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(54) **An injection apparatus and method**

(57) An injection apparatus for injecting a chemical additive into a fluid mixture flowing into an annulus AN of a well-bore WB comprises a body 1 defining an internal chamber 20 receiving a valve arrangement 30. The body 1 comprises at least one port 14, 18 for coupling to a reservoir RS containing the chemical additive, and at least one injection nozzle 11 for injecting the chemical additive into the fluid mixture flowing into the annulus AN. The valve arrangement 30 has a closed position and an open position defined as a function of the fluid flow-rate of the fluid mixture flowing through the valve arrangement 30. In a closed position, the valve arrangement 30 closes the communication between the reservoir RS and the injection nozzle 11, the injection apparatus delivering a non-activated fluid mixture. In an open position, the valve arrangement 30 puts in communication the reservoir RS with the injection nozzle 11, the injection apparatus injecting the chemical additive into the fluid mixture flowing into the annulus AN.

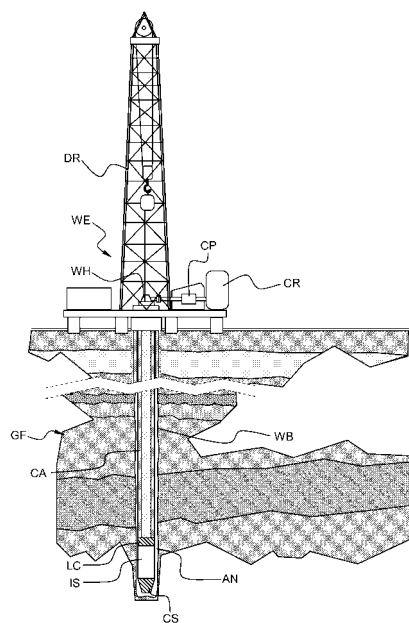


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The invention relates to an injection apparatus for injecting a chemical additive into a fluid mixture flowing in a well-bore. The invention also relates to a corresponding injection method.

[0002] A particular application of the invention relates to the oilfield industry, for example in cementing operation.

BACKGROUND OF THE INVENTION

[0003] During a hydrocarbon well drilling operation and after a hydrocarbon well has been drilled, various fluid injecting operations are generally carried out. The fluid injecting operations serves various purposes, for example delivering a chemical mixture into a fluid present in the borehole for consolidation purpose or fracturing purpose, or delivering a chemical mixture into a cement slurry for borehole cementing operation. These operations are well known in the oilfield industry.

[0004] Reference US 7,013,971 describes a method of cementing a casing in a wellbore with a tool connected at a lower end of a casing. The tool comprises a plurality of holes. The cement slurry is directly injected into the annulus with a plurality of stoppers. The stoppers are pumped down and engage the holes so as to hold the cement slurry in the annulus until the cement slurry hardens. The main disadvantage of such cementing operations is the lack or poor control about what is happening downhole.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to propose an injection apparatus or method that overcomes at least one of the drawbacks of the prior art injection apparatus or method.

[0006] According to an aspect, the invention relates to an injection apparatus for injecting a chemical additive into a fluid mixture flowing into an annulus of a well-bore comprises a body defining an internal chamber receiving a valve arrangement. The body comprises at least one port for coupling to a reservoir containing the chemical additive, and at least one injection nozzle for injecting the chemical additive into the fluid mixture flowing into the annulus. The valve arrangement has a closed position and an open position defined as a function of the fluid flow-rate of the fluid mixture flowing through the valve arrangement. In a closed position, the valve arrangement closes the communication between the reservoir communicates with the injection nozzle, the injection apparatus delivering a non-activated fluid mixture. In an open position, the valve arrangement puts in communication the reservoir with the injection nozzle, the injection apparatus injecting the chemical additive into the

fluid mixture flowing into the annulus.

[0007] The valve arrangement may comprise a main sleeve comprising an internal conduit forming a Venturi and a peripheral groove forming a communication chamber, and an indexer sleeve coupled to the main sleeve and the body defining the position of the main sleeve as a function of the fluid flow-rate of the fluid mixture flowing through the main sleeve. In the closed position, the main sleeve closes the communication between the reservoir and the injection nozzle. In the open position, the main sleeve puts in communication the reservoir with the injection nozzle through the communication chamber.

[0008] According to other various optional aspects, the body may further comprise at least one coupler at one extremity of the body for coupling the injection apparatus to a pipe, e.g. a casing.

[0009] The reservoir may be contained in a casing joint.

[0010] The injection nozzle may be located at a lower extremity of the body, above the port.

[0011] The internal chamber may be filled with a clean fluid.

[0012] The peripheral groove may be isolated from the injection nozzles by a seal in the closed position.

[0013] The valve arrangement may further comprise a compression spring positioned inside the internal chamber, pushing against a first and second shoulder of the body and the main sleeve, respectively. The compression spring characteristic may determine a threshold flow-rate that triggers the main sleeve from the open position to the closed position and vice-versa.

[0014] The indexer sleeve may be positioned between the second shoulder and a third shoulder of the main sleeve, the indexer sleeve rotating around the main sleeve under limitation of an indexer pin secured to the body.

[0015] The indexer pin may be engaged in a groove in an external wall of the indexer sleeve, the groove having a plurality of 'J-slot' shape around the indexer sleeve.

[0016] The valve arrangement may further comprise a compensating piston positioned on top of the main sleeve for compensating the pressure between the internal chamber and the fluid mixture flowing through the injector apparatus.

[0017] According to a further aspect, the invention relates to an injection method for injecting a chemical additive into a fluid mixture flowing into an annulus of a well-bore. The method comprises the following steps:

- running an injection apparatus at a proper location in the well-bore, the injection apparatus comprising a body defining an internal chamber receiving a valve arrangement, at least one injection nozzle for injecting a chemical additive contained in a pressurized reservoir into the fluid mixture flowing into the annulus, the valve arrangement being in a closed configuration,
- letting flow the fluid mixture at a first flow-rate into

- the well-bore through the apparatus, and triggering the valve arrangement to an open position by letting flow the fluid mixture at a second flow-rate into the well-bore through the injection apparatus, so as to put in communication the injection nozzles with the reservoir and letting flow the chemical additive into the annulus of well-bore through injection nozzles.

[0018] The triggering step may comprise sequentially raising the fluid flow-rate of the fluid mixture above a threshold flow-rate then lowering said flow-rate under the threshold flow-rate.

[0019] According to other various optional aspects, the method may further comprise the step of triggering the valve arrangement back to the close position by sequentially raising the fluid flow-rate of the fluid mixture above the threshold flow-rate then lowering said flow-rate under the threshold flow-rate, so as to stop putting in communication the injection nozzles with the reservoir.

[0020] The chemical additive in the reservoir may be at a pressure substantially identical as a pressure of the fluid mixture inside of the casing, which is higher than a pressure of the fluid mixture in the annulus.

[0021] The triggering step may be remotely controlled through a pumping arrangement of a surface equipment.

[0022] The invention enables reducing the wait on cement WOC during the cementing operations by directly injecting the chemical activator into the annulus around the casing whenever and wherever required. Further, the invention may also be used in other applications, such as the downhole preparation of a gelling system, based on polymers and cross-linkers. The chemical additive can be efficiently mixed with the cement slurry during the displacement process in the desired zones of interest, for example near the casing shoe. The invention enables operating the injection apparatus from the surface, by using variations of the pump flow rate, for a total control on opening and closing positions of the injection nozzles. Thus, a selective treatment of the slurry in the zones of interest, minimizing the required volume of chemical additive in the reservoir and reducing costs, is possible with the invention. It also enables using a downhole reservoir having a limited capacity and geometry adapted to the size of casing joints.

[0023] The invention enables, by reducing the WOC, keeping the rig idle as low as possible which is financially advantageous for the rig operators. Further, the invention enables reducing the risk linked with pumping the accelerator from the surface which may be problematic if the slurry sets during displacement.

[0024] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The present invention is illustrated by way of

example and not limited to the accompanying figures, in which like references indicate similar elements:

Figure 1 schematically shows an onshore hydrocarbon well location and equipments comprising a system for injecting a chemical fluid mixture into a well-bore according to the invention;

Figure 2 is a cross-section view schematically illustrating a system for injecting a chemical fluid mixture into a well-bore according to the invention;

Figure 3 is a cross-section view schematically illustrating an apparatus for injecting a chemical fluid mixture into a well-bore according to the invention;

Figures 4, 5 and 6 are half cross-section views schematically illustrating the various positions during operation of the apparatus for injecting a chemical fluid mixture into a well-bore according to the invention, namely a closed, trigger and open position, respectively;

Figure 7 schematically illustrates the operation of an indexer sleeve for determining the various positions during operation of the apparatus for injecting a chemical fluid mixture into a well-bore according to the invention; and

Figure 8 is a cross-section view schematically illustrating the fluid displacement during the injection operation.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Figure 1 schematically shows an onshore hydrocarbon well location and equipments WE above a hydrocarbon geological formation GF after drilling operation has been carried out and after a casing string CA has been run. At this stage, the well-bore WB is a borehole generally filled with various fluid mixtures (e.g. the drilling mud or the like). The equipment WE comprises a drilling rig DR for running the casing string CA in the borehole, cementing equipment comprising cement silo CR and pumping arrangement CP, and a well head and stuffing box arrangement WH providing a sealing for deploying the casing string CS or pumping down the cement into the generally pressurized well-bore WB.

[0027] Subsequently, cementing operations are generally undertaken to seal the annulus AN (i.e. the space between the well-bore WB and the casing CA where fluid can flow). A first application is primary cementing which purpose is to achieve hydraulic isolation around the casing. Other applications are remedial cementing which purposes are to stabilize the well-bore, to seal a lost circulation zone, to set a plug in an existing well or to plug a well so that it may be abandoned. The cement may be pumped into the well casing through a casing shoe CS near the bottom of the borehole or a cementing valve installed in the casing so that the cement is positioned in the desired zone.

[0028] Cementing engineers prepare the cementing operations by determining the volume and physical prop-

erties of cement slurry and other fluids pumped before and after the cement slurry. In many situations, chemical additives are mixed with the cement slurry in order to modify the characteristics of the slurry or set cement. Cement additives may be broadly categorized as accelerators (i.e. for reducing the time required for the set cement to develop sufficient compressive strength to enable further operations to be carried out), retarders (i.e. for increasing the thickening time of cement slurries to enable proper placement), dispersants (i.e. for reducing the cement slurry viscosity to improve fluid-flow characteristics), extenders (i.e. for decreasing the density or increasing the yield of a cement slurry), weighting agents (i.e. for increasing or lightening the slurry weight), fluid-loss or lost-circulation additives (i.e. for controlling the loss of fluid to the formation through filtration) and special additives designed for specific operating conditions.

[0029] Because cement additives have an effect as soon as they are mixed with the cement slurry, the injector system IS of the invention enables injecting cement additives in the cement slurry at the proper time and at the desired location in the well-bore.

[0030] Figure 2 schematically illustrates the injector system IS for injecting a chemical fluid mixture into a well-bore comprising an injector apparatus INJ according to the invention. The injector system IS comprises an injector apparatus INJ and a reservoir RS. The reservoir RS is installed inside the casing CA above the shoe CS, for example inside one or two casing joints. The reservoir RS contains the above mentioned chemical additive which exact composition is determined by the goal of the injection operation. The reservoir RS may consist of a bladder. The injector apparatus INJ is directly connected onto the reservoir RS. The landing collar LC for cement plug is located immediately above the injector apparatus INJ.

[0031] Figure 3 schematically illustrates the injector apparatus INJ according to the invention.

[0032] The injector apparatus INJ comprises a body 1 defining an internal chamber 20 receiving a valve arrangement 30.

[0033] Injection nozzles 11 are drilled through the body so as to put the internal chamber 20 in communication with the annulus AN of the well-bore. The upper extremity of the body 1 is coupled to an upper sub 2 through a threaded connection. A seal 3 is positioned between the upper sub 2 and the upper extremity of the body 1. The threaded connection and sealing enables an easy maintenance of the injector apparatus INJ. The lower extremity of the body 1 is coupled to the casing joint (not shown on Figure 3) through a casing adapter 17. The casing joint contains the reservoir (not shown on Figure 3). The lower extremity of body 1 comprises a first port 14 directed towards the internal chamber 20 of the injector apparatus. The casing adapter 17 comprises a second port 18 directed towards an outlet of the reservoir (not shown on Figure 3). Both ports 14 and 18 communicate through a channel 25 drilled through the tool body 1 and the casing

adapter 17. Advantageously, the injection nozzles 11 are located at the lower extremity of the body, above the first port 14. The reservoir outlet is connected to the injection nozzles via the second port 18, the first port 14 and the valve arrangement.

[0034] The valve arrangement 30 comprises a main sleeve 4, an indexer sleeve 9 and a compression spring 10. The main sleeve 4 comprises an internal conduit forming a Venturi. The external and lower extremity of the main sleeve 4 comprises a peripheral groove 24 forming a communication chamber. The compression spring 10 is installed inside the internal chamber of the body 1, pushing against a first 21 and second 22 shoulder of the body 1 and the main sleeve 4, respectively. The indexer sleeve 9 may be positioned between the second shoulder 22 and a third shoulder 23 of the main sleeve 4. The indexer sleeve 9 may rotate around the main sleeve 4. The rotation movement of the indexer sleeve 9 is controlled by an indexer pin 8 secured to the body 1.

[0035] A first set of seals 16 isolates the ports 14 and 18 from outside and inside fluids. Advantageously, the reservoir is at the same pressure as the pressure inside of the casing, which is slightly higher than the annulus pressure, due to the pressure drop across the casing shoe check valves, or an optional choke (not shown) installed above the casing shoe. As a consequence of the pressure difference, the chemical additive contained in the reservoir starts flowing from the reservoir towards the annulus through the ports, the communication chamber and injection nozzles when the injector valve is in an open position.

[0036] A second set of seals 12A and 12B are positioned at both extremities of the main sleeve 4. They are equal-size seals. They enable providing a internal chamber of constant volume inside the apparatus irrespective of the sleeve position. The internal chamber may be filled with a clean fluid 7, e.g. oil, in order to protect the valve arrangement, for example by avoiding problems with any debris by keeping the internal chamber clean. The oil 7 also acts as a lubricant to ease the reciprocating movement of the main sleeve 4 and the rotation of the indexer sleeve 9.

[0037] The injector apparatus INJ may further comprise a compensating piston 5. The compensating piston 5 is positioned on top of the main sleeve. It comprises seal 12A contacting the main sleeve and seal 6 contacting the body 1. The compensating piston 5 ensures an identical pressure between the oil 7 and the fluid inside the injector apparatus, thus avoiding any pressure drop across the sleeve seals that may create a too high friction.

[0038] The operation of the injector apparatus will now be described in relation with Figures 4 to 8.

[0039] Figures 4, 5 and 6 are half cross-section views schematically illustrating the various positions during operation of the injector apparatus. Figure 4 shows the injector apparatus in a closed position. Figure 5 shows the injector apparatus in a trigger position. Figure 6 shows the injector apparatus in an open position.

[0040] The various positions are controlled by means of the indexer sleeve 9 which is shown in Figure 7. The indexer sleeve 9 is a reciprocating or rotating indexer sleeve.

[0041] The compression spring 10 maintains the main sleeve 4 in a closed position when a fluid of low or normal flow-rates F1 flows through the main sleeve 4 (Figure 4). The indexer sleeve 9 is in a closed position PC (Figure 7).

[0042] A fluid flowing at a flow rate above a threshold flow-rate F2 will trigger the injector apparatus (Figure 5). The fluid flow rate above the threshold creates a downward force on the main sleeve 4 due to the effect of the Venturi. The compression spring 10 is compressed. The fixed indexer pin 8 is engaged in a groove 9A in the external wall of the indexer sleeve 9 being for example several 'J-slot' cut 9A all around the indexer sleeve. The indexer sleeve 9 rotates to an intermediate or trigger position PT (Figure 7). The threshold flow-rate is determined by the characteristic of the compression spring 10.

[0043] In the closed PC and intermediate PT positions, the peripheral groove 24 forming the communication chamber in the main sleeve 4 is isolated from the injection nozzles 11 by the seal 13.

[0044] When the flow-rate of the fluid drops under the threshold flow-rate stops, the compression spring 10 pushes back the main sleeve 4 which continues the rotation (Figure 6). The indexer sleeve 9 achieves the rotation to an open position PO (Figure 7). The indexer pin 8 stops at the extremity of the J-slot groove 9A. Thus, the return stroke of the main sleeve 4 is limited so that the main sleeve moves to the open position PO.

[0045] In the open position PO, the peripheral groove 24 forming the communication chamber in the main sleeve 4 by-passes the seal 13 and put in communication the injection nozzles 11 with the ports 14 and 18 coupled to the reservoir (not shown). Thus, the chemical additive contained in the pressurized reservoir can flow into the annulus of well-bore through the ports, the channel and the injection nozzles. At any time, the valve arrangement may be triggered back to the close position by sequentially raising the fluid flow-rate of the fluid mixture above the threshold flow-rate F2 then lowering said flow-rate under the threshold flow-rate.

[0046] Figure 8 schematically illustrates the fluid displacement during the injection operation. Figure 8 relates to a particular example during which a chemical additive is delivered into a cement slurry for borehole cementing operation.

[0047] A bottom plug BP already landed in the landing collar LC. A slurry SF is pushed downwards by a top plug TP which is pushed by a mud MD pumped downwards from the surface. The slurry SF flows through the bottom plug BP, the injector apparatus INJ, the casing joint CJ receiving the reservoir RS and the check valve of the shoe CS. Then the slurry SF flows into the annulus AN between the casing CA and the wall of the bore-hole WB. The injector apparatus INJ is in the closed position, meaning that the chemical additive is maintained in the

pressurized reservoir.

[0048] The reservoir RS pressure is substantially the same than the casing pressure, which is slightly higher than the annulus pressure.

[0049] The top and bottom plugs are rubber or plastics plugs separating the various fluids and preventing the slurry from depositing on the internal wall of the casing which are typically used in cementing operation.

[0050] Whenever required, the injector apparatus is triggered from the surface. The triggering phase is performed by, firstly, increasing the flow-rate of the slurry SF above the determined threshold flow-rate, for example by increasing the pumping rate of the pumping arrangement CP (Figure 1), and, secondly, stopping, at least reducing under a determined threshold the pumping rate of the pumping arrangement CP. As a consequence, the injector apparatus INJ switches to the open position. When the pumping is resumed, the chemical additive contained in the reservoir RS flows out of the reservoir and is injected via the injection nozzles 11 into the annulus. Thus, the slurry SF flowing in the annulus AN in front of the injection nozzles 11 is treated and becomes an activated slurry ASF. As an example, if the chemical fluid mixture is an accelerator, the cement slurry will set very quickly in the corresponding treated zone.

[0051] Subsequently, the top plug TP lands onto the bottom plug. This provides a sudden pressure bump indicating the end of the displacement. Said bump may be detected by an appropriate detector (not shown) at the surface.

[0052] At any time, the chemical additive injection may be stopped by triggering the valve arrangement back to the close position. This may be performed by sequentially raising the fluid flow-rate of the fluid mixture above the threshold flow-rate F2 then lowering said flow-rate under the threshold flow-rate.

FINAL REMARKS

[0053] It is to be mentioned that the invention is not limited to onshore hydrocarbon well and can also be used in relation with offshore hydrocarbon well.

[0054] Further, though, the invention has been presented with a particular cementing application, it is not limited to the injection of activator in the cement slurry. For example, the invention may also apply for the down-hole preparation of a gelling system, based on polymers and cross-linkers.

[0055] Also, a particular application of the invention relating to the oilfield industry has been described. However, the invention is also applicable to other kind of industry, e.g. the construction industry or the like.

[0056] The drawings and their description hereinbefore illustrate rather than limit the invention.

[0057] Any reference sign in a claim should not be construed as limiting the claim. The word "comprising" does not exclude the presence of other elements than those listed in a claim. The word "a" or "an" preceding an ele-

ment does not exclude the presence of a plurality of such element.

Claims

1. An injection apparatus for injecting a chemical additive into a fluid mixture flowing into an annulus (AN) of a well-bore (WB) comprising a body (1) defining an internal chamber (20) receiving a valve arrangement (30):
wherein the body (1) comprises:

- at least one port (14, 18) for coupling to a reservoir (RS) containing the chemical additive, and
- at least one injection nozzle (11) for injecting the chemical additive into the fluid mixture flowing into the annulus (AN),

wherein the valve arrangement (30) has a closed position and an open position defined as a function of the fluid flow-rate of the fluid mixture flowing through the valve arrangement, such that:

- in a closed position, the valve arrangement (30) closes the communication between the reservoir (RS) communicates with the injection nozzle (11), the injection apparatus delivering a non-activated fluid mixture, and
- in an open position, the valve arrangement (30) puts in communication the reservoir (RS) with the injection nozzle (11), the injection apparatus injecting the chemical additive into the fluid mixture flowing into the annulus (AN).

2. The injection apparatus according to claim 1, wherein the valve arrangement (30) comprises:

- a main sleeve (4) comprising an internal conduit forming a Venturi and a peripheral groove (24) forming a communication chamber, and
- an indexer sleeve (9) coupled to the main sleeve (4) and the body (1) defining the position of the main sleeve as a function of the fluid flow-rate of the fluid mixture flowing through the main sleeve, such that:

- in the closed position, the main sleeve (4) closes the communication between the reservoir (RS) and the injection nozzle (11), and
- in the open position, the main sleeve (4) puts in communication the reservoir (RS) with the injection nozzle (11) through the communication chamber.

3. The injection apparatus according to claim 1 or 2,

wherein the body (1) further comprises at least one coupler (2, 17) at one extremity of the body (1) for coupling the injection apparatus to a pipe (CA, CJ).

4. The injection apparatus according to any one of the claims 1 to 3, wherein the reservoir (RS) is contained in a casing joint (CJ).

5. The injection apparatus according to any one of the claims 1 to 4, wherein the injection nozzle (11) is located at a lower extremity of the body, above the port (14, 18).

6. The injection apparatus according to any one of the claims 1 to 5, wherein the internal chamber (20) is filled with a clean fluid (7).

7. The injection apparatus according to any one of the claims 1 to 6, wherein the peripheral groove (24) is isolated from the injection nozzles (11) by a seal (13) in the closed position.

8. The injection apparatus according to any one of the claims 1 to 7, wherein the valve arrangement (30) further comprises a compression spring (10) positioned inside the internal chamber (20), pushing against a first (21) and second (22) shoulder of the body (1) and the main sleeve (4), respectively.

9. The injection apparatus according to claim 8, wherein the compression spring (10) characteristic determines a threshold flow-rate that triggers the main sleeve from the open position to the closed position and vice-versa.

10. The injection apparatus according to claim 8, wherein the indexer sleeve (9) is positioned between the second shoulder (22) and a third shoulder (23) of the main sleeve (4), the indexer sleeve (9) rotating around the main sleeve (4) under limitation of an indexer pin (8) secured to the body (1).

11. The injection apparatus according to claim 10, wherein the indexer pin (8) is engaged in a groove (9A) in an external wall of the indexer sleeve (9), the groove having a plurality of 'J-slot' shape around the indexer sleeve.

12. The injection apparatus according to any one of the claims 1 to 11, wherein the valve arrangement (30) further comprises a compensating piston (5) positioned on top of the main sleeve for compensating the pressure between the internal chamber (20) and the fluid mixture flowing through the injector apparatus.

13. An injection method for injecting a chemical additive into a fluid mixture flowing into an annulus (AN) of a

well-bore (WB), wherein the method comprises the following steps:

- running an injection apparatus at a proper location in the well-bore, the injection apparatus comprising a body (1) defining an internal chamber (20) receiving a valve arrangement (30), at least one injection nozzle (11) for injecting a chemical additive contained in a pressurized reservoir (RS) into the fluid mixture flowing into the annulus (AN), the valve arrangement being in a closed configuration, 5
 - letting flow the fluid mixture at a first flow-rate (F1) into the well-bore through the injection apparatus, 10
 - triggering the valve arrangement to an open position by letting flow the fluid mixture at a second flow-rate into the well-bore through the injection apparatus, so as to put in communication the injection nozzles (11) with the reservoir (RS) and letting flow the chemical additive into the annulus (AN) of well-bore through injection nozzles (11). 15
14. The injection method according to claim 13, wherein the triggering step comprises sequentially raising the fluid flow-rate of the fluid mixture above a threshold flow-rate (F2) then lowering said flow-rate under the threshold flow-rate. 20
15. The injection method according to claim 14, wherein the method further comprises the step of triggering the valve arrangement back to the close position by sequentially raising the fluid flow-rate of the fluid mixture above the threshold flow-rate (F2) then lowering said flow-rate under the threshold flow-rate, so as to stop putting in communication the injection nozzles (11) with the reservoir (RS). 25
16. The injection method according to claim 13, wherein the chemical additive in the reservoir (RS) is at a pressure substantially identical as a pressure of the fluid mixture inside of the casing, which is higher than a pressure of the fluid mixture in the annulus. 30
17. The injection method according to claim 13, 14 or 15, wherein the triggering step is remotely controlled through a pumping arrangement (CP) of a surface equipment. 35

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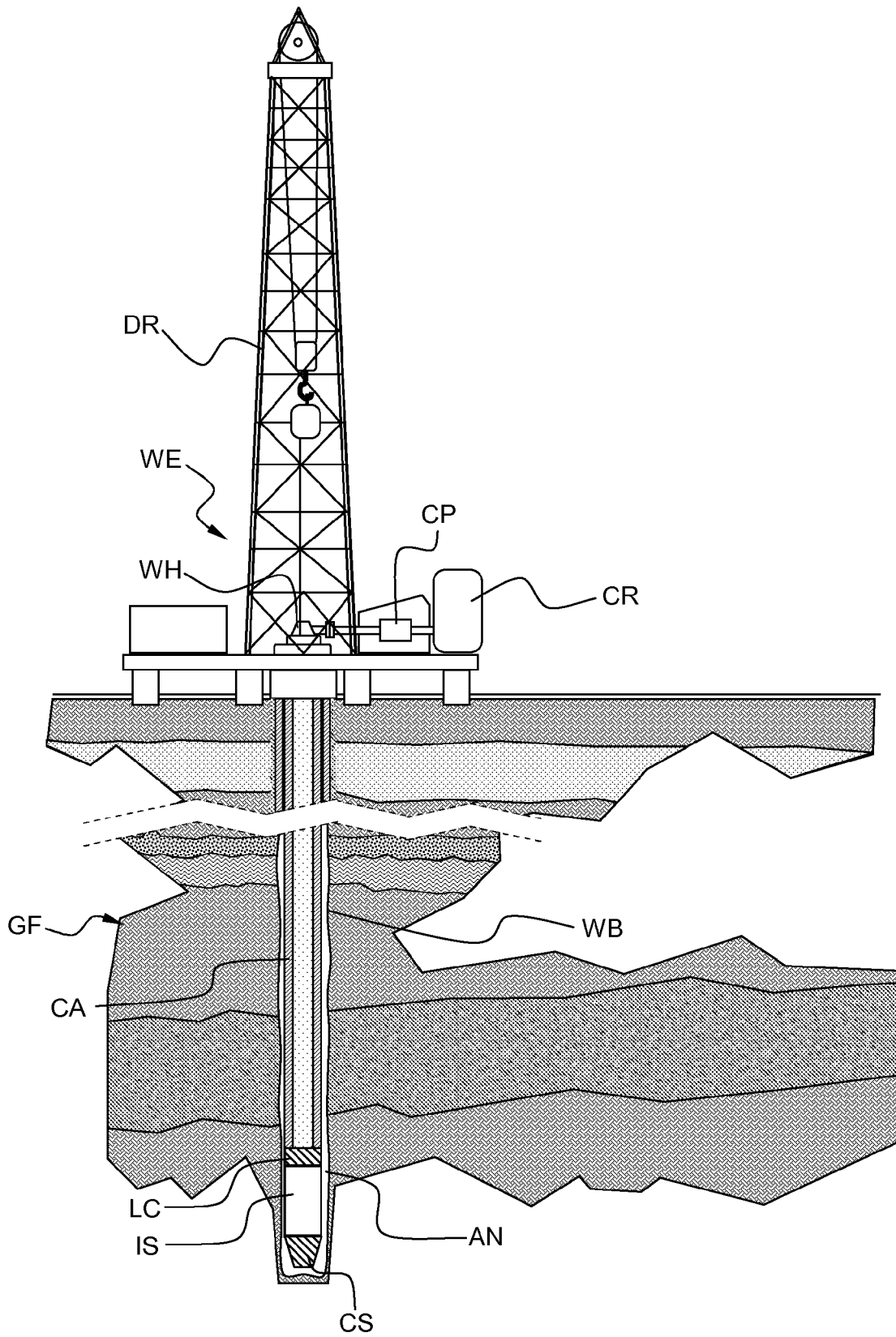


FIG. 1

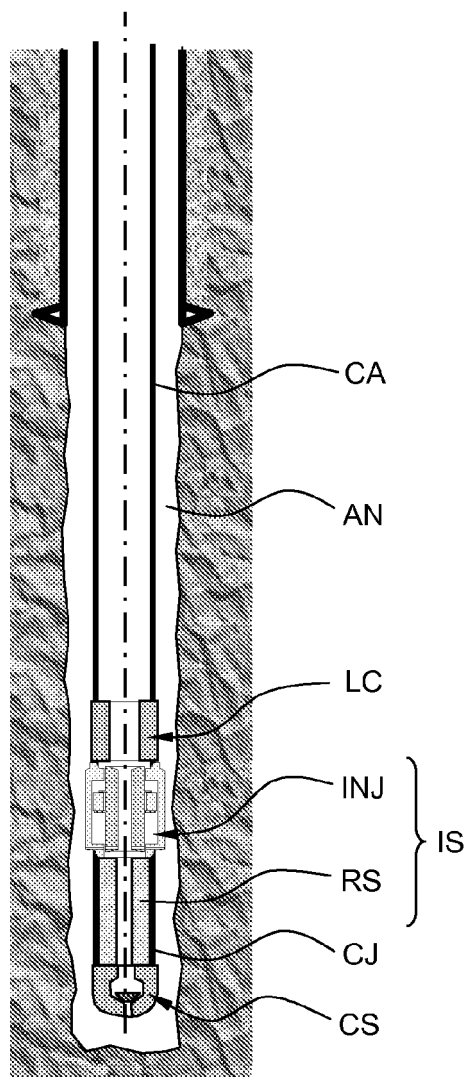


FIG. 2

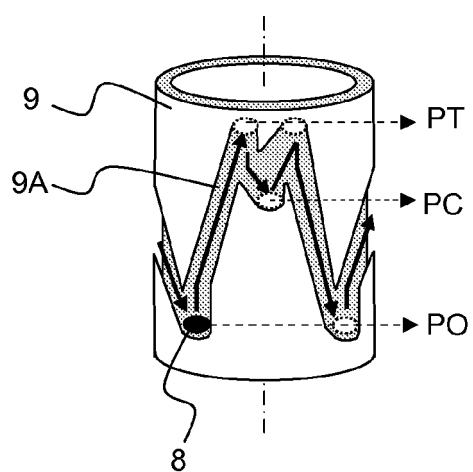


FIG. 7

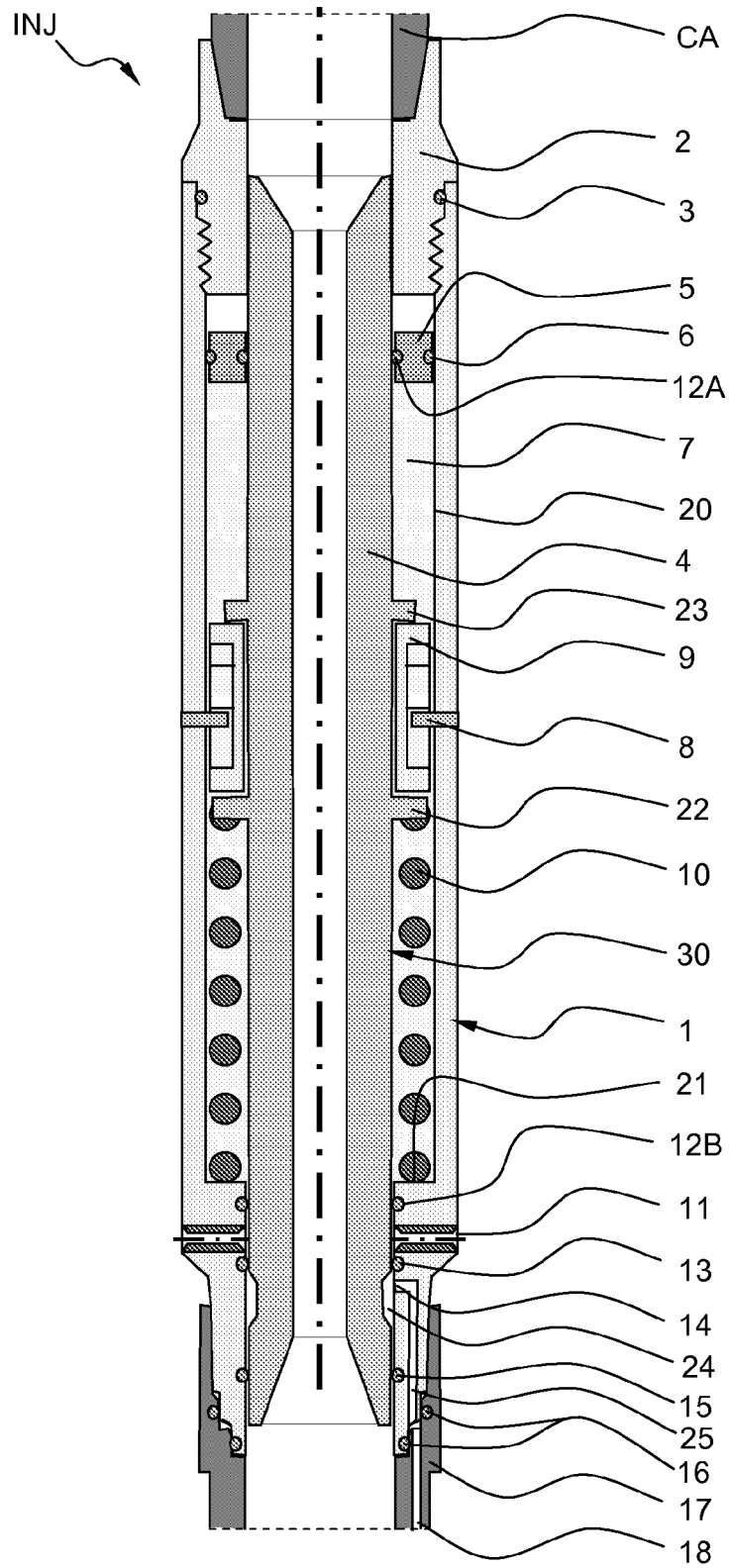


FIG. 3

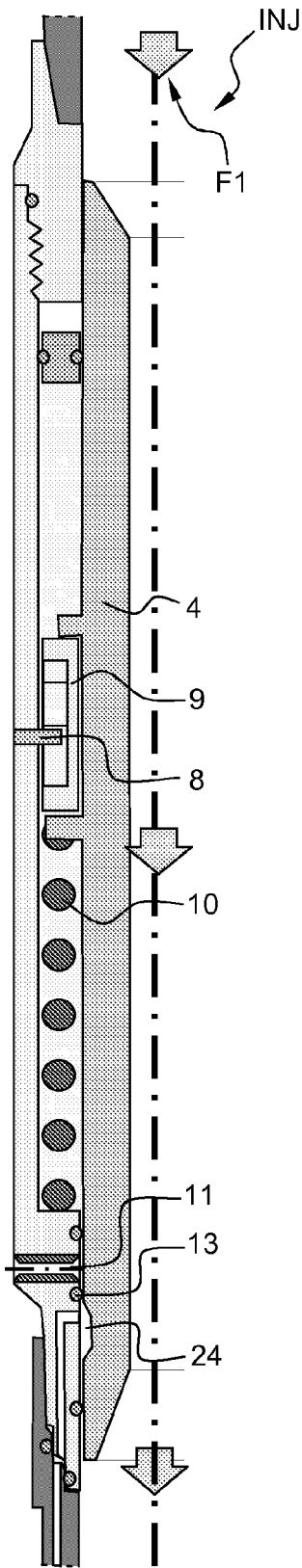


FIG. 4

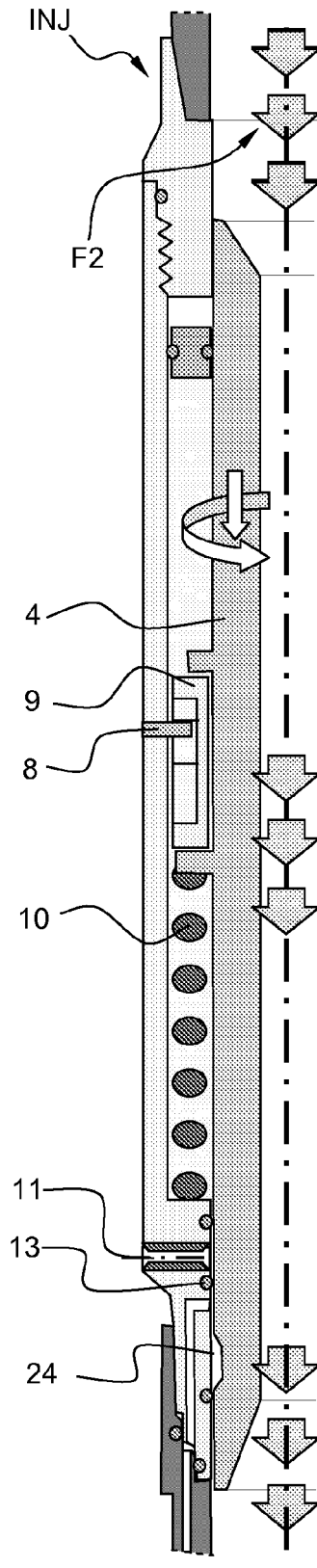


FIG. 5

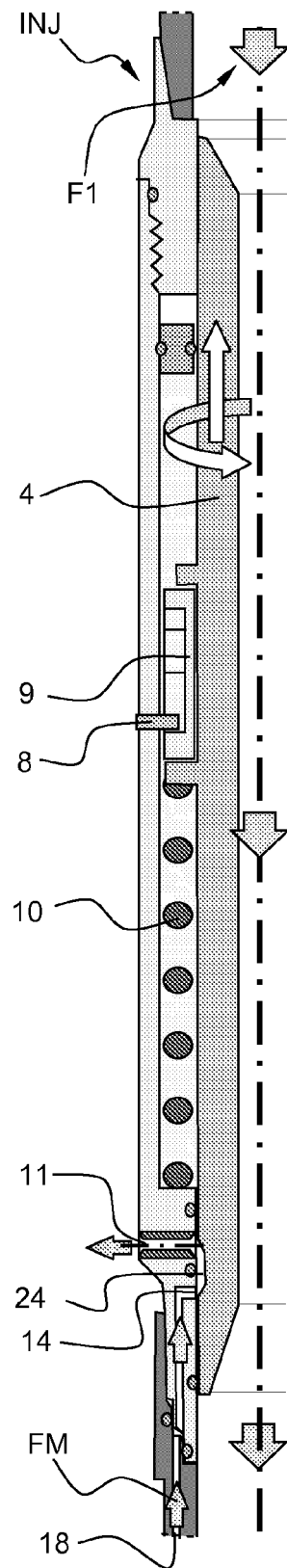


FIG. 6

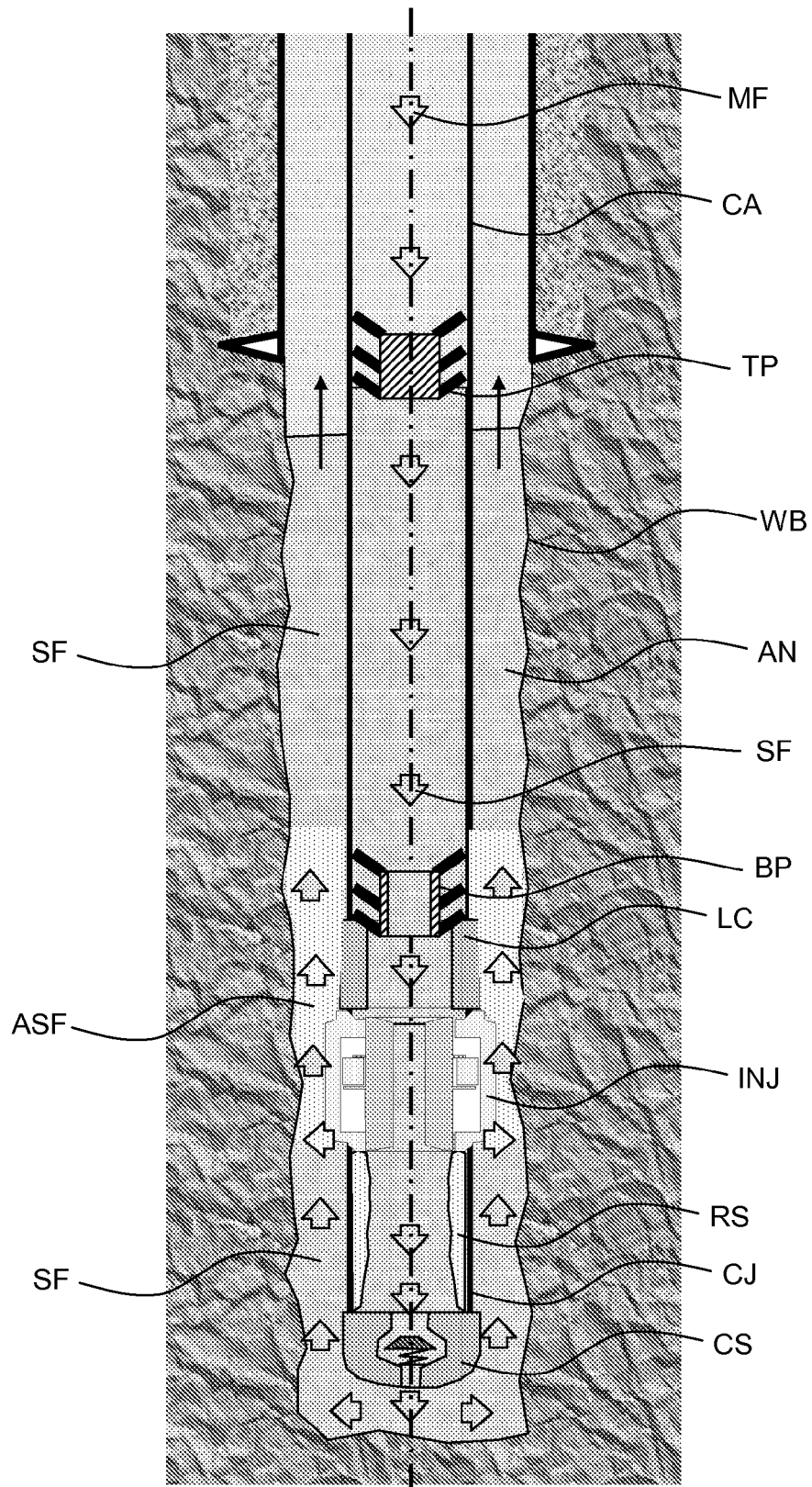


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 08 15 7376

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 653 042 B1 (SCHLUMBERGER SERVICES PETROL [FR]; SCHLUMBERGER TECHNOLOGY BV [NL]; SC) 15 August 2007 (2007-08-15) * column 1, paragraph 2 - column 6, paragraph 26 *	1,13	INV. E21B33/13 E21B33/138 E21B33/14
A	EP 1 653 043 B1 (SCHLUMBERGER SERVICES PETROL [FR]; SCHLUMBERGER HOLDINGS [VG]; SCHLUMB) 12 March 2008 (2008-03-12) * column 1, paragraph 1 - column 5, paragraph 31 *	1,13	
A	EP 1 223 303 A (CARISELLA JAMES VICTOR [US]; COOK ROBERT BRADLEY [US]) 17 July 2002 (2002-07-17) * column 2, paragraph 12 - column 3, paragraph 19 *	1,13	
A	EP 0 722 037 A (HALLIBURTON CO [US] HALLIBURTON ENERGY SERV INC [US]) 17 July 1996 (1996-07-17) * column 4, line 16 - column 6, line 30 *	1,13	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			E21B
3	Place of search Munich	Date of completion of the search 13 October 2008	Examiner Morrish, Susan
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			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 15 7376

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13-10-2008

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 1653042	B1	15-08-2007	AT	370310 T	15-09-2007
			CA	2582941 A1	20-04-2006
			DK	1653042 T3	27-12-2007
			EP	1653042 A1	03-05-2006
			WO	2006040147 A2	20-04-2006
			GB	2433530 A	27-06-2007
			US	2008093077 A1	24-04-2008

EP 1653043	B1	12-03-2008	AT	389096 T	15-03-2008
			CA	2585061 A1	11-05-2006
			EP	1653043 A1	03-05-2006
			WO	2006048210 A1	11-05-2006

EP 1223303	A	17-07-2002	CA	2331473 A1	20-07-2001
			NO	20010314 A	23-07-2001

EP 0722037	A	17-07-1996	DE	69610647 D1	23-11-2000
			DE	69610647 T2	15-02-2001

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7013971 B [0004]