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(54) **Title**: VALVE FOR HYDRAULIC FRACTURING THROUGH CEMENT OUTSIDE CASING

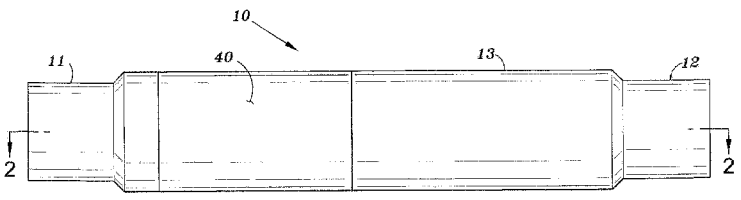

FIG. 1

(57) **Abstract**: A valve for use in fracing through cement casing in a well allows for flow of cement down the well during the cementing process and in the open position allows for fracing fluid to be directed through the cement casing for fracturing the formation adjacent the valve. The valve is constructed so as to reduce the likelihood of the valve to jam as a result of cement or other foreign material.

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VALVE FOR HYDRAULIC FRACTURING THROUGH CEMENT OUTSIDE CASING

Background of Invention

Field of the Invention

This invention is directed to a valve utilized for hydraulically fracturing multiple zones in an oil and gas well without perforating the cement casing. A relatively new oil/gas well completion method involves the use of a valve that is installed as part of the casing string of the well and provides for cement flow within the casing when the valve element is in a closed position and allows for axial flow of fracturing fluid through the cement casing to fracture the formation near the valve. The invention disclosed herein is an improved valve used in this process.

Description of Related Art

Current designs for valves used in the completion method disclosed above are prone to failure because cement or other debris interferes with the opening of the valve after the cementing process has been completed. Portions of the sliding sleeve or pistons commonly used are exposed to either the flow of cement or the cement flowing between the well bore and the casing string.

BRIEF SUMMARY OF THE INVENTION

The valve according to the invention overcomes the difficulties described above by isolating a sliding sleeve between an outer housing and an inner mandrel. A rupture disk in the inner mandrel ruptures at a selected pressure. Pressure will then act against one end of the sliding sleeve and shift the sleeve to an open position so that fracturing fluid will be directed against the cement casing. The sliding sleeve includes a locking ring nut to prevent the sleeve from sliding back to a closing position.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

FIG. 1 is a side view of the valve according to one embodiment of the invention.

FIG. 2 is a cross sectional view of the valve in the closed position taken along line 2-2 of FIG. 1

FIG. 3 is a cross sectional view of the valve taken along line 3-3 of FIG. 2

FIG.4 is a cross sectional view of the sliding sleeve

FIG. 5 is a cross sectional view of the locking ring holder

FIG. 6 is a cross sectional view of the locking ring

FIG. 7 is an end view of the locking ring

FIG. 8 is a cross sectional view of the valve in the open position

FIG. 9 is an enlarged view of the area circled in FIG. 8.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. 1, an embodiment of valve 10 of the invention includes a main housing 13 and two similar end connector portions 11, 12.

Main housing 13 is a hollow cylindrical piece with threaded portions 61 at each end that receive threaded portions 18 of each end connector. End connectors 11 and 12 may be internally or externally threaded for connection to the casing string. As show in FIG. 2, main housing 13 includes one or more openings 19, which are surrounded by a circular protective cover 40. Cover 40 is made of a high impact strength material.

Valve 10 includes a mandrel 30 which is formed as a hollow cylindrical tube extending between end connectors 11, 12 as shown in FIG. 2. Mandrel 30 includes one or more apertures 23 that extend through the outer wall of the mandrel. Mandrel 30 also has an exterior intermediate threaded portion 51. One or more rupture disks 41, 42 are located in the mandrel as shown in FIG. 3. Rupture disks 41, 42 are located within passageways that extend between the inner and outer surfaces of the mandrel 30. Annular recesses 17 and 27 are provided in the outer surface of the mandrel for receiving suitable seals.

Mandrel 30 is confined between end connectors 11 and 12 by engaging a shoulder 15 in the interior surface of the end connectors. End connectors 11 and 12 include longitudinally extending portions 18 that space apart outer housing 13 and mandrel 30 thus forming a chamber 36. Portions 18 have an annular recess 32 for relieving a suitable seal. A sliding sleeve member 20 is located within chamber 36 and is generally of a hollow cylindrical configuration as shown in FIG. 4. The sliding sleeve member 20 includes a smaller diameter portion 24 that is threaded at 66. Also it is provided with indentations 43 that receive the end portions of shear pins 21. Sliding sleeve member 20 also includes annular grooves 16 and 22 that accommodate suitable annular seals.

A locking ring holder 25 has ratchet teeth 61 and holds locking ring 50 which has ratchet teeth 51on its outer surface and ratchet teeth 55 on its inner surface shown in FIG. 9. Locking ring 50 includes an opening at 91 as shown in FIG. 7 which allows it to grow in diameter as the sliding sleeve moves from the closed to open position.

Locking ring holder 25 has sufficient diameter clearance so that the locking ring can ratchet on the mandrel ratcheting teeth 63 yet never loose threaded contact with the lock ring holder. Locking ring holder 25 is threaded at 26 for engagement with threads 24 on the mandrel. Locking ring holder 25 also has a plurality of bores 46 and 62 for set screws, not shown.

In use, valve 10 may be connected to the casing string by end connectors 11, 12. One or more valves 10 may be incorporated into the casing string. After the casing string is deployed within the well, cement is pumped down through the casing and out the bottom

into the annulus between the well bore and the casing as typical in the art. After the cement flow is terminated, a plug or other device is pumped down to wipe the casing and valve clean of residual cement. When the plug or other device has latched or sealed in the bottom hole assembly, pressure is increased to rupture the rupture disk at a predetermined pressure. The fluid pressure will act on sliding sleeve member 20 to cause the shear pins to break and then to move it downward or to the right as shown in FIG. 7. This movement will allow fracing fluid to exit via opening 23 in the mandrel and openings 19 in the outer housing. The fracing fluid under pressure will remove protective cover 40 and crack the cement casing and also fracture the foundation adjacent to the valve 10.

Due to the fact that the sliding sleeve member 20 is mostly isolated from the cement flow, the sleeve will have a lessor tendency to jam or require more pressure for actuation.

In the open position, locking ring 50 engages threads 63 on the mandrel to prevent the sleeve from moving back to the closed position.

A vent 37 is located in the outer housing 13 to allow air to exit when the valve is being assembled. The vent 37 is closed by a suitable plug after assembly.

Although the present invention has been described with respect to specific details, it is not intended that such details should be regarded as limitations on the scope of the invention, except to the extent that they are included in the accompanying claims.

CLAIMS

What is claimed is:

1. A valve comprising:

a housing having an opening,

a mandrel positioned within the housing and having an opening,

a sliding sleeve disposed between the housing and the mandrel and blocking fluid communication between the opening in the housing and the opening in the mandrel when the valve is in the closed position and permitting fluid flow between the openings in the mandrel and the openings in the housing when the valve is in the open position; and

a rupture disk that, upon rupture, permits application of a fluid pressure to actuate the sliding sleeve between the open and closed positions.

2. A valve as claimed in claim 1, wherein the rupture disk is disposed in a wall of the mandrel.

3. A valve as claimed in claim 1, including an end connector on each end of the housing for connection in a casing string in an oil or gas well.

4. A valve as claimed in claim 1, further including a protective sleeve covering the openings in the housing.

5. A valve as claimed in claim 1, wherein the housing and mandrel define a chamber between them in which the sliding sleeve is disposed.

6. A method for actuating a valve, the method comprising:

flowing a fluid through the valve, the valve comprising;

a housing having one or more openings;

a mandrel having one or more openings;

a sliding sleeve disposed between the housing and the mandrel and blocking fluid communication between the opening in the housing and the opening in the mandrel when the valve is in the closed position and permitting fluid flow between the openings in the mandrel and the openings in the housing when the valve is in the open position; and

a rupture disk that, upon rupture, applies a fluid pressure to move the sliding sleeve between the open and closed positions;

rupturing the rupture disk at a selected fluid pressure;

flowing fluid through the ruptured disk;

moving the sliding sleeve responsive to the fluid pressure between the open and closed positions; and

exiting fluid through the one or more openings of the housing and mandrel.

7. The method of claim 6, further comprising cracking a cement casing with the fluid.

8. The method of claim 6, further comprising pumping cement through the valve into a wellbore.

9. The method of claim 8, further comprising wiping the valve with a plug.

10. The method of claim 6, wherein the sliding sleeve is isolated between the housing and the mandrel.

11. A casing string valve for use in fracturing operations, comprising:

a housing having a first opening therein fluidly connecting the interior of the housing with the exterior of the housing;

a mandrel having a bore therethrough defining a cement flow path and having a second opening, the second opening defining with the first opening a fracturing fluid flow path between the bore and the exterior of the housing, the mandrel being disposed within the housing to define in conjunction with the housing a chamber isolated from the cement flow path;

a sliding sleeve blocking and unblocking the fracturing fluid flow path, the sliding sleeve disposed between the housing and the mandrel, at least partially isolated from the cement flow path in the chamber, and actuated by application of fluid pressure applied through the bore and the third opening.

12. The casing string valve of claim 11, further comprising a rupture disk disposed within the third opening to selectively control the application of fluid pressure through the third opening.

13. A casing string valve as claimed in claim 11, including an end connector on each end of the housing for connection in a casing string in an oil or gas well.

14. A casing string valve as claimed in claim 11, further including a protective sleeve covering the openings in the housing.

15. A method for use in hydraulically fracturing a well, comprising:

disposing a casing string in a wellbore, the casing string including a valve defining a cement flow path and a fracturing fluid flow path therethrough, the fracturing fluid flow patch being blocked and unblocked by a sliding sleeve of the valve at least partially isolated from the cement flow path;

cementing the casing string within the wellbore through the cement flow path while the fracturing fluid flow path is blocked;

applying a fluid pressure through the bore of the valve to actuate the sliding sleeve and unblock the fracturing fluid flow path; and

introducing a fracturing fluid into the well bore through the fracturing fluid flow path.

16. The method of claim 15, wherein the sliding sleeve is at least partially isolated from the cement flow path by disposition between a mandrel and a housing in a chamber defined by the mandrel and the housing that is isolated from the cement flow path.

17. The method of claim 15, further comprising cracking a cement casing with the introduced fracturing fluid.

18. The method of claim 15, further comprising wiping the valve with a plug after the cementing and prior to applying the fluid pressure.

19. The method of claim 15 wherein applying the fluid pressure includes rupturing a rupture disk.

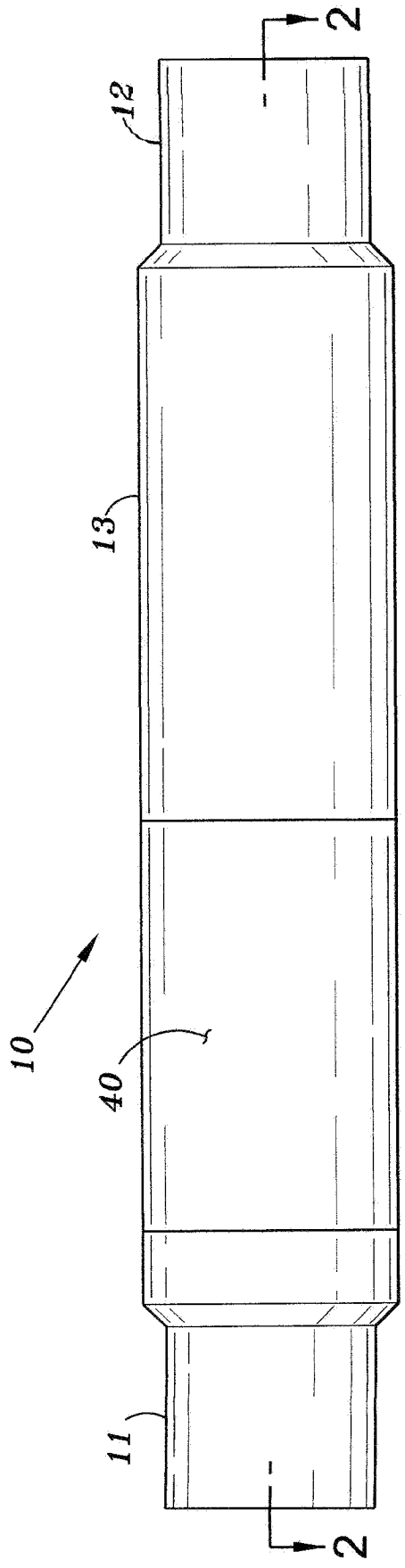
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FIG. 1

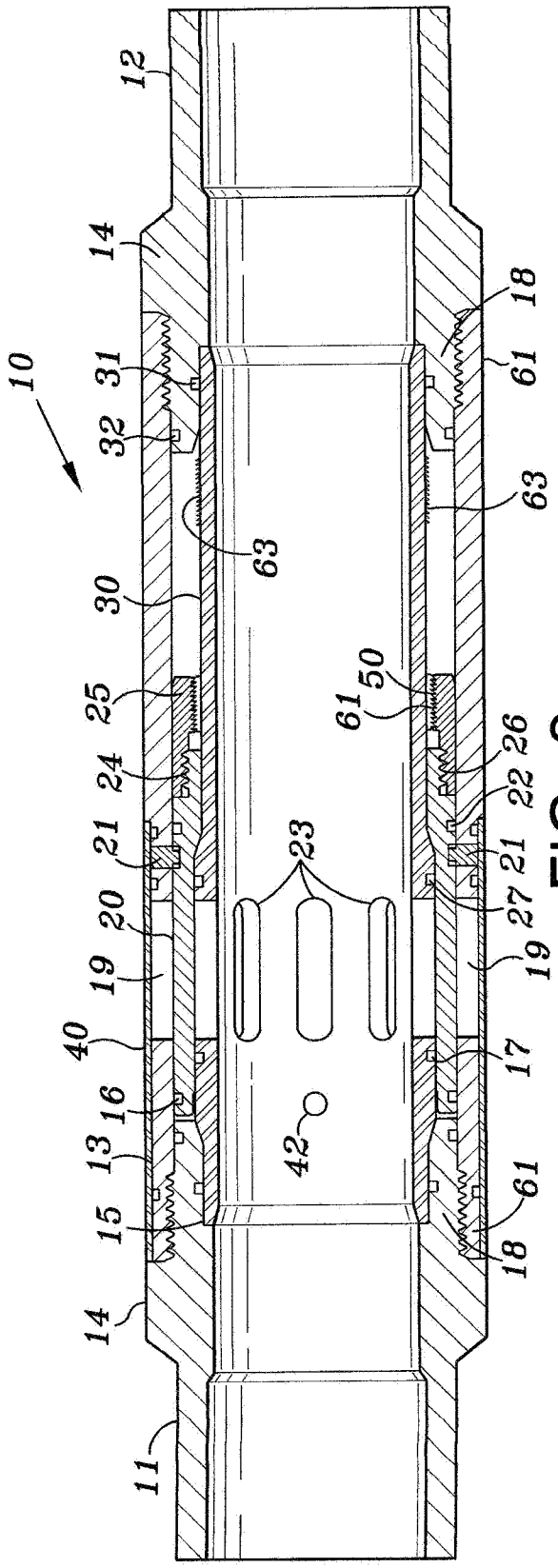
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FIG. 2

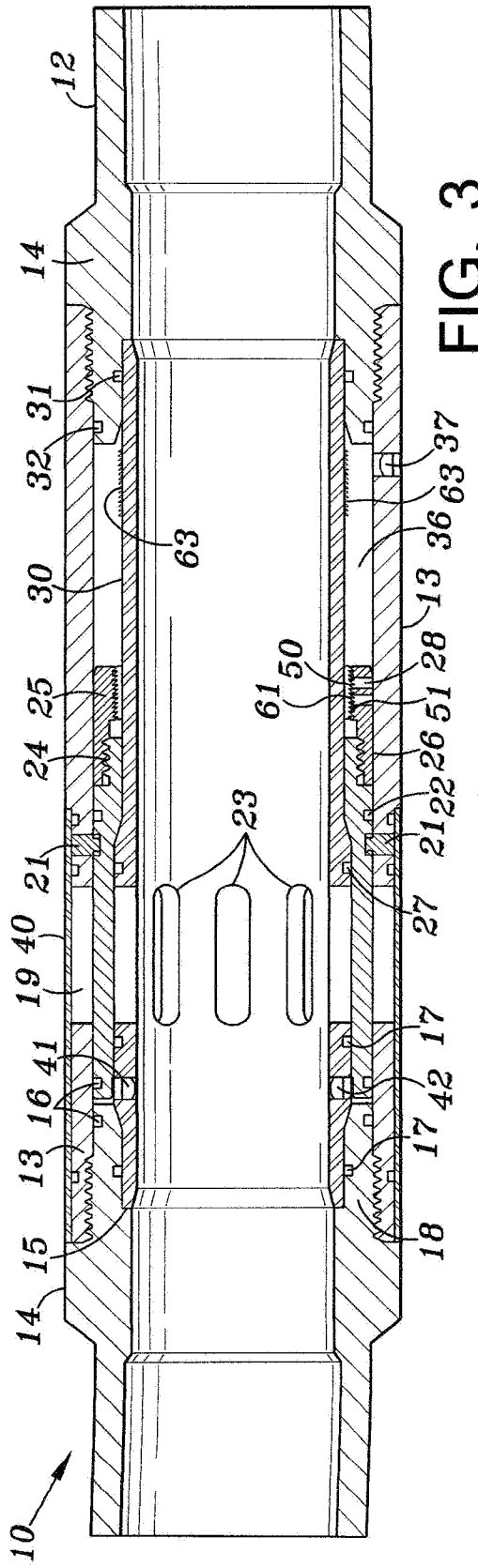
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FIG. 3

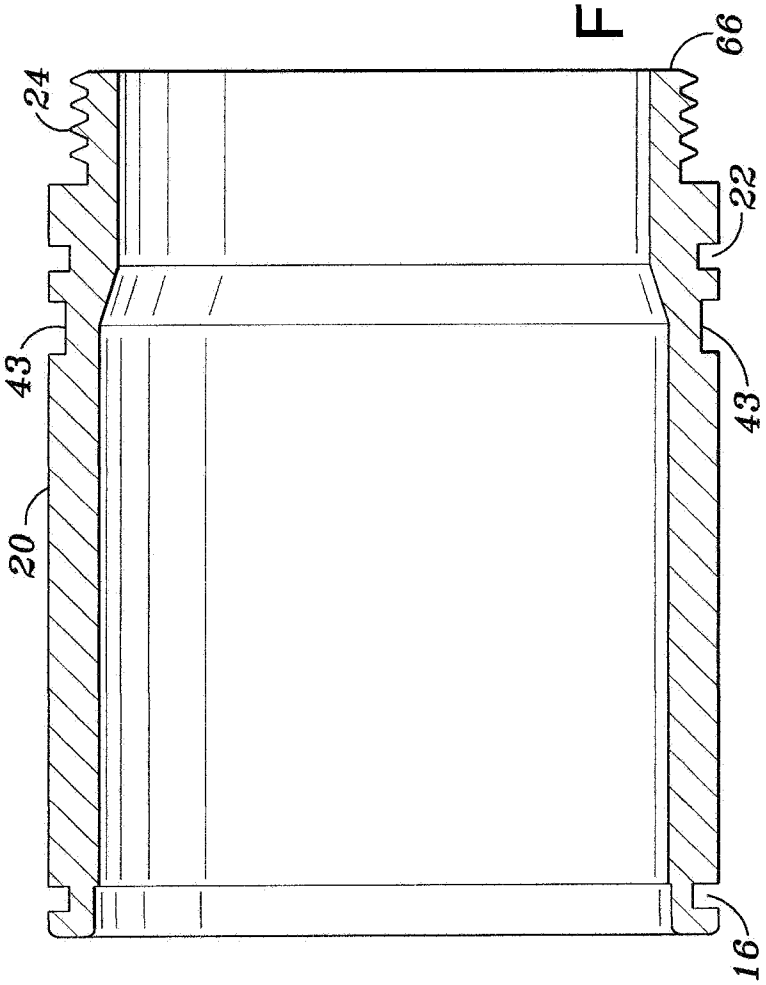
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FIG. 4

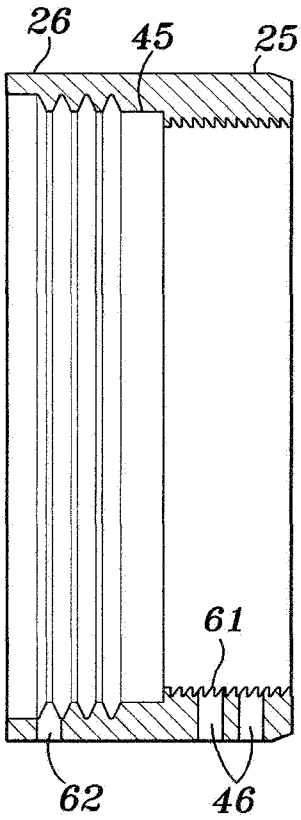

FIG. 5

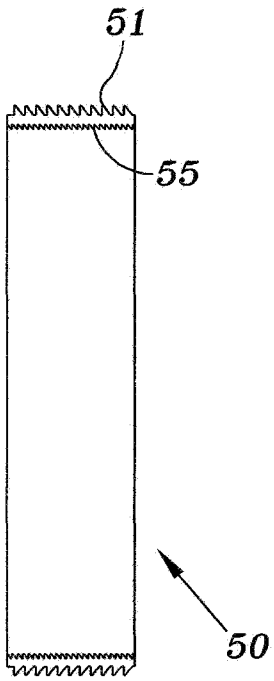

FIG. 6

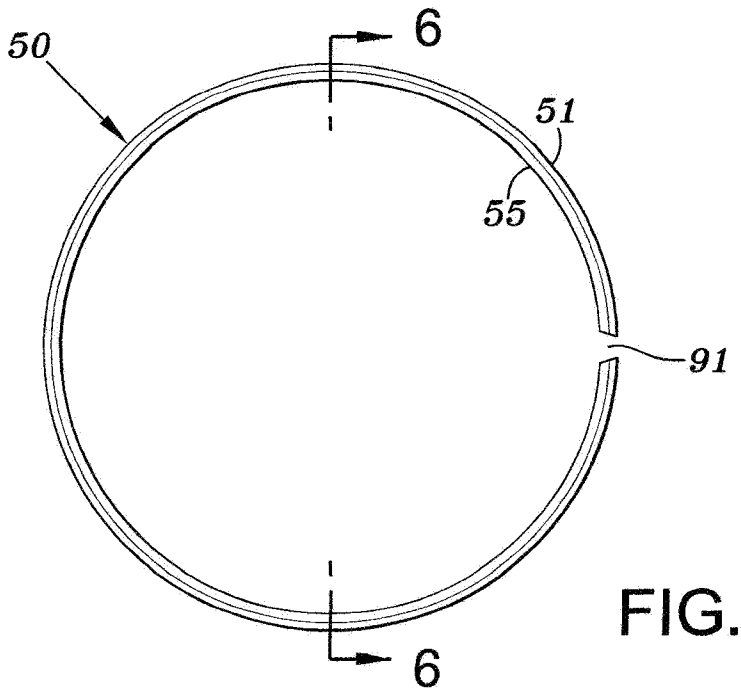

FIG. 7

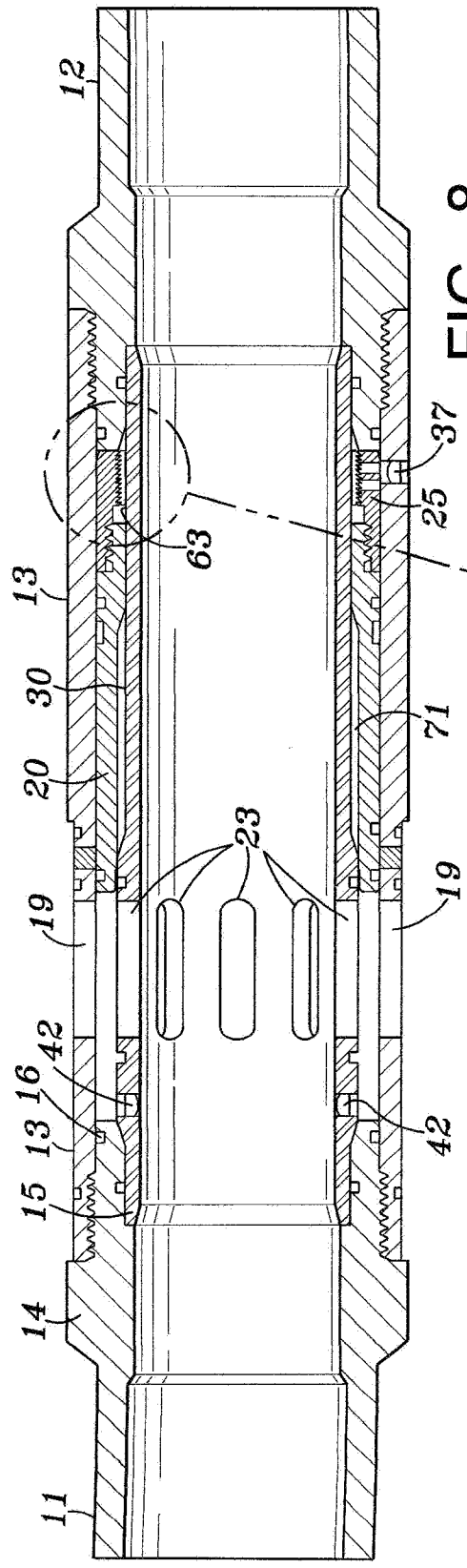
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FIG. 8

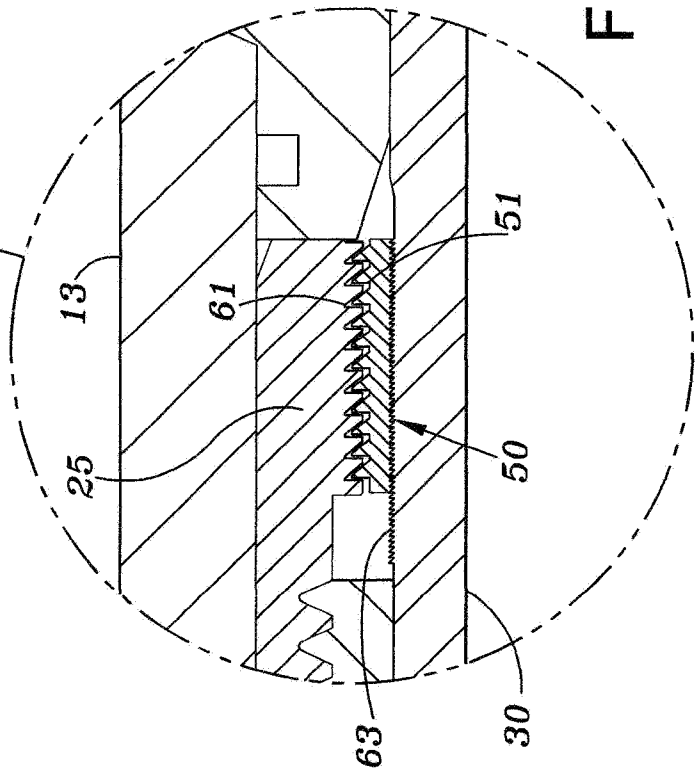
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FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/53554

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 34/08 (2012.01)
USPC - 166/308.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
USPC: 166/308.1
IPC(8): E21B 34/08 (2012.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 166/177.4,177.5,308.1,317,319,321,332.1,373 (Keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWest (USPT,PGPB,EPAB,JPAB); Google Patents; Google Scholar Search terms used: valve sleeve mandrel rupture fracturing fluid disk casing valve protective string housing slide disk cement wall string wiping plug axial exterior shift move actuate

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,651,743 B2 (SZARKA) 25 November 2003 (25.11.2003), entire document, especially col 4, ln 19-33; col 12, ln 23-35, ln 62-67; col 13, ln 1-53; col 14, ln 4-20, ln 59-67; col 15, ln 1-15	11, 13-18
Y	US 7,055,598 B2 (ROSS et al.) 06 June 2006 (06.06.2006), Fig 10; col 11, ln 14-44	11, 13-18
Y	US 4,246,968 A (JESSUP et al.) 27 January 1981 (27.01.1981), Fig 6; col 2, ln 34-48; col 7, ln 3 -11	14
Y	US 7,673,673 B2 (SURJAATMADJA et al.) 09 March 2010 (09.03.2010), col 3, ln 24-46	17
Y	US 4,042,014 A (SCOTT) 16 August 1977 (16.08.1977), col 2, ln 54-68; col 6, ln 11-21; col 13, ln 23-56	18
A	US 2008/0083541 A1 (BUTTERFIELD JR. et al) 10 April 2008 (10.04.2008), Fig 1, 11, 13; para [0020], [0021], [0027], [0031], [0072], [0094]	1-19
A	US 3,272,517 A (HOWARD et al.) 13 September 1966 (13.09.1966), col 1, ln 12-33	1-19
A	US 2009/0044944 A1 (MURRAY et al.) 19 February 2009 (19.02.2009), para [0041]-[0045]	1-19
A	US 2010/0314562 A1 (BISSETT) 16 December 2010 (16.12.2010), para [0008], [0009]	1-19
A	US 6,464,008 B1 (RODDY et al.) 15 October 2002 (15.10.2002), col 4, ln 13-56; col 5, ln 32-63	1-19
A	US 2,251,977 A (BURT) 12 August 1941 (12.08.1941), pg 2, col 1, ln 61-75	1-19

☐ Further documents are listed in the continuation of Box C. ☐

* 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	Date of mailing of the international search report
28 November 2012 (28.11.2012)	17 DEC 2012
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)