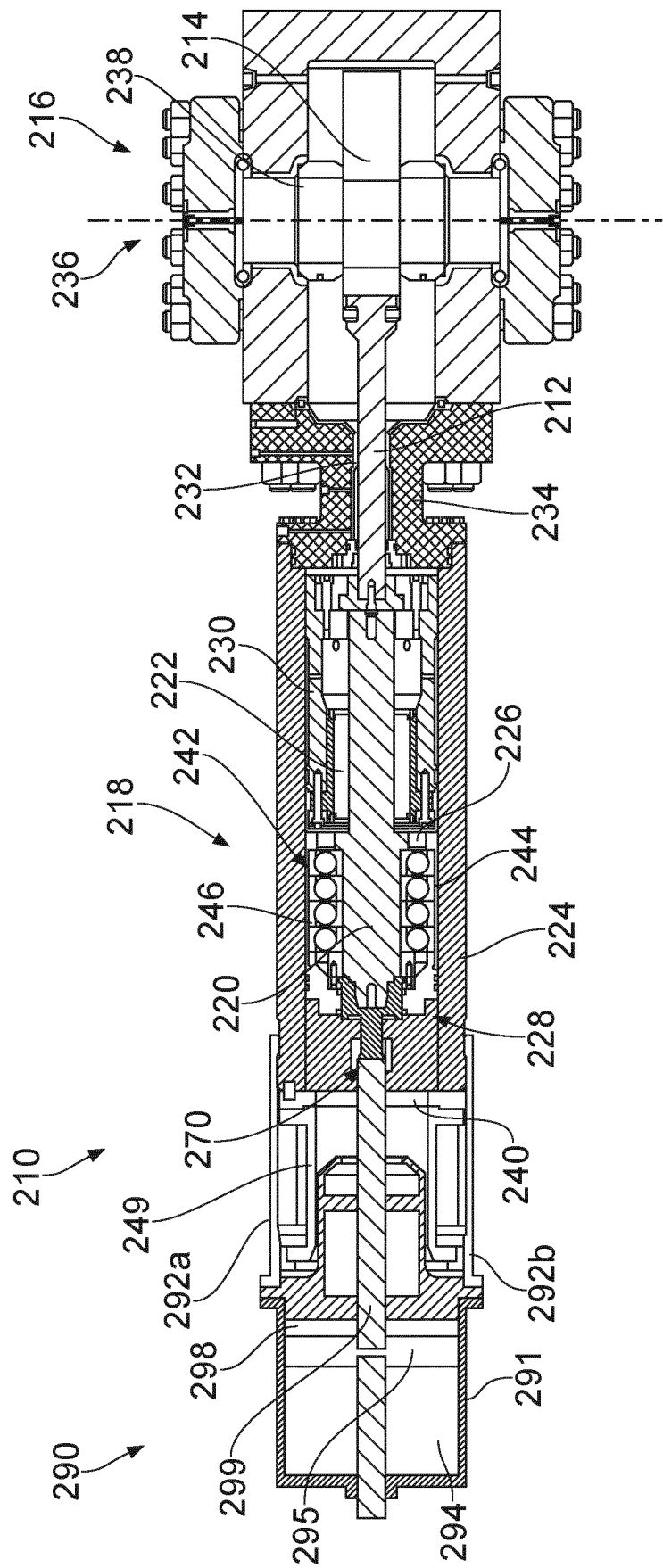


FIG. 21

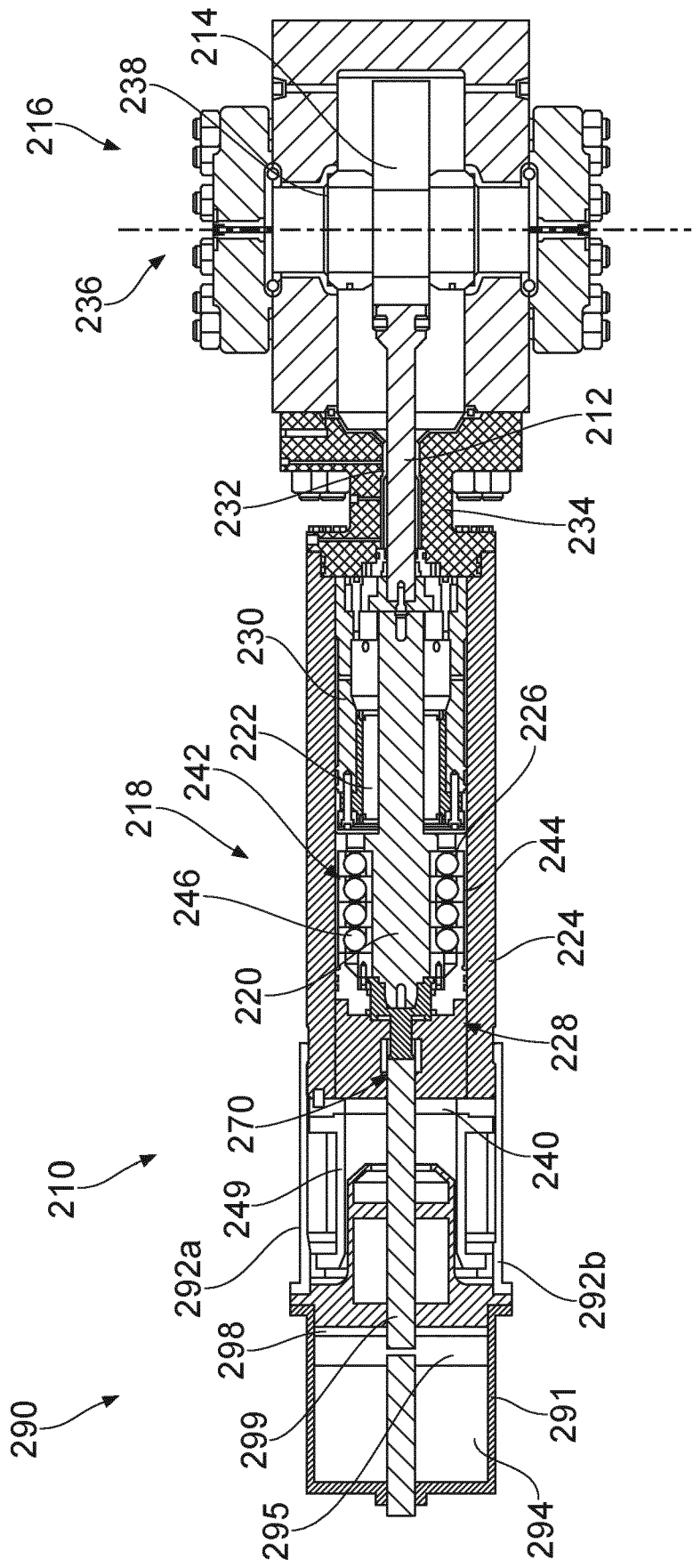


FIG. 22

REFERENCES CITED IN THE DESCRIPTION

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