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(56) Fremdragne publikationer:
WO-A1-2011/128690
WO-A2-03/042485
CA-A1- 2 685 021
US-A- 2 611 146
US-A- 3 965 987
US-A1- 2001 020 770
US-A1- 2005 241 833
US-A1- 2006 037 782

DESCRIPTION

[0001] This invention relates to oilfield equipment and related apparatus and method. Embodiments relate to sealing elements used in drilling wells.

[0002] Sealing elements have been used in rotating control devices (RCDs) for many years in the drilling industry. Passive sealing elements, such as stripper rubber sealing elements, can be fabricated with a desired stretch-fit. An example of a proposed stripper rubber sealing element is shown in US Pat. No. 5,901,964. A stripper rubber sealing element may be attached with a rotatable internal bearing member of an RCD to seal around the outside diameter of an inserted tubular to rotate with the tubular during drilling. The tubular may be slidingly run through the RCD as the tubular rotates or when the tubular, such as a drill string, casing, coil tubing, or any connected oilfield component, is not rotating. Examples of some proposed RCDs are shown in US Pat. Nos. 5,213,158; 5,647,444 and 5,662,181.

[0003] RCDs have been proposed with a single stripper rubber seal element, as in US Pat. Nos. 4,500,094 and 6,547,002; and Pub. No. US 2007/0163784, and with dual stripper rubber sealing elements, as in the '158 patent, '444 patent and the '181 patent, and US Pat. No. 7,448,454. The wellbore pressure in the annulus acts on the cone shaped stripper rubber sealing element with vector forces that augment a closing force of the stripper rubber sealing element around the tubular. US Pat. No. 6,230,824 proposes two opposed stripper rubber sealing elements, the lower sealing element positioned axially downward, and the upper sealing element positioned axially upward (see FIGS. 4B and 4C of '824 patent).

[0004] Unlike a stripper rubber sealing element, an active sealing element typically requires a remote-to-the-tool source of hydraulic or other energy to open or close the sealing element around the outside diameter of the tubular. An active sealing element can be deactivated to reduce or eliminate the sealing forces of the sealing element with the tubular. RCDs have been proposed with a single active sealing element, as in the '784 publication, and with a stripper rubber sealing element in combination with an active sealing element, as in US Pat. Nos. 6,016,880 and 7,258,171 (both with a lower stripper rubber sealing element and an upper active sealing element), and Pub. No. US 2005/0241833 (with a lower active sealing element and an upper stripper rubber sealing element).

[0005] A tubular typically comprises sections with varying outer surface diameters. The RCD sealing element must seal around all of the rough and irregular surfaces of the components of the tubular, such as a hardening surface (as proposed in US Pat. No. 6,375,895), drill pipe, tool joints, drill collars, and other oilfield components. The continuous movement of the tubular through the sealing element while the sealing element is under pressure causes wear of the inwardly facing sealing surface of the sealing element.

[0006] When drilling with a RCD having dual independent annular sealing elements, the lower of the two sealing elements is typically exposed to the majority of the pressurized fluid and cuttings returning from the wellbore, which communicate with the lower surface of the lower sealing element body. The upper sealing element is exposed to the fluid that is not blocked by the lower sealing element. When the lower sealing element blocks all of the pressurized fluid, the lower sealing element is exposed to a significant pressure differential across its body since its upper surface is essentially at atmospheric pressure when used on land or atop a riser. The highest demand and wear on the RCD sealing elements occurs when tripping the tubular out of the wellbore under high pressure.

[0007] American Petroleum Institute Specification 16RCD (API-16RCD) entitled "Specification for Drill Through Equipment - Rotating Control Devices," First Edition, © February 2005 American Petroleum Institute, proposes standards for safe and functionally interchangeable RCDs. At least in the United States of America, the requirements for API-16RCD must be complied with when moving the drill string through an RCD in a pressurized wellbore. The sealing element is inherently limited in the number of times it can be fatigued with larger diameter tool joints that pass under high differential pressure conditions. Of course, the deeper the wellbores are drilled, the more tool joints that will be stripped through a sealing element, some under high pressure.

[0008] RCDs have been proposed in the past to be positioned with marine risers. An example of a marine riser and some of the associated drilling components is proposed in US Pat. Nos. 4,626,135 and 7,258,171. US Pat. No. 6,913,092 proposes a seal housing with a RCD positioned above sea level on the upper section of a marine riser to facilitate a mechanically controlled pressurized system. US Pat. No. 7,237,623 proposes a method for drilling from a floating structure using an RCD positioned on a marine riser. US Pat. Nos. 6,470,975; 7,159,669; and 7,258,171 propose positioning an RCD assembly in a housing disposed in a marine riser. Also, an RCD has also been proposed in US Pat. No. 6,138,774 to be positioned subsea without a marine riser.

[0009] Latching assemblies have been proposed in the past for positioning an RCD. US Pat. No. 7,487,837 proposes a latch assembly for use with a riser for positioning an RCD. Pub. No. US 2006/0144622 proposes a latching system to latch an RCD to a housing. Pub. No. US 2008/0210471 proposes a docking station housing positioned above the surface of the water for latching with an RCD. Pub. No. US 2009/0139724 proposes a latch position indicator system for remotely determining whether a latch assembly is latched or unlatched.

[0010] In the past, when drilling in deepwater with a marine riser, the riser has not been pressurized by mechanical devices during normal operations. The only pressure induced by the rig operator and contained by the riser is that generated by the density of the drilling mud held in the riser (hydrostatic pressure). During some operations, gas can unintentionally enter the riser from the wellbore. If this happens, the gas will move up the riser and expand. As the gas expands, it will displace mud, and the riser will "unload." This unloading process can be quite violent and can pose a significant fire risk when gas reaches the surface of the floating structure via the bell-nipple at the rig floor.

[0011] US Pat. Nos. 4,626,135 proposes a gas handler annular blowout preventer (BOP) to be installed in the riser. The gas handler annular BOP is activated only when needed, but instead of simply providing a safe flow path for mud and gas away from the rig floor, the gas handler annular BOP can be used to hold limited pressure on the riser to control the riser unloading process. However, drilling must cease because movement of the drill string through the annular BOP when the annular seal is engaged against the drill string will damage or destroy the non-rotatable annular seal. During drilling, the annular BOP's seal is open, and drilling mud and cuttings return to the rig through the annulus or annular space. Ram type blowout preventers have also been proposed in the past for drilling operations, such as proposed in US Pat. Nos. 5,735,502; 4,488,703; 4,508,313; and 4,519,577. As with annular BOPs, drilling must cease when the ram BOP seal is engaged against the drill string tubular or damage to the seal will occur.

[0012] Prior to the development of RCDs, packing heads, such as proposed in US Pat. Nos. 2,038,140; 2,124,015; 2,148,844; 2,163,813; and 2,287,205, were used for sealing around the drill string during drilling operations. Unlike an RCD, a packing head has no bearing assembly and its sealing element does not rotate with the drill string or other inserted tubular or oilfield component. US Pat. No. 2,170,915 proposes a stationary stripper rubber seal positioned in a housing over a well casing through which the drill string may be rotated for drilling. A problem with such prior art packing head and stationary stripper rubber devices is that the sealing element can be damaged or destroyed by the heat generated from the friction resisting the movement of the inserted tubular or oilfield component.

[0013] Drilling with casing is gaining some acceptance worldwide for addressing certain onshore and offshore problems such as formation instability, lost circulation, fluids control, and troublesome zones. Drilling with casing eliminates the need to continually replace strings of drill pipe during drilling, saving time since the rig is also drilling while casing is being run into the hole. Although drilling with casing currently constitutes only a small part of worldwide drilling activity, drilling with casing is expected to increase in the future.

[0014] Drilling with casing is being attempted with increasingly larger casing sizes. While drilling with casing has been used in the past with 9 5/8 inch (24.4 cm) diameter casing, it is now being attempted with casing diameters up to 20 inches (50.8 cm). However, the amount of annular space within a riser or housing for positioning an RCD becomes increasing more limited as the casing size gets larger. The RCD has to be sized to accommodate the large casing, and it is often impractical to use a larger riser or housing, particularly in shallow wells or other applications where the larger casing is only needed for relatively short drilling distances, like 100 feet (30.5 m). Drilling with casing may be attempted in the future in certain subsea applications without a marine riser, particularly for drilling relatively short drilling distances.

[0015] Testing performed by the inventors reveals that when a 10 ¾ inch (27.3 cm) diameter casing section is rotated in a prior art stationary stripper rubber sealing element under low pressures of 5 to 10 psi, the prior art sealing element deteriorates and is damaged in about 2 to 10 hours due to heat generated by the frictional resistive forces. When water is applied to the prior art sealing element surfaces not contacting the casing section, the sealing element damage does not occur until about 30 hours. However, when drilling with casing is used in real drilling applications, much longer drilling times are needed.

[0016] Circular seal members positioned within grooves, chambers, pockets or receptacles have been used in the past in applications involving rotating shafts. Kalsi Engineering, Inc. of Houston, Texas and Parker Hannifin, Inc. of Cleveland, Ohio are two manufacturers of such sealing members. US Pat. No. 4,610,319 proposes a circular sealing member for a drill bit application having a wave pattern on the sealing side of the sealing member and positioned within a circular pocket. The sealing member receives lubrication in the pocket from an external lubricant supply system source. US Pat. Nos. 5,230,520; 5,678,829; 5,738,358; 5,873,576; 6,007,105; 6,036,192; 6,109,618; 6,120,036; 6,227,547; 6,315,302; 6,334,619; 6,382,634; 6,494,462; 6,561,520; and 6,685,194 propose circular seals having sealing interfaces with various geometries and disposed within receptacles, grooves, chambers, or pockets. The seal receptacle, groove, chamber or pocket supports and stabilizes the circular seal and may be used to receive lubricant for the seal from an external lubricant supply source.

[0017] International Pub. No. WO2008/133523 proposes a packer seal element with at least one channel within the seal for moving a lubricant through the seal. The packer element is positioned around the drill string, and the lubricant, proposed to be oil or grease, is injected from an external source into a port in the side of the packer seal for travel through the channel in the seal. US Pat. No. 3,472,518 proposes a stationary metal housing positioned close to the surface of a drill pipe with the housing inner surface having a series of rings or grooves forming a tortuous path between the outer surface of the drill pipe and the inner surface of the housing. The tortuous path is proposed to provide for a fluid flow that absorbs the pressure drop from the pressure in the annulus around the drill pipe below the housing to atmospheric pressure on the exterior of the housing.

[0018] CA2685021 A1 discloses a sealing arrangement for dynamic sealing around a drill stem or a coiled tubing comprising a sealing unit with a sealing element including an inlet channel wherein the sealing element is arranged to receive a friction reducing medium through the inlet channel to the seal surface against the drill stem. US Pat. No. 2006037782 discloses a monitoring system for a rotating diverter head for use in the drilling of oil, gas and geothermal wells. The system includes a pressure sensor which is mounted beside the stripper rubber which contacts the drill pipe. An increase in the pressure monitored provides early warning of degradation or imminent failure of the seal.

[0019] The inventors have appreciated that the following would be desirable: It would be desirable to drill with a sealed and pressurized mud system without using an RCD. Particularly, it would be desirable to drill using casing with a sealed and pressurized mud system without using an RCD. It would be desirable to drill for relatively short distances using larger casing sizes without an RCD since the annular space surrounding such casing may be limited. It would be desirable to drill with a non-rotating BOP device that would allow drilling to continue with the sealing element sealed without the sealing element becoming damaged or destroyed from the heat and other effects of friction in a relatively short time period. It would also be desirable to drill with a non-rotating BOP device in relatively shallow subsea wells without a marine riser. It would be desirable to use sealing elements in an RCD that would not become damaged or destroyed from the heat and other effects of friction in a relatively short time period when the RCD bearings or other RCD components malfunction in providing sufficient seal element rotation. It would also be desirable to have a sealing element with bi-directional or redundant sealing. It would be desirable to decrease the differential pressure across the lower seal element in a dual seal configuration. US 2,611,146A describes a soft elastic drill pipe wiper having special means embodied therein for retaining mud-ladened drilling fluid. US 2001/020770A1 describes a hydrodynamically lubricating seal having a dynamic sealing lip projecting from the seal body. WO 2011/128690A1 describes a blowout preventer assembly having an annular packing unit and an actuator and further comprising a stripping sleeve.

[0020] Aspects of the invention are set out in the accompanying claims. Also disclosed herein is a system and a method for drilling using a sealing element having a lubricating seal profile on the inwardly facing bore surface of its sealing section. The lubricating seal profile allows for sealing a drill string tubular or other oilfield component and communicating a fluid between the sealing section of the sealing element and the sealed drill string tubular or other oilfield component while the drill string tubular or other oilfield component rotates and/or slides vertically relative to the sealing element. The sealing element may seal with the drill string tubular or other oilfield component and either remain stationary and non-rotating, or it may rotate. The same fluid used for drilling may also be used for lubrication, such as water, drilling fluid, mud, well bore fluid or other gas or liquid.

[0021] In one embodiment, the sealing element may be positioned with a seal housing above or with a marine riser. In another embodiment, the seal element may be positioned with a seal housing in a marine riser. In yet another embodiment, the sealing element may be positioned with a seal housing subsea without a marine riser. A seal adapter housing may keep the sealing element stationary and non-rotating while the sealed drill string tubular or other oilfield component rotates relative to the sealing element. In another embodiment, the seal housing may be a RCD that allows the sealing element to rotate with the sealed drill string tubular or other oilfield component.

[0022] The lubricating seal profile allows for communicating a fluid between the sealing section of the sealing element and the sealed drill string tubular or other oilfield component when the RCD sealing element either slows or stops rotating and the sealed drill string tubular or other oilfield component continues to rotate relative to the sealing element, such as when the RCD bearings malfunction or require bearing lubrication. In still other embodiments, the sealing element having a lubricating seal profile may be positioned with a BOP, such as an annular BOP or a ram-type BOP, allowing the sealed drill string tubular or other oilfield component to continue rotating relative to the BOP sealing element.

[0023] More than one sealing element having a lubricating seal profile may be positioned with a seal housing. In one embodiment, sealing elements may be positioned axially downwardly. In

another embodiment, sealing elements may be opposed both axially downwardly and axially upwardly. A dual sealing element or dual seal may have two annular sealing surfaces that are spaced apart by a non-sealing surface. In one embodiment, a dual seal may be a unitary bi-directional sealing element having lubricating seal profiles on the inwardly facing surfaces of each of its two nose sections. In another embodiment, a dual seal may have a lubricating seal profile on the inwardly facing surface of its nose section and a lubricating seal profile on the backup or bi-directional sealing surface adjacent the throat
section. The dual seal embodiments also may not have any lubricating seal profiles on their spaced apart annular sealing surfaces. In another embodiment, differential pressures across two seal elements may be managed by filling the cavity between the two seal elements with cuttings-free drilling fluid, mud, water, coolant, lubricant or inert gas at desired amounts of pressure.

[0024] All embodiments of the dual seal may have a hydraulic force surface to move, deform or compress one or both of the sealing surfaces with a drill string tubular or other oilfield component. The hydraulic force surface may take many different forms of embodiments, including a closed curved or radius surface, an open inclined surface, an open curved surface, a combination open inclined surface with a horizontal or flat surface, a combination open curved surface with horizontal or flat surface, and a combination closed upper and lower curved surfaces with a sealing surface therebetween.

[0025] The lubricating seal profile may have many different embodiments, including, but not limited to, a wave pattern or wavy edge, a saw-tooth high film pattern, a downwardly inclined passageway pattern, an upwardly inclined passageway pattern, and a combination upwardly and downwardly inclined passageway pattern. The lubricating seal profile may be positioned and oriented on the inwardly facing sealing surface of the sealing element based upon the intended direction of flow of the lubricating fluid. A lubricating seal profile may be positioned and oriented on either or both of the spaced apart sealing surfaces of a dual seal based upon the intended direction of flow of the lubricating fluid.

[0026] In one embodiment, a stripper rubber sealing element may have an annular lubricating seal profile on the inwardly facing bore surfaces of both its nose section and its throat section. The nose section may seal with a drill string tubular or other oilfield component having a first diameter, and the throat section and nose section may deform to seal with an oilfield component of the drill string tubular having a second and larger diameter, such as a tool joint.

[0027] The system and method may allow drilling without an RCD using larger casing sizes with a sealing element sealed with the casing. The system and method may also allow drilling with a non-rotating BOP device, such as an annular BOP or a ram-type BOP, that allow drilling to continue with the sealing element engaged and without the sealing element becoming damaged or destroyed from the heat and other effects of friction in a relatively short time period. The system and method may also allow drilling with casing using a non-rotating BOP device in relatively shallow subsea wells without a riser. The system and method may further allow the use of sealing elements with an RCD that will not become damaged or destroyed from the heat and other effects of friction in a relatively short time period when the RCD bearings or other RCD components malfunction and do not allow adequate or desired rotation. The system and method may further allow for dual seals with sealing surfaces for redundant, back up or bi-directional sealing with or without lubricating profiles and for use with or without a rotating tubular or other oilfield component.

[0028] Some embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIG. 1 is a cross-sectional elevational view of a stationary seal adapter housing with two sealing elements each having lubricating seal profiles on the inwardly facing surfaces of their nose sections with the adapter housing latched with a latch housing disposed over a diverter housing.

FIG. 2 is a cross-sectional elevational view of an RCD on the left side of the break line, and a stationary seal adapter housing on the right side of the break line, with an upper dual seal having lubricating seal profiles on the inwardly facing surfaces of each of its two nose sections, and a lower sealing element having a lubricating seal profile on the inwardly facing surface of its nose section, where the RCD and adapter housing is latched with a latch housing disposed in a marine riser over a diverter housing.

FIG. 3 is a cross-sectional elevational view of a stationary seal adapter housing with two independent or separate opposed sealing elements each having a lubricating seal profile on the inwardly facing surface of its nose section and the adapter housing latched with a latch housing disposed over a subsea diverter housing.

FIG. 4 is a cross-sectional plan view of a ram type BOP sealing arm in the closed or sealed position with the sealing arm sealing element having a lubricating seal profile disposed with a tubular.

FIG. 5 is a cross-sectional elevational view of a sealing element with a wave pattern lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 5A is a linear isometric representation of the view along line 5A-5A of FIG. 5 showing the wave pattern lubricating seal profile.

FIG. 5B is an enlarged detail view of the sealing element nose section of FIG. 5 with the wave pattern seal profile with an inserted tubular.

FIG. 5C is an enlarged detail view of the sealing element nose section of FIG. 5 with a wave pattern lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 6 is a cross-sectional elevational view of a sealing element with a saw-tooth pattern high film lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 6A is a linear isometric representation of the view along line 6A-6A of FIG. 6 showing the high film saw-tooth pattern lubricating seal profile.

FIG. 6B is an enlarged detail view of the seal element nose section of FIG. 6 with the seal profile with an inserted tubular.

FIG. 7 is a cross-sectional elevational view of a sealing element with a downwardly inclined passageway pattern lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 7A is a linear representation of the view along line 7A-7A of FIG. 7 showing the downwardly inclined passageway pattern lubricating seal profile.

FIG. 8 is a cross-sectional elevational view of a sealing element with an upwardly inclined passageway pattern lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 8A is a linear representation of the view along line 8A-8A of FIG. 8 showing the upwardly inclined passageway pattern lubricating seal profile.

FIG. 9 is a cross-sectional elevational view of a sealing element with a combination upwardly and downwardly inclined passageway pattern lubricating seal profile on the inwardly facing surface of the nose section.

FIG. 9A is a linear representation of the view along line 9A-9A of FIG. 9 showing the combination upwardly and downwardly inclined passageway pattern lubricating seal profile.

FIG. 10 is a cross-sectional elevational view of a sealing element with a combination upwardly and downwardly inclined passageway pattern lubricating seal profile on the inwardly facing surface of the nose section, and a downwardly inclined passageway pattern lubricating seal profile extending on the inwardly facing sloped or inclined surface of the nose section and throat section.

FIG. 10A is a linear representation of the view along line 10A-10A of FIG. 10 showing the lubricating seal profiles.

FIG. 10B is a cross-sectional elevational view of the sealing element of FIG. 10 sealed with a tubular, such as a drill string.

FIG. 10C is a cross-sectional elevational view of the sealing element of FIG. 10 deformed to receive and seal with a tool joint having a larger diameter than the drill string.

FIG. 11 is a cross-sectional elevational view of an RCD on the left side of the break line, and a stationary seal adapter housing on the right side of the break line, with an upper dual seal, and a lower sealing element having a lubricating seal profile on the inwardly facing surface of its nose section, where the RCD and adapter housing is latched with a latch housing disposed in a marine riser over a diverter housing.

FIG. 11A is an isometric view of the nose section of the lower sealing element of FIG. 11 showing a wave pattern lubricating seal profile.

FIG. 12 is a cross-sectional elevational view of a dual seal having a first sealing surface with a combination upwardly and downwardly inclined passageway pattern lubricating seal profile and a second or upper sealing surface with a downwardly inclined passageway pattern lubricating seal profile adjacent to a closed curved hydraulic force surface formed on the top of the dual seal.

FIG. 12A is an isometric view of the first sealing surface of the dual seal of FIG. 12 showing the combination upwardly and downwardly inclined passageway pattern lubricating seal profiles.

FIG. 13A is a partial cross-sectional elevational view of the dual seal shown in FIG. 11.

FIG. 13B is a partial cross-sectional elevational view of a dual seal with a wave pattern lubricating seal profile on the first sealing surface and an inclined hydraulic force surface adjacent the second or upper sealing surface.

FIG. 13C is a partial section isometric view along line 13C-13C of FIG. 13B.

FIG. 13D is a partial cross-sectional elevational view of the top portion of a dual seal with an open curved or radius hydraulic force surface adjacent the second or upper sealing surface.

FIG. 13E is a partial cross-sectional elevational view of the top portion of a dual seal with a combination open inclined hydraulic force surface with a horizontal or flat hydraulic force surface adjacent the second or upper sealing surface.

FIG. 13F is a partial cross-sectional elevational view of the top portion of a dual seal with a combination open curved or radius hydraulic force surface with horizontal or flat hydraulic force surface adjacent the second or upper sealing surface.

FIG. 13G is a partial cross-sectional elevational view of the top portion of a dual seal with a combination closed first or upper curved hydraulic force surface with a second or lower closed curved hydraulic force surface with the second or upper sealing surface therebetween.

[0029] In FIG. 1, diverter housing **4** is disposed over marine riser **2** and below latch housing **6.** Latch housing **6** may be a latch housing such as proposed in FIG. 2 of US Pat. No. 7,487,837, although other housings are contemplated. Seal housing **8** is latched with latch housing **6.** First seal or first sealing element **10** is disposed with seal housing **8** with its first seal supporting or throat section **16.** First sealing element **10** has a first seal lubricating seal profile **12** on the inwardly facing sealing surface **13** of its nose section or sealing section **14,** sealing with drill string tubular **DS.** As used herein, drill string tubular **DS** may be a drill string, casing, liner, coil tubing, drill pipe, tubular, tool joint, collar, bottom hole assembly or any other oilfield component.

[0030] Second seal or second sealing element **18** is disposed with seal housing **8** with its second seal supporting or throat section **24.** Second sealing element **18** has a second seal lubricating seal profile **20** on the inwardly facing sealing surface **21** of it nose section or sealing section **22** for sealing with drill string tubular **DS.** Although two seal elements **(10, 18)** are shown, any number of sealing elements are contemplated, including only one sealing element.

Seal housing **8** is an adapter or seal adapter housing that keeps sealing elements **(10, 18)** stationary and does not allow the sealing elements **(10, 18)** to rotate as drill string tubular DS rotates or moves vertically, such as during drilling.

[0031] First and second seal lubricating profiles **(12, 20)** may be the same or they may be different. First and second seal lubricating profiles **(12, 20)** shown in FIG. 1 are consistent with either a wave pattern or wavy edge lubricating seal profile, such as shown in FIGS. 13B-13C for the nose sealing section, and similar to that shown in FIGS. 5-5C and 11A, or a saw-tooth pattern high film lubricating seal profile, similar to that shown in FIGS. 6-6B. However, any of the lubricating seal profiles shown in any of the Figures may be used with the sealing elements **(10, 18)** in FIG. 1, or with any of the sealing elements shown in any of the other Figures, to achieve the desired lubrication for the sealing element application.

[0032] The location and orientation of profiles **(12, 20)** in FIG. 1 were selected since the seal housing **8** is disposed over marine riser **2,** and it is intended that fluid may flow up the annular space **26** between the drill string tubular **DS** and the marine riser **2** and then the diverter housing **4.** Like for the nose sealing section in FIGS. 13B-13C, first and second seal lubricating profiles **(12, 20)** are positioned on the respective inwardly facing bore sealing surfaces **(13, 21)** of first seal nose section **14** and second seal nose section **22** so that the fluid moving up the annulus or annular space **26** may communicate fluid to lubricate between the respective sealing sections **(14, 22)** and the drill string tubular **DS.** Conversely, as will be discussed below in detail, the lubricating seal profiles shown in FIGS. 5-5C, 6-6B, and 11A are located and oriented for fluid flowing downward, not upward as in FIG. 1.

[0033] When the pressurized fluid flows up the annular space **26** in FIG. 1 while drill string tubular **DS** is rotating and/or moving vertically, the fluid first encounters first sealing element profile passageway **28.** As the drill string tubular **DS** moves and/or rotates relative to the first seal **10,** the pressurized fluid in annulus **26** communicates between first sealing surface **13** via passageway **28** and drill string tubular **DS,** lubricating first seal **10.** The fluid may then move upwards, encountering second seal profile passageway **30.** Again, as the drill string tubular **DS** moves and/or rotates relative to the second sealing element **18,** the pressurized fluid communicates between second seal sealing surface **21** via passageway **30** and drill string tubular **DS,** lubricating second seal **18.** The fluid may be the same fluid used for drilling, such as water, drilling fluid or mud, well bore fluid or other gas or liquids. An external source of fluid is not required for any of the embodiments shown in any of the Figures.

[0034] Passive sealing elements, such as first sealing element **10** and second sealing element **18** in FIG. 1, may each have a respective mounting ring **(3, 5)**, throat **(16, 24)** and nose **(14, 22).** As shown in FIG. 4 of US Pat. No. 5,901,964, the throat is the transition portion of the stripper rubber between the nose and the metal mounting ring. The nose is where the stripper rubber stretches to seal against the drill string tubular, and further stretches to pass a larger diameter, such as on tool joints. Returning to FIG. 1, the mounting ring **(3, 5)** is for attaching the sealing element **(10, 18)** to the seal housing **8.** At high differential pressures, the throat, which unlike the nose, does not have support of the tubular, may extrude up towards the inside diameter of the mounting ring. This more likely occurs when tripping out under high pressure. A portion of the throat inside diameter may be abraded off, usually near the mounting ring, leading to excessive wear of the sealing element. For all embodiments it is contemplated that the throat profile may be different for each tubular size to minimize extrusion of the throat towards the mounting ring, and/or to limit the amount of deformation and fatigue before the tubular backs up or supports the throat. For all embodiments it is contemplated that the mounting ring may have an inside diameter sized for pressure containment for each diameter of tubular and any larger outside diameter. The '964 patent proposes a stripper rubber sealing element having enhanced properties for resistance to wear. It is also contemplated that reinforcement and urging members (not shown), fabricated from metal or plastic, could be formed in the sealing element as is known by those skilled in the art.

[0035] For each of the sealing elements **(10, 18),** each of their respective seal support or throat sections **(16, 24)** and sealing or nose sections **(14, 22)** may have a different wear resistance. Their sealing sections **(14, 22)** and profiles **(12, 20)** may also each have a different wear resistance. Since the sealing sections are not compressed against a groove, each of the sealing sections **(14, 22)** has a stretch fit or other urging member(s) to seal the profiles **(12, 20)** with the drill string tubular **DS** or other inserted oilfield component.

[0036] It is contemplated that first sealing element **10** and second sealing element **18,** as well as all sealing elements in any other embodiment shown in any of the Figures, may be made in whole or in part from SULFRON® material, which is available from Teijin Aramid BV of the Netherlands. SULFRON® materials are a modified aramid derived from TWARON® material. SULFRON material limits degradation of rubber properties at high temperatures, and enhances wear resistance with enough lubricity, particularly to the nose, to reduce frictional heat. SULFRON material also is stated to reduce hysteresis, heat build-up and abrasion, while improving flexibility, tear and fatigue properties. It is contemplated that the stripper rubber sealing element may have para aramid fibers and dust. It is contemplated that longer fibers may be used in the throat of the stripper rubber sealing element to add tensile strength, and that SULFRON material may be used in whole or in part in the nose of the stripper rubber sealing element to add lubricity.

[0037] The '964 patent proposes a stripper rubber with fibers of TWARON® material of 1 to 3 millimeters in length and about 2% by weight to provide wear enhancement in the nose. It is contemplated that the stripper rubber may include 5% by weight of TWARON to provide stabilization of elongation, increase tensile strength properties and resist deformation at elevated temperatures. Para amid filaments may be in a pre-form, with orientation in the throat for tensile strength, and orientation in the nose for wear resistance. TWARON and SULFRON are both registered trademarks of Teijin Aramid BV of the Netherlands.

[0038] It is further contemplated that material properties may be selected to enhance the grip of the sealing element. A softer elastomer of increased modulus of elasticity may be used, typically of a lower durometer value. An elastomer with an additive may be used, such as aluminum oxide or pre-vulcanized particulate dispersed in the nose during manufacture. An elastomer with a tackifier additive may be used. This enhanced grip of the sealing element would be beneficial when one of multiple sealing elements is dedicated for rotating with the tubular.

[0039] It is also contemplated that the sealing elements of all embodiments may be made from an elastomeric material made from polyurethane, HNBR (Nitrile), Butyl, or natural materials. Hydrogenated nitrile butadiene rubber (HNBR) provides physical strength and retention of properties after long-term exposure to heat, oil and chemicals. It is contemplated that polyurethane and HNBR (Nitrile) may preferably be used in oil-based drilling fluid environments 160°F (71°C) and 250°F (121°C), and Butyl may preferably be used in geothermal environments to 250°F (121°C). Natural materials may preferably be used in water-based drilling fluid environments to 225°F (107°C).

[0040] It is contemplated that one of the stripper rubber sealing elements may be designed such that its primary purpose is not for sealability, but for assuring that the inner member of the RCD rotates with the tubular, such as a drill string. This sealing element may have rollers, convexes, or replacement inserts that are highly wear resistant and that press tightly against the tubular, transferring rotational torque to the inner member. It is contemplated that all sealing elements for all embodiments in all the Figures may comply with the API-16RCD specification requirements.

[0041] It is contemplated that the pressure between sealing elements **(10, 18)** may be controllable. The concept of controlling pressure between sealing elements as disclosed in this application is proposed in U.S. Patent Application Serial No. 12/462,266 filed on July 31, 2009 (projected to be published on February 3, 2011). U.S. Serial No. 12/462,266 is owned by the assignee of the present invention. The cavity between the sealing elements **(10, 18)** may be pressurized with cuttings-free drilling fluid, water, mud, coolant, lubricant or inert gas for the purpose of decreasing the differential pressure across the lower sealing element **10** and/or flushing its sealing surface **13** for the purpose of reducing wear and extending seal element life. The cuttings-free fluid may be supplied at a pressure higher than the pressure below the lower sealing element **10,** such as 120 psi higher, so as to allow the cuttings free fluid to lubricate between the drill string **DS** and the sealing surface **13.** Similarly, it is contemplated that the pressure between all sealing elements shown for all embodiments in all of the Figures may be controllable. All cavities between the sealing elements for all embodiments shown in all of the Figures may be pressurized with cuttings-free drilling fluid, mud, water, coolant, lubricant or inert gas for the purpose of decreasing the differential pressure across the lower sealing element and/or flushing its sealing surface for the purpose of reducing wear. The cavity fluid may also include lubricant from the bearings, coolant from a cooling system, or hydraulic fluid used to activate an active sealing element.

[0042] Sensors can be positioned to detect the wellbore annulus fluid pressure and temperature and the cavity fluid pressure and temperature and at other desired locations. The pressures and temperatures may be compared, and the cavity fluid pressure and temperature applied in the cavity may be adjusted. The pressure differential to which one or more of the sealing elements is exposed may be reduced. The cavity fluid may be circulated, which may be beneficial for lubricating and cooling or may be bullheaded. The stationary seal adapter housing and/or RCD may have more than two sealing elements. Pressurized cavity fluids may be communicated to each of the internal cavities located between the sealing elements. Sensors can be positioned to detect the wellbore annulus fluid pressure and temperature and the cavity fluid pressures and temperatures. Again, the pressures and temperatures may be compared, and the cavity fluid pressures and temperatures in all of the internal cavities may be adjusted.

[0043] Turning to FIG. 2, latch housing **36** and diverter housing **34** are disposed between marine riser lower tubular section **32** and marine riser upper tubular section **38.** Latch housing **36** may be a latch housing such as proposed in FIG. 2 of US Pat. No. 7,487,837, although other housings are contemplated. On the right side of the vertical break line **BL,** seal housing **40** is latched with latch housing **36** within the marine riser. Seal housing **40** is an adapter or seal adapter housing that is stationary and does not allow rotation of the sealing elements **(42, 52).** On the left side of the vertical break line **BL,** seal housing or RCD **49** has a stationary outer member **43** and a rotatable inner member **41** with bearings **45** therebetween. Seal housing or RCD **49** allows rotation of the sealing elements **(42, 52).** Outer member **43** of seal housing or RCD **49** is latched with latch housing **36.** As can now be understood, a seal housing that is an RCD or a stationary seal adapter housing may be used with FIG. 2.

[0044] Continuing with FIG. 2, first seal or first sealing element **42** is disposed with seal housing **(40, 49)** with its first seal supporting or throat section **44.** First sealing element **42** has a first seal lubricating seal profile **46** on the inwardly facing sealing surface **47** of its nose section or sealing section **48,** which is sealed with drill string tubular **DS.** Second seal or second sealing element, generally indicated as **52,** is a dual seal with two spaced apart annular sealing surfaces **(57, 63).** Dual seal **52** is a unitary bi-directional sealing element and is disposed with seal housing **(40, 49)** with its second seal supporting or throat sections **(54A, 54B).** Dual seal **52** may be formed or molded as a monolithic seal. Second seal **52** has a first nose section **56A** and a second nose section **56B.** Second seal **52** has a second seal first lubricating seal profile **58** on the inwardly facing first sealing surface **57** of its first nose sealing section **56A,** which is sealed with drill string tubular **DS.** Second seal **52** has a second seal second lubricating seal profile **64** on the inwardly facing second sealing surface **63** of its second nose sealing section **56B,** which is also sealed with drill string tubular **DS.** As can now be understood, second seal **52** has two annular sealing sections **(56A, 56B)** and sealing surfaces **(57, 63)** that are spaced apart with a nonsealing surface therebetween. It is also contemplated that second seal **52** may be formed without any lubricating seal profiles **(58, 64),** or that only one of its nose sections **(56A, 56B)** may have a lubricating seal profile. Although two sealing elements **(42, 52)** are shown in FIG. 2, any number of sealing elements are contemplated, including only one sealing element. It is contemplated that the pressure between seals **(42, 52)** may be controllable.

[0045] First seal lubricating profile **46** and second seal first and second lubricating profiles **(58, 64)** may be the same or they may be different. The application of the lubricating seal profiles

(46, 58, 64) shown in FIG. 2 are consistent with either a wave pattern or wavy edge lubricating seal profile, as shown in FIGS. 13B-13C for the nose section, or a saw-tooth pattern high film lubricating seal profile, similar to that shown in FIGS. 6-6B. However, any of the lubricating seal profiles shown in any of the Figures may be used with the sealing elements **(42, 52)** in FIG. 2, or with any of the sealing elements shown in any of the other Figures, to achieve the desired lubrication for the sealing element application. The location and orientation of the first seal lubricating seal profile **46** and the second seal first lubricating seal profile **58** in FIG. 2 are selected for intended fluid flow up the annular space **68** between the drill string tubular **DS** and the marine riser lower tubular section **32,** or the diverter housing **34.** Like the FIGS. 13B-13C nose sections, first seal lubricating profile **46** and second seal first lubricating profile **58** are positioned on the respective inwardly facing bore sealing surfaces **(47, 57)** of respective first seal nose section **48** and second seal first nose section **56A.** Fluid flowing up the annulus **68** may communicate and lubricate between the respective sealing sections **(48, 56A)** or surfaces **(47, 57)** and the drill string tubular **DS** during rotation and/or to a lesser degree vertical sliding movement of drill string tubular **DS.** As will be discussed below in detail, the lubricating seal profiles shown in FIGS. 5-5C, 6-6B, and 11A are located and oriented for applications for fluid flowing downward.

[0046] Under normal operations of seal housing or RCD **49,** sealing elements **(42, 52)** rotate with the sealed drill string tubular **DS.** Therefore, fluid would not communicate between the seal elements **(42, 52)** and the drill string tubular **DS** because of lack of relative rotation between the seal elements **(42, 52)** and the tubular **DS.** However, any of the profiles on the seal elements disclosed herein may be configured such that fluid may communicate between the seal elements and tubular **DS** from any vertical movement of tubular **DS** relative to the seal elements. If the RCD **49** does not allow adequate rotation of the sealing elements **(42, 52),** such as when the RCD bearings **45** become damaged or require lubrication, there may be relative rotational movement between the sealed drill string tubular **DS** and the sealing elements **(42, 52).** In such situations, when the pressurized fluid bypasses or flows up the annular space **68** in FIG. 2 while drill string tubular **DS** is rotating and/or moving vertically or longitudinally, the fluid first encounters first seal profile passageway **50.** As the drill string tubular **DS** moves and/or rotates relative to the seal elements **(42, 52),** the pressurized fluid in annulus **68** communicates between first seal sealing surface **47** and drill string tubular **DS,** lubricating first seal **42.**

[0047] The fluid may then bypasses upwards through annulus **68A,** encountering second seal first profile passageway **60.** Again, as the drill string tubular **DS** moves and/or rotates relative to the sealing elements **(42, 52),** the pressurized fluid communicates between second seal first sealing surface **57** and drill string tubular **DS,** lubricating second seal **52.** The same fluid communication between the sealing elements **(42, 52)** and the drill string tubular **DS** occurs when seal housing **40** is not an RCD and does not allow rotation of the seal elements **(42, 52)** with the tubular **DS.** Also, like an RCD, vertical movement provides limited lubrication. The fluid may be the same fluid used for drilling, such as water, drilling fluid or mud, well bore fluid or other gas or liquids.

[0048] Second seal second profile **64** is positioned and orientated for intended fluid flow downward from the annular space **70** between drill string tubular **DS** and marine riser upper tubular section **38.** In such situations, when the fluid moves down the annular space **70** while drill string tubular **DS** is rotating and/or moving vertically relative to second seal **52,** the fluid first encounters second seal second profile passageway **66.** As the drill string tubular **DS** moves and/or rotates relative to the seal elements **(42, 52),** the pressurized fluid in annulus **70** communicates between second seal second sealing surface **63** and drill string tubular **DS,** lubricating second seal **52.** It is contemplated that second seal second profile **64** may be alternatively positioned for intended fluid flow from below, like first seal profile **46** and second seal first profile **58.** For such alternative lubricating profile position, the second seal second profile would be similar to that shown in FIGS. 5-5C, 6-6B, and 11A, except with the seals positioned axially upwardly rather than axially downwardly as they are shown in FIGS. 5-5C, 6-6B, and 11A.

[0049] Each of the sealing elements **(42, 52)** respective seal support or throat sections **(44, 54A, 54B)** and sealing or nose sections **(48, 56A, 56B)** may have different wear resistances. Their sealing sections **(48, 56A, 56B)** and profiles **(46, 58, 64)** may each have different wear resistances. Each of the sealing elements **(42, 52)** sealing sections **(48, 56A, 56B)** may provide a stretch fit to seal the profiles **(46, 58, 64)** with the drill string tubular **DS** or other oilfield component. The lubricating seal profiles may be used in different orientations and/or locations with any of the sealing elements **(42, 52)** in FIG. 2 or any other Figure. It is also contemplated that no lubricating seal profiles may be used with any of the sealing elements shown in any of the Figures, including with dual sealing element or dual seal **52** in FIG. 2 and the dual seals shown in FIGS. 11 to 13G.

[0050] In FIG. 3, latch housing **76** is disposed with a subsea diverter housing **74,** which is disposed with subsea lower tubular section **72.** Lower tubular section **72** may be a wellhead section, although other tubular sections are contemplated. Subsea upper tubular section **78** is positioned with latch housing **76.** Latch housing **76** may be a latch housing such as proposed in FIG. 2 of US Pat. No. 7,487,837, although other housings are contemplated. Seal housing **80** is latched with latch housing **76.** As can now be understood, there is no marine riser used in the embodiment of FIG. 3. First seal or first sealing element **82** is disposed with seal housing **80** with its first seal supporting or throat section **84.** First sealing element **82** has a first seal lubricating seal profile **88** on the inwardly facing sealing surface **89** of its nose section or sealing section **86,** which is sealed with drill string tubular **DS.**

[0051] Second seal or second sealing element **94** is disposed with seal housing **80** with its second seal supporting or throat section **96.** Second seal **94** has a second seal lubricating seal profile **100** on the inwardly facing sealing surface **101** of its nose section or sealing section **98,** which is sealed with drill string tubular **DS.** Although two sealing elements **(82, 94)** are shown, any number of sealing elements are contemplated, including only one sealing element. Seal housing **80** is an adapter or seal adapter housing that keeps sealing elements **(82, 94)** stationary so as not to allow rotation as drill string tubular **DS** rotates and moves vertically, such as during drilling. However, it is also contemplated that seal housing **80** may be an RCD, such as seal housing **49** shown on the left side of the break line **BL** in FIG. 2, that allows sealing elements **(82, 94)** to rotate with the sealed drill string tubular **DS.**

[0052] First seal lubricating profile **88** and second seal lubricating profile **100** may be the same or they may be different. The lubricating seal profiles **(88, 100)** shown in FIG. 3 are consistent with either a wave pattern or wavy edge lubricating seal profile, such as shown in FIGS. 13B-13C for the nose section, and similar to that shown in FIGS. 5-5C and 11A, or a saw-tooth pattern high film lubricating seal profile, similar to that shown in FIGS. 6-6B. However, any of the lubricating seal profiles shown in any of the Figures may be used with the sealing elements **(82, 94)** in FIG. 3, or with any of the sealing elements shown in any of the other Figures.

[0053] First seal profile **88** is positioned and oriented with the intention of fluid flowing up the annular space **92** between the drill string tubular **DS** and the lower tubular section **72** or the diverter housing **74.** Like in FIGS. 13B-13C, first seal lubricating profile **88** is positioned on the inwardly facing bore sealing surface **89** of first seal nose section **86** so that the fluid flowing up the annular space **92** may communicate and lubricate between the first seal sealing section **86** or surface **89** and the drill string tubular **DS** during rotation and/or vertical movement of the drill string tubular **DS.**

[0054] When the pressurized fluid flows up the annular space **92** in FIG. 3 while drill string tubular **DS** is rotating and/or moving vertically, the fluid encounters first seal profile passageway **90.** As the drill string tubular **DS** moves and/or rotates relative to the sealing elements **(82, 94),** the pressurized fluid in annulus **92** communicates between first sealing surface **89** and drill string tubular **DS,** lubricating first seal **82.** Second seal profile **100** is positioned and oriented for intended fluid flow downward from the annular space **104** between drill string tubular **DS** and upper tubular section **78.** Fluid moving downward in annular space **104** will encounter second seal passageway **102.** As the drill string tubular **DS** moves and/or rotates relative to the sealing elements **(82, 94),** the pressurized fluid in annulus **104** communicates between second sealing surface **101** and drill string tubular **DS,** lubricating second seal **94.**

[0055] It is contemplated that second seal profile **100** may be alternatively positioned for intended fluid flow from below, like first seal profile **88.** For such alternative lubricating profile position, the second seal profile would be similar to that shown in FIGS. 5-5C, 6-6B, and 11A except with the sealing elements positioned axially upwardly in FIG. 3 rather than axially downwardly as shown in FIGS. 5-5C, 6-6B and 11A. It is contemplated that first seal **82** may be alternatively positioned for intended downward fluid flow, in which case it would appear similar to FIGS. 5-5C, 6-6B and 11A.

[0056] If seal housing **80** is an RCD, during normal operations the sealing elements **(82, 94)** rotate with the sealed drill string tubular **DS.** Therefore, fluid would not communicate between the seal elements **(82, 94)** and the drill string tubular **DS** because of lack of relative rotation between the seal elements **(82, 94)** and the tubular **DS;** however, to a lesser degree, fluid would communicate between the seal elements **(82, 94)** and tubular **DS** from any vertical movement of tubular **DS** relative to the vertically fixed seal elements **(82, 94).** If the RCD slows or stops rotating, such as from bearing failure or lack of bearing lubrication or some other problem, the drill string tubular **DS** may rotate relative to the sealing elements **(82, 94).** In such a situation, the sealing elements **(82, 94)** may allow lubrication from the fluid as described above for a stationary seal housing **80,** thereby advantageously minimizing or reducing damage to the seal elements **(82, 94).**

[0057] For each sealing element **(82, 94),** their respective seal support or throat sections **(84, 96)** and sealing or nose sections **(86, 98)** may have different wear resistances. Their sealing sections **(86, 98)** and profiles **(88, 100)** may have different wear resistances. The respective sealing sections **(86, 98)** of the sealing elements **(82, 94)** may provide a stretch fit to seal the profiles **(88, 100)** with the drill string tubular **DS** or other oilfield component.

[0058] Turning to FIG. 4, arm **106** of ram-type BOP, generally indicated as **112,** is extended with its sealing element **108** in sealing contact with drill string tubular **DS.** Sealing element **108** has a lubricating seal profile on its sealing surface **110.** The lubricating seal profile may be any of the lubricating seal profiles shown in any of the Figures. As the drill string tubular **DS** moves vertically and/or rotates relative to the seal element **108,** the fluid in the passageway surrounding drill string tubular **DS** communicates between sealing surface **110** and drill string tubular **DS,** lubricating seal element **108.** Although not shown, it is also contemplated that any of the lubricating seal profiles shown in any of the Figures may be similarly positioned with a non-rotating annular BOP seal, such as proposed in U.S. Patent No. 4,626,135, for fluid communication between the sealing element and the drill string tubular when the sealing element is sealed upon the drill string tubular and the drill string tubular moves vertically and/or rotates relative to the sealing element.

[0059] In FIGS. 5-5A, sealing element **114** has a wave pattern or wavy edge lubricating seal profile **118** on the sealing surface **119** of its nose or sealing section **116.** Mounting ring **122** is disposed with seal supporting or throat section **120.** The change in bore diameter between seal bore surface **124** and sealing surface **119** creates profile passageway **126,** as best shown in FIG. 5B, when drill string tubular **DS** is inserted in the seal bore. FIG. 5C shows a similar view as FIG. 5B with the drill string tubular **DS** removed.

[0060] As best shown in FIG. 5B, the lubricating seal profile **118** is positioned and oriented on the inwardly facing surface **119** of nose section **116** for intended fluid flow downwardly in profile passageway **126** surrounding drill string tubular **DS.** As the drill string tubular **DS** moves vertically and/or rotates relative to the sealing element **114,** such as during drilling, the fluid may flow relative to profile passageway **126** and communicate between sealing surface **119** and drill string tubular **DS,** thereby lubricating sealing element **114.** If fluid movement in the upward direction is intended, then sealing element **114** may be positioned axially upward rather than in the axially downward position shown in FIGS. 5 and 5B-5C. Alternatively, if upward fluid movement is intended, then the sealing element **114** may remain oriented axially downwardly as shown in FIGS. 5-5C, and the positions of sealing surface **119** and bore surface **124** may be reversed, such as shown for the seal elements **(10, 18)** in FIG. 1 and in

FIGS. 13B-13C for the nose section, for a wave pattern. In FIG. 5B, the difference in length between sealing surface **119A** shown on the left side of the drill string tubular **DS** as compared with the length of the sealing surface **119B** shown on the right side of the drill string tubular **DS** is a result of the changing wave pattern best shown in FIG. 5A.

[0061] Seal support or throat section **120** and sealing or nose section **116** may have a different wear resistance. Sealing section **116** and profile **118** may have a different wear resistance. Sealing section **116** may provide a stretch fit to seal the profile **118** with the drill string tubular **DS** or other oilfield component.

[0062] Turning to FIGS. 6-6A, seal element, generally indicated at **128,** has a saw tooth pattern high film lubricating seal profile **132** on the sealing surface **133** of its nose or sealing section **130.** The profile **132** has, among other geometries, a plurality of inclined grooves. Mounting ring **138** is disposed with seal supporting or throat section **136.** The change in bore diameter between seal bore surface **134** and sealing surface **133** will create profile passageway **140** as best shown in FIG. 6B when drill string tubular **DS** in inserted in the seal bore. In FIG. 6B, the difference in length between sealing surface **133A** shown on the left side of the drill string tubular **DS** as compared with the length of sealing surface **133B** shown on the right side of the drill string tubular **DS** is a result of the changing saw-tooth pattern best shown in FIG. 6A.

[0063] As best shown in FIG. 6B, the lubricating seal profile **132** is positioned and oriented on the inwardly facing sealing surface **133** of nose section **130** for intended fluid flow downwardly in the profile passageway **140** surrounding drill string tubular **DS.** As the drill string tubular **DS** moves vertically and/or rotates relative to sealing element **128,** such as during drilling, the fluid may move through profile passageway **140** and communicate between sealing surface **133** and drill string tubular **DS,** thereby lubricating sealing element **128.** If fluid movement in the upward direction is intended in the profile passageway **140** surrounding drill string tubular **DS,** then seal element **128** may be positioned axially upward rather than in the axially downward position shown in FIGS. 6 and 6B. Alternatively, if upward fluid movement is intended, then the sealing element **128** may remain oriented axially downwardly as shown in FIGS. 6 and 6B, and the positions of sealing surface **133** and bore surface **134** may be reversed, such as for the seal elements **(10, 18)** in FIG. 1 and in FIGS. 13B-13C for the nose section, for a saw-tooth type pattern.

[0064] The saw-tooth pattern profile **132** provides for high fluid leakage for increased film thickness. Seal support or throat section **136** and sealing or nose section **130** may have a different wear resistance. Sealing section **130** and profile **132** may have a different wear resistance. Sealing section **130** may provide a stretch fit to seal the profile **132** with the drill string tubular **DS** or other oilfield component.

[0065] Turning to FIGS. 7-7A, sealing element, generally indicated **142,** has a downwardly inclined passageway pattern lubricating sealing profile in the sealing surface **144** of its nose or sealing section **148.** Mounting ring **152** is disposed with seal supporting or throat section **150.**

Downwardly inclined passageways **146** are formed in the sealing surface **144** of the sealing section **148.** The downwardly inclined passageways **146** are positioned in the inwardly facing surface **144** of nose section **148** for intended fluid flow downwardly in the passageway **146** surrounding an inserted drill string tubular **DS** (not shown). As the drill string tubular **DS** moves vertically and/or rotates relative to the sealing element **142,** such as during drilling, the fluid may move through passageways **146** and communicate fluid between sealing surface **144** and a drill string tubular **DS,** thereby lubricating sealing element **142.** If fluid movement in the upward direction is intended for passageway **146** surrounding drill string tubular **DS,** then sealing element **142** may be positioned axially upward rather than in the axially downward position shown in FIG. 7.

[0066] Turning to FIGS. 8-8A, sealing element, generally indicated as **158,** has a upwardly inclined passageway pattern lubricating seal profile in the sealing surface **154** of its nose or sealing section **160.** Mounting ring **164** is disposed with seal supporting or throat section **162.** Upwardly inclined passageways **156** are formed in the sealing surface **154** of the sealing section **160.** The upwardly inclined passageways **156** are positioned in the inwardly facing surface **154** of nose section **160** for intended fluid flow upwardly in the passageway **156** surrounding an inserted drill string tubular **DS** (not shown). As the drill string tubular **DS** moves vertically and/or rotates relative to sealing element **158,** such as during drilling, the fluid may move through passageways **156** and communicate fluid between sealing surface **154** and drill string tubular **DS,** thereby lubricating sealing element **158.** If fluid movement in the downward direction is intended in the passageways surrounding drill string tubular **DS,** then sealing element **158** may be positioned axially upward rather than in the axially downward position shown in FIG. 8.

[0067] Turning to FIGS. 9-9A, sealing element, generally indicated as **166,** has a combination upwardly and downwardly inclined passageway pattern lubricating seal profile in the sealing surface **168** of its nose or sealing section **170.** Mounting ring **178** is disposed with seal supporting or throat section **176.** Upwardly inclined passageways **174** are formed in the sealing surface **168** of the sealing section **170.** The upwardly inclined passageways **174** are positioned in the inwardly facing surface **168** of nose section **170** for intended fluid flow upwardly in the passageways **174** surrounding an inserted drill string tubular **DS** (not shown). As the drill string tubular **DS** moves vertically and/or rotates relative to seal element **166,** such as during drilling, the fluid may move through upward inclined passageways **174** and communicate fluid between sealing surface **168** and drill string tubular **DS,** thereby lubricating seal element **166.**

[0068] Downwardly inclined passageways **172** are also formed in the sealing surface **168** of the sealing section **170.** The downwardly inclined passageways **172** are positioned in the inwardly facing surface **168** of nose section **170** for intended fluid flow downwardly in the passageways **172** surrounding an inserted drill string tubular **DS** (not shown). As the drill string tubular **DS** moves vertically and/or rotates relative to seal element **166,** such as during drilling, the fluid may move through downward inclined passageways **172** and communicate fluid between sealing surface **168** and drill string tubular **DS,** thereby lubricating seal element **166.** As can now be understood, the lubricating seal profile shown in FIG. 9 may be used whether fluid flow is intended in the upward or downward direction. It is also contemplated that the seal element **166** may be positioned axially upward position rather than in the axially downward position shown in FIG. 9.

[0069] For each of the sealing elements **(142, 158, 166)** shown in FIGS. 7-9A, their respective seal support or throat sections **(150, 162, 176)** and sealing or nose sections **(148, 160, 170)** may have different wear resistances. Each sealing section **(148, 160, 170)** and lubricating seal profile **(144, 154, 168)** may have a different wear resistance. Each sealing section **(148, 160, 170)** may provide a stretch fit to seal the respective lubricating seal profile **(144, 154, 168)** with the drill string tubular **DS** or other oilfield component.

[0070] Turning to FIGS. 10-10A, sealing element, generally indicated as **180,** has a combination upwardly and downwardly inclined passageway pattern lubricating seal profile or first profile in the first sealing surface **182** of its nose or first sealing section **184.** Upwardly inclined passageways **186** are formed in the first sealing surface **182** of the nose section **184.** The upwardly inclined passageways **186** are positioned in the inwardly facing first sealing surface **182** of nose section **184** for intended fluid flow upwardly in the passageways **186** surrounding an inserted drill string tubular **DS** (shown in FIGS. 10B-10C). As the drill string tubular **DS** moves vertically and/or rotates relative to seal element **180,** such as during drilling, the fluid may move through upward inclined passageways **186** and communicate fluid between first sealing surface **182** and drill string tubular **DS,** thereby lubricating seal element **180.**

[0071] Downwardly inclined passageways **188** are also formed in the first sealing surface **182** of the first sealing section **184.** The downwardly inclined passageways **188** are positioned in the inwardly facing first sealing surface **182** of nose section **184** for intended fluid flow downwardly in the passageways **188** surrounding drill string tubular **DS** (shown in FIGS. 10B-10C). As the drill string tubular **DS** moves vertically and/or rotates relative to sealing element **180,** such as during drilling, the fluid may move through downward inclined passageways **188** and communicate fluid between the first sealing surface **182** and drill string tubular **DS,** thereby lubricating seal element **184.** As can now be understood, the lubricating seal profile shown in first sealing surface **182** in FIG. 10 may be used whether fluid flow is intended for upward or downward direction. It is also contemplated that the sealing element **180** may be positioned axially upward rather than in the axially downward position shown in FIG. 10.

[0072] Sealing element **180** also has a downwardly inclined passageway pattern lubricating seal profile or second profile formed in the inclined inwardly facing second sealing surface **192** that spans both nose section **184** and throat section **194** to create a second sealing section. Downwardly inclined passageways **190** are formed in the second sealing surface **192** for intended fluid flow downwardly in the passageways **190** surrounding drill string tubular **DS** with a larger diameter component, such as tool joint **TJ** best shown in FIG. 10C. In other words, the inwardly facing second sealing surface **192** has a greater bore diameter than the inwardly facing first sealing surface **182.**

[0073] As shown in FIG. 10B, when a drill string tubular **DS** with a first diameter rotates and/or moves vertically relative to sealing element **180,** first sealing surface **182** may seal with drill string tubular **DS.** Fluid may communicate via passageways **(186, 188)** between first sealing surface **182** and the outer surface of drill string tubular **DS** during movement of drill string tubular **DS.** However, as shown in FIG. 10C, when a connected following oilfield component has a second diameter greater than the first diameter of tubular **DS,** such as tool joint **TJ** in drill string tubular **DS,** the component or tool joint **TJ** may be sealed with the inwardly facing second sealing surface **192** and the first sealing surface **182.** Fluid may then additionally communicate via passageways **(186, 188)** between the first sealing surface **182** and the outer surface of drill string tubular component **TJ,** and the second sealing surface **192** and the outer surface of drill string tubular component **TJ** via passageway **190** during movement of drill string tubular **DS.**

[0074] As can now be understood, stripper rubber **180** has a first annular sealing surface **182** having a first sealing diameter and a first profile, and a second annular sealing surface **192** having a second sealing diameter greater than the first sealing diameter and a second profile. Drill string tubular **DS** having a first tubular diameter may be in contact with the first profile **182** (FIG. 10B), and drill string tubular **DS** having a second and larger tubular diameter, such as tool joint **TJ,** may be in contact with both first sealing section **182** and second sealing section **192** (FIG. 10C). Stripper rubber **180** is deformable so that the first annular sealing surface **182** and the second annular sealing surface **192** may deform to an aligned position such as shown in FIG. 10C. FIG. 10B shows first sealing surface **182** and second sealing surface **192** in non-aligned positions.

[0075] FIG. 11 is similar to FIG. 2, except for the sealing elements **(196, 198).** On the right side of the vertical break line **BL,** seal housing **200** is latched with latch housing **36** within the marine riser. Seal housing **200** is an adapter or seal adapter housing that is stationary and does not allow rotation of the sealing elements **(196, 198).** On the left side of the vertical break line **BL,** seal housing or RCD **211** has a stationary outer member **215** and a rotatable inner member **213** with bearings **217** therebetween. Seal housing or RCD **211** allows rotation of the sealing elements **(196, 198).** Outer member **215** of seal housing or RCD **211** is latched with latch housing **36.** As can now be understood, a seal housing that is an RCD or a stationary seal adapter housing may be used with FIG. 11.

[0076] First seal or first sealing element **196** is disposed with seal housing **(200, 211)** with its first seal supporting or throat section **204.** First sealing element **196** has a seal lubricating seal profile **202** on the inwardly facing sealing surface **201** of its first seal nose section or sealing section **206,** which is sealed with drill string tubular **DS.** Seal lubricating seal profile **202** is a wave pattern best shown in FIG. 5B. The seal lubricating seal profile **202** is located on the inwardly facing sealing surface **201** of first seal **196** for intended downward fluid flow.

[0077] Second seal or second sealing element **198** is a dual seal best shown in FIG. 13A, with two spaced apart annular sealing surfaces **(207, 209)** spaced apart by a nonsealing surface **208** that is an alternative embodiment to the dual seal **52** shown in FIG. 2. Sealing element **198** is disposed with seal housing **(200, 211)** with its second seal supporting section or throat

212. Second sealing element **198** does not have a lubricating seal profile shown on the inwardly facing first sealing surface **207** of its second seal nose section or first sealing section **220,** which is sealed with drill string tubular **DS,** nor is a lubricating seal profile shown on the inwardly facing second sealing surface **209** of the throat section **212,** which is also sealed with drill string tubular **DS.** It is contemplated that second seal **198** may or may not form lubricating seal profiles on one or both of its sealing surfaces **(207, 209).**

[0078] As can now be understood, second sealing element **198** is a dual seal with two annular sealing sections **(220, 212)** and sealing surfaces **(207, 209)** that are spaced apart by a nonsealing surface **208.** It is contemplated that second sealing element **198** may be a single unit. It may be formed or molded as a unitary or monolithic unit. Although two sealing elements **(196, 198)** are shown in FIG. 11, any number of sealing elements are contemplated, including only one sealing element. It is contemplated that the pressure between sealing elements **(196, 198)** may be controllable as disclosed above.

[0079] First seal lubricating profile **202** is consistent with either a wave pattern or wavy edge lubricating seal profile, such as shown in FIGS. 5-5C and FIG. 11A, or a saw-tooth pattern high film lubricating seal profile, such as shown in FIGS. 6-6B. However, any of the lubricating seal profiles shown in any of the Figures may be used with the sealing elements **(196, 198)** in FIG. 11, or with any of the seals shown in any of the other Figures.

[0080] The orientation and location of the first seal lubricating seal profile **202** is for fluid flow down the annular space **224** between the drill string tubular **DS** and the marine riser upper tubular section **38.** Like in FIGS. 5-5C and 6-6B, first seal lubricating profile **202** is positioned on the inwardly facing bore sealing surface **201** of first seal nose section **206** so that the fluid moving down the annulus or annular space **224** may communicate fluid to lubricate between the sealing surface **201** and the drill string tubular **DS.**

[0081] Under normal operations of seal housing or RCD **211,** sealing elements **(196, 198)** may rotate with the sealed drill string tubular **DS.** Therefore, fluid would not communicate between the seal elements **(196, 198)** and the drill string tubular **DS** because of lack of relative rotation between the seal elements **(196, 198)** and the tubular **DS.** However, as discussed above, a profile on one and/or the other of the seal elements **(196, 198)** may be configured such that fluid may communicate between the seal elements **(196, 198)** and tubular **DS** from any vertical movement of tubular **DS** relative to the seal elements **(196, 198).** If the RCD does not allow adequate rotation of the sealing elements **(196, 198),** such as when the RCD bearings become damaged or require bearing lubrication, there may be relative movement between the sealed drill string tubular **DS** and the sealing elements **(196, 198).** In such situations, when the pressurized fluid flows down the annular space **224** while drill string tubular **DS** is rotating or moving vertically, and dual seal **198** has lubricating seal profiles (not shown) on its sealing surfaces **(207, 209),** the fluid may communicates between the second seal second sealing surfaces **(207, 209)** and drill string tubular **DS,** lubricating dual seal **198.**

[0082] The fluid may then move downwards, encountering first seal profile passageways **214.**

As the drill string tubular **DS** moves and/or rotates relative to the first sealing element **196,** the pressurized fluid communicates fluid between first seal first sealing surface **201** and drill string tubular **DS,** lubricating first sealing element **196.**

[0083] The same fluid communication between the sealing elements **(196, 198)** and the drill string tubular **DS** occurs when dual seal **198** has lubricating seal profiles (not shown) and seal stationary adapter housing **200** does not allow rotation of the sealing elements **(196, 198).** The fluid may be the same fluid used for drilling, such as water, drilling fluid or mud, well bore fluid or gas or other liquids. Although the first seal lubricating seal profile **202** is intended for downward fluid flow, it is also contemplated that that any of the lubricating seal profiles disclosed may be selected for upward fluid flow.

[0084] FIGS. 12-12A show a dual seal, generally indicated as **226,** with two annular sealing surfaces **(228, 230)** spaced apart by a nonsealing surface **229** that may be used with any seal housing, including an RCD, shown in or discussed with any of the Figures. It is contemplated that any lubricating seal profile shown in any of the Figures may be used with either or both of the sealing surfaces **(228, 230)** of dual seal **226.** The two spaced apart annular sealing surfaces **(228, 230)** may seal with a drill string tubular **DS** or other oilfield component (not shown). Seal first profile is a combination upwardly and downwardly inclined passageway pattern, with downwardly inclining passageways **240** and upwardly inclining passageways **242** disposed in the inwardly facing first sealing surface **228** of the nose section or first sealing section **232.**

[0085] Seal second profile is a downwardly inclined passageway pattern, with downwardly inclining passageways **244** formed in the inwardly facing second sealing surface **230** of throat or support section **234.** An annular closed curved or radius hydraulic force surface **238** is formed in the top of the throat section **234.** The annular hydraulic force surface **238** allows fluid flowing downward to apply a force and either move, deform or compress second sealing surface **230** against the sealed drill string tubular **DS** (not shown). The hydraulic force surface **238** also allows fluid flowing downward to move, deform or compress seal **226** downward, adding to the sealing force of second sealing surface **230** against the sealed drill string tubular **DS.** It is contemplated that the hydraulic force surfaces may be a continuing annular surface, although spaced apart or equidistant segmented hydraulic force surfaces could also be used for any of the embodiments disclosed herein. The fluid to apply a force may be the fluid used for drilling, such as water, drilling fluid or mud, well bore fluid or gas or other liquids.

[0086] For the sealing elements **(180, 196, 198, 226)** in FIGS. 10-12A, each of their respective seal support or throat sections **(194, 204, 212, 234)** and sealing or nose sections **(184, 206, 220, 232)** may have a different wear resistance. Their sealing sections **(184, 206, 220, 232)** and lubricating seal profiles may have a different wear resistance. Each sealing element **(180, 196, 198, 226)** may have a sealing section **(184, 206, 220, 232)** that may provide a stretch fit to seal the lubricating seal profile with the drill string tubular **DS** or other oilfield component.

[0087] Turning to FIG. 13A, dual seal, generally indicated at **198,** with two annular sealing surfaces **(207, 209)** spaced apart by a nonsealing surface **208** may be used with any seal housing, including an RCD, shown in or discussed with any of the Figures. Dual seal **198** is shown positioned with seal housings **(200, 211)** in FIG. 11. Returning to FIG. 13A, although no lubricating seal profiles are shown, it is contemplated that any lubricating seal profile shown in any of the Figures may be used with either or both of the sealing surfaces **(207, 209)** of seal element **198.** The two spaced apart annular sealing surfaces **(207, 209)** may seal with drill string tubular **DS** or other oilfield component (not shown). When a fluid force is applied to upwardly facing annular flat hydraulic force surface **212A** formed in dual seal **198,** inwardly facing annular sealing surface **209** moves, deforms or compresses to provide an inwardly sealing force to surface **209** against tubular **DS** or other oilfield component. Although not shown, it is also contemplated that other hydraulic force surfaces may be disposed with the top of the throat section **212,** such as shown in FIGS. 12, 13B, and 13D-13G. Any of the hydraulic force surfaces shown in any of the Figures may be used with any sealing element shown in any of the Figures.

[0088] In FIG. 13B, dual seal, generally indicated at **250,** has two annular sealing surfaces **(252, 260)** spaced apart by nonsealing surface **255.** First inwardly facing sealing surface **252** of nose sealing section **256** has a lubricating seal profile **254.** As best shown in FIG. 13C, lubricating seal profile **254** is a wave pattern or wavy edge pattern. The profile **254** is positioned and oriented with nose sealing section **256** intended for upward fluid flow. Seals **(10, 18)** in FIG. 1 have similar nose sections as the nose section **256** of seal **250** in FIG. 13B. Seal supporting or throat section **258** has a second inwardly facing sealing surface **260.**

[0089] An annular open inclined or angled hydraulic force surface **262** is formed in the top of the throat section **258.** The annular hydraulic force surface **262** allows fluid flowing downward to apply a force to either move, deform or compress second sealing surface **260** against the sealed drill string tubular **DS** (not shown). The annular hydraulic force surface **262** also allows fluid flowing downward to move, deform or compress seal **250** downward, adding to the sealing capacity of second sealing surface **260** against the sealed drill string tubular **DS.** It is contemplated that spaced apart or segmented hydraulic forces surfaces may be used with any of the dual seals shown in any of the Figures 11 to 13G. It is contemplated that nose sealing section **256** may not be formed with a lubricating seal profile **254.** It is also contemplated that nose sealing section **256** may have a different lubricating seal profile. It is also contemplated that second sealing surface **260** may have a lubricating seal profile.

[0090] In FIG. 13D, dual seal, generally indicated at **262,** has two annular sealing surfaces spaced apart by a non-sealing surface **267,** although only the second sealing surface **266** is shown for clarity. Dual seal **262** may have a nose section like any other seal shown in any of the other Figures. Seal supporting or throat section **264** has a second inwardly facing sealing surface **266.** An annular open curved or radius hydraulic force surface **268** is formed in the top of the throat section **264.** The annular hydraulic force surface **268** allows fluid flowing downward to apply a force and either move, deform or compress second sealing surface **266** against the sealed drill string tubular **DS** (not shown). The annular hydraulic force surface **268** also allows fluid flowing downward to move, deform or compress seal **262** downward, adding to the sealing capacity of second sealing surface **266** against the sealed drill string tubular **DS.** It is contemplated that a similar hydraulic force surface may be used with any of the dual seals shown in any of the Figures 11 to 13G. It is also contemplated that second sealing surface **266** may have a lubricating seal profile.

[0091] Turning to FIG. 13E, dual seal, generally indicated at **270,** has two annular sealing surfaces spaced apart by a non-sealing surface **273,** although only the second sealing surface **274** is shown for clarity. Dual seal **270** may have a nose section like any other seal shown in any of the other Figures. Seal supporting or throat section **272** has a second inwardly facing sealing surface **274.** A combination annular open inclined hydraulic force surface **276** with a substantially horizontal or flat hydraulic force surface **278** is formed in the top of the throat section **272.** The annular hydraulic force surface **(276, 278)** allows fluid moving downward to apply a force to either move, deform or compress second sealing surface **274** against the sealed drill string tubular **DS** (not shown). The annular hydraulic force surface **(276, 278)** also allows fluid flowing downward to move, deform or compress seal **270** downward, adding to the sealing capacity of second sealing surface **274** against the sealed drill string tubular **DS.** It is contemplated that a similar hydraulic force surface may be used with any of the dual seals shown in any of the Figures 11 to 13G. It is also contemplated that second sealing surface **274** may have a lubricating seal profile.

[0092] In FIG. 13F, dual seal, generally indicated at **280,** has two annular sealing surfaces spaced apart by a non-sealing surface **283,** although only the second sealing surface **284** is shown for clarity. Dual seal **280** may have a nose section like any other seal shown in any of the other Figures. Seal supporting or throat section **282** has a second inwardly facing sealing surface **284.** A combination annular open curved or radius hydraulic force surface **286** with a substantially horizontal or flat hydraulic force surface **288** is formed in the top of the throat section **282.** The annular hydraulic force surface **(286, 288)** allows fluid flowing downward to apply a force to either move, deform or compress second sealing surface **284** against the sealed drill string tubular **DS** (not shown). The annular hydraulic force surface **(286, 288)** also allows fluid flowing downward to move, deform or compress seal **280** downward, adding to the sealing capacity of second sealing surface **284** against the sealed drill string tubular **DS.** It is contemplated that a similar hydraulic force surface may be used with any of the dual seals shown in any of the Figures 11 to 13G. It is also contemplated that second sealing surface **284** may have a lubricating seal profile.

[0093] In FIG. 13G, dual seal, generally indicated at **290,** has two annular sealing surfaces spaced apart by a non-sealing surface **297,** although only the second sealing surface **294** is shown for clarity. Dual seal **290** may have a nose section like any other seal shown in any of the other Figures. Seal supporting or throat section **292** has a second inwardly facing sealing surface **294.** A combination annular first or upper closed curved hydraulic force surface **296** with an annular second or lower closed curved hydraulic force surface **298** are formed with the second sealing surface **294** therebetween. The annular hydraulic force surfaces **(296, 298)** allows fluid flow downward to apply a force to either move, deform or compress second sealing surface **294** against the sealed drill string tubular **DS** (not shown). The annular hydraulic force surfaces **(296, 298)** also allows fluid to move, deform or compress seal **290** by squeezing downward and upward, adding to the sealing capacity of second sealing surface **294** against the sealed drill string tubular **DS.** It is contemplated that similar hydraulic force surfaces may be used with any of the dual seals shown in any of the Figures 11 to 13. It is also contemplated that second sealing surface **294** may have a lubricating seal profile. Other configurations of hydraulic sealing surfaces are contemplated for all seal elements.

[0094] Although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only and that the claims are not limited to those embodiments. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. Each feature disclosed or illustrated in the present specification may be incorporated in the invention, whether alone or in any appropriate combination with any other feature disclosed or illustrated herein.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US5901964A [0002] [0034]
- US5213158A [0002]
- US5647444A [0002]
- US5662181A [0002]
- US4500094A [0003]
- US6547002B [0003]
- US20070163784A [0003]
- US7448454B [0003]
- US6230824B [0003]
- US6016880A [0004]
- US7258171B [0004] [0008] [0008]
- US20050241833A [0004]
- US6375895B [0005]
- US4626135A [0008] [0011] [0058]
- US6913092B [0008]
- US7237623B [0008]

- US6470975B [0008]
- US7159669B [0008]
- US6138774A [0008]
- US7487837B [0009] [0029] [0043] [0050]
- US20060144622A [0009]
- US20080210471A [0009]
- US20090139724A [0009]
- US5735502A [0011]
- US4488703A [0011]
- US4508313A [0011]
- US4519577A [0011]
- US2038140A [0012]
- US2124015A [0012]
- US2148844A [0012]
- US2163813A [0012]
- US2287205A [0012]
- US2170915A [0012]
- US4610319A [0016]
- US5230520A [0016]
- US5678829A [0016]
- US5738358A [0016]
- US5873576A [0016]
- US6007105A [0016]
- US6036192A [0016]
- US6109618A [0016]
- US6120036A [0016]
- US6227547B [0016]
- US6315302B [0016]
- US6334619B [0016]
- US6382634B [0016]
- US6494462B [0016]
- US6561520B [0016]
- US6685194B [0016]
- WO2008133523A [0017]
- US3472518A [0017]
- CA2685021A1 [0018]
- US20060377782A [0018]
- US2611146A [0019]
- US2001020770A1 [0019]
- WO2011128690A1 [0019]
- US46226609A [0041]
- US12462266B [0041]

Non-patent literature cited in the description

- Specification for Drill Through Equipment - Rotating Control DevicesAmerican Petroleum Institute20050200 [0007]

OLIEFELTUDSTYR OG TILHØRENDE APPARAT OG FREMGANGSMÅDE

PATENTKRAV

1. Tætningselement (10), der er udformet til at blive placeret i et hus (4) til tætning af en oliefeltkomponent (DS), hvilket tætningselement har en boring til modtagelse af oliefeltkomponenten, hvilket tætningselementet omfatter:

en tætningsbærende sektion (16);

en tætningssektion (14) og

en monteringsring (3), der er placeret med den tætningsbærende sektion;

hvor én af sektionerne har en indadvendende boringsoverflade (13);

kendetegnet ved, at en profil (12) er dannet på sektionen med den indadvendende boringsoverflade til at tætne oliefeltkomponenten, mens et borefluid forbindes mellem tætningssektionen og oliefeltkomponenten, hvor borefluidet strømmer fra et ringformet rum (26) mellem huset (4) og oliefeltkomponenten (DS), hvor det ringformede rum er over eller under tætningselementet (10).

2. Tætningselement ifølge krav 1, hvor oliefeltkomponenten omfatter et oliefeltrør (DS) til at forbinde et slam under tryk under boring med slammet under tryk, hvor profilen er udformet til at tætne af oliefeltrøret, når slammet under tryk indvirker på tætningselementet.

3. Tætningselement ifølge krav 1 eller 2, hvor fluidet er vand, boreslam eller brøndboringsfluid.

4. Tætningselement ifølge krav 3, hvor fluidet er indrettet til at blive forbundet ved hjælp af profilen (12), der er placeret i tætningssektionen (14).

5. Tætningselement ifølge krav 1 eller 2, hvor den tætningsbærende sektion (16) og tætningssektionen (14) har en forskellig slidstyrke, og/eller

hvor tætningssektionen (14) og profilen (12) har en forskellig slidstyrke.

6. Tætningselement ifølge krav 1 eller 2, hvor tætningssektionen (14) sikrer en elastisk tilpasning til tætning af profilen (12) med oliefeltkomponenten.

7. Tætningselement ifølge krav 1 eller 2, hvor tætningen er anbragt i en sikkerhedsventil (112) for at tætne oliefeltkomponenten.

8. Tætningselement ifølge krav 1 eller 2, der endvidere omfatter en anden tætningssektion (22) med en indadvendende boringsoverflade (21), hvor den første tætningsoverflade og den anden tætningsoverflade er adskilt af en ikke-tætnende overflade.

9. Tætningselement ifølge krav 1 eller 2, hvor tætningselementet omfatter en gummipakning til tætning af oliefeltkomponenten, hvor:

den tætningsbærende sektion (16) danner en halssektion; og

tætningssektionen (14) danner en næsesektion.

10. Tætningselement ifølge krav 9, hvor oliefeltkomponenten har en første diameter og en anden diameter, der er større end den første diameter, hvor tætningselementet omfatter:

en første ringformet tætningsoverflade (182) med en første diameter og en første profil (186, 188);

en anden ringformet tætningsoverflade (192) med en anden diameter, der er større end den første overfladediameter og en anden profil (190);

hvor oliefeltkomponentens første diameter er indrettet til at være i kontakt med den første ringformede tætningsoverfladeprofil (186, 188) og adskilt fra den anden ringformede tætningsoverfladeprofil (190), og

hvor oliefeltkomponentens anden diameter er indrettet til at være i kontakt med den første ringformede tætningsoverfladeprofil (186, 188) og den anden ringformede tætningsoverflade (192).

11. Tætningselement ifølge krav 9, der omfatter:

et første ringformet tætningsoverflade (182) med en første diameter og en første profil (186, 188); og

et andet ringformet tætningsoverflade (192) med en anden diameter, der er større end den første overfladediameter og en anden profil (190);

hvor tætningselementet kan deformeres, således at den anden ringformede tætningsoverflade (192) deformeres til en i alt væsentligt flugtende position med den første ringformede tætningsoverflade (182).

12. Tætningselement ifølge krav 11, hvor oliefeltkomponenten er indrettet til at kunne bevæges i forhold til tætningselementet for at deformere tætningselementet til den flugtende position, hvor den første profil og den anden profil er indrettet til at forbinde fluidet mellem tætningselementet og oliefeltkomponenten.

13. Tætningselement ifølge krav 1, 2 eller 9, hvor profilen omfatter et bølgemønster (118) eller

et savtaktsmønster (132), der kan være til øget fluidfilmtykkelse, eller

en flerhed af hældende riller (186, 188, 190).

14. Tætningselement ifølge krav 9, hvor tætningselementet har to adskilte ringformede tætningsoverflader (207, 209).

15. Tætningselement ifølge krav 14, der endvidere omfatter en flerhed af næsesektioner og halssektioner på en enkelt gummipakning, hvor den enkelte gummipakning omfatter modstående gummipakningsnæsesektioner for at tilvejebringe en tovejstætning (52).

16. Tætningselement ifølge krav 14, der endvidere omfatter en hydraulisk kraftoverflade (238), der er dannet på tætningselementet, hvor den enkelte gummipakning har en profil på næsesektionen til at tilvejebringe en første ringformet tætningsoverflade og den hydrauliske kraftoverflade dannet på tætningselementet for at tvinge tætningselementet indefter for at tilvejebringe en anden ringformet tætningsoverflade.

17. Tætningselement ifølge krav 16, hvor den hydrauliske kraftoverflade (238) er i halssektionen (234).

18. Tætningsenhed, der omfatter et tætningselement ifølge krav 9, eller ifølge et hvilket som helst af kravene 10 til 17, når det direkte eller indirekte afhænger af krav 9, hvor tætningsenheden endvidere omfatter en anden gummipakning til tætning af oliefeltkomponenten, hvor den anden gummipakning har en boring til modtagelse af oliefeltkomponenten, hvor trykket mellem gummipakningerne kan styres.

19. Fremgangsmåde til smøring mellem et tætningselement (10) og en oliefeltkomponent (DS), hvilken fremgangsmåde omfatter:

positionering af tætningselementet med en profil (12) i et hus (4), hvor tætningselementet har en tætningsbærende sektion (16), en tætningssektion (14) og en monteringsring (3), der er placeret med den tætningsbærende sektion, hvilken profil er i forbindelse med et borefluid;

tætning af oliefeltkomponenten med tætningsprofilen;

bevægelse af oliefeltkomponenten i forhold til tætningselementet; og

at forbinde borefluidet mellem tætningselementet og oliefeltkomponenten under trinnet med bevægelse af tætningselementet i forhold til oliefeltkomponenten, hvor borefluidet strømmer fra et ringformet rum (26) mellem huset (4) og oliefeltkomponenten (DS), hvor det ringformede rum er over eller under tætningselementet (10).

20. Fremgangsmåde ifølge krav 19, hvor fluidet er under tætningselementet og/eller fluidet er over tætningselementet, hvilken fremgangsmåde endvidere omfatter:

tætning af oliefeltkomponenten med en første tætningsoverflade og en anden adskilt tætningsoverflade (21).

21. Fremgangsmåde ifølge krav 19 eller 20, hvor trinnet med bevægelse omfatter at lade oliefeltkomponenten glide i forhold til tætningselementet.

DRAWINGS

FIG.1

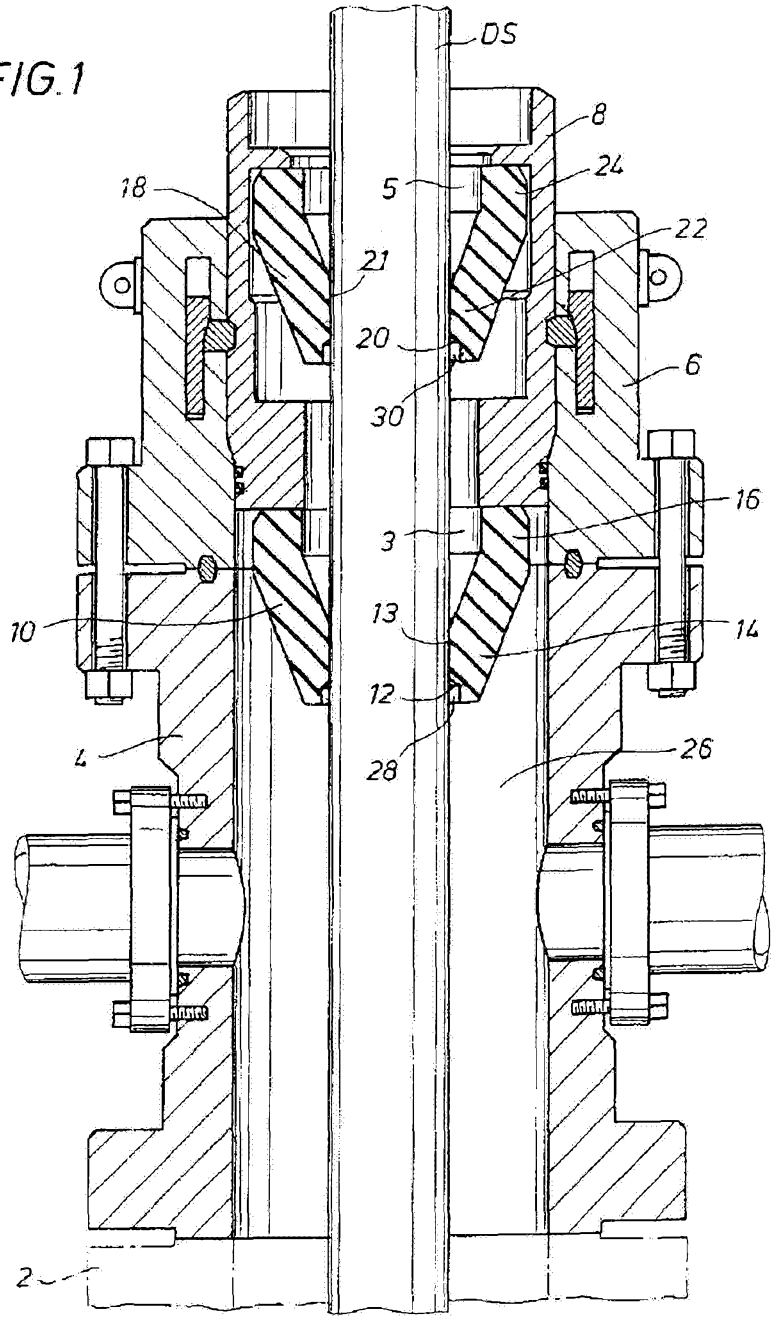
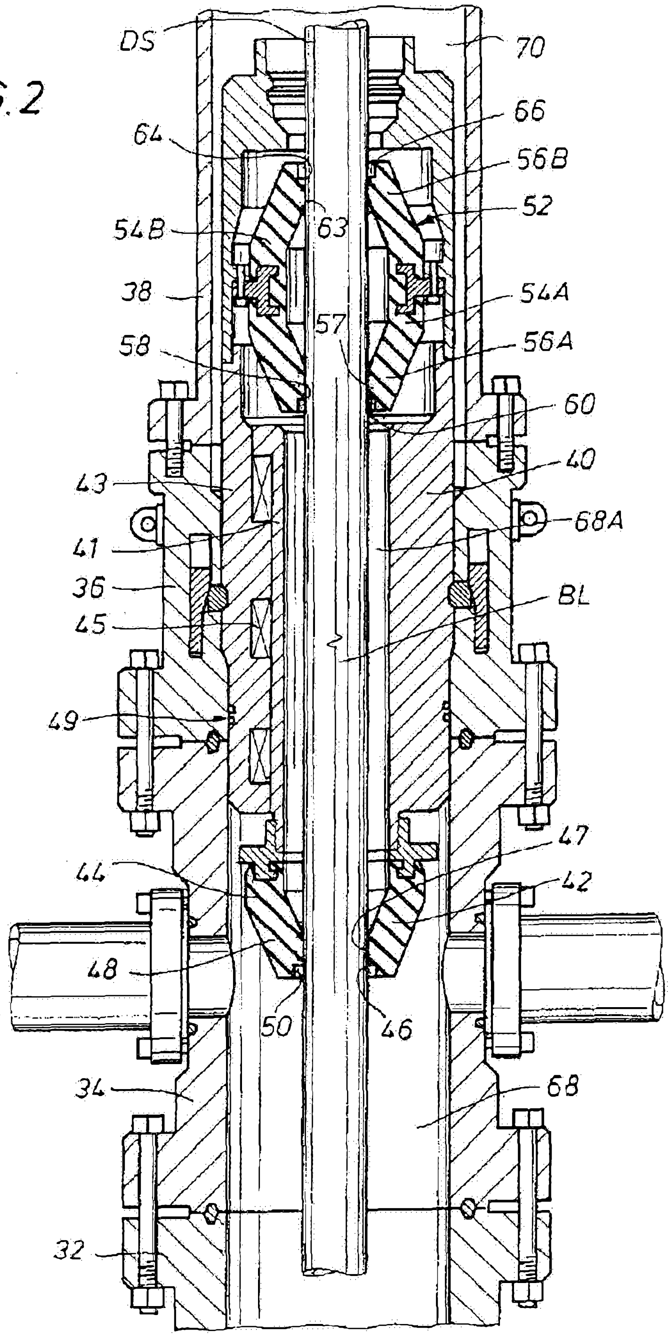


FIG. 2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56B
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52
54B
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54A
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58
56A
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40
41
68A
36
BL
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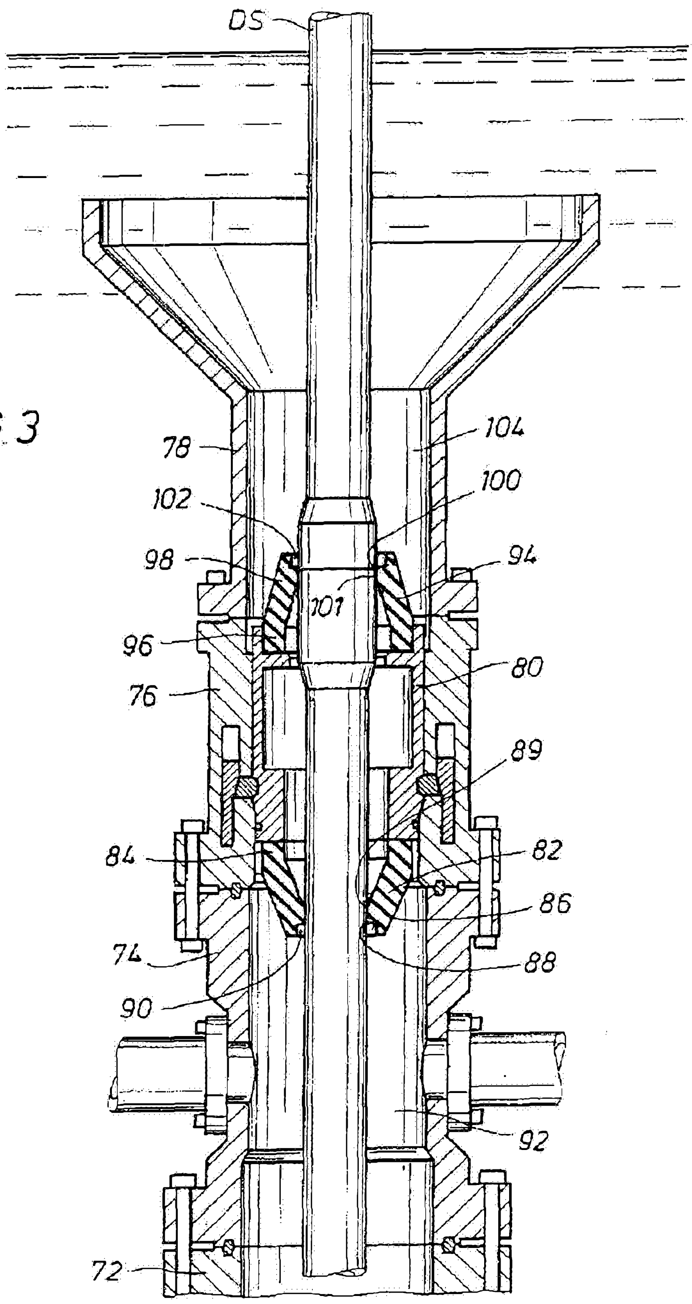
68
32

FIG. 3



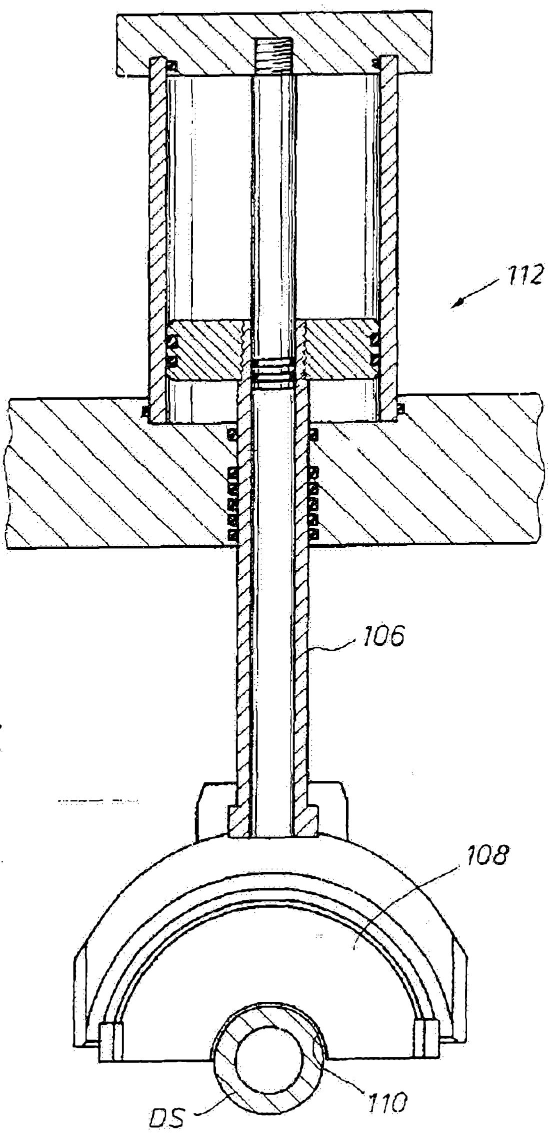


FIG. 4

FIG. 5

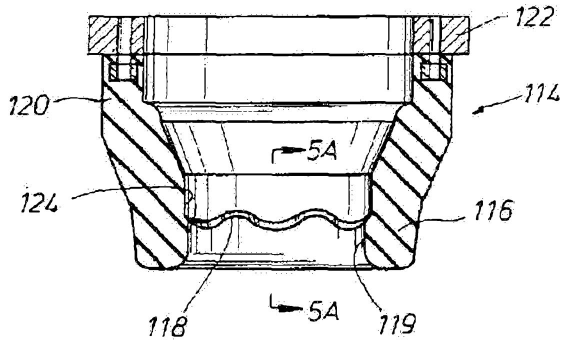
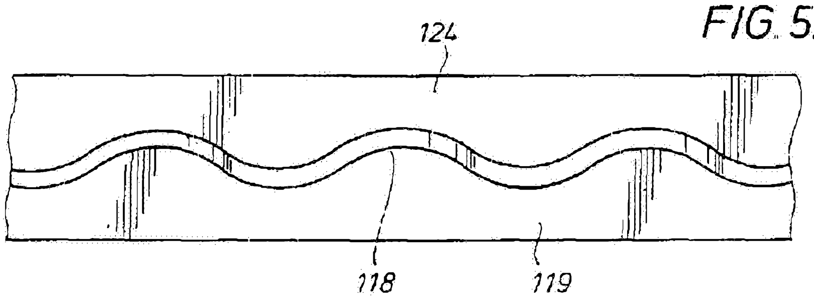


FIG. 5A



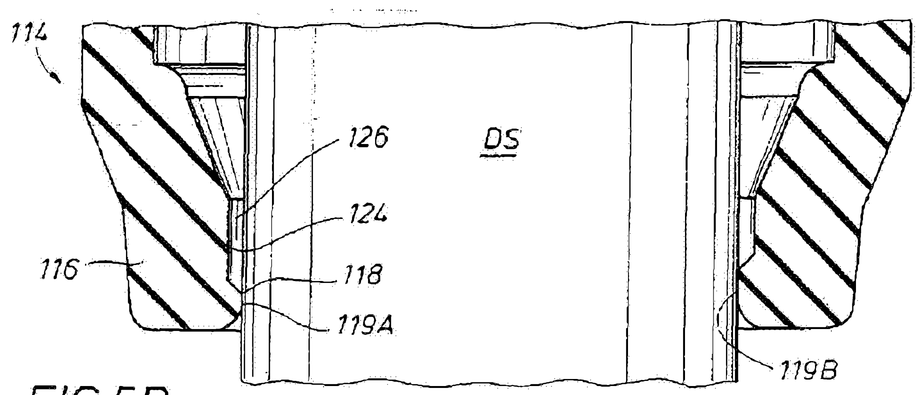
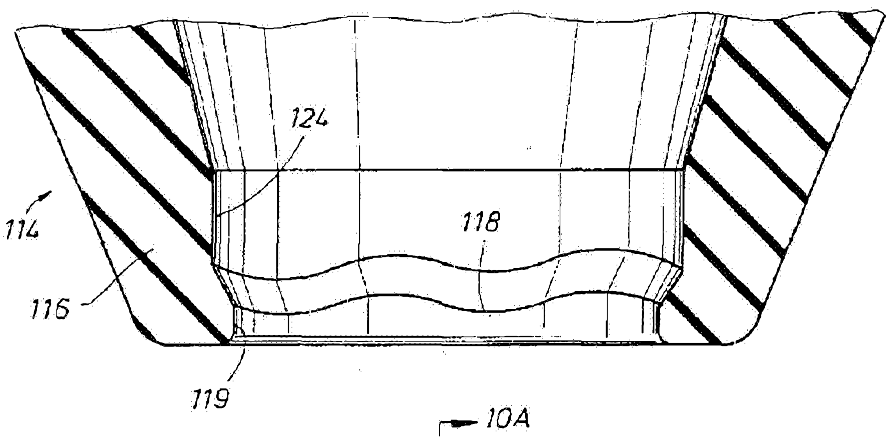


FIG. 5B

FIG.5C



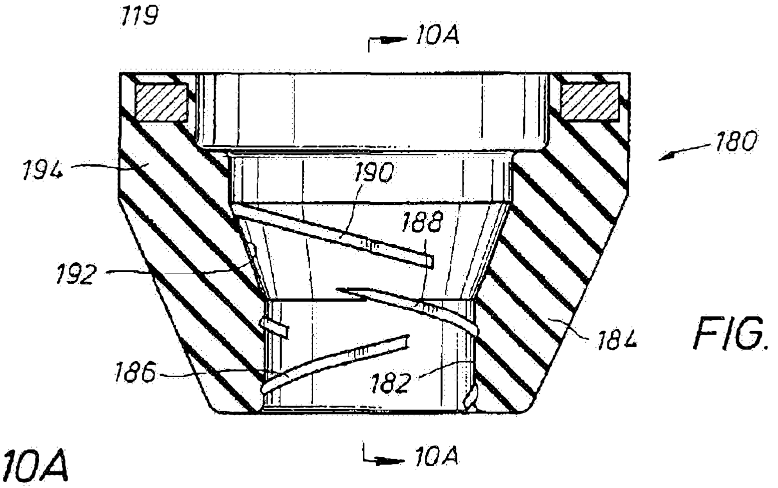


FIG.10

FIG.10A

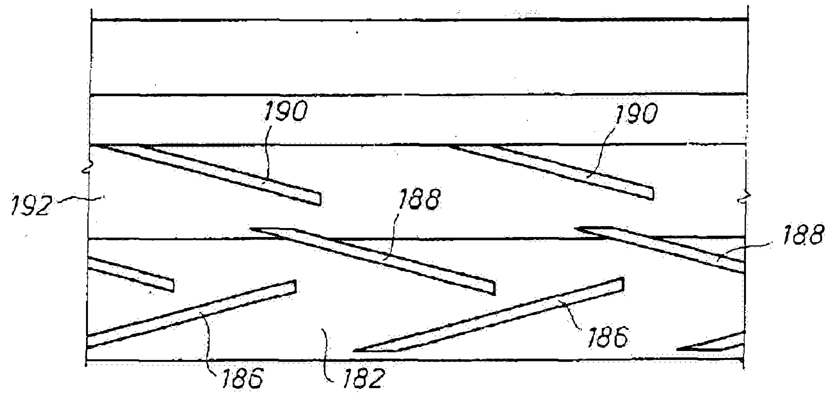
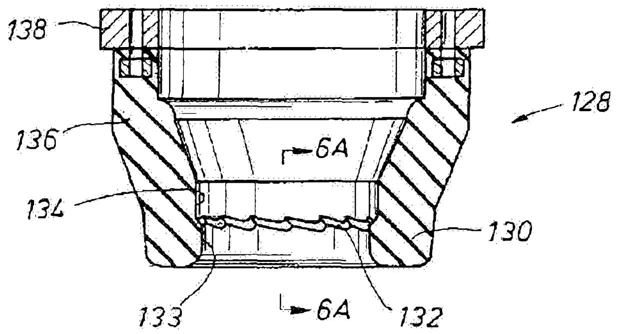


FIG. 6



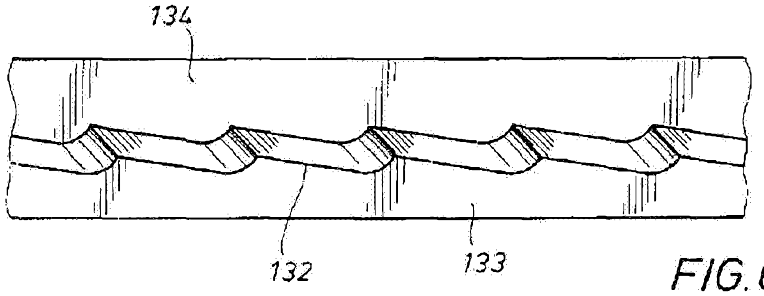


FIG. 6A

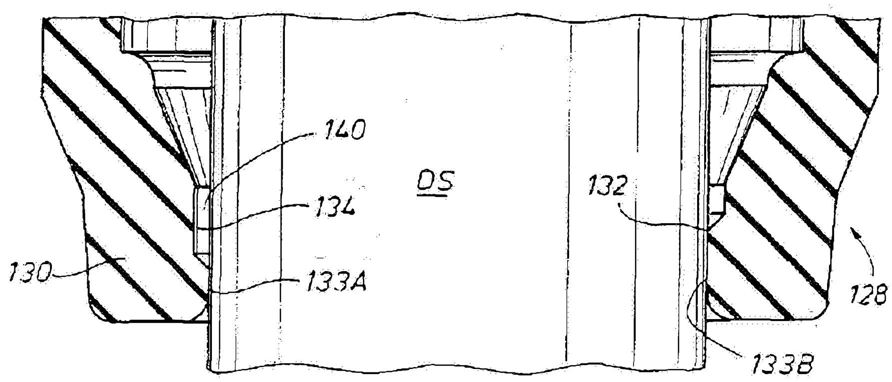


FIG. 6B

FIG.7

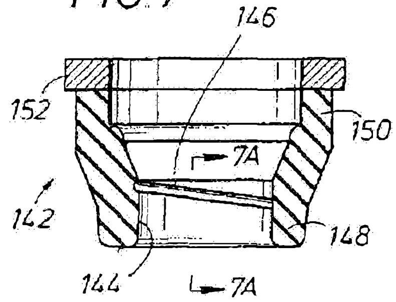


FIG.7A

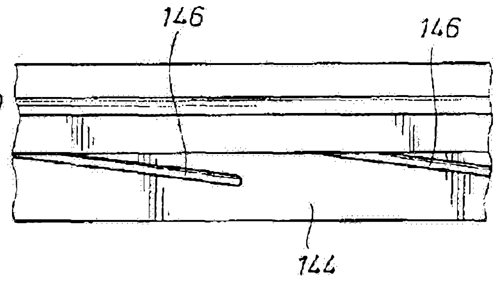


FIG.8

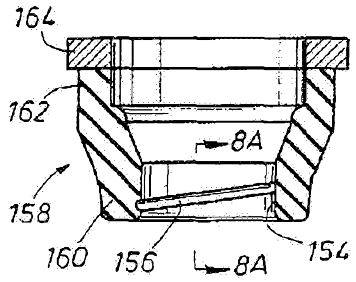


FIG.8A

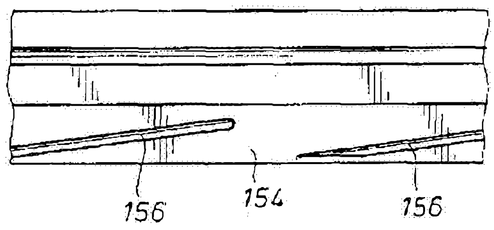


FIG.9

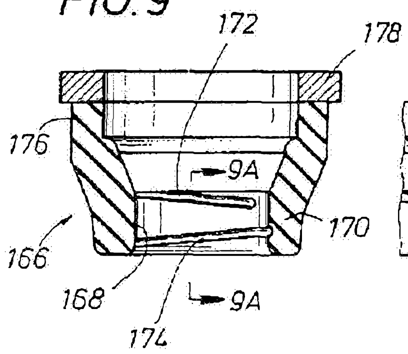


FIG.9A

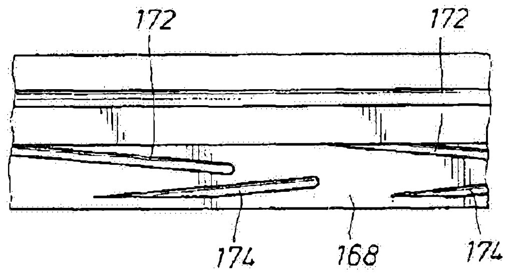


FIG.10B

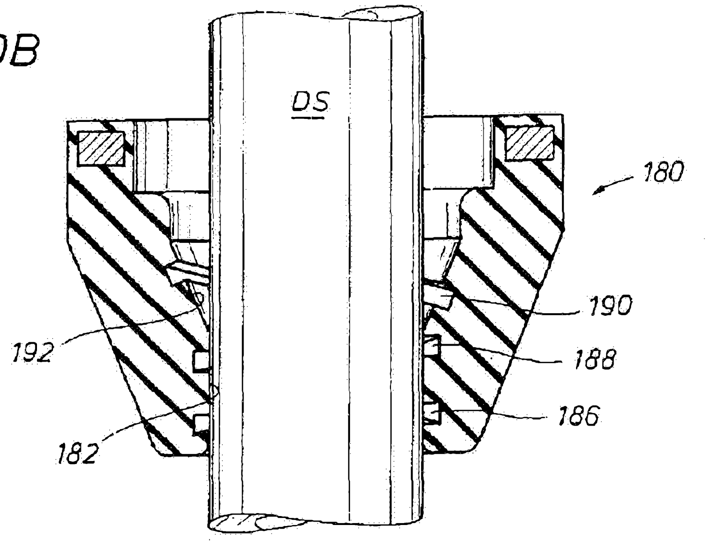


FIG.10C

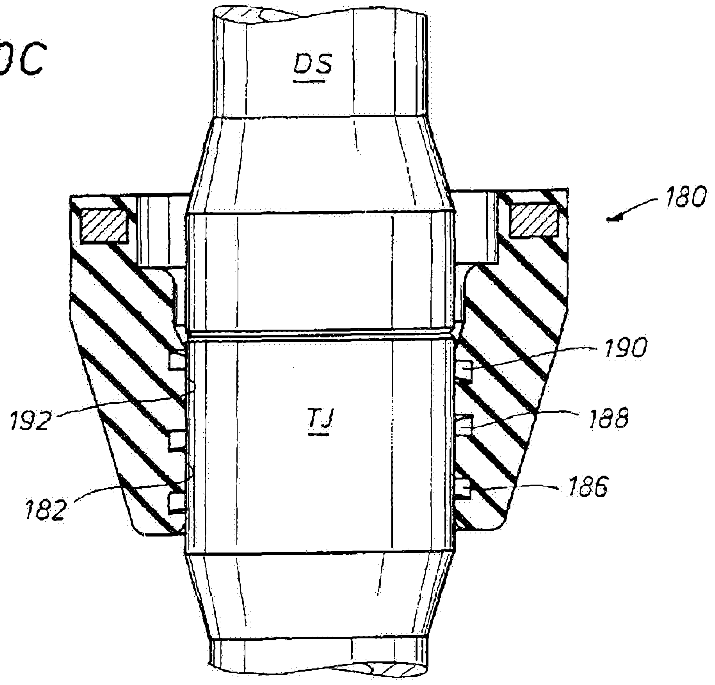


FIG.11

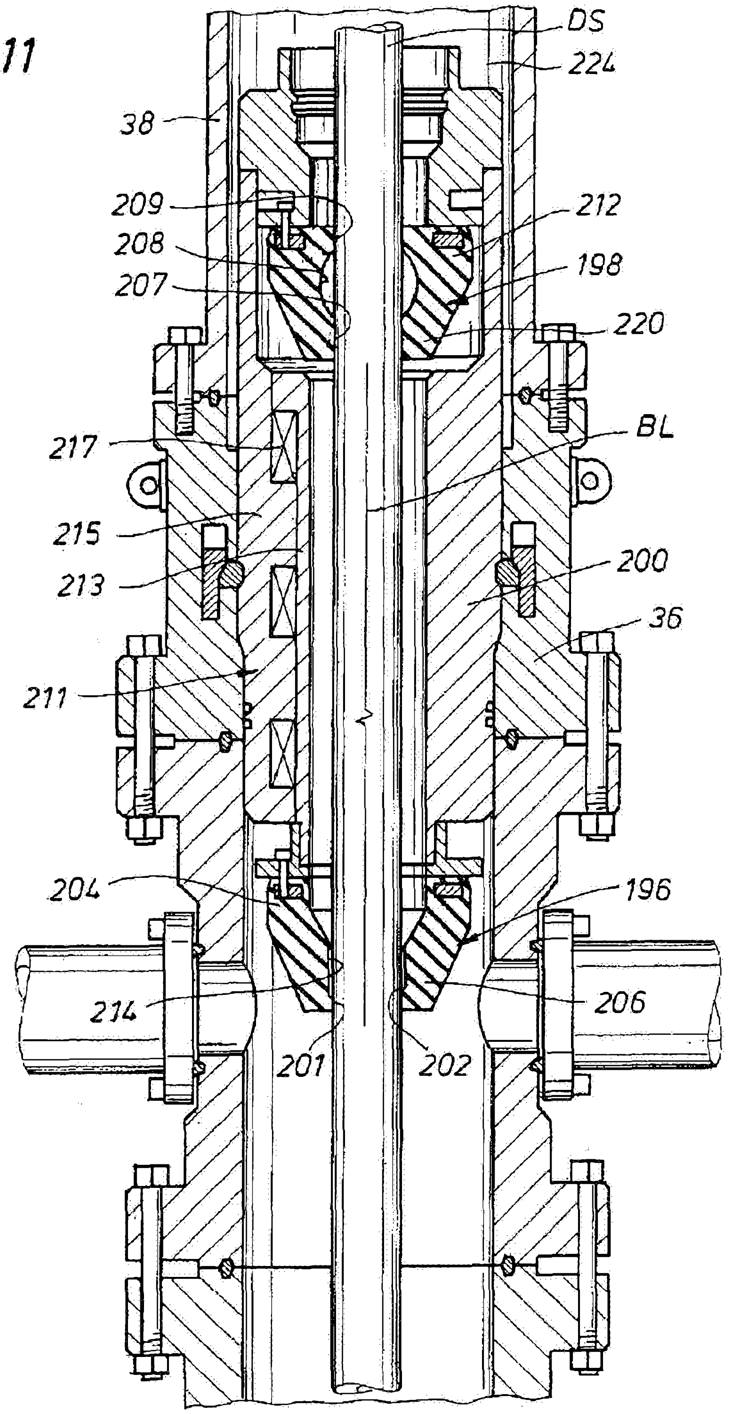

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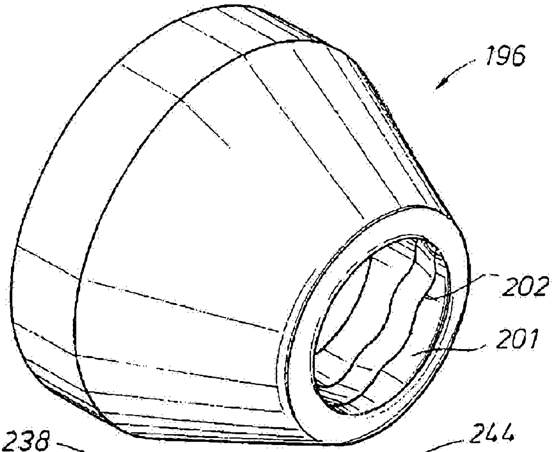
FIG.11A



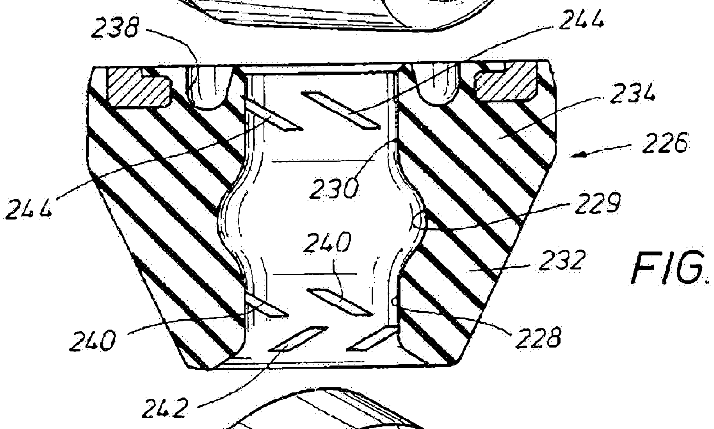


FIG.12

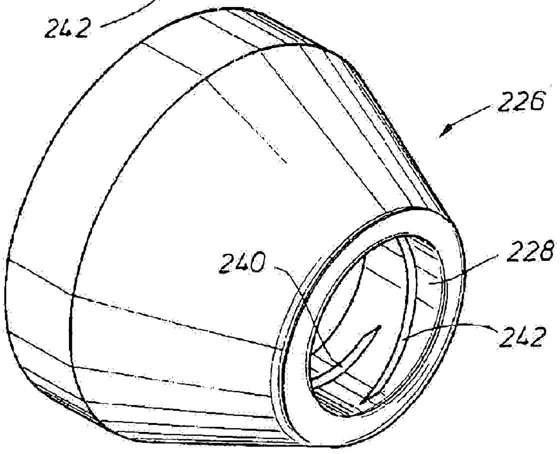


FIG.12A

FIG.13A

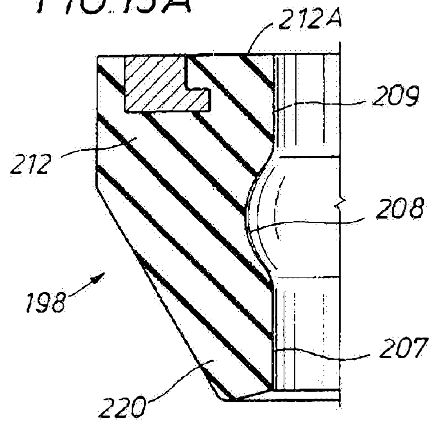
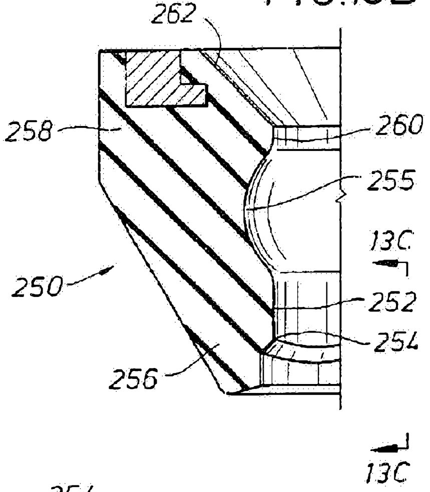


FIG.13B



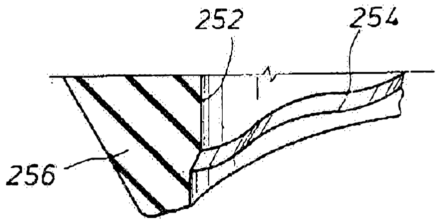


FIG. 13C

FIG. 13D

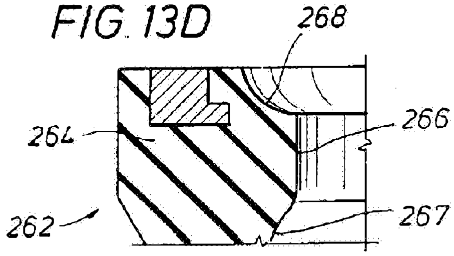


FIG. 13E

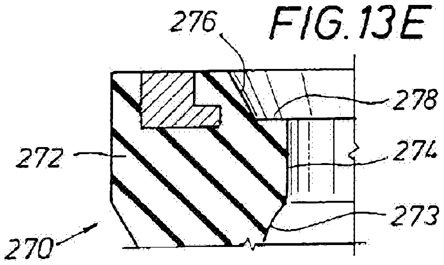


FIG. 13F

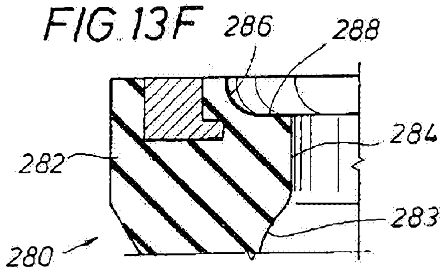


FIG. 13G