(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 317 065 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.05.2011 Bulletin 2011/18

(51) Int Cl.:
E21B 33/05 *(2006.01)*

(21) Application number: **09290830.0**

(22) Date of filing: **30.10.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

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  BG CZ DE DK GR HU IE IT LT MK NO PL RO SI SK SM TR
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  Designated Contracting States:
  AT BE CH CY EE ES FI HR IS LI LU LV MC MT PT SE

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(54) Equipment for remote launching of cementing plugs

(57) An apparatus and methods are presented for remotely launching cementing plugs during the primary cementation of a subterranean well. The apparatus is designed to prevent premature release of the top plug during a cementing operation. The apparatus comprises a latch mechanism that closes when a top dart lands inside a cementing head, thereby restricting further downward movement. The latch reopens when a top dart lands inside a cementing head, thereby ensuring release of the top plug at the correct moment.

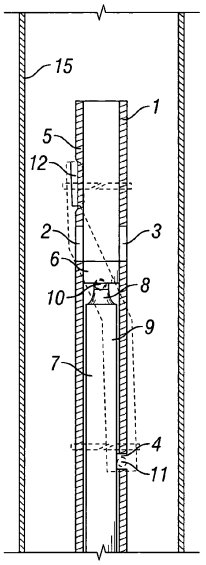

FIG. 1A

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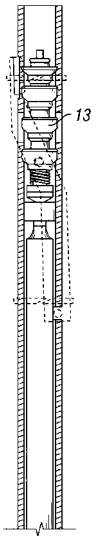

FIG. 1B

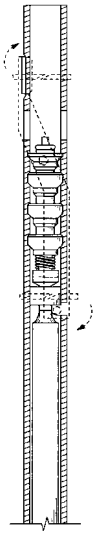

FIG. 1C

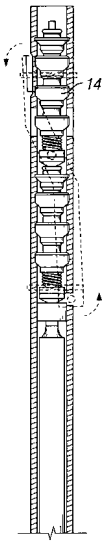

FIG. 1D

Description

BACKGROUND OF THE INVENTION

[0001] The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

[0002] The present invention is related in general to equipment for servicing subterranean wells. Particularly, the invention relates to an apparatus and method for remotely launching cementing plugs during the primary cementation of a subterranean well.

[0003] Most primary cementing treatments involve the use of wiper plugs that travel through the interior of a tubular body (e.g., casing or liner). When launched, the plugs travel from the top of the tubular body to the bottom, where they become seated. The purpose of the plugs is to separate and prevent commingling of different fluids during their journey through the tubular body. In most cases, operators deploy a bottom plug and a top plug.

[0004] After the tubular body is installed in the wellbore, the annulus between the tubular body and the wellbore wall (or another tubular body) is usually filled with drilling fluid. When the primary cementing treatment commences, the bottom plug is first launched into the tubular body, followed by the cement slurry. The cement slurry may be preceded by a spacer fluid, a chemical wash or both. The function of the bottom plug is mainly to scrape traces of drilling fluid from the internal surface of the tubular body, and to prevent contact between the drilling fluid and the cement slurry.

[0005] The bottom-plug launching and conveyance through the tubular body arises from pressure applied by the cement slurry. When the bottom plug completes its journey through the tubular body, it becomes seated on float equipment installed at the bottom of the tubular body. Continued pumping exerts sufficient pressure to rupture a membrane at the top of the bottom plug, allowing the cement slurry to flow through an interior passage in the bottom plug, and then to exit the bottom of the tubular body in order to continue into the annulus.

[0006] After sufficient cement slurry to fill the annulus has been pumped into the tubular body, the top plug is launched into the tubular body, and a displacement fluid is pumped behind the plug. The displacement fluid forces the plug through the tubular body. The function of the top plug is mainly to scrape traces of cement slurry from the internal surface of the tubular body, isolate the cement slurry from the displacement fluid and, upon landing on the bottom plug, seal the interior of the tubular body from the annulus. Unlike the bottom plug, the top plug has no membrane or interior passage through which fluids may flow.

[0007] A thorough description of the primary cementing process and the equipment employed to perform the service may be found in the following references. (1) Piot B. and Cuvillier G.: "Primary Cementing," in Nelson E.B. and Guillot D. (eds.): Well Cementing-2nd Edition, Houston: Schlumberger (2006): 459-501. (2) Leugemors E., Metson J., Pessin J.-L., Colvard R.L., Krauss C.D. and Plante M.: "Cementing Equipment and Casing Hardware," in Nelson E.B. and Guillot D. (eds.): Well Cementing-2nd Edition, Houston: Schlumberger (2006): 343-434.

[0008] Wiper plugs are usually launched from a cementing head that is attached to the tubular body near the drilling rig. The tubular body rises from the bottom of the openhole to the rig floor. However, for subsea completions, the problem becomes more complicated, and fluid isolation becomes more and more critical as water depth increases. It thus becomes impractical to launch wiper plugs from the surface. Therefore, the cementing head containing the wiper plugs rests on the seafloor, and the top of the tubular body ends at the mudline. Drillpipe connects the top of the tubular body to the rig floor on the surface. During the cementing process, darts are released into the drillpipe on surface, travel through the drillpipe to the seafloor and, upon arrival, trigger the release of the wiper plugs.

[0009] After the first dart is launched, cement slurry is pumped behind it. When the first dart lands inside the cementing head, the bottom plug is released. The second dart is launched after sufficient cement slurry has been pumped to fill the annulus. A displacement fluid is pumped behind the second dart. When the second dart arrives, the top plug is released. A brief peak in surface pressure indicates when each wiper plug has been launched. This process is detailed in the following references: (1) Buisine P. and Lavaure G.: "Equipment for Remote Launching of Cementing Plugs into Subsea Drilled Wells," European Patent Application 0 450 676 A1 (1991); (2) Brandt W. et al.: "Deepening the Search for Offshore Hydrocarbons." Oilfield Review (Spring 1998) 10, No.1, 2-21.

[0010] A disadvantage of the subsea plug launching mechanism currently used in the art is that each dart is identical; therefore, after launching, the plug-release process is passive. The plug-releasing mechanism is the same for both the bottom and top plugs. If for any reason the bottom dart does not stop traveling downward after the bottom plug is launched, the potential exists for the top plug to be launched prematurely. Such an occurrence could result in cement slurry being left inside the tubular body-a condition known as "cement left in pipe" or CLIP.

[0011] Therefore, it remains desirable to provide an improved apparatus and methods that would prevent premature release of the top plug resulting from improper function of the bottom dart.

SUMMARY OF THE INVENTION

[0012] The present invention solves the problems mentioned herein.

[0013] Those skilled in the art will understand that process fluids may comprise drilling fluids, cement slurries, chemical washes, spacer fluids and completion fluids.

[0014] The first aspect of the invention is an apparatus that limits the extent to which a bottom dart may travel upon arrival inside a cementing head.

[0015] The second aspect of the invention is a method for launching cementing plugs during a primary cementing operation.

[0016] The third aspect of the invention is a method for cementing a subterranean well.

[0017] All aspects of the invention may be applied in oil and gas wells, geothermal wells, water wells, and wells for chemical waste disposal, enhanced recovery of hydrocarbons and carbon sequestration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Figure 1 illustrates the design and operation of the apparatus of the invention.

[0019] Figure 2 illustrates the exterior appearance of the apparatus of the invention.

DETAILED DESCRIPTION

[0020] When cementing the annular space between tubulars and the walls of a subterranean wellbore, it is usually necessary to minimize or prevent the commingling of the drilling fluid, spacer fluid and cement slurry. Commingling may result, for example, in adverse rheological effects, dilution of the cement slurry and compromised zonal isolation. One way to minimize commingling involves using wiper plugs to separate fluids as they travel down the tubulars. Wiper plugs also clean the inner surface of the tubulars. Most cementing operations involve two wiper plugs: a bottom plug that separates cement slurry from drilling fluid, and a bottom plug that separates cement slurry from displacement fluid. The bottom plug travels through the tubular body (e.g., casing) and lands on float equipment at the bottom end. Continued pumping breaks a membrane in the bottom plug, allowing cement slurry to pass through the plug and enter the annular region around the tubular body. The top plug lands on top of the bottom plug, forcing the cement slurry out of the tubular-body interior, and leaving the tubular-body interior full of displacement fluid. Premature release of the top plug can result in the failure to pump all of the cement slurry out of the tubular body, and incomplete filling of the annular region around the outside of the tubular body. The present invention provides means and methods by which premature release of the top plug may be prevented.

[0021] The first aspect of the invention is an apparatus that limits the extent to which a bottom dart may travel upon arrival inside a cementing head. The apparatus is shown in Fig. 1. The apparatus comprises three portions. The first portion comprises the following elements. A tubular body **1** comprises ports **(2** and **3)** through which wellbore-service fluids may flow, a latch opening **4** and a platen opening **5**. A rod head **6** and main rod **7** are located inside the tubular body **1** and below ports **(2** and **3).** The main rod **7** has a tapered section **8** just below the rod head **6**. A movable arm **9** is mounted on the outside of the tubular body **1** and fixed to the tubular body by a hinge **10**. The lower end of the arm **9** is equipped with a latch **11** that coincides with the latch opening **4**. The upper end of the arm **9** is equipped with a platen **12** that coincides with the platen opening **5.** Below the apparatus shown in Fig. 1, and not shown, are a piston connected to the lower end of main rod **7**. Below the piston is a plug basket that contains a bottom plug and a top plug. The exterior appearance of the first aspect of the invention is shown in Fig. 2.

[0022] The second portion of the apparatus is a bottom dart **13**. The third portion of the apparatus is a top dart **14**. Both the second and third portions are initially separated from the first portion.

[0023] The second aspect of the invention is a method for launching cementing plugs during a primary cementing operation. The method is particularly shown in Fig.1.

[0024] The first portion of the apparatus described in the first aspect of the invention is installed inside a casing string **15**. A first process fluid is pumped from the surface through tubular body **1**. As shown in Step A, process fluid initially flows through ports **2** and **3**, bypassing the rest of the first portion of the apparatus. A bottom dart **13** is launched into the process fluid stream in the tubular body **1**. A second process fluid is pumped behind the bottom dart **13**. After a desired volume of second process fluid has been pumped into the well, a top dart **14** is launched into the process fluid stream in the tubular body **1,** followed by a third process fluid.

[0025] Step B depicts the moment during which the bottom dart **13** lands on rod head **6,** installed on main rod **7.** Fluid flow through ports **2** and **3** is blocked by the bottom dart **13.** Further pumping of process fluid forces the bottom dart downward, thereby forcing the rod 7 downward, thereby causing the piston to move downward and eject the bottom plug from the plug basket. The bottom plug acts as a barrier between the first and second process fluids, preventing their commingling while traveling through the interior of the casing **15.**

[0026] Step C shows the moment during which the tapered portion **8** of the main rod 7 arrives at the latch **11.** The taper in the main rod **7** allows the latch **11** to move inward and lock, preventing further movement of the rod head **6,** and also preventing further movement of the bottom dart **13.** Clearance of the bottom dart **13** past ports **2** and **3** reestablishes process-fluid flow outside the apparatus.

[0027] In Step D, the top dart **14** has landed on the bottom dart **13,** once more obstructing fluid flow through ports **2** and **3.** The top dart **14** also pushes against the platen **12,** thereby causing the arm **8** to rotate around the hinge **10** such that the latch **11** becomes released. The path is now clear for the rod head **6** to move past the latch **11,** thereby forcing the main rod **7** and piston to force the top plug out of the plug basket. The top dart **14** has cleared ports **2** and **3,** and process-fluid flow outside

the apparatus is restored. The top plug acts as a barrier between the second and third process fluids, preventing their commingling while traveling through the interior of the casing **15.** When the top plug lands on the bottom plug, the region in the wellbore surrounding the casing **15** is filled with second process fluid, the interior of the casing is filled with third process fluid, and the interior of the casing is isolated from the annulus.

[0028] It will be understood by those skilled the art that the internal volume of the tubular body **1** may be less than the volume of second process fluid necessary to fill the annular region surrounding the casing **15**. In such cases, the second portion of the first aspect of the invention, the bottom dart **13,** will reach the first portion of the first aspect of the invention before the desired quantity of process fluid has been pumped into the tubular body **1**. Thus, the bottom plug may be launched before the top dart **14** is launched.

[0029] The third aspect of the invention is a method for cementing a subterranean well.

[0030] The first portion of the apparatus described in the first aspect of the invention is installed inside a casing string **15**. Drilling fluid is pumped from the surface through tubular body **1**. As shown in Step A, drilling fluid initially flows through ports **2** and **3**, bypassing the rest of the first portion of the apparatus. A bottom dart **13** is launched into the drilling-fluid stream in the tubular body **1.** Cement slurry is pumped behind the bottom dart **13.** After a desired volume of cement slurry has been pumped into the well, a top dart **14** is launched into the cement-slurry stream in the tubular body **1**, followed by a displacement fluid.

[0031] Step B depicts the moment during which the bottom dart **13** lands on rod head **6**, installed on main rod **7.** Fluid flow through ports **2** and **3** is blocked by the bottom dart **13.** Further pumping forces the bottom dart downward, thereby forcing the rod **7** downward, thereby causing the piston to move downward and eject the bottom plug from the plug basket. The bottom plug acts as a barrier between the drilling fluid and the cement slurry, preventing their commingling while traveling through the interior of the casing **15.**

[0032] Step C shows the moment during which the tapered portion **8** of the main rod **7** arrives at the latch **11.** The taper in the main rod **7** allows the latch **11** to move inward and lock, preventing further movement of the rod head **6**, and also preventing further movement of the bottom dart **13.** Clearance of the bottom dart **13** past ports **2** and **3** reestablishes fluid flow outside the apparatus.

[0033] In Step D, the top dart **14** has landed on the bottom dart **13,** once more obstructing fluid flow through ports **2** and **3**. The top dart **14** also pushes against the platen **12**, thereby causing the arm **8** to rotate around the hinge **10** such that the latch **11** becomes released. The path is now clear for the rod head **6** to move past the latch **11**, thereby forcing the main rod **7** and piston to force the top plug out of the plug basket. The top dart **14** has cleared ports **2** and **3**, and fluid flow outside the apparatus is restored. The top plug acts as a barrier between the cement slurry and the displacement fluid, preventing their commingling while traveling through the interior of the casing **15**. When the top plug lands on the bottom plug, the region in the well bore surrounding the casing **15** is filled with cement slurry, the interior of the casing is filled with displacement fluid, and the interior of the casing is isolated from the annulus.

[0034] It will be understood by those skilled the art that the internal volume of the tubular body **1** may be less than the volume of cement slurry necessary to fill the annular region surrounding the casing **15**. In such cases, the second portion of the first aspect of the invention, the bottom dart **13**, will reach the first portion of the first aspect of the invention before the desired quantity of cement slurry has been pumped into the tubular body **1**. Thus, the bottom plug may be launched before the top dart **14** is launched.

[0035] It will also be understood by those skilled in the art that the cement slurry may be preceded by a spacer fluid, a chemical wash or both. The displacement fluid may include drilling fluid, water or a completion brine.

[0036] All aspects of the invention may be applied in oil and gas wells, geothermal wells, water wells, and wells for chemical waste disposal, enhanced recovery of hydrocarbons and carbon sequestration.

[0037] The preceding description has been presented with reference to presently preferred embodiments of the invention. Persons skilled in the art and technology to which this invention pertains will appreciate that alterations and changes in the described structures and methods of operation can be practiced without meaningfully departing from the principle, and scope of this invention. Accordingly, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

Claims

1. A system for launching cementing plugs in a subterranean well, wherein a bottom plug and a top plug are launched from a plug basket by means, comprising:

i. a first portion, comprising:

(a) a tubular body (1) comprising ports (2, 3), a latch opening (4) and a platen opening (5);
(b) a rod head (6) installed on a main rod (7), wherein a section (8) of the rod is tapered;
(d) a movable arm (9) fixed to the tubular body (1) by a hinge (10), the arm having a latch (11) on the bottom end and a platen

(12) on the top end; and

ii. a second portion, comprising:

a bottom dart (13); and

iii. a third portion, comprising:

a top dart (14).

2. A method for launching cementing plugs in a subterranean well, wherein a bottom plug and a top plug are launched by means, comprising:

i. installing the first portion of the system of claim 1 inside a tubular body (15);
ii. pumping process fluid through tubular body (1) and allowing the fluid to flow through ports (2, 3);
iii. launching a bottom dart (13) into the process-fluid stream inside the tubular body (1);
iv. pumping a desired volume of process fluid behind the bottom dart (11);
v. launching a top dart (14) into the process-fluid stream inside the tubular body;
vi. pumping process fluid behind the top dart (14);
vii. continuing to pump process fluid until the bottom dart (13) forces the platen (12) outward, thereby opening the latch (11);
viii. continuing to pump process fluid until the bottom dart (13) lands on a rod head (6) on a main rod (7);
ix. continuing to pump process fluid until the bottom dart (13) clears flow ports (2, 3), forcing the rod head (6) and main rod (7) to move downward until the tapered portion (8) encounters the latch (11), causing the latch to close and prevent further movement of the rod head, thereby causing the bottom plug to exit a plug basket;
x. continuing to pump process fluid until the top dart (14) forces the platen (12) outward, thereby reopening the latch (11);
xi. continuing to pump until the top dart (14) lands on the bottom dart (13), blocking fluid flow through ports (2 and 3);
xii. continuing to pump process fluid until the top dart (14) clears flow ports (2, 3), thereby causing the bottom dart (13), rod head (6) and main rod (7) to move downward and the rod head to pass through the latch, thereby causing the main rod (7) to force the top plug to exit the plug basket.

3. The method of claim 2, wherein the interior volume of tubular body (1) is less than the volume of second process fluid necessary to fill the annular region surrounding tubular body (15), resulting in the launch of the bottom plug before the launch of top dart (14).

4. A method for cementing a subterranean well, wherein a bottom plug and a top plug are launched by means, comprising:

i. installing the first portion of the system of claim 1 inside a tubular body (15);
ii. pumping drilling fluid through tubular body (1) and allowing the fluid to flow through ports (2, 3);
iii. launching a bottom dart (13) into the drilling-fluid stream inside the tubular body (1);
iv. pumping a desired volume of cement slurry behind the bottom dart (11);
v. launching a top dart (14) into the cement-slurry stream inside the tubular body;
vi. pumping displacement fluid behind the top dart (14);
vii. continuing to pump until the bottom dart (13) forces the platen (12) outward, thereby opening the latch (11);
viii. continuing to pump until the bottom dart (13) lands on a rod head (6) on a main rod (7), blocking fluid flow through flow ports (2, 3);
ix. continuing to pump until the bottom dart (13) clears flow ports (2, 3), forcing the rod head (6) and main rod (7) to move downward until the tapered portion (8) encounters the latch (11), causing the latch to close and prevent further movement of the rod head, thereby causing the bottom plug to exit a plug basket;
x. continuing to pump until the top dart (14) forces the platen (12) outward, thereby reopening the latch (11);
xi. continuing to pump until the top dart (14) lands on the bottom dart (13), blocking fluid flow through ports (2, 3);
xii. continuing to pump until the top dart (14) clears flow ports (2, 3), thereby causing the bottom dart (13), rod head (6) and main rod (7) to move downward and the rod head to pass through the latch, thereby causing the main rod (7) to force the top plug to exit the plug basket.

5. The method of claim 4, wherein the interior volume of tubular body (14) is less than the volume of cement slurry necessary to fill the annular region surrounding tubular body (15), resulting in the launch of bottom plug (1) before the launch of top dart (13).

6. The method of claim 4 or 5, wherein the cement slurry is preceded by a spacer fluid, a chemical wash or both.

7. The method of any one of claims 2-6, wherein the subterranean well is a member of the list comprising: an oil well, a gas well, a geothermal well, a water well, a well for chemical-waste disposal, a well for enhanced recovery of hydrocarbons and a well for carbon sequestration.

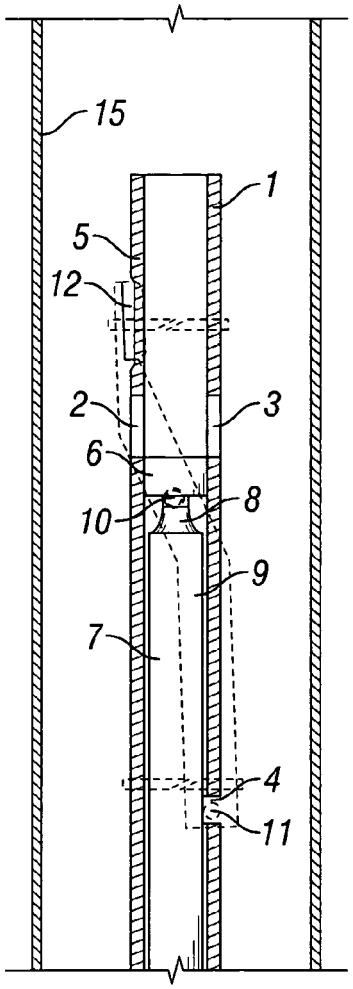

FIG. 1A

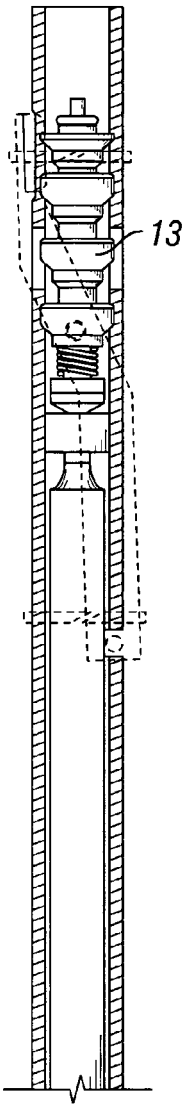

FIG. 1B

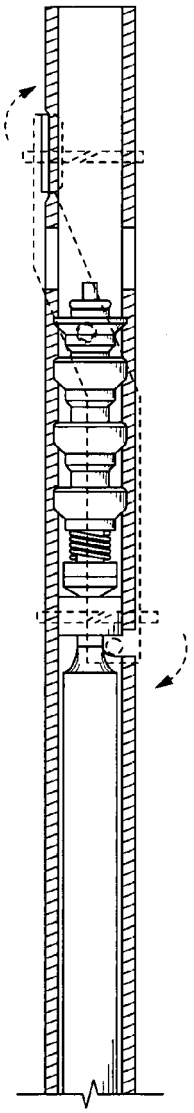

FIG. 1C

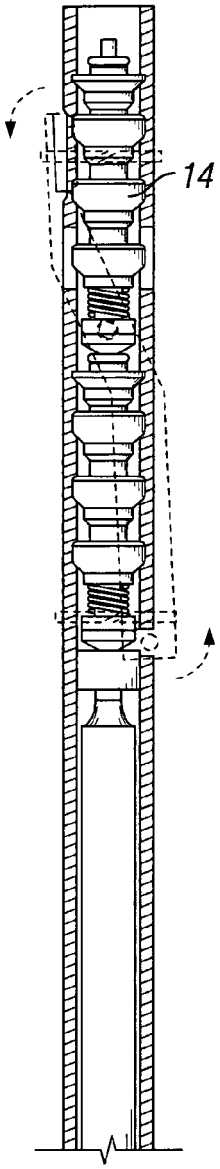

FIG. 1D

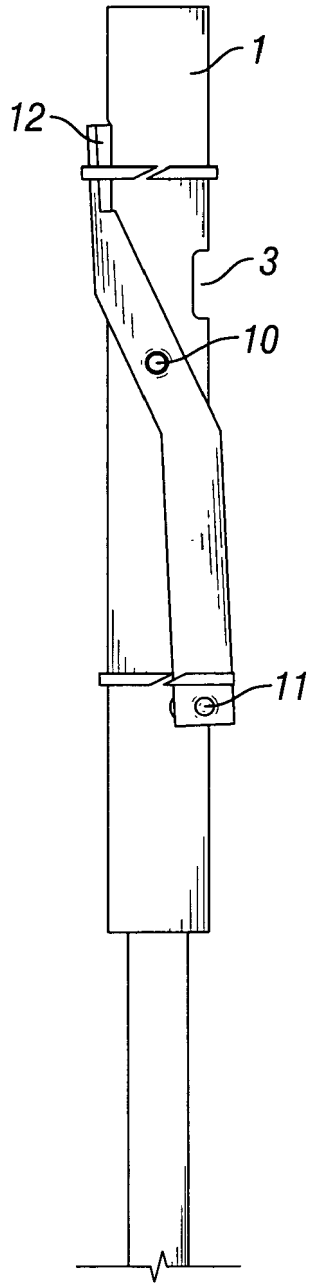

FIG. 2

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PARTIAL EUROPEAN SEARCH REPORT

Application Number EP 09 29 0830

which under Rule 63 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 890 537 A (LAVAURE GILBERT [US] ET AL) 6 April 1999 (1999-04-06) * column 4, line 51 - column 5, line 43; figures 1,2 *	1-2,4	INV. E21B33/05
X	EP 0 377 255 A1 (PUMPTECH NV [BE]; SCHLUMBERGER CIE DOWELL [FR]) 11 July 1990 (1990-07-11) * abstract; figures 1,2 *	1-2,4	
X	EP 1 464 788 A1 (HALLIBURTON ENERGY SERV INC [US]) 6 October 2004 (2004-10-06) * paragraph [0063]; figure 4 *	1-2,4	
X,D	EP 0 450 676 A1 (PUMPTECH NV [BE]; SCHLUMBERGER CIE DOWELL [FR] SOFITECH NV [BE]; SCHLU) 9 October 1991 (1991-10-09) * claim 1; figures 1,2 *	1-2,4	
A	US 4 317 486 A (HARRIS MONTY E) 2 March 1982 (1982-03-02) * abstract; figures 1-2 *	1-2,4	TECHNICAL FIELDS SEARCHED (IPC) E21B

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
Munich	16 February 2010	Strømmen, Henrik

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

3

EPO FORM 1503 03.82 (P04E07)

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INCOMPLETE SEARCH SHEET C

Application Number
EP 09 29 0830

Claim(s) completely searchable:
-

Claim(s) searched incompletely:
1-2, 4

Claim(s) not searched:
3, 5-7

Reason for the limitation of the search:

As set out in the European Search Opinion, the present application and in particular the present set of claims appears so unclear in the meaning of Article 84 EPC that the subject-matter for which protection is sought can not be established (Rule 63 EPC and Guidelines B?VIII, 3). The extent of the search was consequently limited to be based on the parts of the subject-matter of claims 1, 2, 4 that concerns the system for launching having a tubular body, a bottom dart and a top dart. Substantial parts of the sub-features (a), (b), (d) had therefore to be disregarded with respect to the search.
The subject-matter of the corresponding method claims were dealt with in a similar manner.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 29 0830

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-02-2010

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