(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 998 502 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.03.2016 Bulletin 2016/12

(51) Int Cl.:
E21B 33/06 *(2006.01)*

(21) Application number: **14189874.2**

(22) Date of filing: **22.10.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **22.09.2014 US 201414492284**

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(54) Multi-stage blowout preventer and method of using same

(57) A blowout preventer includes a housing, a ram block carrier which moves within the housing, and one or more ram blocks configured to be placed within the ram block carrier. The ram block carrier may include an opening, an upper shelf within the opening configured to hold an upper ram block, and a lower shelf within the opening configured to hold a lower ram block. The housing may include a central bore, cavities on both sides of the bore, and openings which allow ram blocks to access a pipe within the bore.

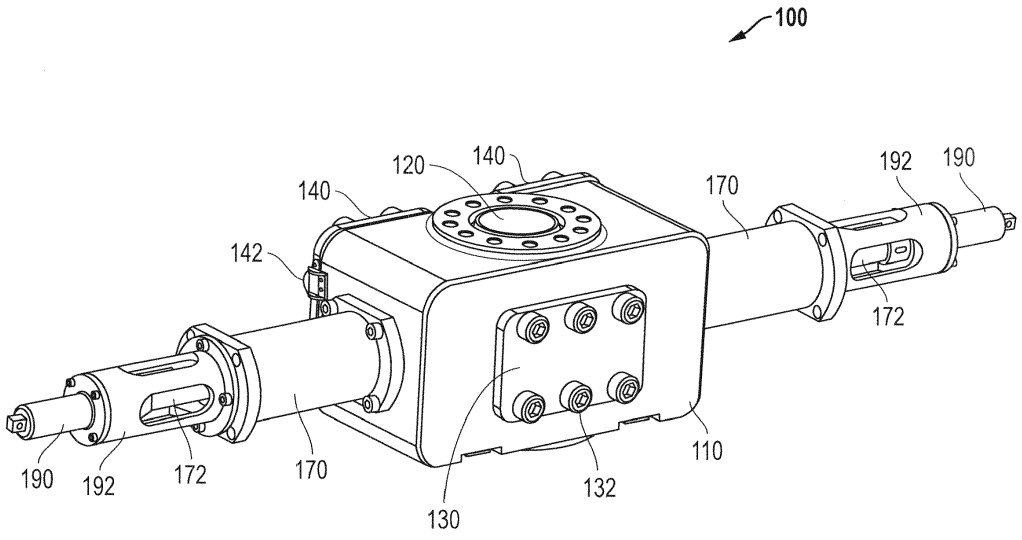

FIG. 1

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Description

BACKGROUND

1. Field

[0001] The following description relates to blowout preventers used in the oil and gas industry during well drilling. For example, a ram-type blowout preventer is used to prevent escape of well bore pressure into the outside environment in the event of an unexpected pressure due to the influx of formation fluid or in other uncontrolled situations.

2. Description of Related Art

[0002] Well control is an important aspect of oil and gas exploration. Typically, when drilling a well, safety devices must be put in place to prevent damage to equipment and, most importantly, to personnel resulting from unexpected events associated with drilling operations. Because of safety conditions and risks of blowouts, devices known as blowout preventers (BOPs) are installed above the wellhead at the surface or on the sea floor in deep water situations to effectively seal a wellbore until measures can be taken to control the kick.

[0003] Blowout preventers are specialized high-pressure valves typically installed in stacks and used to seal and control downhole pressure and monitor oil and gas wells to ultimately prevent the uncontrolled flow of liquids and gases during well drilling operations. Additionally, blowout preventers are typically used to prevent tubing, tools and drilling fluid from being blown out of the wellbore when a blowout threatens. Blowout preventers come in a variety of styles, sizes and pressure ratings and several units serving various functions are typically combined to compose a blowout preventer stack. Blowout preventers may perform any of a variety of functions such as confining well fluid to the wellbore, providing means to add fluid to the wellbore, allowing controlled volumes of fluid to be withdrawn from the wellbore, regulating and monitoring wellbore pressure, centering and hanging off the drill string in the wellbore, shutting in the well, preventing the flow of formation fluid, and sealing the well.

[0004] Blowout preventers are critical to the safety of crew, rig and environment, and to the monitoring and maintenance of well integrity. Thus, blowout preventers are intended to be fail-safe devices. As recommend by authorities and required by various regulations, blowout preventers must be regularly tested, inspected, and refurbished. Blowout preventers typically include one set of corresponding ram blocks, and when the ram blocks need to be replaced or refurbished, companies are required by law to retest the entire blowout preventer stack. This may take long periods of time and may incur great expenses. A number of blowout preventers, including different types of ram blocks, are typically needed on the blowout preventer stack in order to serve a variety of different functions.

SUMMARY

[0005] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0006] According to an example, a ram block carrier includes an opening, an upper shelf within the opening configured to hold an upper ram block, and a lower shelf within the opening configured to hold a lower ram block.

[0007] In another example, a housing of a blowout preventer includes a bore, a first cavity on a side of the bore, a second cavity on another side of the bore, and inside walls, adjacent to the first and second cavities, each comprising an opening which allows a ram block to access the bore.

[0008] In another example, a blowout preventer includes a housing, a ram block carrier configured to move within the housing, and one or more ram blocks configured to be placed within the ram block carrier.

[0009] In another example, a method of operating a blowout preventer includes moving a ram block carrier within the blowout preventer, and moving a ram block of the ram block carrier towards a pipe going through a bore of the blowout preventer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing summary, as well as the following detailed description, will be better understood when read in conjunction with the appended drawings. For the purpose of illustration, certain examples of the present description are shown in the drawings. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate an implementation of system, apparatuses, and methods consistent with the present description and, together with the description, serve to explain advantages and principles consistent with the invention.

FIG. 1 is a diagram illustrating a perspective view of an example of a blowout preventer.

FIG. 2 is a diagram illustrating a perspective view of an example of a blowout preventer in an open-door configuration.

FIG. 3 is a diagram illustrating a perspective view of an example of a housing of a blowout preventer.

FIG. 4 is a diagram illustrating a perspective view of

an example of a ram block carrier of a blowout preventer.

FIGS. 5A and 5B are diagrams illustrating front and top cross-sectional views of an example of a blowout preventer including a hydraulic actuator and mechanical override mechanism for movement of the ram blocks.

FIG. 5C is a diagram illustrating an example of a ram block including a T-slot for connection to an actuating rod.

FIGS. 6A and 6B are diagrams illustrating side cross-sectional views of an example of a blowout preventer including a hydraulic actuator for movement of the ram block carrier into an upper and lower positions.

FIGS. 6C and 6D are diagrams illustrating an example of a blowout preventer including a mechanical override for movement of the ram block carrier into an upper and lower position.

FIG. 7A and 7B are diagrams illustrating an example of a blowout preventer having a ram block carrier in a lower position and upper ram blocks in a retracted position and an engaged position.

FIGS. 8A and 8B are diagrams illustrating an example of a blowout preventer having a ram block carrier in an upper position and lower ram blocks in a retracted position and an engaged position.

FIG. 9 is a diagram illustrating a perspective view of another example of a blowout preventer including a circular rear door.

FIG. 10 is a diagram illustrating a perspective view of another example of a blowout preventer including circular ram doors.

FIG. 11 is a diagram illustrating a top cross-sectional view of another example of a blowout preventer including a hydraulic actuator and mechanical actuating mechanism for movement of the ram block carrier.

FIG. 12 is a diagram illustrating a side cross-sectional view of another example of a blowout preventer including a hydraulic actuator and mechanical actuating mechanism for movement of the ram block carrier.

[0011] Throughout the drawings and the detailed description, unless otherwise described, the same drawing reference numerals will be understood to refer to the same elements, features, and structures. The relative size and depiction of these elements may be exaggerated for clarity, illustration, and convenience.

DETAILED DESCRIPTION

[0012] The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses, and/or systems described herein. Accordingly, various changes, modifications, and equivalents of the systems, apparatuses and/or methods described herein will be suggested to those of ordinary skill in the art. Also, descriptions of well-known functions and constructions may be omitted for increased clarity and conciseness.

[0013] In addition, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting. For example, the use of a singular term, such as, "a" is not intended as limiting of the number of items. Also the use of relational terms, such as but not limited to, "top," "bottom," "left," "right," "upper," "lower," "down," "up," "side," are used in the description for clarity and are not intended to limit the scope of the invention or the appended claims. Further, it should be understood that any one of the features can be used separately or in combination with other features. Other systems, methods, features, and advantages of the invention will be or become apparent to one with skill in the art upon examination of the detailed description. It is intended that all such additional systems, methods, features, and advantages be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

[0014] FIG. 1 is a diagram illustrating an example of a blowout preventer **100,** and FIG. 2 is a diagram illustrating an example of a blowout preventer **100** in an open-door configuration.

[0015] Referring to FIGS. 1 and 2, a blowout preventer **100** includes a housing **110,** a bore **120** going through a center of the housing **110,** a rear door **130,** ram doors **140** on two sides of the housing **110,** hydraulic actuators **170** attached to the sides of the blowout preventer **100,** and mechanical override stems **190** on the ends of the hydraulic actuators **170.** As shown in FIG. 2, the housing **100** includes two cavities **124** for receiving ram block carriers **160.**

[0016] The housing **110** includes a rear door **130** which is shown in a closed position in FIG. 1. In this example, the rear door **130** is attached to the housing **110** using fasteners **132** which bolt the rear door **130** to the housing **110** in a number of positions around the rear door **130.** For example, the rear door **130** may be bolted to the housing **110** using six fasteners **132** but may be attached to the housing **110** using a variety of fasteners **132** in a variety of positions. The rear door **130** is in a closed configuration while the blowout preventer **100** is in use, but may be opened by removing the fasteners **132** and opening the rear door **130.** The rear door **130** may be attached to the housing **110** by a door hinge or without a door

hinge.

[0017] The housing **110** includes ram doors **140** which may be opened for inspecting, replacing, or removing components within the blowout preventer **100** such as ram block carriers, ram blocks, or other components. In this example, two ram doors **140** are attached to the body of the housing **110** using fasteners (not shown) similar to the fasteners **132** used for bolting the rear door **130.** The ram doors **140** may include a number of holes **144** arranged around the doors **140** and configured to receive fasteners which are to be bolted to holes **112** formed within the housing **110.** The ram doors **140** may be attached to the housing **110** using door hinges **142** so that the doors may be swung to an open position about the hinges **142** once the fasteners are removed.

[0018] FIG. 3 is a diagram illustrating an example of the housing **110** and displaying an interior of the housing **110.**

[0019] Referring to FIG. 3, the housing **110** includes cavities **124** for receiving ram block carriers **160.** The interior walls of the housing **110,** which are formed around the cavities **124,** include openings for allowing ram blocks **182, 184,** discussed below, installed within the ram block carriers **160** to be pushed towards and close in on the bore **120.** Outer walls of the housing **110,** also adjacent to the cavities **124,** include grooves **114, 115** for interacting with the ram block carriers **160,** side openings **116** for receiving components of the hydraulic actuators **170.** The bottom walls formed adjacent to the cavities **124** include drain holes **119** for draining residue fluids which enter the housing **110** during the drilling process. The interactions between the grooves **114, 115** of the housing **110** and the ram block carriers **160** will be explained in more detail below in reference to the components of the ram block carriers **160** and their movement within the cavities **124.**

[0020] FIG. 4 is a diagram illustrating an example of a ram block carrier **160** which is capable of holding more than one ram block **182, 184,** as discussed below. In one aspect, this provides a versatility in the types, sizes, and numbers of ram blocks used within a single blowout preventer, and allows an operator to efficiently switch between ram blocks without the burden of accessing the interior cavities of the blowout preventer and needing to retest the blowout preventer stack.

[0021] Referring to FIG. 4, the ram block carrier **160** includes detent button holders **166** and detent buttons **167,** a extension tab **163** for use in the hydraulic actuation of the carrier **160,** and a rack **162** for use in the mechanical override actuation of the carrier **160.** Referring back to FIGS. 2 and 3, the blowout preventer **100** includes two ram block carriers **160,** each placed within one of the two cavities **124** of the housing **110.** The carriers **160** are moved up and down within the cavities **124** of the housing **110.** When the ram block carriers **160** are in the lower position, the detent buttons **167** are engaged with the lower grooves **114** of the housing **110,** whereas ram block carriers **160** in the upper position have detent buttons **167** engaged with the upper grooves of the housing **110.** Accordingly, the detent buttons **167** slide along the interior walls of the cavities **124** as the carriers **160** are moved up and down. For example, the detent buttons **167** may include springs which support the buttons **167** within the button holders **166** and allow the buttons **167** to be pushed inwardly for disengaging from the grooves **114, 115** upon up and down movement of the carriers **160.**

[0022] In an example, the ram block carrier **160** includes an upper shelf **165** and a lower shelf **164** for receiving an upper ram block **182** and a lower ram block **184.** The carrier **160,** including the ram blocks **182, 184** installed therein, can be seen in FIG. 5A. The ram block carriers **160** are configured to carry one or more ram blocks **182, 184.** In this example, the ram block carriers **160** carry two ram blocks **182, 184** each, the upper ram block **182** and the lower ram block **184,** but it should be appreciated that the number of ram blocks carried by the ram block carrier **160** is not limited thereto. For example, the ram block carriers **160** may carry three or more ram blocks.

[0023] Further, the ram block carriers **160** may be smaller in height, width, and length than the cavities **124** of the housing **110.** This allows the ram block carriers **160** to move up and down within the housing **110.** It should be appreciated that the ram block carriers **160** may be formed according to a variety of different sizes based on the types and sizes of the ram blocks **182, 184** used within the ram block carriers **160.** In an example, the carriers **160** may accommodate 3 inch thick or 5 inch thick ram blocks on the upper and lower shelves **164, 165.** The height of the ram block cavities **124** of the housing **110** may be at least two times the height of the openings formed within the interior wall of the housing **110.** The upper and lower ram blocks **182, 184** may have the same size or may have different sizes. Also, the upper and lower ram blocks **182, 184** may be of the same type or may be of different types. For example, the upper ram blocks **182** and the lower ram blocks **184,** or three or more ram blocks installed within the blowout preventer **100,** may include any one or more of pipe, blind, shear, and blind shear ram blocks.

[0024] For purposes of understanding the movements within the blowout preventer **100,** the actuation of the ram blocks **183, 184** into an open, retracted position and closed, engaged position, and the actuation of the ram block carriers **160** into an upper and lower position will be described below. Regarding the movement of the ram blocks **183, 184,** the blocks **183, 184** are moved between a retracted position and an engaged position about the pipe of the bore **120** using a hydraulic actuator **170** or a mechanical override stem **190** which will be described below with reference to FIGS. 5A-5B. Regarding the movement of the ram block carriers **160,** the carriers **160** move up and down within the cavities **124** of the housing **110** using a separate hydraulic actuating mechanism **150** or mechanical override mechanism **155, 162** which will be described below with reference to FIGS. 6A-6D. Dif-

ferent positions of the ram blocks **183, 184** and ram block carriers **160** will be discussed with reference to FIGS. 7A-7B and 8A-8B.

[0025] FIGS. 5A and 5B are diagrams illustrating front and top cross-sectional view of an example of the blowout preventer **160** including hydraulic actuators **170** and mechanical override stems **190.**

[0026] Referring to the example illustrated in FIGS. 5A and 5B, each hydraulic actuator **170** includes a hydraulic cavity **171,** an interior actuating rod **173,** an exterior actuating rod **172,** a piston **174,** fasteners **175** for securing the actuating rods **172, 173** to the piston **174,** and ram open/close hydraulic fluid ports **176, 177.** As shown in the figures, when the ram blocks **182, 184** are in the retracted position, the piston **174** is furthest away from the housing **110.** To move the ram blocks **182, 184** to the engaged position, hydraulic fluid is injected into the hydraulic cavity **171** through the ram-closed fluid port **177** and the piston **174** is pushed towards the housing **110.** This in turn pushes the interior actuating rod **173** into the ram block **182** and closes the ram block **182** in on the pipe of the bore **120.** Similarly, to move the ram blocks **182, 184** back to the retracted position, hydraulic fluid is injected into the cavity **171** through the ram-open fluid port **176** and the piston **174** is pushed away from the housing **110.**

[0027] In the event of failure of the hydraulic actuator **170** or as an alternative to hydraulic actuation, blowout preventer **100** includes override mechanical actuator stem **190** for mechanical actuation of the ram blocks **182, 184.** Mechanical actuator stem **190** is placed on the end of a stem protector **192** using roller bearings **194** which allow the stem **190** to be twisted for initiating mechanical actuation. When the stem **190** is twisted manually by an operator or using a machine, rotation of the stem **190** causes a threaded push rod **196** within the stem to pull away from the stem **190** and to be pushed inwardly towards the housing **110.** This in turn pushes the entire actuating system, including the exterior actuating rod **172,** the piston **174,** and the interior actuating rod **173,** into the ram block **182** for actuating into an engagement position. It should be appreciated that the length of the actuator stem **190** and push rod **196** is at least sufficient to extend the ram block **182** into an entirely engaged position, however, a number of lengths and sizes may be adopted and are appreciated to a person having ordinary skill in the art.

[0028] The stem protector **192** may include windows **193** which allow an operator to monitor the hydraulic and mechanical actuation of the ram blocks **182, 184.** For example, the push rod **196** includes an end holder **197** which receives the exterior actuating rod **172.** The end holder **197** includes one or more holes showing the position of the exterior actuating rod **172** with respect to the end holder **197.** When the hydraulic actuator **170** is in the retracted position, an operator is able to see that the exterior actuating rod **172** is fully inserted within the end holder **197.** When the hydraulic actuator **170** is in the engaged position, an operator is able to see that the exterior actuating rod **172** has separated from the end holder **197.** Similarly, by monitoring the position of the end holder **197** with respect to the windows **192** of the stem protector **193,** an operator may determine whether the mechanical actuator stem **190** has been engaged and whether the push rod **196** is fully inserted within the mechanical actuator stem **190.** Indicators or markings may be added to any one or more of these components to allow the operator to determine the degree of hydraulic or mechanical actuation. Additionally, sensors may be used to detect the relative positions of these components for notifying an operator.

[0029] FIG. 5C is a diagram illustrating an example of a ram block **182** including a T-slot **183** connection to an actuating rod **173.**

[0030] Ram blocks **182, 184** are engaged one at a time with the interior actuating rod **173** through a T-block connector **180** which is attached at the end of the interior actuating rod **173.** The T-block connector **180** is configured to be received by each of the ram blocks **182, 184** through a T-slot **183.** When the ram block carrier **160** is in the lower position, the T-block connector **180** is engaged with the T-slot **183** of the upper ram block **182,** and when the ram block carrier **160** is in the upper position, the T-block connector **180** is engaged with the T-slot **183** of the lower ram block **184.** Accordingly, due to the shape and size of the T-slot **183,** the up and down movement of the ram block carrier **160** simply allows the T-block connector **180** to slide between the T-slots **183** of the different ram blocks **182, 184.** It should be appreciated that the size of the components of the ram block carrier **160** and carrier actuating mechanisms **150, 155, 162** allow the T-block connector **180** to move to an engagement position with each T-slot **183** of the ram blocks **182, 184.** Additionally, a programmable actuator may be utilized to position the T-block connector **180** within the T-slots **183** of each ram block **182, 184.**

[0031] FIGS. 6A and 6B are diagrams illustrating side cross-sectional views of an example of a blowout preventer including a hydraulic actuator **150** for movement of the ram block carrier **160** into an upper position and a lower position.

[0032] Ram block carrier **160** is configured to be in a lower position, as shown in FIG. 6A, when the upper ram block **182** is active and the lower ram block **184** is idle. Also, ram block carrier **160** is configured to be in an upper position, as shown in FIG. 6B, when the lower ram block **184** is active and the upper ram block **182** is idle. Referring to the examples illustrated in FIGS. 6A and 6B, the movement of the ram block carrier **160** into the upper and lower positions may be controlled by a hydraulic actuator **150.** The hydraulic actuator **150** includes an actuating piston **151,** an actuating stem **152,** an extend port **153,** and a retract port **154.** The upper end of the actuating stem **152** may be attached to the ram block carrier **160** using an extension tab **163** of the ram block carrier **160** for receiving the actuating stem **152.**

[0033] In an example, hydraulic fluid controlled by an operator is injected into the extend port **153** and into a cavity of the hydraulic actuator **150.** This causes the actuating piston **151** to rise which in turn pushes the actuating stem **152** and the attached ram block carrier **160** into the upward position shown in FIG. 6B. A retract port **154** may be controlled by an operator to withdraw hydraulic fluid from the cavity of the hydraulic actuator **150.** This causes the actuating piston **151** to drop and in turn pulls the actuating stem **152** and the attached ram block carrier **160** into the downward position shown in FIG. 6A.

[0034] Hydraulic fluid which operates the hydraulic actuator **150** of the ram block carrier **160,** and hydraulic fluid which operates the hydraulic actuator **170** of the ram blocks **182, 184** may be stored in a hydraulic panel which is formed within or outside the blowout preventer **100.** Additionally, control of the hydraulic actuators **150, 170** may be operated manually by an operator, or may be operated according to a programmable control unit and in response to sensors which detect conditions of the carrier **160** and ram blocks **182, 184.** For example, a sensor may detect that a ram block **182** is in a worn condition and programmable control unit may operate hydraulic actuator **150** to move the ram block carrier **160** into the upward position.

[0035] FIGS. 6C and 6D are diagrams illustrating an example of a blowout preventer **100** including a mechanical override mechanism **155, 162** for movement of the ram block carrier **160** into an upper position and a lower position.

[0036] Ram block carrier **160** is configured to be in a lower position, as shown in FIG. 6C, when the upper ram block **182** is active and the lower ram block **184** is idle. Also, ram block carrier **160** is configured to be in an upper position, as shown in FIG. 6D, when the lower ram block **184** is active and the upper ram block **182** is idle. As shown more clearly in FIG. 6D, when the ram block carrier **160** is in the upper position, the detent button **167** of the ram block carrier **160** is in the upper groove **115** of the housing **110** and when the ram block carrier **160** is in the lower position, the detent button **167** is in the lower groove **114.** Accordingly, as the carrier **160** is actuated into an upward or downward position, detent button **167** is depressed inwardly against a supporting spring and slides against the wall until it reaches the corresponding groove **114, 115.** The detent button **167** is then pushed out by its supporting spring once it reaches the corresponding groove **114, 115.** The detent button **167** may have the same size or a smaller size than the openings of the groove **114, 115** such that it fits fully within the groove **114, 115** in its rest position. In this example, the detent button **167** is larger such that it protrudes from the groove **114, 115** in its rest position within the groove **114, 115.** In this example, two grooves **114, 115** and two detent buttons **167** are shown, but it should be appreciated that the number of grooves may vary according to the number of ram block **182, 184** used or may be different than the number of ram blocks **182, 184.** Also, one or more detent buttons **167** may be used on each ram block carrier **160.**

[0037] Referring to the examples illustrated in FIGS. 6C and 6D, the movement of the ram block carrier **160** into the upper and lower positions may be controlled by a mechanical override mechanism **155, 162** in the event that hydraulic actuation fails or as an alternative to hydraulic actuation. The mechanical mechanism includes a pinion **155,** a rotating pin **156,** and a pin retractor **157.** The pinion **155** may be engaged with the rack **162** of the ram block carrier **160** so that the ram block carrier **160** moves up and down based on the rotation of the pinion **155.**

[0038] The rotation of the pinion **155** is controlled by the twisting or rotation of the pin **156.** Rotating the pin **156** in one direction causes it to move in one direction against the rack **162** and causes the carrier **160** to move up. Rotating the pin **156** in another direction causes it to move in another direction against the rack **162** and causes the carrier **160** to move down. Accordingly, indicators may be added on the outside of the pin **156** or the pin retractor **157** which allow an operator to monitor the rotational position of the pin **156** to determine the position of the pinion **155** with respect to the rack **162** and the overall position of the ram block carrier **160.** Additionally, sensors may detect the rotation of the pin **156** for notifying an operator.

[0039] In an example, pin **156** may be rotated manually by an operator using a wrench or automatically. Pin **156** may be rotated using a number of different machines or tools which are known to a person having ordinary skill in the art. For example, pin **156** may be rotated using a variety of electrical motors, hydraulic motors or other rotating devices. When the blowout preventer **100** is used in deep water situations, the mechanical actuator **156** of the ram block carrier **160** or the mechanical actuator **190** of the ram blocks **182, 184** may be operated using a remotely operated vehicle (ROV). The ROV could be used to supply hydraulic fluid to operate a motor or could be used to directly rotate the mechanical actuators **156, 190.**

[0040] FIGS. 7A and 7B are diagrams illustrating a side cross-sectional view of the blowout preventer **100** with the ram block carriers **160** being in the lower position. When the ram block carriers **160** are in the lower position, the upper ram blocks **182** may be engaged and closed around the pipe within the bore **120,** while the lower ram blocks **184** are in an idle position. In FIG. 7A, the hydraulic actuator **170** is connected to upper ram block **182** by the T-block connector **180,** and the upper ram block **182** is in the retracted position. In FIG. 7B, the hydraulic actuator **170** is operated to push the upper ram block **182** into the engaged position about the bore **120.** As previously described, an operator of the blowout preventer **100** is able to determine that the hydraulic actuator **170** is in the ram-closed position by detecting that the exterior actuating rod **172** is separated from the end holder **197.** One or more sensor may be used in any of the components,

such as the exterior actuating rods **172,** the end holder **197,** the stem protector **192,** the pinion **155,** the rack **162,** and the hydraulic actuators **150** to sense relative positions of the components and notify an operator of a status of the hydraulic actuators **170, 150** or mechanical actuators **190, 162, 155** of the ram blocks **182, 184** and ram block carriers **160.**

[0041] FIGS. 8A and 8B are diagrams illustrating a side cross-sectional view of the blowout preventer **100** with the ram block carriers **160** being in the upper position. When the ram block carriers **160** are in the upper position, the lower ram blocks **184** may be engaged and closed around the pipe within the bore **120,** while the upper ram blocks **182** are in an idle position. In FIG. 8A, the hydraulic actuator **170** is connected to the lower ram block **184** by the T-block connector **180,** and the lower ram block **184** is in the retracted position. In FIG. 8B, the hydraulic actuator **170** is operated to push the lower ram block **184** into the engaged position about the bore **120.** As discussed previously, an operator of the blowout preventer **100** may be able to determine that the hydraulic actuator **170** is in the ram-closed position by seeing that the exterior actuating rod **172** is separated from the end holder **197** or by a signal from one or more sensors.

[0042] FIGS. 9 and 10 are diagrams illustrating a perspective view of another example of a blowout preventer **200.** All features previously described in reference to blowout preventer **100** and accompanying figures may be used for blowout preventer **200.** Accordingly, the descriptions provided above for blowout preventer **100,** though not limiting in scope, are fully applicable for understanding the blowout preventer **200.** In this example, the blowout preventer **200** includes circular rear door **230** and circular ram doors **240.** Also, the mechanical actuator **255, 262** of the ram block carrier **260** is on the same side as the hydraulic actuator **250** for the ram block carrier **260.**

[0043] Referring to FIGS. 11 and 12, the blowout preventer **200** includes a hydraulic actuator **250** for moving the ram block carrier **260.** Also, a mechanical actuating system includes a rack **262** installed on the ram block carrier **260,** a pinion **255,** a rotating pin **256,** and a pin retractor **257.** The hydraulic actuator **250** and the mechanical actuating system **255, 262** may operate like the hydraulic actuator **150** and the mechanical actuating system **155, 162** of the blowout preventer **100.** In this example, the hydraulic actuator **250** and the mechanical actuating system **255, 262** are installed on the same side of the blowout preventer **200** as shown in FIG. 11.

[0044] Still referring to FIGS. 11 and 12, the blowout preventer **200** includes a circular rear door **230** and circular ram doors **240.** In this example, the circular rear door **230** and circular ram doors **240** include the same components and operate in the same way; however, a variety of different doors may be used with the blowout preventer **200.** Circular ram doors **230** include a covering member **241,** a top plate **242,** a bottom plate **243,** four through holes **244** going through the top plate **242,** and four fasteners **245** extending through the through holes **244** and into the bottom plate **243.** The bottom plate **243** has an opening in the center, thus allowing a user to inspect or access the interior of the blowout preventer **200.** In this example, the circular ram doors **240** may be opened by removing the four fasteners **245** and subsequently removing the top plate **242** from the bottom plate **243.**

[0045] Additionally, the covering member **241** includes a threaded hole **247** for receiving a threaded screw **248** extending from the bottom plate **243** through the top plate **242** and into the threaded hole **247.** In this example, a flange **246** is placed between the covering member **241** and the top plate **242.** For example, a user may rotate the covering member **241** thereby unscrewing the threaded hole **247** from the threaded screw **248,** and allowing an opening within the top plate **242** to be exposed. This allows inspecting of the interior of the blowout preventer **200** and releasing pressure build up within the blowout preventer **200.**

[0046] One of skill in the art will recognize that the described examples are not limited to any particular size. Further one of skill in the art will recognize that the blowout preventer **100, 200** is not limited to any type of material. As a non-limiting example, the blowout preventer **100, 200** is formed primarily from low alloy steel. In another example, metal components utilized in manufacture, when possible and not restricted by pressure constraints or other operational reasons, may be manufactured and machined from commercially available 4130 steel. One skilled in the art will recognize that other diameters, types and thicknesses of steel or preferred materials can be utilized when taking into consideration safety and the high pressure functioning capacity which can range in operation from 3,000 psi to 20,000 psi. In an example, a housing of the blowout preventer **100, 200** may be machined and ram block carriers may be cast; however, a number of manufacturing techniques may be used such as the machining or casting of any component of the blowout preventer **100, 200.**

[0047] It will be appreciated by those skilled in the art that changes could be made to the embodiments described above without departing from the broad inventive concept thereof. It is understood, therefore, that the invention disclosed herein is not limited to the particular embodiments disclosed, and is intended to cover modifications within the spirit and scope of the present invention.

[0048] Further embodiments of the invention are described by the following examples:

Examples

1. A ram block carrier, comprising:

an opening;
an upper shelf within the opening configured to hold an upper ram block; and

a lower shelf within the opening configured to hold a lower ram block.

2. The ram block carrier of example 1, further comprising an extension tab configured to be attached to a carrier hydraulic actuator for moving the ram block carrier.

3. The ram block carrier of example 1, further comprising a rack configured to contact a pinion for moving the ram block carrier.

4. The ram block carrier of example 1, further comprising a detent button configured to be pressed in response to the ram block carrier moving, inserted into an upper groove in response to the ram block carrier being in an upper position, and inserted into a lower groove in response to the ram block carrier being in a lower position.

5. A housing of a blowout preventer, comprising:

a bore;
a first cavity on a side of the bore;
a second cavity on another side of the bore; and
inside walls, adjacent to the first and second cavities, each comprising an opening which allows a ram block to access the bore,
wherein the first cavity and the second cavity are each configured to receive a ram block carrier that is movable within the housing.

6. The housing of example 5, further comprising outside walls, adjacent to the first and second cavities, each comprising:

a pinion which is configured to contact the ram block carrier and to move the ram block carrier within each cavity; and
an indicator which is configured to indicate a position of the ram block carrier.

7. The housing of example 5, wherein a length of each of the cavities is at least two times greater than a length of each of the openings.

8. The housing of example 5, further comprising outside walls, adjacent to the first and second cavities, each comprising:

an upper detent groove; and
a lower detent groove,
wherein the upper detent groove is configured to receive a detent button of the ram block carrier in response to the ram block carrier being in an upper position and the lower detent groove is configured to receive the detent button of the ram block carrier in response to the ram block carrier being in a lower position.

9. The housing of example 5, further comprising outside walls, adjacent to the first and second cavities, each comprising a hole configured to receive a ram block hydraulic actuator for moving one or more ram blocks towards the bore.

10. A blowout preventer, comprising:

a housing;
a ram block carrier configured to move within the housing; and
one or more ram blocks configured to be placed within the ram block carrier.

11. The blowout preventer of example 10, further comprising a carrier hydraulic actuator for moving the ram block carrier within the housing.

12. The blowout preventer of example 10, further comprising:

a piston; and
an actuating stem attached to the piston,
wherein the ram block carrier comprises an extension tab which is attached to the actuating stem for moving the ram block carrier.

13. The blowout preventer of example 10, further comprising a carrier mechanical actuator for moving the ram block carrier within the housing.

14. The blowout preventer of example 10, further comprising:

a pinion installed on the housing;
a rotating pin for rotating the pinion; and
a rack installed on the ram block carrier and contacting the pinion,
wherein the ram block carrier moves within the housing in response to the pinion rotating.

15. The blowout preventer of example 10, further comprising an indicator for monitoring a position of the ram block carrier.

16. The blowout preventer of example 10, wherein the one or more ram blocks comprises a plurality of ram blocks.

17. The blowout preventer of example 10, further comprising:

a central bore extending through the housing;
another ram block carrier configured to move within the housing; and
one or more ram blocks configured to be placed within the other ram block carrier,
wherein the ram block carrier is on one side of the central bore and the other ram block carrier is on another side of the central bore.

18. The blowout preventer of example 17, wherein the one or more ram blocks of the ram block carrier comprises a plurality of ram blocks, and the one or more ram blocks of the other ram block carrier comprises another plurality of ram blocks.

19. The blowout preventer of example 18, wherein each of the plurality of ram blocks of the ram block carrier corresponds to one of the other plurality of ram blocks of the other ram block carrier.

20. The blowout preventer of example 10, further comprising a ram block hydraulic actuator configured to move the one or more ram blocks.

21. The blowout preventer of example 10, further comprising:

a piston;
an exterior actuating rod attached to the piston;
an interior actuating rod attached to the piston; and
a connector on an end of the interior actuating rod for making contact with and moving the one or more ram blocks.

22. The blowout preventer of example 10, further comprising a ram block mechanical actuator configured to move the one or more ram blocks.

23. The blowout preventer of example 21, further comprising:

a mechanical actuator stem; and
a push rod threadedly engaged to the mechanical actuator stem,
wherein in response to rotating the mechanical actuator stem, the push rod pushes the exterior actuating rod into the piston and the interior actuating rod, and the one or more ram blocks are moved.

24. The blowout preventer of example 10, further comprising one or more doors attached to the housing by fasteners.

25. The blowout preventer of example 10, wherein the one or more doors are circular doors configured to be opened by removing the fasteners.

26. The blowout preventer of example 25, wherein the one or more circular doors comprise a covering member, a top plate, and a bottom plate, and pressure within the blowout preventer is released in response to an opening of the covering member.

27. A method of operating a blowout preventer, the method comprising:

moving a ram block carrier within the blowout preventer; and
moving a ram block of the ram block carrier towards a bore of the blowout preventer.

28. The method of example 27, wherein the moving of the ram block carrier comprises injecting hydraulic fluid into a carrier hydraulic actuator, and the moving of the ram block comprises injecting hydraulic fluid into a ram block hydraulic actuator.

29. The method of example 26, wherein the moving of the ram block carrier comprises rotating a pin on an outside of the blowout preventer and attached to a pinion on an inside the blowout preventer, and moving the ram block comprises rotating an actuator stem on an outside of the blowout preventer.

28. The method of example 26, wherein the moving of the ram block carrier comprises moving the ram block carrier into an upper position in order to use a lower ram block installed on a lower shelf of the ram block carrier.

29. The method of example 28, wherein the moving of the ram block carrier comprises moving the ram block carrier into a lower position in order to use an upper ram block installed on an upper shelf of the ram block carrier.

30. The method of example 29, wherein the moving of the ram block carrier into the upper position causes a connector of a ram block actuator to engage with the lower ram block, and the moving of the ram block carrier into the lower position causes a connector of a ram block actuator to engage with the upper ram block.

Claims

1. A ram block carrier (160, 260), comprising:

   an opening;
   an upper shelf (165) within the opening configured to hold an upper ram block (182); and
   a lower shelf (164) within the opening configured to hold a lower ram block (184).

2. The ram block carrier of claim 1, further comprising an extension tab configured to be attached to a carrier hydraulic actuator (170) for moving the ram block carrier (160) and/or further comprising a rack (162) configured to contact a pinion (155) for moving the ram block carrier (160).

3. The ram block carrier of claim 1 or 2, further comprising a detent button (167) configured to be pressed in response to the ram block carrier (160) moving, inserted into an upper groove (115) in response to the ram block carrier (160) being in an upper position, and inserted into a lower groove (114) in response to the ram block carrier (160) being in a lower position.

4. A housing (110) of a blowout preventer (100), comprising:

   a bore (120);
   a first cavity (124) on a side of the bore (120);
   a second cavity (124) on another side of the bore (120); and
   inside walls, adjacent to the first and second cavities (124), each comprising an opening which allows a ram block to access the bore (120),
   wherein the first cavity and the second cavity (124) are each configured to receive a ram block carrier (160) that is movable within the housing (110).

5. The housing of claim 4, further comprising outside walls, adjacent to the first and second cavities (124), each comprising:

   i) a pinion (155) which is configured to contact the ram block carrier (160) and to move the ram block carrier (160) within each cavity (124); and an indicator which is configured to indicate a position of the ram block carrier (160),
   ii) an upper detent groove (115); and
   a lower detent groove (114),
   wherein the upper detent groove (115) is configured to receive a detent button (167) of the ram block carrier (160) in response to the ram block carrier (160) being in an upper position and the lower detent groove (114) is configured to receive the detent button (167) of the ram block carrier (160) in response to the ram block carrier (160) being in a lower position; and/or
   iii) a hole configured to receive a ram block hydraulic actuator (170) for moving one or more ram blocks (182, 184) towards the bore (120).

6. The housing of claim 4 or 5, wherein a length of each of the cavities (124) is at least two times greater than a length of each of the openings.

7. A blowout preventer, comprising:

   a housing (110);
   a ram block carrier (160) configured to move within the housing (110); and
   one or more ram blocks (182, 184) configured to be placed within the ram block carrier (160).

8. The blowout preventer of claim 7, further comprising

   i) a carrier hydraulic actuator (170) for moving the ram block carrier (160) within the housing (110),
   ii) a piston (151); and
   an actuating stem (152) attached to the piston (151),
   wherein the ram block carrier (160) comprises an extension tab (163) which is attached to the actuating stem (152) for moving the ram block carrier (160),
   iii) a carrier mechanical actuator for moving the ram block carrier (160) within the housing (110), and/or
   iv) a pinion (155) installed on the housing (110);
   a rotating pin (156) for rotating the pinion (155); and
   a rack (162) installed on the ram block carrier (160) and contacting the pinion (155),
   wherein the ram block carrier (160) moves within the housing (110) in response to the pinion (155) rotating.

9. The blowout preventer of claim 7 or 8, further comprising an indicator for monitoring a position of the ram block carrier (160).

10. The blowout preventer of one of the claims 7 to 9, wherein the one or more ram blocks (182, 184) comprises a plurality of ram blocks.

11. The blowout preventer of one of the claims 7 to 10, further comprising:

    a central bore (120) extending through the housing (110);
    another ram block carrier (160) configured to move within the housing (110); and
    one or more ram blocks (182, 184) configured

to be placed within the other ram block carrier (160),
wherein the ram block carrier (160) is on one side of the central bore (120) and the other ram block carrier (160) is on another side of the central bore (120), wherein preferably the one or more ram blocks (182, 184) of the ram block carrier (160) comprises a plurality of ram blocks, and the one or more ram blocks (182, 184) of the other ram block carrier (160) comprises another plurality of ram blocks, wherein especially each of the plurality of ram blocks (182, 184) of the ram block carrier (160) corresponds to one of the other plurality of ram blocks (182, 184) of the other ram block carrier (160).

12. The blowout preventer of one of the claims 7 to 11, further comprising

i) a ram block hydraulic actuator (170) configured to move the one or more ram blocks (160),
ii) a piston (174);
an exterior actuating rod (172) attached to the piston (174);
an interior actuating rod (173) attached to the piston (174); and
a connector (180) on an end of the interior actuating rod (173) for making contact with and moving the one or more ram blocks (182, 184),
wherein preferably the blowout preventer further comprises:

a mechanical actuator stem (190); and
a push rod (196) threadedly engaged to the mechanical actuator stem (190),
wherein in response to rotating the mechanical actuator stem (190), the push rod (196) pushes the exterior actuating rod (172) into the piston and the interior actuating rod, and the one or more ram blocks are moved; and/or

iii) a ram block mechanical actuator (255, 256) configured to move the one or more ram blocks (182, 184).

13. The blowout preventer of one of the claims 7 to 12, further comprising one or more doors (130, 140) attached to the housing (110) by fasteners (132), wherein preferably the one or more doors are circular doors (240) configured to be opened by removing the fasteners (245), wherein especially the one or more circular doors (240) comprise a covering member (246), a top plate (242), and a bottom plate (243), and pressure within the blowout preventer is released in response to an opening of the covering member (241).

14. A method of operating a blowout preventer(100), the method comprising:

moving a ram block carrier (160) within the blowout preventer (100); and
moving a ram block (182, 184) of the ram block carrier (160) towards a bore (120) of the blowout preventer (100).

15. The method of claim 14, wherein the moving of the ram block carrier (160) comprises injecting hydraulic fluid into a carrier hydraulic actuator (150), and the moving of the ram block comprises injecting hydraulic fluid into a ram block hydraulic actuator (170), wherein the moving of the ram block carrier (160) comprises rotating a pin (156) on an outside of the blowout preventer (100) and attached to a pinion (155) on an inside the blowout preventer (100), and moving the ram block (182, 184) comprises rotating an actuator stem (190) on an outside of the blowout preventer (100), and/or wherein the moving of the ram block carrier (160) comprises moving the ram block carrier (160) into an upper position in order to use a lower ram block (184) installed on a lower shelf (164) of the ram block carrier (160), wherein preferably the moving of the ram block carrier (160) comprises moving the ram block carrier (160) into a lower position in order to use an upper ram block (182) installed on an upper shelf (165) of the ram block carrier (160), wherein especially the moving of the ram block carrier (160) into the upper position causes a connector (180) of a ram block actuator (170) to engage with the lower ram block (184), and the moving of the ram block carrier (160) into the lower position causes a connector (180) of a ram block actuator (170) to engage with the upper ram block (182).

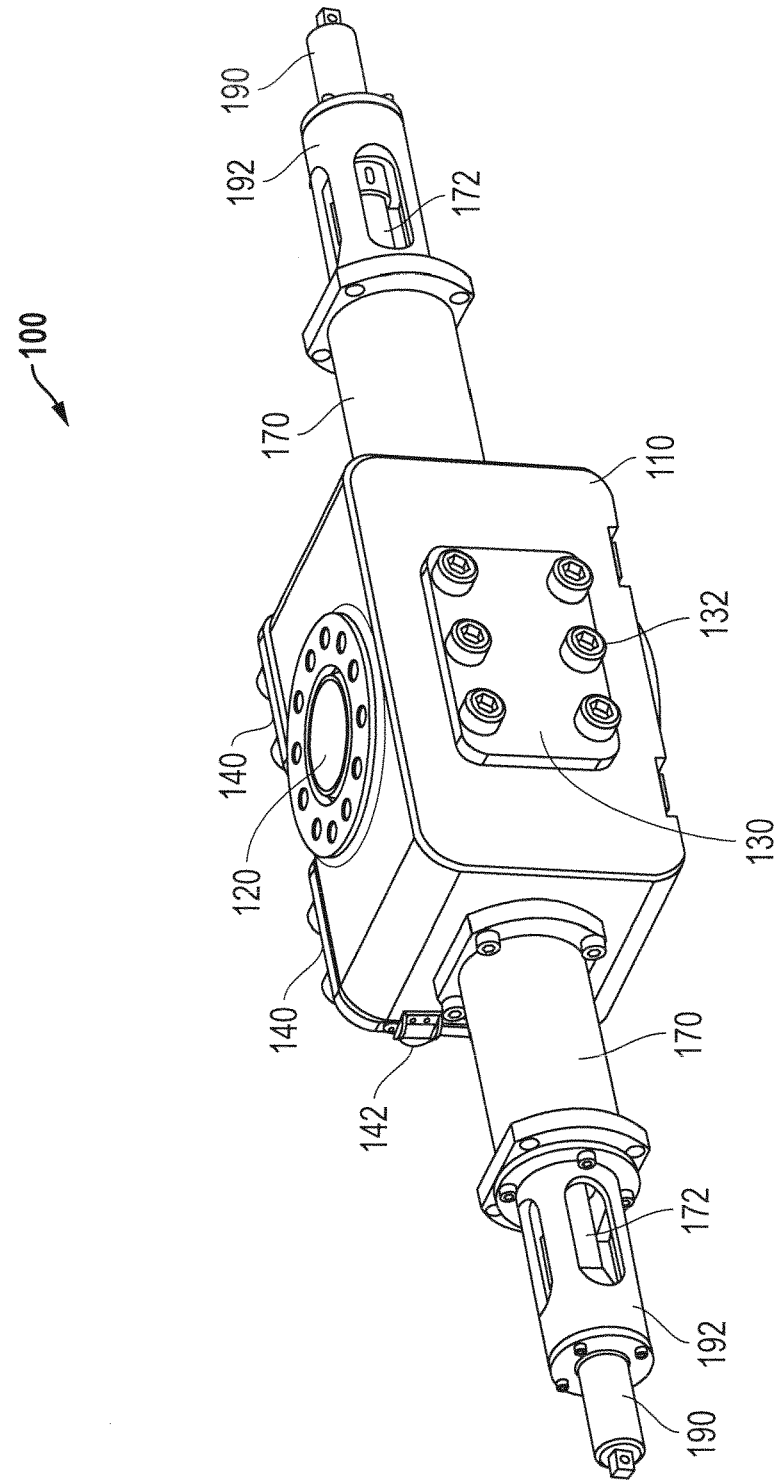

FIG. 1

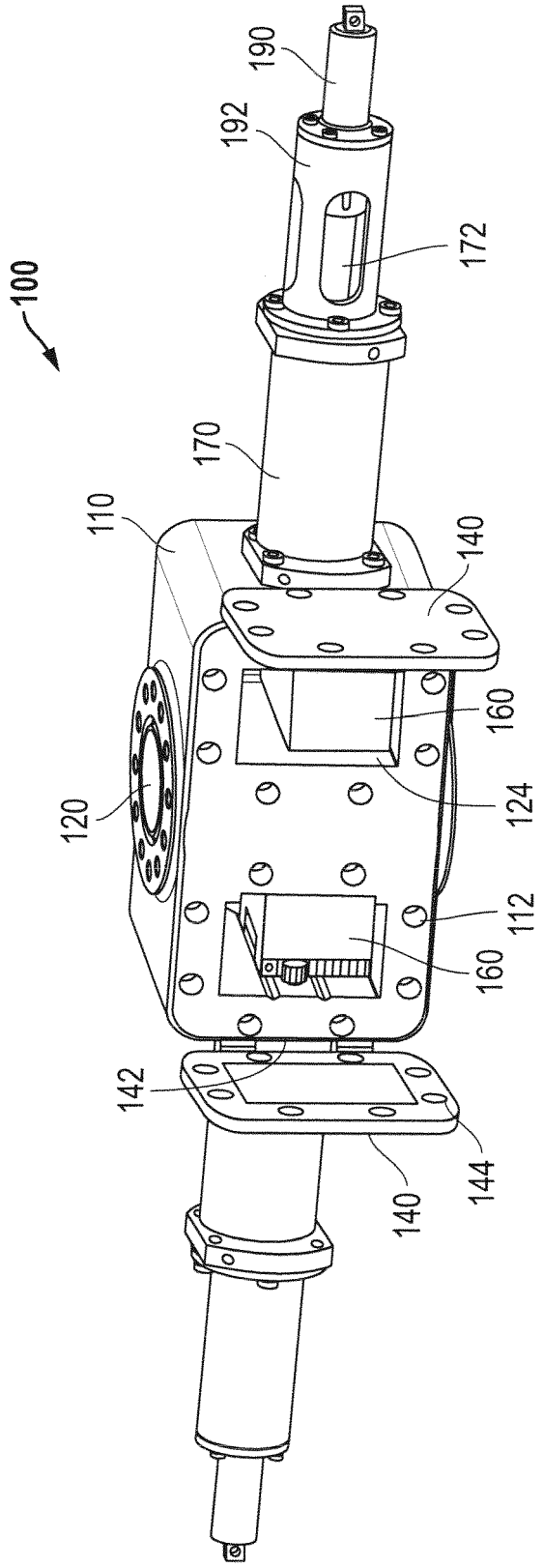

FIG. 2

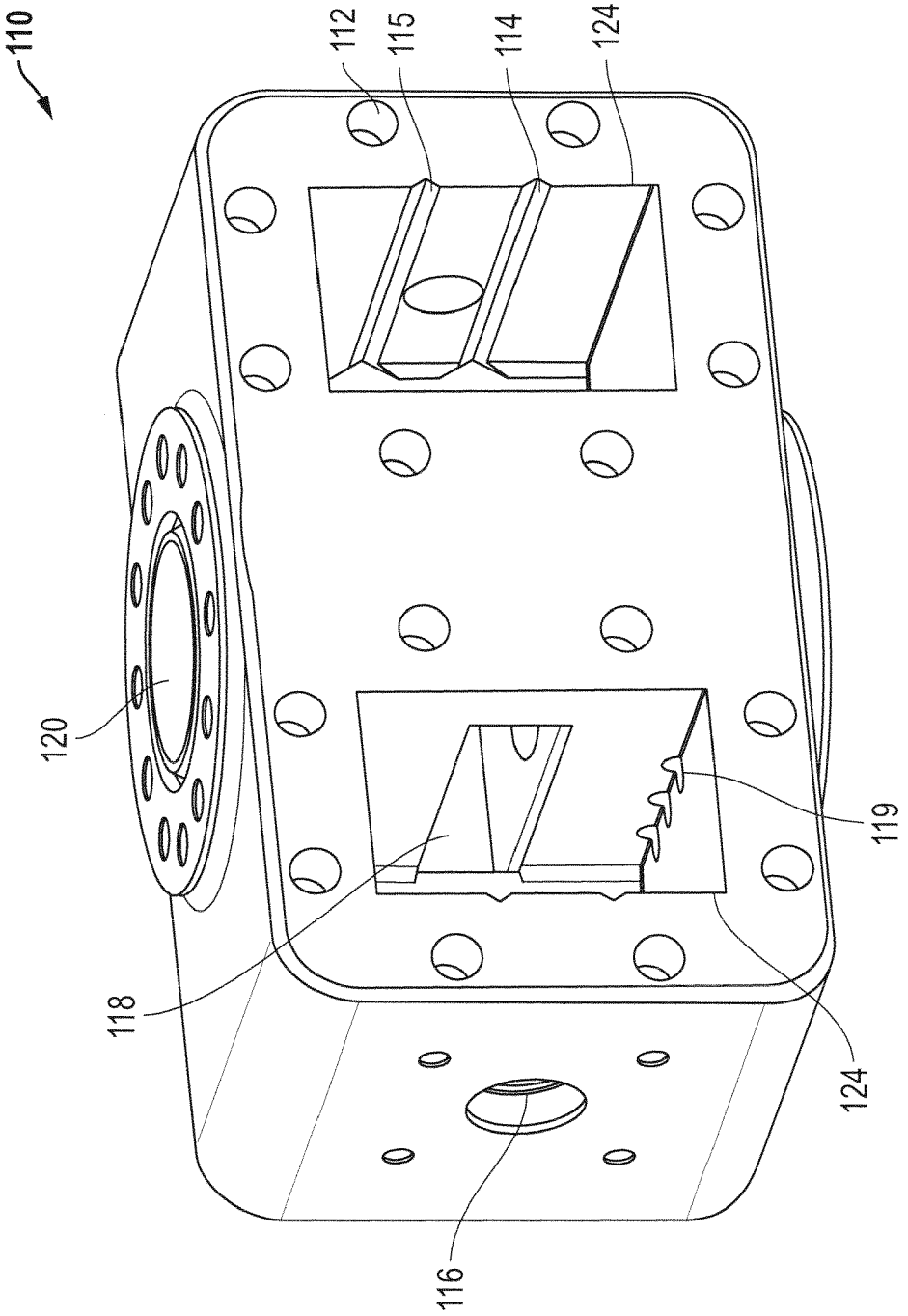

FIG. 3

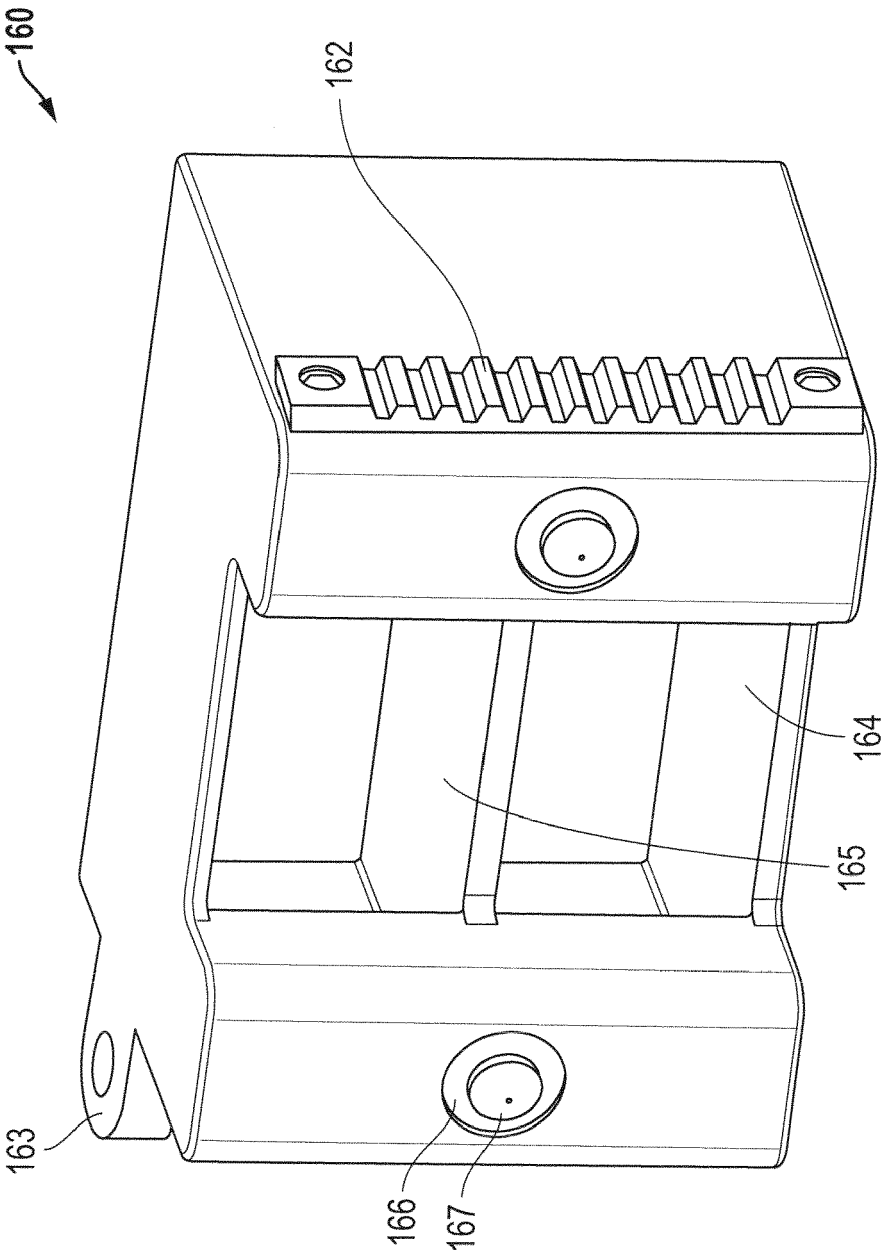

FIG. 4

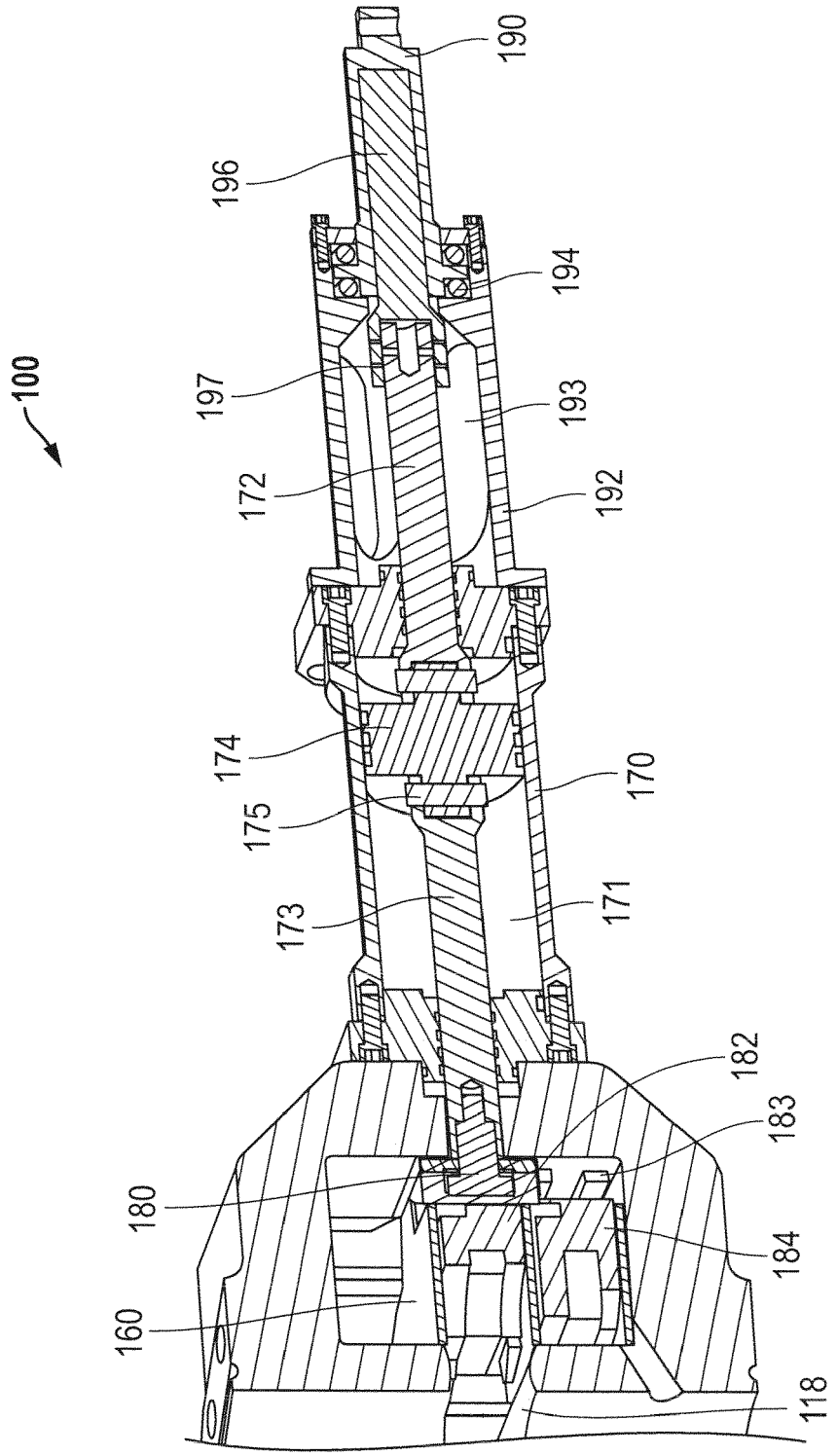
100
190
196
194
197
193
172
192
174
170
175
171
173
182
183
180
184
160
118

FIG. 5A

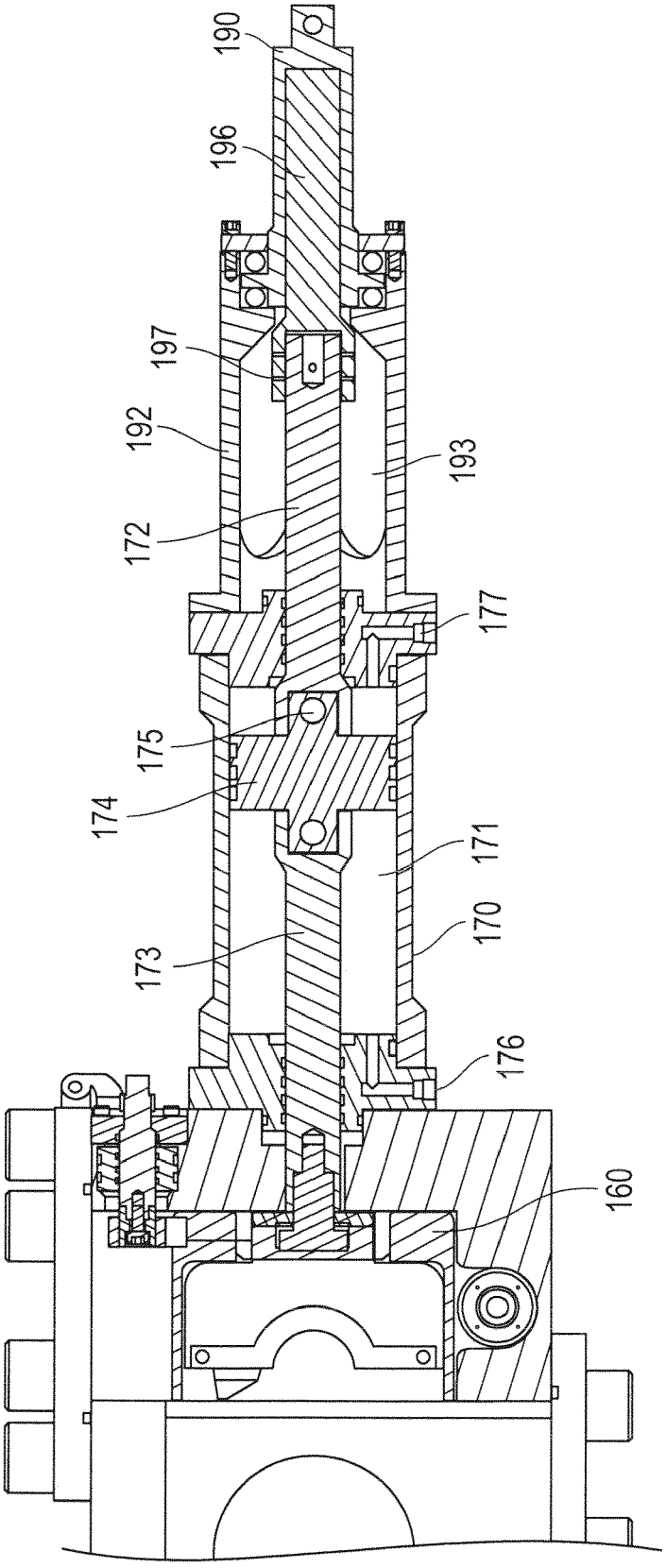

FIG. 5B

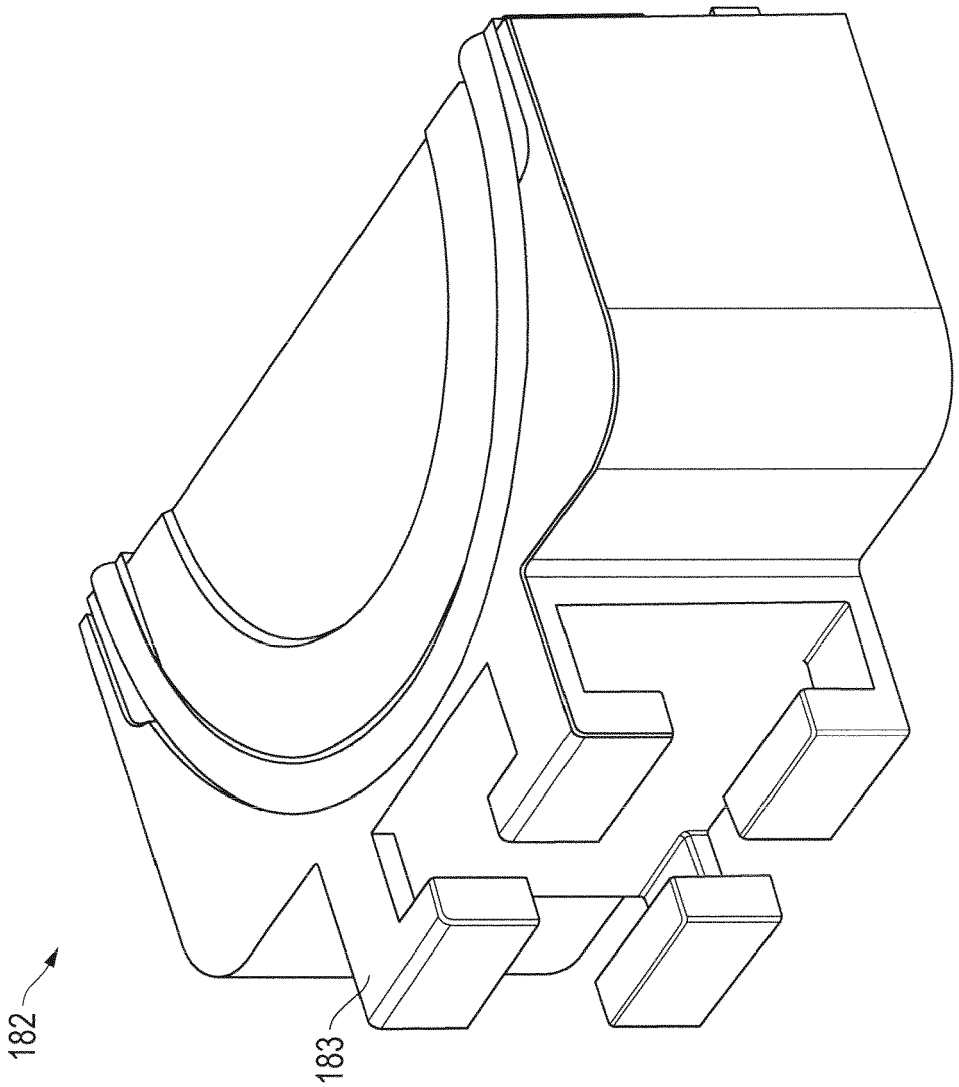

FIG. 5C

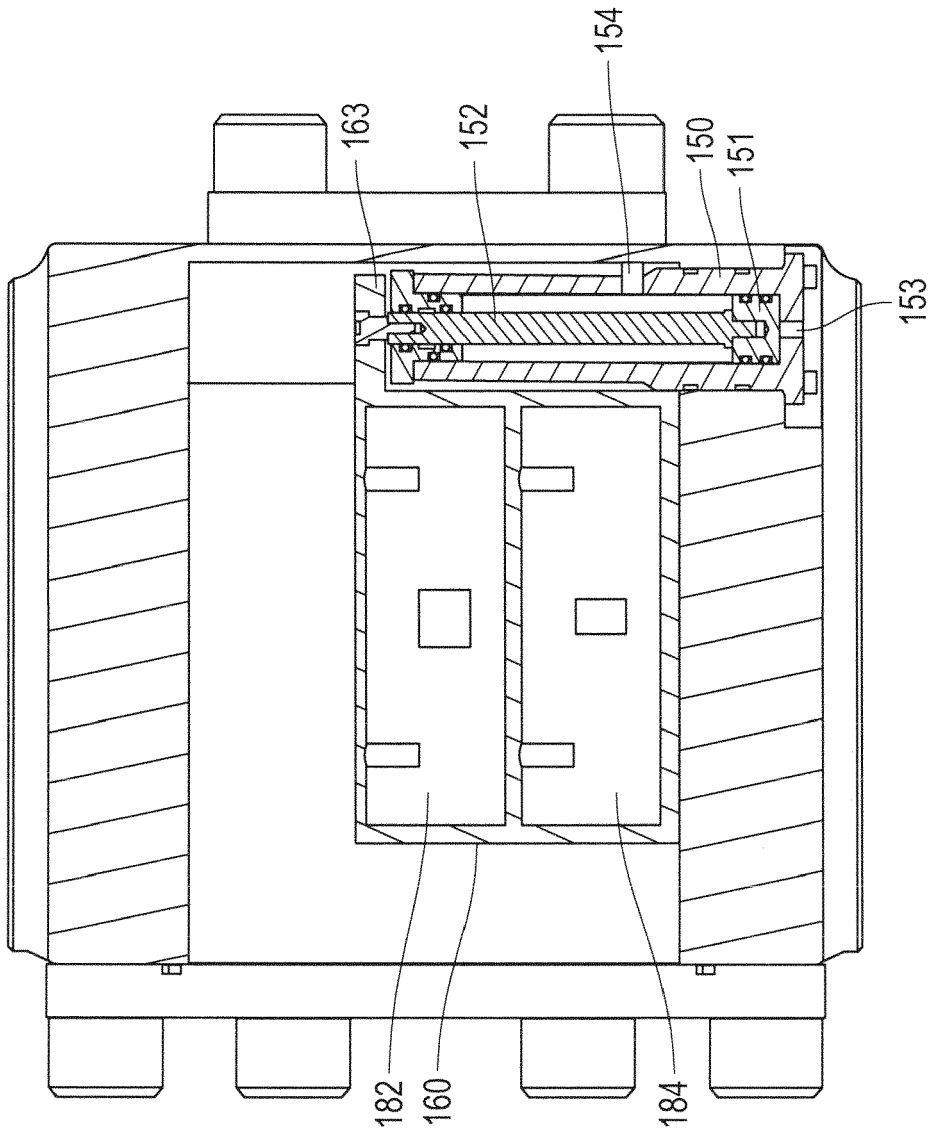

FIG. 6A

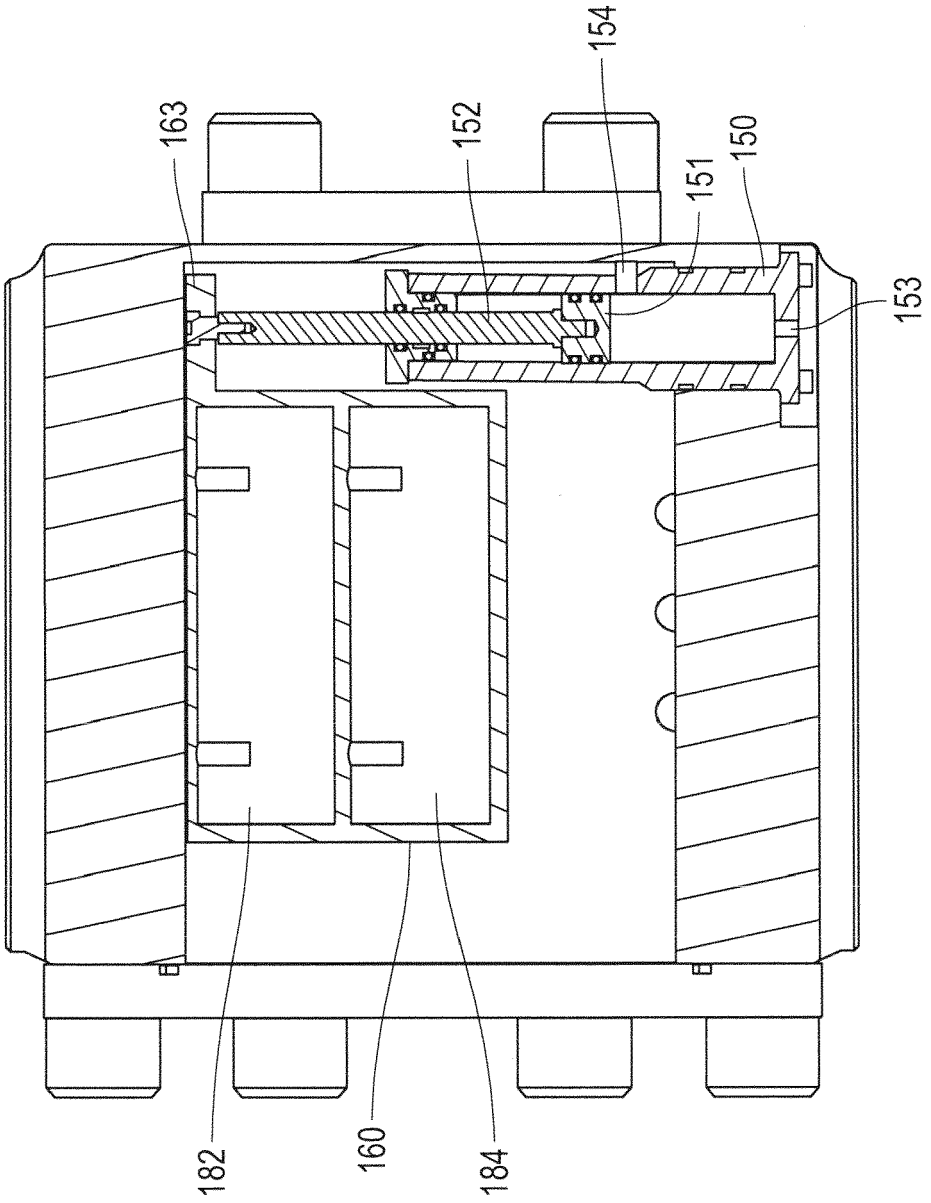

FIG. 6B

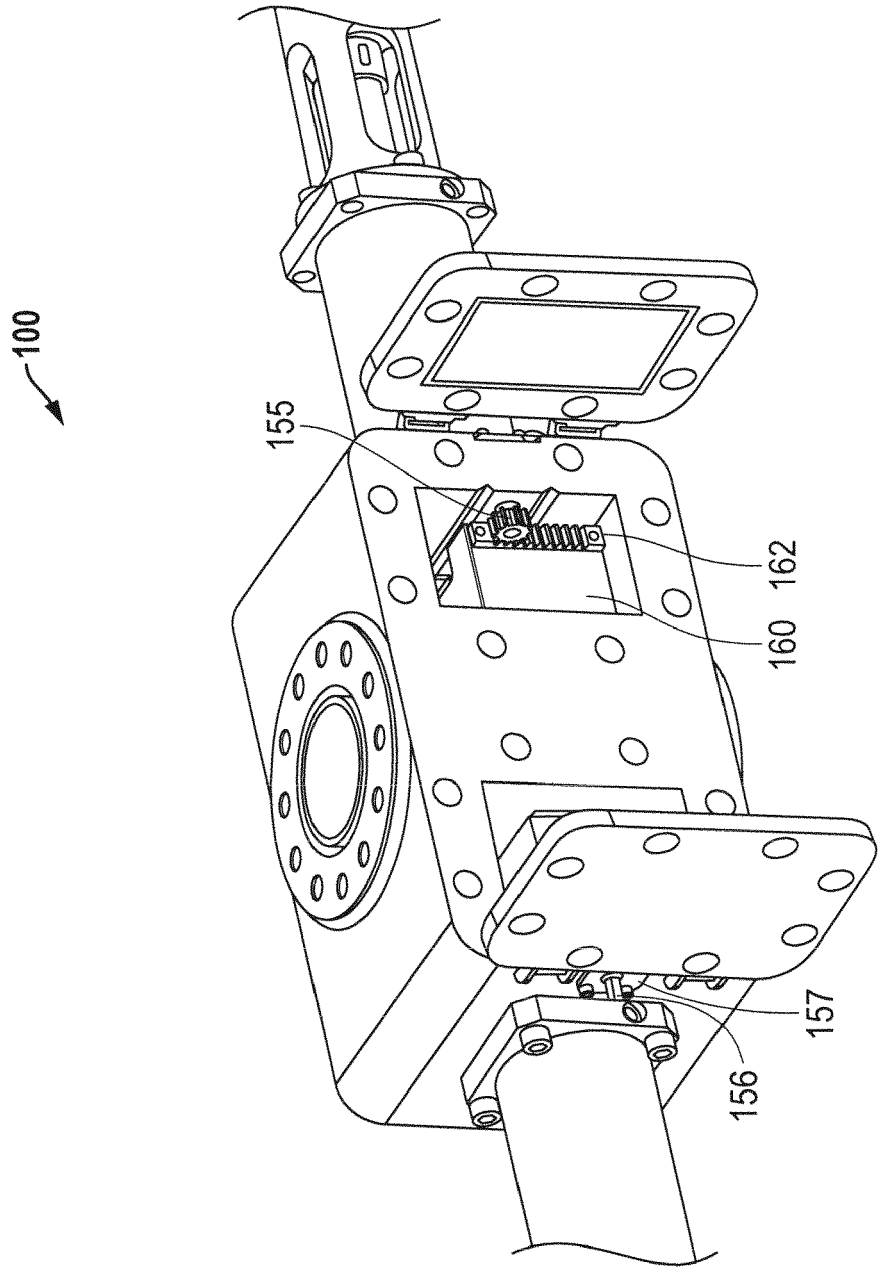

FIG. 6C

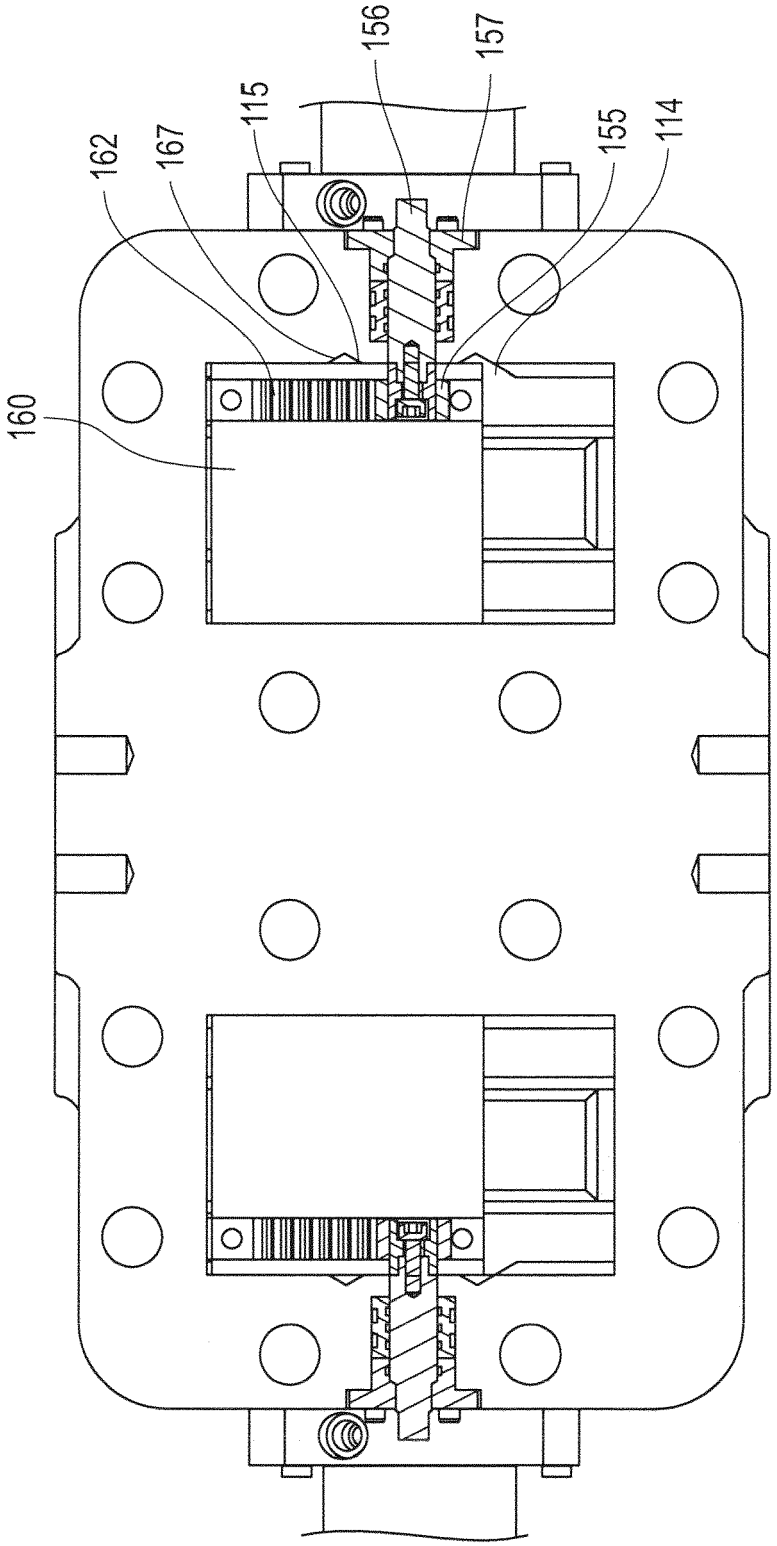

FIG. 6D

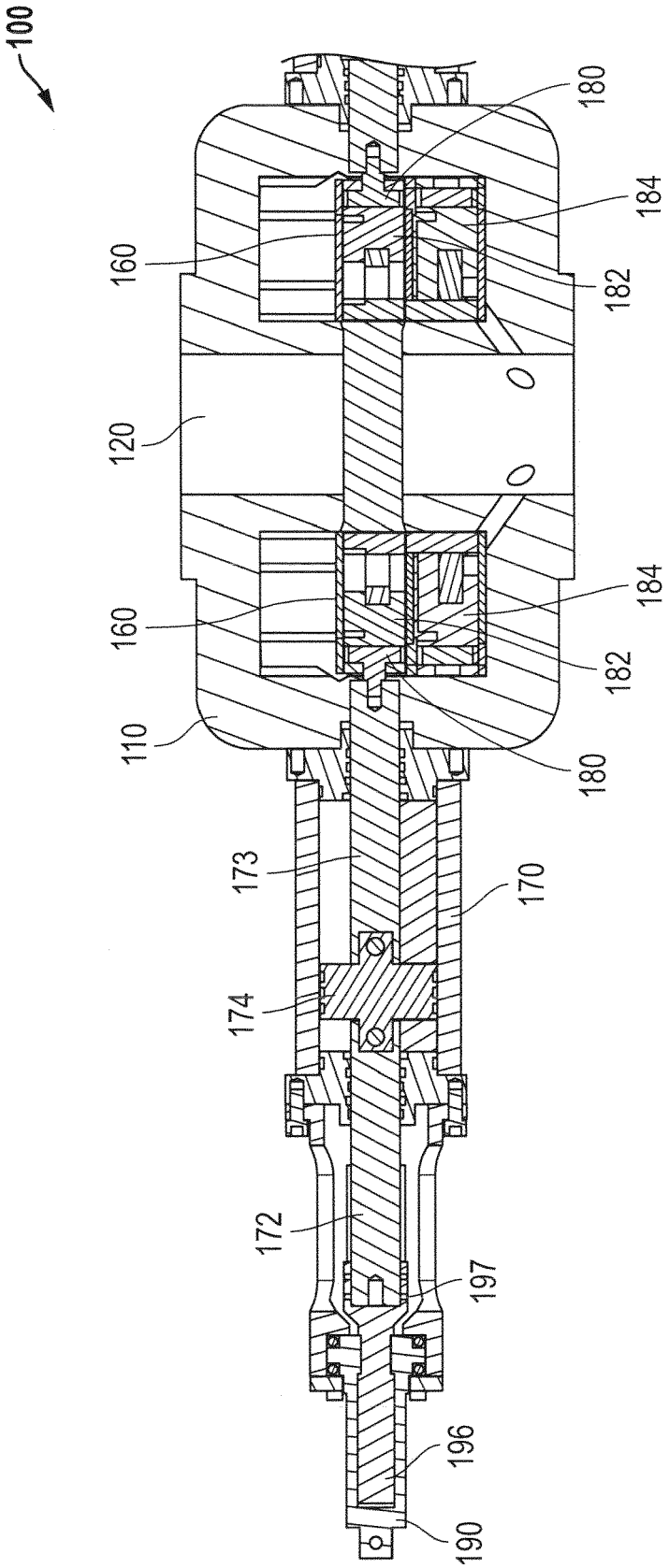
100
180
184
160
182
120
184
160
182
110
180
173
170
174
172
197
196
190

FIG. 7A

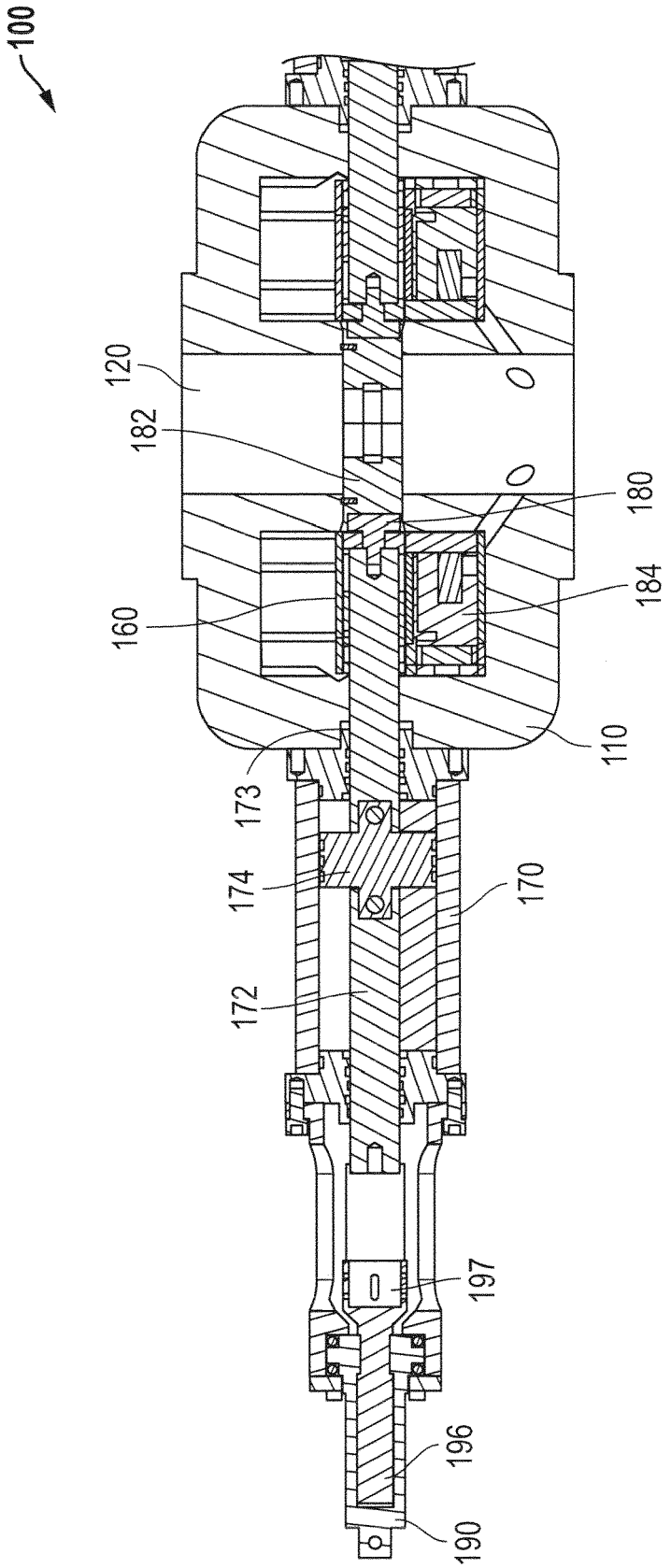

FIG. 7B

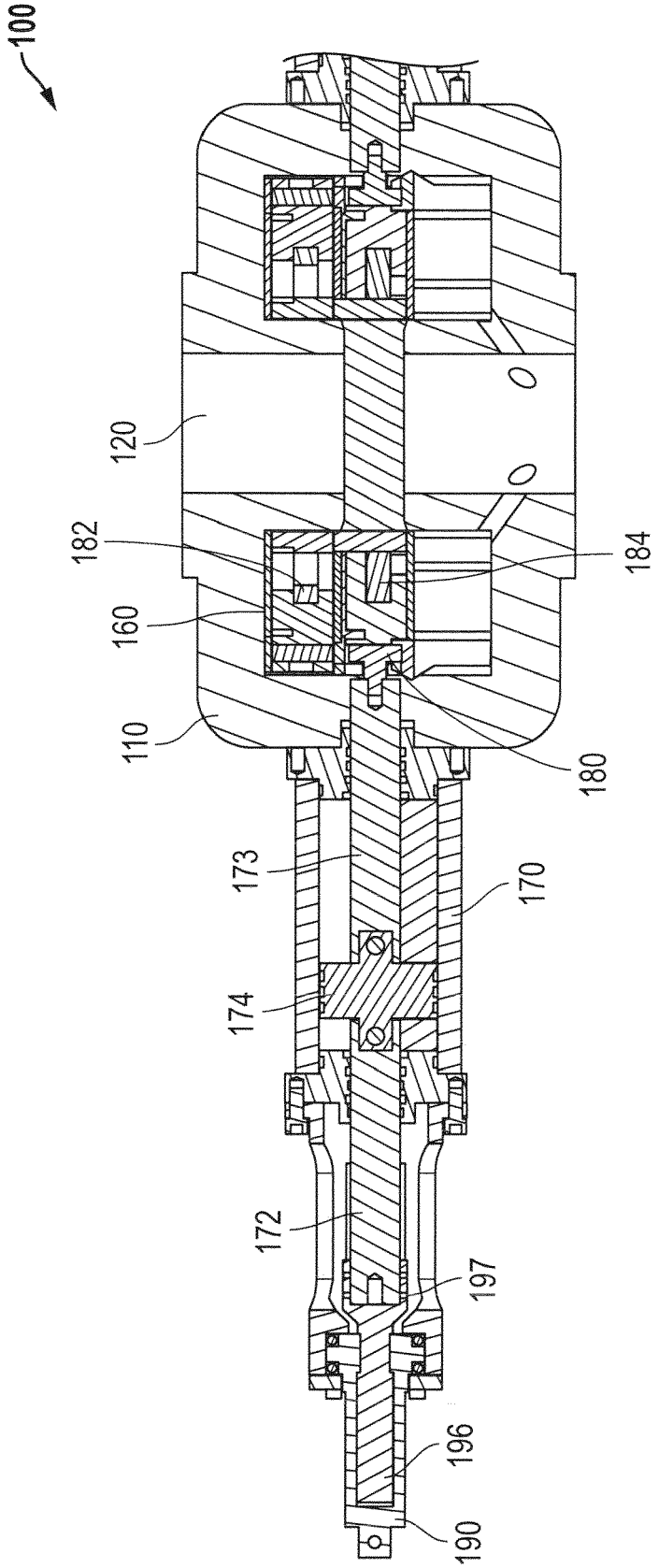

FIG. 8A

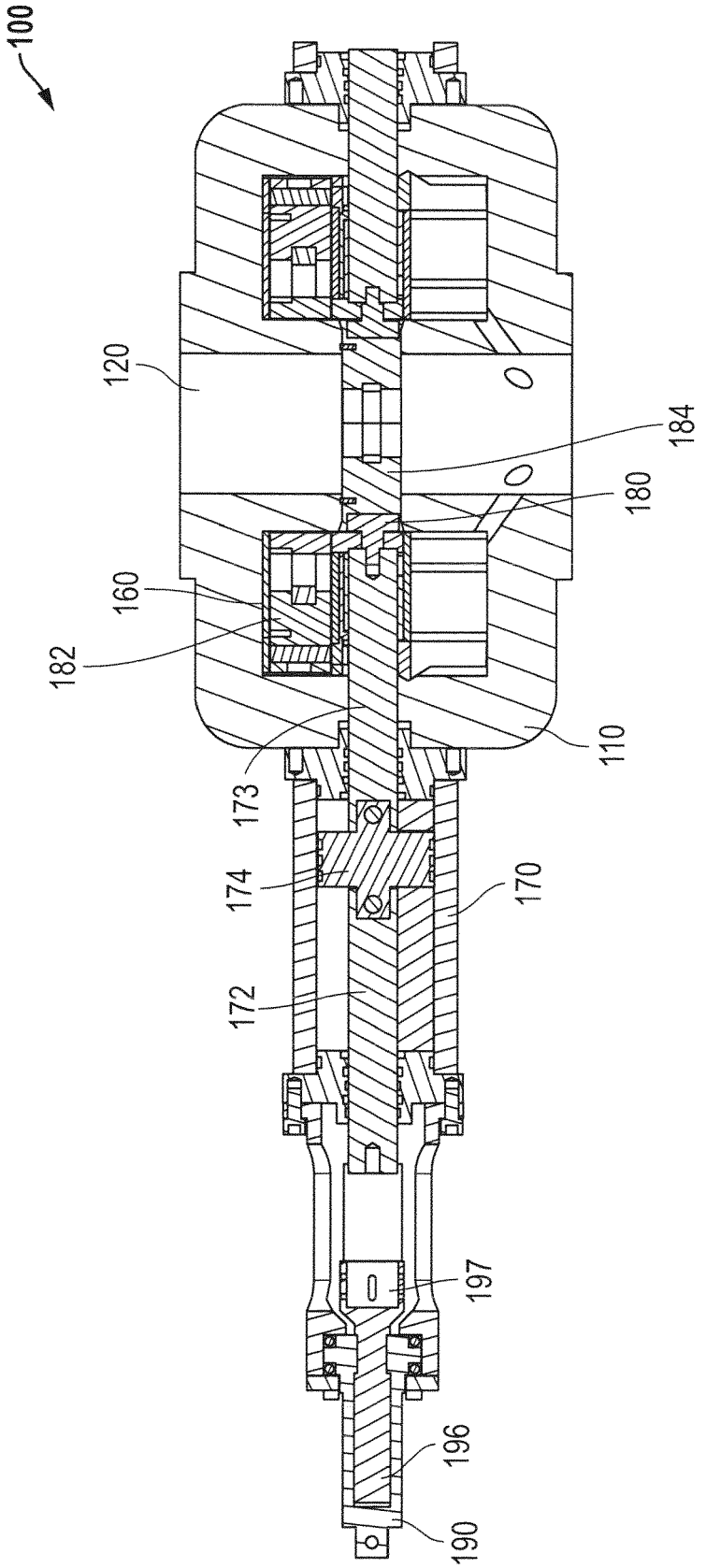

FIG. 8B

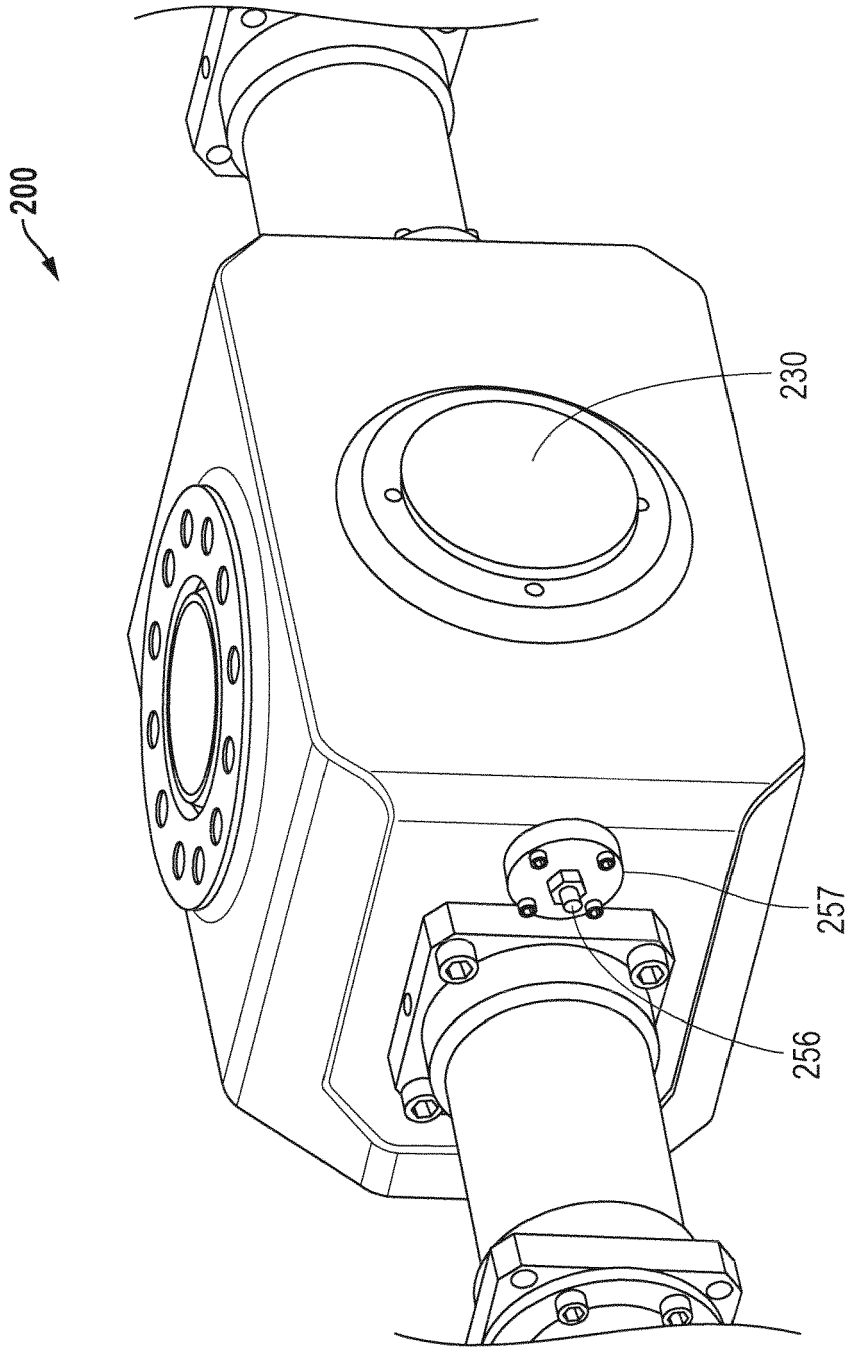

FIG. 9

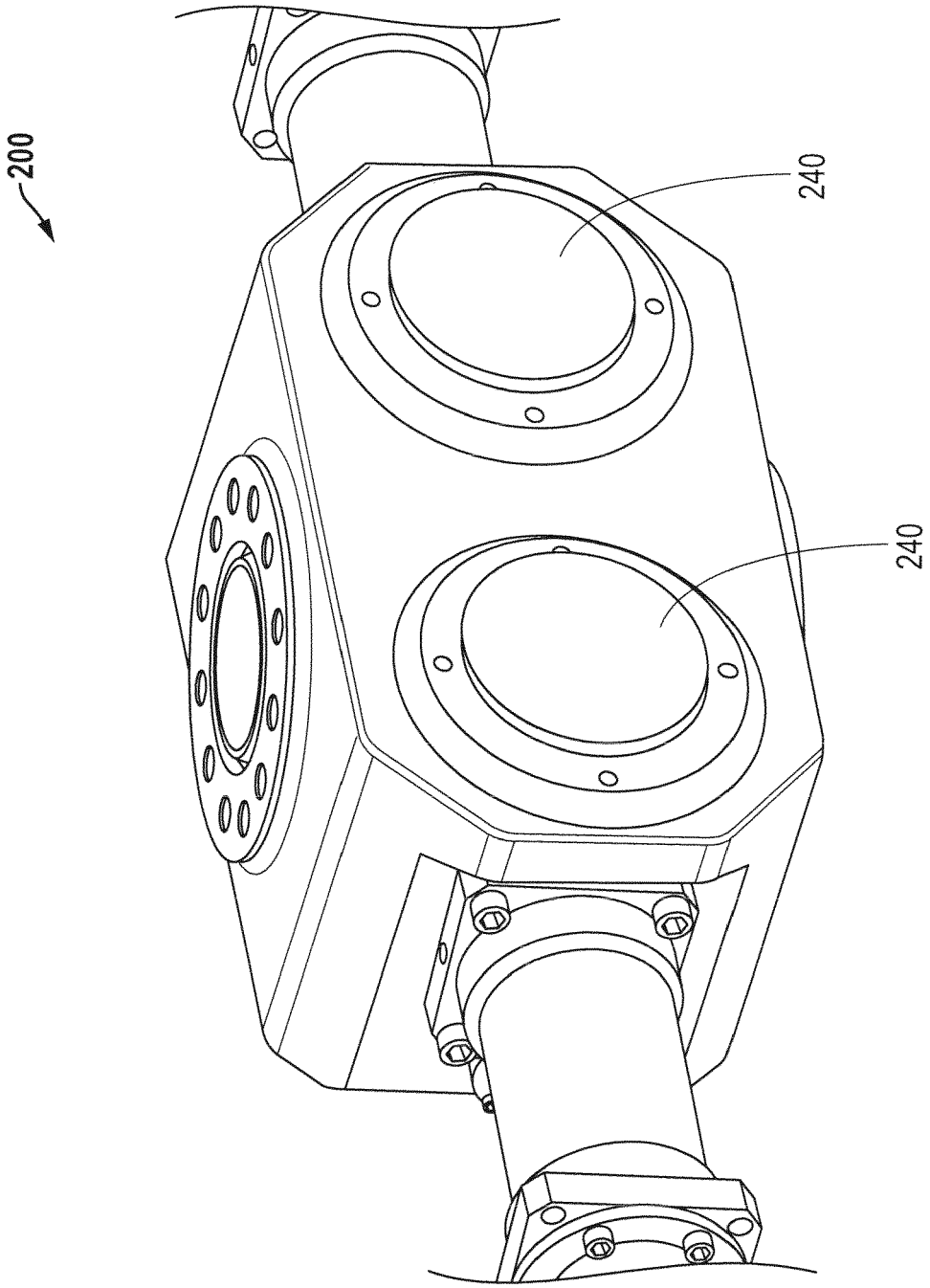

FIG. 10

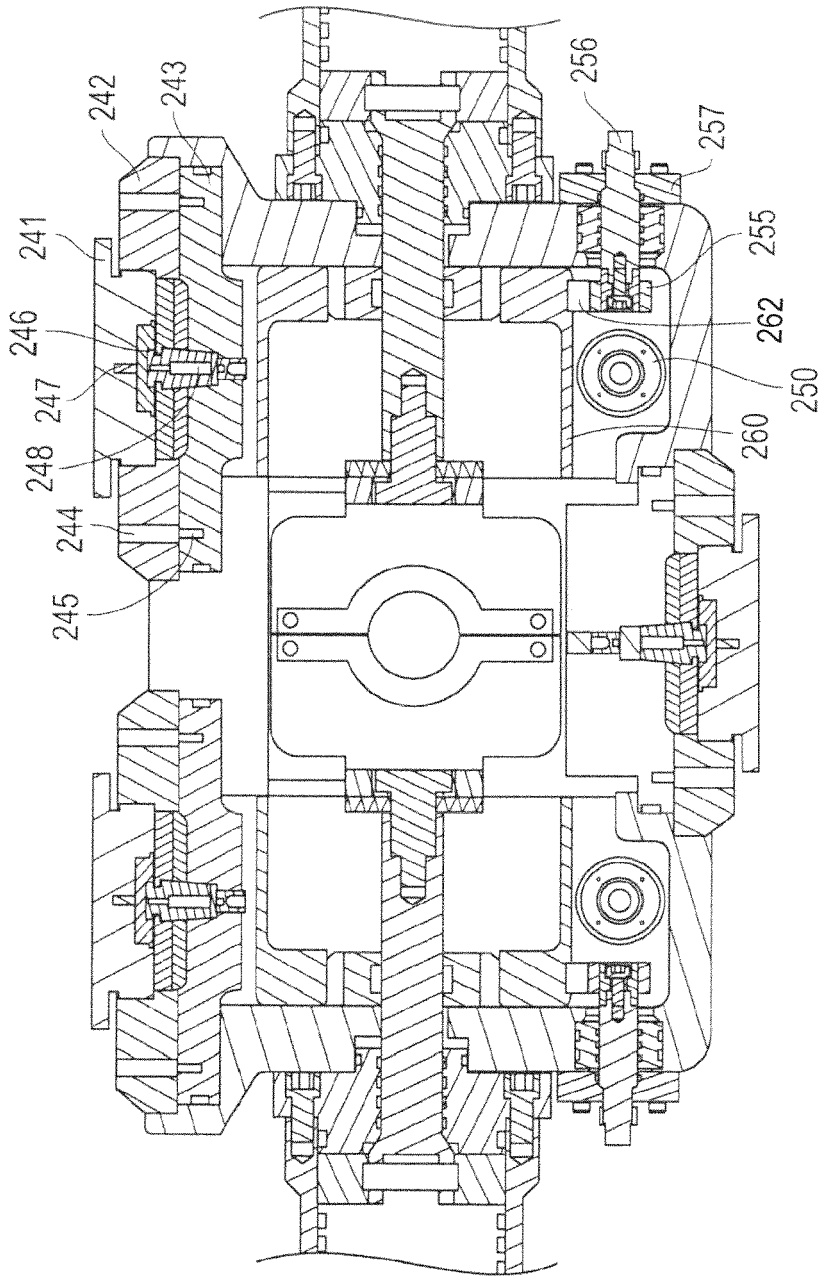

FIG. 11

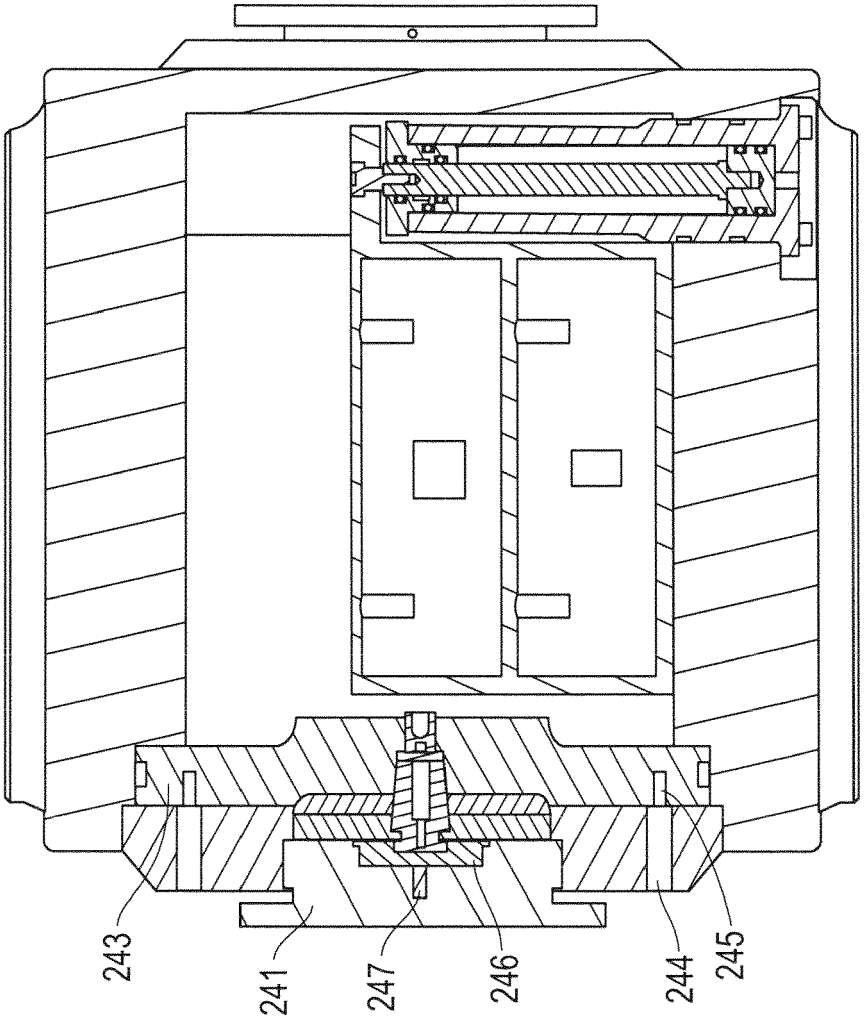

FIG. 12