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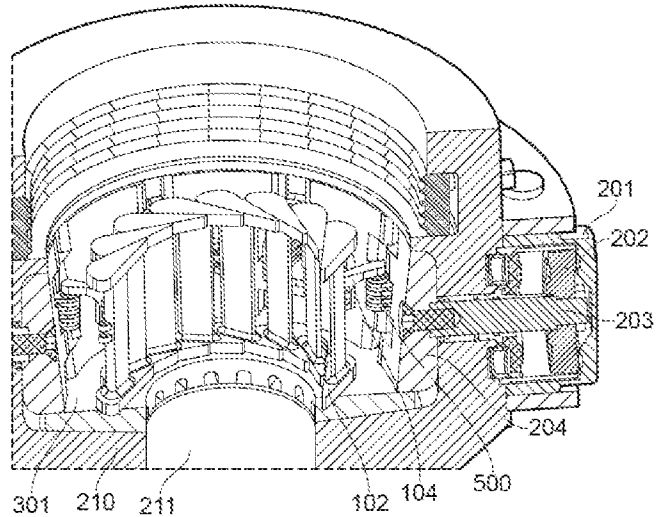
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(73)	Proprietor	ELECTRICAL SUBSEA & DRILLING AS, Teknologisenteret, 5354 STRAUME, Norge		
(72)	Inventor	Thor Arne Håverstad, Pallaneveien 25, 4700 VENNESLA, Norge Erik Norbom, Sandviksveien 91 A, 1363 HØVIK, Norge J Gilbert Nance, 26923 Carmel Falls Lane, TX77494 KATY, USA John L Alsup, 5005 Georgi Lane #115, TX77092 HOUSTON, USA Bolie C Williams, 5242 Jason Street, TX77096 HOUSTON, USA		
(74)	Agent or Attorney	ZACCO NORWAY AS, Postboks 2003 Vika, 0125 OSLO, Norge		

(54)	Title	ANNULAR BLOWOUT PREVENTER
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(57)	Abstract	

A blowout preventer of the type having a resilient packer element (101) comprising a contractor arrangement (230) which has a plurality of plates (204) adjacent one another which enclose an area, the contractor arrangement (230) is configured to move from an expanded position to a contracted position in which the enclosed area decreases, wherein adjacent plates (204a, 204b) are configured to interlock with one another when in the contracted position.



ANNULAR BLOWOUT PREVENTER

The present invention relates to a packer actuation system for a blowout preventer (BOP). For example, a blowout preventer for use in the drilling of a wellbore, which may be in to a subterranean fluid reservoir and/or the production of fluid, typically hydrocarbon fluids, from such a reservoir.

BACKGROUND

The drilling of a borehole or well is typically carried out using a steel pipe known as a drill pipe or drill string with a drill bit on the lowermost end. The drill string comprises a series of tubular sections, which are connected end to end. The entire drill string is typically rotated using a rotary table mounted on top of the drill pipe, and as drilling progresses, a flow of mud is used to carry the debris created by the drilling process out of the wellbore. Mud is pumped down the drill string to pass through the drill bit, and returns to the surface via the annular space between the outer diameter of the drill string and the wellbore (generally referred to as the annulus). For a subsea well bore, a tubular, known as a riser, extends from the rig to the top of the wellbore and provides a continuous pathway for the drill string and the fluids emanating from the well bore. In effect, the riser extends the wellbore from the sea bed to the rig, and the annulus also comprises the annular space between the outer diameter of the drill string and the riser.

The use of blow out preventers to seal, control and monitor oil and gas wells is well known, and these are used on both land and off-shore rigs. Blowout preventers are generally arranged in combinations that include ram-type and annular BOPs, connectors, valves, and control systems that enable actuation of the various pressure control functions. These combinations are called BOP stacks. During drilling of a typical high-pressure wellbore, the drill string is routed through a BOP stack toward a reservoir of oil and/or gas. The BOP is operable to seal around the drill string, thus closing the annulus and stopping flow of fluid from the wellbore. The BOP stack may also be operable to sever

the drill string to close the wellbore completely. Two types of BOP are in common use – ram and annular, and a BOP stack typically includes at least one of each type.

5 Blowout preventers (BOPs) were developed to cope with extreme erratic pressures and uncontrolled flow emanating from a well reservoir during drilling. Known as a “kick”, this flow of pressure can lead to a potentially catastrophic event called a blowout. In addition to controlling the downhole well pressure and the flow of oil and gas, blowout preventers are intended to prevent tubular goods used in well drilling, such as, drill pipe, casing, collars, tools and drilling
10 fluid from being blown out of the wellbore when a kick or blowout threatens. Blowout preventers are critical to the safety of crew, drilling rig, and environment, and to the monitoring and maintenance of well integrity; thus blowout preventers are intended to provide an additional and fail-safe barrier to the systems that include them.

15 Annular blowout preventers can be used as a part of a subsea BOP stack in order to enable an immediate response to a kick. Annular preventers can close on a wide variety of drill string elements such as tool joints, collars, casing etc. so that it is not necessary to determine which element of the drill string is located inside the annular BOP before closing it. Ram type BOPs can only close
20 on a restricted range of drill string elements, so that it is necessary to take the time to determine what part of the drill string is located inside the ram BOP before closing it. Annular BOPs may also enable BOP coverage for drill string elements which would not be practical to cover with a combination of ram type BOPs. Annular BOPs may also enable moving the drill string while sealing the
25 annulus between the drill string and the well bore, which is desirable in certain well control operations.

Related solutions in the field of annular blow out preventers which may be useful for understanding and practicing the present invention include US patent documents US3572627, US3897038, US4099699, US4458876, US4579314,
30 US3994472, US3915424, US3915426, US4458876, US4460151, US4007904, US3915425, US 3,572,627 A, and US 2012/0227987 A1.

BOPs are safety-critical components and there is a continuous need for solutions which improve the reliability and operational performance of such systems. Moreover, when BOPs are used subsea it is very time-consuming and expensive to pull the BOP to the surface for maintenance. It is therefore an object of the present invention to provide an annular blow out preventer having a structure that provides improved performance compared to known solutions.

SUMMARY

According to the invention, we provide a blowout preventer of the type having a resilient packer element comprising a contractor arrangement which has a plurality of plates adjacent one another which enclose an area, the contractor arrangement is configured to move from an expanded position to a contracted position in which the enclosed area decreases, wherein adjacent plates are configured to interlock with one another when in the contracted position and each plate has first and second edges which include alternate protrusions such that the second and first edges of the adjacent plates engage and interlock in the contracted position.

Further features of embodiments of the invention are set out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example, with reference to the drawings in which:

- Figure 1 shows a packing element for an annular blow out preventer.
- Figure 2 shows an annular blow out preventer seen from above, comprising a packing element as shown in Fig. 1.
- Figure 3 shows a partial view of the annular blow out preventer of Fig. 2.
- Figure 4 shows a detailed view of a pusher plate.
- Figure 5 shows two pusher plates and a linkage mechanism in an open position.

Figure 6 shows two pusher plates and a linkage mechanism in a closed position.

Figure 7 shows a housing of an annular BOP with actuators in an open position.

Figure 8 shows a housing of an annular BOP with actuators in a closed position.

5 Figures 9-10 show an annular BOP having a position indicator system.

Figures 11-12 illustrate aspects of a method for determining the condition of an annular BOP.

10 DETAILED DESCRIPTION

The basic functionality of an annular blow out preventer (BOP) is well known in the art and will not be more detailed here. Reference is made to the above mentioned patent documents.

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An annular BOP according to one embodiment of the present invention may have a sealing element contained within an external housing, referred to as the packer or packing element, and a double-acting hydraulic actuator mounted within or connected to the housing. The actuator, for example in the form of a
20 piston/cylinder arrangement, forces the annular sealing element inwards via a plurality of pusher plates, until it engages with the external surface of the drill pipe positioned in the BOP's internal passageway (also known as a bore). Releasing the pressure on the actuator, or actively driving it in the radially outwardly direction, releases the force from the pusher plates on the sealing
25 element, thus allowing the element to relax to its original position away from the drill pipe body.

In the embodiments described here, the actuators are hydraulic piston/cylinder arrangements, however the actuators may be of any type, for example electro-
30 mechanical or pneumatic actuators.

Figure 1 shows a packer arrangement 100 for an annular blowout preventer according to one embodiment of the present invention. The packing arrangement 100 comprises an annular packer element 101 made of resilient

material e.g. elastomer, which has a substantially central axial passageway (shown transparent in the figures for clarity). The packer arrangement 100 is provided with packer (also known as anti-extrusion) inserts, e.g. 102, disposed within the resilient packer element 101. Each anti-extrusion insert comprises an upper body 109a, a lower body 109b and a stem 110 which is substantially parallel to the axial passageway through the packer arrangement 100 (the stem 110 may also be parallel to the longitudinal axis of the housing). The stem 110 joins the upper body 109a to the lower body 109b. The plurality of packer inserts 102 are provided in the packing element in a circumferential arrangement in relation to the packer element's axial passageway 211.

In the embodiment shown in Figure 1, the upper and lower bodies 109a, 109b are substantially triangular-shaped and have a generally vertical stem 110 in between. The stems 110 are provided with connection formations 103 for a retractor part 104. Each connection formation 103 having one or more recesses or openings 107 to permit the insertion of a connection pin 105 between the retractor part 104 and the connection formation 103. The retractor part 104 has a body 108 complementary to the connection formations 103 so that they can receive the connection pin 105. Hence, the retractor part 104 can be connected to the packer inserts 102.

Figure 2 shows a packer actuation system in plan view, including the packer arrangement 100 shown in Fig. 1. The packer actuation system comprises the packer arrangement 100 and an actuation system. The actuation system comprises at least one double-acting actuator 200, a contractor arrangement 230 and a retractor arrangement 240. In the embodiment shown in Figure 2, there is a plurality of double-acting actuators 200 with hydraulic actuation cylinders 201 located within the housing 210 of the annular blowout preventer. Each hydraulic actuation cylinder 201 has a piston 202 with a piston stem 203, the piston 202 dividing the cylinder 201 into an open chamber 201a and a closed chamber 201b.

The contractor arrangement 230 includes a plurality of arcuate / curved plates (also called pusher plates) 204 positioned adjacent one another. Each piston

stem 203 is connected to a respective pusher plate 204 (see also Fig. 3). The pusher plates 204 enclose an area (and in some embodiments may form a discontinuous circular element) that surrounds an outer periphery 101a of the annular packer element 101. Each pusher plate 204 is arranged to apply a radial pressure force on the outer circumference of the annular packer element 101, so as to move the annular blowout preventer from an expanded position towards a contracted position when a force is applied by actuators 200, so that the area of the axial passageway through the packer arrangement 100 decreases.

At each intersection between two pusher plates 204, there is a packer retractor mechanism 500 (also called a packer retraction linkage 500). The retractor part 104 is connected to the packer retractor mechanism 500. As can be seen from
5 Figure 2, each retractor part 104 is attached to a packer retractor mechanism 500 at one end and to one of the packer inserts 102 at the other end. The connection of the retractor part 104 to a packer retractor mechanism 500 will be discussed in more detail below in relation to Figures 5 and 6.

10 In the embodiment shown in Figure 2, the triangular shaped bodies 109a, 109b of each packer insert 102 are in contact with the adjacent triangular shaped body 109a, 109b of the adjacent packer insert 102 so that the triangular shaped bodies 109a, 109b form a ring shaped element surrounding the central passageway 211, around which the packer element 101 is positioned.

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Figure 3 shows the annular blowout preventer of Fig. 2 in a different view. The housing 210 has an annular recess 301 about the bore 211. In use, the bore 211 forms part of a wellbore. The packer arrangement 100 is positioned in the recess 301 (for clarity, in Fig. 3 the packing arrangement 100 is shown without
20 the resilient packer element 101). By operating the actuators 200 the packer arrangement 100 may thus form sealing engagement about an object in a wellbore, for example a drill pipe or a wireline, or seal upon itself when the wellbore is empty. The piston stems 203 of the actuators 200 are connected with and act directly on the pusher plates 204.

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As can be seen in Figure 3, the retractor parts 104 connect the packer inserts 102 to the pusher plates 204 via the packer retractor mechanism 500. Each triangular shaped body 109a, 109b of each packer insert 102 is in contact with the adjacent triangular shaped body of the adjacent packer insert 102 so that
30 the triangular shaped bodies 109a, 109b form two ring shaped elements surrounding the central bore 211, around which the packer arrangement 100 is positioned. In this manner the resilient packer element 101 is supported in its upper and lower regions.

Figure 4 shows a pusher plate 204 in more detail. The pusher plate 204 comprises first and second edges which, in use, extend generally parallel to the axial passageway through the packer arrangement 100, and which have alternate lateral engagement protrusions 401, 402, 403, 404. The pusher plates 204 are arranged circumferentially around the bore and when they are driven radially towards the bore 211 under the action of the actuators 200, the protrusions 401, 402, 403, 404 of neighboring (i.e. adjacent) pusher plates 204 engage / interlock with each other.

Therefore under the action of the actuators 200, the pusher plates 204 will interweave so as to form a continuous ring shaped element around the packer arrangement 100.

Figure 4 also shows that each pusher plate 204 is provided with a central opening and recess 405. The opening 405 connects the pusher plate 204 to the piston stem 203 of the actuators 200. The pusher plates 204 have an inner curved surface generally conforming with the outer curved surface of the annular packer arrangement 100 so that they form a substantially circular element that surrounds the outer periphery 101a of the packer arrangement 100.

During closing of the blowout preventer, there is lateral engagement between adjacent pusher plates 204 and the pusher plates 204 contact the outside diameter of the resilient packer element 101. In conventional designs, this action may cause damage to the outside diameter of the packer element 101 during repeated open and close cycles, as a portion of the packer element 101 is pinched between adjacent pusher plates 204. The lateral engagement in this construction reduces damage to the packer element 101 by means of the overlapping engagement protrusions 401, 402, 403 404. Thus, during closing, the protrusions 401, 402, 403, 404 overlap those of the adjacent plates 204 so that the plates interweave / interlock and form a continuous ring shape element around the packer element 101. The pattern of the protrusions 401, 402, 403, 404 provides synchronized movement of the plates 204. This also provides a more robust synchronization of the actuator pistons 202 than, for example, the

dowel pins known from conventional designs. For example, one known design uses dowel pins protruding from one side of each pusher plate to engage holes in the opposite side of each pusher plate.

5 As mentioned above, the packer actuation system further comprises a retractor arrangement 240. The retraction arrangement 240 includes a packer retraction mechanism 500 and the retractor parts 104. Figure 5 shows the packer retraction mechanism 500 in more detail. The packer retraction mechanism 500 has a first connection formation (also known as a first fixation point) to be
10 attached to a first pusher plate 204a and a second connection formation (also known as a second fixation point) to be attached to a second pusher plate 204b which is adjacent to the first pusher plate 204a.

The packer retraction mechanism 500 of the present invention is also provided
15 with a third connection formation (also known as a third fixation point) 501 to be attached to a retractor part 104 which is connected to one of the packer insert 102 disposed within the packer element 101 of the blowout preventer. The retractor part 104 extends radially outwardly of the packer element 101 generally perpendicular to its axial passageway 211. A first end of each
20 retractor part 104 is pivotally connected to the packer insert 102, whilst a pin 106 is provided at the other end of the retractor part 104. The pin 106 extends generally parallel to the axial passageway 211 of the packer element 101, and is used to connect the packer element 101 to the packer retraction mechanism 500, as will be described further below.

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Figures 5 and 6 show that the packer retraction mechanism 500 comprises a first, second and third portions (also known as flat portions) 507, 502, 505 pivotally connected one to another via five pivot points 509a, 509b, 509c, 509d, 509e having parallel pivoting axes. The first portion 507 of the packer retraction
30 linkage 500 comprises an opening / hole 501 and two legs 503, 504 which are pivotally connected about the hole 501. The second and third portions 502, 505 have a central pivot point which allows relative movement of the second and third portions 502, 505 relative to one another. The second and third portions 502, 505 are a similar but inverted shape of one another and are located one on

the other such that their central portion are superposed to form the central pivot point 509c. As shown in Figures 5 and 6 the shape of the second and third portions 502, 505 comprises three crests in between two shallow parts. This shape ensures the second and third portions 502, 505 are complementary with the shape of the legs 503, 504 of the first portion 507 when the legs are fully opened (Fig.5) and when the legs are closed (Fig. 6).

The first central pivot point 509c is located in the central part of the second and third portions 502, 505 and allows these two portions to slide against / move relative to each other. The second and third portions 502, 505 are each pivotally connected to a pusher plate 204a, 204b on one end such that when the two portions slide against each other, the adjacent pusher plates 204a, 204b are displaced in a direction perpendicular to the pivoting axis of each pivot point.

The second and third portions 502, 505 are also each pivotally connected to a leg 503, 504 of the first portion 507 on their other end such that when the legs of the first portion 507 pivot about the hole 501, this forces the second and third portions 502, 505 to pivot about the central pivot point 509c, and thus displace the adjacent pusher plates 204a, 204b in a direction perpendicular to the pivoting axis of each pivot point.

It should be appreciated that in this embodiment the packer retraction mechanism 500 is connected to the pusher plates 204, but this need not necessarily be the case. The packer retraction mechanism 500 could be connected directly to an actuator 200 and move independently of the pusher plates 204.

In this embodiment, each packer retraction mechanism 500 is installed in between two adjacent pusher plates 204a and 204b (pusher plates shown flat for simplicity) and comprises a pantographic mechanism having articulated linkages between the pusher plates 204a, 204b. The two adjacent pusher plates are thus linked by a pantograph mechanism in an articulated manner that permits them to move, in a limited way, one towards the other when pushed by the actuators 200 or one away from the other when retracted by the actuators

200. When the separation of the pusher plates 204 increases, the separation of the pivotal connections 509b, 509d between the leg 503, 504 and its respective second 502 or third 505 portion also increases. Thus, the legs of the first portion 507 pivot away from one another, so that the hole 501 moves towards the pusher plates 204. This is illustrated in Figure 5. Conversely, when the separation of the pusher plates 204 decreases, the separation of the pivotal connections 509b, 509d also decreases. Thus, the legs 503, 504 of the first portion 507 pivot towards one another, so that the hole 501 moves away from the pusher plates 204. This is illustrated in Figure 6.

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As mentioned above, each packer retraction mechanism 500 is also provided with an opening 501 (i.e. the opening 501 of the first portion 507) and, in use, this engages with the fastening means / connection part 106 of a retractor part 104. Thus, the packer inserts 102 of the annular packer element 101 and the pusher plates 204 are linked together so that their movements are interrelated.

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Figure 5 shows the packer retraction mechanism 500 and pusher plates 204a, 204b when the annular blowout preventer is in an open / expanded position (i.e. the axial passageway through the packer arrangement 100 has a maximum size / dimension). In this configuration, the pusher plates 204a, 204b and the packer retraction mechanism 500 are in their outermost position i.e. the two adjacent plates 204a, 204b are as distant as possible. The pusher plates 204 of the contractor arrangement 230 forming a discontinuous circular element that surrounds the outer periphery 101a of the packer arrangement 100. Figure 6 shows the packer retraction mechanism 500 and pusher plates 204a, 204b when the annular blowout preventer is in a closed / contracted position (i.e. when the axial passageway through the packer arrangement 100 is at a minimum size / dimension). In this configuration, the pusher plates 204 and the packer retraction mechanism 500 are in their innermost position i.e. the two adjacent plates 204a and 204b have their protrusions interwoven / interlocked (not shown for simplicity). The pusher plates 204 of the blowout preventer thus forming a continuous circular element that surrounds the outer periphery 101a of the compressed packer arrangement 100.

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Figures 7 and 8 illustrate the operation of the annular blowout preventer. For simplicity, the packer element 101 is not shown. Figure 7 shows the annular blowout preventer in an open / expanded position. In this case, the pistons 202 in the hydraulic actuation cylinders 201 are fully retracted by means of the supply of pressurised fluid to the open chamber 201a and the venting of fluid from the closed chamber 201b, and the pusher plates 204 and the packer retraction linkages 500 are in their outermost position. Figure 8 shows the annular blowout preventer in a closed / contracted position, achieved by the supply of pressurised fluid to the closed chamber 201b and the release of fluid from the open chamber 201a. In this case, the pistons 202 in the hydraulic actuation cylinders 201 are fully advanced, and the pusher plates 204 and the packer retraction mechanism 500 are in their innermost position.

During closing, i.e. going from the state in Fig. 7 to that in Fig. 8, the pusher plates 204 and packer retraction mechanism 500, by means of the actuators 200, push the packer arrangement 100 towards the center of the bore, thus closing the annular blowout preventer (thus, the axial passageway of the packer arrangement 100 decreases in size / dimension). During opening, i.e. going from the state in Fig. 8 to that in Fig. 7, the packer retraction mechanism 500, by means of the return (radially outwards) force of the actuators 200, will retract the packer arrangement 100 away from the center of the bore, thus opening the annular blowout preventer (thus, moving to the expanded position increases the dimension / size of the axial passageway through the packer arrangement 100).

As the pusher plates 204 are forced to retract by the actuators 200 upon opening the BOP, the packer retraction mechanism 500 engage with the inserts 102 via the retractor part 104. The packer inserts 102 (that are embedded within the packer element 101) are pulled radially outwards and fully open the packer element 101.

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In this embodiment, the engagement of the retractor part 104 and the retraction mechanism 500 (e.g. the pin 106 through the opening 501) may take place when the packer element 101 is lowered (with the packer element 101 arranged so that the pin(s) 106 extends downwardly from the end of the retractor parts

104) into the BOP housing during installation, so that the pin 106 of each retractor part 104 slides into the opening 501 of one of the packer retraction mechanisms 500.

5 According to the invention, there is thus provided means to actively retract the packer arrangement 100 to the fully open position. Conventionally annular BOPs rely on the strain energy stored in the resilient packer element to provide the force necessary to urge the packer arrangement to the fully open position. Cold weather or loss of elasticity in the rubber due to fatigue can slow this
10 opening process significantly, or can cause the BOP to fail to fully open. The new structure described here permits the use the BOP operating system to urge the packing to the fully open position in a positive and expeditious manner. A further advantage is the ability to use elastomer materials which are very durable, but which lack sufficient elasticity to fully open within a practical time
15 interval.

Another advantage provided by an embodiment of the current invention is that the packer arrangement 100 is releasable from the actuation system. The pins 106 can simply slide out of the openings 501 in the packer retraction
20 mechanisms 500 as the packer element 101 is lifted up. Since the resilient material of the packer element 101 is more prone to damage and/or wear than the actuators 200 and/or the contractor arrangement 230 and/or the retractor arrangement 240, it is advantageous to be able to replace the packer arrangement 100 without needing to replace the other parts at the same time.

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In all embodiments described the packer inserts 102 are preferably made of metal but could also be made of any resistant material rigid enough to resist the environment of and the retractable force exerted by the actuators 200 on the pusher plates 204 and packer retraction mechanism 500 and thus on the packer
30 inserts 102. It should be appreciated that the contractor arrangement 230 (e.g. the pusher plates 204) and the retractor arrangement 240 (e.g. the retraction mechanism 500) may also be made of metal.

In a further aspect of the invention, illustrated in Figs 9 and 10, a position sensor 600 is arranged on the actuator 200 to measure the position of the movable element in the actuator. In the embodiment shown, the movable element comprises the pusher plate 204, the piston stem 203 and the piston 202. The sensor 600 may comprise a stationary part and a movable part. In the embodiment shown, the sensor 600 is a magneto restrictive linear displacement transducer, where the stationary part is a sensor housing 602 which is fixed on the housing of the actuator 200 while the movable part is a pin 601 fixed on the piston stem 203. A bore 603 through the housing of the actuator allows the pin 601 to extend into the sensor housing 602.

By means of the position sensor 600, it is possible to identify, at any desired time, the position of the actuator, and thereby the position of a packer in the annular blow out preventer. The sensor readings from the sensor 600 can be transmitted via a signal cable 604 to a computer system 605 for storage, display or processing, as illustrated schematically in Fig. 9. If the blow out preventer is used subsea the computer system 605 may be located topside on a platform, or onshore.

Having a position sensor 600 arranged as described above allows monitoring of BOP functionality at all times, as well as using the sensor data to obtain information about the reliability and operational state of the BOP. For example, it is possible to establish with more certainty that the annular BOP has reached the fully open position after having been closed, which is important for example when entering large tools down into the wellbore. Such tools may otherwise get stuck, or even damage the tool or the BOP, if the annular BOP is not correctly opened.

The position sensor 600 can be used to obtain an indication of packer wear. When the packer is in service over a period of time, the resilient material will wear, particularly at its inner circumference. This may require the actuator to provide a longer stroke in order to fully close the BOP. By comparing the actual closing stroke or actuator end position, to a nominal value, an indication can be

obtained as to whether the annular BOP requires replacement and whether it is fit for continued service.

5 The position sensor can thus be used for determining the condition of a packer arrangement for an annular blow out preventer, by actuating the packer actuation system to close on either a drill pipe of known diameter or on itself (i.e. without a drill pipe extending along the central passageway 211 through the packer element 101), then reading a position value of the movable actuation element measured by the position sensor 601, and comparing the position
10 value to a pre-determined, nominal position value. If a longer actuation stroke than the nominal value is required, then that can be taken as an indication that the packer element is worn. The difference between an actual stroke length and a nominal value may provide an indication of how much the packer element is worn.

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The process of reading the end position of the actuator in the closed state, either with the annular BOP closed on a pipe of known diameter (such as drill pipe) or on itself can be repeated on a plurality of occasions over time, and the measured position value recorded on each occasion. The resulting data can be
20 used in the creation of a position measurement over time graph, as illustrated in Figure 11, where x denotes the displacement required by the actuator to fully close the annular BOP in a given state (e.g. around a regular drill pipe). The data points indicate different readings of actual closing displacement, taken at different times t . A nominal actuator displacement value x_n is provided, for
25 example that value obtained by test data as the value required to close the annular in the newly installed state. A limit displacement value x_m indicates a displacement value which requires replacement of the annular, because the packer element may be so worn, or has otherwise lost its properties, that its operational integrity is no longer sufficient.

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Further, by comparing subsequent readings of the closing displacement, a time t_m when the packer element would need replacement can be predicted. This is illustrated in Fig. 12, where a set of position readings is extrapolated to predict a

time t_m at which the threshold displacement value x_m which would require replacement, is reached.

5 Computer system 605 may be programmed to output a warning signal (visual or audible) to alert an operator if the latest position reading suggests that the packer element 101 is so worn that it requires replacement, i.e. being close to or higher than x_m . In this case, the computer system may be configured to issue a series of staggered warnings – for example, an yellow warning when the packer element 101 has worn by a first pre-determined amount, an orange
10 warning when the packer element 101 has worn by a second, greater, pre-determined amount, and, as such, the need for replacement is imminent, and a red warning when the packer element 101 has worn by a third, even greater, amount and needs immediate replacement.

15 Computer system 605 may, alternatively or additionally, be programmed to output a remaining useful lifetime value, a wear rate value, and/or a predicted time for maintenance value, t_m , to an operator. The wear rate may be calculated based on a development in the packer wear readings, e.g. as a function of the slope shown in Fig. 12. The remaining useful lifetime value may be calculated
20 based on a calculated packer condition value, established as described above, and a predicted packer wear rate based on an estimated future usage rate.

Thus, by means of a system and/or method according to aspects of the present invention, such replacement and maintenance of the BOP can, for example, be
25 better planned in advance and, for example, combined or coordinated with other maintenance activities.

According to aspects of the present invention, the operational integrity of such safety critical components as annular blow out preventers may therefore be
30 ensured and predicted in a better way.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or

integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

5 The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

10

CLAIMS

- 5 1. A blowout preventer of the type having a resilient packer element (101) comprising a contractor arrangement (230) which has a plurality of plates (204) adjacent one another which enclose an area, the contractor arrangement (230) is configured to move from an expanded position to a contracted position in which the enclosed area decreases, wherein adjacent plates (204a, 204b) are configured to interlock with one another when in the contracted position, **characterized in that** each plate (204) has first and second edges which include alternate protrusions (401, 402, 403, 404) such that the second and first edges of the adjacent plates (204a, 204b) engage and interlock in the contracted position.
- 10
- 15 2. A blowout preventer according to claim 1 wherein each plate (204) is arcuate.
3. A blowout preventer according to claims 1 or 2 wherein the contractor arrangement (230) further includes a pantographic packer retractor mechanism (500).
- 20
4. A blowout preventer according to claim 3 wherein the packer retractor mechanism comprises second and third portions (502, 505) which are pivotally connected at a first end to adjacent plates (204a, 204b), and operable such that when the adjacent plates (204a, 204b) are moved towards one another a second opposing end of the second and third portions (502, 505) moves towards an axial passageway (211) of the blowout preventer, and when adjacent plates (204a, 204b) are moved apart from one another the second end moves away from the axial passageway (211).
- 25
- 30 5. A blowout preventer according to claim 4 wherein a second end of each of the second and third portions (502, 505) is pivotally connected

to a first portion (507), the first portion (507) having two legs (503, 504) pivotally connected about an opening (501).

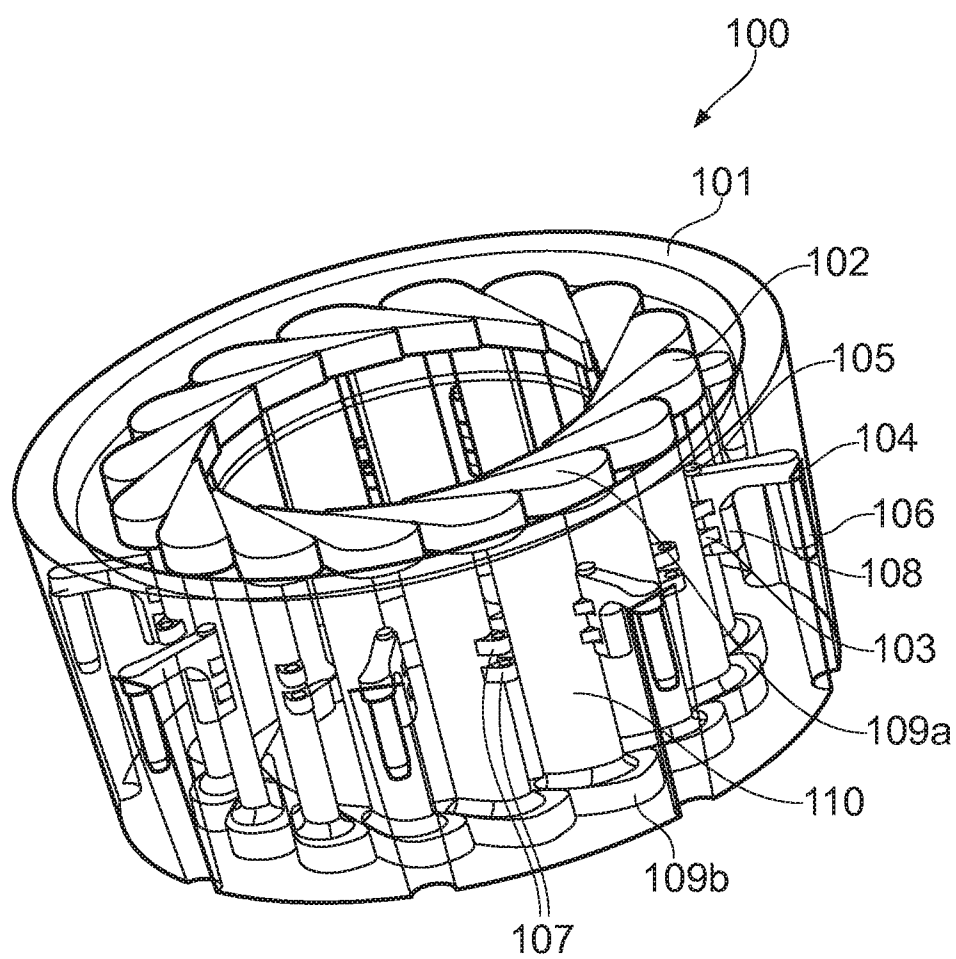
- 5 6. A blowout preventer according to claim 5 wherein the opening (501) of the first portion (507) provides a releasable connection to a packer insert (102).
- 10 7. A blowout preventer according to claims 5 or 6 wherein each of the first, second and third portions (502, 505, 507) is pivotally connected one to another about five pivot points (509a, 509b, 509c, 509d, 509e) all having parallel pivoting axes,
- 15 such that when the contractor arrangement moves to the contracted position, the second and third portions (502, 505) move relative to one another about their central pivot point (509c), and the two legs (503, 504) are forced to move relative to each other and the opening (501) moves towards / away from the plates (204).

Patentkrav

1. Utblåsingssikring av typen med fleksibelt pakningselement (101), omfattende en sammentrekningsanordning (230) som har en flerhet tilstøtende plater (204) som omslutter et område, der sammentrekningsanordningen (230) er konfigurert for å bevege seg fra en utvidet posisjon til en sammentrukket posisjon hvor det omsluttete området er redusert, hvori de tilstøtende platene (204a, 204b) er konfigurert for å sammenlås i den sammentrukne posisjonen, karakterisert ved at hver plate (204) har en første og andre kant som inkluderer alternerende fremspring (401, 402, 403, 404), slik at den andre og første kanten på tilstøtende plater (204a, 204b) griper inn i hverandre og sammenlås i den sammentrukne posisjonen.
5
2. Utblåsingssikring ifølge krav 1, hvori hver plate (204) er buet.
15
3. Utblåsingssikring ifølge krav 1 eller 2, hvori sammentrekningsanordningen (230) ytterligere inkluderer en pantografisk pakningstilbaketrekkingsmekanisme (500).
20
4. Utblåsingssikring ifølge krav 3, hvori pakningstilbaketrekkingsmekanismen omfatter et andre og tredje parti (502, 505) som ved en første ende er dreibart forbundet med tilstøtende plater (204a, 204b), og er betjenbar slik at når de tilstøtende platene (204a, 204b) beveges mot hverandre, beveger en andre, motstående ende på det andre og tredje partiet (502, 505) seg mot en aksial passasje (211) i utblåsingssikringen, og når tilstøtende plater (204a, 204b) beveges bort fra hverandre, beveger den andre enden seg bort fra den aksiale passasjen (211).
25
5. Utblåsingssikring ifølge krav 4, hvori en andre ende på hvert av det andre og tredje partiet (502, 505) er dreibart forbundet med et første parti (507), der det første partiet (507) har to ben (503, 504) som dreibart forbundet om en åpning (501).
30
6. Utblåsingssikring ifølge krav 5, hvori åpningen (501) i det første partiet (507) tilveiebringer en løsnbar forbindelse med en pakningsinnsats (102).
35

7. Utblåsningssikring ifølge krav 5 eller 6, hvori hvert av det første, andre og tredje partiet (502, 505, 507) er dreibart forbundet med hverandre om fem dreiepunkter (509a, 509b, 509c, 509d, 509e) som alle har parallelle dreieakser, slik at når sammentrekningsanordningen beveger seg til den sammentrukne posisjonen, beveger det andre og tredje partiet (502, 505) seg i forhold til hverandre om sitt sentrale dreiepunkt (509c), og de to benene (503, 504) tvinges til å bevege seg i forhold til hverandre, og åpningen (501) beveger seg mot / bort fra platene (204).
- 5

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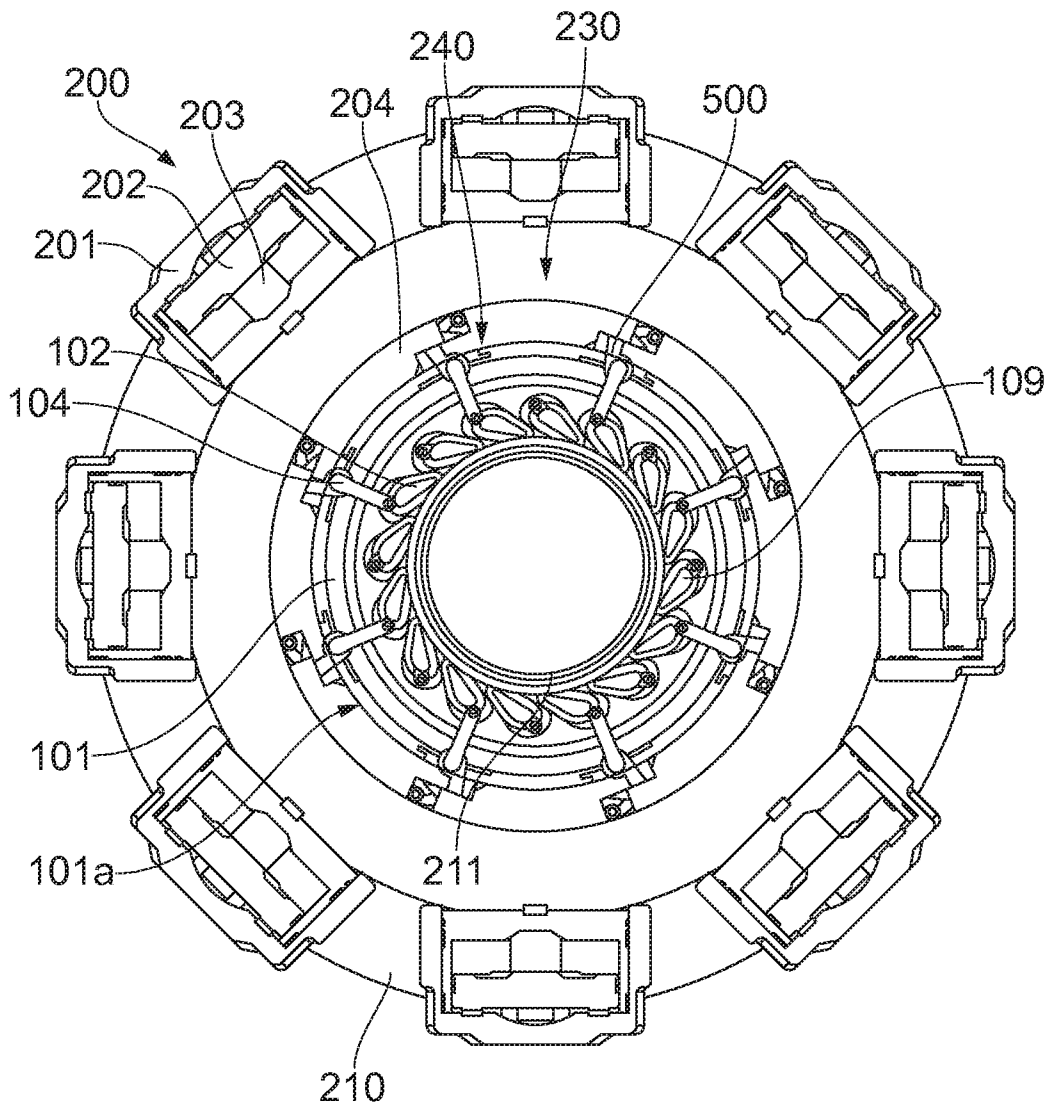


FIG. 2

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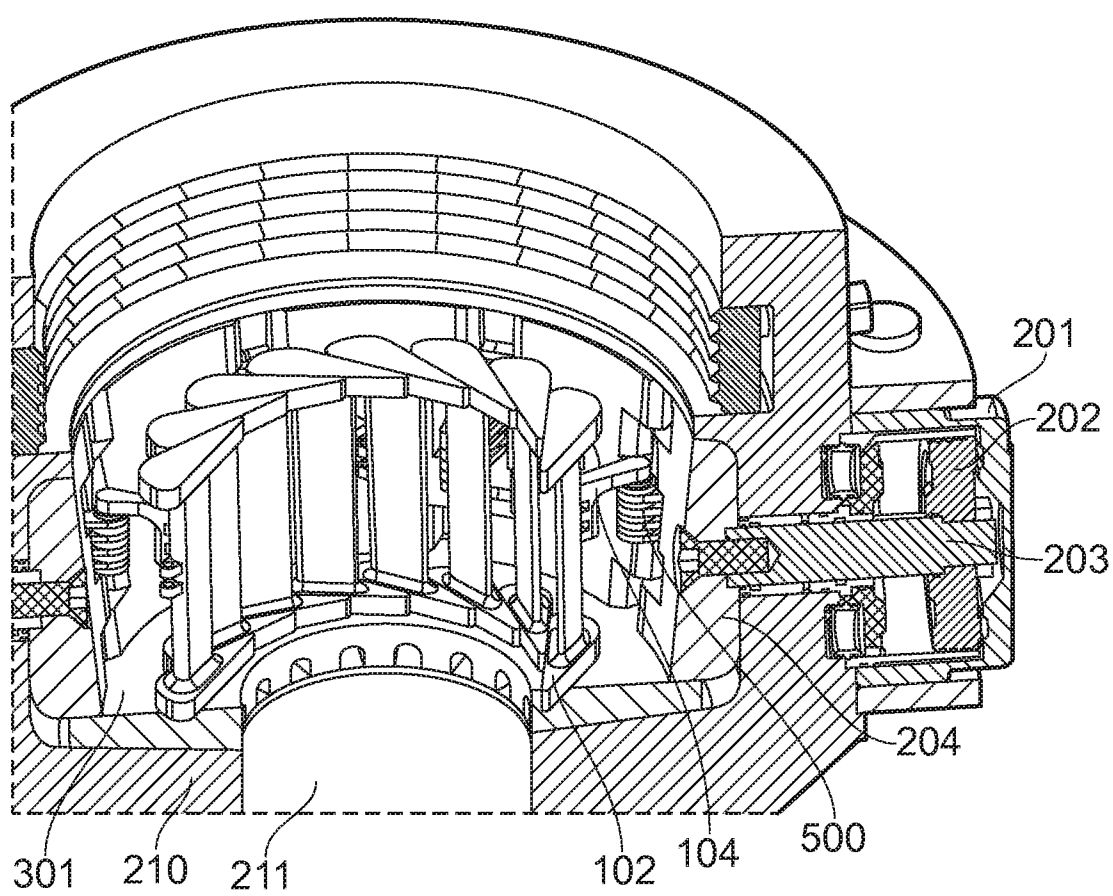


FIG. 3

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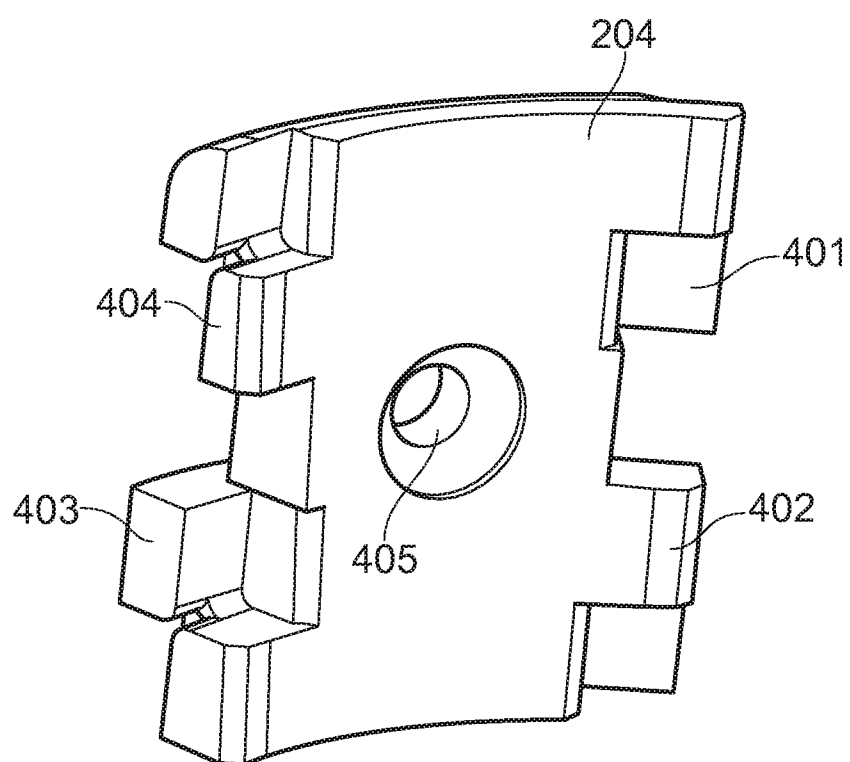


FIG. 4

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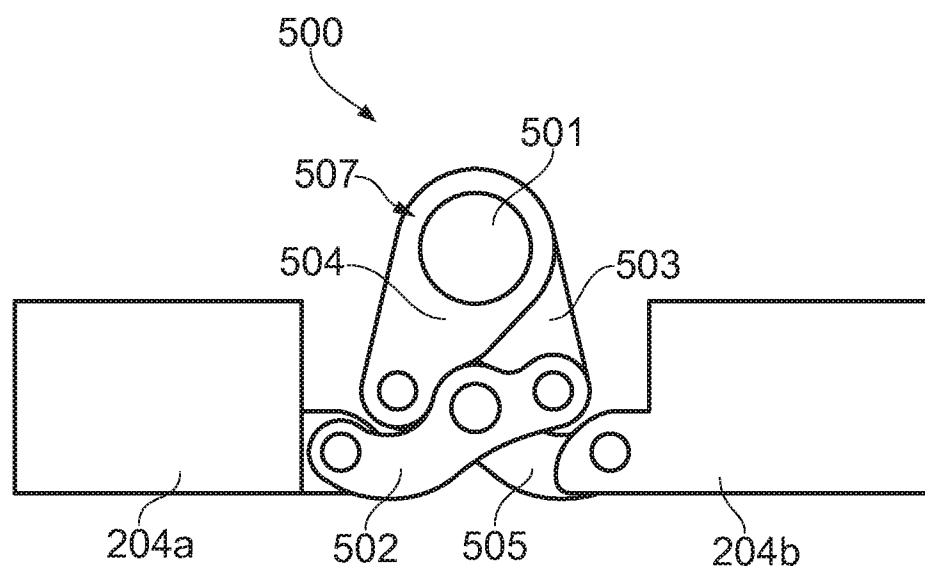


FIG. 5

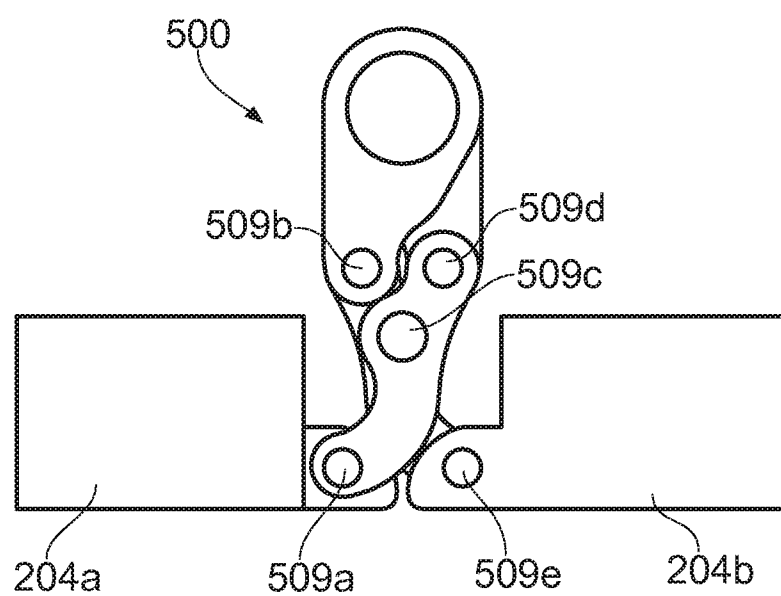


FIG. 6

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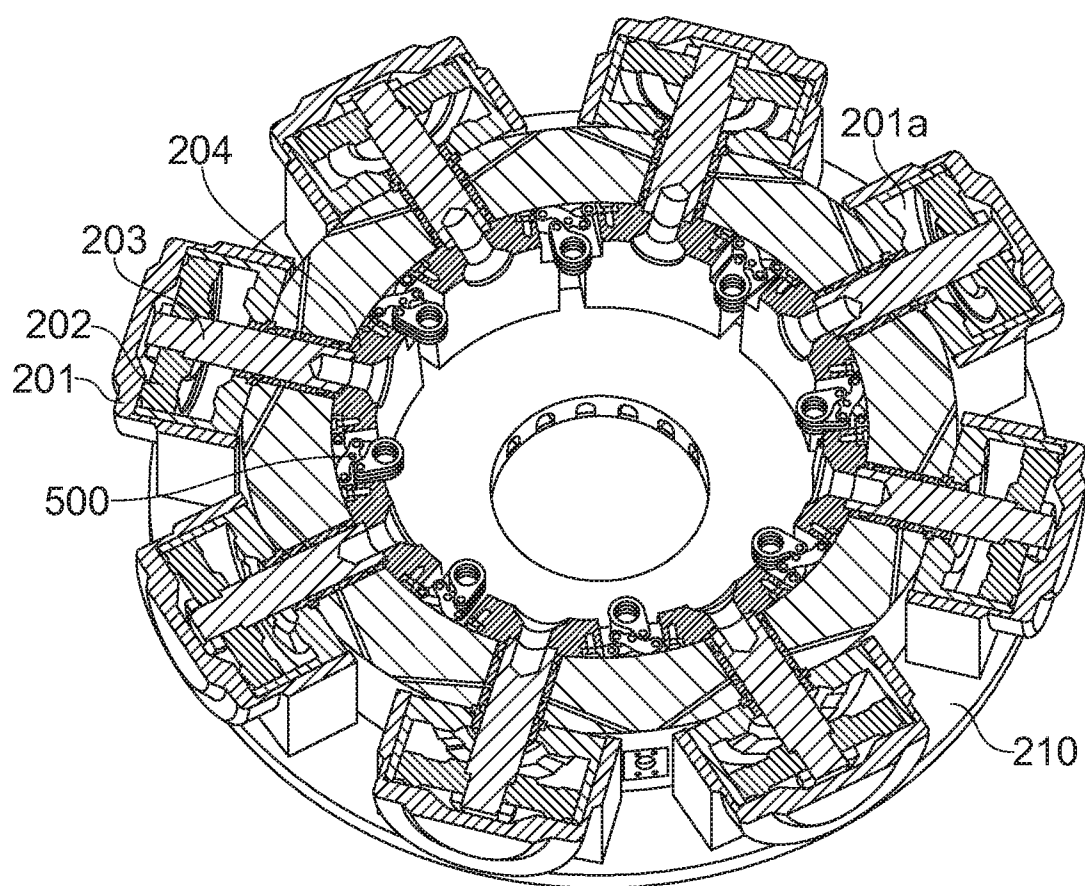


FIG. 7

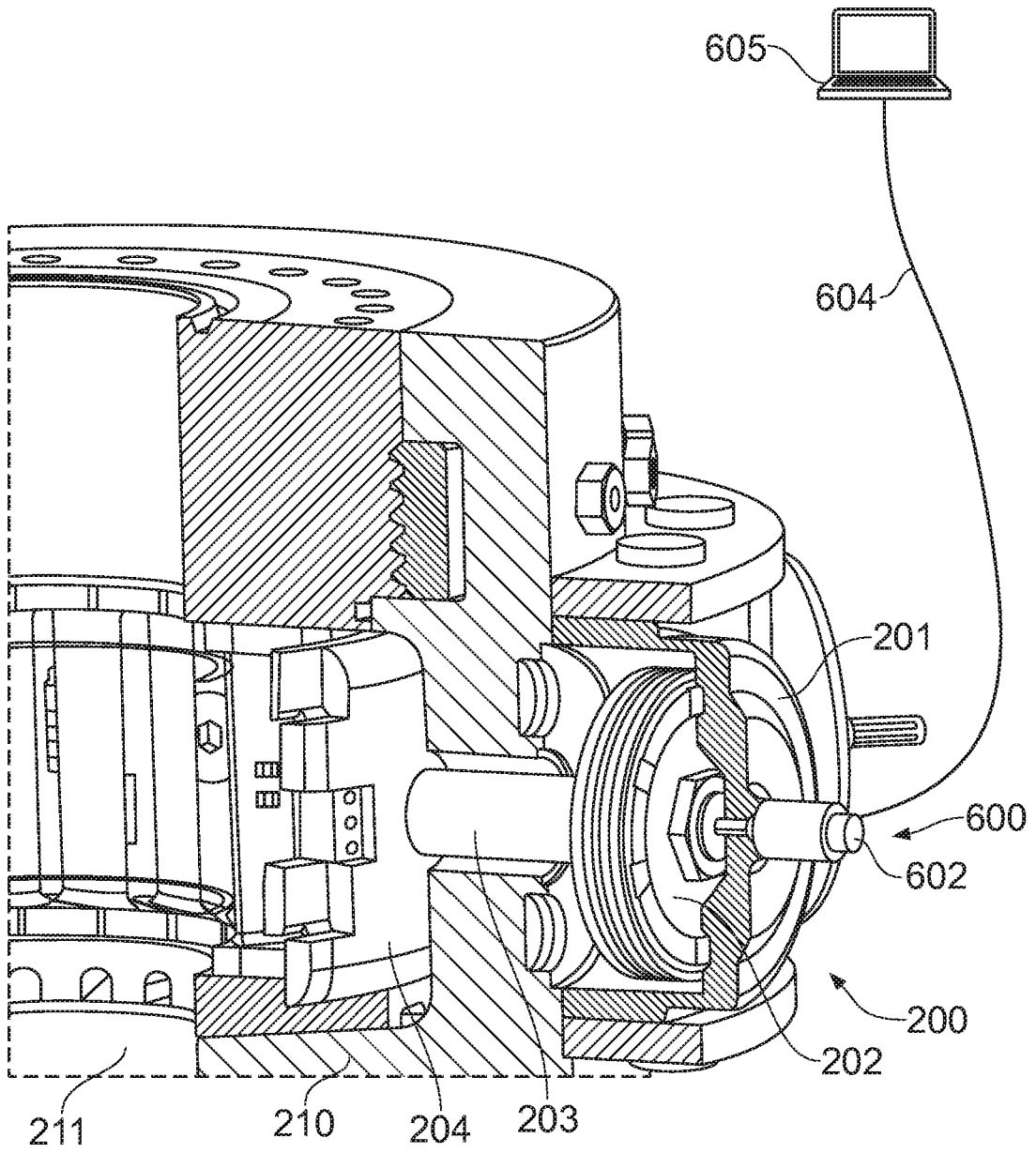


FIG. 9

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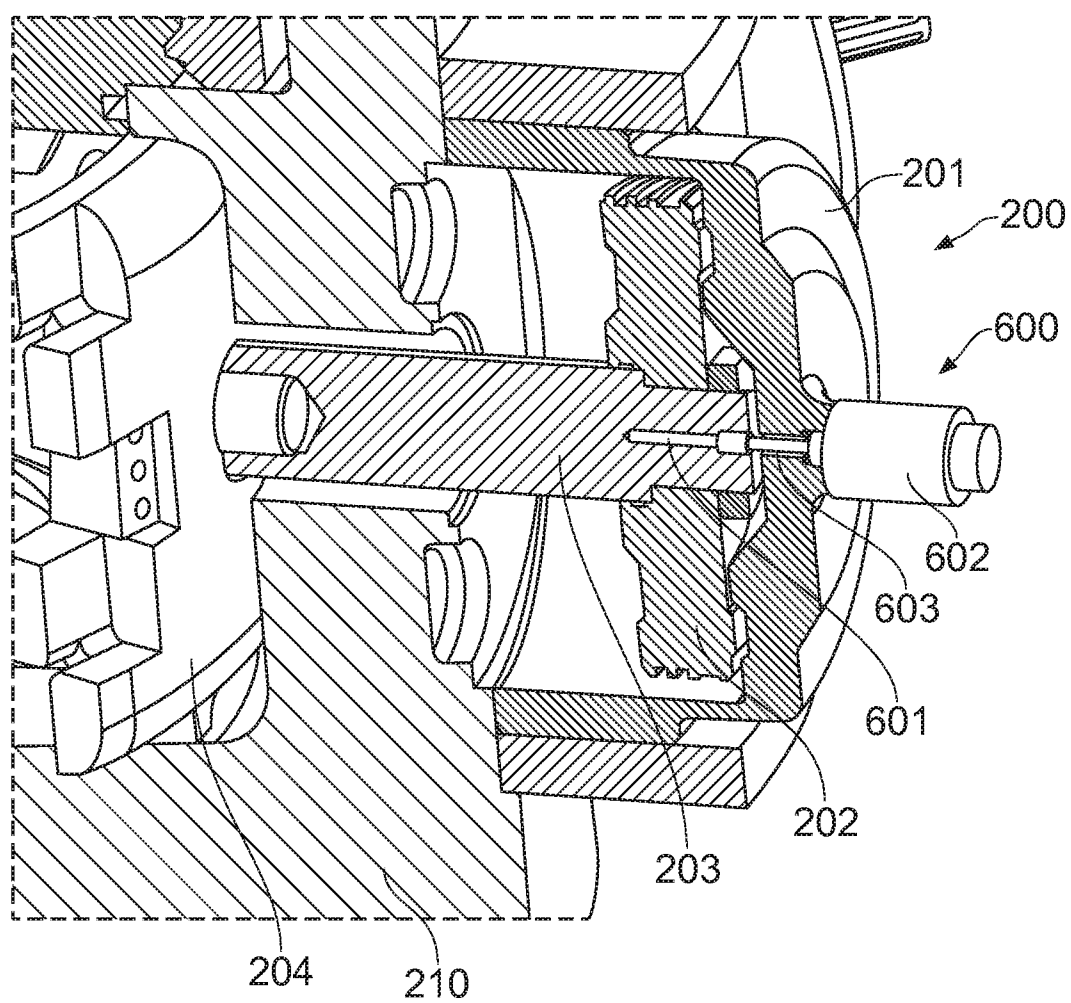


FIG. 10

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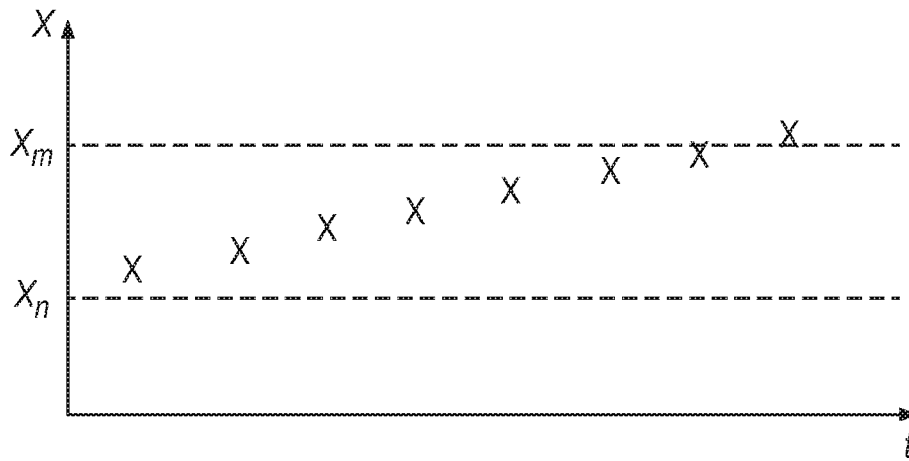


FIG. 11

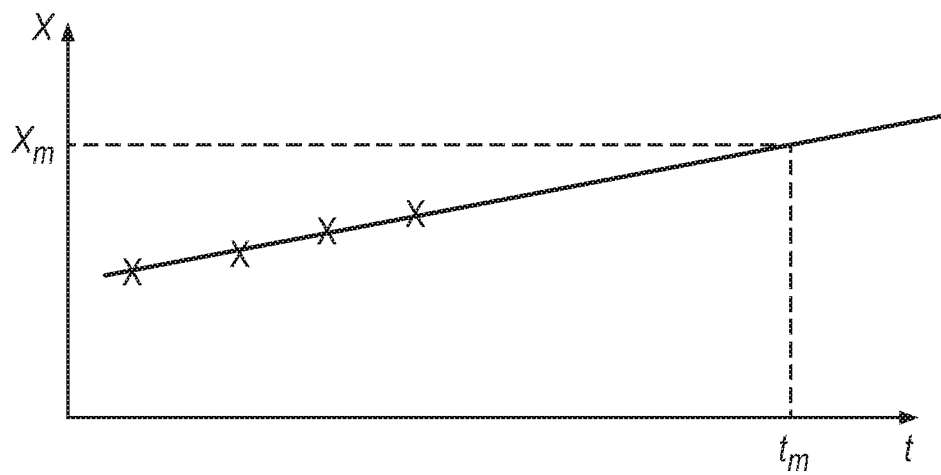


FIG. 12