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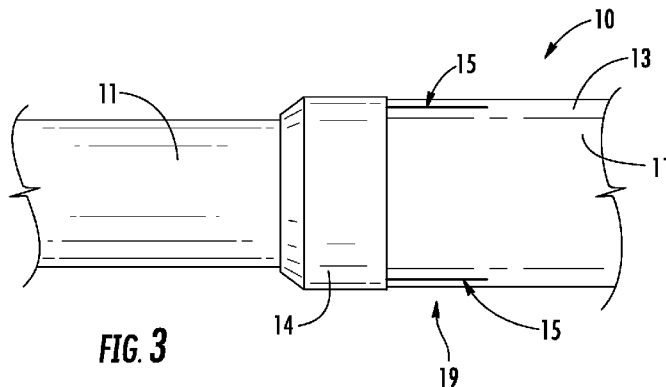
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(54) Title: IMPROVED PROCESS FOR MANUFACTURING SWELLABLE DOWNHOLE PACKERS AND ASSOCIATED PRODUCTS



(57) Abstract: Embodiments of the present invention provide a process for manufacturing swellable packers with reinforcing fabrics and associated products used for sealing off chambers within well bores. According to one embodiment, the swellable packer (10) is formed around a pipe (11) by embedding a sheet of the reinforcing fabric (15) within layers of a swellable polymer (13) wrapped around the pipe. A sheet of reinforcing fabric is situated near each end (19) of the swellable packer. Thus, as exposure to oil or water will cause the swellable packer to expand, the reinforcing fabric will initially retard swelling at the ends (19) to allow for greater initial swelling along the center portion (20). The reinforcing fabric also strengthens the polymer to resist tearing or breakage caused by the flow of oil or water. A pair of swellable packers (10) according to embodiments of the present invention can be placed on a pipe (11) and placed within a bore (12) and exposed to oil or water to create a pressurized chamber (18).



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IMPROVED PROCESS FOR MANUFACTURING SWELLABLE DOWNHOLE PACKERS AND ASSOCIATED PRODUCTS

FIELD OF THE INVENTION

The present invention relates to improved manufacturing processes for downhole packers and associated products, and in particular downhole packers that
5 have improved sealing characteristics.

BACKGROUND OF THE INVENTION

In the oil and natural gas industries, a bore is typically formed into the earth to define a well, and oil or natural gas is withdrawn from the well. However, over
10 time, the level of production from these wells can decrease and, as a result, several methods have been developed for increasing the oil or natural gas withdrawn from the well.

One of these methods involves sealing a section of the bore wall at a location above the bottom of the well. In particular, one or more plugs can be
15 placed along the depth of the bore that seal against the bore wall. Between two of these plugs, or between one plug and the top or the bottom of the well, a chamber can be defined. These chambers are then subjected to very high pressures of water or other fluids so as to cause the walls of the bore to fracture. This can create additional flow of oil or natural gas into the chamber after the pressure is released.

20 Conventionally, these plugs have been formed of concrete or other cementitious materials. However, the concrete can degrade over time and leak. To improve upon concrete plugs, the industry has developed swellable packers made from polymers that swell when exposed to oil and/or water. The swellable packer is sized to have an outer diameter just smaller than the diameter of the bore and
25 then it is placed down the bore in an unswelled state. Oil or water is then brought into contact with the swellable packer. However, pressure from the impact of oil or water may cause pieces of polymer to tear or break away. The polymer of the swellable packer begins to swell as it takes on the oil or water. This swelling causes the swellable packer to seal against the wall of the bore and create a seal so
30 that pressurized chambers can be defined for fracturing the bore wall.

One measure of performance of these swellable packers is the amount of pressure to which the pressurized chambers can be exposed before the swellable packers begin to leak. Chamber pressures of at least 4,000 psi are achievable with conventional technology. However, it is desirable to achieve even higher chamber pressures, to allow more oil or gas production.

BRIEF SUMMARY OF THE INVENTION

These and other advantages are provided by the swellable downhole packers and improved processes of manufacturing provided by the present invention. Advantageously, embodiments of the present invention provide a reinforcing fabric in conjunction with a swellable polymer to provide improved sealing pressures. The reinforcing fabric according to one embodiment is provided at the ends of the swellable packers and can retard swelling of the swellable polymer at those locations. This retardation of the swelling at the ends of the packers allows for more swelling along the center portion of the packer before the ends of the packer are fully swollen. As such, improved sealing pressures are achievable.

BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a partially sectional view of an oil or gas well showing the position of two swellable packers in a bore;

Figure 2 is a perspective view of a swellable packer according to embodiments of the present invention;

Figure 3 is an expanded and partially sectioned view of one end of a swellable packer according to embodiments of the present invention; and

Figure 4 is a plan view of a reinforcing fabric according to embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the inventions are shown. Indeed, these inventions may be embodied in many
5 different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain
10 having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and
15 descriptive sense only and not for purposes of limitation.

Figure 1 illustrates an oil or natural gas well that defines a bore **12**. Positioned in the bore **12** are two swellable packers **10**. These swellable packers **10**, when fully swollen, create a chamber **18** that can be pressurized between the swellable packers. The swellable packers **10**, in the illustrated embodiment, are
20 both supported on a support tube **11**. This support tube **11** can be made of a steel pipe or any other suitable material. In some embodiments, the support tube **11** could be used as a conduit for oil, gas or other fluids, and/or could be used for allowing other downhole components to extend down the bore. The support tube **11** may also be completely or partially blocked along its length.

Figure 2 is a closer view of one of the swellable packers **10**. The swellable packer **10** of the illustrated embodiment is comprised of a swellable polymer **13** that is secured to the support tube **11**. The swellable packer **10** should define a length along the support tube **11** sufficient to adequately seal the bore, and in one
25 embodiment this length may be 24". The swellable packer may be provided with end caps **14** at one or both ends of the swellable packer. The end caps **14** can be
30 formed of metal or other resilient material and have a chamfered or tapered portion (as best seen in Fig. 3) that helps guide the swellable packer **10** through the bore as the support tube **11** is lowered or raised in the bore.

According to embodiments of the present invention, the swellable polymer **13** can be applied to the support tube **11** by wrapping a continuous sheet of swellable polymer around the support tube so as to define multiple layers. The first layer of the swellable polymer **13** can be secured to the support tube with a bonding agent. One bonding agent that is effective is THIXON 532-A-EFAPH available from Dow Chemical.

In an exemplary embodiment, a sheet of swellable polymer material is 24" in width and is wrapped around the support tube 16 times. The thickness of the sheet of swellable polymer according to one embodiment is 0.045", although the thickness of the sheet can increase as the winding around the support tube **11** continues. After the wrapping process has been finished, the swellable polymer **13** can be subjected to a curing process such as in a steam autoclave. This curing process can cause the various wrapped layers to bond together and define a substantially homogeneous thickness to the swellable polymer.

One particularly advantageous swelling polymer **13** is available from Tendeka under model no. JSSEO-5. This proprietary formulation provides strong swelling and sealing characteristics. However, other swellable polymers from other manufacturers could be used in embodiments of the present invention.

To achieve a desired tolerance on the outside diameter of the cured swellable packer, the swellable polymer **13** (while supported on the support tube **11**) can be subjected to a machining operation, such as turning on a lathe. The end caps **14** can then be placed over the ends of the swellable polymer **13** and bonded in place with the bonding agent.

When swellable packers **10** are placed in a bore and exposed to oil or water to initiate the swelling process, the inventors have recognized that the swelling begins at the end portions **19** of the swellable polymer that are first exposed to the oil or water. The swelling process is not instantaneous and so, as the swelling proceeds, the end portions **19** of the swellable polymer **13** swell faster than central portion **20** of the swellable polymer. The inventors have recognized that this sequence can have a deleterious effect on the overall sealing pressure of the swellable packer because the central portion of the swellable polymer **13** may not swell as much as the end portions **19** of the swellable polymer. As such, the outward pressure exerted on the bore wall will not be uniform along the length of the swellable packer **10**, and will be higher at the end portions **19** of the swellable

packer exposed to the oil or water. Thus, the configuration of a conventional swellable packer does not allow the swellable polymer to fully swell along its length. The end portions **19** seal the central portion **20** from receiving sufficient oil or water to fully swell.

5 Figure 3 is an expanded and partially sectioned view of one end of a swellable packer **10** according to embodiments of the invention. The illustrated end of the swellable packer **10** includes a reinforcing fabric **15** extending along a length at the end of the swellable packer. The reinforcing fabric **15** is positioned in the illustrated embodiment at a depth below the outer surface of the swellable
10 polymer **13**. In one embodiment, the reinforcing fabric **15** is inserted during the winding process for the sheet of swellable polymer after a first section of sheet has been wrapped but before a second section is wrapped. For example, the reinforcing fabric **15** is inserted after the 12th wrap of 16 total wraps has been completed. This forms a swellable pack including an inner annulus of swellable
15 polymer radially inward of the reinforcing fabric and an outer annulus of swellable polymer radially outward of the reinforcing fabric. In some embodiments, the reinforcing fabric **15** has a bonding agent applied thereto to bond with the swellable polymer.

 In one embodiment of the manufacturing method according to the present
20 invention, the reinforcing fabric **15** is first positioned between two sheets of swellable polymer and then the assembly is calendered to define a sandwich structure having a thickness of approximately 0.040". This sandwich structure is then inserted during the wrapping process. The sandwich structure has more flexural strength than the reinforcing fabric **15** by itself, which makes it easier to
25 insert during the wrapping process.

 In addition, in some embodiments, the reinforcing fabric **15** may not extend all the way to the end face of the swellable polymer **13** so as to be fully encapsulated within the swellable polymer. If the reinforcing fabric **15** extends all the way to the end face, it could present a possibility for the portion of the
30 swellable polymer radially outside of the reinforcing fabric **15** to swell disproportionately more quickly than the portion radially inside of the reinforcing fabric because oil or water would have an additional path (i.e. along the fabric) to cause swelling. In some circumstances, this could cause delamination and failure of the swellable packer. In one embodiment, the reinforcing fabric **15** is one-third

the length of the swellable polymer **13**, as measured along the axis of the support tube **11**, and the reinforcing fabric **15** ends 0.125 inches from the end cap **14**. As illustrated, the reinforcing fabric **15** can be 3 inches in length.

One embodiment of reinforcing fabric is shown in more detail in Figure 4, and includes relatively stronger fibers **16** extending in a warp direction and relatively weaker fibers **17** extending in a weft direction. The reinforcing fabric **15** is positioned during the manufacturing process so that the relatively stronger fibers **16** are aligned with the axis of the support tube **11** and the weaker fibers **17** extend generally circumferentially around the axis of the support tube **11**. However, the fibers of the reinforcing fabric may have the same tensile strength in both the warp and weft directions, and in another embodiment, the fibers extending in one direction, such as the warp direction, may be more densely spaced than in the other direction.

As oil or water is introduced into the bore to begin the swelling process, the oil or water is first contacted against the end portions **19** of the swellable polymer. The reinforcing fabric **15** strengthens the end portions **19** and prevents the swellable polymer from tearing or breaking away. Furthermore, rather than swelling at a rate faster than the central portion **20** of the swellable polymer, the reinforcing fabric **15** retards the swelling process by mechanically restraining the end portions **19** of the swellable polymer from swelling more quickly than the central portion **20**. This retardation of the swelling of the end portions **19** allows the central portion **20** of the swellable polymer to swell at a comparable rate and thus create a tighter seal against the walls of the bore.

According to some embodiments of the invention, after some swelling of the end portions **19** has occurred, the relatively weaker fibers **17** can rupture, thus allowing the relatively stronger fibers **16** to separate in a circumferential direction and then the swelling of the end portions of the swellable polymer to continue without circumferential retardation. The relatively stronger fibers help reinforce the swellable polymer **13** after it has swollen, which is advantageous because the strength of the polymer decreases when it is swollen. Thus, after the installation process has been completed, the amount of swelling exhibited by the swellable polymer is more uniform along its length than in conventional packers, thus creating a stronger seal. Indeed, sealing pressures of up to 7,500 psi have been achieved with a 6 foot length of the swellable packer having reinforcing fabric **24**

inches long at each end. Such a sealing pressure is of great benefit to the oil and gas industry and allows improved production of oil and gas wells.

In the embodiment depicted in Figure 4, the reinforcing fabric **15** is a cloth material. In another embodiment, the reinforcing fabric **15** can comprise tire cord, and in particular nylon fabric intended for use in the construction of tires. One commercially-available product that is suitable is LNF085, a nylon leno weave available from Firestone Fibers & Textiles Company in Kings Mountain, NC. However, in various other embodiments, the reinforcing fabric may be formed of other types of material, such as wire, carbon fibers, basalts, etc.

Although a single strip of reinforcing fabric **15** is illustrated at both ends of the swellable packer **10**, other embodiments include multiple layers of reinforcing fabric and layers of reinforcing fabric extending further along the length of the swellable packer **10**. In order to achieve a more uniform swell profile after installation, some embodiments of the invention include two layers of reinforcing fabric at the ends of the swellable packer, a single layer of reinforcing fabric adjacent to those end portions, and a central portion with no reinforcing fabric provided. A more uniform swell profile may also be provided by reinforcing fabrics that have circumferential strength that varies along the length of the fabric.

THAT WHICH IS CLAIMED:

1. A method for manufacturing a swellable packer comprising:
wrapping a first section of swellable material around a tubular member to
5 define an inner annulus of a swellable member;
inserting at least one reinforcing member between the inner annulus and a
second section of swellable material, and
wrapping the second section of the swellable member around the inner
annulus to define an outer annulus of the swellable member.
10
2. The method of claim 1, wherein the wrapping steps comprise
wrapping swellable material in the form of a polymer sheet and the inserting step
comprises inserting a fabric as the least one reinforcing member.
- 15 3. The method of claim 1, wherein the inserting step further comprises
inserting a reinforcing member adjacent to an end of the swellable member.
4. The method of claim 3, wherein the inserting step comprises
inserting the reinforcing member adjacent to but spaced from the end of the
20 swellable member.
5. The method of claim 1, further comprising inserting the at least one
reinforcing member between two sheets of swellable polymer before inserting the
reinforcing member and two sheets of swellable polymer between the inner
25 annulus and second section of swellable material .
6. The method of claim 2, further comprising inserting a fabric having
stronger fibers extending in one direction and weaker fibers extending
perpendicularly thereto, and orienting the fabric so that the stronger fibers extend
30 in a direction aligned with an axis of the tubular member.
7. The method of claim 1, further comprising the step of securing the
inner annulus to the tubular member with a bonding agent.

8. The method of claim 1, further comprising the step of subjecting the swellable member to a curing process.

9. The method of claim 1, further comprising the step of securing an
5 end cap on at least one of the ends of the swelling member.

10. A swellable packer for use in a bore comprising:
a swellable member circumferentially disposed about an axis of a tubular
member, wherein the thickness of the swellable member includes an inner annulus
10 and an outer annulus; and
at least one reinforcing member interposed between the inner annulus and
the outer annulus.

11. The swellable packer of claim 10, wherein the swellable member is
15 formed from at least one sheet of polymer.

12. The swellable packer of claim 11, wherein each of the inner annulus
and the outer annulus comprises a plurality of layers of the sheet of polymer.

20 13. The swellable packer of claim 10, wherein the at least one
reinforcing member is adjacent to an end of the swellable member.

14. The swellable packer of claim 10, wherein the at least one
reinforcing member comprises:
25 a set of strengthening fibers axially aligned with the tubular member; and
a set of restraining fibers circumferentially extending around the axis of the
tubular member.

15. The swellable packer of claim 14, wherein the tensile strength of the
30 strengthening fibers is generally greater than the tensile strength of the restraining
fibers.

16. The swellable packer of claim 10, wherein the reinforcing member
is adjacent to but spaced from the end of the swellable member.

17. The swellable packer of claim 10, wherein the reinforcing member extends approximately three inches along the axial direction.

5 18. The swellable packer of claim 14, wherein the strengthening fibers are arranged more densely than the restraining fibers.

19. The swellable packer of claim 10, wherein the swellable member entirely surrounds the reinforcing member.

10

20. The swellable packer of claim 10, wherein at least one end of the swellable member is covered by an end cap.

21. The swellable packer of claim 10, wherein the at least one
15 reinforcing member comprises a sandwich assembly comprised of a reinforcing layer positioned between two swellable layers.

22. The swellable packer of claim 21, wherein the sandwich assembly has a thickness of approximately 0.040 inches.

20

23. A packer system for use in a bore comprising:
a tubular member;

at least one swellable packer disposed about the tubular member, wherein the at least one swellable packer comprises:

25

a swellable member circumferentially disposed about an axis of a tubular member, wherein the thickness of the swellable member includes an inner annulus and an outer annulus; and

at least one reinforcing member interposed between the inner annulus and the outer annulus.

30

24. The packer system of claim 23, wherein the at least one reinforcing member comprises:

a first reinforcing member adjacent to a first end of the swellable member;

and

5 a second reinforcing member adjacent to a second end of the swellable member.

25. The packer system of claim 23 further comprising at least two swellable packers spaced apart along the tubular member and defining a chamber

10 therebetween.

26. The packer system of claim 23, wherein the at least one reinforcing member comprises:

a set of strengthening fibers axially aligned with the tubular member; and

15 a set of restraining fibers circumferentially extending around the axis of the tubular member.

27. The packer system of claim 26, wherein the tensile strength of the strengthening fibers is generally greater than the tensile strength of the restraining

20 fibers.

28. The packer system of claim 23, wherein the reinforcing member is adjacent to but spaced from the end of the swellable member.

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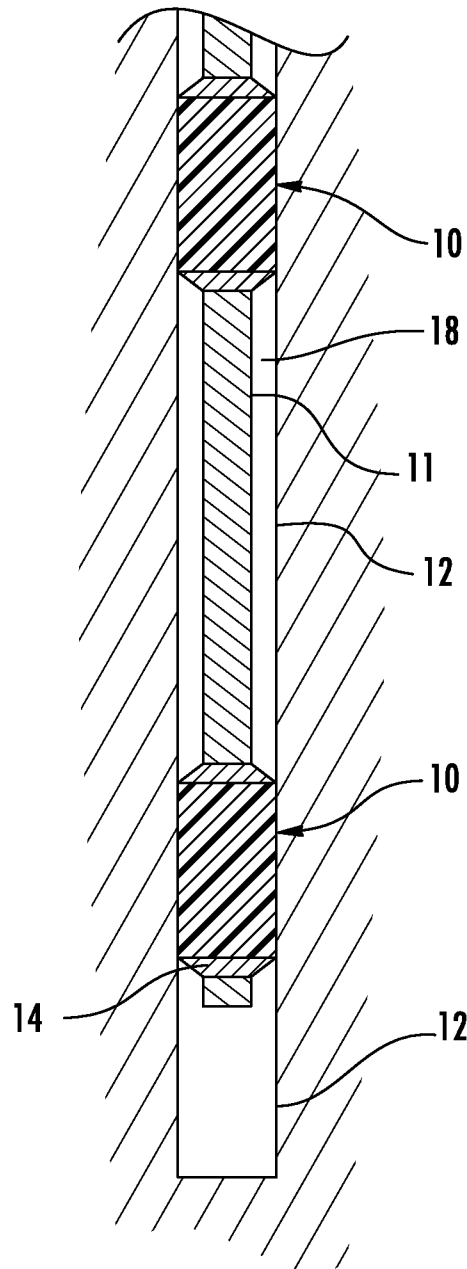


FIG. 1

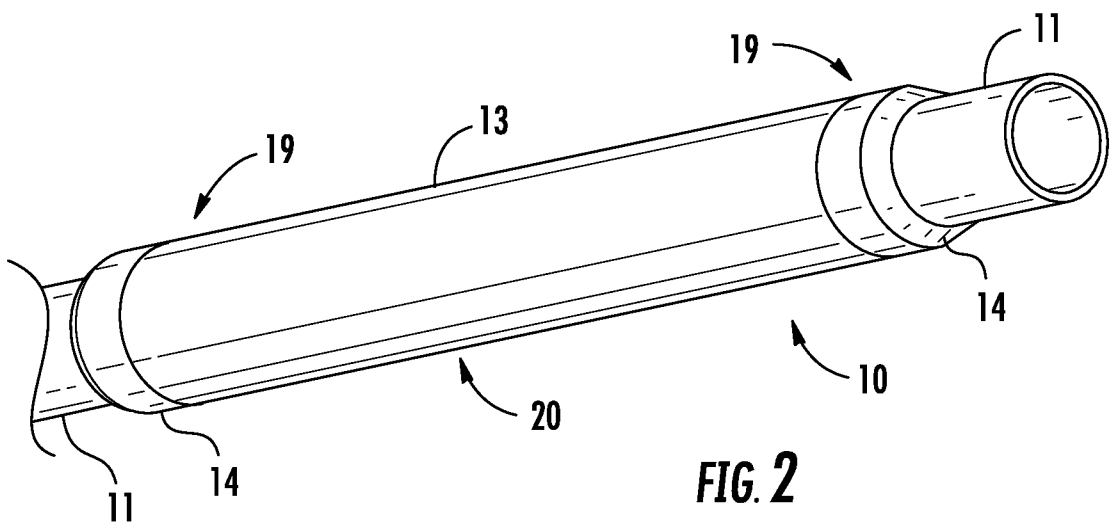
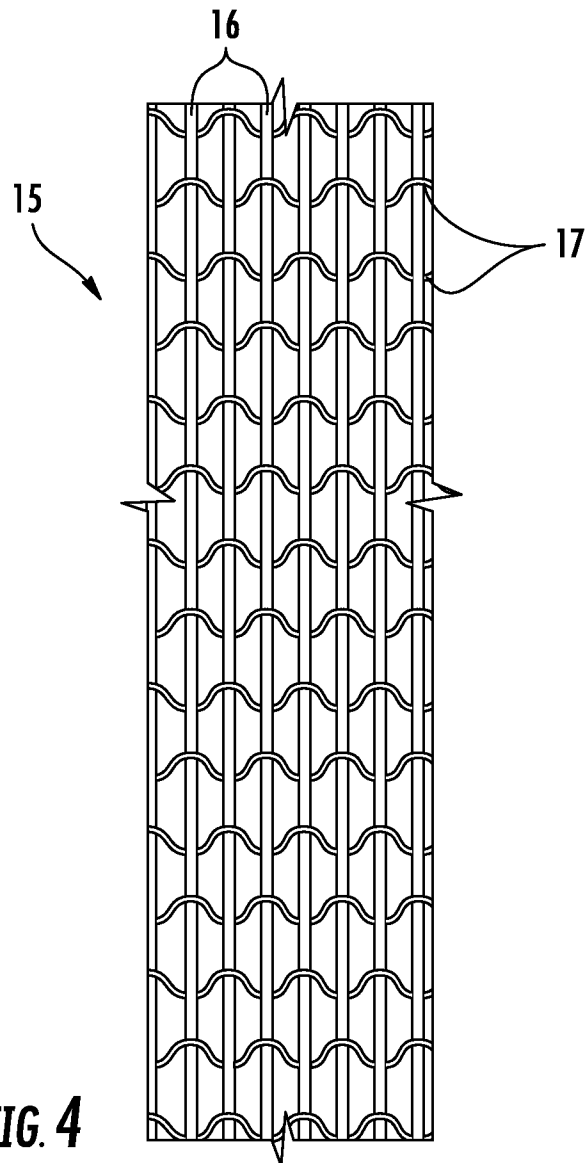
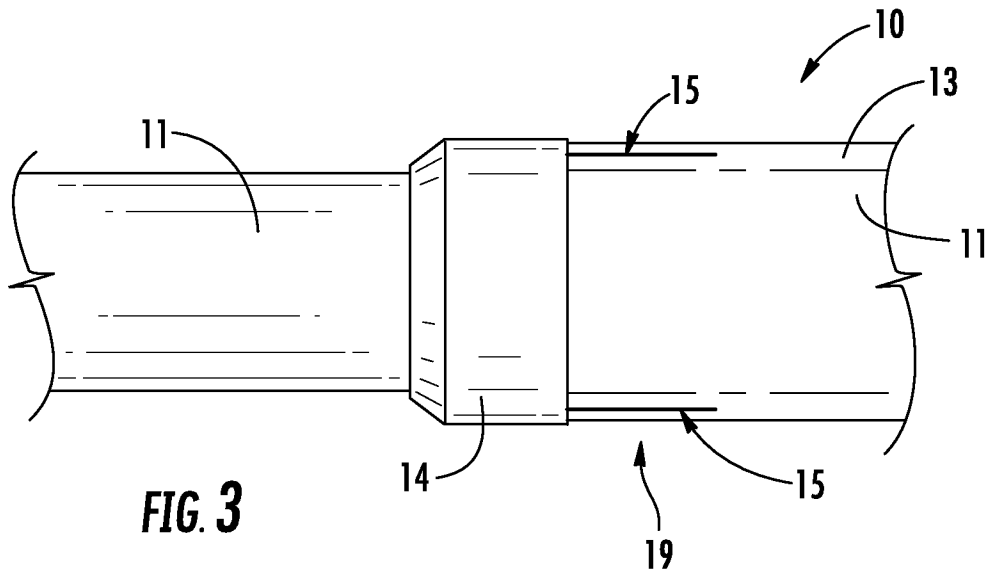


FIG. 2

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/038406

A. CLASSIFICATION OF SUBJECT MATTER INV. E21B33/12 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) E21B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	WO 2006/121340 A1 (EASY WELL SOLUTIONS AS [NO]; FREYER RUNE [NO]) 16 November 2006 (2006-11-16)	1,3,5, 7-13,17, 19-23
Y	page 2, line 24 - page 3, line 3; figure 2	2,4,6, 14,15, 18,26,27
X	----- WO 2008/097312 A1 (HALLIBURTON ENERGY SERV INC [US]; CHALKER CHRISTOPHER J [NO]; SOLHAUG) 14 August 2008 (2008-08-14) claims 5,13,14,15; figures 1,6 ----- -/--	10-13, 16, 19-21, 23-25,28
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C.		
<input checked="" type="checkbox"/> 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 document 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 24 August 2011		Date of mailing of the international search report 31/08/2011
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Dantine, Patrick

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