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Other: **SEARCH-PATENT**

(54) Title of the Invention: **Surge control system for managed pressure drilling operations**
Abstract Title: **Surge control system for managed pressure drilling operations**

(57) A managed pressure drilling (MPD) system (58, Fig 1) including a work string 30 including tubulars having an internal flow path 54. The work string supports a liner string (50, Fig 1) which terminates in a liner float (52, Fig 2C). A liner hanger running tool (62, Fig 1) is coupled to the work string uphole of the liner float. A surge control sub is arranged uphole of the liner hanger running tool. A MPD sub 200 is coupled to the work string and is operable to close off the internal flow path to fluid pressure passing uphole from the liner float in a first position during MPD operations and opens the internal flow path to fluid pressure after the liner string reaches a target depth. The MPD sub includes a housing 78 having an uphole end, a downhole end and a rotatable ball valve 98 including a ball portion 100 arranged between the uphole end and downhole end. A ball seat 88 is arranged between the rotatable ball valve and the downhole end, and a ball engagement member 114 arranged between the rotatable ball valve and the uphole end. The ball engagement member includes a seal component 140 that engages the ball portion.

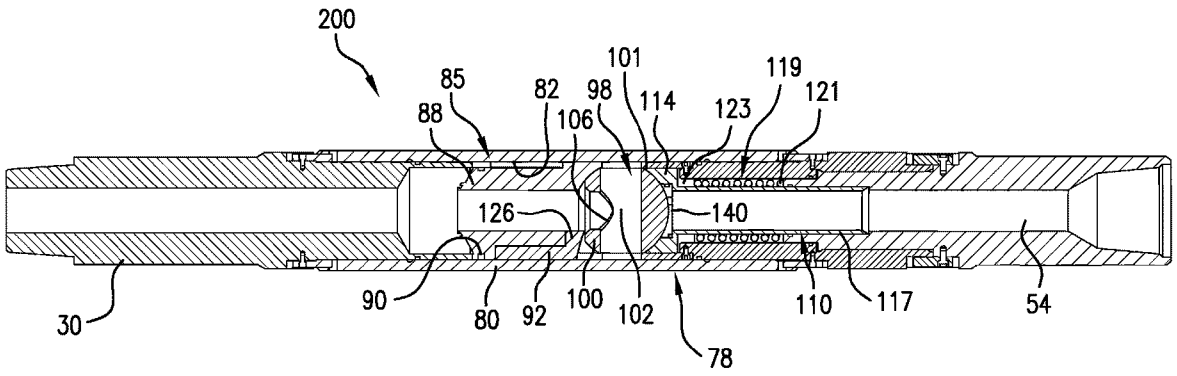

FIG.5

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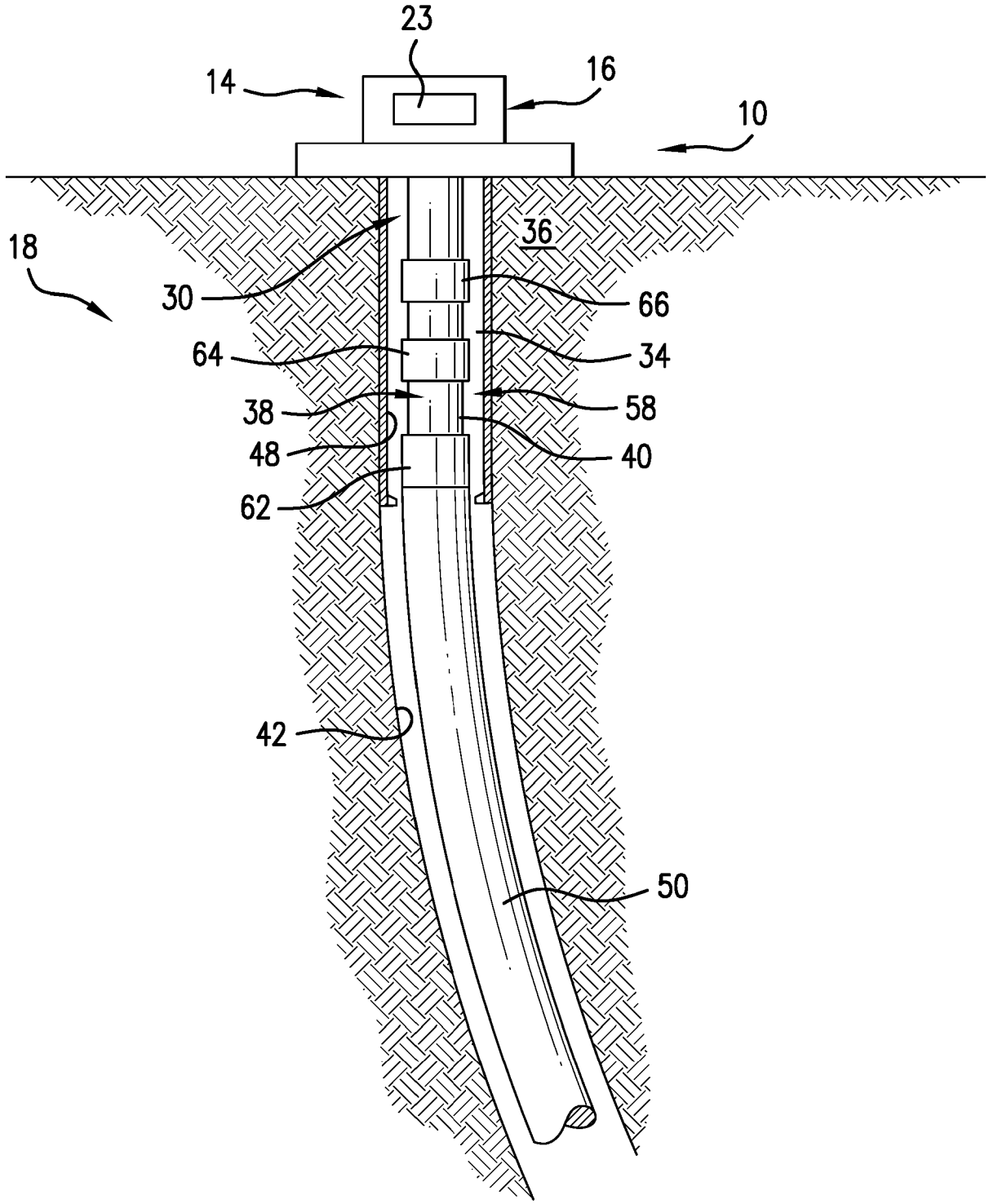

FIG. 1

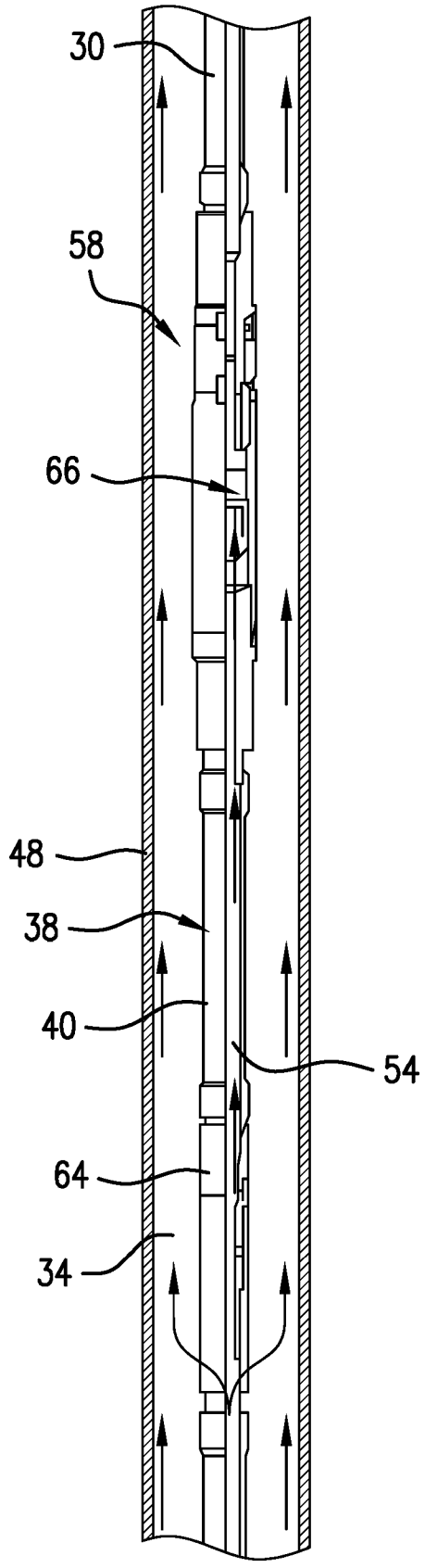

FIG.2A

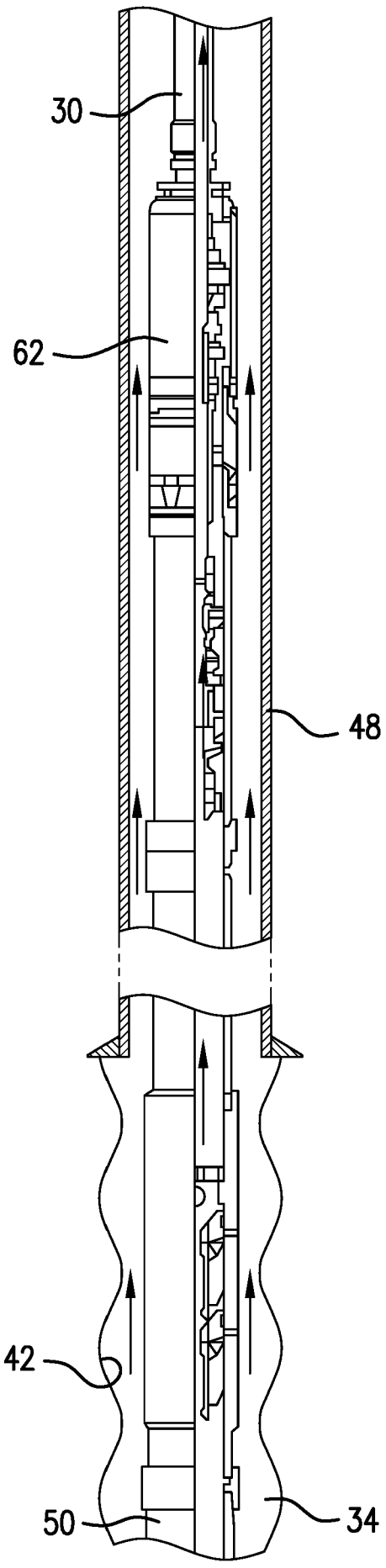

FIG.2B

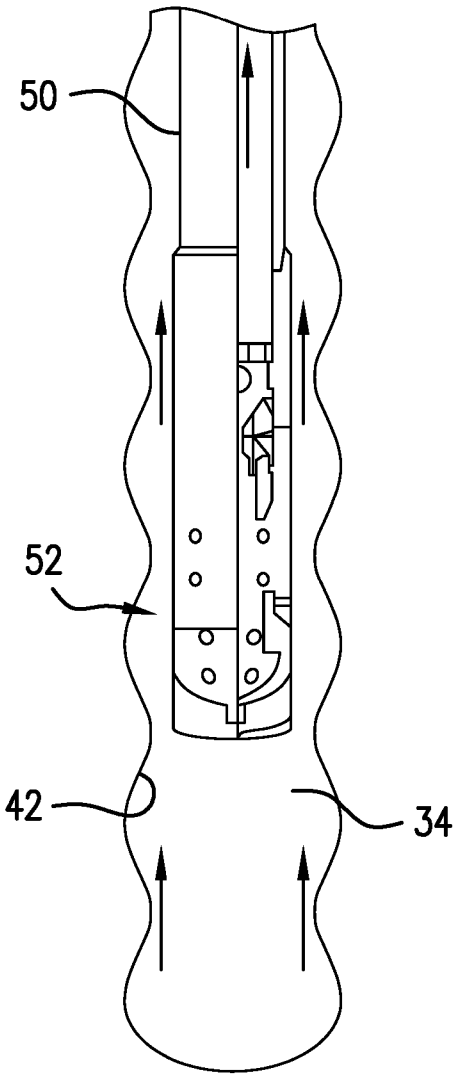

FIG.2C

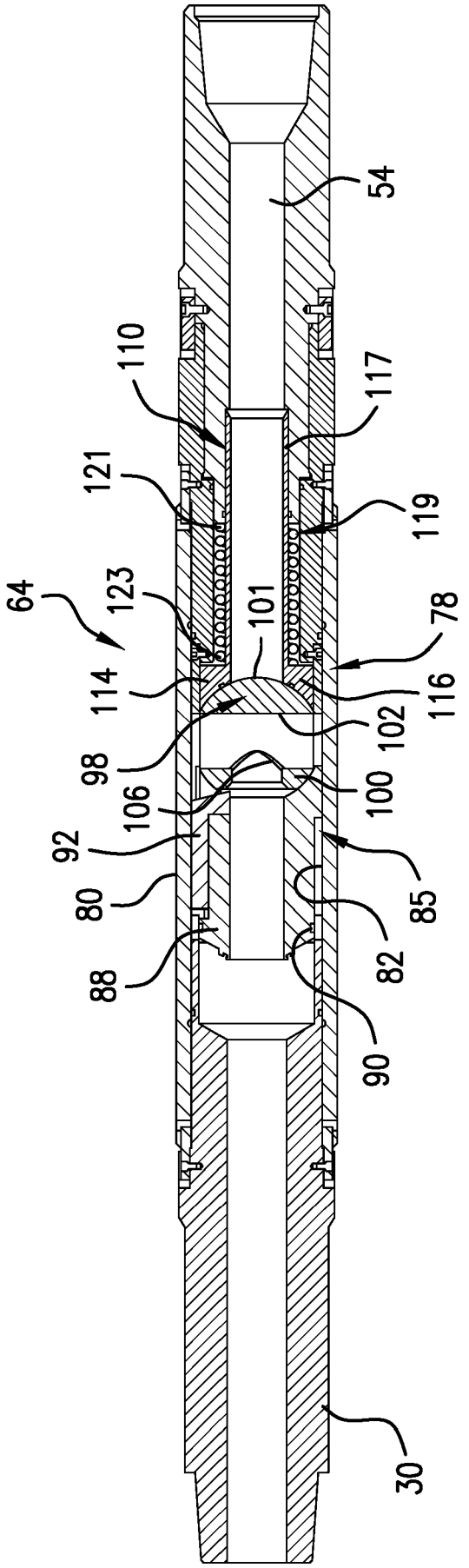
54
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FIG.3

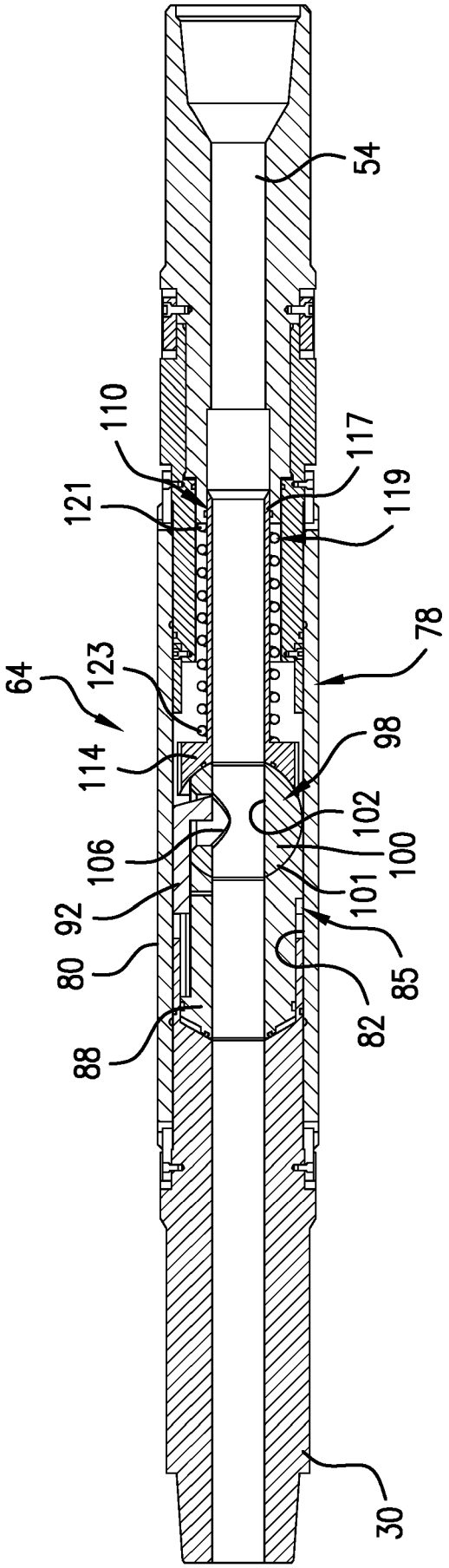
54
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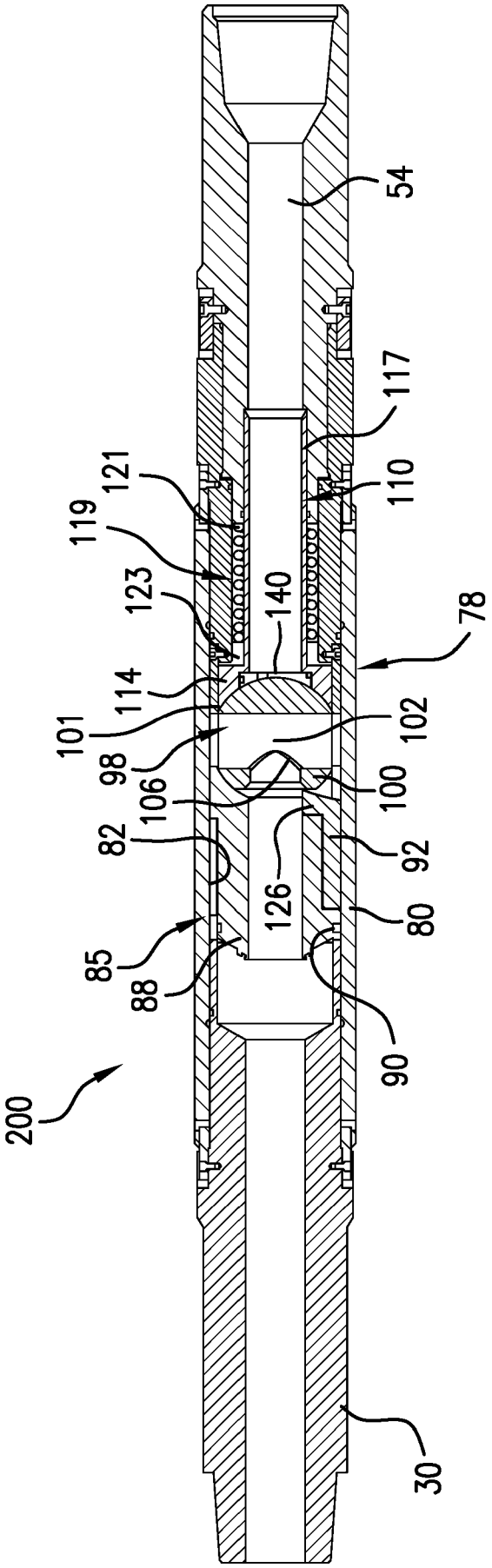
FIG.4


54
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140
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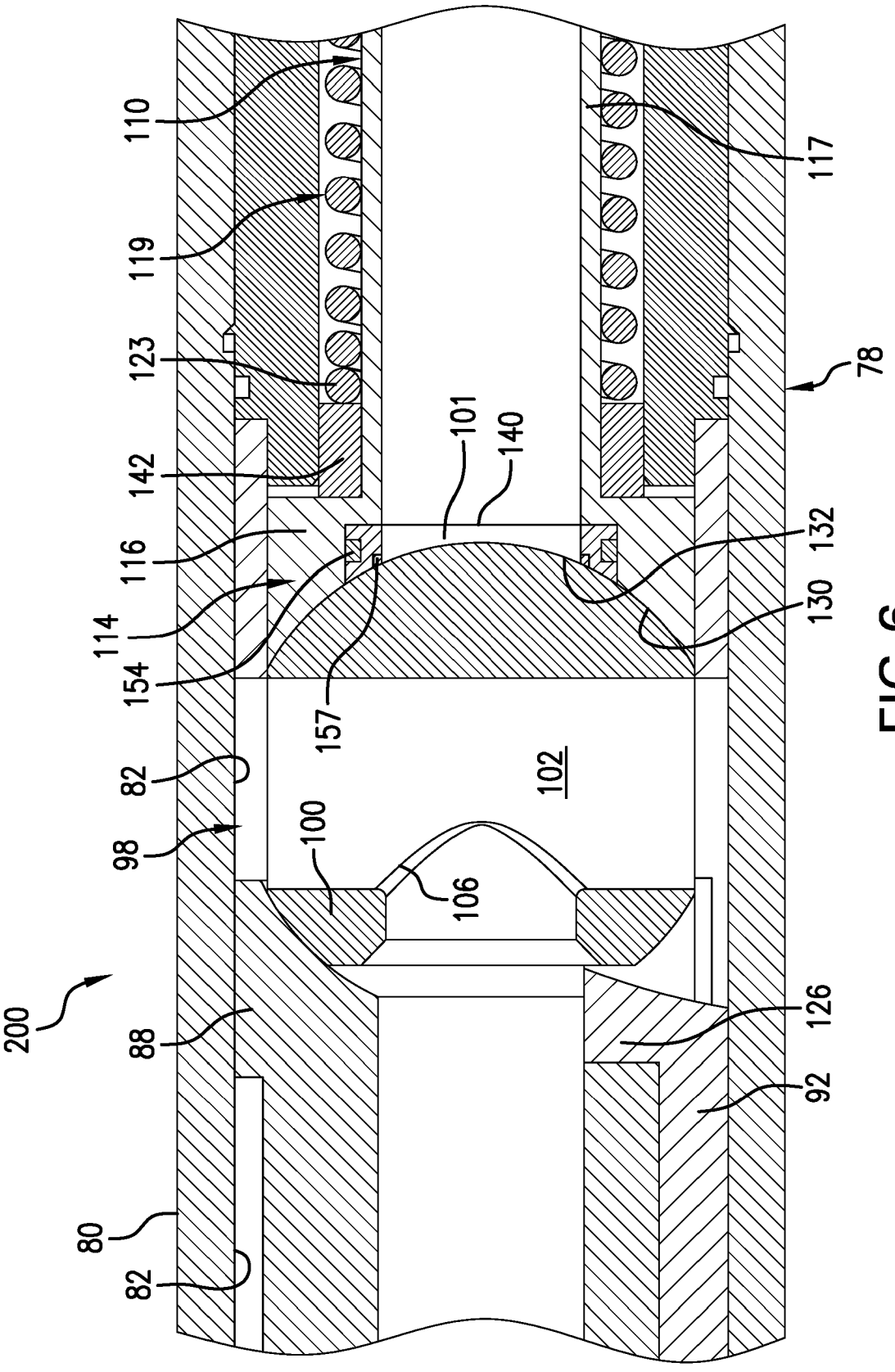
200
30

FIG.5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142
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154
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80
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200

FIG.6

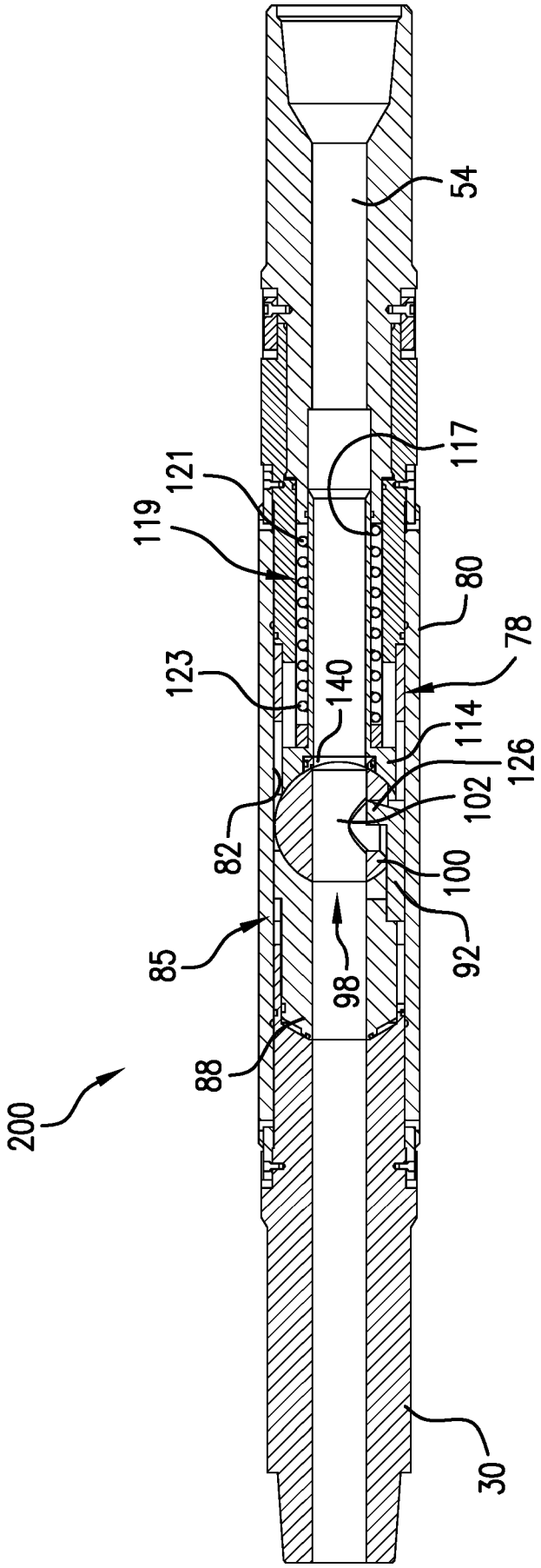
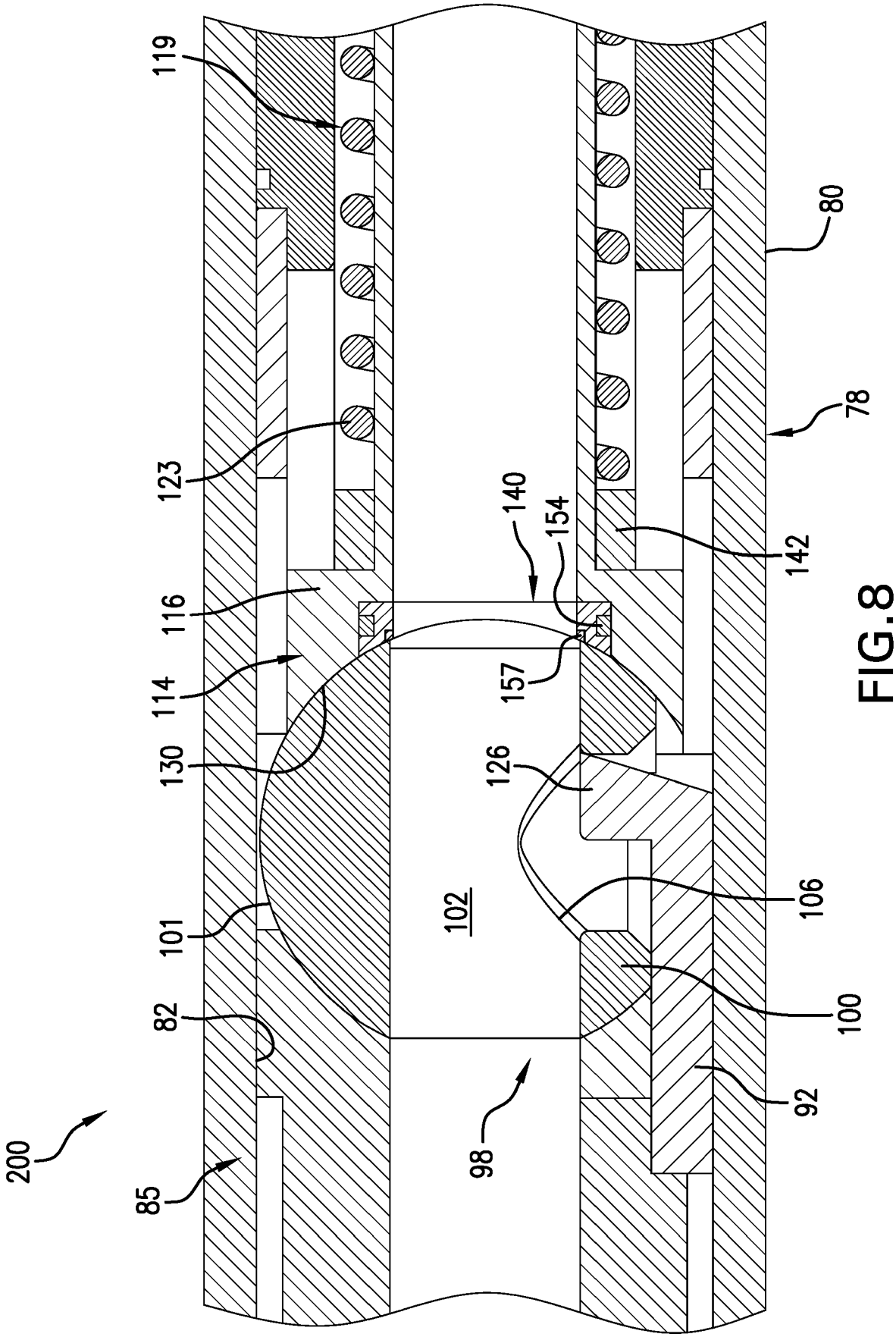


FIG. 7


119
80
78
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140
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142
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114
157
130
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101
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200

FIG.8

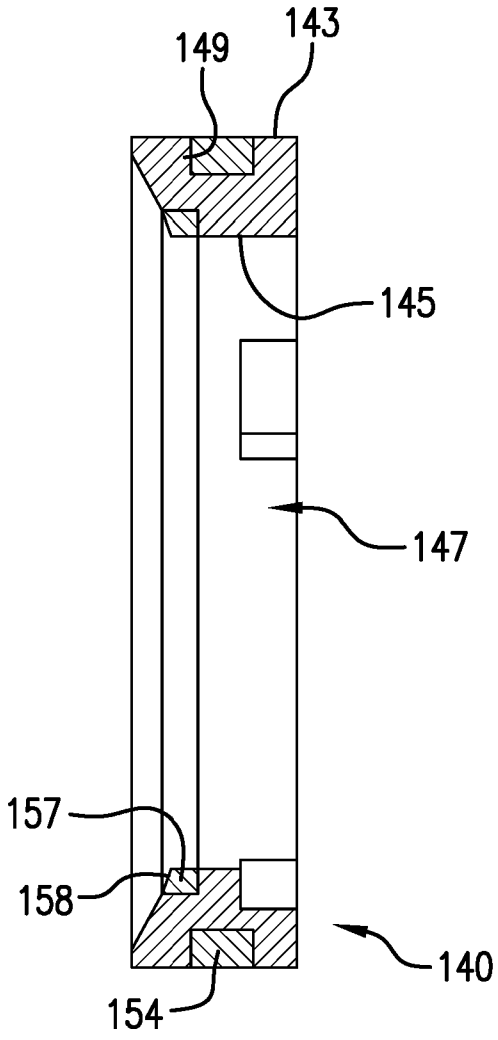

FIG.9

SURGE CONTROL SYSTEM FOR MANAGED PRESSURE DRILLING OPERATIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation in Part of U.S. Application Serial no. 16/996,085 filed August 18, 2020, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] In the resource recovery industry managed pressure drilling is often used in order to reduce forces on a formation. During a managed pressure drilling (MPD) operation, drillers manage wellbore pressure constrained by formation property limits. Annular pressure is maintained slightly above pore pressure to prevent an influx of formation fluids into the wellbore and below fracture pressure by using hydrostatic pressure created by the wellbore fluid combined with added applied pressure down the annulus to create a downhole combined pressure that exceeds pore pressure, but stays below fracture gradient. The applied pressure down the annulus, if left unchecked, will force fluid up the work string and onto the drill floor/top drive/mud handling system.

[0003] Currently, fluid flow up the work string is controlled by utilizing a drill-pipe float check valve during drilling operations and casing float during casing operations. It is desirable to control surge pressure during an MPD operation in order to prevent fracturing/damaging the open formation in the well bore. With conventional liner running operations, the use of a conventional casing float places undesirable stresses on the formation due to a large volume of fluid that is being displaced by the casing. In addition, the passing drill pipe through the casing creates an additional source of increased pressure.

[0004] Formation surface effects create stresses on the formation that could lead to undesirable fracture gradient breakdown. While running casing with an active MPD

system, there is a need to reduce formation surge effects while, at the same time, prevent mud from being pushed up the drillstring. Accordingly, the industry would be open to a system for reducing surge effects during an MPD operation.

SUMMARY

[0005] Disclosed is a managed pressure drilling (MPD) system including a work string including one or more tubulars having an internal flow path. The work string supports a liner string terminating in a liner float. A liner hanger running tool is coupled to the work string uphole of the liner string and the liner float. A selectively operable surge control sub is arranged uphole of the liner hanger running tool. A selectively operable MPD sub is coupled to the work string and is operable to close off the internal flow path to fluid pressure passing uphole from the liner float in a first position during MPD operations and opens the internal flow path to fluid pressure after the liner string reaches a target depth. The selectively operable MPD sub includes a housing having an uphole end, a downhole end and a rotatable ball valve including a ball portion arranged between the uphole end and the downhole end. A ball seat is arranged between the rotatable ball valve and the downhole end, and a ball engagement member arranged between the rotatable ball valve and the uphole end. The ball engagement member includes a seal component that engages the ball portion.

[0006] Also disclosed is a resource exploration and recovery system including a surface system including a managed pressure drilling controller, a host casing extending downhole into a wellbore, and a subsurface system including a work string extending through the host casing into the wellbore. The work string includes one or more tubulars having an internal flow path. The work string further includes a liner string and a liner float. A liner hanger running tool is coupled to the work string uphole of the liner string and the liner float. A selectively operable surge control sub is arranged uphole of the liner hanger running tool. A selectively operable MPD sub is coupled to the work string and is operable to close off the internal flow path to fluid pressure passing uphole from the liner float in a first position during MPD operations and opens the internal flow path to fluid pressure after the liner string reaches a target depth. The selectively operable MPD sub includes a housing having an uphole end, a

downhole end and a rotatable ball valve including a ball portion arranged between the uphole end and the downhole end. A ball seat is arranged between the rotatable ball valve and the downhole end, and a ball engagement member arranged between the rotatable ball valve and the uphole end. The ball engagement member includes a seal component that engages the ball portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0008] FIG. 1 depicts a resource exploration and recovery system having a managed pressure drilling (MPD) system, including an MPD sub, a surge control valve, and a liner hanger running tool, in accordance with an exemplary embodiment;

[0009] FIG. 2A depicts a first portion of a work string supporting the MPD sub, surge control valve and liner hanger running tool, in accordance with an exemplary aspect;

[0010] FIG. 2B depicts a second portion of the work string of FIG. 2A;

[0011] FIG. 2C depicts a third portion of the work string of FIG. 2A;

[0012] FIG. 3 depicts the MPD sub in a closed configuration for lowering a liner to a target depth, in accordance with an exemplary aspect;

[0013] FIG. 4 depicts the MPD sub of FIG. 3 in an open configuration for post MPD operations, in accordance with an exemplary aspect;

[0014] FIG. 5 depicts an MPD sub in accordance with another non-limiting example, in a closed configuration for lowering a liner to a target depth;

[0015] FIG. 6 is a detail view of a rotatable ball valve of the MPD sub of FIG. 5, in accordance with a non-limiting example;

[0016] FIG. 7 depicts the MPD valve of FIG. 5 in an open configuration for post MPD operations, in accordance with a non-limiting example;

[0017] FIG. 8 depicts the rotatable ball valve of the MPD sub of FIG. 7, in accordance with a non-limiting example; and

[0018] FIG. 9 depicts a seal component having an integrated ball valve seal, in accordance with a non-limiting example.

DETAILED DESCRIPTION

[0019] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0020] A resource exploration and recovery system, in accordance with an exemplary embodiment, is indicated generally at 10, in FIG. 1. Resource exploration and recovery system 10 should be understood to include well drilling operations, completions, resource extraction and recovery, CO_2 sequestration, and the like. Resource exploration and recovery system 10 may include a first system 14 which, in some environments, may take the form of a surface system 16 operatively and fluidically connected to a second system 18 which, in some environments, may take the form of a subsurface or downhole system (not separately labeled).

[0021] First system 14 may include a control system 23 that may provide power to, monitor, communicate with, and/or activate one or more downhole operations as will be discussed herein. Surface system 16 may include additional systems such as pumps, fluid storage systems, cranes and the like (not shown).

[0022] Second system 18 includes a work string 30 that extends into a wellbore 34 formed in a formation 36. Work string 30 may take the form of a managed pressure drilling (MPD) string 38 formed from a plurality of interconnected tubulars, one of which is indicated at 40. Wellbore 34 includes an annular wall 42 which may be defined by a surface of formation 36. A host casing 48 extends from first system 14 in a downhole direction. Work string 30 passes through host casing 48 and, as will be detailed herein, supports a liner string 50 that terminates in a liner float 52.

[0023] In an embodiment illustrated in FIGS. 2A-2C, work string 30 includes an internal flow path 54 that is fluidically connected to a managed pressure drilling (MPD) system 58. Internal flow path 54 extends through work string 30 from a liner hanger running tool 62 that is operable to install liner string 50 inside wellbore 34. Work string 30 also includes a selectively operable surge control valve 64 and a selectively operable MPD sub 66 arranged uphole of liner hanger running tool 62 within host casing 48. As will be detailed more fully herein, a selectively operable surge control valve 64 is positioned between selectively operable MPD sub 66 and liner hanger running tool 62. Selectively operable MPD sub 66 is operable to dissipate surge pressure during MPD operations. That is, selectively operable MPD sub 66 substantially prevents fluid pressure generated from MPD system 58 from passing uphole via internal flow path 54 to surface system 16.

[0024] In an embodiment illustrated in FIGS. 3 and 4, selectively operable MPD sub 66 includes a housing 78 having an outer surface 80 and an inner surface 82 that defines a valve chamber 85. A ball seat 88 is supported in valve chamber 85. Ball seat 88 is coupled to inner surface 82 through a shear member 90. A tripping member 92 is fixedly mounted relative to inner surface 82 radially outwardly of ball seat 88. Ball seat 88 includes a curvilinear surface (not separately labeled) that supports a rotatable ball valve 98. Rotatable ball valve 98 includes a ball portion 100 having an outer surface 101 and a central passage 102 that may be selectively aligned with internal flow path 54, and a recess 106 that is selectively receptive of tripping member 92.

[0025] Selectively operable MPD sub 66 is further shown to include an activation member 110 arranged uphole of rotatable ball valve 98. Activation member 110 includes a ball engagement member 114 having a ball engagement portion 116 including an internal curvilinear surface (not separately labeled) that engages outer surface 101 of ball portion 100. A conduit portion 117 extends axially outwardly and upwardly from ball engagement portion 116 of ball engagement member 114. A spring 119 extends about conduit portion 117. Spring 119 includes a first end 121 that engages a surface (also not separately labeled) within valve chamber 85 and a second end 123 that act upon ball engagement member 114.

[0026] In operation, liner string 50 is run into wellbore 34 on work string 30 with selectively operable MPD sub 66 in a closed configuration such as shown in FIG. 3. MPD system 58 remains active at surface to apply pressure via an external flow path (not separately labeled) to wellbore 34 to maintain a selected operating pressure. As liner string 50 progresses downhole, fluids are displaced upwardly. Selectively operable MPD sub 66 ensures that those fluids do not progress up internal flow path 54 beyond MPD system 58 and interfere with well operations at surface system 12.

[0027] Once liner string 50 has reached target depth in wellbore 34, selectively operable MPD sub 66 may be opened and selectively operable surge control valve 64 may be closed to circulate fluid down internal flow path 54 and back up an annulus defined between liner string 50 and annular wall 42 of wellbore 34 allowing conventional activation of liner hanger running tool 62 and any other tools below selectively operable MPD sub 66.

[0028] In an embodiment, pressure may be applied to ball portion 100 of rotatable ball valve 98 via conduit portion 117. The pressure acts on ball seat 88 via rotatable ball valve 98 causing shear member 90 to give way. Shear member 90 may break, shear, fracture or otherwise cease to be an impediment to the movement of ball seat 88. That is, once shear member 90 breaks, spring 119 acts on ball engagement member 114 forcing rotatable ball valve 98 downward. Recess 106 engages with tripping member 92 causing rotatable ball valve 98 to rotate such that central passage 102 aligns with internal flow path 54 thereby fluidically connecting MPD system 58 with surface system 16.

[0029] Reference will now follow to FIGS. 5-9, wherein like reference numbers represent corresponding parts in the respective views, in describing an MPD sub 200 in accordance with a non-limiting example. In a manner similar to that discussed herein, when at a selected depth, rotatable ball valve 98 is transitioned from a closed position as shown in FIGS. 5 and 6 to an open position as shown in FIGS. 7 and 8. Pressure is applied to ball portion 100 of rotatable ball valve 98 via conduit portion 117. The pressure acts on ball seat 88 via rotatable ball valve 98 causing shear member 90 to give way. At this point, spring 119 acts on ball engagement member

114 forcing rotatable ball valve 98 downward. Recess 106 engages with a radially inwardly directed projection 126 on tripping member 92 causing rotatable ball valve 98 to rotate such that central passage 102 aligns with internal flow path 54 thereby fluidically connecting MPD system 58 with surface system 16.

[0030] In a non-limiting example, ball engagement portion 116 of ball engagement member 114 includes a curvilinear surface 130 and a central recess 132. A seal component 140 is disposed in central recess 132. Seal component 140 is fit into central recess 132 and engages with outer surface 101 of ball portion 100. In a non-limiting example, when opened, seal component 140 engages outer surface 101 and prevents or substantially eliminates leakage from central passage 102 of ball portion 100. Ball engagement member 114 supports a spring spacer ring 142 that is disposed about conduit portion 117 and arranged between second end 123 of spring 119 and ball engagement member 114.

[0031] In a non-limiting example shown in FIG. 9, seal component 140 includes an outer surface section 143 and an inner surface section 145 that defines an opening 147. Once installed, opening 147 aligns with central passage 102. Outer surface section 143 includes an annular groove 149 that supports an O-ring 154. O-ring 154 engages with an inner surface (not separately labeled) of recess 132. That is, in a non-limiting example, seal component 140 is press-fit into central recess 132 with O-ring establishing a seal.

[0032] In a non-limiting example, a seal element 157 is integrated into seal component 140. That is, seal element 157 is bonded to seal component 140. In a non-limiting example, seal component is formed from a low alloy steel such as AISI 4140 steel and seal element 157 is formed from nitrile rubber. Seal element 157 includes an angled surface 158 that receives ball portion 100. In a non-limiting example, seal component 140 is formed from a first material and seal element 157 is formed from a second material that is distinct from the first material. Seal element 157 selectively engages an outer surface (not separately labeled) of ball portion 100. By integrating seal element 157 into seal component 140, a more robust flow path is established. That is, rotation of rotatable ball portion 100 does not unseat, dislodge,

or impart excessive wear on seal element 157 ensuring that fluid does not leak from rotatable ball valve 98.

[0033] Set forth below are some embodiments of the foregoing disclosure:

[0034] Embodiment 1. A managed pressure drilling (MPD) system comprising: a work string including one or more tubulars having an internal flow path, the work string supporting a liner string terminating in a liner float; a liner hanger running tool coupled to the work string uphole of the liner string and the liner float; a selectively operable surge control sub arranged uphole of the liner hanger running tool; and a selectively operable MPD sub coupled to the work string and being operable to close off the internal flow path to fluid pressure passing uphole from the liner float in a first position during MPD operations and opens the internal flow path to fluid pressure after the liner string reaches a target depth, wherein the selectively operable MPD sub includes a housing having an uphole end, a downhole end and a rotatable ball valve including a ball portion arranged between the uphole end and the downhole end, a ball seat arranged between the rotatable ball valve and the downhole end, and a ball engagement member arranged between the rotatable ball valve and the uphole end, the ball engagement member including a seal component that engages the ball portion.

[0035] Embodiment 2. The MPD system according to any prior embodiment, wherein the seal component includes an outer surface section and an inner surface section, the outer surface section including a groove supporting an O-ring.

[0036] Embodiment 3. The MPD system according to any prior embodiment, wherein the ball engagement member includes a recess, the seal component being installed in the recess.

[0037] Embodiment 4. The MPD system according to any prior embodiment, wherein the seal component includes a seal element having an angled surface that is receptive of the ball portion.

[0038] Embodiment 5. The MPD system according to any prior embodiment, wherein the seal element is bonded to the seal component.

[0039] Embodiment 6. The MPD system according to any prior embodiment, wherein the seal component is formed from a first material and the seal element is formed from a second material that is distinct from the first material.

[0040] Embodiment 7. The MPD system according to any prior embodiment, wherein the first material is steel and the second material is nitrile rubber.

[0041] Embodiment 8. The MPD system according to any prior embodiment, wherein the ball engagement member includes a ball engagement portion and a conduit portion extending from the ball engagement portion, and a spring that extends about the conduit portion.

[0042] Embodiment 9. The MPD system according to any prior embodiment, further comprising: a pressure balancing ring disposed about the conduit portion between the ball engagement portion and the spring.

[0043] Embodiment 10. The MPD system according to any prior embodiment, wherein the selectively operable MPD sub includes a tripping member arranged between the rotatable ball valve and the downhole end and the ball portion includes a recess receptive of the tripping member.

[0044] Embodiment 11. A resource exploration and recovery system comprising: a surface system including a managed pressure drilling controller; a host casing extending downhole into a wellbore; a subsurface system including a work string extending through the host casing into the wellbore, the work string including one or more tubulars having an internal flow path, the work string including a liner string and a liner float; a liner hanger running tool coupled to the work string uphole of the liner string and the liner float; a selectively operable surge control sub arranged uphole of the liner hanger running tool; and a selectively operable MPD sub coupled to the work string and being operable to close off the internal flow path to fluid pressure passing uphole from the liner float in a first position during MPD operations

and opens the internal flow path to fluid pressure after the liner string reaches a target depth, wherein the selectively operable MPD sub includes a housing having an uphole end, a downhole end and a rotatable ball valve including a ball portion arranged between the uphole end and the downhole end, a ball seat arranged between the rotatable ball valve and the downhole end, and a ball engagement member arranged between the rotatable ball valve and the uphole end, the ball engagement member including a seal component that engages the ball portion.

[0045] Embodiment 12. The resource exploration and recovery system according to any prior embodiment, wherein the seal component includes an outer surface section and an inner surface section, the outer surface section including a groove supporting an O-ring.

[0046] Embodiment 13. The resource exploration and recovery system according to any prior embodiment, wherein the ball engagement member includes a recess, the seal component being installed in the recess.

[0047] Embodiment 14. The resource exploration and recovery system according to any prior embodiment, wherein the seal component includes a seal element having an angled surface that is receptive of the ball portion.

[0048] Embodiment 15. The resource exploration and recovery system according to any prior embodiment, wherein the seal element is bonded to the seal component.

[0049] Embodiment 16. The resource exploration and recovery system according to any prior embodiment, wherein the seal component is formed from a first material and the seal element is formed from a second material that is distinct from the first material.

[0050] Embodiment 17. The resource exploration and recovery system according to any prior embodiment, wherein the first material is steel and the second material is nitrile rubber.

[0051] Embodiment 18. The resource exploration and recovery system according to any prior embodiment, wherein the ball engagement member includes a ball

engagement portion and a conduit portion extending from the ball engagement portion, and a spring that extends about the conduit portion.

[0052] Embodiment 19. The resource exploration and recovery system according to any prior embodiment, further comprising: a pressure balancing ring disposed about the conduit portion between the ball engagement portion and the spring.

[0053] Embodiment 20. The resource exploration and recovery system according to any prior embodiment, wherein the selectively operable MPD sub includes a tripping member arranged between the rotatable ball valve and the downhole end and the ball portion includes a recess receptive of the tripping member.

[0054] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Further, it should be noted that the terms "first," "second," and the like herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another.

[0055] The terms "about" and "substantially" are intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application. For example, "about" and/or "substantially" can include a range of ± 8% or 5%, or 2% of a given value.

[0056] The teachings of the present disclosure may be used in a variety of well operations. These operations may involve using one or more treatment agents to treat a formation, the fluids resident in a formation, a wellbore, and / or equipment in the wellbore, such as production tubing. The treatment agents may be in the form of liquids, gases, solids, semi-solids, and mixtures thereof. Illustrative treatment agents include, but are not limited to, fracturing fluids, acids, steam, water, brine, anti-corrosion agents, cement, permeability modifiers, drilling muds, emulsifiers, demulsifiers, tracers, flow improvers etc. Illustrative well operations include, but are not limited to, hydraulic fracturing, stimulation, tracer injection, cleaning, acidizing, steam injection, water flooding, cementing, etc.

[0057] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited.

What is claimed is:

1. A managed pressure drilling (MPD) system (58) comprising:

a work string (30) including one or more tubulars having an internal flow path (54), the work string (30) supporting a liner string (50) terminating in a liner float (52);

a liner hanger running tool (62) coupled to the work string (30) uphole of the liner string (50) and the liner float (52);

a selectively operable surge control sub arranged uphole of the liner hanger running tool (62); and

a selectively operable MPD sub (66) coupled to the work string (30) and being operable to close off the internal flow path (54) to fluid pressure passing uphole from the liner float (52) in a first position during MPD operations and opens the internal flow path (54) to fluid pressure after the liner string (50) reaches a target depth, wherein the selectively operable MPD sub (66) includes a housing (78) having an uphole end, a downhole end and a rotatable ball valve (98) including a ball portion (100) arranged between the uphole end and the downhole end, a ball seat (88) arranged between the rotatable ball valve (98) and the downhole end, and a ball engagement member (114) arranged between the rotatable ball valve (98) and the uphole end, the ball engagement member (114) including a seal component (140) that engages the ball portion (100).

2. The MPD system (58) according to claim 1, wherein the seal component (140) includes an outer surface section (143) and an inner surface section (145), the outer surface section (143) including a groove supporting an o-ring (154).

3. The MPD system (58) according to claim 2, wherein the ball engagement member (114) includes a recess (106), the seal component (140) being installed in the recess (106).

4. The MPD system (58) according to claim 2, wherein the seal component (140) includes a seal element (157) having an angled surface (158) that is receptive of the ball portion (100).

5. The MPD system (58) according to claim 4, wherein the seal element (157) is bonded to the seal component (140).

6. The MPD system (58) according to claim 4, wherein the seal component (140) is formed from a first material and the seal element (157) is formed from a second material that is distinct from the first material.

7. The MPD system (58) according to claim 6, wherein the first material is steel and the second material is nitrile rubber.

8. The MPD system (58) according to claim 1, wherein the ball engagement member (114) includes a ball engagement portion (116) and a conduit portion (117) extending from the ball engagement portion (116), and a spring (119) that extends about the conduit portion (117).

9. The MPD system (58) according to claim 8, further comprising: a pressure balancing ring disposed about the conduit portion (117) between the ball engagement portion (116) and the spring (119).

10. The MPD system (58) according to claim 1, wherein the selectively operable MPD sub (66) includes a tripping member (92) arranged between the rotatable ball valve (98) and the downhole end and the ball portion (100) includes a recess (106) receptive of the tripping member (92).

Intellectual Property Office

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Claims searched:	1-10	**Date of search:**	28 February 2024

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-10	GB2601596 A (BAKER HUGHES) See Figures for a managed pressure drilling system 58 with a managed pressure drilling sub 66 and a rotatable ball valve 98.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

E21B

The following online and other databases have been used in the preparation of this search report

SEARCH-PATENT

International Classification:

Subclass	Subgroup	Valid From
E21B	0021/10	01/01/2006
E21B	0021/08	01/01/2006
E21B	0034/06	01/01/2006