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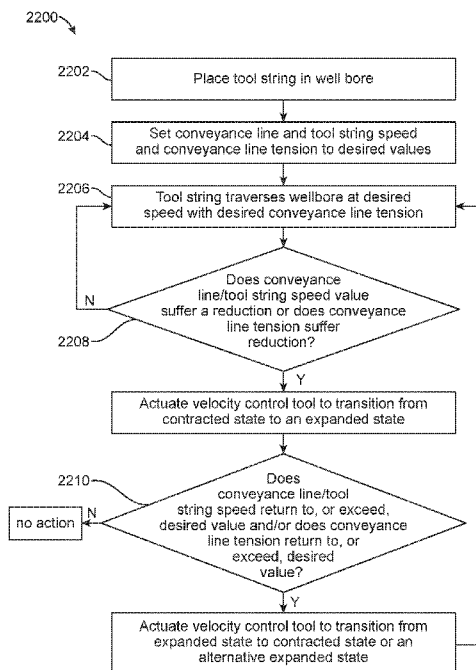


FIG. 22

(57) Abstract: A downhole tool velocity control apparatus includes a body having a portion with static circumferential diameter and a portion with a variable circumferential diameter. The portion with variable circumferential diameter has at least one velocity control member extendible radially beyond the portion with the static diameter. A method of varying the force applied by a fluid to a tool string includes traversing a tool string through a well bore using a pump fluid, the pump fluid applying a force on the tool string, monitoring a tool string characteristic, and actuating a downhole tool velocity control apparatus of the tool string to variably expand radially in response to a change in the tool string characteristic.

TITLE

APPARATUS, METHOD AND SYSTEM FOR REGULATING ANNULAR FLUID
FLOW AROUND A TOOL STRING

FIELD

5 [0001] The present disclosure relates to an apparatus, method and
system for regulating the rate of movement of a tool string in a downhole
environment. More particularly, the present disclosure relates to a downhole
tool velocity control apparatus having a portion with variable circumferential
diameter having a velocity control member which is variably extendible and
10 contractible radially to restrict or permit fluid flow in the annulus around the
downhole tool.

BACKGROUND

[0002] Various downhole tools for completion, stimulation, diagnostic
logging and other applications can be incorporated in a tool string and
15 attached to a conveyance line (for example, wirelines, slicklines and coiled
tubing) for disposing downhole into a wellbore. In some cases, the tools
must be pumped to a target zone within a hydrocarbon-producing well using
hydraulic pressure applied from the surface of the well. Pump down
operations in vertical, horizontal, or deviated wells can be frustrated by
20 materials such as sand, mud, wellbore debris, or other obstructions which
have accumulated or are otherwise disposed within the well or casing string.
When the tool string reaches such downhole obstructions, it will generally
slow down or completely cease to traverse the well bore.

[0003] Slowing or stopping of the tool string results in an increase in
25 hydraulic pressure above, or uphole with respect to, the tool string. In some
instances, the increased hydraulic pressure forces or impels the tool string
through the downhole obstruction. In such instances, the force of the

surface pump on the tool can result in the tool string, or tools on the tool string, being severed from or “pumped-off” the conveyance line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Implementations of the present technology will now be described,
5 by way of example only, with reference to the attached figures, wherein:

[0005] FIG. 1 is an overview diagram of the equipment for use in placement of a tool string downhole in a wellbore in accordance with an exemplary embodiment of the present disclosure;

[0006] FIG. 2 is a side view of a tool string having a perforation tool and
10 a velocity control tool in accordance with an exemplary embodiment of the present disclosure;

[0007] FIG. 3 is a side view of a tool string having various logging tools and a velocity control tool in accordance with an exemplary embodiment of the present disclosure;

[0008] FIG. 4 is a side view of the velocity control tool of FIGS. 1-3 in
15 accordance with an exemplary embodiment of the present disclosure;

[0009] FIG. 5 is a cross-sectional view of a velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0010] FIG. 6 is a cross-sectional view of the velocity control tool of FIG.
20 5 in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0011] FIG. 7 is a top plan view of a velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0012] FIG. 8 is a top plan view of another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0013] FIG. 9 is a cross-sectional view of another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0014] FIG. 10 is a cross-sectional view of yet another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0015] FIG. 11 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0016] FIG. 12 is a cross-sectional view of the velocity control tool of FIG. 11 in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0017] FIG. 13 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0018] FIG. 14 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0019] FIG. 15A is a cross-sectional view of another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0020] FIG. 15B is a cross-sectional view of the velocity control tool of FIG. 15A in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0021] FIG. 16 is a top plan view of the velocity control tool of FIGS. 15A-B in an expanded configuration in accordance with an exemplary embodiment of the present disclosure

[0022] FIG. 17A is a cross-sectional view of another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure;

[0023] FIG. 17B is a cross-sectional view of the velocity control tool of FIG. 17A in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0024] FIG. 18 is a top plan view of the velocity control tool of FIGS. 17A-B in an expanded configuration in accordance with an exemplary embodiment of the present disclosure;

[0025] FIG. 19 is a block diagram of a computing device in accordance with certain embodiments of the present disclosure;

[0026] FIG. 20 is a block diagram of a tool string conveyance control system in accordance with certain embodiments of the present disclosure;

[0027] FIG. 21 is a block diagram of another tool string conveyance control system in accordance with certain embodiments of the present disclosure; and

[0028] FIG. 22 is a block diagram of a method for controlling the velocity of a tool string as it traverses a well bore in accordance with certain embodiments of the present disclosure.

[0029] It should be understood that the various aspects are not limited to the arrangements and instrumentality shown in the drawings.

DETAILED DESCRIPTION

[0030] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale and the proportions of certain parts have been exaggerated to better illustrate details and features of the present disclosure.

[0031] In the following description, terms such as "upper," "upward," "uphole," "lower," "downward," "above," "below," "downhole," "longitudinal," "lateral," and the like, as used herein, shall mean in relation to the bottom or furthest extent of, the surrounding wellbore even though the wellbore or portions of it may be deviated or horizontal. Correspondingly, the transverse, axial, lateral, longitudinal, radial, etc., orientations shall mean orientations relative to the orientation of the wellbore or apparatus. Additionally, the illustrated embodiments are illustrated such that the

orientation is such that the right-hand side or bottom of the page is downhole compared to the left-hand side, and the top of the page is toward the surface, and the lower side of the page is downhole. Furthermore, the term "proximal" refers directionally to portions further toward the surface in relation to the term "distal" which refers directionally to portions further downhole and away from the surface in a wellbore.

[0032] Several definitions that apply throughout this disclosure will now be presented. The term "coupled" is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The term "communicatively coupled" is defined as connected, either directly or indirectly through intervening components, and the connections are not necessarily limited to physical connections, but are connections that accommodate the transfer of data between the so-described components. The connections can be such that the objects are permanently connected or releasably connected. The term "outside" refers to a region that is beyond the outermost confines of a physical object. The term "axially" means substantially along a direction of the axis of the object. If not specified, the term axially is such that it refers to the longer axis of the object. The terms "comprising," "including" and "having" are used interchangeably in this disclosure. The terms "comprising," "including" and "having" mean to include, but are not necessarily limited to, the things so described. A "processor" as used herein is an electronic circuit that can make determinations based upon inputs. A processor can include a microprocessor, a microcontroller, and/or a central processing unit, among others. While a single processor can be used, the present disclosure can be implemented using a plurality of processors.

[0033] FIG. 1 is an overview diagram of the equipment for use in placement of a tool string downhole in a wellbore in accordance with an

exemplary embodiment. The system 100 includes surface equipment above the ground surface 105 and a well bore 150 and its related equipment and instruments below the ground surface 105. Surface equipment provides power, material, and structural support for the operation of a pump down tool string 200. In FIG. 1, the surface equipment includes a rig 102 and associated equipment and a conveyance line 111 and a control truck 115. The rig 102 can include equipment such as a rig pump 122 disposed proximal to the rig 102. The rig 102 can include equipment used for logging, perforation, completion, production, mudlogging or other applications such as a tool lubrication assembly 104 and a pack off pump 120. In some instances, a blowout preventer 103 can be coupled with a casing head 106 which is coupled with an upper end of a well casing 114. The rig pump 122 provides pressurized fluid to the rig 102 which is directed downhole in the well bore 150.

[0034] The well bore 150 extends from the ground surface 105 into the earth 110 and passes through one or more subterranean formations 107 forming a vertical portion 147 of the well bore 150. As illustrated in FIG. 1, as the well bore 150 penetrates the formations 107, a deviated path can be formed, which can include a substantially horizontal portion 148. The well bore 150 can be reinforced with one or more well casing 114. An annulus 160 is formed between the well casing 114 and the tool string 200.

[0035] The tool string 200 is attached to a conveyance line 111 via a cable head 211 (See FIG. 2). The conveyance line 111 can be, for example, a cable or wireline, a slickline or coiled tubing. Conveyance of the tool string 200 downhole in the well bore 150 can be accomplished by force of gravity due to the weight of the tool string 200. In many instances however, conveyance of the tool string 200 downhole in the well bore 150 is accomplished by pumping a fluid from the rig pump 122 into the well bore

150 to assist movement of the tool string 200 downhole via application of fluid pressure on the tool string 200. As the tool string 200 is pumped downhole by the fluid, the conveyance line 111 is spooled out from the truck 115 or by the truck 115 from a conveyance line spool located adjacent to or
5 coupled with the truck 115. A conveyance line tension sensing device 117 can be located between the truck 115 and the rig 102 to provide conveyance line tension data. A conveyance line speed sensing device 119 can also be located between the truck 115 and the rig 102 to provide conveyance line speed data.

10 [0036] One of ordinary skill will appreciate that, while FIG. 1 depicts an onshore operation, the present disclosure is equally well-suited for use in offshore operations.

[0037] FIG. 2 is a side view of a tool string having a perforation tool and a velocity control tool in accordance with an exemplary embodiment. The
15 velocity control tool can also be referred to as an annulus fluid flow restriction tool. As illustrated, the tool string 200a is located in a portion of the well bore 150 having well casing 114, and the tool string 200a is separated from the well casing 114 by the annulus 160. Portions of the well casing 114, when the well casing 114 is, for example, a length of piping, the
20 portions are coupled with casing collars 116. The casing collars 116 add mass to the well casing 114 at connection points of lengths of piping and such a change in mass can be measured or otherwise detected using a casing collar locator 220 and a gamma ray tool 231.

[0038] FIG. 3 is a side view of a tool string having various logging tools
25 and a velocity control tool in accordance with an exemplary embodiment. As illustrated, the tool string 200b is located in a portion of the well bore 150 having well casing 114, and the tool string 200b is separated from the well casing 114 by the annulus 160. Portions of the well casing 114, when the

well casing 114 is, for example, a length of piping, the portions are coupled with casing collars 116. The casing collars 116 add mass to the well casing 114 at connection points of lengths of piping and such a change in mass can be measured or otherwise detected using a casing collar locator 220 and a
5 gamma ray tool 231.

[0039] The tool strings 200a, 200b are securely coupled with the conveyance line 111 by the cable head 211. The cable head 211 can be composed of, at least in part, a rope socket or other means of coupling the conveyance line 111 to the tool strings 200a, 200b as known to one of skill
10 in the art. Characteristics of the tool strings 200a, 200b include the tension and speed of the tool string 200a, 200b and indirectly, the conveyance line 111. The tool strings 200a, 200b include a downhole conveyance line tension sensing device 213 and a downhole tool string speed sensing device 215. The downhole tool string speed sensing device 215 can be, for
15 example, an accelerometer. The tool string 200b can have various logging tools coupled therewith such as a telemetry gamma ray tool 231, a density neutron logging tool 241, a borehole sonic array logging tool 251, and a compensated true resistivity tool array 251. The number or type of logging tools is not considered to be limited by this disclosure and other logging
20 tools can be added or substituted as known to one of skill in the art.

[0040] FIG. 4 is a side view of the velocity control tool of FIGS. 1-3 in accordance with an exemplary embodiment of the present disclosure. As illustrated, the velocity control tool 280 is coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 via coupling sections
25 410. The casing collar locator 220 and telemetry gamma ray tool 231 can be employed to determine depth control as well as the velocity of the velocity control tool 280 as it travels through the wellbore. The velocity control tool 280 includes upper and lower tapered sections 420 and 422,

each of which are coupled with a corresponding coupling section 410. The upper and lower sections 420, 422 are tapered such that they decrease in outer diameter from the corresponding coupling section 410 toward the center of velocity control tool 280. A velocity control member 430 is located
5 between the upper tapered section 420 and the lower tapered section 422. The upper and lower tapered sections 420 and 422 and coupling sections 410 have static diameters. The velocity control member 430 is further composed of a plurality of plates 432. In the contracted configuration, each of the plurality of plates 432 is situated relative to each other to form a
10 tubular body as illustrated in FIG. 4. Each of the plurality of plates 432 are coupled with the upper tapered section 420. Each of the plurality of plates 432 are coupled with the upper tapered section 420 such that they can be pivoted, deflected, or otherwise translated from the contracted configuration, wherein the plates are co-axial with the longitudinal axis of
15 the tool string 200, 200a, 200b, to an expanded configuration, wherein each of the plates are no longer coaxial with the longitudinal axis of the tool string 200, 200a, 200b. The plurality of plates 432 are therefore contractable and expandable radially about the body of the velocity control tool 280. Such radial expansion and contraction results in a velocity control member 430
20 having variable diameter.

[0041] Varying the diameter results in a decrease or increase in the size of the annulus 160 thereby resulting in a restriction or increase in fluid flow past the tool. When the diameter is increased, fluid is restricted and as a result the velocity control tool 280 may increase its velocity traveling
25 through the wellbore, and/or increase in tension on the conveyance line 111 or the tool string 200a, 200b itself. If a decrease in velocity is desired, or if tension on the conveyance line 111 or tool string 200a, 200b is too great, or if pressure in the wellbore is so great that a pump off may occur, the diameter of the velocity control tool 280 can be decreased, resulting in an

enlargement of the annulus 160 and an increase in flow of fluid. While the plurality of plates 432 can be employed to variably restrict fluid flow, any device can be used to vary the diameter and restrict flow, such as bladder(s) or pad(s) (discussed with respect to FIGS. 15A-18).

5 [0042] With respect to the plurality of plates 432, these can partially overlap each other. When the each of the plurality of plates 432 partially overlap each other, each plate 432 can be flat or slightly curved to be transitionable from the contracted configuration to an expanded configuration. In an expanded configuration, the plurality of plates 432 can
10 form a solid, substantially solid, or otherwise uniform ring extending beyond the outer diameter of velocity control tool 280 when in the contracted configuration, thereby increasing the effective outer diameter of the velocity control tool 280 when in an expanded configuration. Alternatively, each of the plurality of plates 432 does not overlap each other. In this instance,
15 each plate 432 has an arced surfaced which forms a portion of the tubular velocity control member 430 body. In each instance, overlapping or non-overlapping, the number of plates can be determined by one of skill in the art and can be based on considerations such as, for example, the desired outer diameter of the velocity control tool 280 in contracted and expanded
20 configurations, the amount of force or thrust able to be applied to each plate 432, design efficiency, and other considerations. Each plate 432 can be fabricated from a metal, a metal alloy, an inorganic-organic composite material, a woven or non-woven fabric material, or any other suitable material.

25 [0043] FIG. 5 is a cross-sectional view of a velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure. As illustrated, the velocity control tool 280 is coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 at

the upper and lower coupling sections 410 respectively. The velocity control tool 280 is coupled with the casing collar locator 220 via a recess 510 of the velocity control tool 280 designed to conformance fit a protrusion 520 of the casing collar locator 220, and is coupled with the telemetry gamma ray tool 231 via a recess 514 of the velocity control tool 280 designed to conformance fit a protrusion 522 of the gamma ray tool 231. The recesses 510 and 514 can extend along the entire circumference of the velocity control tool 280 or along in discrete portions of the circumference velocity control tool 280. The protrusions 520 and 522 can extend along the entire inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231, respectively, or along in discrete portions of the inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231. In alternative embodiments, the velocity control tool 280 can be coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 using threaded couplings, snap-lock couplings, or any other coupling means known to one of ordinary skill in the art.

[0044] The velocity control tool 280 has a central bar 540 extending therethrough. The central bar 540 includes upper and lower cylindrical portions 541 and a central block 542. The central block 542 includes a sloped surface 544 sloping inward in an uphole direction, a vertical surface 546, and a horizontal surface 548. The central block can be described as having a cylindrical portion bounded by the vertical surface 546 and the horizontal surface 548 and a frustoconical portion bounded by the sloped surface 544. In other instances, the central block 542 can have a polygonal portion bounded by the vertical surface 546 and the horizontal surface 548 with 3-8 vertical surfaces 546 and the same number of sloped surfaces 544, alternatively 3-6 vertical surfaces 546 and the same number of sloped surfaces 544, and alternatively 4-6 vertical surfaces 546 and the same number of sloped surfaces 544. For example, when the central block 542 is

defined by 3 vertical surfaces 546 and 3 sloped surfaces 544, the central block 542 can be described as having a triangular prismatic portion bounded by the 3 vertical surfaces 546 and the horizontal surface 548, and as having a pyramidal portion bounded by 3 sloped surfaces 544. Also for example, when the central block 542 is defined by 4 vertical surfaces 546 and 4 sloped surfaces 544, the central block 542 can be described as having a cubic portion bounded by the 3 vertical surfaces 546 and the horizontal surface 548, and as having a square pyramidal portion bounded by the 3 sloped surfaces 544. In yet other instances, the vertical surface(s) 546 can be omitted, resulting in a central block 542 having only 1 or more sloped surface(s) 544 and the horizontal surface 548.

[0045] The velocity control tool 280 further includes a plurality of linear actuation controllers 550. Each of the linear actuation controllers 550 includes an extending arm 552 and an abutment face 554. To each abutment face 554, an actuatable arm 570 is coupled therewith using a hinged or pivoting connection 560. The actuatable arm 570 has a major curved surface 572, for movement along the surface of sloped surface 544, and a plate engagement member 574, which is configured for movement along the interior surface of the plate 432. Each actuation controller 550 is at least partially supported to withstand torsion, flexion, bending, or other deleterious movement via a retention plate 556 located in the upper coupling section 410. As illustrated, each of the plurality of plates 432 are coupled with the upper tapered section 420 via a hinged or pivoting connection 534 and each of the plurality of plates 432 are not coupled with the lower tapered section 422. In alternative embodiments, the hinged or pivoting connection 534 can be in the form of a flexible but resilient material, such as, for example rubber, Kevlar[®], Tyvek[®], or similar material which is riveted or otherwise connected to the upper tapered section 420 and plates 432.

[0046] In FIG. 5, two linear actuation controllers 550 and two actuatable arms 570 are illustrated. In other instances, the velocity control tool 280 can have between 2-12 linear actuation controllers 550 and the same number of actuatable arms 570, alternatively between 2-8 linear actuation controllers 550 and the same number of actuatable arms 570, and alternatively between 3-6 linear actuation controllers 550 and the same number of actuatable arms 570. In yet other instances, the velocity control tool 280 can have a single actuation controller that encircles the upper cylindrical portion 541. In this instance, the single actuation controller can have between 2-12 extending arms 552 and abutment faces 554 coupled with the same number of actuatable arms 570, alternatively between 2-8 extending arms 552 and abutment faces 554 coupled with the same number of actuatable arms 570, and alternatively between 3-6 extending arms 552 and abutment faces 554 coupled with the same number of actuatable arms 570. In other instances, the number of actuatable arms and extending arms can be equal to the number of sloped surfaces 544 on central block 542 such as, for example, 1 sloped surface (frustoconical), three sloped surfaces (pyramidal), four sloped surfaces (square pyramidal), and so on as described above.

[0047] The linear actuation controllers 550 can be hydraulic, pneumatic, or electric pistons. Alternatively, the linear actuation controllers 550 can be composed of a casing, an internal biasing member (for example, a coiled spring), and an extending rod coaxial with and inside the biasing member. The casing is coupled, directly or indirectly, with the conveyance line and biases (that is, compresses) the biasing member in response to a pulling force of the conveyance line. Upon biasing of the biasing member, the extending rod will extend in a downhole direction and cause the corresponding actuatable arm 570 to move as described above. The above

described embodiments or linear actuation controllers are merely exemplary other actuation controllers known to one of ordinary skill can be used.

[0048] FIG. 6 is a cross-sectional view of the velocity control tool of FIG. 5 in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. Upon a decrease of conveyance line tension as indicated by one or both of the conveyance line tension sensing device 117 and the downhole conveyance line tension sensing device 213, or decrease in tool string speed as indicated by one or both of the conveyance line speed sensing device 119 and the downhole tool string speed sensing device 215, as described herein, the linear actuation controllers 550 can be actuated to extend their respective extending arms 552 to transition from the contracted configuration (FIG. 5) to an expanded configuration. As the extending arms 552 extend in a downhole direction, the actuatable arms 570 hingedly or pivotally coupled therewith will traverse the surface of the sloped surface 544 radially outward. As the actuatable arms 570 are pushed by the linear actuation controllers 550 to extend radially outward, the plates 432 will resultantly extend radially outward as illustrated to increase the effective outer diameter of the velocity control tool 280. The actuation of the linear actuation controllers 550 and resultant extension of the plates 432 radially outward can be an infinitely variable process, meaning that the plates 432 can be expanded to any state between the fully contracted configuration and the fully expanded configuration, resulting in an infinitely variable effective outer diameter of the velocity control tool 280.

[0049] FIG. 7 is a top plan view of a velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. In FIG. 7, the velocity control tool 280 comprises eight plates 732. In alternative embodiments, the velocity control tool 280 can comprise between 4 and 32 plates 732, alternatively between 6 and 16 plates 732,

and alternatively between 8 and 12 plates 732. In the contracted configuration, the plates 732 partially overlap each other as described in relation to FIG. 4 above. As illustrated, the plurality of plates 732 does not contact the well casing 114 when in an expanded configuration. As can be appreciated, the transitioning of the plurality of plates 732 from the contracted configuration to an expanded configuration increases the effective diameter of the velocity control tool 280, thereby reducing the size of the annulus 160 and restricting the flow of fluid downhole. The increased restriction results in an increase in velocity and/or increase in tension of the conveyance line or tool string, and/or pressure in the wellbore above the velocity control tool.

[0050] FIG. 8 is a top plan view of another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. In FIG. 8, the velocity control tool 280 comprises four plates 832. In alternative embodiments, the velocity control tool 280 can comprise between 2 and 16 plates 832, alternatively between 3 and 12 plates 832, and alternatively between 4 and 8 plates 832. In the contracted configuration, the plates 832 do not overlap each other as described in relation to FIG. 4 above. As illustrated, the plurality of plates 732 does not contact the well casing 114 when in an expanded configuration. As can be appreciated, the transitioning of the plurality of plates 832 from the contracted configuration to an expanded configuration increases the effective diameter of the velocity control tool 280, thereby reducing the size of the annulus 160 and restricting the flow of fluid downhole. This can have the effect of decreasing tension in the conveyance line or tool string, decreasing velocity and potentially avoiding pump off situations.

[0051] FIG. 9 is a cross-sectional view of another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of

the present disclosure. The velocity control tool 980 has a plurality of plates 982. Each plate 982 has a plurality of arms 984 extending from the outer surface of the plate 982 at a desired angle relative to the plate 982. The arms 984 increase the surface area of the plate 982, thereby allowing greater transfer of force or thrust from the fluid pumped from the surface downhole to the velocity control tool 980 and concomitantly to the tool string 200, 200a, 200b.

[0052] FIG. 10 is a cross-sectional view of yet another velocity control tool in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. The velocity control tool 1080 has plates 1082. Each plate 1082 has a plurality of protrusions 1084 extending from the outer surface of the plate 1082. The protrusions 1084 increase the surface area of the plate 1082, thereby allowing greater transfer of force or thrust from the fluid pumped from the surface downhole to the velocity control tool 1080 and concomitantly to the tool string 200, 200a, 200b.

[0053] FIG. 11 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure. The velocity control tool 1180 illustrated in FIG. 11 is structurally similar to the velocity control tool 280 as described with reference to FIG. 5. As with FIG. 5, the velocity control tool 1180 includes a plurality of linear actuation controllers 550. Each of the linear actuation controllers 550 includes an extending arm 552 and an abutment face 554. To each abutment face 554, an actuatable arm 1170 is coupled therewith using a hinged or pivoting connection 560. Each actuatable arm 1170 has an upper portion 1171 which is linear with its corresponding linear actuation controller 550 and a lower portion 1173 which is planar with and abuts the sloped surface 544 when in the contracted configuration. Each actuatable arm 1170 can have a curved elbow 1172, for

movement along the surface of sloped surface 544, and a plate engagement member 1174, which is configured for movement along the interior surface of the plate 432.

[0054] FIG. 12 is a cross-sectional view of the velocity control tool 1180 of FIG. 11 in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. As with velocity control tool 280 as described in FIGS. 5-6, as the arms 552 of velocity control tool 1180 extend in a downhole direction, the actuatable arms 1170 hingedly or pivotally coupled therewith will traverse the surface of the sloped surface 544 radially outward. As the actuatable arms 1170 are pushed by the linear actuation controllers 550 along the sloped surface 544 to extend radially outward, the plates 432 will also extend radially outward as illustrated to increase the effective diameter of the velocity control tool 1180. The pushing of the actuatable arms 1170 and resultant extension of the plates 432 radially outward can be an infinitely variable process, meaning that the plates 432 can be expanded to any state between the fully contracted configuration and the fully expanded configuration, resulting in an infinitely variable effective diameter of the velocity control tool 1180.

[0055] FIG. 13 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure. The velocity control tool 1380 is substantially to velocity control tool 280 (FIGS. 4-6). In velocity control tool 1380 the actuator 550 is located opposite the casing collar locator 220, adjacent to the telemetry gamma ray tool 231, such that actuation of the extension arm 552 proceeds in an uphole direction to produce an expanded configuration of the velocity control tool 1380. Additionally, the central member 540 is flipped as compared to FIGS. 5-6 such that the tapered portion 544 of the central block 542 tapers outward in an uphole direction.

[0056] FIG. 14 is a cross-sectional view of yet another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure. The velocity control tool 1480 is substantially the same as velocity control tool 1180 (FIGS. 11-12). In velocity control tool 1480, the actuator 550 is located opposite the casing collar locator 220, adjacent to the telemetry gamma ray tool 231, such that actuation of the extension arm 552 proceeds in an uphole direction to produce an expanded configuration of the velocity control tool 1480. Additionally, the central member 540 is flipped as compared to FIGS. 11-12 such that the tapered portion 544 of the central block 542 tapers outward in an uphole direction.

[0057] FIG. 15A is a cross-sectional view of another velocity control tool in a contracted configuration in accordance with an exemplary embodiment of the present disclosure. In FIG. 15A, the velocity control tool 1580 is coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 at the upper and lower coupling sections 1510 respectively. The velocity control tool 1580 is coupled with the casing collar locator 220 via a recess 1512 of the velocity control tool 1580 designed to conformance fit a protrusion 520 of the casing collar locator 220, and is coupled with the telemetry gamma ray tool 231 via a recess 1514 of the velocity control tool 1580 designed to conformance fit a protrusion 522 of the gamma ray tool 231. The recesses 1512 and 1514 can extend along the entire circumference of the velocity control tool 1580 or along in discrete portions of the circumference velocity control tool 1580. The protrusions 520 and 522 can extend along the entire inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231, respectively, or along in discrete portions of the inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231. In alternative embodiments, the velocity control tool 1580 can be coupled with the casing collar locator 220

and the telemetry gamma ray tool 231 using threaded couplings, snap-lock couplings, or any other coupling means known to one of ordinary skill in the art.

[0058] The velocity control tool 1580 has inward sloping surfaces 1520 and a vertically aligned surface 1530. The velocity control tool also has an expandable bladder 1550 coupled with the points where coupling sections 1510 and inwardly sloped surfaces 1520 meet. The inward sloping surfaces 1520, vertical surface 1530, and bladder 1550 form a hollow space therebetween. Fluid communication with the hollow space is accomplished with a fluid inlet 1560 and a fluid outlet 1570 which is fluidically coupled with a hollow central bar 1540. The hollow central bar 1540 can be in fluidic communication with a fluid source (not shown) located either uphole or downhole. The bladder 1550 can be made of any material that is elastically deformable or stretchable, and any material that is substantially resistant to ripping, tearing, puncturing, or any other forms of compromise when a fluid pressure is exerted thereon. In the contracted configuration, the bladder 1550 is substantially planar with the coupling sections 1510. The velocity control tool 1580 can be transitioned from the contracted configuration to an expanded configuration via introduction of a fluid, such as for example, air, water or fluid-sand mixtures, through fluid inlet 1560 into bladder 1550.

[0059] FIG. 15B is a cross-sectional view of the velocity control tool of FIG. 15A in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. To transition the velocity control tool 1580 from an expanded configuration to the contracted configuration by actuating the fluid outlet 1570 to open to allow the fluid contained by the bladder 1550 to exit the bladder. The fluid from fluid outlet 1570 may be sent downhole or uphole via hollow central bar 1540. Alternatively, a plurality of bladders 1550 could be employed and placed radially or

longitudinally about the circumference of the velocity control tool 1580. To adjust flow and velocity control, one or more of the plurality of bladders 1550 can be expanded or contracted to restrict or permit flow of fluid past the tool. These can also be expanded or contracted in succession. For example, if an increase in velocity is desired, one or more of the bladders 1550 can be expanded. Thereafter, if an increase in velocity is desired, then additional bladders 1550 can expand. Conversely if a decrease in velocity is desired, a portion or subset of the expanded bladders can be contracted. Alternatively, the bladders can be increased or decreased by varying amounts, for example, 10% 25%, 50%, 75%, or more of the annulus space to restrict or permit flow.

[0060] FIG. 16 is a top plan view of the velocity control tool of FIGS. 15A-B in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. As shown, the velocity control tool has a single bladder 1550 encircling the velocity control tool. In other instances, the velocity control tool 1580 can have 2-12 bladders 1550, alternatively 2-8 bladders, alternatively 2-6 bladders, and alternatively 3-5 bladders. When the velocity control tool has more than one bladder 1550, each bladder will have a corresponding fluid inlet 1560 and a corresponding fluid outlet 1570. Furthermore, when the velocity control tool 1580 has more than one bladder 1580, each bladder can be simultaneously transitioned from the contracted configuration to a similar expanded configuration. In other instances, when the velocity control tool 1580 has more than one bladder 1580, only some of the bladders 1580 can be transitioned from the contracted configuration to a similar expanded configuration by some are held in the contracted configuration.

[0061] FIG. 17A is a cross-sectional view of another velocity control tool in a contracted configuration in accordance with an exemplary embodiment

of the present disclosure. In FIG. 17A, the velocity control tool 1780 is coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 at the upper and lower coupling sections 1710 respectively. The velocity control tool 1780 is coupled with the casing collar locator 220 via a recess 1712 of the velocity control tool 1780 designed to conformance fit a protrusion 520 of the casing collar locator 220, and is coupled with the telemetry gamma ray tool 231 via a recess 1714 of the velocity control tool 1580 designed to conformance fit a protrusion 522 of the gamma ray tool 231. The recesses 1712 and 1714 can extend along the entire circumference of the velocity control tool 1780 or along in discrete portions of the circumference velocity control tool 1780. The protrusions 520 and 522 can extend along the entire inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231, respectively, or along in discrete portions of the inner circumference of the casing collar locator 220 and the telemetry gamma ray tool 231. In alternative embodiments, the velocity control tool 1780 can be coupled with the casing collar locator 220 and the telemetry gamma ray tool 231 using threaded couplings, snap-lock couplings, or any other coupling means known to one of ordinary skill in the art.

[0062] The velocity control tool 1780 has inwardly sloped portions 1720, vertical surfaces 1722 and 1726, and horizontal surfaces 1724. The inwardly sloped portions 1720, vertical surfaces 1722 and 1726, and horizontal surfaces 1724 form an abutment surface for a corresponding paddle 1750. Each paddle 1750 is coupled with a linear actuation controller 1760. Each linear actuation controller 1760 includes an extending arm 1762 and an abutment face 1764. Each abutment face 1764 is coupled with a corresponding paddle 1750 via a retention tab 1752. Each linear actuation controller 1760 is communicatively coupled with a computing system via a

hollow central bar 1740 for actuation of the linear actuation controller 1760 between the contracted configuration and an expanded configuration.

[0063] In FIG. 17A, one linear actuation controllers 1760 per paddle 1750 is illustrated. In other instances, the velocity control tool 1780 can have between 2-4 linear actuation controllers 1760 per paddle 1750. The linear actuation controllers 1760 can be hydraulic, pneumatic, or electric pistons. Alternatively, the linear actuation controllers 17600 can be composed of a casing, an internal biasing member (for example, a coiled spring), and an extending rod coaxial with and inside the biasing member. The casing is coupled, directly or indirectly, with the conveyance line and biases (that is, compresses) the paddles 1750 in response to a pulling force of the conveyance line. The above described embodiments or linear actuation controllers are merely exemplary other actuation controllers known to one of ordinary skill can be used.

[0064] FIG. 17B is a cross-sectional view of the velocity control tool of FIG. 17A in an expanded configuration in accordance with an exemplary embodiment of the present disclosure.

[0065] FIG. 18 is a top plan view of the velocity control tool of FIGS. 17A-B in an expanded configuration in accordance with an exemplary embodiment of the present disclosure. As shown, the velocity control tool has 4 paddles 1750. In other instances, the velocity control tool 1780 can have between 2-3 paddles 1780, alternatively between 5-12 paddles 1780, and alternatively between 5-8 paddles 1780.

[0066] FIG. 19 illustrates an exemplary system embodiment which can be employed to practice the concepts, methods, and techniques disclosed herein. With reference to FIG. 19, an exemplary computing device and/or system 1900 includes a processing unit (CPU or processor) 1910 and a system bus 1905 that couples various system components including the system memory 1915 such as read only memory (ROM) 1920 and random

access memory (RAM) 1925 to the processor 1910. The system 1900 can include a cache 1912 of high-speed memory connected directly with, in close proximity to, or integrated as part of the processor 1910. The system 1900 copies data from the memory 1915 and/or the storage device 1930 to the
5 cache 1912 for quick access by the processor 1910. In this way, the cache provides a performance boost that avoids processor 1910 delays while waiting for data. These and other modules can control or be configured to control the processor 1910 to perform various operations or actions. Other system memory 1915 may be available for use as well. The memory 1915
10 can include multiple different types of memory with different performance characteristics. It can be appreciated that the disclosure may operate on a computing device 1900 with more than one processor 1910 or on a group or cluster of computing devices networked together to provide greater processing capability. The processor 1910 can include any general purpose
15 processor and a hardware module or software module, such as module 1 1932, module 2 1934, and module 3 1936 stored in storage device 1930, configured to control the processor 1910 as well as a special-purpose processor where software instructions are incorporated into the processor. The processor 1910 may be a self-contained computing system, containing
20 multiple cores or processors, a bus, memory controller, cache, etc. A multi-core processor may be symmetric or asymmetric. The processor 1910 can include multiple processors, such as a system having multiple, physically separate processors in different sockets, or a system having multiple processor cores on a single physical chip. Similarly, the processor 1910 can
25 include multiple distributed processors located in multiple separate computing devices, but working together such as via a communications network. Multiple processors or processor cores can share resources such as memory 1915 or the cache 1912, or can operate using independent resources. The processor 1910 can include one or more of a state machine,

an application specific integrated circuit (ASIC), or a programmable gate array (PGA) including a field PGA.

[0067] The system bus 1905 may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. A basic input/output (BIOS) stored in ROM 1920 or the like, may provide the basic routine that helps to transfer information between elements within the computing device 1900, such as during start-up. The computing device 1900 further includes storage devices 1930 or computer-readable storage media such as a hard disk drive, a magnetic disk drive, an optical disk drive, tape drive, solid-state drive, RAM drive, removable storage devices, a redundant array of inexpensive disks (RAID), hybrid storage device, or the like. The storage device 1930 can include software modules 1932, 1934, 1936 for controlling the processor 1910. The system 1900 can include other hardware or software modules. The storage device 1930 is connected to the system bus 1905 by a drive interface. The drives and the associated computer-readable storage devices provide nonvolatile storage of computer-readable instructions, data structures, program modules and other data for the computing device 1900. In one aspect, a hardware module that performs a particular function includes the software component stored in a tangible computer-readable storage device in connection with the necessary hardware components, such as the processor 1910, bus 1905, output device 1935, and so forth, to carry out a particular function. In another aspect, the system can use a processor and computer-readable storage device to store instructions which, when executed by the processor, cause the processor to perform operations, a method or other specific actions. The basic components and appropriate variations can be modified depending on the type of device, such as whether the device 1900 is a small, handheld computing device, a desktop computer, or a computer server. When the

processor 1910 executes instructions to perform "operations", the processor 1910 can perform the operations directly and/or facilitate, direct, or cooperate with another device or component to perform the operations.

[0068] Although the exemplary embodiment(s) described herein employs
5 the hard disk 1930, other types of computer-readable storage devices which can store data that are accessible by a computer, such as magnetic cassettes, flash memory cards, digital versatile disks (DVDs), cartridges, random access memories (RAMs) 1925, read only memory (ROM) 1920, a cable containing a bit stream and the like, may also be used in the
10 exemplary operating environment. Tangible computer-readable storage media, computer-readable storage devices, or computer-readable memory devices, expressly exclude media such as transitory waves, energy, carrier signals, electromagnetic waves, and signals per se.

[0069] To enable user interaction with the computing device 1900, an
15 input device 1945 represents any number of input mechanisms, such as a microphone for speech, a touch-sensitive screen for gesture or graphical input, keyboard, mouse, motion input, speech and so forth. An output device 1935 can also be one or more of a number of output mechanisms known to those of skill in the art. In some instances, multimodal systems
20 enable a user to provide multiple types of input to communicate with the computing device 1900. The communications interface 1940 generally governs and manages the user input and system output. There is no restriction on operating on any particular hardware arrangement and therefore the basic hardware depicted may easily be substituted for
25 improved hardware or firmware arrangements as they are developed.

[0070] For clarity of explanation, the illustrative system embodiment is presented as including individual functional blocks including functional blocks labeled as a "processor" or processor 1910. The functions these blocks

represent may be provided through the use of either shared or dedicated hardware, including, but not limited to, hardware capable of executing software and hardware, such as a processor 1910, that is purpose-built to operate as an equivalent to software executing on a general purpose processor. For example, the functions of one or more processors presented in FIG. 19 may be provided by a single shared processor or multiple processors (use of the term "processor" should not be construed to refer exclusively to hardware capable of executing software). Illustrative embodiments may include microprocessor and/or digital signal processor (DSP) hardware, read-only memory (ROM) 1920 for storing software performing the operations described below, and random access memory (RAM) 1925 for storing results. Very large scale integration (VLSI) hardware embodiments, as well as custom VLSI circuitry in combination with a general purpose DSP circuit, may also be provided.

[0071] The logical operations of the various embodiments are implemented as: (1) a sequence of computer implemented steps, operations, or procedures running on a programmable circuit within a general use computer, (2) a sequence of computer implemented steps, operations, or procedures running on a specific-use programmable circuit; and/or (3) interconnected machine modules or program engines within the programmable circuits. The system 1900 illustrated in FIG. 19 can practice all or part of the recited methods, can be a part of the recited systems, and/or can operate according to instructions in the recited tangible computer-readable storage devices. Such logical operations can be implemented as modules configured to control the processor 1910 to perform particular functions according to the programming of the module. For example, FIG. 19 illustrates three modules Mod1 1932, Mod2 1934 and Mod3 1936 which are modules configured to control the processor 1910. These modules may be stored on the storage device 1930 and loaded into

RAM 1925 or memory 1915 at runtime or may be stored in other computer-readable memory locations.

[0072] One or more parts of the example computing device 1900, up to and including the entire computing device 1900, can be virtualized. For example, a virtual processor can be a software object that executes according to a particular instruction set, even when a physical processor of the same type as the virtual processor is unavailable. A virtualization layer or a virtual "host" can enable virtualized components of one or more different computing devices or device types by translating virtualized operations to actual operations. Ultimately however, virtualized hardware of every type is implemented or executed by some underlying physical hardware. Thus, a virtualization compute layer can operate on top of a physical compute layer. The virtualization compute layer can include one or more of a virtual machine, an overlay network, a hypervisor, virtual switching, and any other virtualization application.

[0073] The processor 1910 can include all types of processors disclosed herein, including a virtual processor. However, when referring to a virtual processor, the processor 1910 includes the software components associated with executing the virtual processor in a virtualization layer and underlying hardware necessary to execute the virtualization layer. The computing system 1900 can include a physical or virtual processor 1910 that receive instructions stored in a computer-readable storage device, which cause the processor 1910 to perform certain operations. When referring to a virtual processor 1910, the system also includes the underlying physical hardware executing the virtual processor 1910.

[0074] The above described system 1900 can be located at the ground surface 105 or in the tool string 200, 200a, 200b. Alternatively, two systems 1900 can be located at the ground surface 105 and in the tool string

200, 200a, 200b and communicatively coupled with each other either by a wired connected or a wireless connection. The computing system(s) 1900, whether at the ground surface 105, the tool string 200, 200a, 200b or both, is further communicatively coupled with the either or both of the conveyance
5 line tension sensing device 117 and the downhole conveyance line tension sensing device 213 and with either or both of the conveyance line speed sensing device 119 and downhole tool string speed sensing device 215 to receive line tension and tool string speed data for operations as described herein.

10 [0075] In cased well bores, as illustrated, there can be an existing record of the depth of each of the casing collars 116. Such an existing record can be established by obtaining a log with the casing collar detector 220 and the gamma ray tool 231. The depth of each casing collar 220 can be recorded on a processor (FIG. 19) for future use. As used herein with regard to speed
15 calculations and speed adjustments of the tool string 200, 200a, 200b, the term "actual known depth" is the depth as determined from casing collar locator log. The depth can also be referred to as the "expected depth." The "measured depth" is the depth as calculated based on the measured amount of conveyance line 111 spooled out and measured at the surface 105.

20 [0076] In some methods of operations of the tool string 200, 200a, 200b, before entering a section of the well bore 150 that is deviated from vertical, a casing collar 116 at a known depth can be recorded and the actual depth of the tool string 200, 200a, 200b can be recorded or compared to the known depth of the specified casing collar 116. The conveyance line 111
25 can then be spooled, lowering the tool string 200, 200a, 200b into the well bore 150. Data corresponding to casing collar locations, the speed of the tool string 200, 200a, 200b, and the conveyance line tension can be transmitted uphole to a processor located at the surface 105 or to a

processor located within the tool string 200, 200a, 200b itself (FIG. 19). Downhole and/or uphole conveyance line tension data can be used in speed correction algorithms. As the tool string 200, 200a, 200b passes each casing collar 116, the depth of each casing collar 116 will be recorded relative to the time at which it was passed. The conveyance line speed or the tool string speed can be calculated at the surface 105 or downhole as the average speed or incremental speed as it passes by the casing collars 116. The recorded depth of each casing collar 116 can be compared to the expected actual depth.

[0077] FIG. 20 is a block diagram of a tool string conveyance control system 2000 for pump down operations in accordance with certain embodiments of the present disclosure. During pump down operations, as described herein, automated monitoring and control of various operational parameters are performed. In some instances, the conveyance line and/or downhole tool string speed and surface and/or downhole conveyance line tension can be automatically monitored by the computing system 1900 located either at the ground surface 105 or in the tool string 200, 200a, 200b itself and any of the above described velocity control tools can be controlled by the computing system 1900 to transition between the contracted configuration and an expanded configuration to enable efficient pump down operations. In general, it is preferred that the pump rate of fluid entering the well bore 150 from rig pump 122 be kept at a constant pressure. In some instances, however, one of ordinary skill may find it beneficial that the pump rate of fluid entering the well bore 150 from rig pump 122 be monitored and controlled by the computing system 1900 as well.

[0078] As a specific example, suppose it is desired to run a tool string at a conveyance line speed of 500 feet per minute (ft/min) in the vertical

portion 147 of well bore 150 and run the tool at a conveyance line speed of 375 ft/min in the horizontal portion 148 of the well bore 150. Further, suppose it is desired to run the tool string such that the conveyance line tension is desired to be set to 3000 pounds of tension. The desired set of parameters can be input in the computing system 1900 for use by the system to control the velocity control tool. The computing system 1900 then initially sets the conveyance line tension parameter at 3000 lbs and the conveyance line speed parameter at 500 ft/min and 375 ft/min for the vertical portion 147 and the horizontal portion 148 of the well bore 150, respectively. The system 1900 then controls the control truck 115 or conveyance line spool located adjacent to or coupled with the truck 115 (FIG. 1) to initiate spooling of the conveyance line, lowering the tool string 200, 200a, 200b downhole. If the tool string experiences a lowered speed as it traverses the well bore 150, as evidenced by a lowered conveyance line speed or a lowered tool string speed, as sensed by the conveyance line speed sensor 119 or downhole tool string speed sensor 215 respectively, or a decrease in conveyance line tension, as sensed by the conveyance line tension sensor 117 or downhole conveyance line tension sensor 213 respectively, the computing system 1900 will control the velocity control tool 280 to transition from the contracted configuration to an expanded configuration while the fluid pump rate is left unchanged. Conversely, when tool string experiences a speed that exceeds the desired speed (that is, 500 ft/min or 375 ft/min) as it traverses the well bore 150, as evidenced by an increased conveyance line speed or a lowered tool string speed, as sensed by the conveyance line speed sensor 119 or downhole tool string speed sensor 215 respectively, or an increase in conveyance line tension exceeding the desired conveyance line tension (3000 lbs), as sensed by the conveyance line tension sensor 117 or downhole conveyance line tension sensor 213 respectively, the computing system 1900 will control the velocity

control tool to transition from the expanded configuration to the contracted configuration or to an alternative expanded configuration.

[0079] As stated above with respect to FIG. 20, the conveyance line and/or downhole tool string speed and surface and/or downhole conveyance line tension can be automatically monitored by a computing system 1900 located either at the ground surface 105 or in the tool string 200, 200a, 200b itself and the velocity control tool can be controlled by the computing system 1900 to transition between the contracted configuration and an expanded configuration to enable efficient pump down operations. When the system 1900 is located at the ground surface 105, the computing system 1900 can be communicatively coupled with all four sensors 117, 119, 213 and 215 or can be communicatively coupled with only the surface sensors 117 and 119 if desired. Furthermore, when the computing system 1900 is located in the tool string 200, 200a, 200b, the computing system 1900 can be communicatively coupled with all four sensors 117, 119, 213 and 215 or can be communicatively coupled with only the tool string sensors 213 and 215 if desired.

[0080] FIG. 21 is a block diagram of another tool string conveyance control system 2100 in accordance with certain embodiments of the present disclosure. The tool string conveyance control system 2100 comprises a computing system 2102 located at the ground surface 105 and a computing system 2104 located within the tool string 200, 200a, 200b. Computing systems 2102 and 2104 are substantially the same as computing system 1900 as described with reference to FIG. 19 and can be used with any one of the velocity control tools described above. The ground computing system 2102 is communicatively coupled with the conveyance line tension sensor 117 and the conveyance line speed sensor 119. The tool string computing system 2104 is communicatively coupled with the downhole line tension

sensor 213 and the downhole tool string speed sensor 215. The tool string conveyance control system 2100 further includes a control unit which receives instructions from either the ground computing system 2102 or the tool string computing system 2104, or both, to actuate the velocity control tool to transition between the contracted configuration and an expanded configuration in response to a change in conveyance line or tool string speed or conveyance line tension as described herein. The control unit can be programmed to use input from both the ground computing system 2102 and the tool string computing system 2104 or from only one of the computing systems 2102, 2104 wherein one of the computing systems 2102, 2104 serves as a primary input means and the other computing system 2102, 2104 serves as an auxiliary input means in the event the primary input means or sensors associated therewith become compromised.

[0081] As a specific example using tool string conveyance control system 2100, suppose it is desired to run a tool string at a conveyance line speed of 500 feet per minute (ft/min) in the vertical portion 147 of well bore 150 and run the tool at a conveyance line speed of 375 ft/min in the horizontal portion 148 of the well bore 150. Further, suppose it is desired to run the tool string such that the conveyance line tension is desired to be set to 3000 pounds of tension. The desired set of parameters can be input in the ground computing system 2102 and the tool string computing system 2104 as overlapping, redundant, or primary and auxiliary systems to control the velocity control tool 280. The computing systems 2102 and 2104 then initially set the conveyance line tension parameter at 3000 lbs and the conveyance line speed parameter at 500 ft/min and 375 ft/min for the vertical portion 147 and the horizontal portion 148 of the well bore 150, respectively. The computing systems 2102 and/or 2104 then controls the control truck 115 or conveyance line spool located adjacent to or coupled with the truck 115 (FIG. 1) to initiate spooling of the conveyance line,

lowering the tool string 200, 200a, 200b downhole. If the tool string experiences a lowered speed as it traverses the well bore 150, as evidenced by a lowered conveyance line speed or a lowered tool string speed, as sensed by the conveyance line speed sensor 119 or downhole tool string speed sensor 215 respectively, or a decrease in conveyance line tension, as sensed by the conveyance line tension sensor 117 or downhole conveyance line tension sensor 213 respectively, the systems 2102 and/or 2104 will control the velocity control tool to transition from the contracted configuration to an expanded configuration while the fluid pump rate is left unchanged. Conversely, when tool string experiences a speed that exceeds the desired speed (that is, 500 ft/min or 375 ft/min) as it traverses the well bore 150, as evidenced by an increased conveyance line speed or a lowered tool string speed, as sensed by the conveyance line speed sensor 119 or downhole tool string speed sensor 215 respectively, or an increase in conveyance line tension exceeding the desired conveyance line tension (3000 lbs), as sensed by the conveyance line tension sensor 117 or downhole conveyance line tension sensor 213 respectively, the computing systems 2102 and/or 2104 will control the velocity control tool to transition from the expanded configuration to the contracted configuration or to an alternative expanded configuration.

[0082] FIG. 22 is a block diagram of a method for controlling the velocity of a tool string as it traverses a well bore in accordance with certain embodiments of the present disclosure. Though depicted sequentially as a matter of convenience, at least some of the steps can be performed in a different order and/or in parallel. Additionally, in some instances, only some of the actions can be performed as desired. In some instances. The operations of FIG. 22, as well as other operations described herein, can be implemented as instructions stored in a computer-readable storage medium and executed by a processor as described above.

[0083] The method 2200 starts in block 2202 by placing a tool string in a well bore. In block 2204, desired conveyance line and/or tool string speeds and conveyance line tension are input into a tool string conveyance control system. In block 2206, the tool string traverses the well bore at the desired conveyance line and/or tool string speeds and conveyance line tension. In block 2208, if the conveyance line and/or tool string speed is reduced below the corresponding desired speed or if the conveyance line tension is lower than the desired tension, the velocity control tool is actuated to transition from the contracted configuration to an expanded configuration resulting in an increased effective outer diameter of the velocity control tool and smaller annulus diameter. If such a reduction in conveyance line and/or tool string speed or conveyance line tension does not occur, the method returns to block 2206. In block 2210, if the conveyance line and/or tool string speed is returned to, or exceeds, the corresponding desired speed and/or if the conveyance line tension is returned to, or exceeds, the desired tension, the velocity control tool is actuated to transition from the expanded configuration to the contracted configuration or to an alternative expanded configuration which is characterized by a smaller effective outer diameter of the velocity control tool and a larger annulus diameter than the previous expanded configuration, while still have a larger effective velocity control tool diameter and smaller annulus diameter than when in the contracted configuration. The method then proceeds back to step 2206 and steps 2206, 2208 and 2210 are continuously performed until the tool string reaches the production zone of interest.

STATEMENTS OF THE DISCLOSURE INCLUDE:

[0084] Statement 1: A downhole tool velocity control apparatus comprising a body having a portion with static diameter and a portion with a variable diameter; and the portion with variable diameter having at least one velocity control member expandable radially beyond the portion with the static diameter.

[0085] Statement 2: An apparatus according to Statement 1, wherein the velocity control member is extendable and contractible by an actuatable member.

[0086] Statement 3: An apparatus according to Statement 2, wherein the actuatable member comprises one or more extendable and contractible arms.

[0087] Statement 4: An apparatus according to any one of Statements 2-3, further comprising a controller coupled with the velocity control member for controlling the degree of extension and contraction of the actuatable member.

[0088] Statement 5: An apparatus according to Statement 4, wherein the controller is electronic, pneumatic or hydraulic.

[0089] Statement 6: An apparatus according to Statement 5, wherein the controller is an electronic piston, a pneumatic piston or a hydraulic piston, the piston coupled with the body and the actuatable member and configured to variably extend and contract the actuatable member.

[0090] Statement 7: An apparatus according to any one of Statements 4-6, wherein the controller further comprises a processor.

[0091] Statement 8: An apparatus according to any one of Statements 1-7, wherein the velocity control member encircles at least 180 degrees of the circumference of the body when expanded radially.

[0092] Statement 9: An apparatus according to any one of Statements 1-8, wherein an uphole end is couplable with a first component of the tool

string and a downhole end is couplable with a second component of a tool string.

[0093] Statement 10: An apparatus according to any one of Statements 1-9, wherein the velocity control member is configured to actuate in response to a change in line tension of a conveyance line coupled with a tool string.

[0094] Statement 11: An apparatus according to any one of Statements 1-10, wherein the velocity control member is configured to actuate in response to a change in the velocity of the apparatus as it traverses a well bore.

[0095] Statement 12: An apparatus according to any one of Statements 1-11, wherein the velocity control member is an expandable bladder.

[0096] Statement 13: An apparatus according to Statements 1-11, wherein velocity control member is a plurality of plates.

[0097] Statement 14: A tool placement system, the system comprising a pump in fluid communication with a wellbore for pressurizing the wellbore; and a tool string coupled with a conveyance line, the tool string disposed in the wellbore extending downhole from the surface uphole thereby forming an annulus between the tool string and a surface of the wellbore, the tool string having a portion with a static diameter and a portion having a velocity control tool incorporated into the tool string, the velocity control tool comprising a portion with a variable diameter, and the portion with variable diameter having a velocity control member variably extendible and contractible radially beyond the portion of the tool string with the static diameter thereby decreasing the size of the annulus.

[0098] Statement 15: A system according to Statement 14, further comprising a conveyance line tension sensor coupled with a portion of the conveyance line near the tool string; and a tool string speed sensor located in the tool string.

[0099] Statement 16: A system according to Statement 15, further comprising a controller communicatively coupled with the velocity control tool, the conveyance line sensor and the tool string speed sensor, wherein the controller located in the tool string and configured to control actuation of the velocity control tool in response to any one of a change in conveyance line tension sensed by the conveyance line tension sensor, and a change in conveyance line speed sensed by the tool string speed sensor.

[00100] Statement 17: A system according to Statement 15, further comprising a second conveyance line tension sensor and a conveyance line speed sensor, the second conveyance line tension sensor and the conveyance line speed sensor coupled with a portion of the conveyance line at the surface of the well bore.

[00101] Statement 18: A system according to Statement 17, further comprising a controller communicatively coupled with the velocity control tool, the conveyance line sensor, the tool string speed sensor, the second conveyance line tension sensor and the conveyance line speed sensor, wherein the controller is configured to control actuation of the velocity control tool in response to any one of a change in conveyance line tension sensed by the conveyance line tension sensor and the second conveyance line tension sensor, and a change in conveyance line speed sensed by the tool string speed sensor and the conveyance line speed sensor.

[00102] Statement 19: A system according to any one of Statements 14-18, wherein the conveyance line is any one of a wireline, a slickline, and a coiled tubing.

[00103] Statement 20: A method of varying the force applied by a fluid to a tool string, the method comprising traversing a tool string through a well bore using a pump fluid, the pump fluid applying a force on the tool string; monitoring a tool string characteristic of the tool string; and actuating a

downhole tool velocity control apparatus of the tool string to variably expand radially in response to a change in the tool string characteristic.

[00104] Statement 21: A method according to Statement 20, wherein the actuation of the downhole tool velocity control apparatus is controlled by a mechanical system coupled with the downhole tool velocity control apparatus.

[00105] Statement 22: A method according to Statement 20, wherein the actuation of the downhole tool velocity control apparatus is controlled by a computing system coupled with the downhole tool velocity control apparatus and located in the tool string.

[00106] Statement 23: A method according to any one of Statements 20-22, wherein the tool string is coupled with a conveyance line, the conveyance line being any one of a wireline, a slickline, and a coiled tubing.

[00107] Statement 24: A method according to Statement 23, wherein the tool string characteristic is a tension of the conveyance line.

[00108] Statement 25: A method according to Statement 24, wherein the downhole tool velocity control apparatus is actuated to expand from a contracted configuration in response to a decrease in conveyance line tension relative to a predetermined conveyance line tension.

[00109] Statement 26: A method according to Statement 24, wherein the downhole tool velocity control apparatus is actuated to contract from an expanded configuration in response to an increase in conveyance line tension relative to a predetermined conveyance line tension.

[00110] Statement 27: A method according to any one of Statements 20-23, wherein the tool string characteristic is a speed of the tool string as it traverses through the well bore.

[00111] Statement 28: A method according to Statement 27, wherein the downhole tool velocity control apparatus is actuated to expand from a

contracted configuration in response to a decrease in tool string speed relative to a predetermined tool string speed.

[00112] Statement 29: A method according to Statement 27, wherein the downhole tool velocity control apparatus is actuated to contract from an expanded configuration in response to an increase in tool string speed relative to a predetermined tool string speed.

[00113] Statement 30: A downhole tool annulus fluid flow restriction apparatus comprising a body having a portion with static diameter and a portion with a variable diameter; and the portion with variable diameter having at least one annulus fluid flow restriction member expandable radially beyond the portion with the static diameter.

[00114] Statement 31: An apparatus according to Statement 30, wherein the annulus fluid flow restriction member is extendable and contractible by an actuatable member.

[00115] Statement 32: An apparatus according to Statement 31, wherein the actuatable member comprises one or more extendable and contractible arms.

[00116] Statement 33: An apparatus according to any one of Statements 31-32, further comprising a controller coupled with the annulus fluid flow restriction member for controlling the degree of extension and contraction of the actuatable member.

[00117] Statement 34: An apparatus according to Statement 33, wherein the controller is electronic, pneumatic or hydraulic.

[00118] Statement 35: An apparatus according to Statement 34, wherein the controller is an electronic piston, a pneumatic piston or a hydraulic piston, the piston coupled with the body and the actuatable member and configured to variably extend and contract the actuatable member.

[00119] Statement 36: An apparatus according to any one of Statements 33-35, wherein the controller further comprises a processor.

[00120] Statement 37: An apparatus according to any one of Statements 30-36, wherein the annulus fluid flow restriction member encircles at least 180 degrees of the circumference of the body when expanded radially.

[00121] Statement 38: An apparatus according to any one of Statements 30-37, wherein an uphole end is couplable with a first component of the tool string and a downhole end is couplable with a second component of a tool string.

[00122] Statement 39: An apparatus according to any one of Statements 30-38, wherein the annulus fluid flow restriction member is configured to actuate in response to a change in line tension of a conveyance line coupled with a tool string.

[00123] Statement 40: An apparatus according to any one of Statements 30-39, wherein the annulus fluid flow restriction member is configured to actuate in response to a change in the velocity of the apparatus as it traverses a well bore.

[00124] Statement 41: An apparatus according to any one of Statements 30-40, wherein the annulus fluid flow restriction member is an expandable bladder.

[00125] Statement 42: An apparatus according to Statements 30-40, wherein annulus fluid flow restriction member is a plurality of plates.

[00126] Statement 43: A tool placement system, the system comprising a pump in fluid communication with a wellbore for pressurizing the wellbore; and a tool string coupled with a conveyance line, the tool string disposed in the wellbore extending downhole from the surface uphole thereby forming an annulus between the tool string and a surface of the wellbore, the tool string having a portion with a static diameter and a portion having an annulus fluid flow restriction tool incorporated into the tool string, the annulus fluid flow restriction tool comprising a portion with a variable diameter, and the portion with variable diameter having an annulus fluid flow

restriction member variably extendible and contractible radially beyond the portion of the tool string with the static diameter thereby decreasing the size of the annulus.

[00127] Statement 44: A system according to Statement 43, further comprising a conveyance line tension sensor coupled with a portion of the conveyance line near the tool string; and a tool string speed sensor located in the tool string.

[00128] Statement 45: A system according to Statement 44, further comprising a controller communicatively coupled with the annulus fluid flow restriction tool, the conveyance line sensor and the tool string speed sensor, wherein the controller located in the tool string and configured to control actuation of the annulus fluid flow restriction tool in response to any one of a change in conveyance line tension sensed by the conveyance line tension sensor, and a change in conveyance line speed sensed by the tool string speed sensor.

[00129] Statement 46: A system according to Statement 44, further comprising a second conveyance line tension sensor and a conveyance line speed sensor, the second conveyance line tension sensor and the conveyance line speed sensor coupled with a portion of the conveyance line at the surface of the well bore.

[00130] Statement 47: A system according to Statement 46, further comprising a controller communicatively coupled with the annulus fluid flow restriction tool, the conveyance line sensor, the tool string speed sensor, the second conveyance line tension sensor and the conveyance line speed sensor, wherein the controller is configured to control actuation of the annulus fluid flow restriction tool in response to any one of a change in conveyance line tension sensed by the conveyance line tension sensor and the second conveyance line tension sensor, and a change in conveyance line

speed sensed by the tool string speed sensor and the conveyance line speed sensor.

[00131] Statement 48: A system according to any one of Statements 43-47, wherein the conveyance line is any one of a wireline, a slickline, and a coiled tubing.

[00132] Statement 49: A method of varying the force applied by a fluid to a tool string, the method comprising traversing a tool string through a well bore using a pump fluid, the pump fluid applying a force on the tool string; monitoring a tool string characteristic of the tool string; and actuating a downhole tool annulus fluid flow restriction apparatus of the tool string to variably expand radially in response to a change in the tool string characteristic.

[00133] Statement 50: A method according to Statement 49, wherein the actuation of the downhole tool annulus fluid flow restriction apparatus is controlled by a mechanical system coupled with the downhole tool annulus fluid flow restriction apparatus.

[00134] Statement 51: A method according to Statement 49, wherein the actuation of the downhole tool annulus fluid flow restriction apparatus is controlled by a computing system coupled with the downhole tool velocity control apparatus and located in the tool string.

[00135] Statement 52: A method according to any one of Statements 49-51, wherein the tool string is coupled with a conveyance line, the conveyance line being any one of a wireline, a slickline, and a coiled tubing.

[00136] Statement 53: A method according to Statement 52, wherein the tool string characteristic is a tension of the conveyance line.

[00137] Statement 54: A method according to Statement 53, wherein the downhole tool annulus fluid flow restriction apparatus is actuated to expand from a contracted configuration in response to a decrease in conveyance line tension relative to a predetermined conveyance line tension.

[00138] Statement 55: A method according to Statement 53, wherein the downhole tool annulus fluid flow restriction apparatus is actuated to contract from an expanded configuration in response to an increase in conveyance line tension relative to a predetermined conveyance line tension.

5 [00139] Statement 56: A method according to any one of Statements 49-52, wherein the tool string characteristic is a speed of the tool string as it traverses through the well bore.

[00140] Statement 57: A method according to Statement 56, wherein the downhole tool velocity control apparatus is actuated to expand from a
10 contracted configuration in response to a decrease in tool string speed relative to a predetermined tool string speed.

[00141] Statement 58: A method according to Statement 56, wherein the downhole tool velocity control apparatus is actuated to contract from an expanded configuration in response to an increase in tool string speed
15 relative to a predetermined tool string speed.

[00142] The foregoing descriptions of specific compositions and methods of the present disclosure have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the disclosure to the precise compositions and methods disclosed and obviously
20 many modifications and variations are possible in light of the above teaching. The examples were chosen and described in order to best explain the principles of the disclosure and its practical application, to thereby enable others skilled in the art to best utilize the disclosure with various modifications as are suited to the particular use contemplated. It is intended
25 that the scope of the disclosure be defined by the claims appended hereto and their equivalents.

CLAIMS

What is claimed is:

1. A downhole tool velocity control apparatus comprising:

a body having

5 a portion with static diameter and a portion with a variable diameter; and

the portion with variable diameter having at least one velocity control member extendible radially beyond the portion with the static diameter.

10 2. The apparatus of claim 1, wherein the velocity control member is extendable and contractible by an actuatable member.

3. The apparatus of claim 2, wherein the actuatable member comprises one or more extendable and contractible arms.

15 4. The apparatus of claim 2, further comprising a controller coupled with the velocity control member for controlling the degree of extension and contraction of the actuatable member.

20 5. The apparatus of claim 4, wherein the controller is electronic, pneumatic or hydraulic.

6. The apparatus of claim 5, wherein the controller is an electronic piston, a pneumatic piston or a hydraulic piston, the piston coupled with the body and
25 the actuatable member and configured to variably expand and contract the actuatable member.

7. The apparatus of claim 4, wherein the controller further comprises a processor.

8. The apparatus of claim 1, wherein the velocity control member encircles at least 180 degrees of the circumference of the body.

5 9. The apparatus of claim 1, wherein an uphole end is couplable with a first component of the tool string and a downhole end is couplable with a second component of a tool string.

10 10. The apparatus of claim 1, wherein the velocity control member is configured to actuate in response to a change in line tension of a line or tubing coupled with a tool string.

15 11. The apparatus of claim 1, wherein the velocity control member is configured to actuate in response to a change in the velocity of the apparatus as it traverses a well bore.

12. The apparatus of claim 1, wherein the velocity control member is an expandable bladder.

20 13. The apparatus of claim 1, wherein the velocity control member is a plurality of plates.

14. A tool placement conveyance system, the system comprising:

a pump in fluid communication with a wellbore for pressurizing the wellbore; and

a tool string coupled with a conveyance line, the tool string disposed in the wellbore extending downhole from the surface uphole thereby forming an annulus between the tool string and a surface of the wellbore, the tool string having a portion with a static diameter and a portion having a velocity control tool incorporated into the tool string, the velocity control tool comprising

a portion with a variable diameter, and

the portion with variable diameter having a velocity control member variably extendible and contractible radially beyond the portion of the tool string with the static diameter thereby decreasing the size of the annulus.

15. The system of claim 14, further comprising:

a conveyance line tension sensor coupled with a portion of the conveyance line near the tool string; and

a tool string speed sensor located in the tool string.

16. The system of claim 15, further comprising a controller communicatively coupled with the velocity control tool, the conveyance line sensor and the tool string speed sensor, wherein

the controller located in the tool string and configured to control actuation of the velocity control tool in response to any one of a change in conveyance line tension sensed by the conveyance line tension sensor, and a change in conveyance line speed sensed by the tool string speed sensor.

17. The system of claim 15, further comprising a second conveyance line tension sensor and a conveyance line speed sensor, the second conveyance

line tension sensor and the conveyance line speed sensor coupled with a portion of the conveyance line at the surface of the well bore.

18. The system of claim 17, further comprising a controller communicatively
5 coupled with the velocity control tool, the conveyance line sensor, the tool string speed sensor, the second conveyance line tension sensor and the conveyance line speed sensor, wherein

the controller is configured to control actuation of the velocity control tool in response to any one of a change in conveyance line tension sensed by
10 the conveyance line tension sensor and the second conveyance line tension sensor, and a change in conveyance line speed sensed by the tool string speed sensor and the conveyance line speed sensor.

19. The system of claim 14, wherein the conveyance line is any one of a
15 wireline, a slickline, and a coiled tubing.

20. A method of varying the force applied by a fluid to a tool string, the method comprising:

traversing a tool string through a well bore using a pump fluid, the
20 pump fluid applying a force on the tool string;

monitoring a tool string characteristic of the tool string; and

actuating a downhole tool velocity control apparatus of the tool string to variably expand radially in response to a change in the tool string characteristic.

21. The method of claim 20, wherein the actuation of the downhole tool velocity control apparatus is controlled by a mechanical system coupled with the downhole tool velocity control apparatus.

22. The method of claim 20, wherein the actuation of the downhole tool velocity control apparatus is controlled by a computing system coupled with the downhole tool velocity control apparatus and located in the tool string.

5 23. The method of claim 20, wherein the tool string is coupled with a conveyance line, the conveyance line being any one of a wireline, a slickline, and a coiled tubing.

10 24. The method of claim 23, wherein the tool string characteristic is a tension of the conveyance line.

15 25. The method of claim 24, wherein the downhole tool velocity control apparatus is actuated to expand from a contracted configuration in response to a decrease in conveyance line tension relative to a predetermined conveyance line tension.

20 26. The method of claim 24, wherein the downhole tool velocity control apparatus is actuated to contract from an expanded configuration in response to an increase in conveyance line tension relative to a predetermined conveyance line tension.

27. The method of claim 20, wherein the tool string characteristic is a speed of the tool string as it traverses through the well bore.

25 28. The method of claim 27, wherein the downhole tool velocity control apparatus is actuated to expand from a contracted configuration in response to a decrease in tool string speed relative to a predetermined tool string speed.

29. The method of claim 27, wherein the downhole tool velocity control apparatus is actuated to contract from an expanded configuration in response to an increase in tool string speed relative to a predetermined tool string speed.

5

30. A downhole tool annulus fluid flow restriction apparatus comprising:

a body having

a portion with static diameter and a portion with a variable diameter;

and

10 the portion with variable diameter having at least one annulus fluid flow restriction member expandable radially beyond the portion with the static diameter.

15 31. The apparatus of claim 30, wherein the annulus fluid flow restriction member encircles at least 180 degrees of the circumference of the body when expanded radially.

32. A tool placement system, the system comprising:

a pump in fluid communication with a wellbore for pressurizing the wellbore; and

a tool string coupled with a conveyance line, the tool string disposed in the wellbore extending downhole from the surface uphole thereby forming an annulus between the tool string and a surface of the wellbore, the tool string having a portion with a static diameter and a portion having an annulus fluid flow restriction tool incorporated into the tool string, the annulus fluid flow restriction tool comprising

a portion with a variable diameter, and

the portion with variable diameter having a annulus fluid flow restriction member variably extendible and contractible radially beyond the portion of the tool string with the static diameter thereby decreasing the size of the annulus.

33. The system of claim 32, further comprising:

a conveyance line tension sensor coupled with a portion of the conveyance line near the tool string; and

a tool string speed sensor located in the tool string.

34. A method of varying the force applied by a fluid to a tool string, the method comprising:

traversing a tool string through a well bore using a pump fluid, the pump fluid applying a force on the tool string;

monitoring a tool string characteristic of the tool string; and

actuating a downhole tool annulus fluid flow restriction apparatus of the tool string to variably expand radially in response to a change in the tool string characteristic.

35. The method of claim 34, wherein

the tool string is coupled with a conveyance line, the conveyance line being any one of a wireline, a slickline, and a coiled tubing; and

the tool string characteristic is a tension of the conveyance line.

5

36. The method of claim 34, wherein the tool string characteristic is a speed of the tool string as it traverses through the well bore.

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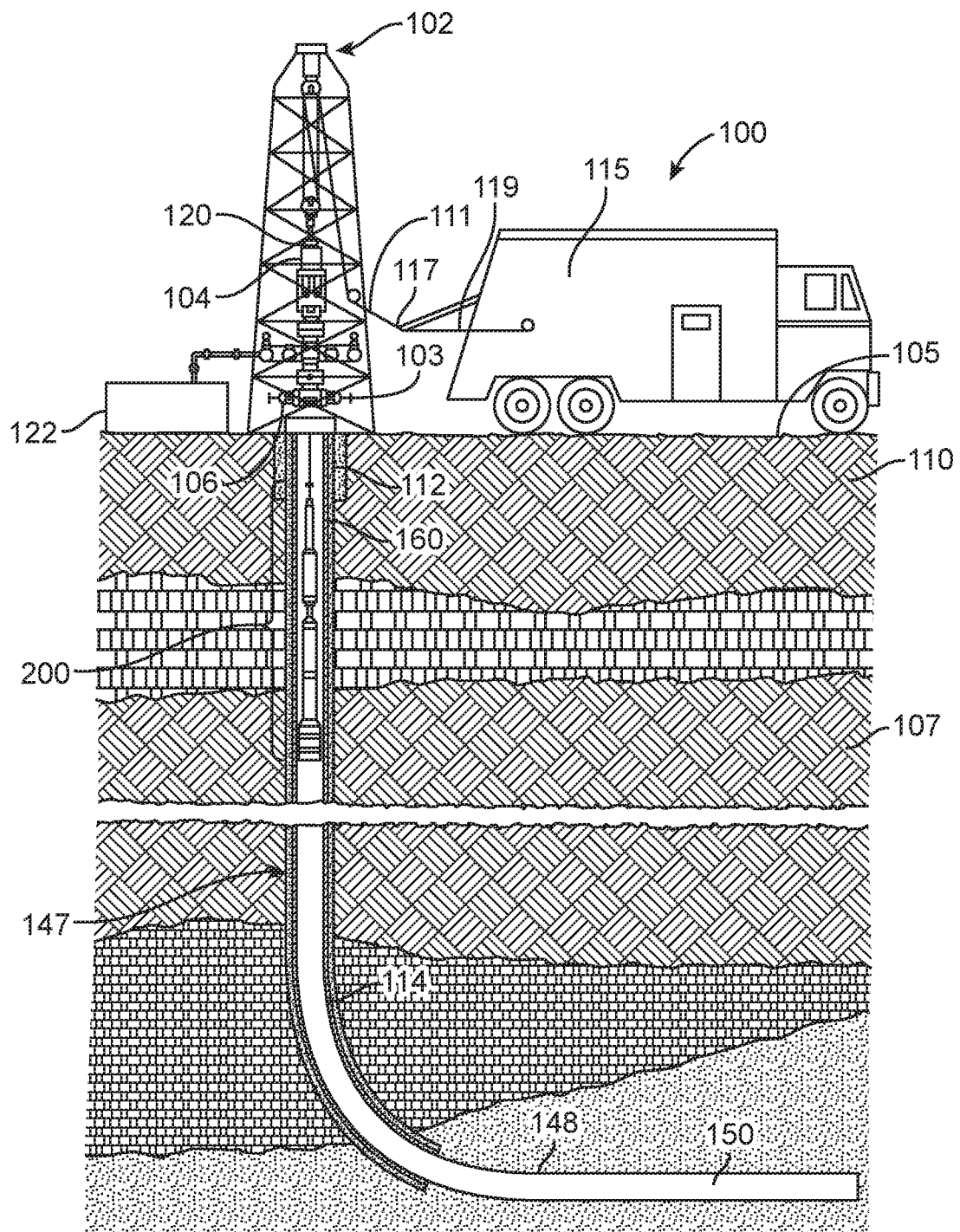


FIG. 1

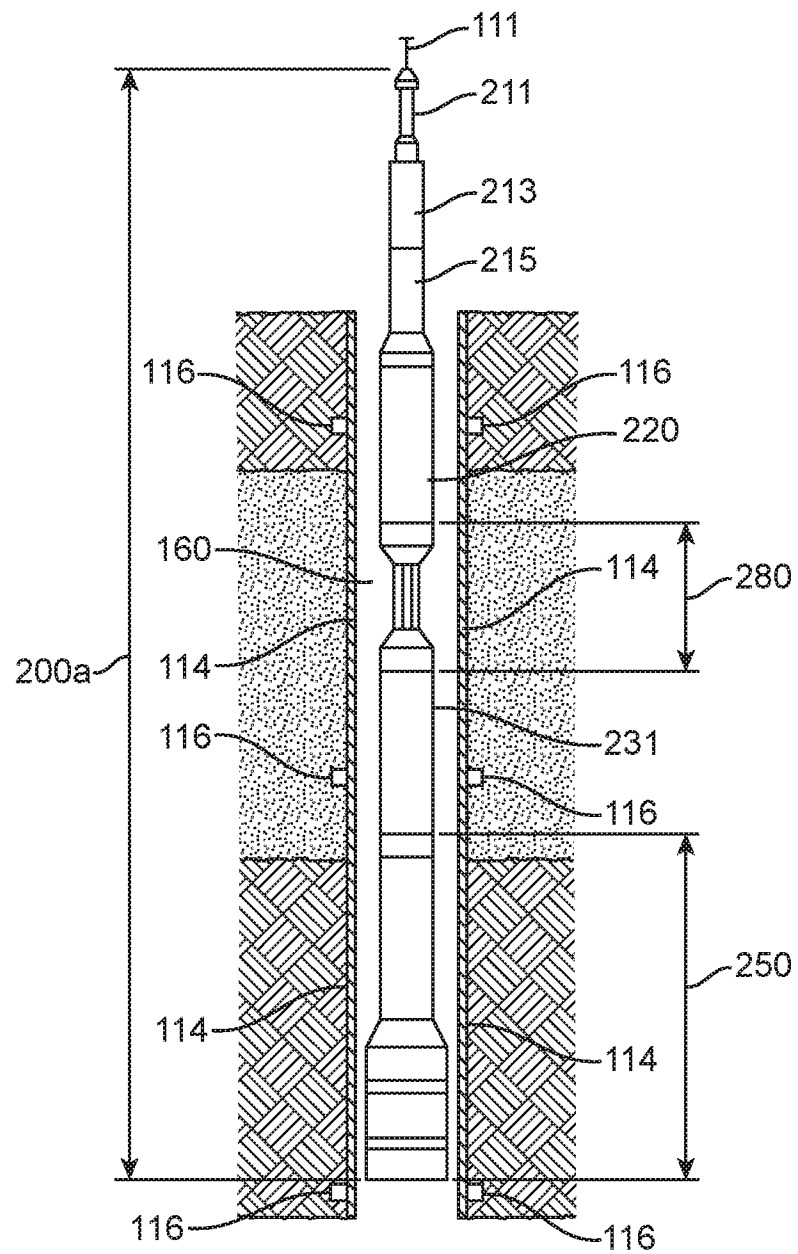


FIG. 2

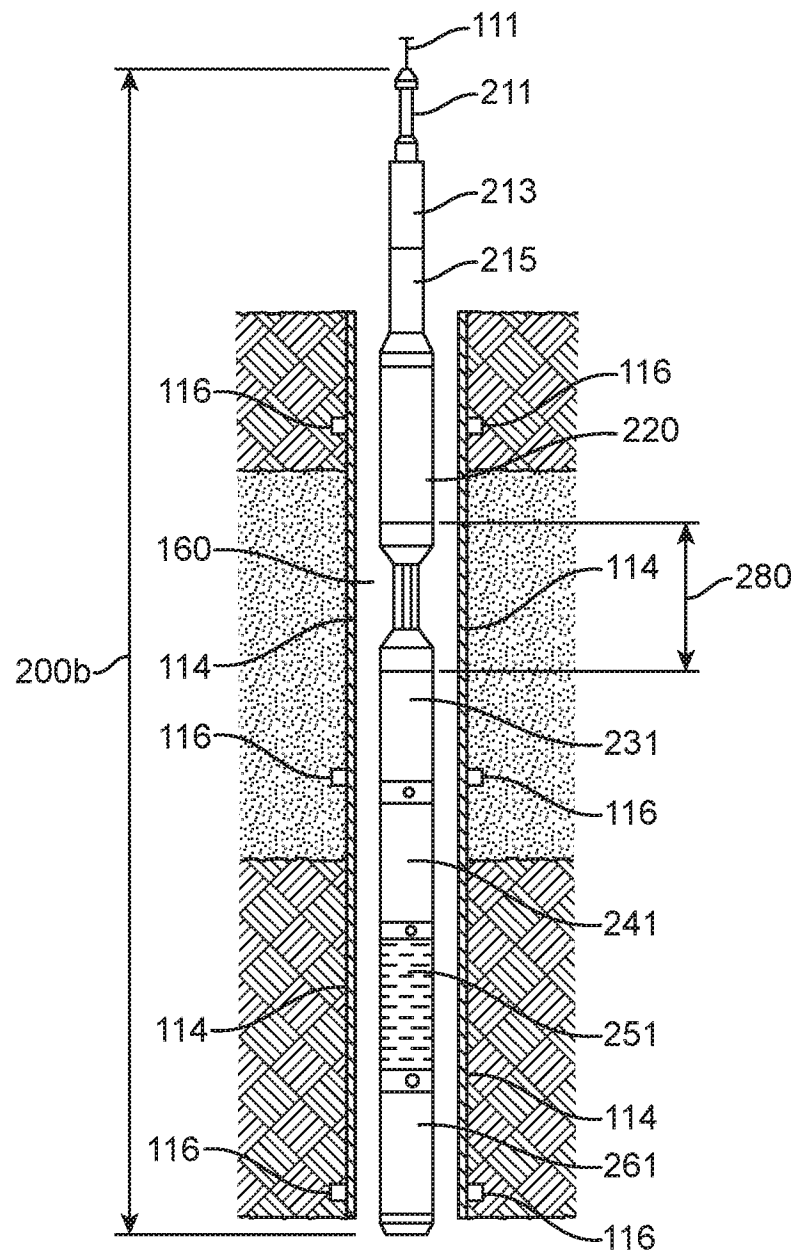


FIG. 3

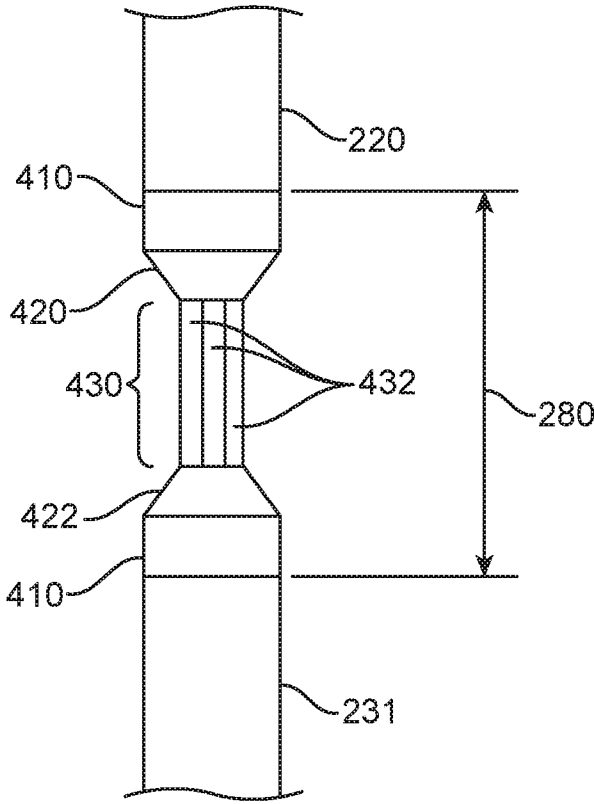


FIG. 4

5 / 22

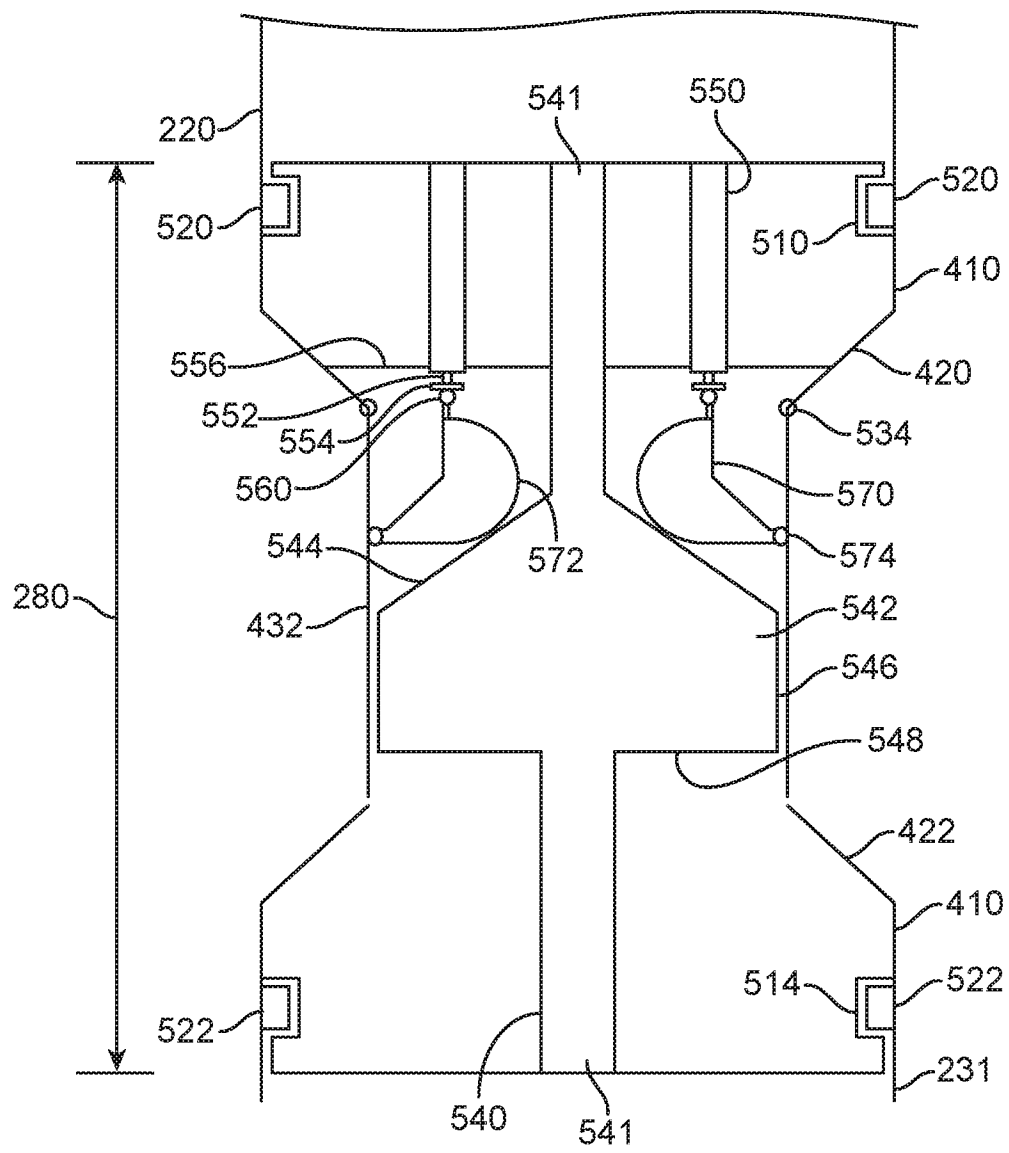


FIG. 5

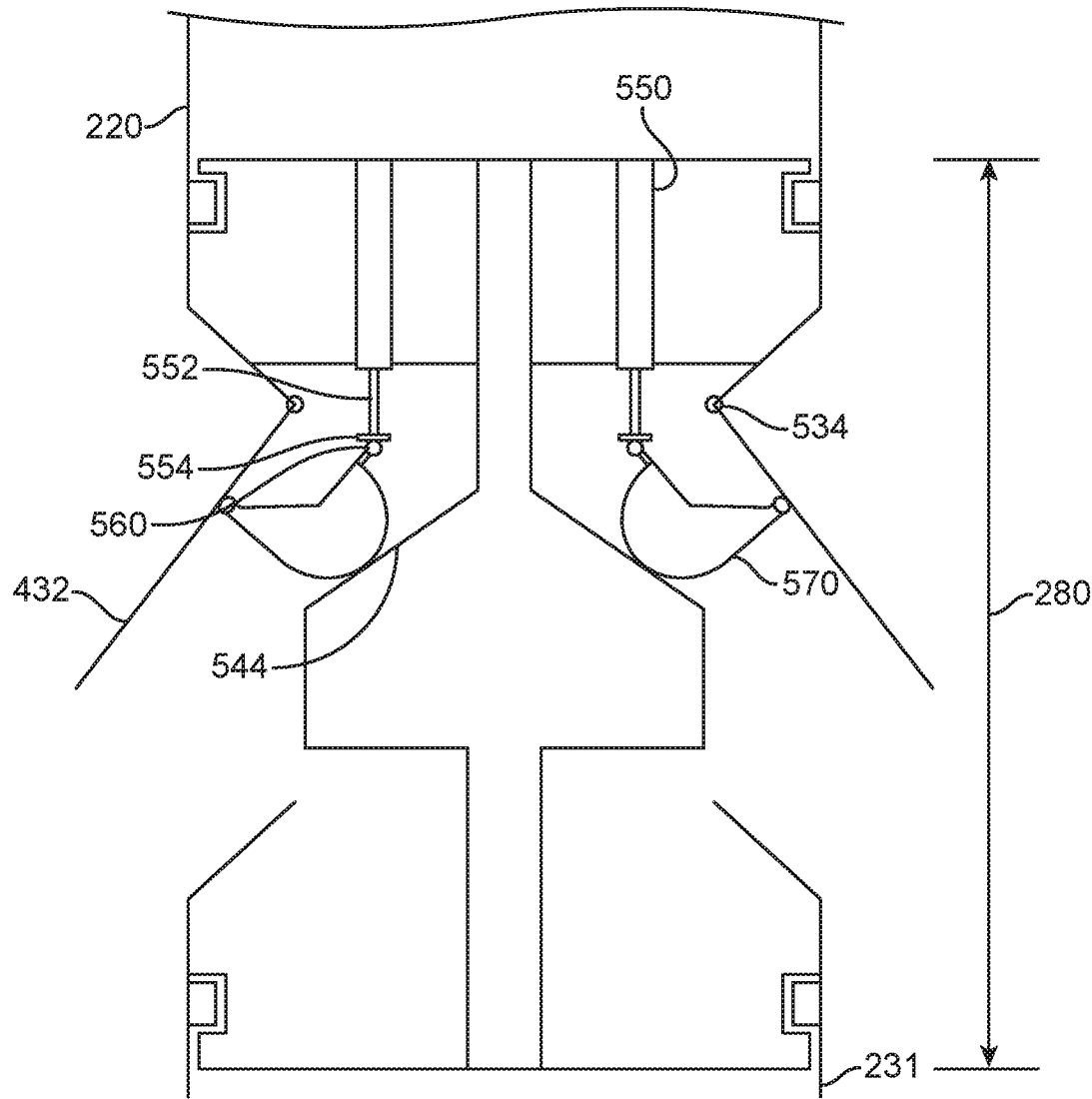


FIG. 6

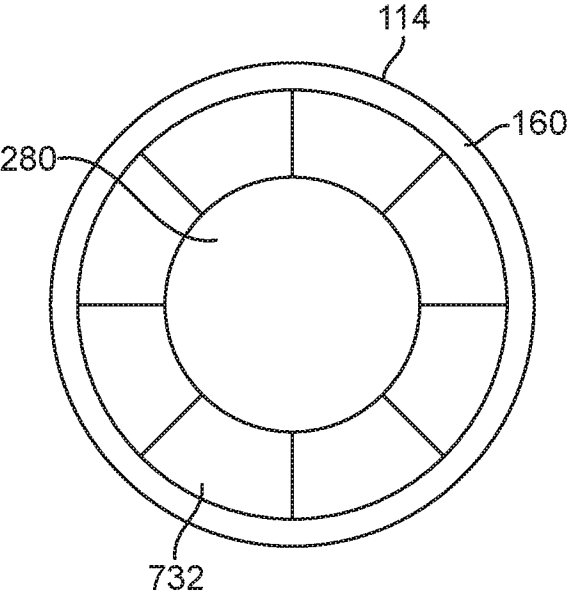


FIG. 7

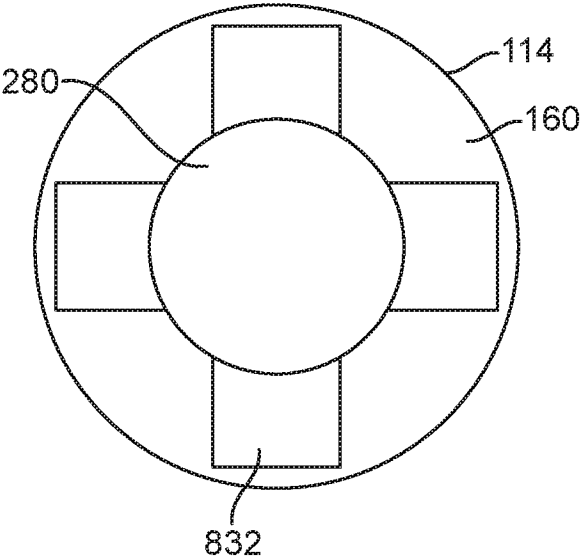


FIG. 8

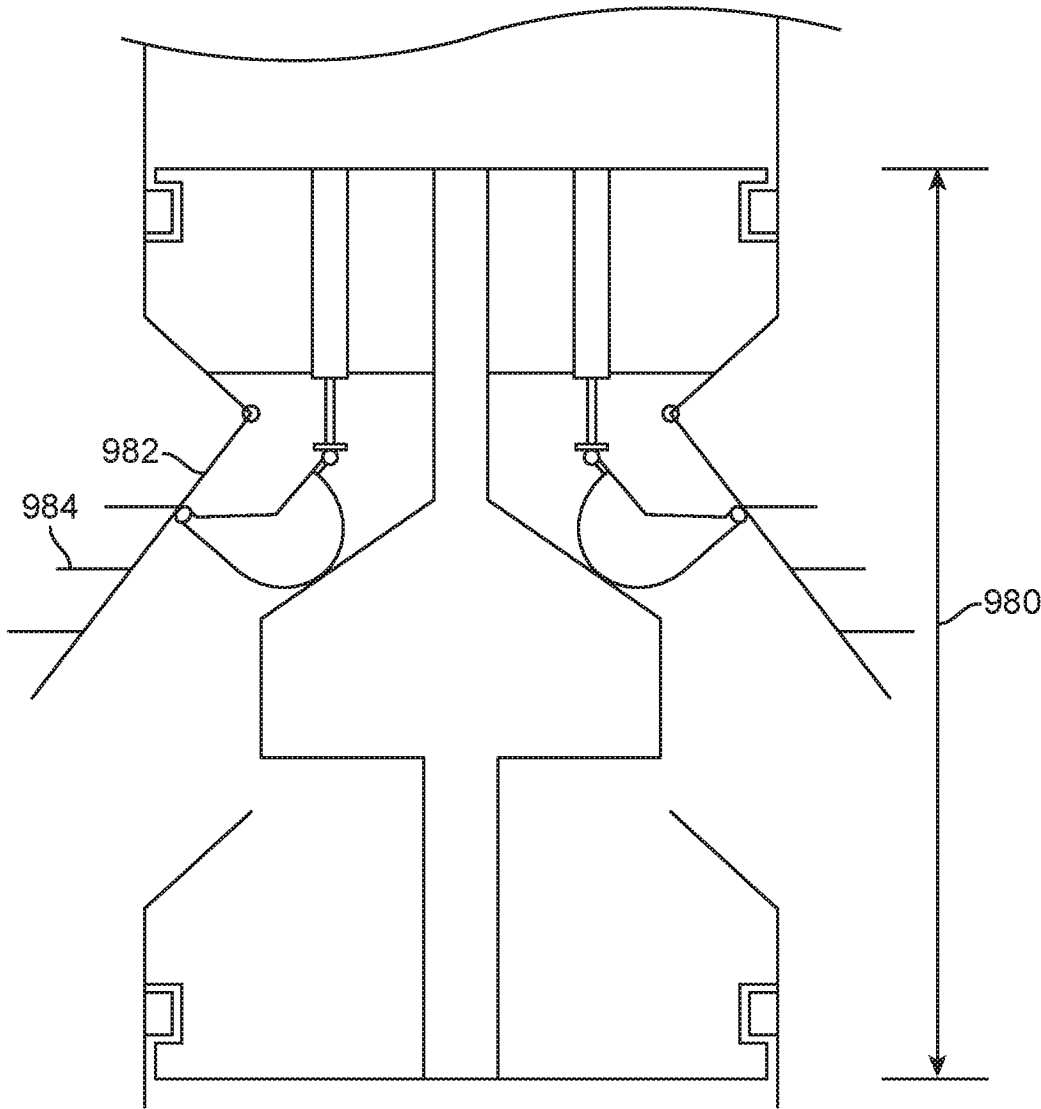


FIG. 9

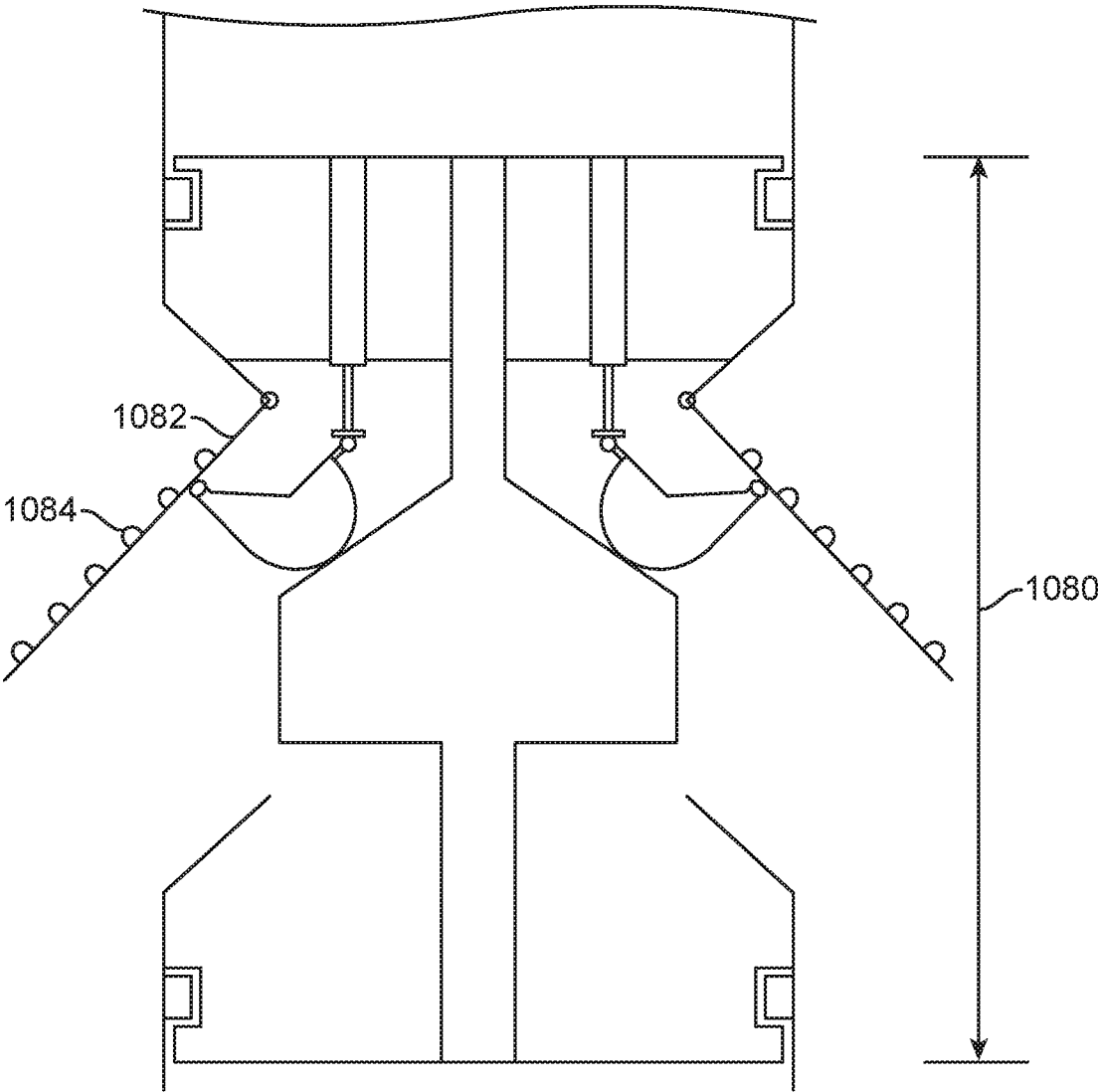


FIG. 10

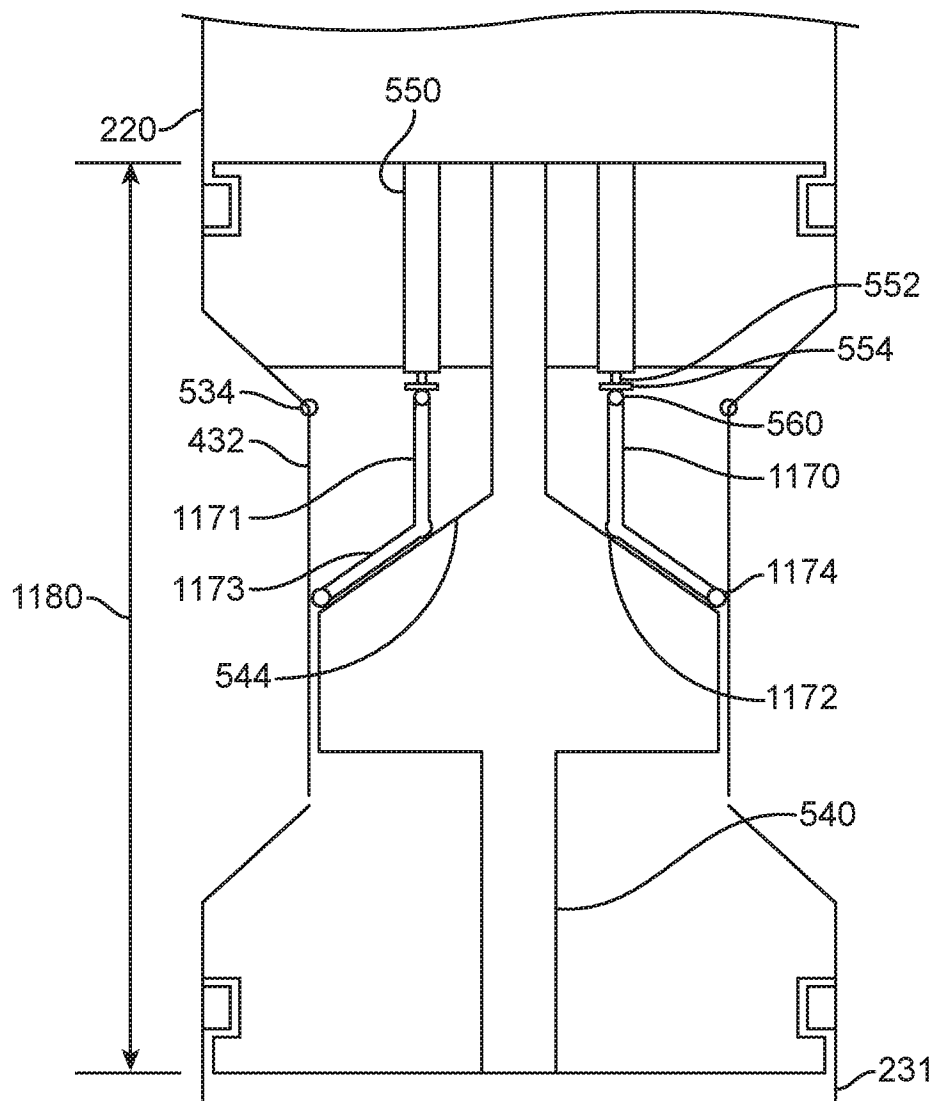


FIG. 11

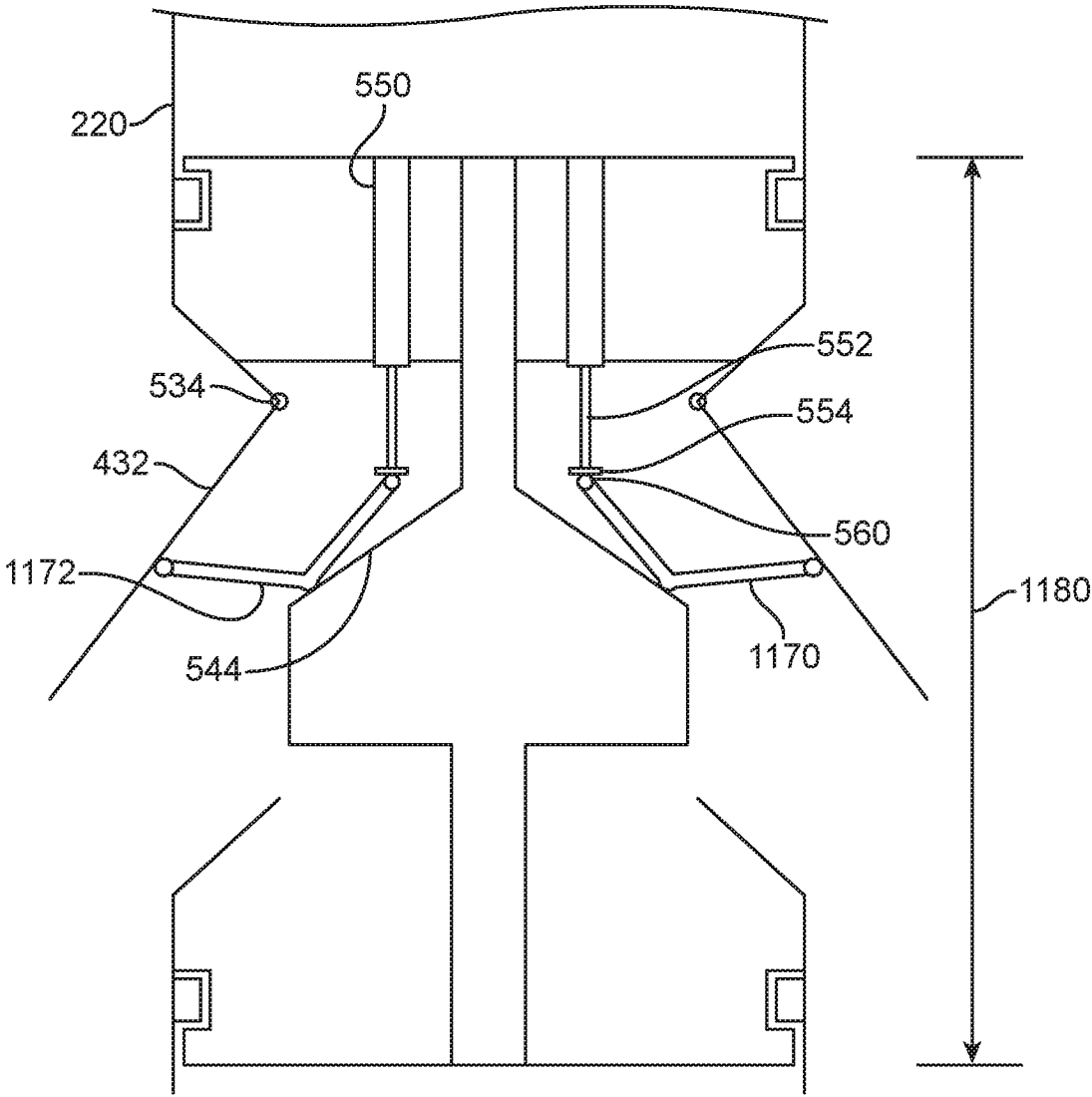


FIG. 12

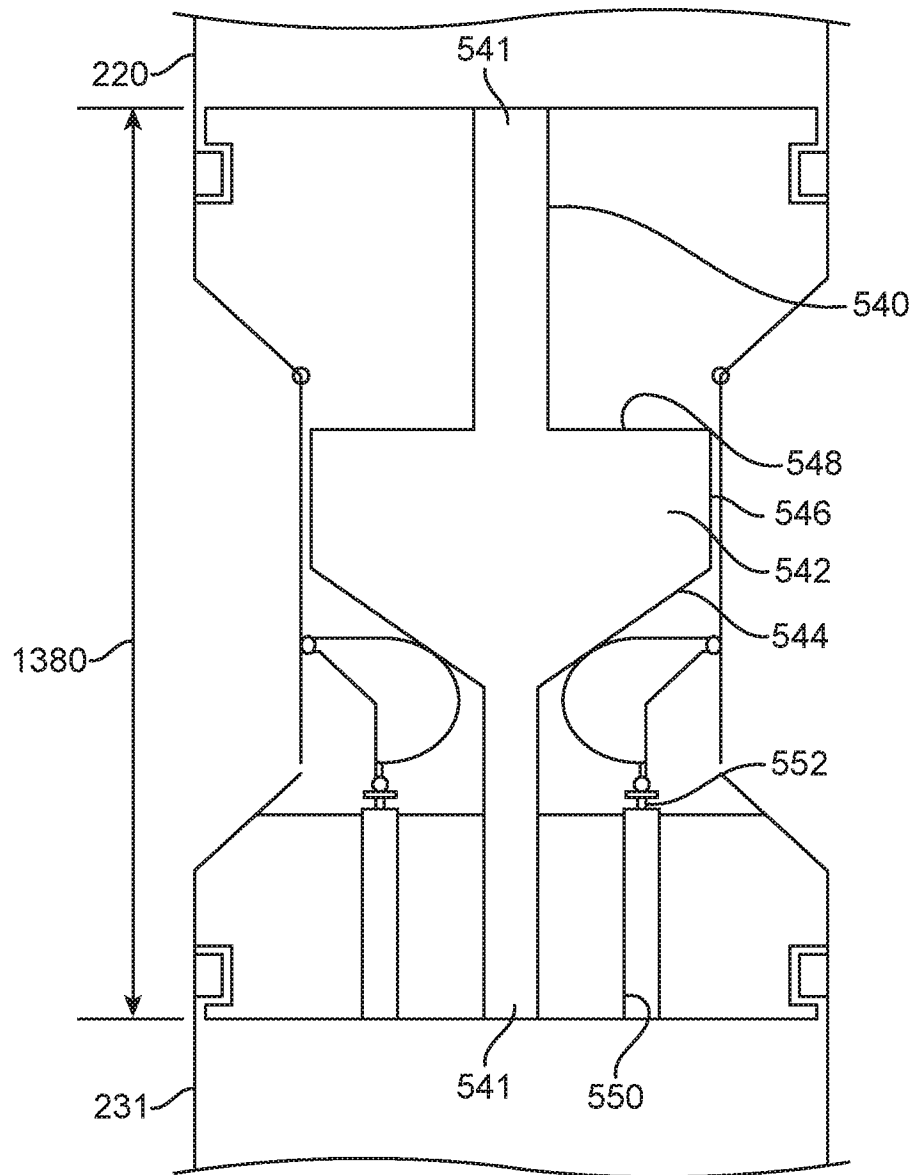


FIG. 13

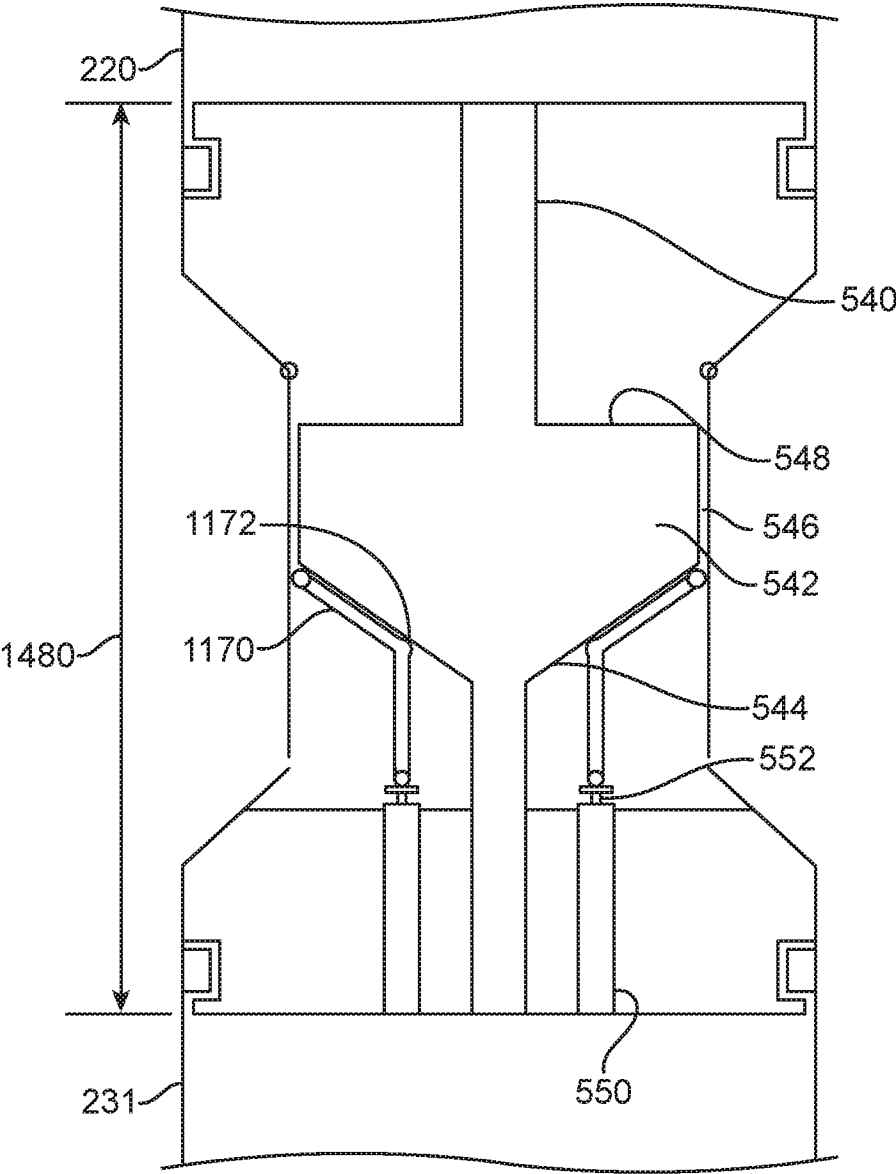


FIG. 14

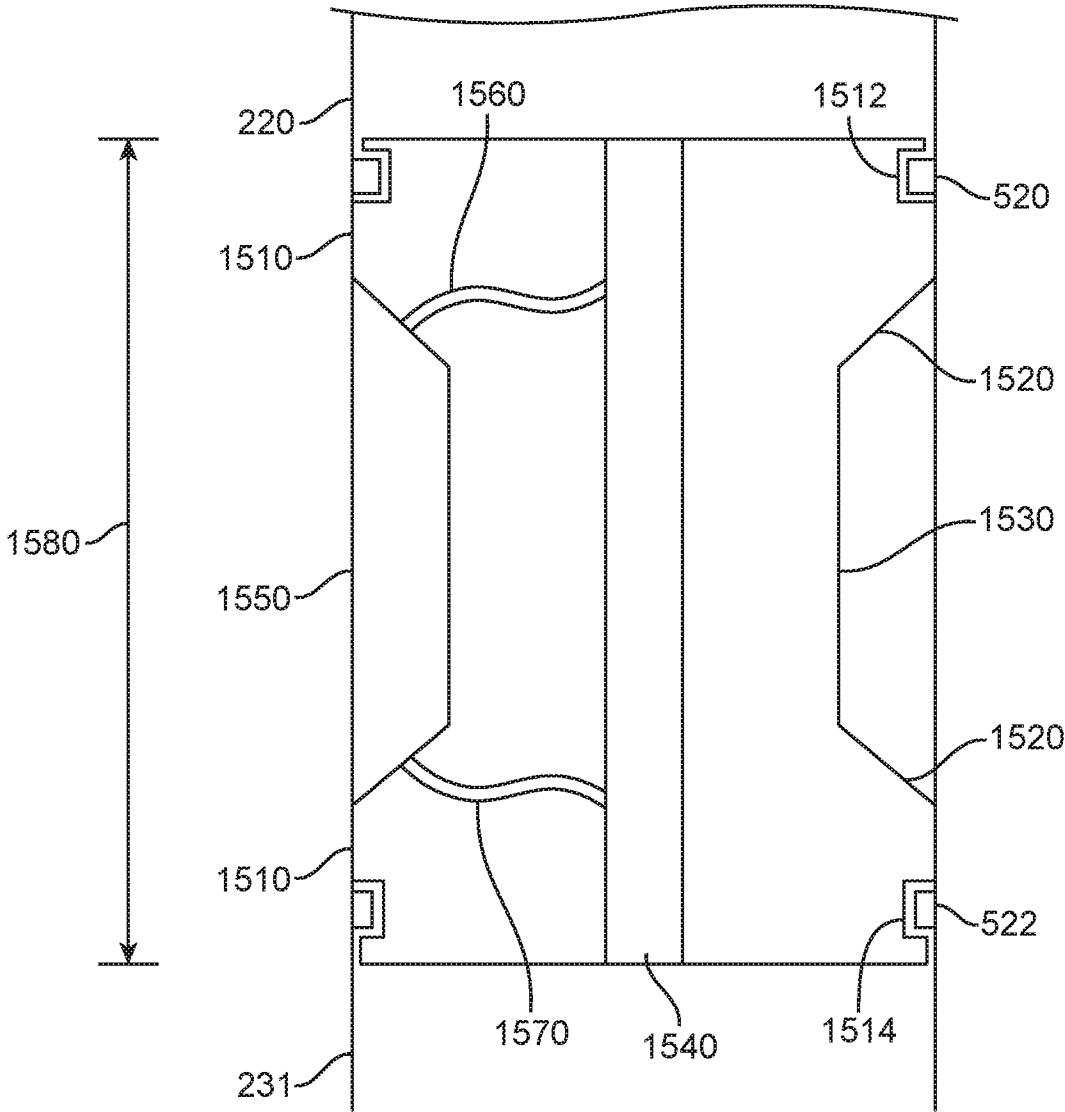


FIG. 15A

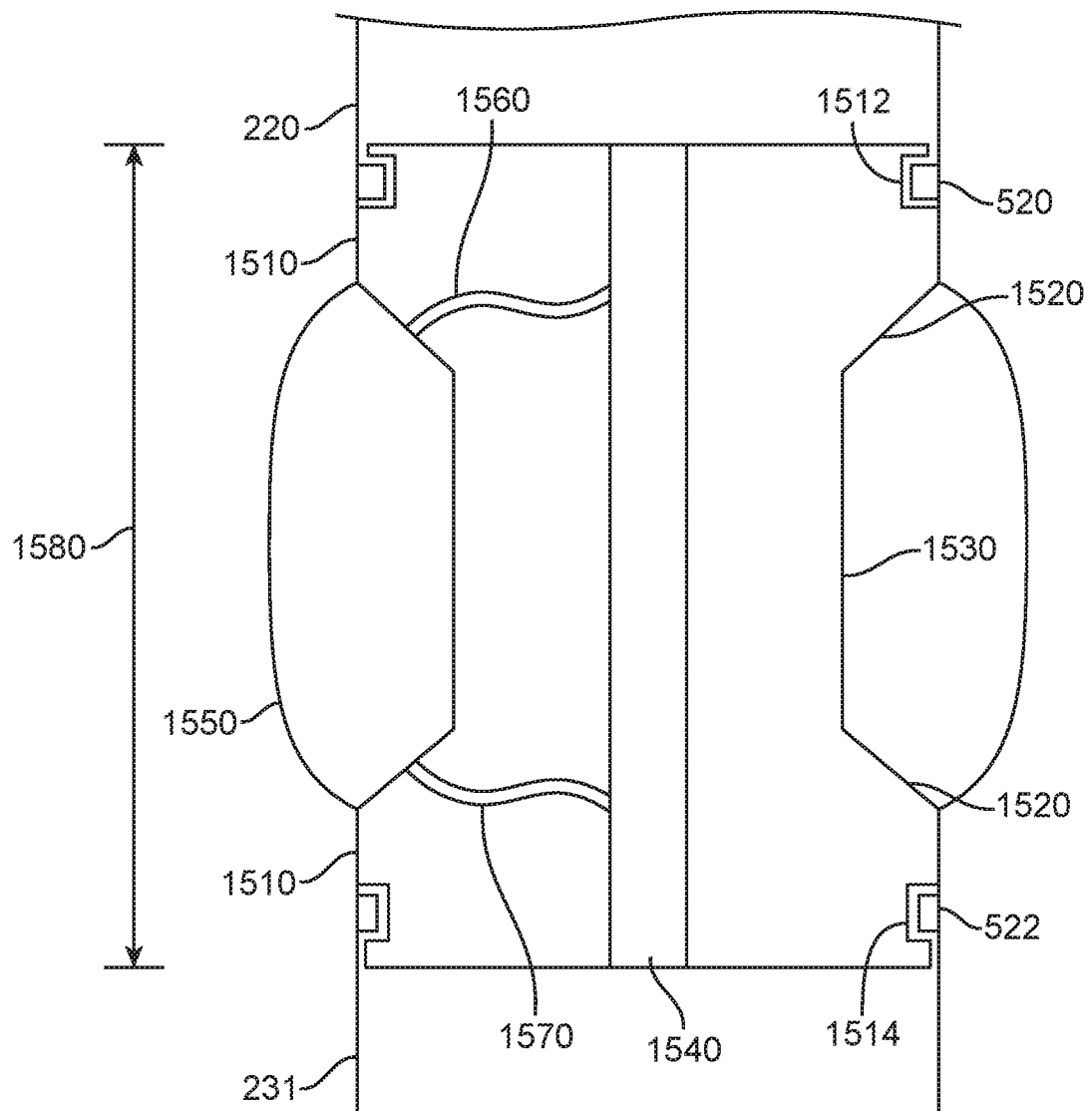


FIG. 15B

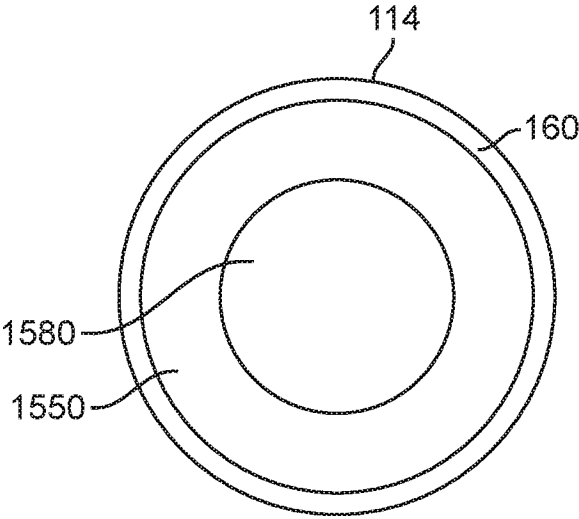


FIG. 16

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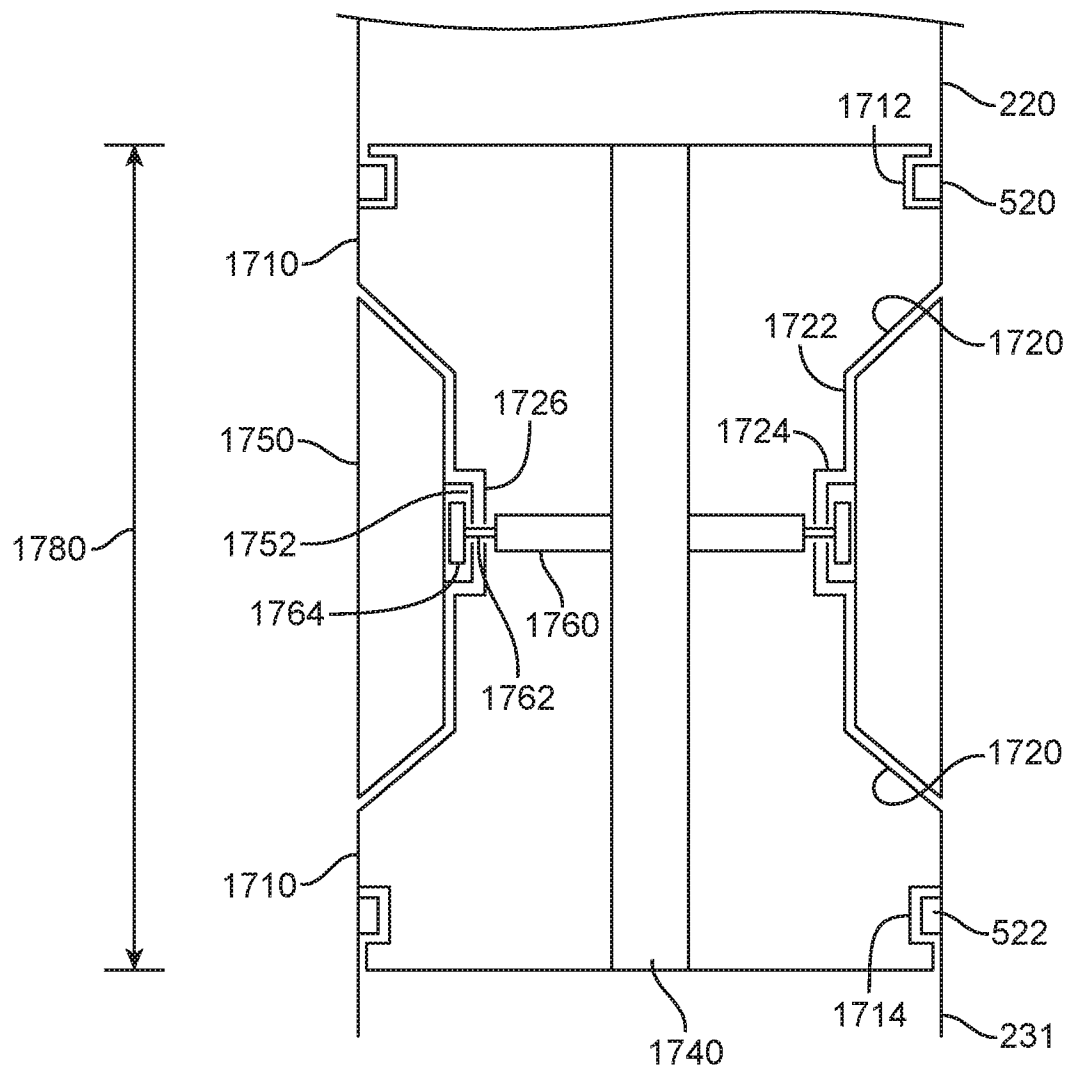


FIG. 17A

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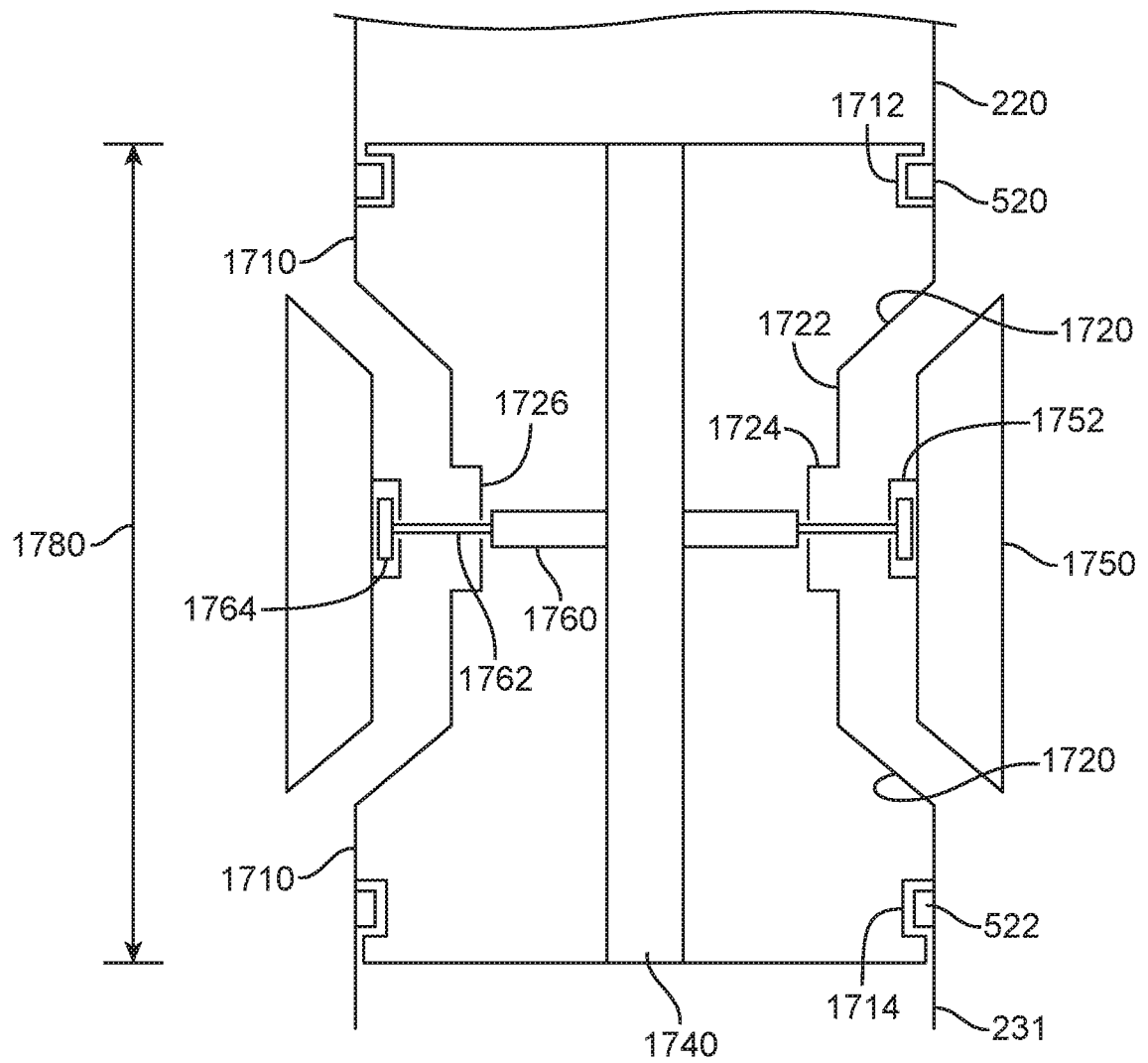


FIG. 17B

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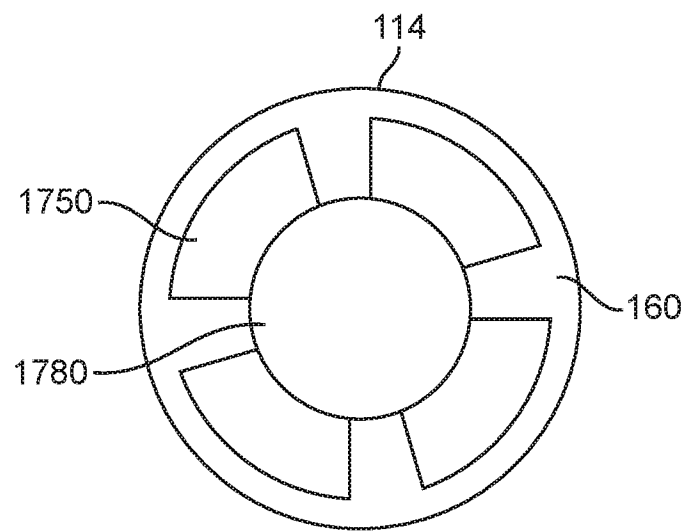


FIG. 18

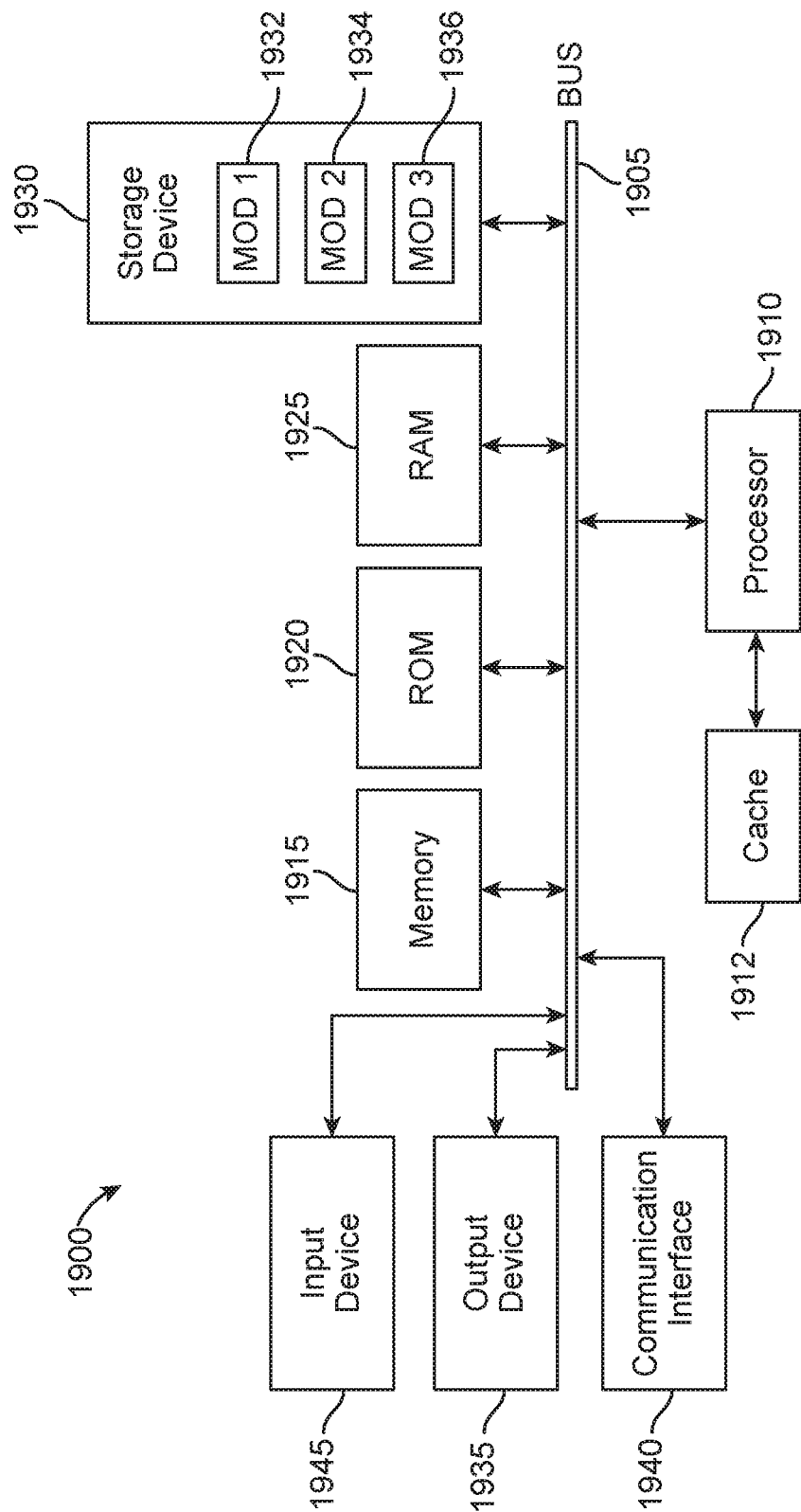


FIG. 19

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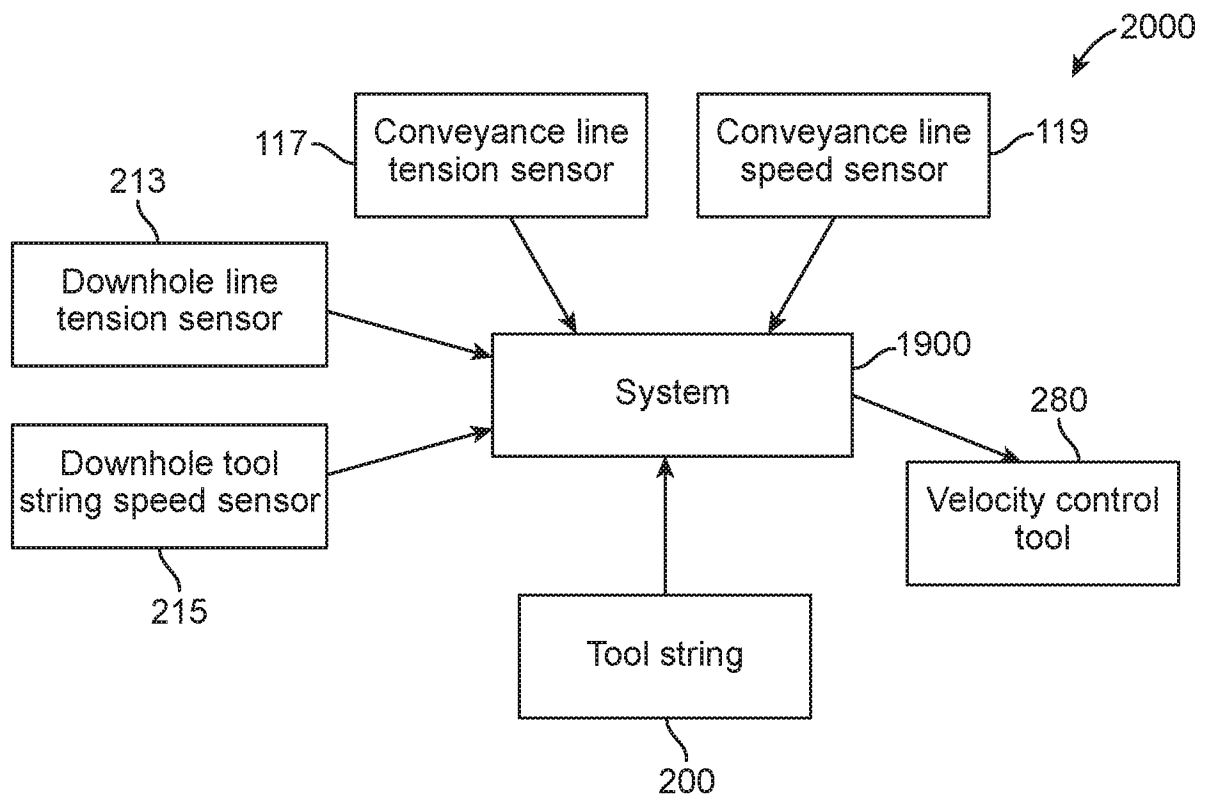


FIG. 20

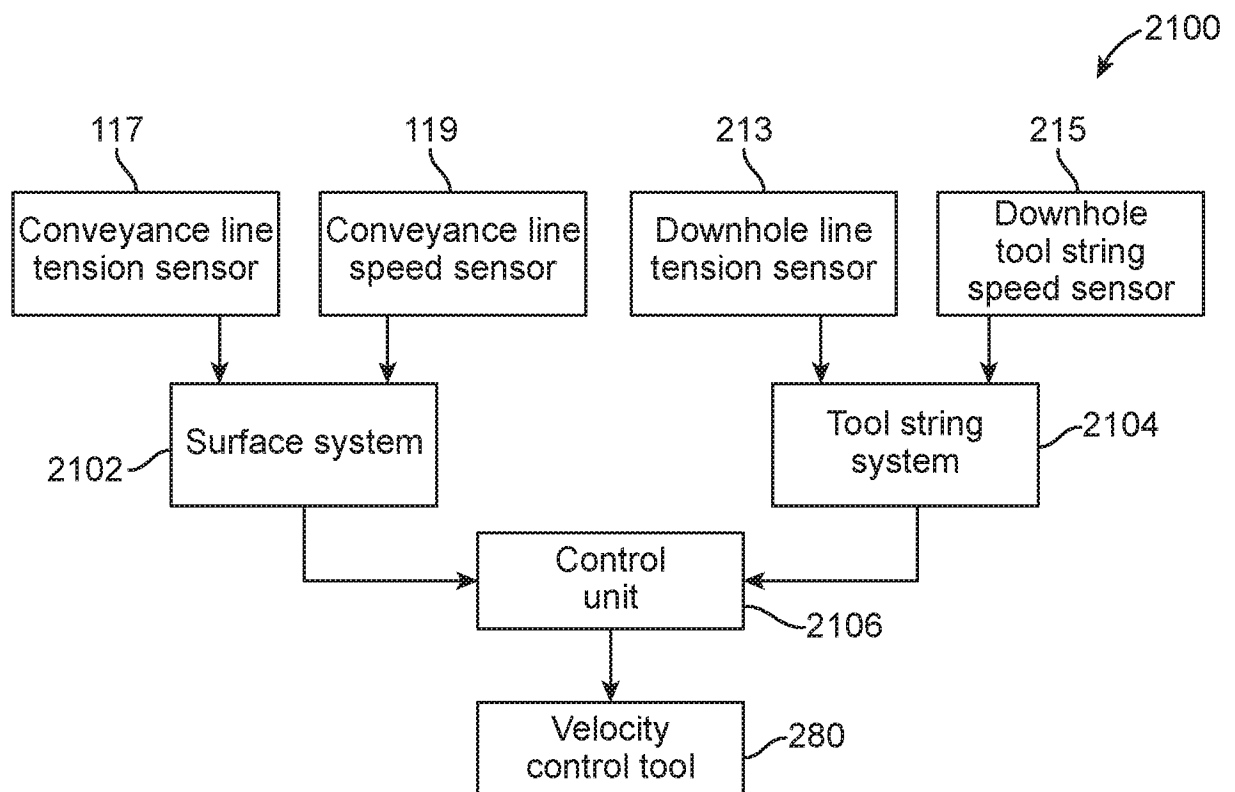


FIG. 21

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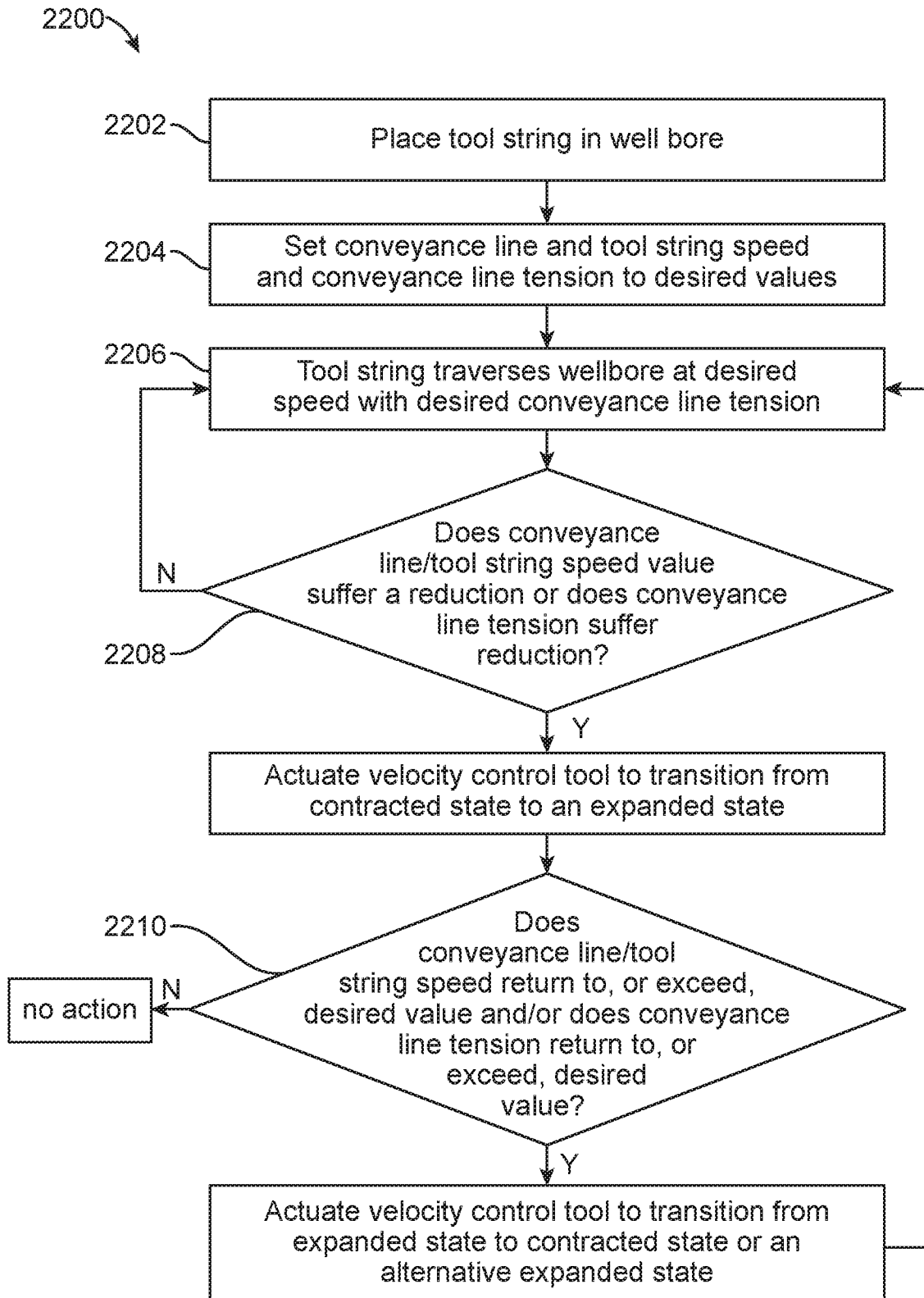


FIG. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/013662**A. CLASSIFICATION OF SUBJECT MATTER****E21B 17/00(2006.01)i, E21B 7/20(2006.01)i, E21B 34/06(2006.01)i**

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 17/00; E21B 23/08; E21B 10/32; E21B 47/09; E21B 47/12; E21B 21/08; E21B 23/00; E02D 5/80; E21B 7/20; E21B 34/06

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 models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: string, conveyance line, wellbore, speed, velocity, sensor, tension, extend, expand, retract, diameter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 07-062967 A (TAISEI CORP.) 07 March 1995	1-5, 7-11, 13, 30, 31
Y	See abstract, paragraphs [0008]-[0014], and figures 1-3.	6, 12, 14-29, 32-36
Y	US 2004-0045719 A1 (MOORE et al.) 11 March 2004	6, 12
	See paragraphs [0087], [0088], claim 29, and figures 2A, 2B.	
Y	US 2015-0167414 A1 (COLES et al.) 18 June 2015	14-29, 32-36
	See paragraphs [0031]-[0036], [0044], [0045], [0049] and figures 1, 3, 5, 7A.	
A	US 2008-0308279 A1 (ZAZOVSKY et al.) 18 December 2008	1-36
	See paragraphs [0036]-[0040], [0043], claims 1-11, and figures 5-8B.	
A	US 7303010 B2 (DE GUZMAN et al.) 04 December 2007	1-36
	See abstract, column 15, lines 1-25, and figures 10-10E.	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 October 2016 (14.10.2016)

Date of mailing of the international search report

14 October 2016 (14.10.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

KIM, Jin Ho

Telephone No. +82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/013662

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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