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(71) Applicant (for CA only): **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 525-3rd Avenue Southwest, Calgary, Alberta T2P-0G4 (CA).

(71) Applicant (for FR only): **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, F-75007 Paris (FR).

(71) Applicant (for GB, JP, NL only): **SCHLUMBERGER HOLDINGS LIMITED** [GB/GB]; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola, Virgin Islands, British, 1110 (VG).

(71) Applicant (for AL, AM, AT, AU, AZ, BF, BG, BJ, BN, BY, CF, CG, CH, CI, CL, CM, CO, CY, CZ, DE, DK, EG, GA, GE, GN, GQ, GR, GW, HR, HU, ID, IE, IL, IT, KE, KG, KP, KR, KZ, LT, MD, MG, ML, MR, MX, MY, NE, NO, NZ, OM, PL, QA, RO, RU, SI, SK, SN, TD, TG, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, ZA only): **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83-89m, NL-25 14 JG The Hague (NL).

(71) Applicant (for all designated States except AL, AM, AT, AU, AZ, BG, BN, BY, CA, CH, CL, CO, CY, CZ, DE, DK, EG, FR, GB, GE, GR, HR, HU, ID, IE, IL, IT, JP, KE, KG, KP, KR, KZ, LT, MG, MX, MY, NL, NO, NZ, OM, PL, QA, RO, RU, SI, SK, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, ZA): **PRAD RESEARCH AND DEVELOPMENT LIMITED** [GB/GB]; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola, Virgin Island, British, 1110 (VG).

(71) Applicant (for US only): **SCHLUMBERGER TECHNOLOGY CORPORATION** [US/US]; 300 Schlumberger Drive, Sugar Land, Texas 77478 (US).

(72) Inventors: **SCRANTON, Joseph D.**; 2823 Manion Drive, Missouri City, Texas 77459 (US). **SUFFRIDGE, Riley**; 8918 Sager, Houston, Texas 77096 (US).

[Continued on next page]

(54) Title: MARINE ISOLATION ASSEMBLY

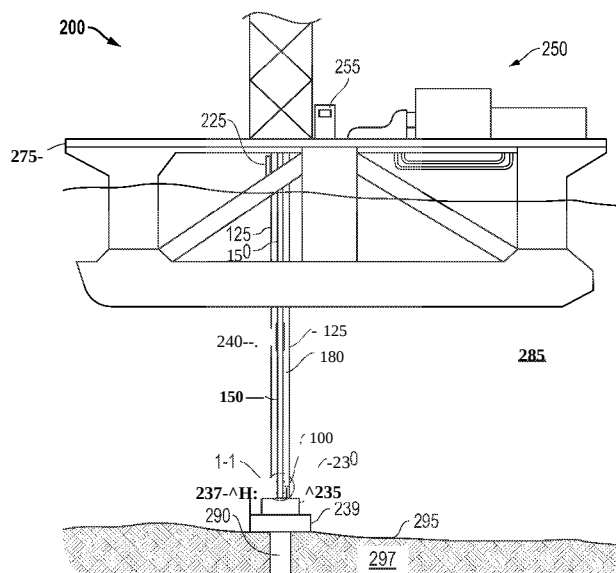


FIG. 2

(57) Abstract: An isolation assembly that employs a pack-off device at an annular space between a landing string and a riser. The assembly is configured to ensure sealing off of an annular space below the pack-off device such that potentially hazardous well test - ing applications may safely proceed early on in completions operations. That is, in advance of any significant rig-level pressure con - trol equipment hook-up, the pack-off device may seal off the annulus from any potential hydrocarbon leaks up the riser toward the rig. Further, where such seal holds back pressures exceeding a predetermined level, a burst element may be incorporated into the wall of the riser to allow for controlled venting therefrom.

(74) **Agents:** WARFFORD, Rodney V. et al.; 10001 Richmond Avenue, IP Administration Center of Excellence, Room 4720, Houston, Texas 77042 (US).

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MARINE ISOLATION ASSEMBLY

BACKGROUND

[0001] Exploring, drilling, completing, and operating hydrocarbon and other wells are generally complicated, time consuming and ultimately very expensive endeavors. In recognition of these expenses, added emphasis has been placed on well access, monitoring and management throughout the productive life of the well. That is to say, from a cost standpoint, an increased focus on ready access to well information and/or more efficient interventions have played key roles in maximizing overall returns from the completed well.

[0002] By the same token, added emphasis on completions efficiencies and operator safety may also play a critical role in maximizing returns. That is, ensuring safety and enhancing efficiencies over the course of well testing, hardware installation and other standard completions tasks may also ultimately improve well operations and returns.

[0003] Well completions operations do generally include a variety of features and installations with enhanced safety and efficiencies in mind. For example, a blowout preventor (BOP) is generally installed on the well head in advance of the myriad of downhole hardware to follow. Thus, a safe and efficient workable interface to downhole pressures may be provided. However, added measures may be called for where the well is of an offshore variety. That is, in such circumstances the BOP is located at the well head on the seabed. Therefore, as detailed further below, the opportunity remains for pressure issues to arise between the seabed and the offshore platform several hundred feet above.

[0004] In most offshore circumstances, the well head, BOP and other equipment are found disposed within a tubular riser which provides cased access up to the offshore platform. Indeed, other lines and tubulars may run within the marine riser between the noted seabed equipment and the platform. For example, a landing string which provides well access to the newly drilled well below the well head will run within the marine riser along with a variety of hydraulic and other umbilicals.

[0005] Unfortunately, hydrocarbon uptake from the well is not always limited to the route provided by the above noted landing string. For example, a gaseous pressurized leak through the BOP may develop into the annulus between the string and the riser. Thus, during completions operations, in advance of permanent pressure regulating surface installations, the upward migration of this hydrocarbon 'bubble' may proceed toward the platform in an unregulated manner. As such, platform equipment damage, cessation of operations, and most importantly operator safety, may all be placed at significant risk.

[0006] In order to help avoid the hazards associated with the hydrocarbon bubble reaching the platform, an inflatable diverter and sealing mandrel may combine to seal off the annulus at an elevation below the platform and near the water line. More specifically, a sealing mandrel is generally already provided about the landing string near the indicated location and serves as a conventional feed-thru for umbilicals as referenced above. Therefore, a diverter, similar to an inflatable packer, may be located at a corresponding location of the riser, adjacent the mandrel. With this combination structure in place, the diverter may be inflated as needed so as to seal off the annulus, thereby preventing any migrating hydrocarbon bubble from reaching the platform.

[0007] Unfortunately, a variety of factors combine so as to limit the effectiveness of the combined mandrel diverter structure in serving as a reliable seal in the annular space. For example, as opposed to being constructed with the purpose of serving as a

unitary seal, the combined structure leverages off of the likely pre-positioned mandrel designed to serve as an umbilical feed thru. As a result, an independent 30-40 foot long mandrel is non-uniformly paired against a separate diverter structure. Thus, from the outset, the sealability of the structure is unlikely to exceed about 500 PSI.

[0008] Further complicating matters, these independent elements may be particularly prone to frictional wear over time as they rub against one another. That is, as the vertically 'floating' riser and landing string equipment moves, so to would their corresponding diverter and mandrel elements relative one another. Thus, frictional wear would naturally result, perhaps even exacerbated by the structural non-uniformity of the separate elements. Indeed, the location of the sealing structure may also compound frictional wear. That is to say, the further the annular seal is located from the anchoring provided at the seabed, the greater the relative movement of the riser and string as noted.

[0009] As a matter of combating the noted frictional wear issues, the diverter is often left uninflated for certain calculated periods of time. Of course, this increases the risk of a sudden hazardous appearance of hydrocarbons at the floor of the rig platform. Regardless, operators are ultimately left with a temporary device of limited sealing capacity that is generally thrown out after a few uses over the course of a few days due to significant reliability concerns.

SUMMARY

[0010] An isolation assembly is disclosed for use in a marine well. The assembly includes a landing string that is coupled to a well head system at the seabed. A riser is provided about the string and a pack-off device is sealably disposed in the annulus between the landing string and the marine riser. In terms of elevation, this device may be positioned adjacent the well head system within the riser. Additionally, in one embodiment a burst element is incorporated into the riser below the pack-off device

such that a pressurized release of hydrocarbons from the annulus may be allowed where appropriate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1 is an enlarged view of an embodiment of a marine isolation assembly taken from 1-1 of Fig. 2.

[0012] Fig. 2 is an overview of an offshore oilfield including a well accessed by equipment incorporating the marine isolation assembly of Fig. 1.

[0013] Fig. 3A is an enlarged view of the marine isolation assembly of Fig. 1 in a fully deployed state and sealing off a hydrocarbon bubble in an annulus therebelow.

[0014] Fig. 3B is an enlarged view of the assembly of Fig. 3A with a burst element thereof broken to allow release of the bubble from the annulus.

[0015] Fig. 4 is an overview of the oilfield and well of Fig. 2 employing an alternate embodiment of equipment and isolation assembly.

[0016] Fig. 5 is a flow-chart summarizing an embodiment of employing a marine isolation assembly.

DETAILED DESCRIPTION

[0017] Embodiments are described with reference to certain packer-type sealing devices utilized in sealing off an annular space between a riser and landing string in marine applications. For example, inflatable pack-off devices are disclosed and referenced throughout. However, alternate forms of pack-off devices may be employed such as packer swab cups or compressably deployed devices. Regardless, embodiments of the isolation assemblies include a pack-off device of some variety that may be disposed in the annular space, preferably adjacent a well head system at the seabed.

[0018] Referring now to Fig. 1, an enlarged view of an embodiment of a marine isolation assembly taken from 1-1 of Fig. 2 is depicted. The assembly includes a pack-

off device 100 configured to occupy an annular space 180 between a landing string 150 and a marine riser 125. The annular space 180 between the string 150 and riser 125 may be considerable given that the riser 125 may exceed about 20 inches in diameter whereas the interior string 150 is likely closer to 9 inches in diameter. With this architecture in mind and added reference to Fig. 2, offshore operations may take place at an oilfield served by an offshore rig 200 which is provided access to a subsea well 290 via the noted string 150 and riser 125.

[0019] Continuing with reference to Figs. 1 and 2, the landing string 150 is configured to provide a flow-path for recovered hydrocarbons from the well 290 back up to the rig 200. The riser 125 on the other hand is provided so as to provide an open and stable channel to support completions operations ranging from drilling and testing to the accommodating of the string 150 and other hardware as shown.

[0020] As a result of the described architectural layout, the riser 125 may also provide an accessible channel all the way up to the rig 200, for example, to any hydrocarbons undesirably reaching the indicated annular space 180. Once more, unlike the string 150 which terminates at production and gas management equipment of the rig 200, the riser 125 provides a largely unregulated channel to the rig floor 275. Therefore, to prevent hazardous hydrocarbon breach of the annular space 180, the pack-off device 100 is provided to seal off the annular space 180 from potential leak points below. As such, the potentially unregulated hydrocarbon pathway to the rig floor 275 is effectively closed off.

[0021] Continuing with reference to Fig. 1, the pack-off device 100 is shown in an undeployed state, prior to sealing at the inner wall of the riser 125 by way of the seal element 110. That is, in the embodiment shown, the device 100 is of an inflatable variety with a hydraulic line 177 fluidly coupled to a bladder 112 for inflation directed from the rig floor 275 (see Fig. 2). Thus, the expanding bladder 112 may act on the

seal element 110 forming a seal at the wall of the adjacent riser 125 as indicated. As such, the leakage of a hydrocarbon bubble 300 into the annulus 180 from points below the pack-off device 100 may be avoided (see Fig. 3A). The seal element 110 may be of a conventional corrosion resistant elastomer. Additionally, in other embodiments, the pack-off device itself may be of a mechanically compressible, swell-type or other suitable expansive seal forming nature.

[0022] The pack-off device 100 of Fig. 1 is constructed similar to a conventional packer tool, secured and delivered to the depicted location via the landing string 150. In contrast to a sealing mandrel, the device 100 may occupy less than a few feet along the string 150. Additionally, to reduce rig up time and effort, the landing string 150 may be particularly configured with a segmented portion for accommodating the device 100 joined to the remainder of the string 150 at a coupling 155. The device 100 itself may also include a conventional frame 101 to accommodate gauge rings 115 for securing the seal element 110.

[0023] As shown in Fig. 1, the noted frame 101 also allows for sealed feed-thru of the described hydraulic line 177. Similarly, an umbilical assembly 175 accommodating a host of power, communication and other lines may be afforded feed-thru relative the frame 101 so as to reach a subsea test tree 235 of a well head system 230 therebelow (see Fig. 2). More specifically, with added reference to Fig. 2, a seabed control unit 237 of the system 230 may be directed by and/or communicate with a rig control unit 255 of the rig 200 via the umbilical assembly 175.

[0024] With specific reference to Fig. 2, an overview of an offshore oilfield is depicted which includes a well 290 accessed by equipment incorporating the marine isolation assembly of Fig. 1. More particularly, the noted riser 125 and landing string 150 are shown providing a structural link between the well 290 and an offshore rig 200. Further, the pack-off device 101 is shown at the annular space 180 between the riser

125 and string 150 as detailed hereinabove. However, in the embodiment of Fig. 2, the device 100 is inflated to effectively seal the space 180 as opposed to the pre-inflated view shown in Fig. 1.

[0025] While annular space 180 is present both above and below the device 100, it is apparent in the embodiment of Fig. 2 that the device 100 is nevertheless positioned directly adjacent the well head system 230 at the seabed 295 (e.g. within a few feet thereof). In other embodiments, the device 100 may be located further uphole for isolation of the annular space 180. Preferably, however, the device 100 is located below a lubricator valve 240 of the string 150 and a slip joint 225 of the riser 125. In this manner, the profile of the annular space 180 below the pack-off device 100 remains consistently uniform. As a result, the pressure capacity of the pack-off device 100 may be maximized due to the lack of any pressure related weakpoints as may be found at such valve 240 and joint 225 locations.

[0026] As a matter of further enhancing the effectiveness of the seal afforded by the pack-off device 100, it may not only be located below the indicated valve 240 and joint 225, but also directly adjacent the seabed positioned system 230 as described. Thus, not only are pressure related weakpoints below the device 100 avoided, but a pressurized leakage into the annular space 180 from the location of the system 230 is afforded less than, for example, five vertical feet of room for expansion. Therefore, with added reference to Fig. 3A, a hydrocarbon bubble 300 into the annular space 180 below the device 100 is sealed off before having the chance to substantially expand as it rises uphole. Rather, trapping of the bubble 300 is more immediate.

[0027] Locating the pack-off device 100 directly adjacent the system 230 at the seabed 295 also enhances the effectiveness of the device 100 over the long term. That is, the riser 125 and landing string 150 are vertically disposed from a rig 200 across a body of water 285 in a largely free manner. Thus, a certain degree of sea induced

movement of the riser 125 and string 150 are inherent to the offshore operations. However, such motion is increasingly limited at locations closer and closer to the well head system 230 at the seabed 295 where the riser 125 and string 150 are ultimately anchored. As a result, motion induced wear on a fully expanded pack-off device 100 sandwiched between the riser 125 and string 150 is minimized when the device 100 is positioned adjacent the system 230.

[0028] All in all, when positioned and utilized as detailed herein, embodiments of the pack-off device 100 may effectively seal off several thousand pounds of differential pressure in the annulus 180 therebelow. In one embodiment, a device 100 may seal off more than 6,000 PSI in excess of several days without any significant concern over breach of pressure tolerance or failure due to motion-induced wear. In fact, the pressure capacity of the pack-off device 100 may be so great that a burst element 350 may be built into the riser 125 below the location of the device 100 (see Fig. 3A). Thus, once a predetermined pressure is reached, an intentional controlled release of pressure may take place so as to avoid damage to the riser 125 or portions of the well head system 230.

[0029] Continuing with reference to Fig. 2, the well head system 230 itself includes a well head 239 providing access to the well 290 which is defined by a formation 297 from which hydrocarbons are to be produced. A conventional subsea test tree 235, utilized during completions operations, is shown above the head 239 and annularly sealed off by the pack-off device 100 thereof. Thus, any hydrocarbon leak into the annular space 180 via the subsea test tree 235 is effectively sealed off as detailed above. The system 230 is also equipped with a seabed control unit 237 for directing a variety of seabed and downhole applications. Indeed, in one embodiment, hydraulics from the unit 237 may be utilized for inflation of the adjacent pack-off device 100 as opposed to running a separate dedicated hydraulic line 177 from the rig 200 as depicted in Fig. 1.

[0030] As noted above, the offshore rig 200 accommodates a rig control unit 255 for communication with the seabed control unit 237. However, completions operations involving a host of other equipment, such as the depicted circulation system 250, may be directed by way of the rig control unit 255. Regardless, such early stage completions operations may proceed in advance of rig installed pressure safety measures, such as a conventional 'Christmas tree', without undue concern over unregulated hydrocarbon migration to the rig floor 275.

[0031] Referring now to Figs. 3A and 3B, enlarged views of the assembly of Fig. 1 are shown with the pack-off device 100 in a fully deployed state. In these views, the sealing off of a hydrocarbon bubble 300 in the annulus 180 below the device 100 is apparent. More specifically, Fig. 3A depicts the bubble 300 trapped below the device 100 within the riser 125 whereas Fig. 3B reveals the breaking of a burst element 350 of the riser 125 so as to release the bubble into the surrounding water 285.

[0032] With more specific reference to Fig. 3A and added reference to Fig. 2, a bladder 112 of the pack-off device 100 has been fully expanded via the hydraulic line 177 as detailed above. However, in other embodiments such hydraulic inflation may be achieved by way of the adjacent subsea control unit 237. Regardless, such inflation may form a seal between the seal element 110 and the inner diameter of the riser 125 sufficient for holding back several thousand pounds of pressure in the annulus 180 therebelow. Thus, the emergence of the noted hydrocarbon bubble 300, for example due to a leak in the adjacent subsea test tree 235 poses no significant risk of reaching the rig 200 internally through the riser 125. As a result, well testing through the tree 235 becomes a safe and reliable alternative to more complicated open water interventional system testing.

[0033] Indeed, from a pressure standpoint, the seal provided by the pack-off device 100 may be so effective that pressure buildup in the annulus 180 therebelow may risk

reaching levels capable of damaging other downhole equipment or the riser 125 itself. This risk may be mitigated to a certain extent due to the proximity of the device 100 to the likely source of the hydrocarbon leak (e.g. at the test tree 235 of Fig. 2). Nevertheless, with more specific reference to Fig. 3B, a burst element 350 may be incorporated into the riser 125 below the device 100.

[0034] The burst element 350 may be a conventional rupture disk configured to break upon exposure to pressures exceeding a predetermined limit. In this manner, a controlled release of pressure at a specified location may be intentionally allowed as opposed to uncontrolled damage to the riser 125, test tree 235 or other adjacent equipment. For example, in one embodiment the burst element 350 may be configured to rupture upon exposure to pressures exceeding about 5,000 PSI so as to avoid such equipment damage. Thus, the pressure and associated hydrocarbon bubble 300 may escape into the adjacent water 285 in a controlled manner. Of course, to the degree that such venting of pressure and hydrocarbons is viewed as an uncontrolled release relative the adjacent water 285, additional measures may also be taken (see Fig. 4).

[0035] Referring now to Fig. 4, an overview of the oilfield and well 290 of Fig. 2 is shown but with an alternate embodiment of equipment layout employed. In this embodiment, the riser 125 is again configured to vent in a manner similar to that depicted in Figs. 3A and 3B. However, rather than allow venting directly into the surrounding water 285, additional hydrocarbon collection measures are taken.

[0036] Continuing with reference to Fig. 4, these collection measures include providing an access line 400 which terminates at the riser 125 at the location of the burst element 350 of Figs. 3A and 3B. Thus, rather than potentially allowing the free venting of pressurized hydrocarbons into the surrounding water 285, controlled production of such hydrocarbons may actually be achieved. This not only alleviates environmental concerns, but may actually increase overall recovery. That is, the access

line 400 may terminate at gas management and collection equipment 450 at the rig 200. As such, these hydrocarbons may reach the rig 200 in a non-hazardous fashion and actually be further managed through conventional recovery techniques.

[0037] Referring now to Fig. 5, a flow-chart is depicted summarizing an embodiment of employing a marine isolation assembly with a pack-off device as described hereinabove. The assembly may be utilized in conjunction with offshore completion operations from a rig as indicated at 505. Such operations generally unfold without the degree of pressure control and safety measures at the rig which are available in later operations. Thus, deploying a landing string with a pack-off device as indicated at 520 may be particularly beneficial at this stage of well development. That is to say, with the device employed to form a high pressure seal with an annulus of the riser, safety concerns may be minimized (see 535).

[0038] Indeed, with improved safety provided from a pressure control standpoint, well testing through a testing tree at the seabed may proceed as noted at 550 without undue concern over unsafe pressure buildup coming up through the riser. In fact, as indicated at 565, once a predetermined amount of pressure has been built up below the deployed pack-off device, such may be vented away from the equipment entirely. This may include allowing escape into the surrounding water (580) or perhaps even hydrocarbon recovery back to the rig (595). Regardless, safe and effective techniques for preventing highly pressurized hydrocarbons from reaching the rig floor through the riser in an uncontrolled fashion are provided.

[0039] Embodiments detailed herein provide an isolation assembly directed at sealing off an annulus between a landing string and a riser in marine well operations. The assembly is constructed in a manner that minimizes frictional wear given that discrete elements independently dedicated to each of the string and riser are avoided in achieving the seal. Further, the assembly is configured in a manner that lends itself to

deployment at a location adjacent a well head system at the seabed. Thus, potentially frictional relative motion between the string and riser is substantially eliminated. Additionally, embodiments herein require no intermittent periods of non-deployment in order to extend life of the assembly in a potentially hazardous manner.

[0040] The preceding description has been presented with reference to presently preferred embodiments. Persons skilled in the art and technology to which these embodiments pertain will appreciate that alterations and changes in the described structures and methods of operation may be practiced without meaningfully departing from the principle, and scope of these embodiments. Furthermore, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

CLAIMS

We Claim:

- 1 An isolation assembly for a marine well, the assembly comprising:
 - 2 a landing string coupled to a rig above sea level and to a well head system at a
 - 3 seabed therebelow;
 - 4 a riser disposed about said string and coupled to the rig and system; and
 - 5 a pack-off device for sealable disposal in an annulus between said string and
 - 6 said riser.
- 7 2. The assembly of claim 1 further comprising a burst element incorporated into
 - 8 said riser below a location of said pack-off device to allow pressurized release of
 - 9 hydrocarbons from within the annulus.
- 10 3. The assembly of claim 1 wherein said pack-off device is located below a
 - 11 lubricator valve of said string and below a slip joint of said riser.
- 12 4. The assembly of claim 1 wherein said pack-off device is located within less
 - 13 than about five feet of the system.
- 14 5. An offshore completions equipment assembly comprising:
 - 15 a rig having a floor above a sea level;
 - 16 a well head system anchored to a seabed below the rig and providing access to a
 - 17 well below the seabed;
 - 18 a riser providing a stable channel between said rig and said system; and
 - 19 a landing string disposed from said rig and through said riser to said system,

20 said string outfitted with a pack-off device for sealing an annular space between said
21 riser and said string at a location adjacent said system.

22 6. The assembly of claim 5 wherein said well head system further comprises:
23 a test tree for well testing applications; and
24 a seabed control unit coupled to said tree for driving the applications as directed
25 from a rig control unit at the rig.

26 7. A method comprising:
27 deploying a pack-off device on a landing string from an offshore rig through a
28 riser anchored to a well head system at a seabed; and
29 sealing off an annulus between the string and the riser with the device at a
30 location adjacently uphole of the system.

31 8. The method of claim 7 further comprising performing a well test application
32 with a test tree of the system after said sealing.

33 9. The method of claim 7 further comprising venting pressure from the annulus
34 below the pack-off device and through the riser.

35 10. The method of claim 9 wherein said venting comprises one of releasing pressure
36 into surrounding water and releasing pressure through a line coupled to the riser and
37 leading back to the rig.

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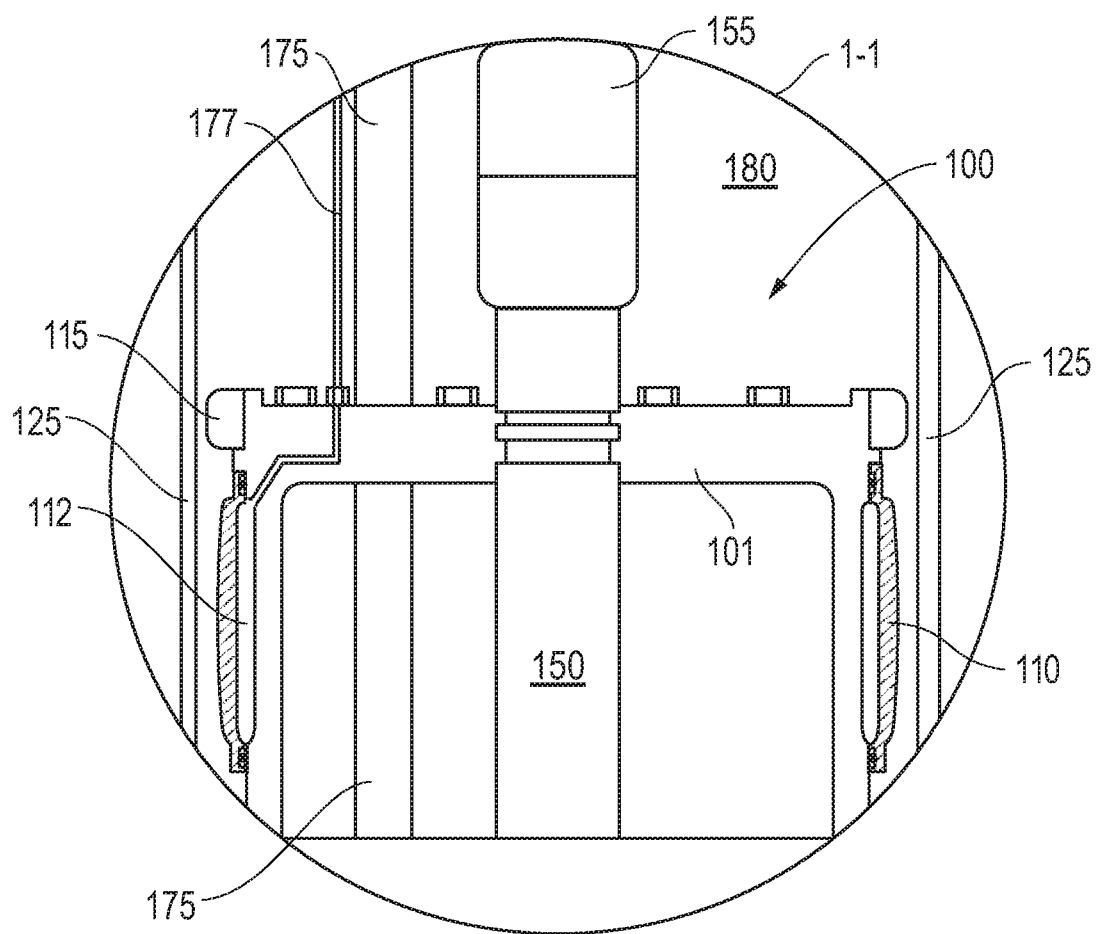


FIG. 1

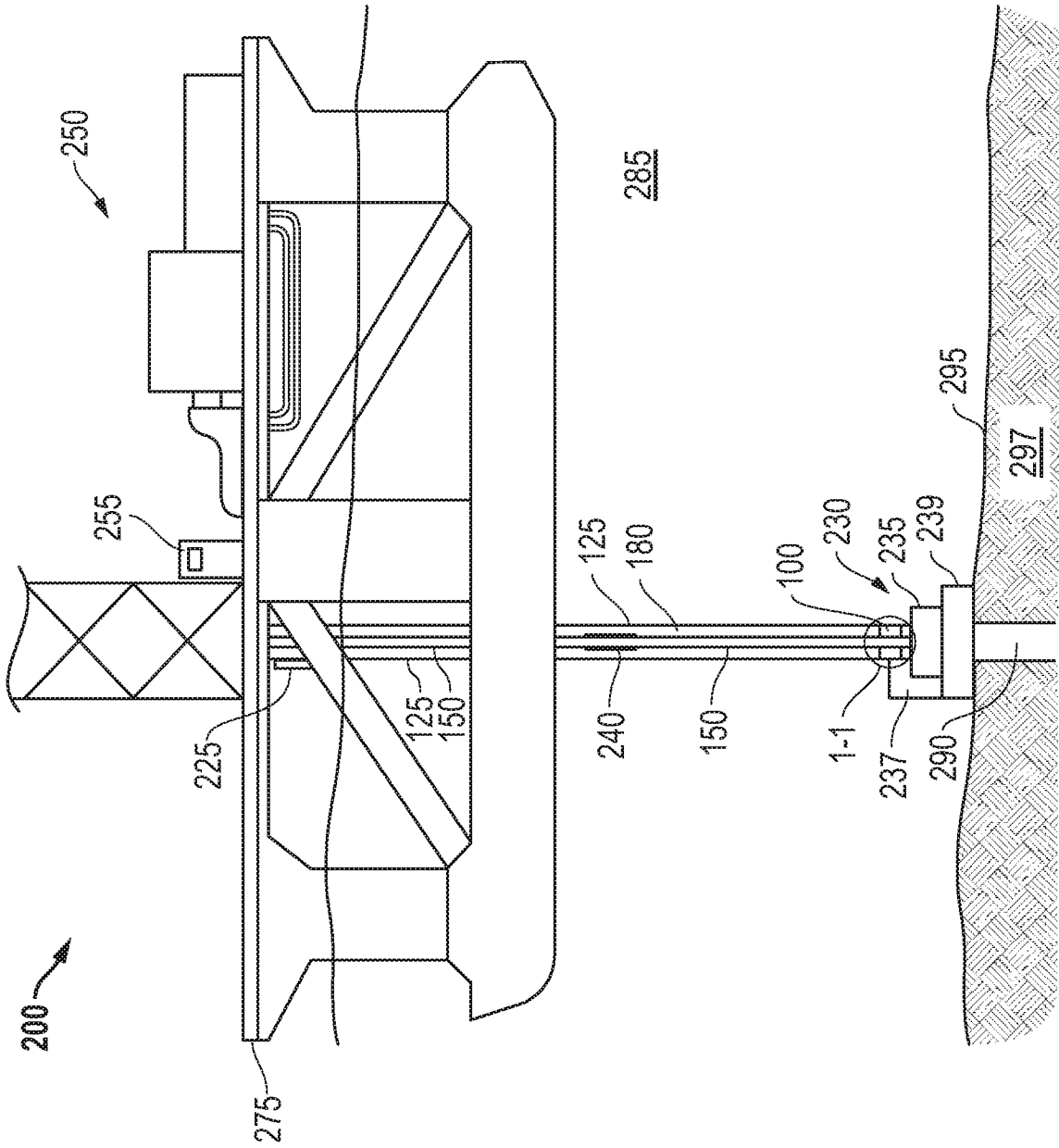


FIG. 2

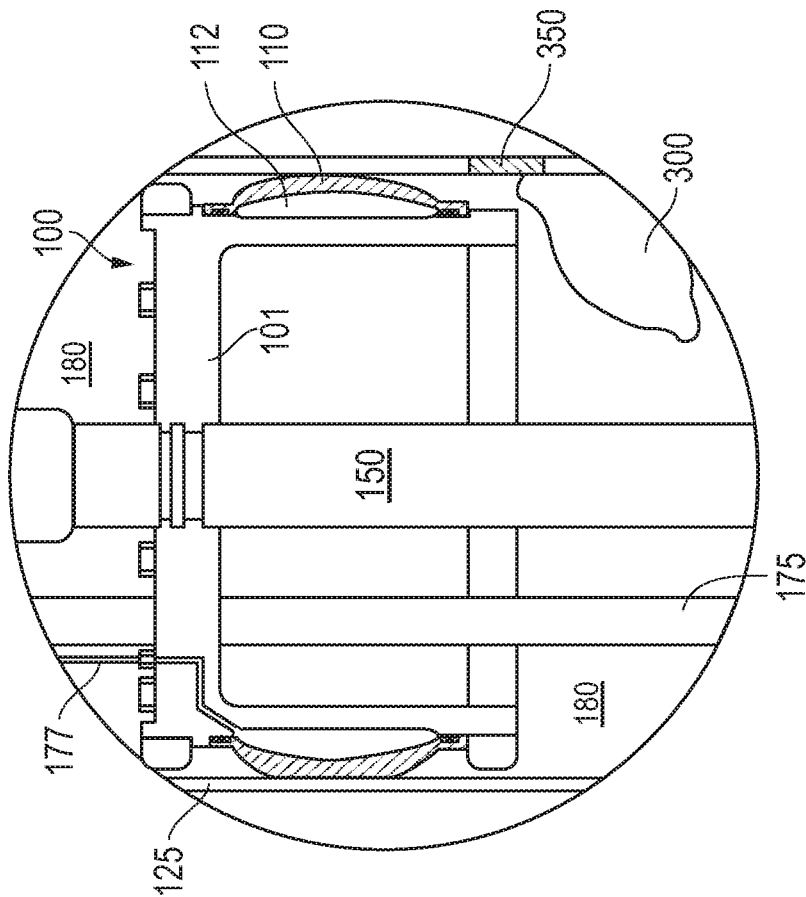


FIG. 3A

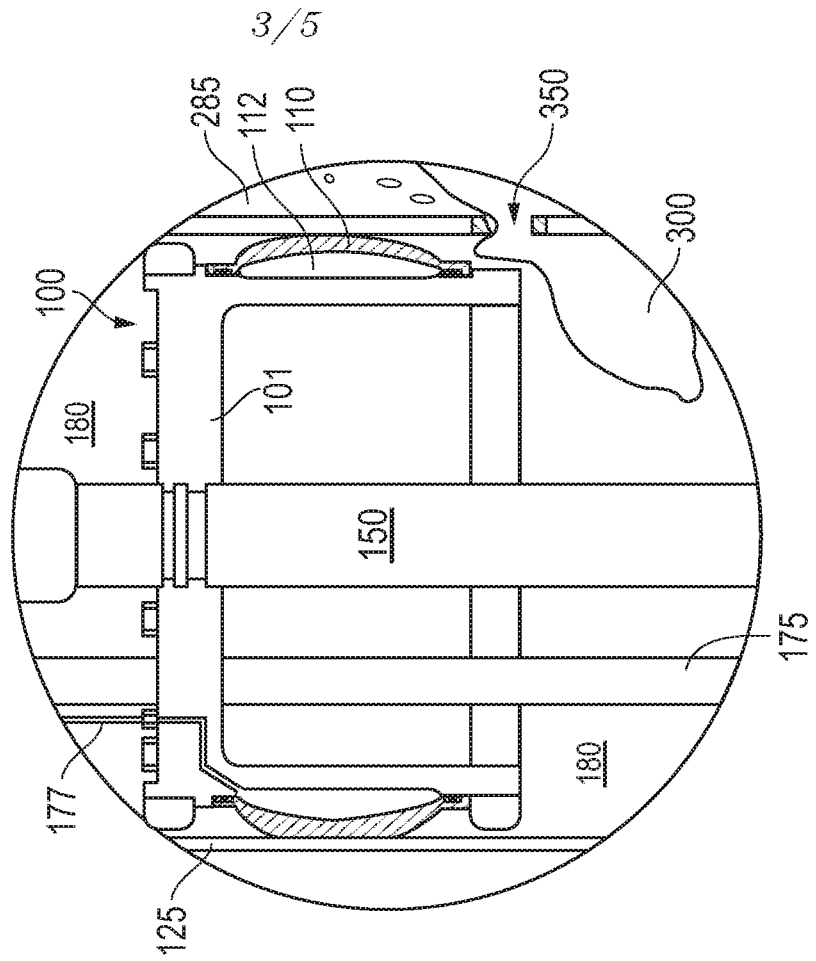


FIG. 3B

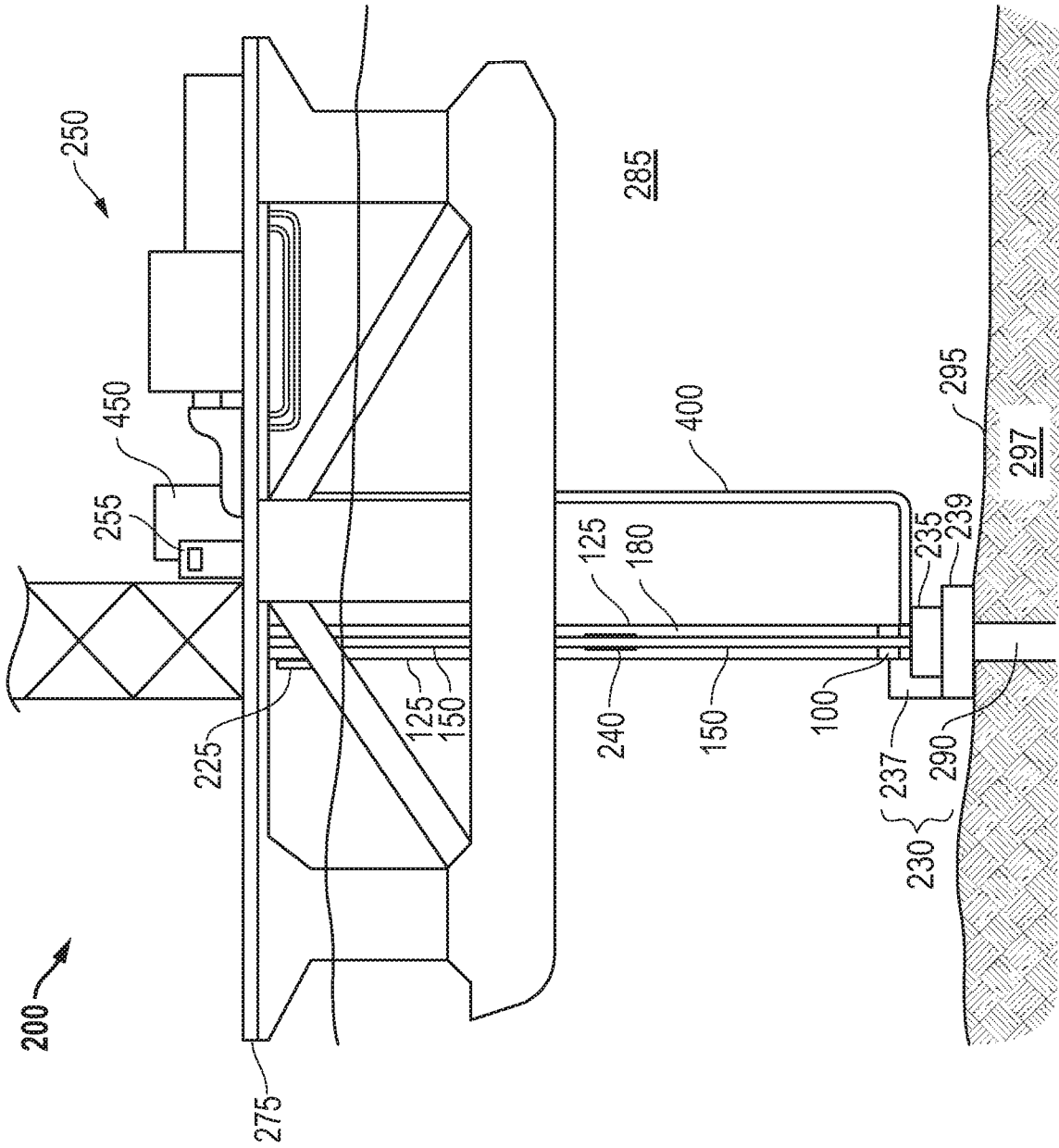


FIG. 4

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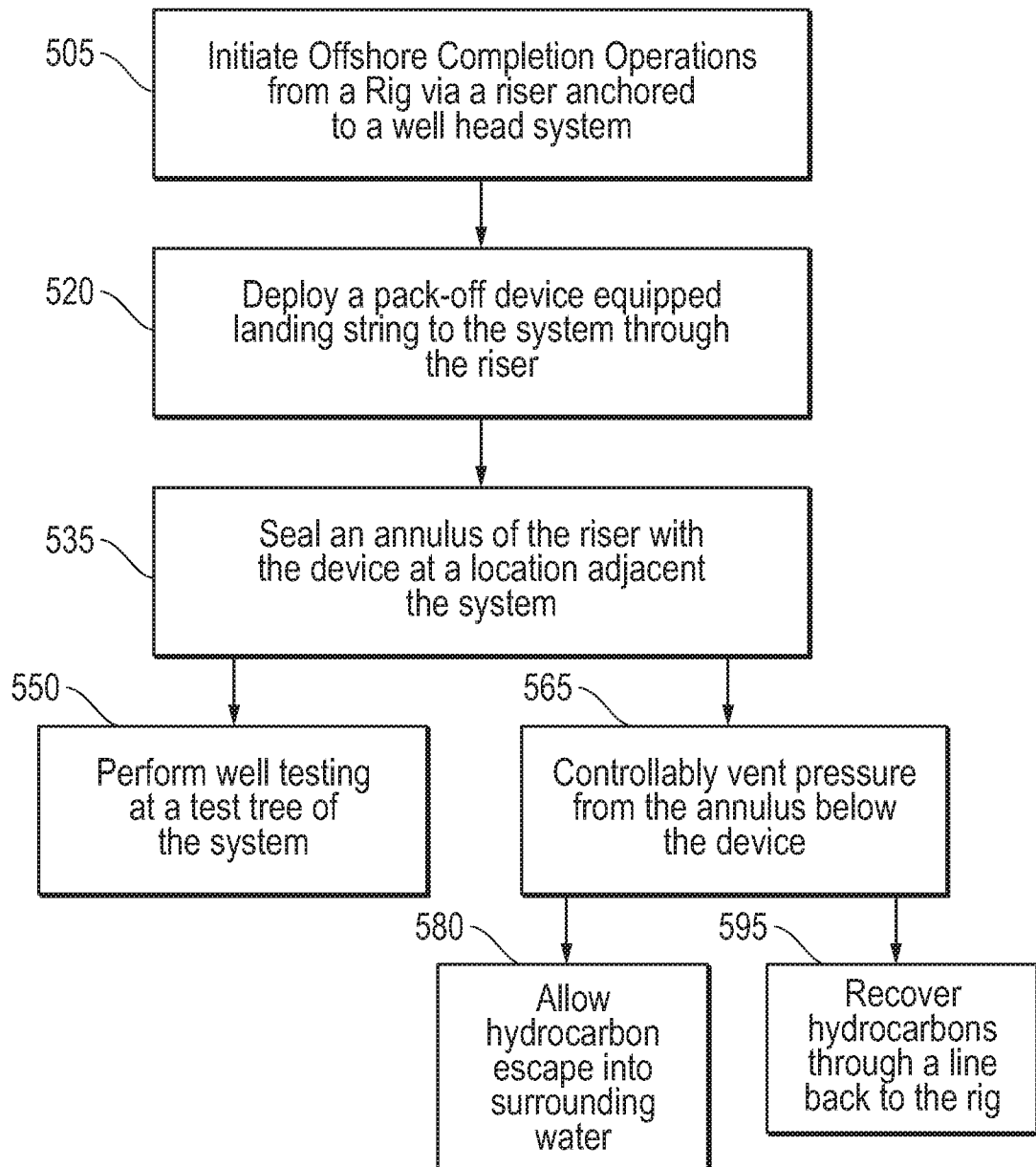


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/064625**A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/038(2006.01)i, E21B 47/001(2012.01)1, E21B 7/12(2006.01)1, E21B 49/00(2006.01)1**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 33/038; E21B 7/12; E21B 21/00; E21B 33/076; E21B; E21B 33/064

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: pack, riser, string, burst**c. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	W0 2004-055316 A2 (NIVENS, H. W. et al.) 01 July 2004 See abstract, page 7 lines 3-13, and claims 1 and 2, and figure 1.	1-10
A	US 2003-0145994 A1 (NICHOLAS GATHERAR et al.) 07 August 2003 See abstract, paragraphs [0045]-[0050], and figures 1-5.	1-10
A	W0 86-02696 A1 (ROCHE, J. R.) 09 May 1986 See abstract and figures 1 and 2.	1-10

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Korean Intellectual Property Office
189 Cheongsu-ro, Seo-gu, Daejeon Metropolitan
City, 302-701, Republic of Korea

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Authorized officer

PARK, Sang Hyun

Telephone No. 82-42-481-5434



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