

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau



(10) International Publication Number

WO 2016/182574 A1

(43) International Publication Date

17 November 2016 (17.11.2016)

WIPO | PCT

(51) International Patent Classification:

E21B 34/06 (2006.01) *F16K 5/08* (2006.01)
F16K 5/06 (2006.01)

(21) International Application Number:

PCT/US2015/030736

(22) International Filing Date:

14 May 2015 (14.05.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: HALLIBURTON ENERGY SERVICES, INC. [US/US]; 3000 N. Sam Houston Parkway E., Houston, TX 77032-3219 (US).

(72) Inventor: NAPIER, Roy, Archibald; Broomley Mews, Montrose, Angus DD10 9LQ (GB).

(74) Agents: MORICO, Paul et al.; Baker Botts LLP, 910 Louisiana Street, Houston, TX 77002 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

(54) Title: BALL AND SEAT VALVE FOR HIGH TEMPERATURE AND PRESSURE APPLICATIONS

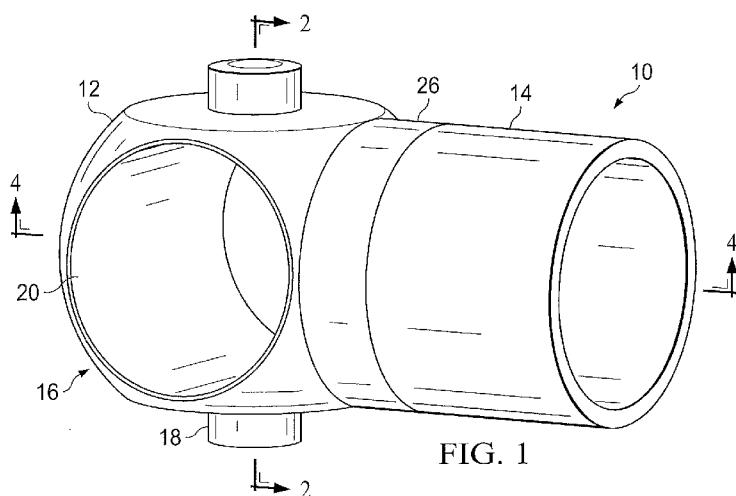


FIG. 1

(57) **Abstract:** A ball and seat valve for high temperature and pressure applications, such as those used in isolation barrier valves in subterranean wells, is disclosed. The valve incorporates thermally fitted sleeve into the ball and/or the seat to allow for greater pressures and temperatures due to resultant stresses left with the parts due to interference. Additionally, the materials making up the sleeves may be chosen to allow for greater resistance to corrosive and erosive wellbore fluids.

WO 2016/182574 A1

BALL AND SEAT VALVE FOR HIGH TEMPERATURE
AND PRESSURE APPLICATIONS

TECHNICAL FIELD

5 This disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and in one example described below more particularly, provides a ball and seat valve capable of withstanding high temperature and high pressure applications.

BACKGROUND

10 Hydrocarbons, such as oil and gas, are commonly obtained from subterranean formations that may be located onshore or offshore. The development of subterranean operations and the processes involved in removing hydrocarbons from a subterranean formation typically include a number of different steps such as, for example, drilling a wellbore at a desired well site, treating the wellbore to optimize production of hydrocarbons, and performing the necessary steps to 15 produce and process the hydrocarbons from the subterranean formation.

As oil and gas wells increase in depth to find sustainable reserves, the resultant reservoir pressures and temperatures have increased significantly. For example, at depths of 30,000 feet, it is not uncommon to experience temperatures over 350°F and pressures over 10,000 psi. These increased downhole conditions have placed increased demands on downhole equipment, 20 including, Isolation Barrier Valves. Current Isolation Barrier Valves utilize a simple spherical ball and seat arrangement as the closure device. In order to meet the current performance demands, the choice of materials to manufacture the ball and seat is becoming restricted and may be nearing the limits of currently approved materials.

The present disclosure is directed to an improved ball and seat valve which incorporates 25 thermally fitted sleeves into the ball and/or the seat to allow greater pressures and temperatures due to the resultant stresses left within the parts due to interference.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure and its features and advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

5 FIG. 1 is a schematic diagram illustrating one embodiment of an isolation barrier valve in accordance with the present disclosure;

FIG. 2 is a cross sectional view of the isolation barrier valve shown in FIG. 1 taken along line 2-2.

10 FIG. 3 is a schematic diagram illustrating another embodiment of an isolation barrier valve in accordance with the present disclosure.

FIG. 4 is a schematic diagram illustrating an isolation barrier valve installed in a section of production tubing.

DETAILED DESCRIPTION

An isolation barrier valve 10 in accordance with the present disclosure is illustrated in FIG. 1. The valve 10 includes a ball 12 and a seat 14. The ball 12 is generally spherically-shaped and formed of a metal alloy. In one embodiment, the ball 12 is formed of a metal alloy, such as a 41XX Series chromium-molybdenum alloy or more noble nickel alloy. As those of ordinary skill in the art will appreciate, other materials may be used in forming the ball 12, which are capable of withstanding the high temperature and high pressure environments found in deep water subsea and other deep and ultra-deep wells. The ball 12 is formed with a flow passage 16 formed therethrough. The flow passage 16 is generally cylindrically shaped and occupies a significant volume of the ball 12. The flow passage 16 is designed to withstand high pressure, high velocity flow of downhole fluids.

The ball 12 is formed with an axis 18 about which the ball is capable of rotating. As will be described further below, the ball 12 is capable of rotating through at least 90 degrees so as to assume one of two positions, one which can be characterized as an “open” position and the other which can be characterized as a “closed” position. In the “open” position, fluids are permitted to flow through the flow passage 16, for example, during the production of hydrocarbons from a subterranean formation of an oil and gas reservoir to the surface. In the “closed” position, fluid flow is shut off, thereby ceasing the flow of hydrocarbons to the surface. The isolation barrier valve can also be used to open and close the flow of completion and/or enhancement fluids downhole.

The seat 14 is a generally cylindrically-shaped tubular member. Like the ball 12, the seat 14, is formed of a metal alloy, for example, a 41XX Series chromium-molybdenum alloy or more noble nickel alloy. Again, as those of ordinary skill in the art will appreciate, other materials capable of withstanding the high temperature, high pressure environment of deep and ultra-deep wells can be used. The seat 14 in one example may have an inner diameter of approximately 4.5 inches and an outer diameter of approximately 5.0 inches, although, as those of ordinary skill in the art will appreciate, any suitably sized seat may be employed.

In one embodiment in accordance with the present disclosure, a support sleeve 20 is formed in and lines the surface of the flow passage 16 of the ball 12. In one embodiment, the support sleeve 20 is formed of the same metal alloy used to form the ball 12 and seat 14. The support sleeve is generally cylindrically-shaped and in one embodiment may vary in thickness from 0.0625 to 0.125 inches, although other suitable thicknesses and materials may be used. The support sleeve 20 may be thermally fit to the inner cylindrical surface of the ball 12 forming the

flow passage 16. In one embodiment, the support sleeve 20 is cooled before being placed into the flow passage 16. Once it warms again, it forms an interference fit with the inner cylindrical surface of the ball 12. Alternatively, the ball 12 is heated hereby causing it to expand. The support sleeve 20 is then inserted into the ball 12, which is then allowed to cool. Once cooled, 5 the support sleeve 20 is interference fit within the flow passage 16 of the ball 12. In the embodiment illustrated in FIG. 1, the support sleeve 20 is formed as a single sleeve which extends along the entire length of the cylindrical surface forming the flow passage 16.

In another embodiment in accordance with the present disclosure, a pair of generally cylindrically-shaped support sleeves 22 and 24 are used in place of the single support sleeve 20, 10 as shown in FIG. 3. In this embodiment, the pair of support sleeves 22 and 24 may be made of the same material and installed in the manner described with reference to the single support sleeve 20. The pair of support sleeves 22 and 24 is installed each at opposite ends of the longitudinal length of the flow passage 16. Alternatively, a plurality of support sleeves are installed along the longitudinal length of the flow passage 16.

15 In accordance with the present disclosure, the seat 14 also may be provided with a support sleeve 26, as shown in FIGs. 1 and 3. The support sleeve 26 may also be formed of the same metal allow, for example, a 41XX Series chromium-molybdenum alloy or more noble nickel alloy, as the ball 12 and seat 14. Again, as those of ordinary skill in the art will appreciate other suitable materials may be used. The support sleeve 26 in one embodiment is 20 approximately 0.0625 to 0.125 inches thick, but other suitable thicknesses may be employed. The support sleeve 26 is thermally fit to the seat 14. In one embodiment, the sleeve is heated and placed over a cool seat 14 and allowed to cool, thereby shrinking into an interference fit on the seat 14. In another embodiment, the support sleeve 26 is placed over the seat 14, which has been cooled and then allowed to warm so as to thereby form an interference fit between the support 25 sleeve 26 and the seat 14.

As those of ordinary skill will appreciate at high temperatures and/or pressures which are experienced in deep well applications, the ball 12 and seat 14 have a tendency to deform due to the stresses created by the high temperature, high pressure fluid flow. This is illustrated in FIG. 2, by arrows A and B, which represent upstream and downstream pressure, respectively. These 30 pressures cause the ball and seat to deform which can cause leakage of fluids out of the valve. The support sleeves 20 (or 22 and 24) and 26 in accordance with the present disclosure act to pre-stress the ball 12 and seat 14, respectively, and thereby prevent these components from deforming at higher temperatures and/or pressures than would be possible without the support

sleeves. This is best illustrated in FIG. 2 where the support sleeve 26 is shown pre-stressing the seat 14 such that deformation at the point of contact between the ball 12 and seat 14 is prevented or at least minimized thereby preserving the integrity of the seal at point C.

FIG. 4 shows valve 10 with ball 12 and seat 14 installed within a downhole tool 28, 5 which in turn is shown within a section of production casing or tubing 30. In this application, the valve 10 would be used as a lower completion isolation valve and installed just below the uppermost gravel pack packer in the wellbore formed in the reservoir of interest. As those of ordinary skill in the art will appreciate, however, the valve mechanism 10 may be used in other applications both in the oil field, such as in subsea trees, and outside of the oil field where high 10 temperature, high pressure reliable valves are needed. As those of skill in the art will appreciate, the deeper a hole is in a subterranean formation, the higher the downhole temperatures and pressures will be. In deep and ultra-deep applications the pressures, for example, can be as high as 15,000 psi and possibly even higher. The valve 10 would be suitable for such applications.

Although various examples have been described above, with each example having certain 15 features, it should be understood that it is not necessary for a particular feature of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope of this disclosure 20 encompasses any combination of any of the features.

Although each example described above includes a certain combination of features, it should be understood that it is not necessary for all features of an example to be used. Instead, any of the features described above can be used, without any other particular feature or features also being used.

It should be understood that the various embodiments described herein may be utilized in 25 various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of this disclosure. The embodiments are described merely as examples of useful applications of the principles of the disclosure, which is not limited to any specific details of these embodiments.

In the above description of the representative examples, directional terms (such as 30 “above,” “below,” “upper,” “lower,” etc.) are used for convenience in referring to the accompanying drawings. However, it should be clearly understood that the scope of this disclosure is not limited to any particular directions described herein.

The terms “including,” “includes,” “comprising,” “comprises,” and similar terms are used in a non-limiting sense in this specification. For example, if a system, method, apparatus, device, etc., is described as “including” a certain feature or element, the system, method, apparatus, device, etc., can include that feature or element, and can also include other features or 5 elements. Similarly, the term “comprises” is considered to mean “comprises, but is not limited to.”

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many 10 modifications, additions, substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of this disclosure. For example, structures disclosed as being separately formed can, in other examples, be integrally formed and vice versa. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the invention being limited solely by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A valve, comprising:

a ball having a flow passage formed therein;

a support sleeve formed in the flow passage of the ball; and

5 a seat disposed adjacent to and in engagement with the ball.

2. The valve according to claim 1, wherein the support sleeve is thermally fit to the flow passage of the ball and extends the entire length of the flow passage.

10 3. The valve according to claim 2, further comprising a second support sleeve, wherein both support sleeves are thermally fit to the flow passage of the ball with one support sleeve being disposed at a first end of the flow passage and the other support sleeve being disposed at a second end of the flow passage opposite the first end of the flow passage.

15 4. The valve according to claim 1, further comprising a support sleeve disposed around at least a portion of the seat.

5. The valve according to claim 4, wherein the support sleeve disposed around at a portion of the seat is thermally fit to an outer circumferential surface of the seat.

20 6. The valve according to claim 5, wherein the support sleeve on the seat and the support sleeve in the ball are formed of a metal alloy selected from the group consisting of the same alloy used to form the ball and seat, a different metal alloy and combinations thereof.

25 7. The valve according to claim 5, wherein the support sleeve thermally fit to the seat is disposed at an end of the seat which engages with the ball.

8. The valve according to claim 7, wherein the flow passage comprises a generally-cylindrically shaped hollow region within the ball and the seat comprises a generally tubular-shaped member having a hollow interior region capable of accommodating fluid flow therethrough.

9. The valve according to claim 8, wherein the ball can rotate through at least 90 degrees and is capable of being placed into a first position wherein the flow passage of the ball aligns with the hollow interior region of the seat so as to allow fluid to pass therebetween and capable of being placed into a second position wherein the flow passage of the ball is out of alignment with the hollow interior region of the seat thereby preventing fluid from passing therebetween.

10. The valve according to claim 9, wherein in the first position a seal is created between the support sleeve on the seat and the support sleeve formed in the flow passage of the ball and in the second position a seal is created between the support sleeve on the seat and an outer circumferential surface of the ball.

11. A valve, comprising:

15 a ball having a flow passage formed therein;
a seat disposed adjacent to and in engagement with the ball; and
a support sleeve disposed around at least a portion of the seat.

12. The valve according to claim 11, wherein the support sleeve is thermally fit to an outer circumferential surface of the seat.

20 13. The valve according to claim 11, further comprising a support sleeve formed in the flow passage of the ball.

25 14. The valve according to claim 13, wherein the support sleeve formed in the flow passage of the ball is thermally fit to the flow passage and extends the entire length of the flow passage.

30 15. The valve according to 13, further comprising a second support sleeve, wherein both support sleeves are thermally fit to the flow passage of the ball with one support sleeve being disposed at a first end of the flow passage and the other support sleeve being disposed at a second end of the flow passage opposite the first end of the flow passage.

16. The valve according to claim 13, wherein the support sleeves on the seat and in the ball are formed of a metal alloy selected from the group consisting of the same alloy used to form the ball and seat, a different metal alloy and combinations thereof.

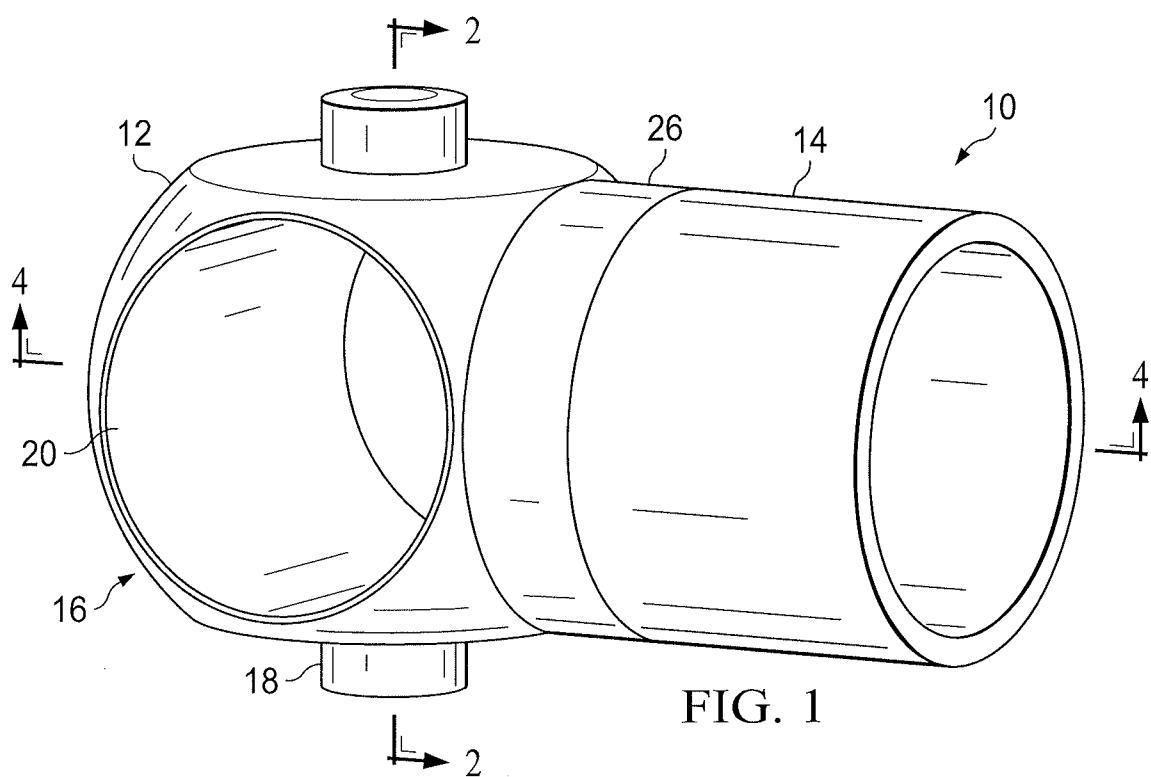
5 17. The valve according to claim 16, wherein the flow passage comprises a generally-cylindrically shaped hollow region within the ball and the seat comprises a generally tubular-shaped member having a hollow interior region capable of accommodating fluid flow therethrough.

10 18. The valve according to claim 17, wherein the ball can rotate through at least 90 degrees and is capable of being placed into a first position wherein the flow passage of the ball aligns with the hollow interior region of the seat so as to allow fluid to pass therebetween and capable of being placed into a second position wherein the flow passage of the ball is out of alignment with the hollow interior region of the seat so to prevent fluid from passing 15 therebetween.

19. The valve according to claim 18, wherein in the first position a seal is created between the support sleeve on the seat and the support sleeve formed in the flow passage of the ball and in the second position a seal is created between the support sleeve on the seat and an 20 outer circumferential surface of the ball.

20. The valve according to claim 11, wherein the support sleeve is disposed at an end of the seat which engages with the ball.

1/3



2/3

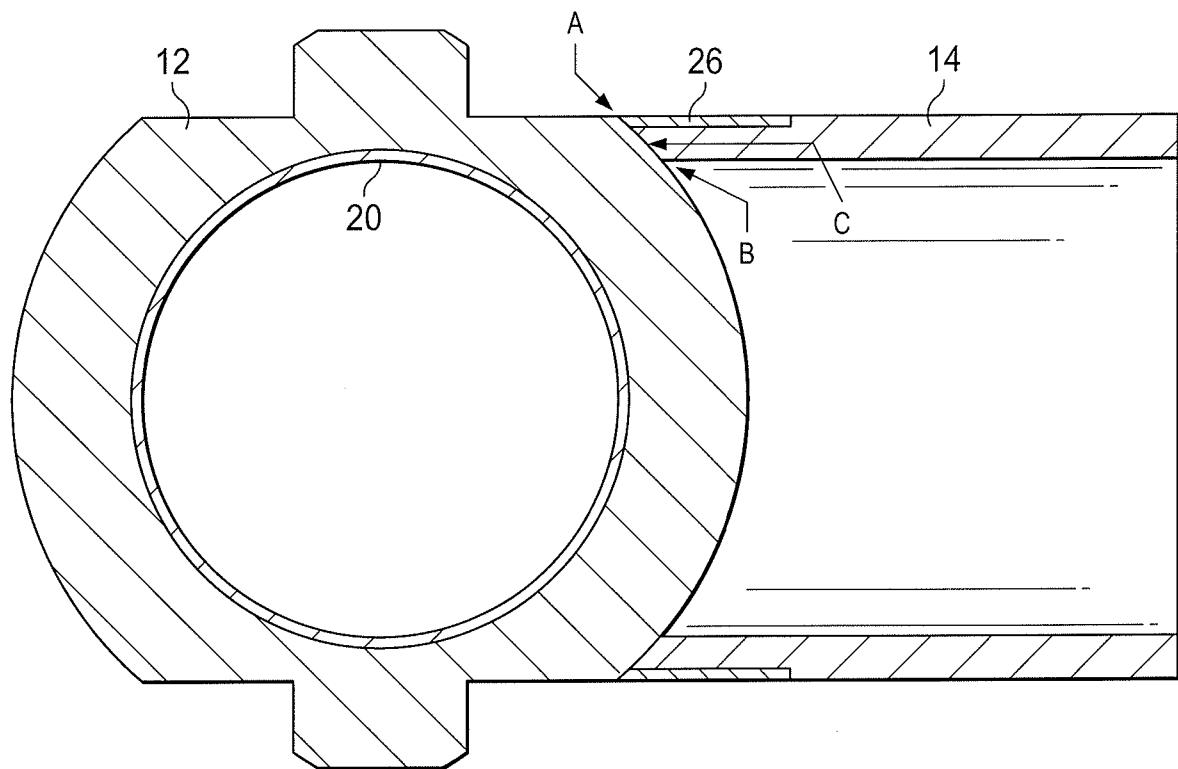


FIG. 2

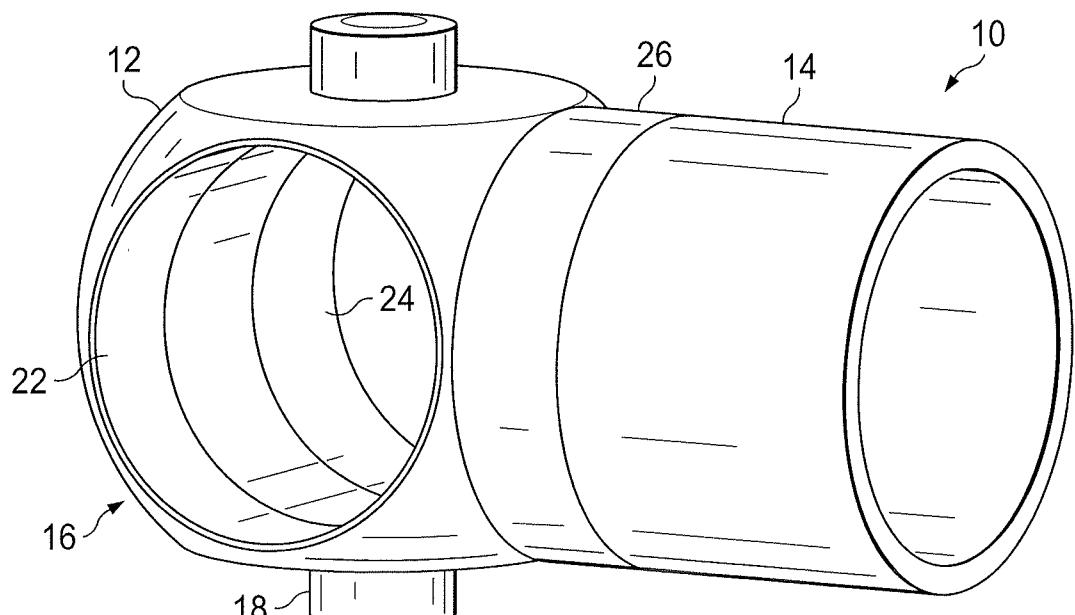
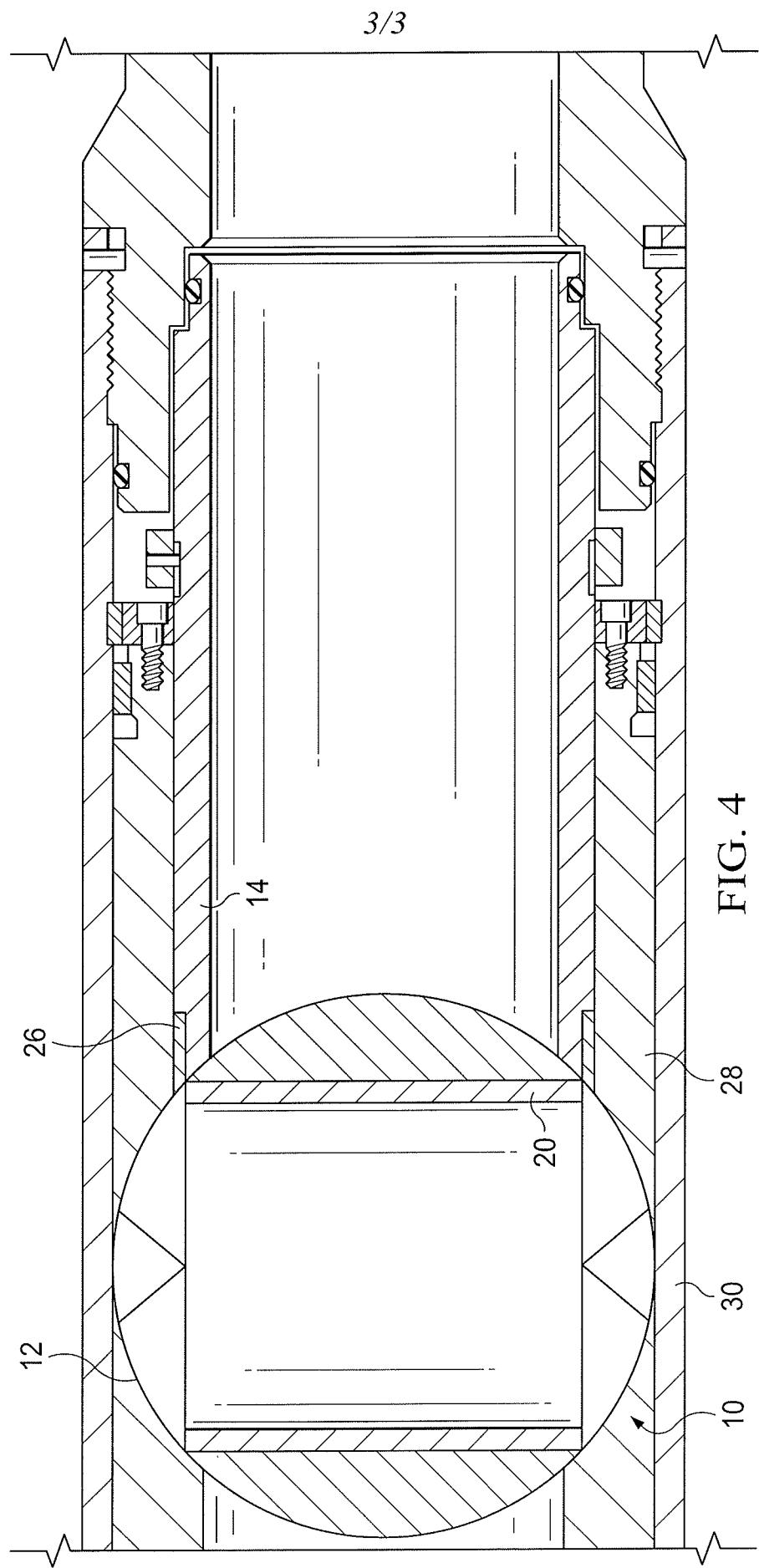


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/030736**A. CLASSIFICATION OF SUBJECT MATTER****E21B 34/06(2006.01)i, F16K 5/06(2006.01)i, F16K 5/08(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
E21B 34/06; E21B 33/12; E21B 34/12; F16K 5/12; F16K 5/06; F16K 5/08Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:valve, ball, flow passage, support sleeve, seat and thermally fit**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0082202 A1 (WEATHERFORD/LAMB, INC.) 04 April 2013 See paragraphs [0009], [0032], [0038], [0054], [0057] and figures 1, 3A-3B, 4A, 10B.	1-20
Y	US 2003-0205688 A1 (MILBERGER et al.) 06 November 2003 See paragraphs [0034], [0036], [0043] and figures 1, 9.	1-20
A	WO 2013-119255 A1 (HALLIBURTON ENERGY SERVICES, INC.) 15 August 2013 See paragraphs [0023], [0027]-[0028] and figures 3A-3C.	1-20
A	US 2008-0283787 A1 (ZAMBONIN et al.) 20 November 2008 See paragraphs [0024], [0028], [0030] and figures 1-3.	1-20
A	US 2009-0032762 A1 (JUNIER, MARIUS ROBERT) 05 February 2009 See paragraphs [0036]-[0042] and figures 3-6.	1-20

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

- * Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

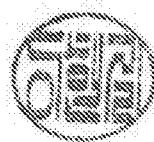
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search
26 January 2016 (26.01.2016)Date of mailing of the international search report
26 January 2016 (26.01.2016)Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 35208,
Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer

LEE, Hun Gil

Telephone No. +82-42-481-8525



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/030736

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013-0082202 A1	04/04/2013	AU 2012-316205 A1 CA 2849979 A1 EP 2761124 A2 WO 2013-049122 A2 WO 2013-049122 A3	17/04/2014 04/04/2013 06/08/2014 04/04/2013 19/09/2013
US 2003-0205688 A1	06/11/2003	AU 2003-225063 A1 BR 0309750 A BR 0309750 B1 GB 2403280 A GB 2403280 B GB 2413373 A GB 2421067 A GB 2421067 B NO 20044821 A NO 329437 B1 US 6698712 B2 WO 03-093705 A1	17/11/2003 22/03/2005 04/03/2014 29/12/2004 02/08/2006 26/10/2005 14/06/2006 02/08/2006 26/11/2004 18/10/2010 02/03/2004 13/11/2003
WO 2013-119255 A1	15/08/2013	AU 2012-369167 A1 CA 2860359 A1 EP 2812528 A1 US 2013-0206417 A1 US 8534360 B2	21/08/2014 15/08/2013 17/12/2014 15/08/2013 17/09/2013
US 2008-0283787 A1	20/11/2008	AT 463693 T CN 101283208 A CN 101283208 B DK 1924793 T3 EP 1924793 A1 EP 1924793 B1 HK 1122349 A1 US 7900653 B2 WO 2007-030960 A1	15/04/2010 08/10/2008 06/04/2011 26/07/2010 28/05/2008 07/04/2010 02/12/2011 08/03/2011 22/03/2007
US 2009-0032762 A1	05/02/2009	None	