

SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO	
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DEP: 2020 DIRECCION DE NUEVAS CREACIONES	EVE: 378 FASE NACIONAL INCLUIDO CAPITULO I
TRA: 11 PCT-PATENTE DE INVENCION CAPITULOS I Y II	FOLIOS: 7
ACT: 430 REQUERSOLICITA	

DIRECCIÓN DE NUEVAS CREACIONES

2020
Bogotá, D.C.,

Abogado(a)/Señor(a)
SILVANA MARÍA LÓPEZ DÍAZ

Asunto: Radicación: 14-120180- -2
Trámite: 11
Evento: 378
Actuación: 430
Oficio: 8966
Folios: 7

Patente de Invención	X			Patente de Modelo de Utilidad	
Vía Nacional					
Vía PCT (Fase Nacional)	X	Capítulo I	X	Capítulo II	
No. Solicitud Internacional	PCT/US2012/071739				
Fecha de Presentación Internacional	27/12/2012				

Como resultado del examen de fondo realizado, con fundamento en el Artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se comunica:

1. Documentos estudiados

Descripción:	Rad. N° 14-120180-00000-0000	04/Junio/2014
Reivindicaciones:	Rad. N° 14-120180-00000-0000	04/Junio/2014
Dibujos:	Rad. N° 14-120180-00000-0000	04/Junio/2014
Prioridad:	US 13/353,564	19/Enero/2012

2. Objeto de la invención

De acuerdo con lo establecido en el numeral 1.2.2.2 del Capítulo Primero del Título X de la Circular Única para efectos del examen de patentabilidad, se tendrá en cuenta la tasa pagada por el solicitante al momento de comenzar el examen para las reivindicaciones adicionales; esto es que cuando la solicitud contenga más de diez (10) reivindicaciones y

no se haya pagado la tasa complementaria, sólo se estudiarán las cubiertas por la tasa pagada. Por lo tanto, se estudiarán las reivindicaciones 1 a 23.

Título de la solicitud: “Dispositivo contador para atrapar tapones selectivamente” (Fl. 1).

El problema planteado en esta solicitud, consiste en lograr un mecanismo contador para habilitar y restringir de manera selectiva el paso de un tapón dependiendo de un número de tapones que se han contado al pasar.

Para resolver este problema técnico, la solicitud en estudio propone un ensamble contador que comprende un componente accionable, un componente contador dispuesto con dicho componente accionable y un miembro de bloqueo enganchado en una pista formada entre el componente accionable y el componente contador.

El objeto de la presente solicitud se relaciona con la Clasificación Internacional de Patentes (CIP): E 21 B 17/043, 17/046, 19/16.

3. De la solicitud de patente

Reivindicaciones (Art 30 D 486, Art 22 PCT)

El capítulo reivindicatorio no es claro porque:

- La reivindicación 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 20, 22, 23 y las expresiones: “... accionable...”, “...e inicialmente en una primera posición con relación al componente accionable y que se puede mover con respecto hacia el componente accionable...”, “... el miembro de bloqueo se dispone de forma operativa para permitir el movimiento relativo entre el componente accionable (...) cuando el miembro de bloqueo ha alcanzado un extremo de la pista.” (reivindicación 1), “...el asiento se dispone de forma operativa para recibir un tapón para impedir flujo de fluido a través del asiento.” (reivindicación 2), “...para regresar el componente contador a la primera posición.” (reivindicación 4), “...para mantener inicialmente el componente accionable en una posición no accionada.” (reivindicación 21), “...dispuesto de forma operativa para enganchar el componente accionable cuando el componente accionable se mueve a una posición accionada.” (reivindicación 22); describen funciones, efectos, ventajas o resultados a alcanzar, los cuales no son aspectos susceptibles de patente. Para mayor claridad, el producto reclamado se debe definir técnicamente mediante sus características estructurales. Se sugiere al solicitante eliminar la reivindicación y las expresiones citadas.
- No es clara la dependencia entre la reivindicación 15 y la reivindicación 11, ya que la reivindicación 15 reclama un sistema que incluye un grupo de ensambles, mientras que la reivindicación 11 se refiere a un solo ensamble. En este caso, se sugiere al solicitante eliminar la expresión “...de acuerdo con la reivindicación 11.”, por características constructivas de la invención. Se resalta que la reivindicación 11 no contiene características técnicas, como se mencionó en la objeción anterior.
- La reivindicación 22 no cumple con lo establecido en el artículo 30 de la decisión 486, por cuanto el elemento de bloqueo ya había sido reclamado en la reivindicación 1. Cabe mencionar, que dicha reivindicación 22 no incluye alguna característica estructural adicional al elemento de bloqueo. Se sugiere al solicitante eliminar la reivindicación 22.

- La expresión: “por lo menos” (reivindicación 1, 5, 8, 9, 16, 19) precediendo una característica no es limitativo, porque hace opcional a la característica y no limita el alcance de la reivindicación. Se sugiere incluir las características opcionales o preferentes en una reivindicación dependiente.

4. Determinación del Estado de la Técnica

El estado de la técnica se determinó con base en la fecha de presentación de la solicitud de prioridad: enero 19 de 2012 y se encontraron los siguientes documentos que anticipan el objeto de esta solicitud:

Ítem	Documento	Título	Fecha de Publicación
D1	US 2011/0180270	'Position retention mechanism for maintaining a counter mechanism in an activated position'	28/Julio/2011
D2	US 2009/0308588	'Method and apparatus for exposing a servicing apparatus to multiple formation zones'	17/Diciembre/2009
D3	US 2004/0055753	'Downhole ball dropping apparatus'	25/Marzo/2004

El documento D1¹ divulga un mecanismo de conteo que es accionable por ciclos de presiones para activar una posición que permite la actuación del dispositivo a su estado objetivo (resumen).

El documento D2² divulga un aparato de servicio en poso que comprende una primera manga dispuesta de forma deslizable en una sección de tubo, una segunda manga dispuesta deslizable en la primera manga y una ranura de indexación dispuesta en una de las mangas, así como una agarradera de control dispuesta en la manga opuesta (resumen).

El documento D3³ divulga un mecanismo de liberación de bola que es montado cerca de un asiento. La bola o bola son mantenidas fura del flujo circulante. Altos ratios de circulación posiciona un puerto exterior en posición para permitir que la bola o bolas sean empujadas por un resorte (resumen).

5. Examen de Patentabilidad (Art 14 D486)

Novedad (Art 16 D486)

La reivindicación 1 consiste en: “*Un ensamble contador que comprende: un componente accionable...*” (Ver página 14 del radicado N° 14-120180-00000-0000).

Comparación de las características técnicas esenciales, con las del estado de la técnica:

Características esenciales	D1
Ensamble de contador que comprende:	Un mecanismo de retención para mantener un mecanismo de conteo en una posición activada caracterizado por:
Un componente accionable.	Un mandril de cámara y un mandril de ciclo (220) (Párr. [0034]).
Un componente contador dispuesto con el componente accionable.	Un mecanismo contador (118) dispuesto con un mandril de ciclo

1 <https://www.google.ca/patents/US20110180270?dq=US2011180270&hl=es&sa=X&ei=L3mVVfpyhbiCBNfNgLAL&ved=0CB8Q6AEwAA>

2 <https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US20090308588.pdf>

3 <https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US20040055753.pdf>

	(220) (Fig. 2; Párr. [0030]).
Un miembro de bloqueo enganchado en una pista formada entre el componente accionable y el componente contador.	Un arreglo de ranuras (302) del mecanismo contador (118), que puede incluir las ranuras (304), (306), (308), (312) y (314) formadas en la superficie (222) del mandril de ciclo (220). El pin (224) viaja por las ranuras (304) a (314) (Figs. 2 y 3; Párr. [0030]).

De acuerdo con la tabla anterior, las características esenciales del sistema de la reivindicación 1 habían sido divulgadas previamente en el documento D1, por lo tanto, la materia reivindicada no es nueva.

La reivindicación 15 consiste en: “*Un sistema que incluye por lo menos un grupo de ensambles dispuestos en una sarta tubular...*” (Ver página 17 del radicado N° 14-120180-00000-0000).

Comparación de las características técnicas esenciales, con las del estado de la técnica:

Características esenciales	D2
Un sistema que incluye:	Un mecanismo de retención para mantener un mecanismo de conteo en una posición activada caracterizado por:
Un grupo de ensambles dispuestos en una sarta tubular.	Un pozo que comprende con su correspondiente línea de trabajo, una sarta tubular acoplada a la línea, una pluralidad de camisas dispuestas en la sección tubular y una pluralidad de asientos para recibir el miembro obturador (Párr. [0007])

De acuerdo con la tabla anterior, las características esenciales del sistema de la reivindicación 15 habían sido divulgadas previamente en el documento D2, por lo tanto, la materia reivindicada no es nueva.

Asimismo, los documentos D1 y D2 enseñan las características de las reivindicaciones dependientes así:

- Reivindicación 17: Manga estriada (216) y manga cortante (214) (D1: Párrs. [0031 y 33]). Camisa interna (504) y camisa externa (502) (D2:Fig. 6A; Párr. [0044]).
- Reivindicación 18: La apertura central (186) en cada ensamble de camisas (158) es de un diámetro (188) a través del cual la bola (194) puede pasar para enganchar con los asientos de las camisas (184) en los ensambles de camisas posteriores. Por lo tanto, los diámetros de los asientos posteriores se incrementa gradualmente del más bajo hacia el más alto ensamble de camisas (Párr. [0040]). Una primera bola pasa a través del orificio (505) y llega al asiento (542) en el extremo inferior (508) (D2: Párr. [0043]).
- Reivindicación 19: El miembro de bloqueo comprende un anillo (D1: reivindicación 9).

Nivel inventivo (Art18 D486)

En cuanto a la reivindicación 2 se tiene que:

Comparación de las características técnicas esenciales, con las del estado de la técnica:

Características esenciales	D1	D3
Ensamble de contador que comprende:	Un mecanismo de retención para mantener un mecanismo de conteo en una posición activada caracterizado por:	Aparato para tirar una bola de pozo caracterizado por:
Un componente accionable.	Un mandril de cámara y un mandril de ciclo (220) (Párr. [0034]).	Una camisa (30) (Figs. 1 a 3; Párr. [0009]).
Un componente contador dispuesto con el componente accionable.	Un mecanismo contador (118) dispuesto con un mandril de ciclo (220) (Fig. 2; Párr. [0030]).	No menciona.
Un miembro de bloqueo enganchado en una pista formada entre el componente accionable y el componente contador.	Un arreglo de ranuras (302) del mecanismo contador (118), que puede incluir las ranuras (304), (306), (308), (312) y (314) formadas en la superficie (222) del mandril de ciclo (220). El pin (224) viaja por las ranuras (304) a (314) (Figs. 2 y 3; Párr. [0030]).	
Un asiento acoplado al componente contador.	No menciona.	El alojamiento (10) comprende un asiento de bola montado en el portador de pelota (16) o en otro alojamiento en comunicación con el alojamiento (10) (D1: Figs. 1 a 3; Párr. [0008]).

Los documentos D1 y D3 se consideran el estado de la técnica cercano a la invención definida en las reivindicaciones 1 y 2 porque divulgan un mecanismo de retención para mantener un mecanismo de conteo en una posición activada en un pozo y una herramienta para taponado de pozo.

La diferencia entre la invención, definida en las reivindicaciones 1 y 2 y el mecanismo de D1 consiste en un asiento acoplado al componente contador.

La diferencia entre la invención, definida en las reivindicaciones 1 y 2 y la herramienta de D3 consiste en un componente contador y un miembro de bloqueo formado entre el componente accionable y el componente contador.

El efecto que logra el incluir un asiento acoplado al componente contador es recibir un tapón para impedir el flujo de fluido a través del asiento.

Por lo tanto, el problema técnico objetivo que pretende resolver esta invención se puede formular así: “¿cómo modificar el mecanismo conocido en D1 para poder es recibir un tapón para impedir el flujo de fluido a través del asiento?”.

Sin embargo, un asiento acoplado al componente contador para recibir un tapón para impedir el flujo de fluido a través del asiento, ya está divulgada en el documento D3 que se refiere a un alojamiento (10) comprende un asiento de bola montado en el portador de

pelota (16) o en otro alojamiento en comunicación con el alojamiento (10) (D3: Figs. 1 a 3; Párr. [0008]).

En consecuencia, la persona del oficio normalmente versada en la materia, un alojamiento (10) comprende un asiento de bola montado en el portador de pelota (16) o en otro alojamiento en comunicación con el alojamiento del documento D3 en el mecanismo divulgado en el documento D1 para llegar así al objeto de las reivindicaciones 1 y 2 de la solicitud. Por lo cual se considera obvia.

Asimismo, los documentos antecedentes D1 y D3 enseñan las características de las reivindicaciones dependientes así:

- Reivindicación 4 y 21: El resorte (32) desplaza la camisa (30) (D3: Figs. 1 a 3; Párr. [0009]).
- Reivindicación 7: Las bolas (22) y (24) (D3: Fig. 1; Párr. [0009]).

Las reivindicaciones 3, 5, 6, 8, 9, 10, 11, 12, 13, 14, 16, 20, 22, 23 ya fueron afectadas en el numeral 4 de la presente comunicación.

6. Conclusión

Los requisitos de Patentabilidad de la presente solicitud están afectados así:

Ítem	Documento	Reivindicaciones afectadas	Requisito que afecta
D1	US 2011/0180270	1 , 17	Novedad/Nivel Inventivo
D2	US 2009/0308588	15, 17, 18	Novedad/Nivel Inventivo
D3	US 2004/0055753	4, 7, 21	Novedad/Nivel Inventivo

En cumplimiento del artículo 45 de la Decisión 486 de la Comisión de la Comunidad Andina, se le indica que debe dar respuesta dentro del término de sesenta (60) días contados a partir del día siguiente de la fecha de notificación de la presente comunicación. En caso de no dar respuesta al presente requerimiento, o si a pesar de la respuesta subsistieran los impedimentos para la concesión, se denegará la patente.

Se invita al solicitante se sirva indicar, si así lo considera, su renuncia al término faltante de sesenta (60) días para dar respuesta a este requerimiento y presentarla por escrito.

Finalmente, se le recuerda al solicitante que si como respuesta a este requerimiento llegara a modificar el capítulo reivindicatorio y éste contenga más de diez (10) reivindicaciones, no pagará la tasa de modificación voluntaria pero sí la correspondiente al pago por reivindicación adicional.

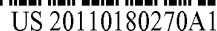
Notifíquese el presente oficio conforme a lo dispuesto en el numeral 5.2, literal e), del capítulo quinto del título primero de la Circular Única No. 10 de 2001.



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El anterior requerimiento fue notificado por fijación en lista, de fecha 2015-08-04

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(12) **Patent Application Publication**
Martin et al.

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(22) Filed: **Jan. 27, 2010**

Publication Classification

(52) **U.S. Cl.** **166/374; 166/321**

(57) **ABSTRACT**

To operate a device for use in a well, a counter mechanism is provided that is actuatable by pressure cycles to an active position that allows actuation of the device to a target state. A position retention mechanism is coupled to the counter mechanism to maintain the counter mechanism in the active position once the counter mechanism has been incremented by the pressure cycles to the active position.

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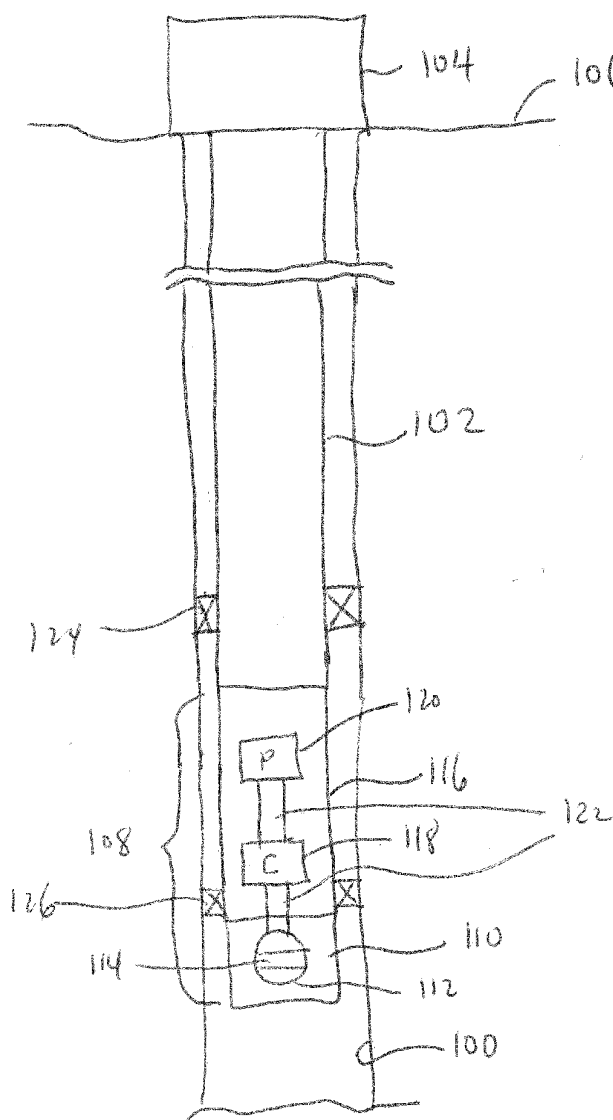
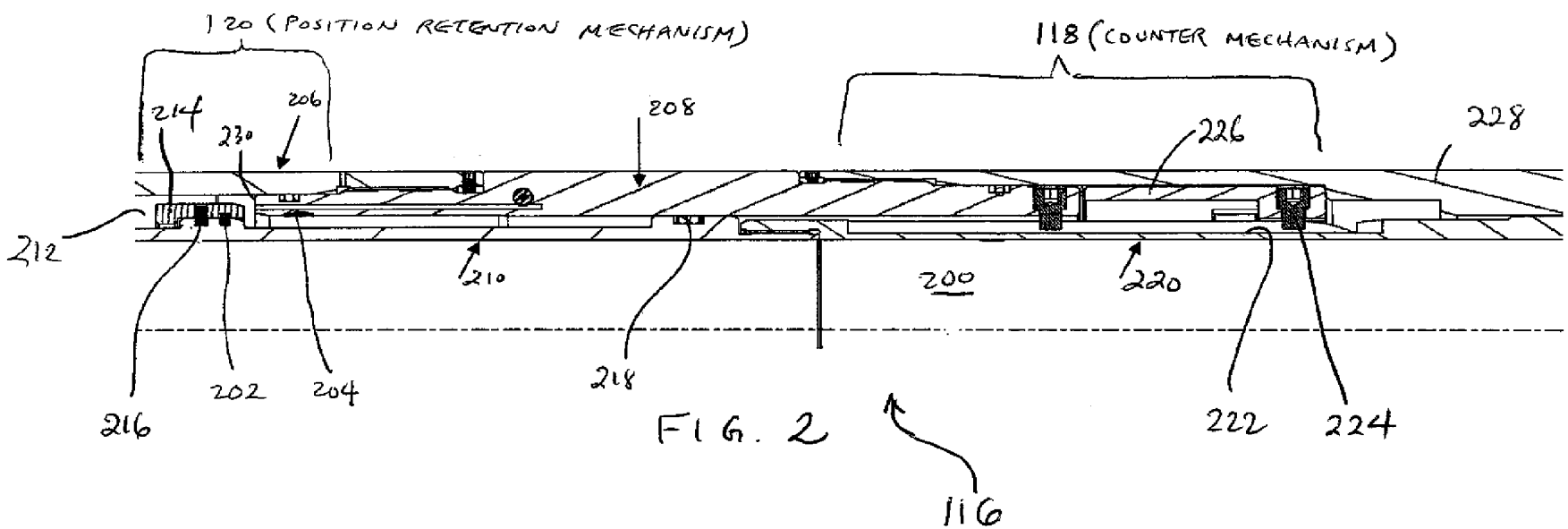


Fig. 1



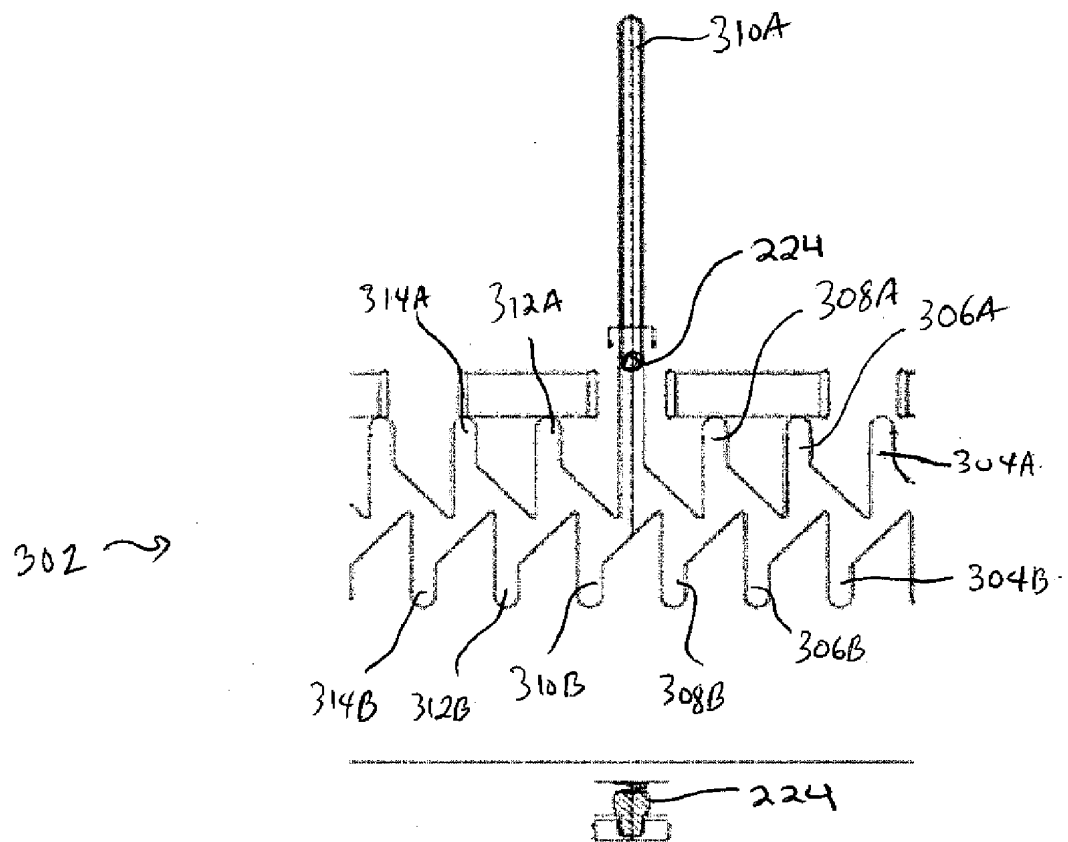
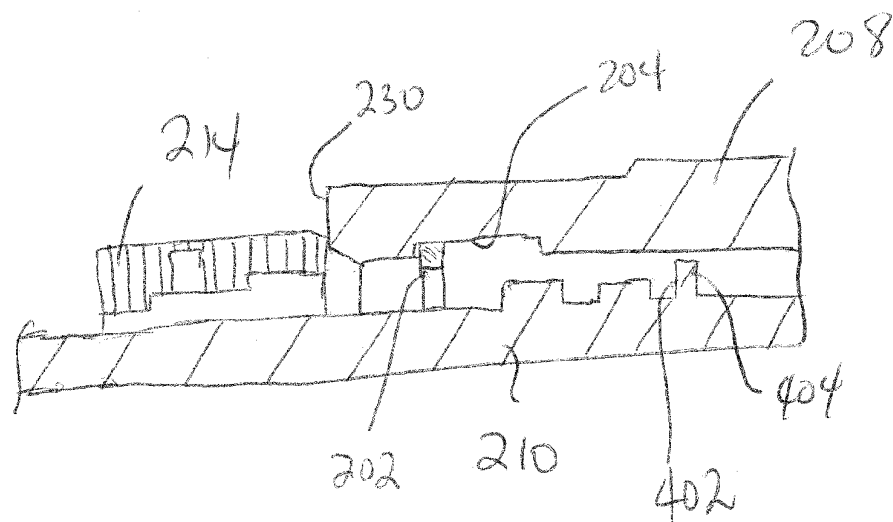
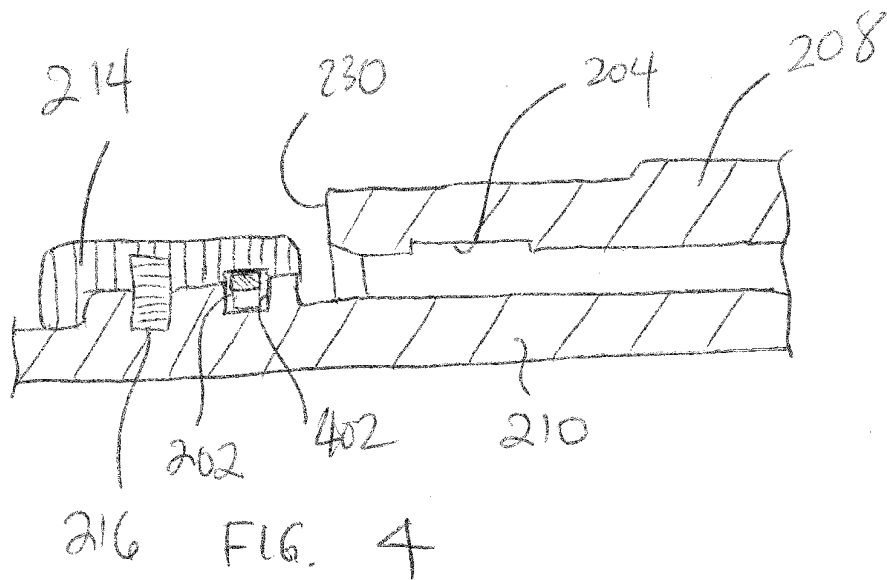


Fig. 3



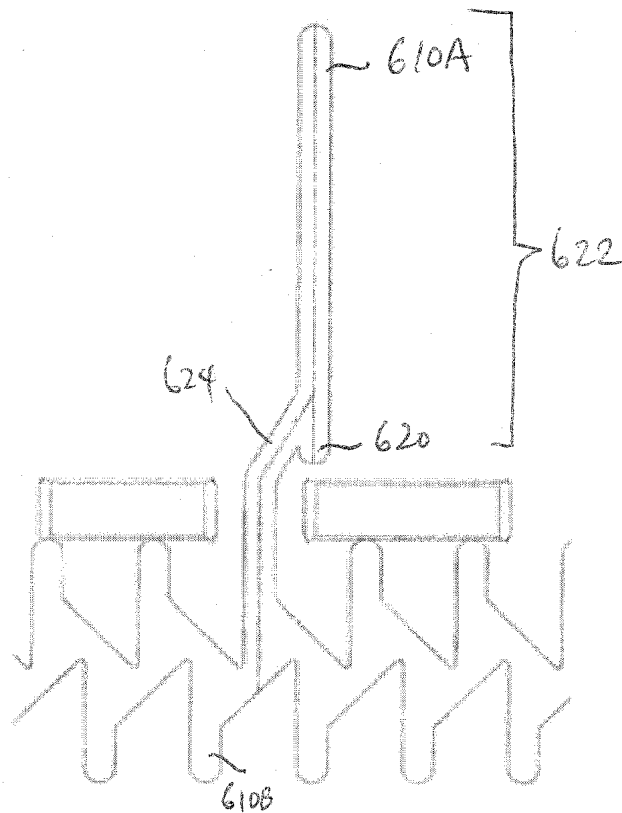


Fig. 6

POSITION RETENTION MECHANISM FOR MAINTAINING A COUNTER MECHANISM IN AN ACTIVATED POSITION

BACKGROUND

[0001] Various types of equipment may be deployed in a well for enabling production or injection of fluids through the well. Examples of such equipment include tubings, valves, and sealing elements for controlling fluid flow.

[0002] One type of valve deployed in a well is a formation isolation valve. When closed, the formation isolation valve isolates one region of the well from another region of the well, such that fluid flow is blocked between the two regions. Formation isolation valves can be actuated between an open position and a closed position using an operating mechanism. Typically, the operating mechanism is a hydraulically or pressure-actuated operating mechanism. In some implementations, the hydraulically or pressure-actuated operating mechanism may include a counter or indexing mechanism that is incrementally advanced in response to application of successive pressure cycles. A counter mechanism may have multiple positions, where at least one of the positions (e.g., an “active position”) corresponds to a position in which the formation isolation valve is configured to be actuated to an open position. The remaining positions of the counter mechanism may correspond to positions configured to maintain the formation isolation valve in a closed position.

[0003] In some cases, the presence of debris or other faults may prevent the formation isolation valve from being successfully actuated to the open state, even though the counter mechanism has been incremented to its active position. When this occurs, any further pressure cycles will cause the counter mechanism to leave its active position. This situation would require the performance of another round of multiple pressure cycles in order to actuate the formation isolation valve to its open position, which is time-consuming and expensive.

SUMMARY

[0004] In general, according to an embodiment, an apparatus to operate a device for use in a well includes a counter mechanism actuatable by pressure cycles to an active position for actuating the device to a target state. In addition, the apparatus has a position retention mechanism coupled to the counter mechanism to maintain the counter mechanism in the active position once the counter mechanism has been incremented by the pressure cycles to the active position.

[0005] Other or alternative features will become apparent from the following description, from the drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Certain embodiments of the invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying drawings illustrate only the various implementations described herein and are not meant to limit the scope of various technologies described herein. The drawings are as follows:

[0007] FIG. 1 is a schematic diagram of a tool string including a counter mechanism and position retention mechanism coupled to the counter mechanism, according to an embodiment;

[0008] FIG. 2 is a sectional view of a portion of the tool string that includes the counter mechanism and position retention mechanism, according to an embodiment;

[0009] FIG. 3 is a side view of a counter mechanism used in the tool string according to an embodiment;

[0010] FIGS. 4 and 5 are schematic diagrams of the position retention mechanism in different positions, according to an embodiment; and

[0011] FIG. 6 is a side view of a counter mechanism that incorporates a position retention mechanism according to an alternative embodiment.

DETAILED DESCRIPTION

[0012] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that embodiments of the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments are possible.

[0013] As used here, the terms “above” and “below”; “up” and “down”; “upper” and “lower”; “upwardly” and “downwardly”; and other like terms indicating relative positions above or below a given point or element are used in this description to more clearly describe some embodiments of the invention. However, when applied to equipment and methods for use in wells that are deviated or horizontal, such terms may refer to a left to right, right to left, or diagonal relationship as appropriate. In the specification and appended claims: the terms “connect”, “connection”, “connected”, “in connection with”, “connecting”, “couple”, “coupled”, “coupled with”, and “coupling” are used to mean “in direct connection with” or “in connection with via another element”.

[0014] In accordance with some embodiments, a position retention mechanism is provided and operably coupled to a counter mechanism in order to maintain the position of the counter mechanism once the counter mechanism has been incremented by pressure cycles to an active position of the counter mechanism. The “active position” of the counter mechanism corresponds to a position of the counter mechanism where an operating mandrel, which is operatively coupled to the counter mechanism, is allowed to actuate a downhole device to a target state.

[0015] In some embodiments, the downhole device that is to be actuated can be a valve, such as a formation isolation valve. The target state of the valve can be an opened state or a closed state, depending upon the application. In the ensuing discussion, reference is made to a formation isolation valve as an example of the downhole device. The target state of the formation isolation valve in the illustrative embodiments discussed is the open state. Note that in other embodiments, the downhole device can be another type of device, such as a sealing element, another type of valve, and so forth, and the target state can be another state, such as a closed state, incremental position, and others as appropriate.

[0016] An “operating mandrel” that is operatively coupled to the counter mechanism refers to a moveable member that is moveable between different positions. For example, a first position of the operating mandrel may cause the formation isolation valve to be closed, while a second position of the operating mandrel may cause the formation isolation valve to be opened. Although reference is made to “operating man-

drel” in the singular sense, note that the operating mandrel can actually include multiple elements that are directly or indirectly coupled together.

[0017] Pressure cycles may be applied to the counter mechanism in order to actuate the counter mechanism between different positions. A “pressure cycle” refers to a sequence of an elevated pressure and a reduced pressure. The counter mechanism may be actuated on the application of elevated or reduced pressure, or actuated through the elevated and reduced pressure sequence. In the ensuing discussion, it is assumed that the illustrative counter mechanism has just one active position and multiple non-active positions. In other exemplary embodiments, it is possible for the counter mechanism to have multiple active positions. In the non-active positions of the counter mechanism, the operating mandrel is not allowed to actuate the formation isolation valve to an open position (i.e., when the counter mechanism is in a non-active position, the operating mandrel is either kept in a single position or allowed to move between positions that maintain the formation isolation valve in the closed position).

[0018] The position retention mechanism maintains the counter mechanism in an active position by preventing or inhibiting the counter mechanism from moving from an active position to a non-active position. Maintaining the counter mechanism in the active position can be useful in various applications. For example, when the counter mechanism initially reaches its active position, the presence of debris or another fault condition may prevent the formation isolation valve from being successfully actuated to its target state (e.g., the open position).

[0019] When such a condition is detected, a well operator would normally perform some intervention operation to remove the condition, such as by flowing fluid to the debris containing region of the well in order to remove the debris, or by performing another intervention operation to fix a fault condition in the tool. Once the condition that prevents opening of the formation isolation valve is removed, the formation isolation valve may then be able to open. However, in a situation in which no position retention mechanism is provided, another cycle may be inadvertently applied to the counter mechanism during the actions performed to clear the debris or fault, or the counter mechanism may be otherwise incremented. The counter mechanism would then go from the active position to the adjacent non-active position. As a result, the well operator would have to apply another round of multiple pressure cycles in order to increment the counter mechanism back to the active position, which can be quite time consuming.

[0020] On the other hand, if a position retention mechanism according to some embodiments is used, the counter mechanism is maintained in its active position once the counter mechanism reaches such active position. Therefore, another pressure cycle would not increment the counter mechanism out of its active position. As a result, the operating mandrel can actuate the formation isolation valve to an opened position when the debris or fault is cleared.

[0021] FIG. 1 illustrates exemplary completion equipment that may include tubing 102 installed in a well 100. The tubing 102 can be production tubing for producing fluids from a surrounding reservoir to the earth surface 106. Alternatively, the tubing 102 can be injection tubing for injecting fluids into the surrounding reservoir. Of course, some tubing

102 may be used for both injection and production. The tubing 102 may extend from wellhead equipment 104 located at the earth surface 106.

[0022] A valve assembly 108 is attached below a sealing element 124 (e.g., such as a packer) to the lower end of the production tubing 102. However, locations of valve assemblies may not be limited to this illustrative example. Other valve assembly locations may be above or concurrent with a packer 124 or may include multiple valve assemblies in multiple producing zones, such as in multiple intervention completions. The valve assembly 108 may comprise a formation isolation valve 110, which can be implemented with a ball valve for example. A ball valve may include a ball that has an inner bore 114 through which fluids can pass. The ball is rotated between different positions. In a closed position the ball 112 is oriented to prevent fluid from flowing through the inner bore 114, and in an open position the ball is aligned with a fluid flow path to allow fluid to pass through the inner bore 114. Although the term “ball” is used to describe the formation isolation valve, this term should not be limited to its literal spherical geometric definition. Other types of ball valves may include half ball sections, rotating cylindrical sections or other configurations.

[0023] The valve assembly 108 may further comprise an operating mechanism 116 that includes a counter mechanism 118 and a position retention mechanism 120. The counter mechanism 118 may be incremented among its incremental positions by applications of hydraulic pressure cycles via the tubing 102 (e.g., such as from a hydraulic pressure source, not shown, provided at the earth surface 106). In an alternative implementation, the application of hydraulic pressure cycles can be applied through a hydraulic control line (not shown) that may extend from the wellhead equipment 104 at the earth surface 106 into the wellbore and extend to the operating mechanism 116. In some exemplary embodiments, the operating mechanism 116 also includes an operating mandrel 122 that is shiftable between different positions for actuating the ball valve 110 between the open position and closed position. Also shown in FIG. 1 are sealing elements 124 and 126 (e.g., such as packers for example) for sealing various annular regions in the well 100.

[0024] Although the schematic diagram of FIG. 1 shows the counter mechanism 119, position retention mechanism 120, and operating mandrel 122 as occupying a centralized location within the area defined by operating mechanism 116, it is noted that in practice, the various components of the operating mechanism 116 may be implemented in an annular region around an inner bore. The inner bore extends through the area bounded by the schematic representation of the operating mechanism 116 and forms part of a fluid path. In operation, when the formation isolation valve 112 is in its open position, fluids (e.g., production fluids or injection fluids) can flow through the inner bore 114 of the formation isolation valve 112, the inner bore through the area of the operating mechanism 116, and the inner bore of the tubing 102, in the example shown. Note that FIG. 1 illustrates one exemplary arrangement of the tool string and operating mechanism 116. In other implementations, other arrangements and configurations can be employed.

[0025] FIG. 2 illustrates a partial cross-sectional portion of the operating mechanism 116 of FIG. 1, according to an embodiment. As described earlier, the operating mechanism 116 may include the exemplary counter mechanism 118 and position retention mechanism 120 shown in the drawing. Also

shown is an inner bore **200** along the length of the operating mechanism **116** through which fluid can flow. Only one half of the cross-sectional portion of the operating mechanism **116** is shown, and it may be assumed for the purposes of simplifying the detailed description that the operating mechanism **116** is substantially symmetrical about an axis defining the inner bore **200**.

[0026] The position retention mechanism **120** may include a locking member **202** and a locking profile **204**, according to the illustrative embodiment. The locking member **202** may be configured to be lockingly coupled to or engageable with the locking profile **204**, which in some embodiments may be a groove formed in an intermediate housing section **208**, for example. The intermediate housing section **208** may be attached (e.g., such as by threaded connection) to a gas chamber housing section **206**. The housing sections **206**, **208**, in cooperation with a gas chamber mandrel **210**, define a gas chamber **212** between the housing sections **206**, **208** and the mandrel **210**. The gas chamber **212** may be a sealed gas chamber that contains a gas, such as nitrogen or other type of gas. Alternatively, the sealed chamber **212** can contain a liquid or be functionally replaced with a resilient member such as a spring, for example. In still other cases, there may be a pressure source to actively drive the gas chamber mandrel **210** in a first direction and another pressure source to actively drive the gas chamber mandrel **210** in a direction opposite to the first direction (of course, other mandrels may be driven as well as or in place of the gas chamber mandrel **210**). The gas in the gas chamber **212** may be maintained at an elevated pressure in order to be able to apply a downward force against a shear sleeve **214** that is initially attached to the gas chamber mandrel **210** by a shear element **216**. The shear element **216** can be a shear pin, shear screw, or other form of temporary restraint, for example.

[0027] A sealing element **218** may be provided on an outer wall of the gas chamber mandrel **210**. The sealing element **218** (e.g., one or more O-ring seals, or other types of seals) may be engaged with the inner wall of the intermediate housing section **208** in order to establish and maintain a sealed gas chamber **212**. The gas chamber mandrel **210** may be threadably connected at its lower end (i.e., the rightmost end in the middle of the page as viewed in FIG. 2) to a cycle mandrel **220**, which is part of the counter mechanism **118**. The outer surface **222** of the cycle mandrel **220** may be configured with slots or pathways, which will be referred to as J-slots.

[0028] An engagement member, such as pin **224**, may be configured to be accommodated within and to travel relative to the slots. The pin **224** may be attached to a rotatable spline sleeve **226**, which is rotatably arranged inside of a counter housing section **228**. The counter housing section **228** may be attached at its upper portion (i.e., the leftmost end in the middle of the page as viewed in FIG. 2) to the intermediate housing section **208**. As the engagement member **224** travels relative to the slots of the counter mechanism **118** in response to pressure cycles, the cycle mandrel **220** does not rotate but does translate back and forth longitudinally, while the rotatable spline sleeve **226** incrementally rotates relative to the counter housing section **228**.

[0029] The slots formed in the outer surface **222** of the cycle mandrel **220** may include a number of slots having a first length, and at least one elongated slot having a second length that is longer than the first length, although the particular combination and configuration of the slots may be determined as appropriate for a specific application. In this

illustrative example, when the pin **224** is inside one of the shorter slots, the counter section **118** is considered to be in a non-active position. Once the pin **224** has traveled to the elongated slot in response to the application of pressure cycles, then the counter mechanism **118** is considered to be in its active position. When the pin **224** is in the elongated slot or actuatable length slot of the counter mechanism **118**, the mandrels **210** and **220** are able to shift downwardly (i.e., to the right) through a particular distance determined to allow for actuation of the ball valve **110** (see FIG. 1) to the open position. The mandrels **210** and **212** may be considered to be part of the operating mandrel **122** shown in FIG. 1.

[0030] In response to pressure cycles, the cycle mandrel **220** may be shifted back and forth in the longitudinal direction, which causes the pin **224** to move between adjacent slots. This incremental movement of the pin **224** between adjacent slots increments the counter mechanism **118**. Activation of an elevated pressure of a particular pressure cycle causes the cycle mandrel **220** to shift in the upward direction (i.e., to the left). When the elevated pressure is removed (resulting in the application of a reduced pressure), then the stored pressure inside the gas chamber **212** (e.g., gas spring) would cause the cycle mandrel **220** to shift backward in the lower direction (i.e., to the right).

[0031] FIG. 3 shows an illustrative example of a slot arrangement **302** of the counter mechanism **118**. Slot arrangement **302** may include slots **304**, **306**, **308**, **310**, **312**, and **314**, formed in the surface **222** of the cycle mandrel **220**. Each slot may include two slot segments, A and B. For example, slot **304** includes slot segments **304A**, **304B**; slot **306** includes slot segments **306A**, **306B**; slot **308** includes slot segments **308A**, **308B**; slot **310** includes slot segments **310A**, **310B**; slot **312** includes slot segments **312A**, **312B**; and slot **314** includes slot segments **314A**, **314B**. The pin **224** travels via the slots **304-314**. A pressure cycle causes an up and down relative motion of the pin **224** compared to the slots. The motion causes the pin **224** (and rotatable spline sleeve **226**) to rotate about an axis defining the central bore **200** (see FIG. 2) and move between adjacent slots. Thus, for example, assuming that pin **224** is initially in slot segment **304A**, a pressure cycle would cause an up and down relative motion (as the cycle mandrel **220** (FIG. 2) longitudinally moves along with the slots) which would cause the pin **224** to relatively travel from slot segment **304A** to slot segment **304B**, and then to slot segment **306A**. This pressure cycle effectively causes the pin **224** to relatively travel from slot **304** to slot **306**. In addition, the rotatable spline sleeve **226** would rotate through an arc defined by the distance between **304A** and **306A**. The up and down pressure cycle represents an incremental movement of the counter section **118**.

[0032] Slot **310** is an elongated slot or actuatable length slot that is longer than the other slots **304**, **306**, **308**, **312** and **314**. When the pin **224** is in the elongated slot segment **310A**, the operating mandrel **122** (FIG. 1) (e.g., including mandrels **210** and **220** (FIG. 2)) is allowed to move downwardly by a sufficient distance necessary to actuate the ball valve **110** (FIG. 1) to an opened position. When the pin **224** is in one of the shorter slots **304**, **306**, **308**, **312**, and **314**, the operating mandrel **122** is restricted from moving downwardly by a distance sufficient to actuate the ball valve **110**. Accordingly, when the pin **224** is in one of the shorter slots, the ball valve **110** remains in its closed position.

[0033] FIG. 4 is an enlarged cross-sectional view of a portion of an end of the operating mechanism **116** (FIG. 2) that

shows the locking member **202** and locking groove **204** in greater detail. In some embodiments, the locking member **202** can be a compressed C-ring that is retained inside of a chamber **402** defined between the shear sleeve **214** and the gas chamber mandrel **210**. When the gas chamber mandrel **210** has moved downwardly by a sufficient distance such that the C-ring **202** is positioned adjacent the locking groove **204**, the C-ring **202** may expand (e.g., such as by a spring-loaded action) to couple with the inside of the locking groove **204**, as shown in FIG. 5. Therefore, the C-ring **202** may be lockingly engaged with the locking groove **204**.

[0034] In operation, pressure cycles applied by elevating and removing fluid pressure within the tubing **102** (FIG. 1) causes the gas chamber mandrel **210** and cycle mandrel **220** to translate in two directions. As a result, the pin **224** relatively travels from its current slot to an adjacent slot in the slot arrangement **302**, such as those depicted in FIG. 3. If the adjacent slot segment is the elongated or actuatable length slot segment **310A**, then the elevated pressure of the gas inside of the gas chamber **212** would cause the shear sleeve **214** to abut against an end (i.e., the upper) surface **230** of the lower gas chamber housing section **208**. The gas chamber **212** should be configured so as to impart a sufficient force onto the shear sleeve **214** from the gas chamber mandrel **210** such that the shear pin **216** breaks. Once the shear pin **216** breaks, the gas chamber mandrel **210** is able to move further downwardly such that the C-ring **202** (FIGS. 4 and 5) expands and engages the locking groove **204**.

[0035] Under normal operating conditions (i.e., no debris or other fault conditions preventing or inhibiting the opening of the ball valve **110**) the location of the pin **224** in the actuatable length or elongated slot segment **310A** enables the gas chamber mandrel **210** and cycle mandrel **220** (FIG. 2) to move downwardly by a sufficient distance required to open the ball valve **110** (FIG. 1). However, if debris or another fault condition is present, then the mandrels **210** and **220** may be restricted in their travel and unable to open the ball valve **110**, even though the counter mechanism **118** is in an active position.

[0036] In accordance with some exemplary embodiments, the position retention mechanism **120** that includes the locking member **202** and locking groove **204** will prevent the pin **224** from exiting the elongated slot section **310A** of the counter mechanism **118**, maintaining the counter mechanism **118** in its active position. If another pressure cycle is inadvertently or directly applied in an effort to remove the debris or correct the fault condition, a protruding member **404** (FIG. 5) on the outer wall of the gas chamber mandrel **210** will engage the locking member **202** and prevent the gas chamber mandrel **210** from being able to move upwardly by a distance sufficient to allow the pin **224** to exit from the elongated slot segment **310A**. In this manner, when the debris or other fault condition is removed (by performing an intervention operation, for example), the gas chamber mandrel **210** and the cycle mandrel **220** may be free to move a sufficient distance (defined by the elongated slot section **310A**) to actuate the ball valve **110** to the open position.

[0037] FIG. 6 illustrates an alternative embodiment of a position retention mechanism. Rather than using the position retention mechanism **120** (FIG. 1) that includes the locking member **202** and locking groove **204** (shown in FIGS. 2, 4, and 5), an alternative embodiment as shown in FIG. 6 provides a position retention mechanism by altering the configuration of the counter mechanism **118** (FIG. 1), specifically the

configuration of the slots **302** shown in FIG. 3. In this embodiment, an altered actuatable length or elongated slot section **610A** is provided. The altered elongated slot segment **610A** has a notch **620** that is configured to receive the pin **224** when the pin **224** travels downwardly (as seen in FIG. 6). The notch **620** prevents the pin **224** from exiting the lower portion of the elongated slot segment **610A**.

[0038] The elongated slot segment **610A** has an angled portion **624** that allows the pin **224** to enter the actuation slot **622**. However, once the pin **224** enters the actuation slot **622**, the pin **224** will not be allowed to exit, thereby retaining the counter mechanism **118** in its active position.

[0039] While the invention has been disclosed with respect to a limited number of embodiments, those skilled in the art, having the benefit of this disclosure, will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the invention.

What is claimed is:

1. An apparatus to operate a device for use in a well, comprising:

- a counter mechanism actuatable by pressure cycles to an active position that allows actuation of the device to a target state; and
- a position retention mechanism coupled with the counter mechanism to maintain the counter mechanism in the active position.

2. The apparatus of claim 1, wherein the counter mechanism comprises two or more slots, at least one of the slots being an actuatable length longer than the other slots, and wherein the counter mechanism further comprises:

- an engagement member to move along the slots with successive actuations of the counter mechanism in response to the pressure cycles.

3. The apparatus of claim 2, wherein the active position of the counter mechanism corresponds to the engagement member being in the actuatable length slot.

4. The apparatus of claim 3, further comprising an operating mandrel coupled to the counter mechanism, wherein the operating mandrel is allowed to move through a particular distance to actuate the device to the target state in correspondence to movement of the engagement member in the actuatable length slot.

5. The apparatus of claim 4, wherein the counter mechanism is configured to prevent the operating mandrel from moving by the particular distance if the engagement member is in one of the slots other than the longer slot.

6. The apparatus of claim 1, wherein the position retention mechanism comprises a locking member and a locking profile, wherein the locking member is configured to engage the locking profile once the locking member is moved adjacent the locking profile in response to the counter mechanism reaching the active position.

7. The apparatus of claim 6, further comprising:

- a first housing section in which the locking profile is defined; and
- a moveable first mandrel on which the locking member is arranged, wherein movement of the first mandrel is defined by the counter mechanism.

8. The apparatus of claim 7, wherein the locking member is moved adjacent the locking profile once the first mandrel has moved by a distance allowed by the active position of the counter mechanism.

9. The apparatus of claim 7, wherein the locking member is an expandable C-ring.

10. The apparatus of claim 7, wherein the mandrel further has a protruding member that interacts with the locking member to prevent the mandrel from moving by a sufficient distance to allow the counter mechanism to exit the active position.

11. The apparatus of claim 7, wherein the counter mechanism has a cycle mandrel having a surface on which slots are formed, and where the cycle mandrel is attached to the first mandrel.

12. The apparatus of claim 1, wherein the position retention mechanism is provided by an element of the counter mechanism.

13. The apparatus of claim 12, wherein the counter mechanism has slots defined in a wall of the cycle mandrel, wherein one of the slots is an actuatable length longer than the other slots, wherein the active position of the counter mechanism is defined by the actuatable length slot, and wherein the element of the counter providing the position retention mechanism includes a notch that is part of the actuatable length slot.

14. The apparatus of claim 13, wherein the counter mechanism further comprises an engagement member to move along the slots, wherein the notch is engageable with the engagement member to prevent the engagement member from moving out of the actuatable length slot.

15. The apparatus of claim 14, wherein the actuatable length slot further has an angled section to allow the engagement member to enter a portion of the actuatable length slot that includes the notch, wherein the notch is positioned to prevent the engagement member from exiting the portion.

16. A method for use with a well, comprising:

positioning a device in the well;
cycling pressure to activate an operating mechanism; and
activating the device to a target state after activating the operating mechanism a predetermined number of times;
wherein the operating mechanism includes a counter mechanism actuatable by the pressure cycles to an active position that allows the actuation of the device to the

target state, and a position retention mechanism coupled to the counter mechanism to maintain the counter mechanism in the active position once the counter mechanism has been incremented by the pressure cycles to the active position.

17. The method of claim 16, wherein the counter mechanism has two or more slots, wherein at least one of the slots is an active slot that is longer than the other slots, and wherein the active position corresponds to an engagement member being in the active slot,

wherein activating the operating mechanism comprises incrementing the counter mechanism such that the engagement member enters the active slot, wherein entry of the engagement member into the active slot allows for activation of the position retention mechanism such that the counter mechanism is maintained in the active position.

18. The method of claim 17, further comprising:

in response to another pressure cycle, the position retention mechanism preventing the engagement member from exiting the active slot.

19. The method of claim 16, wherein positioning the device in the well comprises positioning a formation isolation valve in the well.

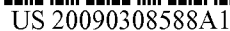
20. A system comprising:

a formation isolation valve for positioning in a well; and
an operating mechanism for actuating the formation isolation valve to a target state, wherein the operating mechanism comprises:

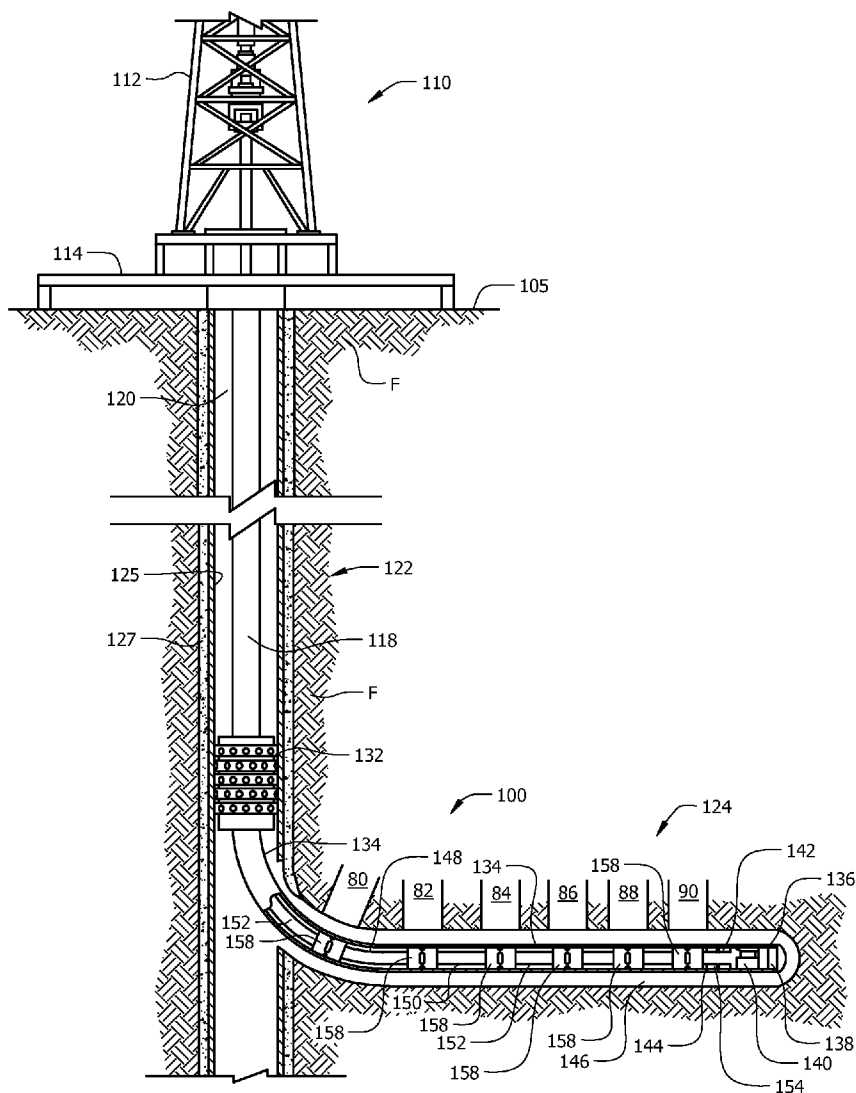
a counter mechanism actuatable by pressure cycles to an active position that allows actuation of the formation isolation valve to the target state; and

a position retention mechanism coupled to the counter mechanism to maintain the counter mechanism in the active position once the counter mechanism has been incremented by the pressure cycles to the active position.

* * * * *



(43) **Pub. Date:** **Dec. 17, 2009**



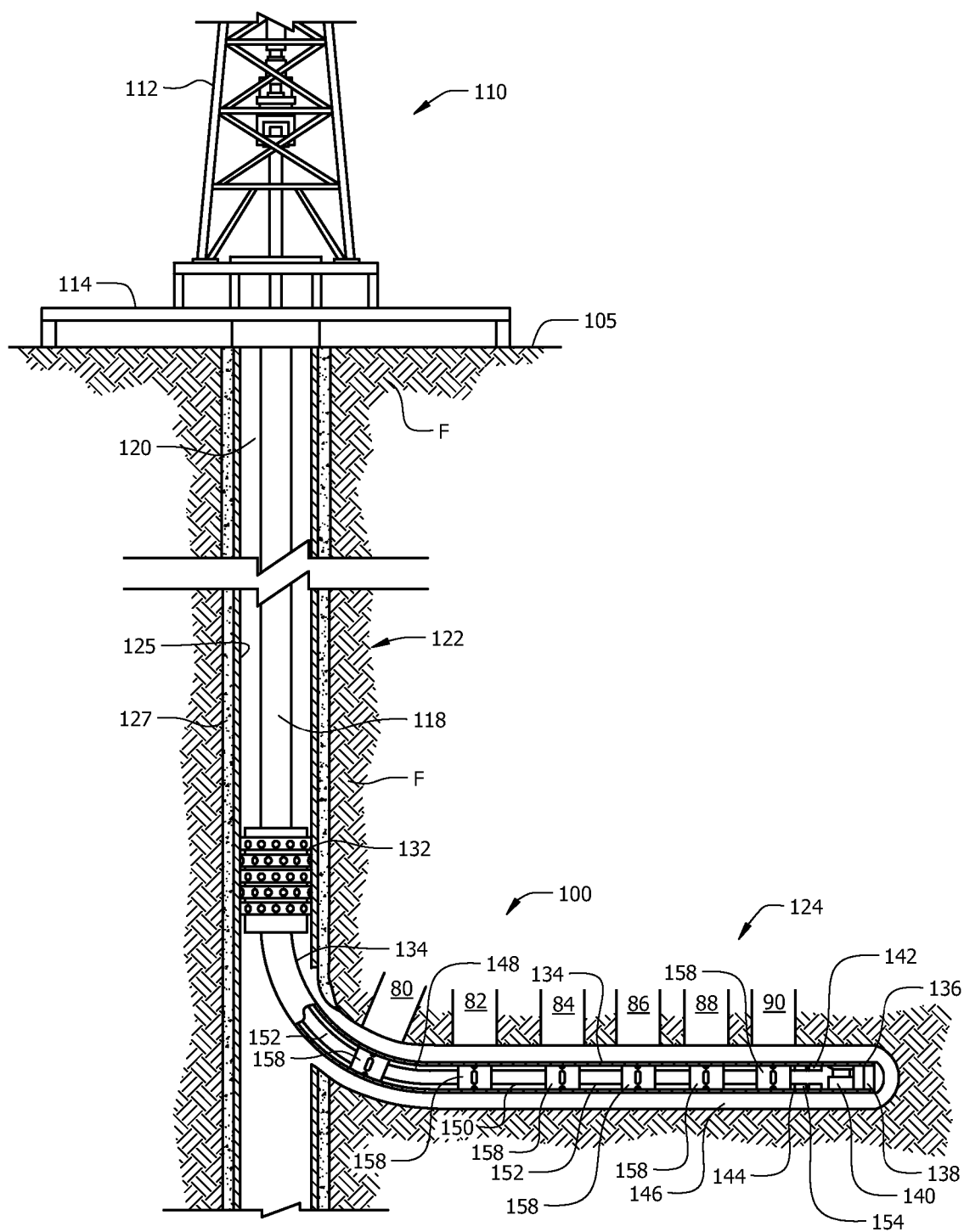


FIG. 1

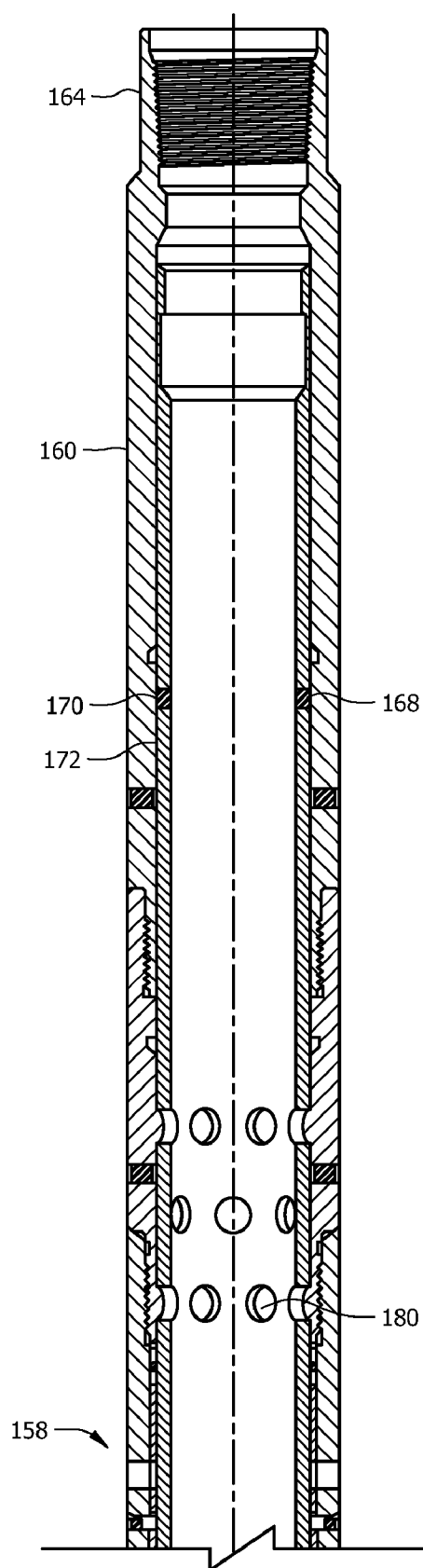


FIG. 2A

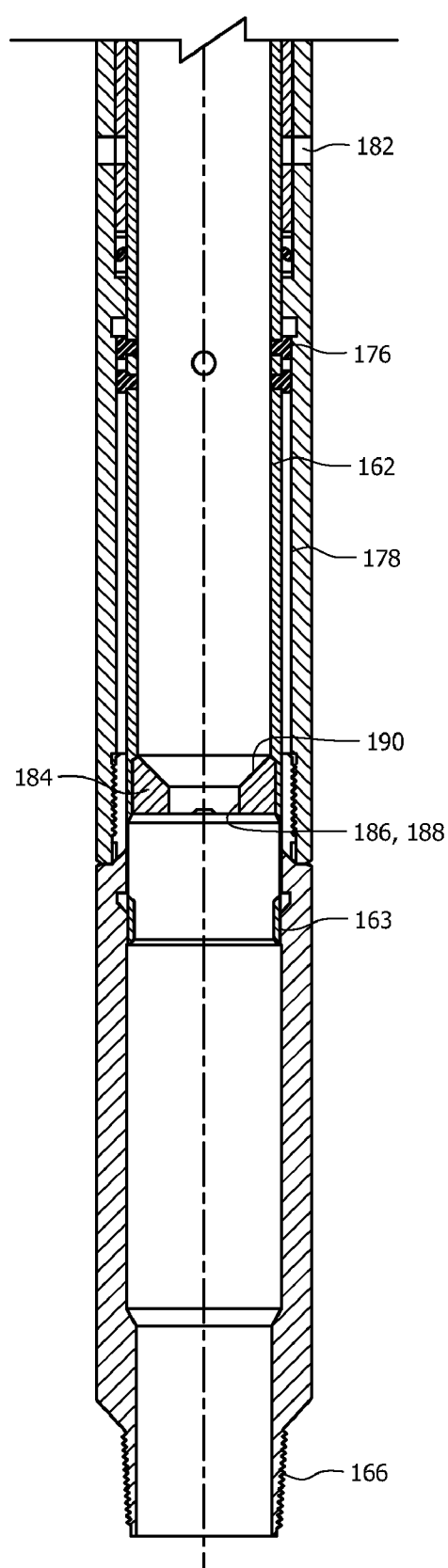


FIG. 2B

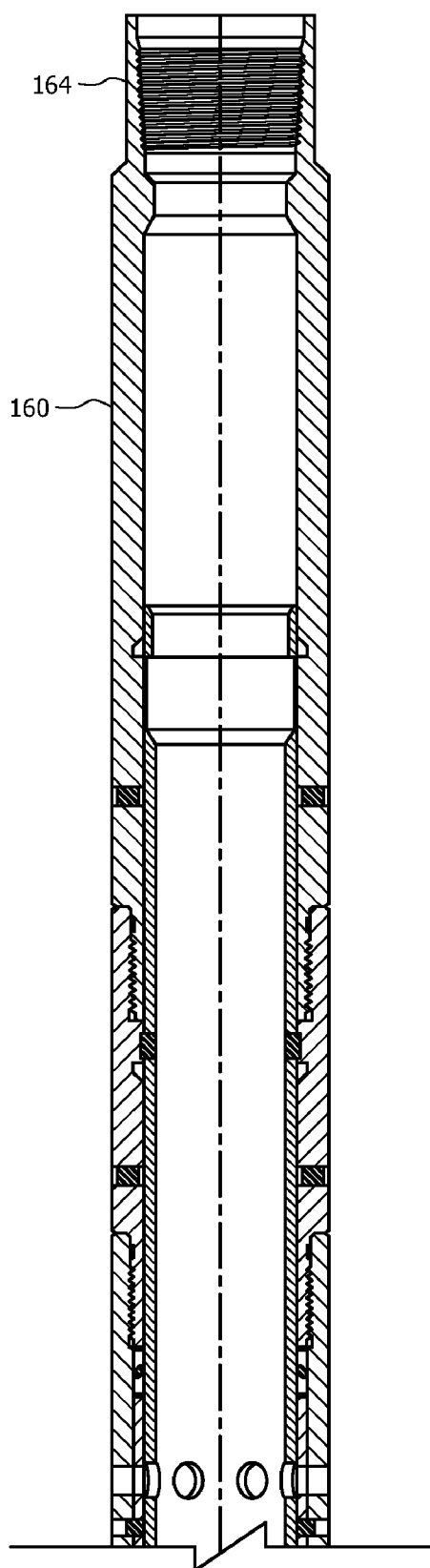


FIG. 3A

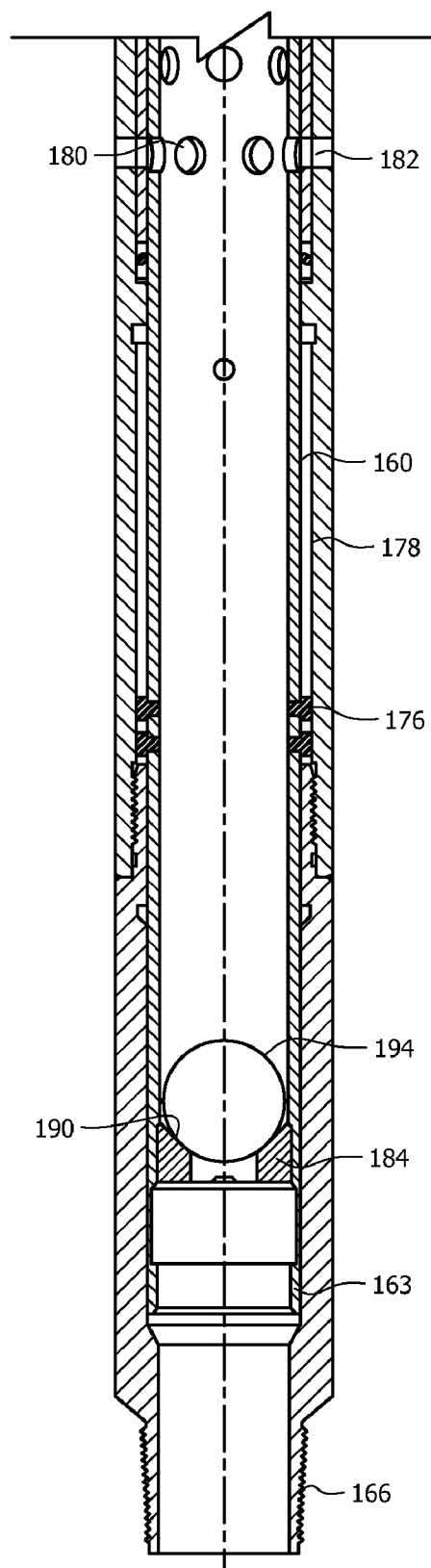


FIG. 3B

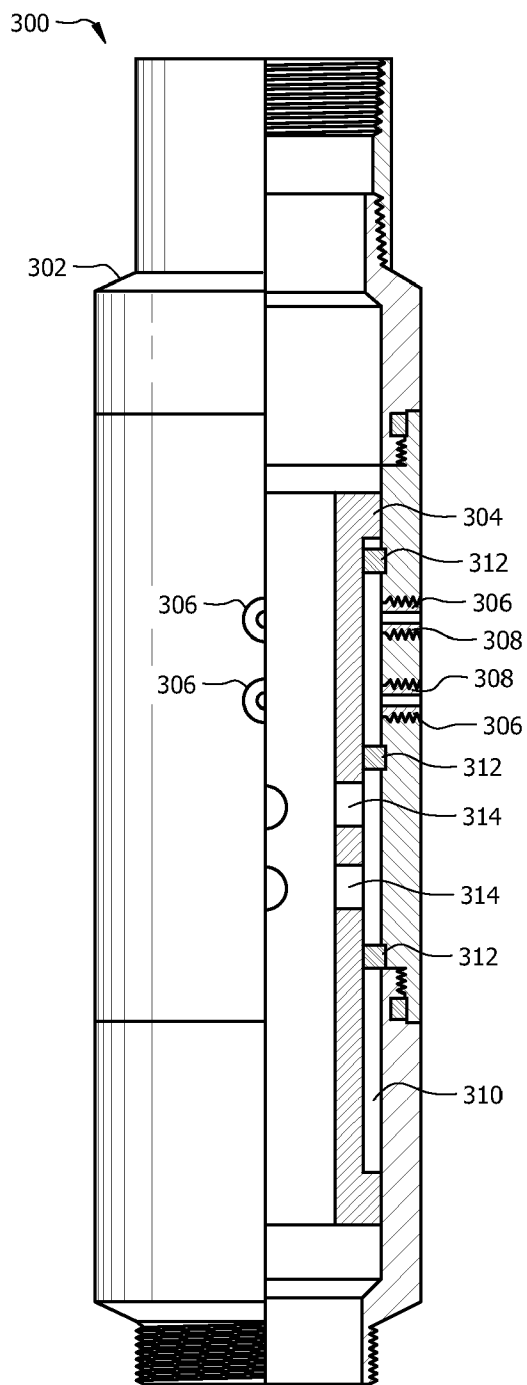


FIG. 4A

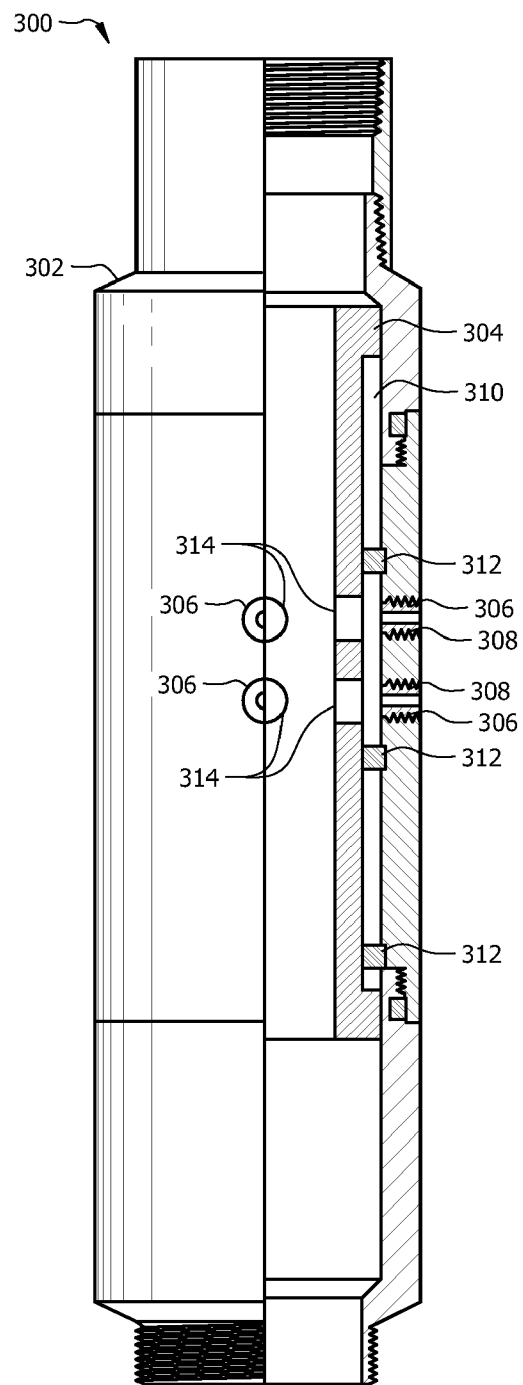
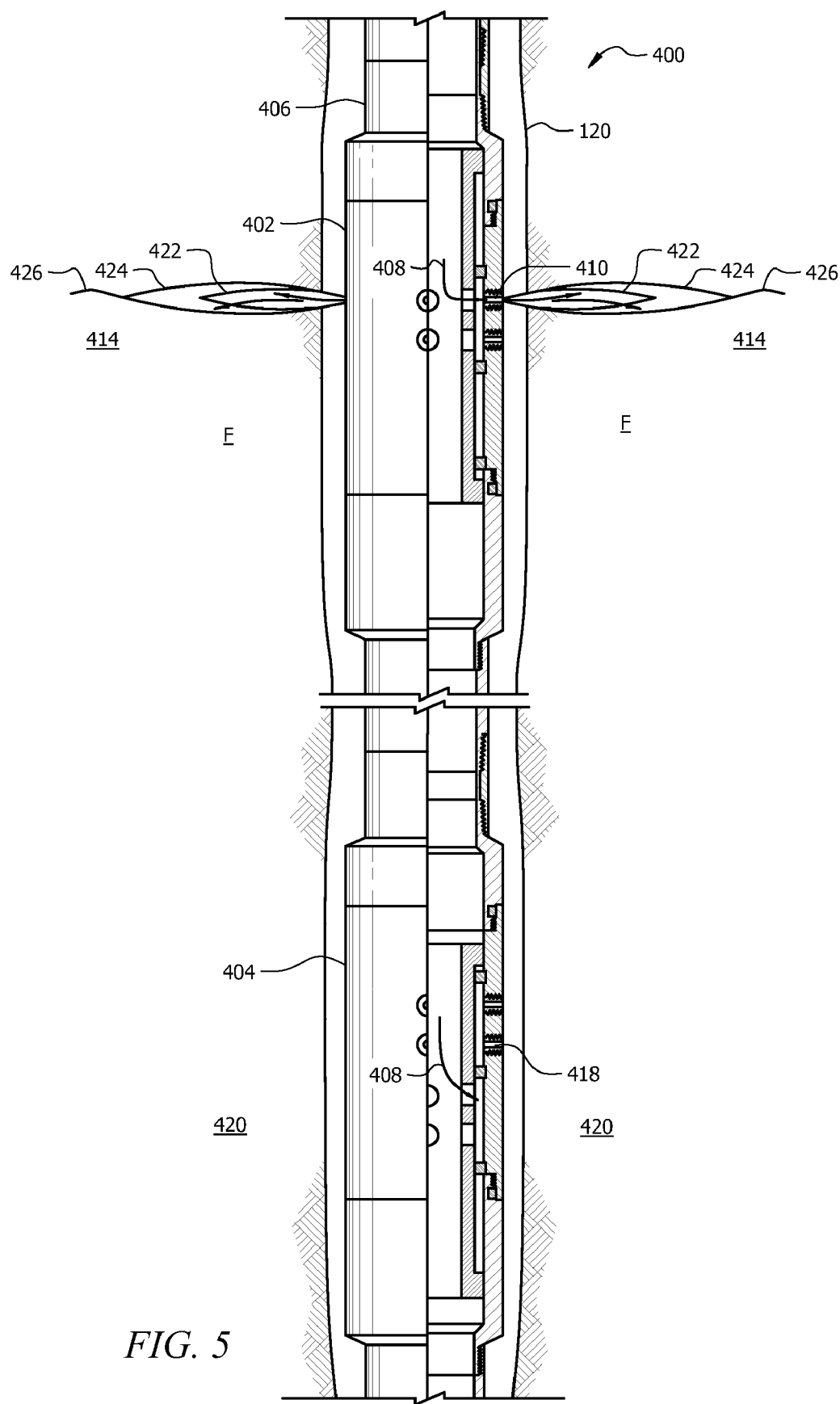


FIG. 4B



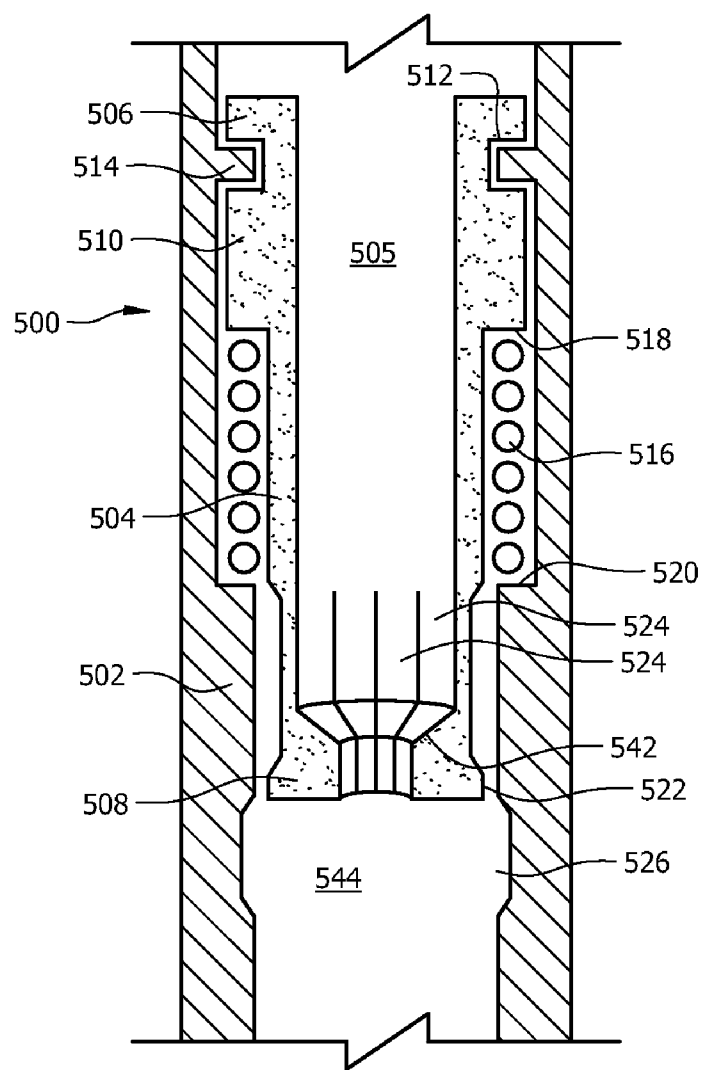


FIG. 6A

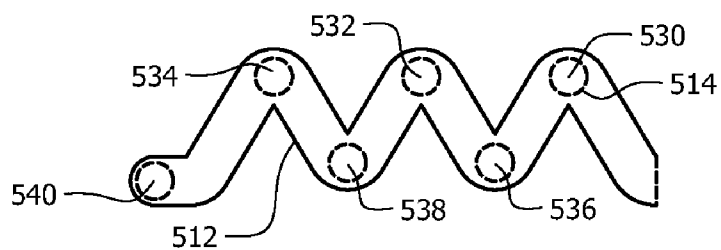


FIG. 6B

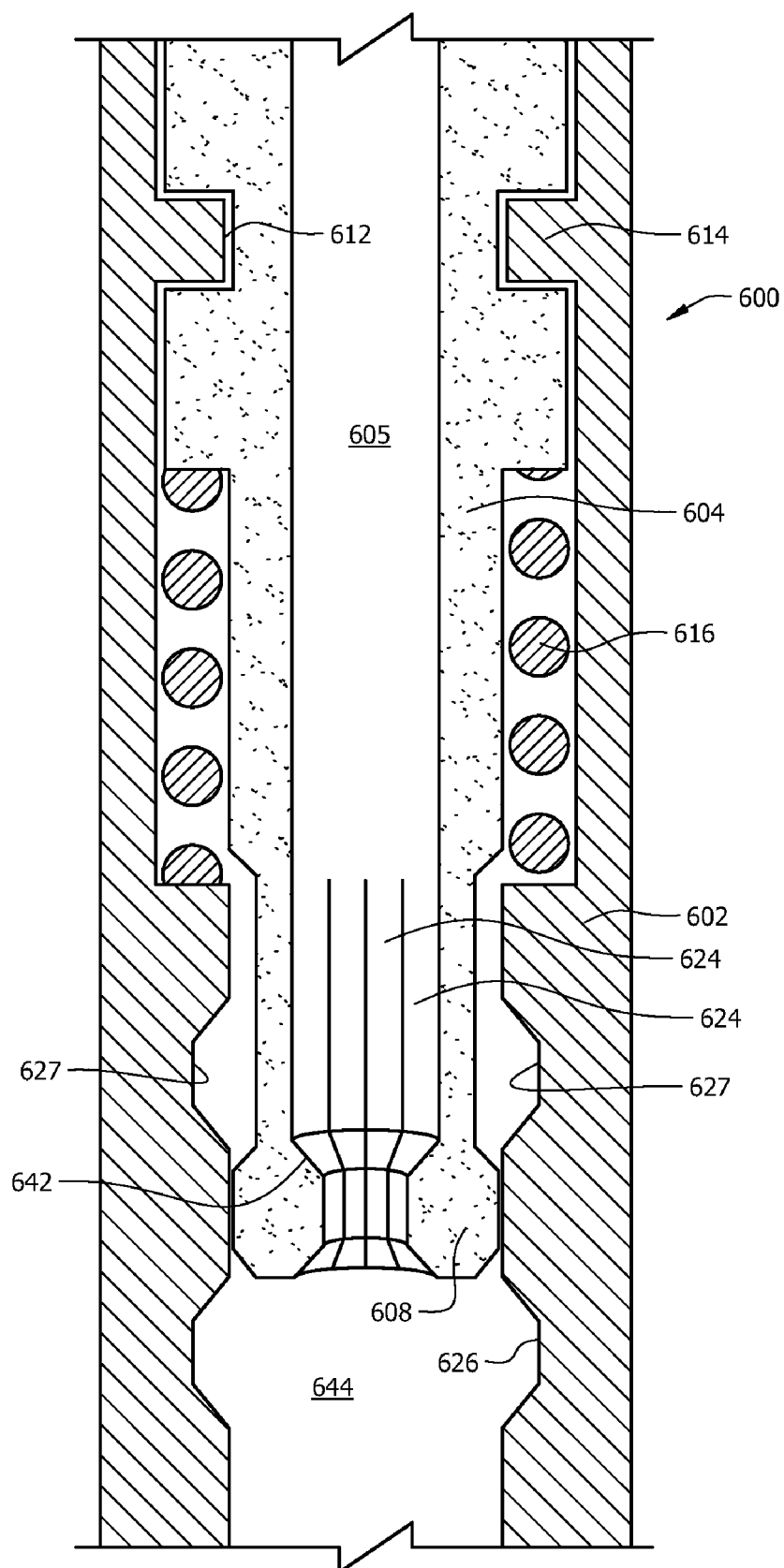


FIG. 7

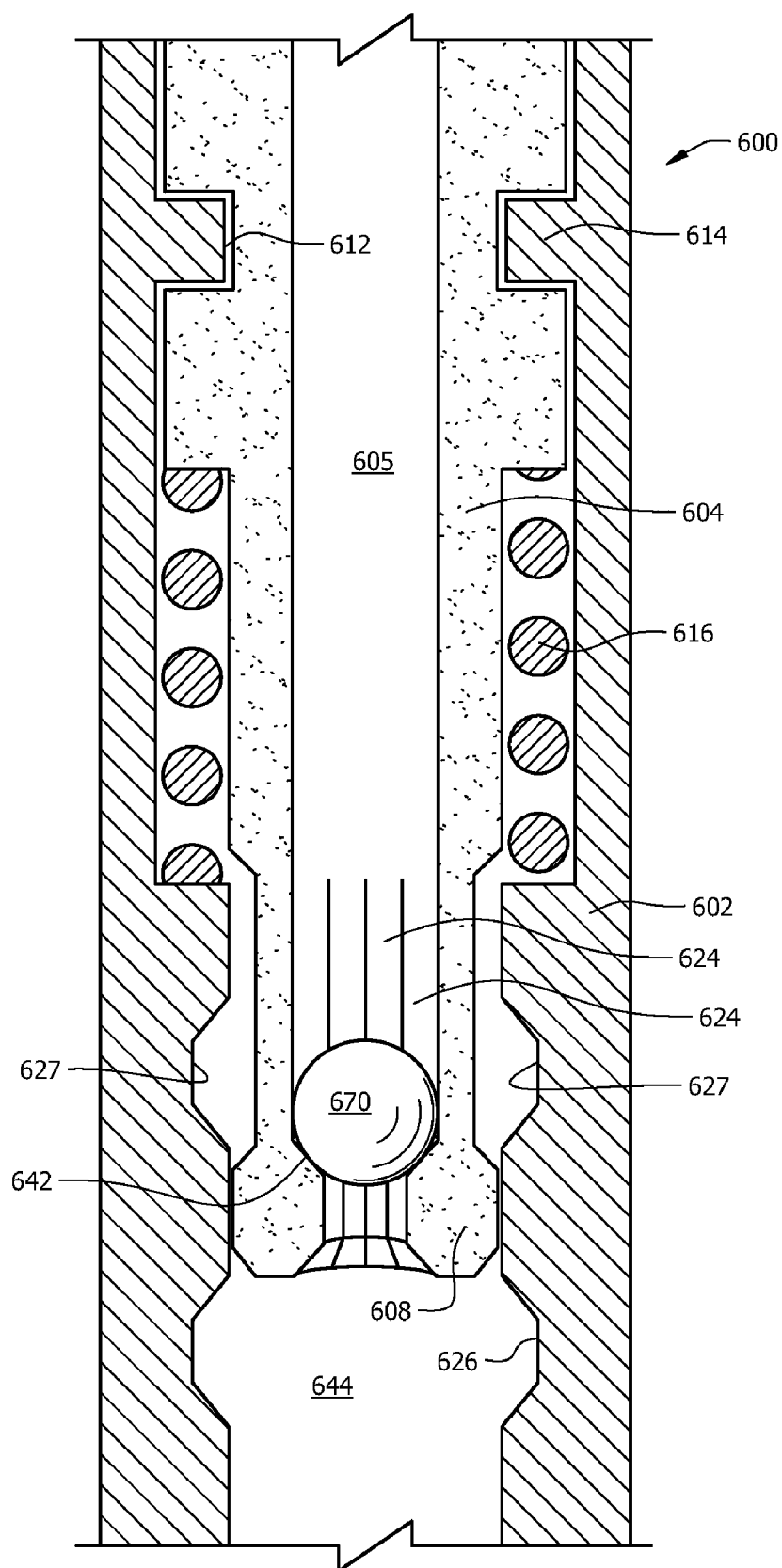


FIG. 8

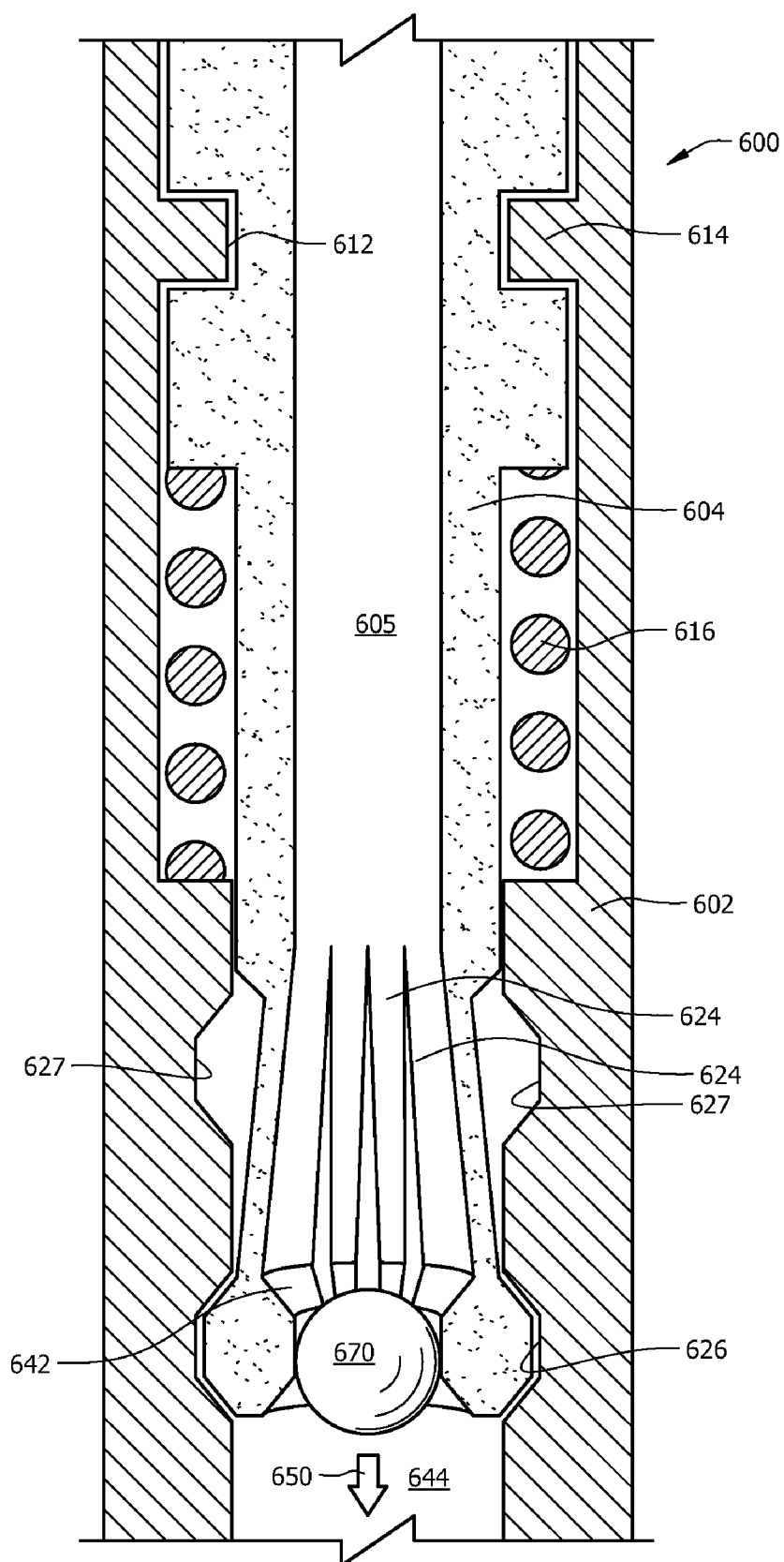


FIG. 9

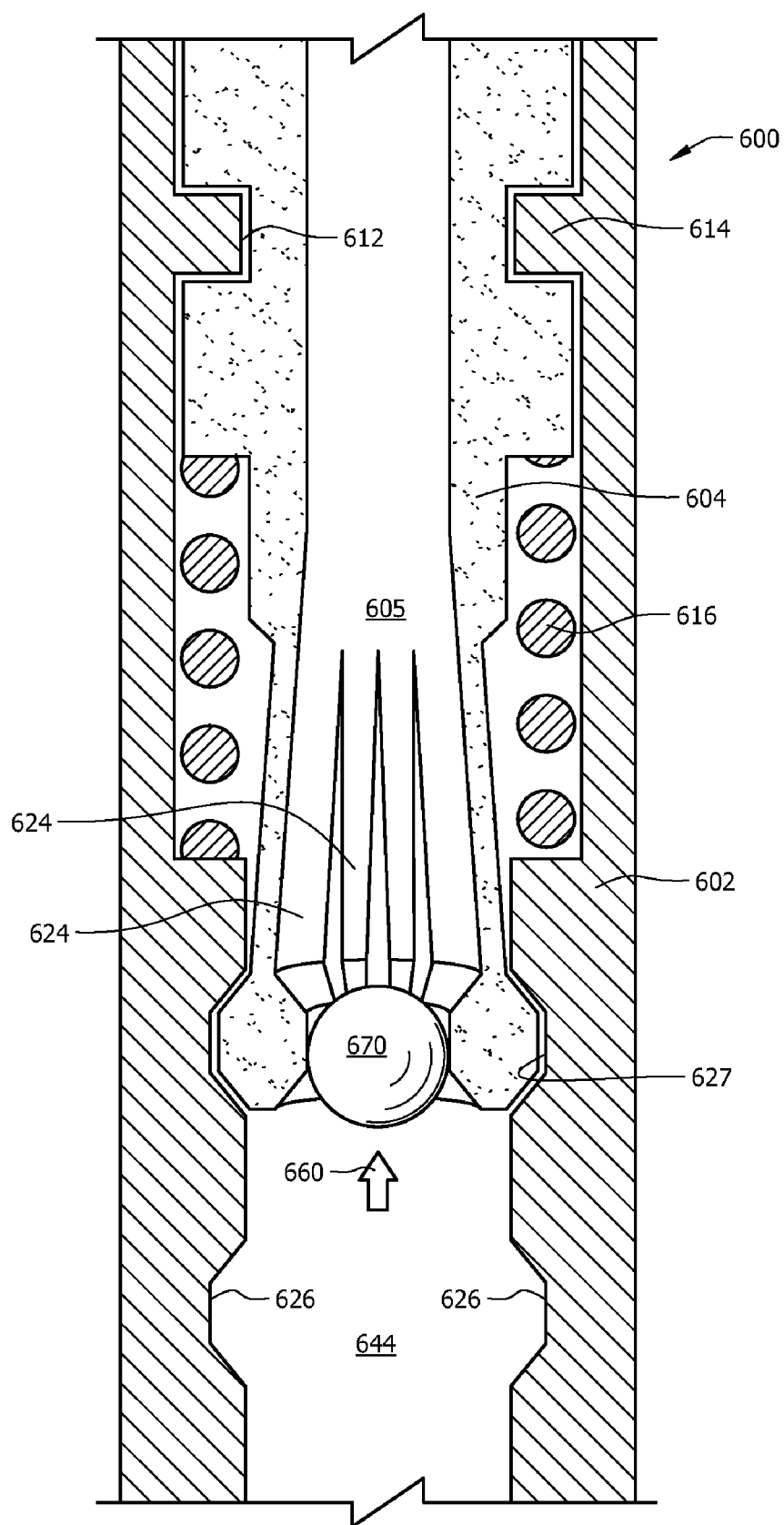


FIG. 10

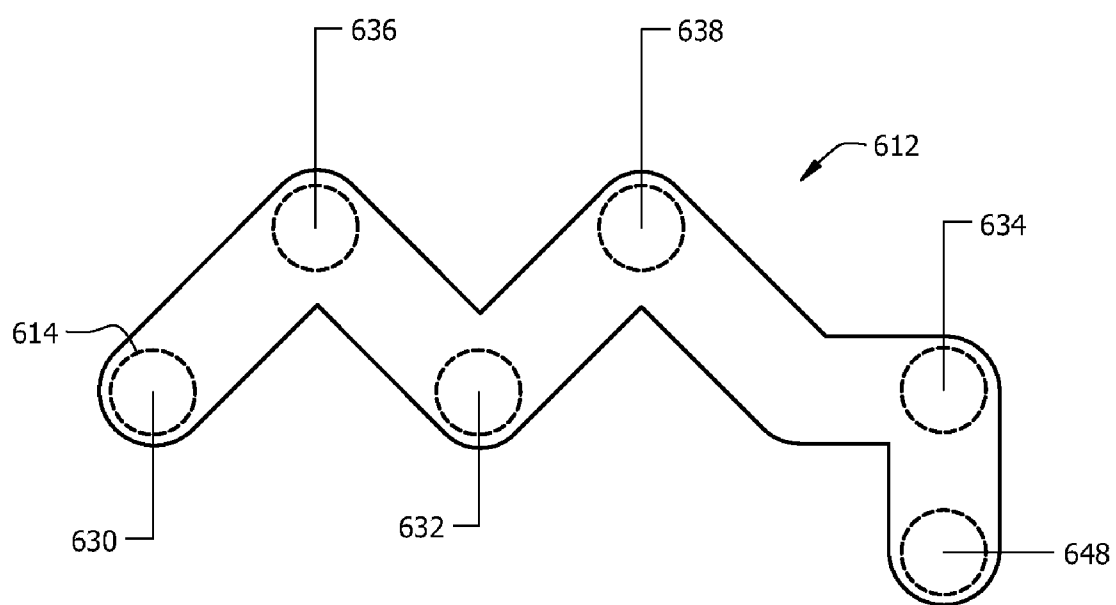


FIG. 11

METHOD AND APPARATUS FOR EXPOSING A SERVICING APPARATUS TO MULTIPLE FORMATION ZONES

BACKGROUND

[0001] Hydrocarbon-producing wells often are stimulated by hydraulic fracturing operations, wherein a fracturing fluid may be introduced into a portion of a subterranean formation penetrated by a well bore at a hydraulic pressure sufficient to create or enhance at least one fracture therein. Stimulating or treating the well in such ways increases hydrocarbon production from the well. The fracturing equipment may be included in a completion assembly used in the overall production process.

[0002] In some wells, it may be desirable to individually and selectively create multiple fractures along a well bore at a distance apart from each other, creating multiple "pay zones." The multiple fractures should have adequate conductivity, so that the greatest possible quantity of hydrocarbons in an oil and gas reservoir can be drained/produced into the well bore. When stimulating a formation from a well bore, or completing the well bore, especially those well bores that are highly deviated or horizontal, it may be advantageous to create multiple pay zones with a series of actuatable sleeve assemblies disposed in a downhole tubular. The actuatable sleeve assemblies are also referred to as stimulation sleeves, or casing or tubing windows.

[0003] A stimulation sleeve may include a section of tubing having holes or apertures pre-formed in the tubing, and a sliding sleeve movable relative to the tubing section. The sliding sleeve also includes apertures alignable with the apertures in the tubing section. Upon actuation of the stimulation sleeve, such as by ball drop or other obturating member interference, the sliding sleeve moves and the sliding sleeve apertures are aligned with the tubing section apertures. This exposes the reservoir to the interior of the tubing string, and vice versa. The flow path created between the reservoir and the tubing string through the stimulation sleeve can be used for fracturing or production operations. The apertures in the tubing section may include jet forming nozzles to provide a fluid jet into the formation, causing tunnels and fractures therein.

[0004] While the stimulation sleeve just described is one embodiment, other embodiments of actuatable sleeve assemblies may be used in series along a downhole tubular to communicate with multiple pay zones during fracturing or completion operations. To selectively actuate each successive sleeve assembly, differently sized balls or other obturating members are released into the tubing string. Each sleeve assembly includes a ball seat having a different inner diameter. The sleeve assembly having the largest ball seat is disposed furthest uphole, or closest to the surface of the well, while each successive sleeve assembly below the initial assembly includes an incrementally decreasing ball seat diameter. Thus, smaller balls may be released into the tubing string to pass through the larger diameter ball seats and selectively actuate the lower sleeve assemblies. Subsequently, incrementally larger sized balls are released into the tubing string to actuate each successive sleeve assembly in ascending order up the well.

[0005] Such a tubing assembly with successive diameter sleeves tends to restrict the inner diameter of the flow bore through the tubing string with the lower, smaller diameter sleeves, thereby also restricting the flow rates and treatment

pressures that can be achieved with the tubing assembly. Further, a successive diameter system limits the number of sleeve assemblies that can be disposed in the tubing string because the flow bore of the tubing string has a limited number of incremental diameters between the maximum diameter of the flow bore and the minimum diameter that can still achieve treatment pressure flow rates. To achieve desirable results in the aforementioned treatment and production processes, maintaining an inner diameter of the flow bore for flow rates and treatment pressures, and increasing the number of pay zones is needed. The present disclosure includes embodiments for maintaining an increased or substantially uniform inner diameter of a treatment or completion assembly having stimulation sleeves, and for increasing the number of stimulation sleeves included in the treatment or completion assembly.

SUMMARY

[0006] Disclosed herein is a well bore servicing apparatus comprising an first sleeve slidably disposed in a tubing section, an second sleeve slidably disposed in the first sleeve, an indexing slot disposed on one of the outer sleeve and inner sleeve, and a control lug disposed on the other of the outer sleeve and the inner sleeve to communicate with the indexing slot, and an expandable seat disposed in the inner sleeve to receive a plurality of obturating members.

[0007] Also disclosed herein is a well bore servicing apparatus comprising a work string, a tubing section coupled to the work string, a plurality of sleeve assemblies disposed in the tubing section, and a plurality of seats for receiving an obturating member, one seat disposed in each of the sleeve assemblies, wherein the plurality of seats are substantially the same size.

[0008] Further disclosed herein is a method of servicing a well bore comprising disposing a tubing section in the well bore, positioning the tubing section adjacent a plurality of formation zones, passing a first obturating member through a first moveable sleeve, catching the first obturating member in a second moveable sleeve to actuate a sleeve assembly adjacent a first formation zone, and catching a second obturating member in the first moveable sleeve to actuate a second sleeve assembly adjacent a second formation zone, wherein the first and second obturating members are substantially the same size.

[0009] Further disclosed herein is a method of servicing a well bore comprising placing a tubing section in the well bore via a work string, and actuating a plurality of sleeve assemblies in the tubing section with same-size obturating members.

[0010] Further disclosed herein is a method of servicing a well bore comprising disposing a tubing section having a plurality of actuatable sleeve assemblies in the well bore, providing a series of obturating members having substantially the same size to actuate the sleeve assemblies, and successively actuating the sleeve assemblies with the same-size obturating member to successively treat a plurality of formation zones.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For a more detailed description of the embodiments, reference will now be made to the following accompanying drawings:

[0012] FIG. 1 is a schematic, partial cross-section view of a fluid treatment and completion apparatus in an operating environment;

[0013] FIGS. 2A and 2B are cross-section views of a stimulation sleeve in a closed position;

[0014] FIGS. 3A and 3B are cross-section views of the stimulation sleeve of FIGS. 2A and 2B in an open position;

[0015] FIG. 4A is a partial cross-section view of a hydro-jetting casing window assembly;

[0016] FIG. 4B is a partial cross-section view of the casing window assembly of FIG. 4A in a shifted open position;

[0017] FIG. 5 is a partial cross-section view of a well completion assembly including embodiments of FIGS. 4A and 4B;

[0018] FIG. 6A is a partial cross-section view of an indexing assembly;

[0019] FIG. 6B is a profile view of an indexing slot of the indexing assembly of FIG. 6A;

[0020] FIG. 7 is a partial cross-section view of an alternative embodiment of an indexing assembly in an initial position;

[0021] FIG. 8 is a partial cross-section view of the indexing assembly of FIG. 7 receiving a dropped ball;

[0022] FIG. 9 is a partial cross-section view of the indexing assembly of FIG. 7 in a release position;

[0023] FIG. 10 is a partial cross-section view of the indexing assembly of FIG. 7 in a return position; and

[0024] FIG. 11 is a profile view of an indexing slot of the indexing assembly of FIG. 7.

DETAILED DESCRIPTION

[0025] In the drawings and description that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals, respectively. The drawing figures are not necessarily to scale. Certain features of the invention may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. The present invention is susceptible to embodiments of different forms. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that illustrated and described herein. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce desired results.

[0026] Unless otherwise specified, any use of any form of the terms “connect”, “engage”, “couple”, “attach”, or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the elements and may also include indirect interaction between the elements described. In the following discussion and in the claims, the terms “including” and “comprising” are used in an open-ended fashion, and thus should be interpreted to mean “including, but not limited to . . .”. Reference to up or down will be made for purposes of description with “up”, “upper”, “upwardly” or “upstream” meaning toward the surface of the well and with “down”, “lower”, “downwardly” or “downstream” meaning toward the terminal end of the well, regardless of the well bore orientation. The term “zone” or “pay zone” as used herein refers to separate parts of the wellbore designated for treatment or production and may refer to an

entire hydrocarbon formation or separate portions of a single formation such as horizontally and/or vertically spaced portions of the same formation. The term “seat” as used herein may be referred to as a ball seat, but it is understood that seat may also refer to any type of catching or stopping device for an obturating member or other member sent through a work string fluid passage that comes to rest against a restriction in the passage. The various characteristics mentioned above, as well as other features and characteristics described in more detail below, will be readily apparent to those skilled in the art upon reading the following detailed description of the embodiments, and by referring to the accompanying drawings.

[0027] Disclosed herein are several embodiments of a well bore servicing apparatus including multiple sleeve assemblies disposed in a work string that are selectively actuatable to expose different formation zones to an inner fluid passage of the work string at different times. The sleeve assemblies may be sequentially actuated to expose the inner fluid passage to the formation zones such that they are treated at different times in a certain order. The sleeve assemblies may also include an inner indexing assembly allowing the sleeve assemblies to be actuated without loss of the inner diameter of the fluid passage in the work string, and without using multiple sizes of dropped balls. The indexing assembly may include an inner sleeve that is moveable and lockable relative to the moveable sleeve of the sleeve assemblies. The indexing assembly can be manipulated to allow a pre-determined number of obturating members to pass through a seat in the indexing assembly before a selected obturating members is caught in the seat and the indexing assembly is moved to actuate the sleeve assembly. In essence, the indexing assembly is configured to count the number of passing obturating members before actuation. The number of counted obturating members can be adjusted. The counting can be achieved with a J-slot or indexing slot communicating between the inner sleeve of the indexing assembly and the moveable or outer sleeve of the sleeve assembly, and an expandable seat for the obturating member.

[0028] Referring to FIG. 1, a schematic representation of an exemplary operating environment for a fluid treatment or completion apparatus 100 is shown. The apparatus 100 is an exemplary embodiment, and various other embodiments of the apparatus 100 consistent with the teachings herein are included. As depicted, a drilling rig 110 is positioned on the earth's surface 105 and extends over and around a well bore 120 that penetrates a subterranean formation F for the purpose of recovering hydrocarbons. The well bore 120 may be drilled into the subterranean formation F using conventional (or future) drilling techniques. The well bore 120 may extend substantially vertically away from the surface 105 over a vertical portion 122, or may deviate at any angle from the surface 105 over a deviated or horizontal portion 124. In some instances, all or portions of the well bore 120 may be vertical, deviated, horizontal, and/or curved.

[0029] At least a portion of the vertical well bore 122 may be lined with casing 125 that may be cemented 127 into position against the formation F in a conventional manner. Alternatively, the horizontal portion 124 may be cased and cemented also, or the operating environment for the apparatus 100 includes an uncased well bore 120. The drilling rig 110 includes a derrick 112 with a rig floor 114 through which a tubing or work string 118 extends downwardly from the drilling rig 110 into the well bore 120. The tubing string 118

suspends a representative downhole apparatus **100** to a pre-determined depth within the well bore **120** to perform a specific operation, such as perforating a casing, expanding a fluid path therethrough, fracturing the formation **F**, producing the formation **F**, or other completion operation. The tubing string **18** may also be known as the entire conveyance above and coupled to the apparatus **100**. The drilling rig **110** is conventional and therefore includes a motor driven winch and other associated equipment for extending the tubing string **118** into the well bore **120** to position the apparatus **100** at the desired depth.

[0030] While the exemplary operating environment depicted in FIG. 1 refers to a stationary drilling rig **110** for lowering and setting the apparatus **100** within a land-based well bore **120**, one of ordinary skill in the art will readily appreciate that mobile workover rigs, well servicing units, such as coiled tubing units, and the like, could also be used to lower the apparatus **100** into the well bore **120**. It should be understood that the apparatus **100** may also be used in other operational environments, such as within an offshore well bore.

[0031] In one embodiment, the apparatus **100** comprises an upper end having a liner hanger **132** such as, for example, a Halliburton VersaFlex® liner hanger, a lower end **136**, and a tubing section **134** extending therebetween. The lower end **136** may have a float shoe **138** and a float collar **140** of a type known in the art connected therein, and other tubing conveyed devices **142**, **144** connected therein. The horizontal well bore **124** and the tubing section **134** define an annulus **146** therebetween. The tubing section **134** includes an interior **148** that defines a flow passage **150** therethrough. In the embodiment shown, an inner string **152** is disposed in tubing section **134** and extends therethrough so that a lower end **154** thereof extends into and is received in a polished bore receptacle **144**. The inner string **152** may be used to carry cement if the completion operation requires cement. Alternatively, cement may not be needed and the tubing section **134** may be without the inner string **152** such that the flow passage **150** is the main flowbore through the apparatus **100**. A plurality of actuatable sleeve assemblies or stimulation sleeves **158** are connected in the tubing section **134**. The stimulation sleeves **158** may be, for example, ball drop activated, Delta Stim® Sleeves available from Halliburton Energy Services, Inc.

[0032] Referring now to FIGS. 2A and 2B, the stimulation sleeve **158** comprises an outer housing **160** with an opening sleeve **162** detachably connected therein. The opening sleeve **162** has a lower end **163**. After becoming detached from the housing **160**, the opening sleeve **162** is slidable or movable in the housing **160** as explained in more detail hereinbelow. The outer housing **160** has an upper end **164** and a lower end **166**, both of which are adapted to be directly connected or threaded into a tubing section such that the outer housing **160** makes up a part of the tubing section **134**. The opening sleeve **162** is initially connected to the outer housing **160** with a snap ring **168** which extends into a groove **170** defined on an inner surface **172** of the outer housing **160**. In addition, shear pins extending through the outer housing **160** and into the sleeve **162** may be utilized to detachably connect the sleeve **162** to the outer housing **160**. Guide pins **176** may be threaded or otherwise attached to the sleeve **162** and may be received in axial grooves or axial slots **178** in the housing **160**. The guide pins **176** are slidable in the axial slots **178**, which will prevent relative rotation between the sleeve **162** and the outer housing **160**. The sleeve **162** has a plurality of sleeve or door ports **180**

therethrough. The outer housing **160** has a plurality of housing ports **182** defined therein. In the position shown in FIGS. 2A and 2B, the sleeve ports **180** are misaligned from the housing ports **182** such that the stimulation sleeve **158** is in a closed position. The sleeve **162** has a seat ring **184** operably associated therewith and is connected therein at or near the lower end **163**. The seat ring **184** has a central opening **186** defining a diameter **188** therethrough, and has a seat surface **190** for engaging an obturating member to be dropped through the tubing string.

[0033] To move the opening sleeve **162** from the closed position to an open position, an obturating member **194**, such as a closing ball shown in FIG. 3B, is dropped through the tubing string **118** so that it will engage the seat **190** on the seat ring **184**. Although shown as a closing ball, the obturating member **194** may be other closing devices such as plugs and darts that will engage the seat **190** and prevent flow therethrough. Pressure is increased to overcome the holding force applied by the snap ring **168** and the shear pins, thereby moving the opening sleeve **162** to the position shown in FIGS. 3A and 3B in which the sleeve ports **180** and the casing ports **182** are aligned to allow for the passage of fluids therethrough.

[0034] Referring now to FIGS. 4A and 4B, an exemplary casing window assembly **300** is shown and can be adapted for use as an alternative embodiment of the stimulation sleeve **158**. As used herein, the term "casing window" refers to a section of casing configured to enable selective access to one or more specified zones of an adjacent subterranean formation. A casing window has a window that may be selectively opened and closed by an operator, for example, movable sleeve member **304**. The casing window assembly **300** can have numerous configurations and can employ a variety of mechanisms to selectively access one or more specified zones of an adjacent subterranean formation.

[0035] The casing window **300** includes a substantially cylindrical outer casing **302** that receives a movable sleeve member **304**. The outer casing **302** includes one or more apertures **306** to allow the communication of a fluid from the interior of the outer casing **302** into an adjacent subterranean formation. The apertures **306** are configured such that fluid jet forming nozzles **308** may be coupled thereto. In some embodiments, the fluid jet forming nozzles **308** may be threadably inserted into the apertures **306**. The fluid jet forming nozzles **308** may be isolated from the annulus **310** (formed between the outer casing **302** and the movable sleeve member **304**) by coupling seals or pressure barriers **312** to the outer casing **302**.

[0036] The movable sleeve member **304** includes one or more apertures **314** configured such that, as shown in FIG. 4A, the apertures **314** may be selectively misaligned with the apertures **306** so as to prevent the communication of a fluid from the interior of the movable sleeve member **304** into an adjacent subterranean formation. The movable sleeve member **304** may be shifted axially, rotatably, or by a combination thereof such that, as shown in FIG. 4B, the apertures **314** selectively align with the apertures **306** so as to allow the communication of a fluid from the interior of the movable sleeve member **304** into an adjacent subterranean formation. The movable sleeve member **304** may be shifted via the use of a ball drop mechanism.

[0037] Referring now to FIG. 5, an exemplary well completion assembly **400** includes open casing window **402** and closed casing window **404** formed in a tubing section or

conduit 406. Alternatively, the well completion assembly 400 may be selectively configured such that the casing window 404 is open and the casing window 402 is closed, such that the casing windows 402 and 404 are both open, or such that the casing windows 402 and 404 are both closed.

[0038] A fluid 408 may be pumped down the conduit 406 and communicated through the fluid jet forming nozzles 410 of the open casing window 402 against the surface of the well bore 120 in the zone 414 of the subterranean formation F. The fluid 408 would not be communicated through the fluid jet forming nozzles 418 of the closed casing window 404, thereby isolating the zone 420 of the subterranean formation F from any well completion operations being conducted through the open casing window 402 involving the zone 414. The fluid 408 may include any of the embodiments disclosed elsewhere herein.

[0039] In one embodiment, the fluid 408 is pumped through the fluid jet forming nozzles 410 at a velocity sufficient for fluid jets 422 to form perforation tunnels 424. In one embodiment, after the perforation tunnels 424 are formed, the fluid 408 is pumped into the conduit 406 and through the fluid jet forming nozzles 410 at a pressure sufficient to form cracks or fractures 426 along the perforation tunnels 424.

[0040] Referring back to FIG. 1, a plurality of the sleeve assemblies 158 are included in the tubing section 134 of the treatment and completion apparatus 100. The sleeve assemblies 158 are positioned adjacent the selected zones to be treated, such as the plurality of selected zones 80, 82, 84, 86, 88 and 90 that may be treated and produced with the methods and apparatus described herein. After work string 118 having apparatus 100 is lowered into well bore 120, and the apparatus 100 is appropriately set, a first ball or other obturating member may be dropped into the work string 118. The ball seats in the lowermost sleeve assembly 158 to actuate, as described herein, the sleeve assembly and establish a fluid path to the formation zone 90. Then, a treatment fluid, such as an acidizing fluid or a fracturing fluid, may be flowed through the work string 118, the tubing section 134, the fluid path in the sleeve assembly, and toward the zone 90. In some embodiments, a high pressure fluid is communicated through the sleeve assembly fluid path to provide a hydrojet stream to the zone 90. As used herein, high pressure, for example, is generally greater than about 1,000 p.s.i., alternatively greater than about 3,500 p.s.i., alternatively greater than about 10,000 p.s.i., and alternatively greater than about 15,000 p.s.i. Once the selected zone 90 has been treated, a second ball is dropped to engage the sleeve seat in the next sleeve assembly 158 in ascending order, adjacent the zone 88. When the ball is seated, fluid flow is blocked to the lower sleeve assembly and fluid pressure will increase to actuate the new sleeve assembly. The zone 88 can then be treated. This procedure may be followed to selectively and successively actuate the sleeve assemblies 158 in ascending order, and service any and/or all of the zones 80, 82, 84, 86, 88, 90. Typically, the center opening 186 (FIGS. 2B and 3B) in each of the sleeve assemblies 158 is of a diameter 188 such that the balls 194 may pass therethrough to engage the seat sleeves 184 in sleeve assemblies therebelow. Therefore, the seat sleeve diameter 188 will be gradually and incrementally larger from the lowermost seat sleeve through the final seat sleeve in the uppermost sleeve assembly.

[0041] Referring now to FIG. 6A, an assembly is shown that is adaptable to be used with the various sleeve assembly embodiments described herein. A sliding sleeve sub or index-

ing assembly 500 includes an outer sleeve 502 and an inner sleeve member 504 disposed therein. For reference purposes, the outer sleeve 502 is analogous to the opening sleeve 162 of FIGS. 2A-3B. The inner sleeve member 504 includes an upper end 506, a lower end 508 and a flow bore 505 therethrough. The upper end 506 includes an increased diameter portion 510 having an indexing slot or J-slot pattern 512 that receives a control lug 514 disposed on an inner surface of the outer sleeve 502. The interaction between the lug 514 and the indexing slot 512, as will be described in more detail hereinbelow, is the primary mode of communication between the outer sleeve 502 and the inner sleeve member 504. The lower end 508 includes a projection 522 and a series of collet fingers 524. Disposed between an outer sleeve shoulder 520 and an inner sleeve shoulder 518 is a biasing spring 516. The inner surface of the outer sleeve 502 also includes a recessed portion 526.

[0042] Referring next to FIG. 6B, the indexing slot 512 is shown in an unwrapped or flattened profile view. The indexing slot 512 may also be referred to as a continuous J-slot or a control groove. The indexing slot 512 includes a plurality of biased, reset or stop positions 530, 532, 534 and a plurality of release positions 536, 538 for the lug 514. The slot 512 also includes a final engagement or actuation position 540. The indexing slot 512 is disposed about the upper portion of the tube forming the inner sleeve 504. The indexing slot 512, in some embodiments, may be a solid member, such as a metal sheet, having a slot or groove formed therein. The indexing slot may be shaped to extend around a cylindrical member, as is shown in FIG. 6A. In some embodiments described, the lug 514 includes a circular shape from a top view of the lug. The lug may include other shapes, such as an oval or elliptical shape. Furthermore, other control slot operating members may interact with the indexing slot 512 to provide the relationships described herein.

[0043] In operation, the indexing assembly 500 is assembled as shown in FIG. 6A, with the inner sleeve 504 biased upward by the spring 516 such that the collet fingers 524 and the projection 526 are above the recess 526. The control lug 514 is initially disposed in one of the stop positions 530, 532, 534 and limits the upward movement of the inner sleeve 504. Preferably, the initial position of the lug 514 is the furthest from the final position 540 to allow the most number of cycles through the indexing slot, though the initial position can be selected to pre-determine the number of cycles through the indexing slot and thus the number of balls that pass through the inner sleeve 504. A first ball, such as that shown in FIG. 8, passes through the flow bore 505 and arrives at a seat 542 in the lower end 508. A pressure buildup above the ball causes the inner sleeve to overcome the biasing force of the spring 516 and move downward, as similarly depicted in FIG. 9. As the inner sleeve 504 moves downward, the projection 526 slides into the recess 526 and the collet fingers expand into the recess, as shown in FIG. 9. Simultaneously, the inner sleeve 504 and the indexing slot 512 are guided about the lug 514, which is stationary on the outer sleeve 502, such that the lug moves from initial slot 530 to the release position 536. The ball is then allowed to pass into the flow bore 544 below the inner sleeve 504. After the ball passes, the pressure on the inner sleeve 504 is relieved the biasing spring moves the inner sleeve 504 upward. At the same time, the inner sleeve 504 and the indexing slot 512 are guided about the lug 514 such that the lug is now placed in the stop position 532.

[0044] The lug 514 is guided through any number of sets of stop and release positions until the lug 514 reaches the final position 540. In the final position 540, vertical movement of the inner sleeve 504 is restricted such that the pressure buildup in the inner sleeve 504 is transferred to the outer sleeve 502 and the overall sleeve assembly is actuated as described herein. For example, when the lug 514 is in the final position 540, the ball seat 542 acts analogously to the ball seat 190 in the seat ring 184 of FIGS. 2B and 3B. The outer sleeve 502 then moves similarly to the sleeve 162 of the sleeve assembly 158. Thus, the indexing assembly 500 can replace the seat ring 184 arrangement of the sleeve assembly 158 while providing increased flexibility for inner sleeve 504 movement and ball pass-through while the overall sleeve assembly remains unactuated.

[0045] The indexing assembly 500 can be pre-set to count any number of ball pass-throughs. For example, if an indexing assembly 500 is placed in the second lowermost position, wherein another assembly is below it, and it is known that one ball must pass through the indexing assembly 500, then the assembly is adjusted accordingly. In one embodiment, the indexing slot 512 is simply manufactured to have the initial position 532, the release position 538, the reset position 534 and the final position 540. Therefore, one cycle from position 532 to position 538 to position 534 allows one ball to pass through the indexing assembly 500 before the final position 540 is reached and the sleeve assembly is actuated. In another embodiment, the indexing slot 512 is manufactured to have any number of stop and release positions, and the indexing assembly 500 is assembled such that the initial position of the lug 514 is in the second to last stop position, or position 532.

[0046] A plurality of indexing assemblies 500 may be disposed in a tubing section in series, such as in the series of stimulation sleeves 158 shown in FIG. 1. The series of indexing assemblies 500 will include ball seats 542 all having the same unexpanded diameter to receive the same size balls. For example, the diameter of unexpanded ball seat 542 in FIG. 6A may be 2.75 inches, while the balls may be 3 inches in diameter. Each assembly 500 can be pre-set to catch and release a different number of 3-inch balls such that the series of assemblies will actuate a series of sleeve assemblies 158 or 300 to successively expose the work and tubing strings to different zones of interest 80, 82, 84, 86, 88, 90 while passing the same size ball through the plurality of indexing and sleeve assemblies. In alternative embodiments, a first series of indexing and sleeve assemblies is adapted to receive a first size ball while a second series of indexing and sleeve assemblies is adapted to receive a second size ball, thereby further expanding the total number of sleeve assemblies that can be actuated in the well. Alternatively, a third series may be added and so on. For example, a bottom series of four indexing and sleeve assemblies may be adapted to successively actuate upon receiving a series of four 2-inch balls. A next series of four indexing and sleeve assemblies may be adapted to successively actuate upon receiving a series of four 2.25-inch balls. A third series disposed uphole of the second series may be adapted to successively actuate upon receiving a series of four 2.5-inch balls. In this embodiment, a total of twelve indexing and sleeve assemblies can be actuated to expose zones of interest. Further added series will add indexing and sleeve assemblies in increments of four, or however many balls the indexing assembly is designed to catch and release as designed herein.

[0047] In some embodiments, the collet fingers 524 are dipped in stiffening or hardening agents for added strength or resistance. In one embodiment, the collet fingers 524 are at rest in the contracted position shown in FIG. 6A, and the force of the ball passing through the collet fingers causes them to expand into the recess 526. These collet fingers 524 may also be referred to as “normally closed” or “normally contracted.” In another embodiment, the collet fingers are formed and strengthened to normally be in the expanded position shown in FIG. 9, such that the collet fingers are forced together as shown in FIG. 6A and allowed to spread automatically when placed in the position of FIG. 9. These collet fingers 524 may also be referred to as “normally open” or “normally expanded.” In other embodiments, the collet fingers 524 are dipped in an elastomer or other compressible material such that when the collet fingers are contracted as shown in FIG. 6A, the elastomer coating on one finger will compress against the elastomer coating on an adjacent finger to close the spaces between the fingers and provide a sealed ball seat 542.

[0048] In an alternative embodiment, the control lug 514 is disposed on the outer surface of the inner sleeve 504 and the indexing slot 512 is disposed on the inner surface of the outer sleeve 502, i.e., they are switched. In this embodiment, the profile view of FIG. 6B would be flipped such that the stop positions would be on top and the release positions on bottom, and the final position would be on top.

[0049] With reference to FIG. 7-11, a further embodiment includes an indexing assembly 600 having similar components as the assembly 500, such as an outer sleeve 602 and an inner sleeve 604. However, assembly 600 further includes an upper recessed portion 627. In operation, a ball 670 enters the flow bore 605 and arrives at the seat 642 as shown in FIG. 8. The pressure buildup above the ball 670 overcomes the biasing force provided by the spring 616 and moves the inner sleeve 604 downward. As shown in FIG. 9, the collet fingers 624 expand into the recess 626, either by the force provided by the ball 670 or by the normally open disposition of the fingers, and the ball 670 passes through the fingers 624 and the seat 642 to travel downward 650 through the flow bore 644. The biasing force of the spring 616 then returns the inner sleeve 604 to the middle position shown in FIG. 8, readying the indexing assembly 600 to receive another ball 670. During this process, the lug 614 and indexing slot 612 operate as previously described.

[0050] However, at some point, it may be desirable to return a ball or balls to the surface of the well. A ball may be forced upward along a return path 660 in the flow bore 644 by fluid pressure or other means, and the indexing assembly 600 is adapted to work in reverse wherein the upper recess 627 receives the expanding collet fingers 624 as shown in FIG. 10. As shown in FIG. 11, a reserve position 648 is provided in the indexing slot 612 to accommodate the upward movement of the inner sleeve 604 as shown in FIG. 10. For example, the indexing assembly 600 may be assembled such that the lug 614 is given an initial position 630. Ball engagement on the seat 642 causes the inner sleeve 604 to move downward, and thus the lug 614 moves upward in the indexing slot 612 to the first release position 636. The ball 670 passes through the collet fingers 624, thereby relieving the pressure in the inner sleeve 604. The biasing spring 616 returns the inner sleeve 604 and the indexing slot 612 to a position placing the lug 614 in a first reset position 632. Another ball 670 may be cycled through the inner sleeve 604, placing the lug 614 in a second release position 638, then in a second reset position 634

which is also the catch position. Position **634** is a catch position because the lug **614** is not allowed to move upward to a position similar to positions **636**, **638**, thereby preventing downward movement of the inner sleeve **604** and release of the ball **670**. The pressure buildup above the ball **670** is transferred to the outer sleeve **602**, which is the slidable sleeve of a larger sleeve assembly as described herein. However, unlike indexing slot **512**, the slot **612** provides an additional position **648** that allows upward movement of the inner sleeve **604** to accommodate the return of the ball **670** shown in FIG. **10**. Once the balls have been returned as described, the well can be produced unobstructed and without intervention to drill out the ball-engaged indexing and sleeve assemblies. In other embodiments, the balls or other obturating members are breakable or dissolvable to remove them from the inner flow bores.

[0051] In other embodiments, the total number of reset and release positions is adjusted to increase or decrease the number of balls the indexing assemblies are designed to catch and release. For example, the indexing slots **512**, **612** are designed to release two balls before catching the third ball. However, additional sets of reset and release positions can be added to increase the number of balls that are released before the final ball is caught.

[0052] The number of zones, indexing assemblies and sleeve assemblies shown herein is not intended to be limiting and is shown only for exemplary purposes. Any desired number of zones may be treated or produced. The plurality of zones will be treated sequentially upwardly. For example, when a sleeve assembly is moved to align openings, dissolving fluid and then treatment fluid may be flowed into the zone to be treated, and the next zone desired to be treated is done so in the manner described. Once the selected zones have been treated, the balls can be flowed back to the surface, as previously described, or drilled out and the well can be produced through each of the selected zones in a manner known in the art.

[0053] In alternative embodiments, the mechanical assemblies **500**, **600** may be similar with the exception of the indexing slots **512**, **612**. The indexing slots **512**, **612** act as counter mechanisms to count the number of balls that pass through the assemblies. While the other elements and components of the assemblies remain similar, the indexing slots **512**, **612** can be replaced by alternative counting mechanisms. The electro-mechanical sliding sleeve assemblies or subs may incorporate electronics, and the counter or reader in the sleeve assembly could be actuated by magnets, RFID tags or other "smarts" in the balls. For example, the sliding sleeve sub can be placed in the open or release position as the normal position. An electronic reader in the inner sleeve electronically counts the magnets or tags in the balls as they pass through the expandable seat, and upon counting a pre-determined number of balls, the sleeve is actuated to move to the closed position. The inner sleeve can be moved to the closed position by a motor or other drive means known in the art. Thus, while the sliding inner sleeve and collet finger arrangement provides the same uniformity of flow bore diameter and ball size, the counting of the balls is accomplished by electronic or electrical means rather than mechanical means, and the inner sleeve is driven not by fluid pressure but by a drive means such as an electro-mechanical actuator. In alternative embodiments, the electro-mechanical actuator can be replaced by pressurized chambers adjacent the inner sliding sleeve. An unpressurized chamber is adjacent and communi-

cates with the inner sleeve, and is separate from a pressurized chamber by a burst disc. Upon an actuation command from the electronic counter, the disc can be burst to expose the unpressurized chamber and thus the inner sliding sleeve to fluid pressure to move the sleeve to its closed position as described herein.

[0054] In addition to servicing, treatment and completion systems, the embodiments of the indexing or sliding sleeve assemblies can be used in other systems. For example, a system including a series open-hole packer can incorporate the indexing or sliding sleeve assemblies for successive actuation of the packers.

[0055] While specific embodiments have been shown and described, modifications can be made by one skilled in the art without departing from the spirit or teaching of this invention. The embodiments as described are exemplary only and are not limiting. Many variations and modifications are possible and are within the scope of the invention. Accordingly, the scope of protection is not limited to the embodiments described, but is only limited by the claims that follow, the scope of which shall include all equivalents of the subject matter of the claims.

What is claimed is:

1. A well bore servicing apparatus comprising:
 - an first sleeve slidably disposed in a tubing section;
 - an second sleeve slidably disposed in the first sleeve;
 - an indexing slot disposed on one of the outer sleeve and inner sleeve, and a control lug disposed on the other of the outer sleeve and the inner sleeve to communicate with the indexing slot; and
 - an expandable seat disposed in the inner sleeve to receive a plurality of obturating members.
2. The apparatus of claim 1 wherein the lug is disposed within the indexing slot to guide relative movement between the first sleeve and the second sleeve.
3. The apparatus of claim 1 wherein the plurality of obturating members are the same size.
4. The apparatus of claim 2 wherein the indexing slot includes a plurality of stop positions and a plurality of release positions for the lug.
5. The apparatus of claim 4 wherein the plurality of stop positions correspond to a contracted position of the expandable seat and the plurality of release positions correspond to an expanded position of the expandable seat for passing through the plurality of obturating members.
6. The apparatus of claim 1 wherein the expandable seat includes a plurality of collet fingers.
7. The apparatus of claim 6 wherein the collet fingers are normally open.
8. The apparatus of claim 6 wherein the collet fingers are normally closed.
9. The apparatus of claim 6 wherein the collet fingers are dipped or coated.
10. A well bore servicing apparatus comprising:
 - a work string;
 - a tubing section coupled to the work string;
 - a plurality of sleeve assemblies disposed in the tubing section; and
 - a plurality of seats for receiving an obturating member, one seat disposed in each of the sleeve assemblies;
 wherein the plurality of seats are substantially the same size.

11. The apparatus of claim 10 wherein the seats are operable to receive a series of obturating members having substantially the same size.

12. The apparatus of claim 11 wherein the series of obturating members are operable to successively actuate the plurality of sleeve assemblies adjacent multiple formation zones.

13. The apparatus of claim 10 wherein the tubing section having the plurality of sleeve assemblies includes a substantially uniform minimum flow bore diameter over its axial length.

14. The apparatus of claim 10 wherein all sleeve assemblies disposed in the tubing section are actuatable by the same size obturating member.

15. The apparatus of claim 10 further comprising an indexing slot and a corresponding control lug disposed in each of the sleeve assemblies.

16. The apparatus of claim 15 wherein the control lugs communicate with positions in the indexing slot to count the number of obturating members that pass through an inner sleeve assembly.

17. The apparatus of claim 10 further including an electronic counter operable to detect the obturating member.

18. The apparatus of claim 10 further including a drive means coupled to an indexing assembly in each of the sleeve assemblies.

19. The apparatus of claim 11 further comprising an electronic tag in each of the obturating members, an electronic counter in each of an inner sleeve assembly disposed in each of the sleeve assemblies, and an electro-mechanical actuator coupled to the inner sleeves.

20. A method of servicing a well bore comprising:
disposing a tubing section in the well bore;
positioning the tubing section adjacent a plurality of formation zones;
passing a first obturating member through a first moveable sleeve;

catching the first obturating member in a second moveable sleeve to actuate a sleeve assembly adjacent a first formation zone; and

catching a second obturating member in the first moveable sleeve to actuate a second sleeve assembly adjacent a second formation zone;

wherein the first and second obturating members are substantially the same size.

21. The method of claim 20 further comprising passing a plurality of same-size obturating members through the first moveable sleeve and actuating a plurality of sleeve assemblies below the first moveable sleeve with the same-size obturating members.

22. A method of servicing a well bore comprising:
placing a tubing section in the well bore via a work string;
and

actuating a plurality of sleeve assemblies in the tubing section with same-size obturating members.

23. The method of claim 22 further comprising pumping a treatment fluid through a flow bore in the tubing section having a substantially uniform inner diameter.

24. The method of claim 22 further comprising maintaining constant flow rates over the axial length of the tubing section having the plurality of sleeve assemblies.

25. The method of claim 22 further comprising maintaining constant treatment pressures over the axial length of the tubing section having the plurality of sleeve assemblies.

26. A method of servicing a well bore comprising:
disposing a tubing section having a plurality of actuatable sleeve assemblies in the well bore;
providing a series of obturating members having substantially the same size to actuate the sleeve assemblies; and
successively actuating the sleeve assemblies with the same-size obturating member to successively treat a plurality of formation zones.

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(19) **United States**(12) **Patent Application Publication****Davis et al.**(10) **Pub. No.: US 2004/0055753 A1**(43) **Pub. Date: Mar. 25, 2004**(54) **DOWNHOLE BALL DROPPING APPARATUS****Publication Classification**(76) Inventors: **John P. Davis**, Cypress, TX (US);
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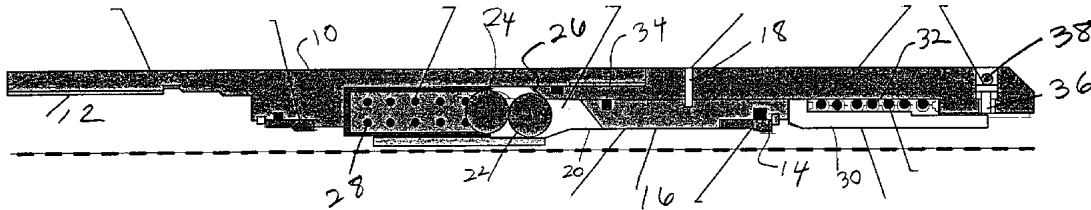
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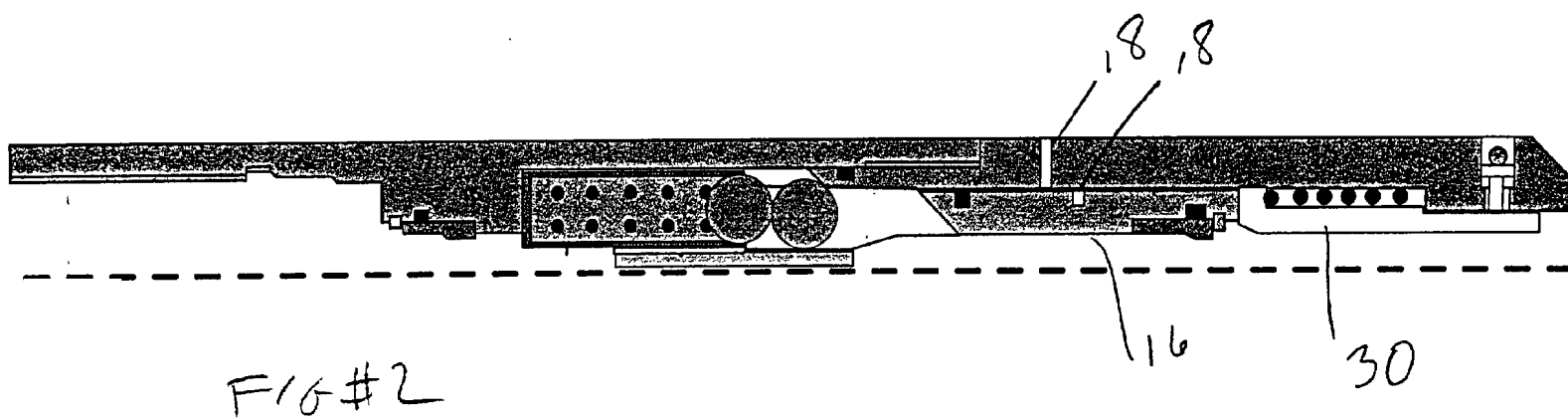
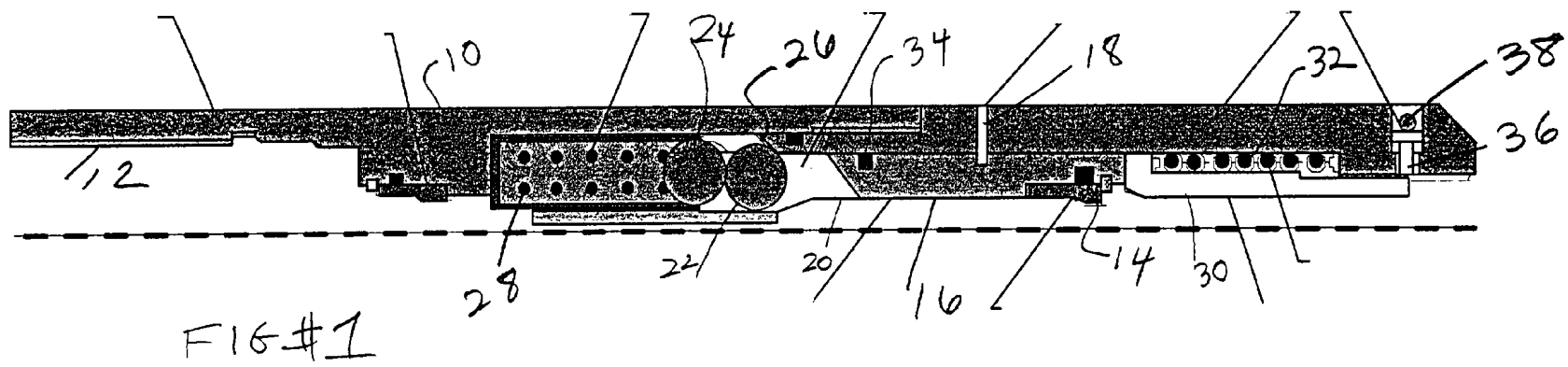
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ABSTRACT

A ball release mechanism is mounted near the intended seat. The ball or balls are kept out of the circulating stream. High circulation rates followed by curtailment of circulation places an outlet port in position to allow the ball or balls to be pushed out by a spring. The spring or one of the balls prevents the return of an ejected ball back into the protected pocket. The ball is delivered to the seat without circulation.

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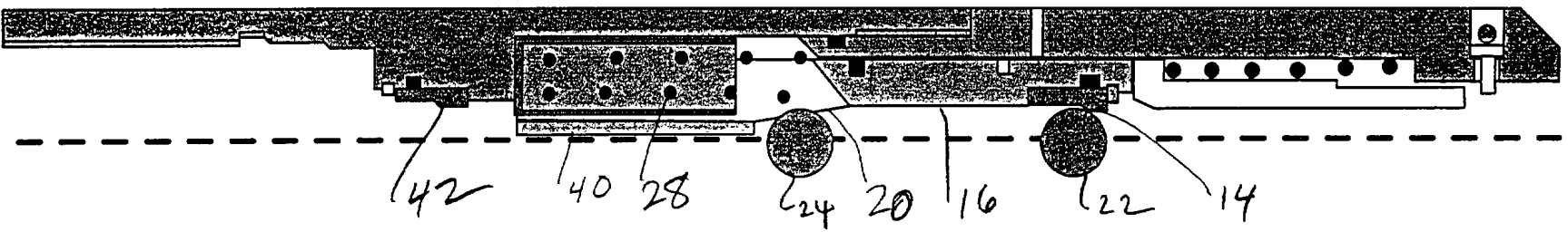


FIG. 3

DOWNHOLE BALL DROPPING APPARATUS

FIELD OF THE INVENTION

[0001] The field of the invention is a ball release device and more particularly a device that is mounted near the hole bottom with the stored ball or balls protected until release after circulation.

BACKGROUND OF THE INVENTION

[0002] Most prior ball release devices store the ball in the fluid stream and use circulation to transport it to the seat. Several problems can occur with this design. The ball may not release because the carrier gets clogged with debris from the mud. The carrier can become worn resulting in premature release of the ball. The ball is released during high circulation. It can slam against a seat and create high pressure spikes that can damage other equipment. The high circulation rates around the ball can erode parts of it causing it to not hold pressure even if it lands on the ball seat. Some examples of prior designs that have the ball in the circulating path are U.S. Pat. Nos. 6,390,200; 6,220,360; and 5,960,881. U.S. Pat. No. 4,171,019 shows a cement float shoe with a ball in a side pocket such that it can be displaced against a ball seat if the flow direction reverses. Balls have been used to fix a range of motion of a sleeve valve member, as shown in U.S. Pat. No. 4,406,335.

[0003] What the prior devices lacked is addressed by the present invention. The ball is retained near its intended seat near the bottom of the hole. It is retained out of the flowing stream. The ball discharge procedure is such that ball release occurs after circulation is stopped and not during circulation. Once the ball is released it is prevented from reentering its original storage location. These and other benefits of the present invention will be more apparent to those skilled in the art from a review of the description of the preferred embodiment and the claims, which appear below.

SUMMARY OF THE INVENTION

[0004] A ball release mechanism is mounted near the intended seat. The ball or balls are kept out of the circulating stream. High circulation rates followed by curtailment of circulation places an outlet port in position to allow the ball or balls to be pushed out by a spring. The spring or one of the balls prevents the return of an ejected ball back into the protected pocket. The ball is delivered to the seat without circulation.

DETAILED DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 is a part section view of the tool during the run in;

[0006] FIG. 2 is the view of FIG. 1 in the circulation position;

[0007] FIG. 3 is the view of FIG. 2 with the ball released after circulation has ceased.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] Referring to FIG. 1, a housing 10 is connected at thread 12 to a string and downhole equipment (not shown). Housing 10 comprises a primary ball seat 14 preferably mounted on ball carrier 16 or in another housing in fluid

communication with housing 10. As illustrated, ball seat 14 provides resistance to circulation to move the ball carrier 16. However, that resistance can be from another constriction on ball carrier 16 with the ball seat in another housing in fluid communication with housing 10. In the preferred embodiment, the balls 22 and 24 drop less than a meter to get to ball seat 14. A shear pin 18 initially holds the ball carrier 16 to the housing 10. In the run in position, an outlet port 20 is so positioned that balls 22 and 24 cannot escape. Balls 22 and 24 are biased toward tapered surface 26 on ball carrier 16 by spring 28. Housing 10 further comprises a sleeve 30 biased by spring 32 toward ball carrier 16. A seal 34 seals between ball carrier 16 and housing 10. For run in, sleeve 30 holds in detent pin 36 against the bias of spring 38.

[0009] The operation of the tool will now be reviewed. Circulation is started through housing 10. As a result a net force is applied to ball carrier 16 shifting it down against sleeve 30 and compressing spring 32. While the restriction from ball seat 14 that causes ball carrier 16 to be displaced by circulation is shown at the lower end of the ball carrier 16, the actual restriction that causes the ball carrier 16 to shift can be located elsewhere on ball carrier 16, while the ball seat 14 can be in any other location below balls 22 and 24. The shear pin 18 is broken by movement of ball carrier 16. Balls 22 and 24 are held retained by tapered surface 26. Circulation is then stopped. Spring 32 displaces sleeve 30 to position outlet port 20 in alignment to let balls 22 and 24 escape with a push from spring 28. Ball 22 lands on primary ball seat 14, which is less than a meter away, while ball 24 is optional. Ball 24 keeps ball 22 near seat 14 because the upper end 40 of ball carrier 16 as well as spring 28 in its extended position help to maintain ball 24 in the position shown in FIG. 3. Spring 38 has pushed out detent pin 36 to prevent needless cycling of ball carrier 16 at a later time when circulation is resumed for other purposes.

[0010] A secondary ball seat 42 is provided to accept a ball dropped from the surface in a known manner, in the event ball 22 fails to seal or hold enough pressure against primary ball seat 14.

[0011] Those skilled in the art will appreciate that the present invention has many unique features. The ball or balls are stored out of the flowing path of mud and are less likely to be eroded or deformed by circulation. The balls are not released during circulation. Pressure spikes are eliminated as the balls are released from a location very close to the seat after circulation has stopped. There is no need to wait a long time for the ball to seat from the time of release, because the release point is so close to the ultimate seat location. This tool can be run below tools that would not be able to pass a ball. The tool is of particular advantage on a horizontal run. In the past, a ball dropped from the surface could land in many places short of the desired seat. This is particularly the case when running long lengths of screen to be expanded in a horizontal run. In the present invention, seating occurs almost immediately after release due to the close proximity between the release point and the seat. In the unlikely event of a failure of the tool, a secondary seat is provided to allow a backup ball to be dropped in the known manner. Alternatively, a plurality of balls of different sizes can be stored in the tool. Bigger balls can reuse Ball seat 14 after an initial ball expands the seat a given amount in a known manner. Alternatively, smaller balls can be subsequently released that will pass through seat 14 after the first ball is blown

through it and land on another seat further down. While the preferred embodiment has been shown with two balls, one ball or more balls can be used. They can be released all at once or one at a time such as by using a ratchet device actuated by cycling the circulation on and off. To do this the detent pin **36** could be eliminated. No rotation is required to operate the tool making it useful in deviated wells.

[0012] The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made without departing from the spirit of the invention.

We claim:

1. A ball dropping apparatus, comprising:

a housing having an uphole and a downhole end and a passage through it;

at least one obstructing member mounted in said housing;

said obstructing member selectively movable from an initial position where it is located outside of said passage to an obstructing position in said passage.

2. The apparatus of claim 1, further comprising:

a seat in one of said passage and a connected housing to the ball dropping apparatus, said obstructing member allowing pressure buildup at said uphole end of said housing when it is located on said seat.

3. The apparatus of claim 1, further comprising:

said obstructing member is selectively released by virtue of flow through said passage.

4. The apparatus of claim 3, wherein:

said obstructing member is selectively released only by the onset and subsequent cessation of flow through said passage.

5. The apparatus of claim 1, wherein:

said obstructing member in said initial position is disposed in a side compartment selectively accessible to said passage.

6. The apparatus of claim 5, further comprising:

a selectively movable carrier to hold said obstructing member in said side compartment, in a first position, and to allow release of said obstructing member from said side compartment, when placed in a second position.

7. The apparatus of claim 6, wherein:

said carrier further comprises a flow passage therethrough and wherein a primary seat is mounted in one of said flow passage and a housing connected to the ball dropping apparatus to receive said obstructing member.

8. The apparatus of claim 6, wherein:

said carrier is biased in a direction where said obstructing member will be allowed to exit said side compartment.

9. The apparatus of claim 8, wherein:

said carrier is initially secured to said housing with said bias overcome.

10. The apparatus of claim 9, wherein:

said carrier is mounted in said passage;

said initial securing of said carrier is broken with flow through said flow passage.

11. The apparatus of claim 10, wherein:

said obstructing member remains trapped in said side compartment while flow through said passage overcomes said bias on said carrier.

12. The apparatus of claim 11, wherein:

said obstructing member is released from said side compartment when said bias on said carrier shifts it, upon cessation of flow through said passage.

13. The apparatus of claim 12, wherein:

said carrier comprises an outlet opening that shifts into alignment with said obstructing member as a result of its movement under said bias.

14. The apparatus of claim 12, wherein:

said carrier is locked into position after being shifted by said bias.

15. The apparatus of claim 14, wherein:

said bias on said carrier comprises a spring protected from said passage by a sleeve, said sleeve initially covers a detent in said housing, whereupon when said sleeve is biased against said carrier to move it in a first direction, said detent emerges from said housing into said passage to prevent significant movement of said carrier in a second direction opposite said first direction.

16. The apparatus of claim 5, wherein:

said obstructing member is biased toward said passage from within said side compartment.

17. The apparatus of claim 6, further comprising:

a spring in said side compartment, said spring preventing reentry of said obstructing member into said side compartment.

18. The apparatus of claim 6, wherein:

said at least one obstructing member comprises a plurality of balls; and

a second of said balls prevents a first of said balls, that exits said side compartment, from reentering.

19. The apparatus of claim 2, wherein:

said obstructing member enters said passage within 1 meter of said seat.

20. The apparatus of claim 19, wherein:

said obstructing member comprises a ball; and

said housing comprises a backup seat for use if said ball fails to hold pressure against said seat.

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