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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 July 2014 (10.07.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/107113 A1

(51) International Patent Classification:
G01N 33/28 (2006.01) *E21B 43/12* (2006.01)
G01F 1/74 (2006.01) *G01F 5/00* (2006.01)
G01N 1/20 (2006.01)

(21) International Application Number:
PCT/NO2013/050002

(22) International Filing Date:
2 January 2013 (02.01.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **SCALE PROTECTION AS** [NO/NO]; Tore Hunds gt. 7, N-9404 Harstad (NO).

(72) Inventor: **DRØNEN, Ole, Magnar**; Kolmilhågen 12, N-9415 Harstad (NO).

(74) Agent: **HÅMSØ PATENTBYRÅ ANS**; Postboks 171, N-4302 Sandnes (NO).

(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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, 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, 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, ML, MR, NE, SN, TD, TG).

Published:

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

(54) Title: SCALE INDICATION DEVICE AND METHOD

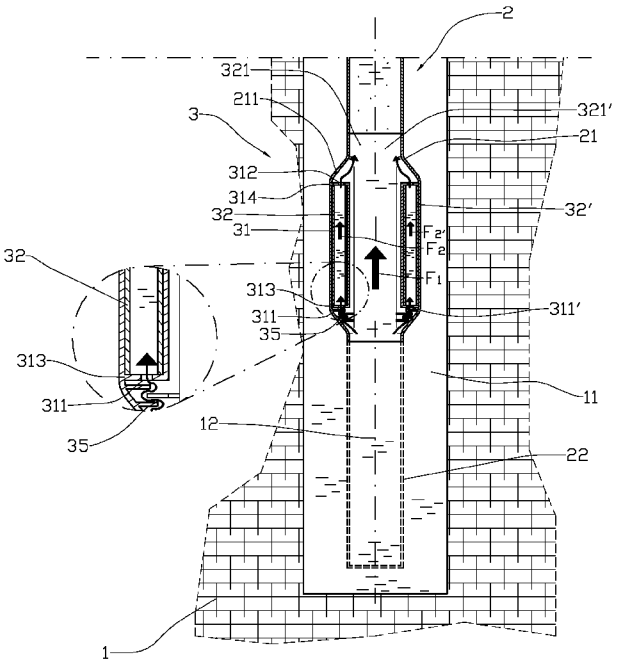

Fig. 1

(57) Abstract: A scale indicator (3) for a flowline (2) for a fluid (12) is described, in which at least one partial fluid line (31) which is arranged to carry a partial fluid flow (F2) is provided with an inlet port (311) arranged upstream in a main fluid flow (Fi) and an outlet port (312) arranged downstream in the main fluid flow (Fi), and in which the at least one partial fluid line (31) contains a tracer depot (32) which is in fluid communication with the partial fluid flow (F2).A method of monitoring a scaling state in a flowline (2) is described as well.

WO 2014/107113 A1

SCALE INDICATION DEVICE AND METHOD

A scale indicator for a flowline for a fluid is described, in which, more precisely, at least one partial fluid line which is arranged to carry a partial fluid flow is provided with an inlet port arranged upstream in a main fluid flow and an outlet port arranged downstream in the main fluid flow. A method of monitoring a scaling state in a flowline is described as well.

In production wells for hydrocarbons, the formation of mineral scaling constitutes a problem as the scaling results in the flow capacity of pipes, ports, filters, perforations etc. being considerably reduced as the scaling builds up. The type of scaling contributing to the greatest extent to the problem arises when injected sea water is mixed with reservoir water. Barium ions (Ba^{2+}) dissolved in the formation water react with sulphate ions (SO_4^{2-}) dissolved in the sea water and form barium sulphate ($BaSO_4$).

The development of scale is not always predictable, and there is a need for improving the quality and the reliability of the monitoring of the wells, so that necessary action may be taken before the development has gone too far.

From the prior art, it is known to do chemical analyses of the production water from the well in question. These measuring results may indicate that scaling is going on, but not whether this is happening in the reservoir, where the consequences are limited, or in the production equipment, where protection against scaling is necessary. The production development may be used as an indicator of adverse scaling in production equipment. However, the drawback is that the scaling downhole has already developed to a harmful level before it has been possible to take necessary action, and the well may already have suffered irreparable damage.

The problems that have been described above for a well could also occur in other parts of a production system for hydrocarbons. In the further description, unless something else has explicitly been mentioned, the term "well" will also include other installations

in which the build-up of scale or other types of precipitations may cause reduction in a flow capacity.

By the terms "scaling" and "scale" are also meant forms of clogging of a fluid flow path other than the chemically induced formation of solids mentioned, for example precipitation, the formation of wax and ice, the formation of hydrates, the sedimentation of solid particles and so on.

From EP 0622630 A2, a system and a method for optimizing the dosing of a scale inhibitor are known, wherein a sensor for heat transfer rate or heat transfer resistance through a contact surface which is in contact with water in a water circulation system is connected to a monitor, and a first temperature modulator is arranged near the contact surface to maintain a temperature that encourages scaling. Reading values for heat transfer rate or heat transfer resistance are used as indicators of scaling to see whether the desired conditions for scale inhibition have been achieved, in order thereby to control the supply of the scale inhibitor.

US 2008163700 A1, US 6880402 B1 and US 2003071988 A1 disclose other examples of devices and methods for detecting scale on the internal walls of a pipe by the use of either thermal, acoustic or ultrasonic methods.

From the applicant's own patent application NO 20100557, a scale indicator for a flowline for a fluid is known, characterized by a partial fluid line, which is arranged to carry a partial fluid flow, being provided with means arranged to provide and register a differential temperature between a partial fluid flow through the partial fluid line and a main fluid flow. The document also discloses a method of monitoring a scaling state in a flowline.

The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art or at least provide a useful alternative to the prior art.

The object is achieved through features which are specified in the description below and in the claims that follow.

In a fluid flowline, at least one partial fluid line is arranged, provided with an amount of a tracer, preferably in solid form, arranged in a depot which is in fluid communication with a partial fluid flow. The partial fluid line has an upstream inlet port, and said partial fluid flow which is directed into the partial fluid line, where it picks up and carries along some of the tracer, mixes with a main fluid flow as the partial fluid flow leaves the partial fluid line through an outlet port located downstream. By analytical

methods known *per se*, the tracer may be found in the fluid flow downstream of the partial fluid line. With scaling around and in the inlet port, the partial fluid flow will decrease, and this will have an effect on the amount of tracer in the fluid flow downstream of the partial fluid line. The amount of tracers that are found in the fluid flow may therefore be an indicator of the scaling state in the area in which the partial fluid line is located, by the very fact of the partial fluid flow being affected by scale at the inlet port.

By the use of several partial fluid lines provided with different tracers and with different inlet port characteristics, finding the different tracers in the fluid flow may give an indication of the degree of scaling.

The partial fluid line may be formed as a side pocket in the flowline, but it may also be placed directly in the flowline. In a practical embodiment of the invention, the partial fluid line will be arranged in a pipe section (a so-called sub) for quick assembling and disassembling relative to a pipe string, for example a production tubing string in a hydrocarbon well.

To encourage scaling at the partial fluid line(s), scale-increasing means may appropriately be provided at the inlet port(s), typically turbulence-encouraging means and the use of materials encouraging scaling. The materials may be of a type and/or provided with a surface which is scale-encouraging in itself.

In a first aspect, the invention more specifically relates to a scale indicator for a flowline for a fluid in a hydrocarbon well or a production system for hydrocarbons, in which at least one partial fluid line which is arranged to carry a partial fluid flow is provided with an inlet port arranged upstream in a main fluid flow and an outlet port arranged downstream in the main fluid flow, characterized by the at least one partial fluid line containing a tracer depot which is in fluid communication with the partial fluid flow.

The inlet port of a partial fluid line may exhibit fluid-flow characteristics that differ from the fluid-flow characteristics of the inlet port of each of the other partial fluid line(s), and the contents of the tracer depot of one partial fluid line are different from the contents of the tracer depots of each of the other partial fluid line(s).

The partial fluid line may be arranged in a side pocket in a pipe section.

The highest flow rate of the partial fluid flow may be substantially lower than the flow rate of the main fluid flow.

At the inlet port arranged upstream, turbulence-amplifying means may have been formed.

At least a portion of the partial fluid line surrounding the inlet may be formed of a material with scale-increasing properties.

The scale-increasing material may be copper.

The scale-increasing material may have a rough surface.

In a second aspect, the invention relates to a method of monitoring a scaling state in a flowline for a fluid in a hydrocarbon well or a production system for hydrocarbons, the method including the step of:

carrying a partial fluid flow through a partial fluid line from an inlet port arranged upstream in a main fluid flow to an outlet port arranged downstream in the main fluid flow,

characterized by the method including the further steps of:

bringing the partial fluid flow into contact with a tracer depot which is arranged in the partial fluid line;

monitoring the tracer content in the main fluid flow downstream of the outlet from the partial fluid line; and

by means of a change in the tracer content, calculating a change in the flow rate of the partial fluid flow and thereby simulating the scaling state of the flowline at the partial fluid line.

In what follows, an example of a preferred embodiment is described, which is visualized in the accompanying drawings, in which:

Figure 1 shows a longitudinal section through a scale indicator arranged for a flowline forming a production tubing in a well, the scale indicator being arranged in pockets in the flowline; and

Figure 2 shows a longitudinal section through an alternative embodiment of a scale indicator, in which one partial fluid line is arranged in the main bore of the flowline.

In the drawings, the reference numeral 1 indicates an underground structure including a borehole 11 which forms a well from which a well fluid 12 is produced through a flowline 2. In a portion of the flowline 2, a scale indicator 3 is arranged, shown in figure 1 in pockets in a pipe section 21 and, in figure 2, arranged in the flow path of the

pipe section 21.

In a manner known *per se*, the flowline 2 is provided with means for controlling the inflow of well fluid, shown schematically in the figures as a perforated downhole section 22.

The scale indicator 3 is formed of at least one partial fluid line 31 in the form of a container with a fluid inlet port 311 arranged upstream in a first end portion 313 of the container 31 and an outlet port 312 arranged downstream in a second end portion 314 of the container 31. The inlet port 311 and the outlet port 312 exhibit a flow area which provides a partial fluid flow F_2 with a flow rate substantially lower than the flow rate of a main fluid flow F_1 in the flowline 2. For practical purposes, it is favourable that the outlet port 312 is substantially larger than the inlet port 311, so that the partial fluid flow F_2 is not restricted by the size of the outlet port 312.

In figure 1, two partial fluid lines 31 are shown, whereas figure 2 shows one partial fluid line 31.

Upstream of the inlet 311, means 35 are arranged, also called a turbulence amplifier, arranged to provide a turbulent fluid flow towards the inlet port 311.

In the partial fluid line(s) 31, a tracer depot 32 is arranged, which is in direct contact with the partial fluid flow F_2.

As the partial fluid flow F_2 passes the tracer depot 32, an amount of tracer 321 is released into the partial fluid flow F_2. This release of tracer 321 depends on the flow rate of the partial fluid flow F_2. The partial fluid flow F_2 passes out of the partial fluid line(s) 31 through the outlet port(s) 312 and mixes with the main fluid flow F_1. When the main fluid flow rate and the flow characteristics of the inlet port(s) 311 are known, the amount of tracer 321 found in the main fluid flow F_1 may thereby be used to determine the partial fluid flow rate. From this, it will be possible to calculate the actual size of the of the inlet port 311. The amount of tracer 321 in the main fluid flow F_1 can thereby be used as a scale indicator.

Reference is now made to figure 1 in particular. By the use of several partial fluid lines 31 having different maximum flow rates by the partial fluid lines 31 being provided with different-size inlet ports 311, 311' and by the tracer depots 32, 32' containing different tracers 321, 321', the release of tracers 321, 321' into the different partial fluid flows F_2, $F_{2'}$ will give an indication of how the scaling is developing.

For most substances, for example sulphate salts, which are dominant in this sphere, turbulence will increase the scaling tendency. Said turbulence amplifier 35 increases the scaling tendency at the inlet port(s) 311, possibly 311'.

By forming at least parts of the first end portion 313, for example an annular portion surrounding the inlet port(s) 311, possibly 311', of a material which increases the scaling tendencies, the risk of scaling may be detected more quickly. It is known that copper has such properties. A rough material surface could also increase the scaling tendencies, and it will be beneficial to form the inlet port(s) 311, possibly 311', with a rough surface on the side wall(s).

Claims

1. A scale indicator (3) for a flowline (2) for a fluid (12) in a hydrocarbon well or a production system for hydrocarbons, in which at least one partial fluid line (31) which is arranged to carry a partial fluid flow (F_2) is provided with an inlet port (311) arranged upstream in a main fluid flow (F_1) and an outlet port (312) arranged downstream in the main fluid flow (F_1), characterized in that the at least one partial fluid line (31) contains a tracer depot (32) which is in fluid communication with the partial fluid flow (F_2).

2. The scale indicator (3) according to claim 1, wherein the inlet port (311) of a partial fluid line (31) exhibits fluid flow characteristics that differ from the fluid flow characteristics of the inlet port (311') of each of the other fluid line(s) (31), and the contents of the tracer depot (32) of one partial fluid line (31) are different from the contents of the tracer depots (32') of each of the other partial fluid line(s) (31).

3. The scale indicator (3) according to claim 1, wherein the partial fluid line (31) is arranged in a side pocket (211) in a pipe section (21).

4. The scale indicator (3) in accordance with claim 1, wherein the highest flow rate of the partial fluid flow (F_2) is substantially lower than the flow rate of the main fluid flow (F_1).

5. The scale indicator (3) according to claim 1, wherein, at the inlet port (311) arranged upstream, turbulence-amplifying means (35) have been formed.

6. The scale indicator (3) in accordance with claim 1, wherein at least a portion (313) of the partial fluid line (31) surrounding the inlet (311) is formed of a material with scale-increasing properties.

7. The scale indicator (3) in accordance with claim 6, wherein the scale-increasing material is copper.

8. The scale indicator (3) in accordance with claim 6, wherein the scale-increasing material has a rough surface.

9. A method of monitoring a scaling state in a flowline (2) for a fluid (12) in a hydrocarbon well or a production system for hydrocarbons, the method including the step of:

carrying a partial fluid flow (F_2) through a partial fluid line (31) from an inlet port (311) arranged upstream in a main fluid flow (F_1) to an outlet port (312) arranged downstream in the main fluid flow (F_1), c h a r a c t e r i z e d i n that the method includes the further steps of:

bringing the partial fluid flow (F_2) into contact with a tracer depot (32) which is arranged in the partial fluid line (31);

monitoring the contents of tracer (321) in the main fluid flow (F_1) downstream of the outlet (312) from the partial fluid line (31); and

by means of a change in the contents of tracer (321), calculating a change in the flow rate of the partial fluid flow (F_2) and thereby simulating the scaling state of the flowline (2) at the partial fluid line (31).

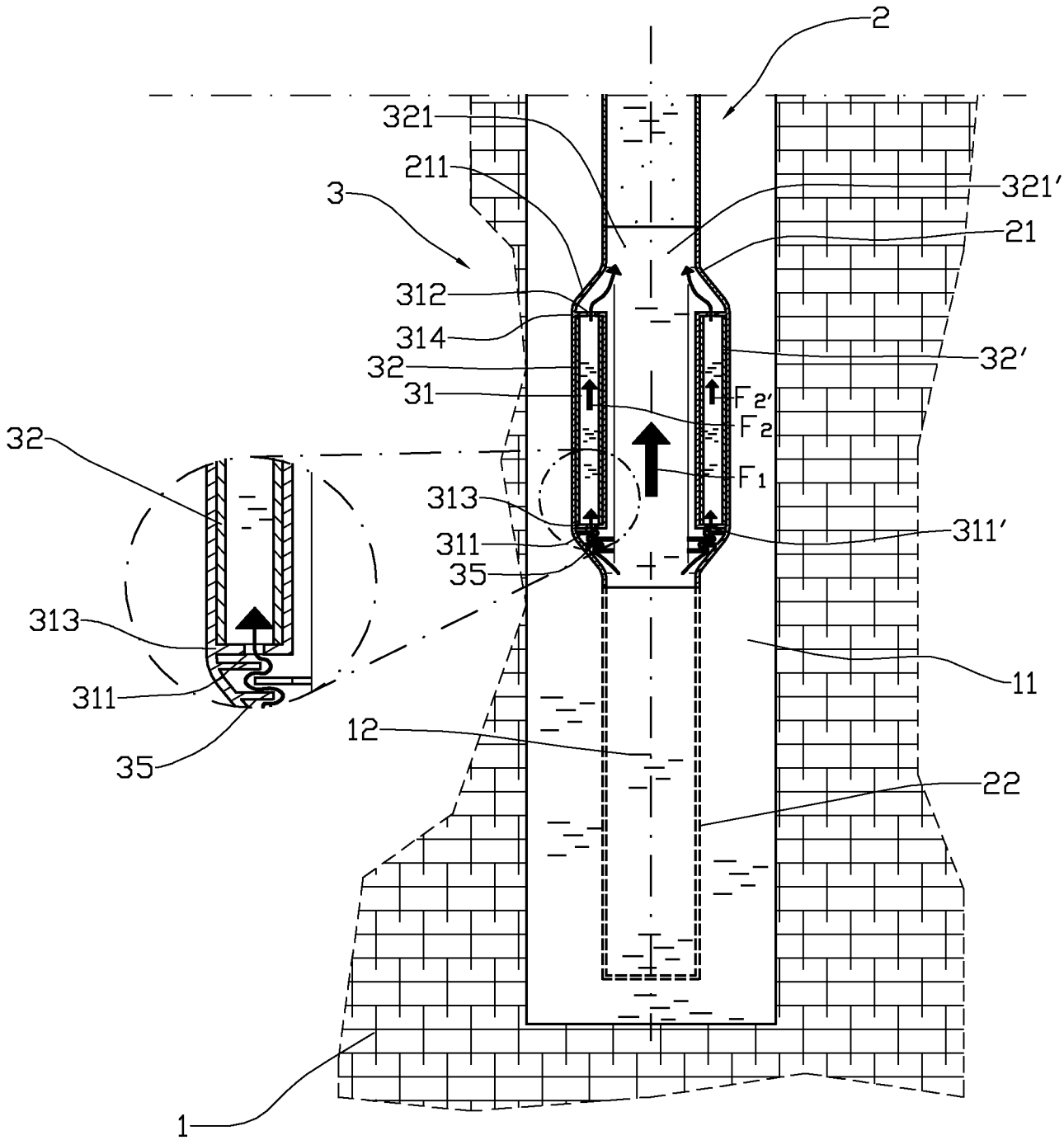
2
321
211
3
321'
21
312
314
32
31
32'
F2'
F2
F1
313
311
35
311'
11
12
22
1
32
313
311
35

Fig. 1

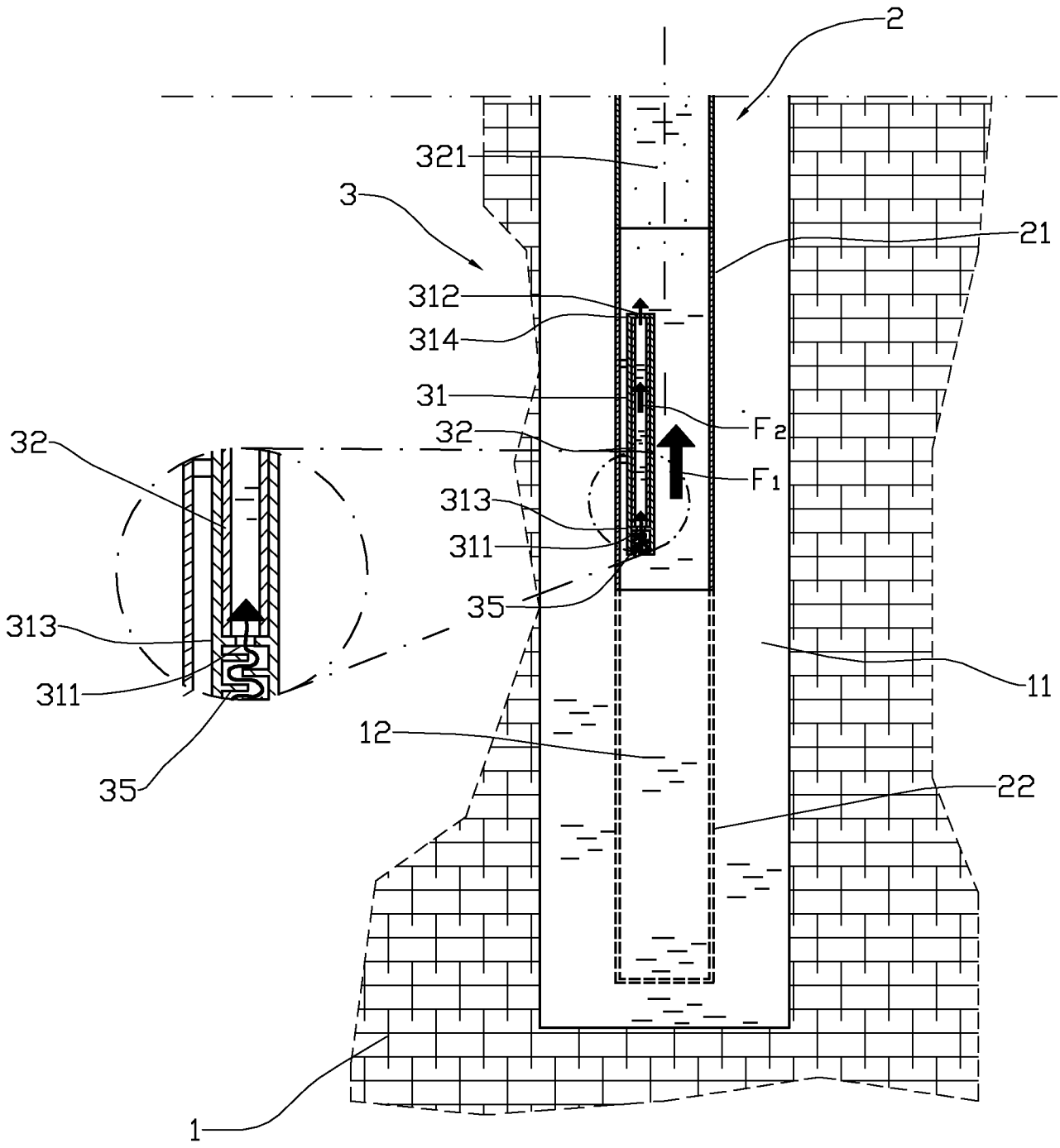

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2013/050002

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: E21B, G01F, G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20120312078 A1 (BAKHTIAR MEHRDAD SHARIF), 13 December 2012 (2012-12-13); abstract; paragraph [0140] --	1-9
A	NO 20100557 A (DRONEN UTVIKLING), 20 October 2011 (2011-10-20); abstract; figure 1; Cited in the application. --	1-9
A	US 7711486 B2 (THIGPEN BRIAN L ET AL), 23 October 2008 (2008-10-23); column 5, line 25 - line 67; claim 10 --	1-9
A	US 20080163700 A1 (HUANG SONGMING), 10 July 2008 (2008-07-10); abstract; figure 3A; Cited in the application. --	1-9

☒ 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	Date of mailing of the international search report
24-10-2013	24-10-2013
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Agneta Seidel Telephone No. + 46 8 782 25 00

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2013/050002

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006063094 A1 (CALEB BRETT USA INC ET AL), 15 June 2006 (2006-06-15); abstract; paragraphs [0087], [0087]; figure 1	1-9
	--	
A	US 6880402 B1 (COUET BENOIT ET AL), 19 April 2005 (2005-04-19); figure 8; claim 1; Cited in the application.	1-9
	--	
A	US 20030071988 A1 (SMITH J KEVYN ET AL), 17 April 2003 (2003-04-17); abstract; figure 1; Cited in the application.	1-9
	--	
A	EP 0531067 A1 (NALCO CHEMICAL CO), 10 March 1993 (1993-03-10); abstract; figure 1	1-9
	--	

Continuation of: second sheet

International Patent Classification (IPC)

G01N 33/28 (2006.01)
G01F 1/74 (2006.01)
G01N 1/20 (2006.01)
E21B 43/12 (2006.01)
G01F 5/00 (2006.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2013/050002

US	20120312078	A1	13/12/2012	NONE			
NO	20100557	A	20/10/2011	NO	332968	B1	11/02/2013
US	7711486	B2	23/10/2008	AU	2008275494	A1	15/01/2009
				CA	2684292	A1	15/01/2009
				GB	2461445	B	25/04/2012
				NO	20093166	A	18/01/2010
				RU	2009142438	A	27/05/2011
				RU	2468191	C2	27/11/2012
				US	20080262736	A1	23/10/2008
				WO	2009009196	A3	19/03/2009
US	20080163700	A1	10/07/2008	US	7673525	B2	09/03/2010
				WO	2008084182	A1	17/07/2008
WO	2006063094	A1	15/06/2006	US	8525995	B2	03/09/2013
				US	7697141	B2	13/04/2010
				US	20100265509	A1	21/10/2010
				US	20100245096	A1	30/09/2010
				US	20060142955	A1	29/06/2006
				US	8237920	B2	07/08/2012
US	6880402	B1	19/04/2005	AU	1042201	A	08/05/2001
				AU	1042101	A	08/05/2001
				GB	2369680	B	28/04/2004
				GB	2369679	B	14/04/2004
				NO	20021988	A	25/06/2002
				NO	20021987	A	25/06/2002
				NO	324740	B1	03/12/2007
				NO	322854	B1	11/12/2006
				US	6886406	B1	03/05/2005
				WO	0131329	A1	03/05/2001
				WO	0131328	A1	03/05/2001
US	20030071988	A1	17/04/2003	AT	489616	T	15/12/2010
				BR	0212913	A	13/10/2004
				CA	2463276	A1	17/04/2003
				DE	60238427	D1	05/01/2011
				EA	005707	B1	28/04/2005
				EP	1434980	A1	07/07/2004
				MX	PA04003271	A	23/07/2004
				NO	20041622	A	21/04/2004
				US	6891606	B2	10/05/2005
				WO	03031950	A1	17/04/2003

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2013/050002

EP	0531067 A1	10/03/1993	AT	132253 T	15/01/1996
			AU	2131992 A	11/03/1993
			AU	648928 B2	05/05/1994
			DE	69207122 T2	11/07/1996
			ES	2084293 T3	01/05/1996
			GR	3019189 T3	30/06/1996
			JP	2686026 B2	08/12/1997
			JP	5209725 A	20/08/1993
			US	5185533 A	09/02/1993