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(54) A clean-out tool for cleaning out a well bore and a method for cleaning out a well bore using such a clean-out tool

(57) A clean-out tool for cleaning out a well bore comprises a helical displacing member (3) which is secured against rotation about a longitudinal axis thereof. A tubular barrel (2) surrounds the helical displacing member and is rotatably journalled in a first bearing (9) and a second bearing (10). A drive mechanism (7) rotatably drives the tubular barrel. The tubular barrel comprises a hollow bit at a free end of the tubular barrel, the second bearing being provided within the hollow bit (12). The hollow bit is provided with scoop openings (13).

In a method for cleaning out a well bore using such a clean-out the tool is completely lowered into a preformed well bore until the hollow bit engages debris or other material. The drive mechanism is activated to rotate the tubular barrel relative to the helical displacing member while the helical displacing member is kept stationary to convey debris or other material into the tubular barrel via the scoop openings and further into the tubular barrel. The tool is pulled out of the well bore and debris or other material is removed out of the tubular barrel.

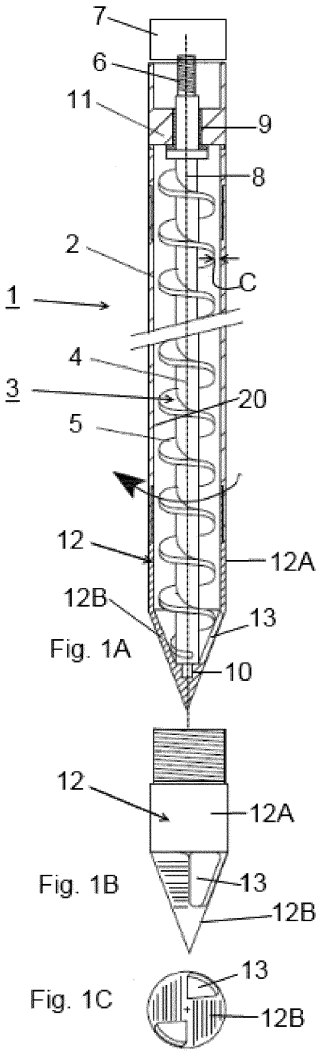

Fig. 1A

Fig. 1B

Fig. 1C

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a well clean-out tool and, in particular, to a well clean-out tool for removing debris or other material from well bores with sub-hydrostatic reservoir pressure, well bores where sufficient lifting velocity cannot be achieved or wellbores filled with high density debris or other material which cannot be circulated to the surface.

[0002] From time to time it can become necessary to remove sand, scale and other types of debris or material from a well bore in order to maintain or increase the productivity and/or life of the well.

[0003] Conventional well clean-out operations, such as the circulating type, require that the well bore be filled with liquid or at least contain a substantial liquid column. In many instances, however, the formation cannot sustain a substantial column of liquid for a conventional clean-out operation. In addition removing such debris or material from such a well with for example a wire line bailer can take substantial time as the volume of such bailer is limited and fill efficiency unpredictable. Other known methods involve the use of foam which may have negative effect on the producing formation or can pose problems in handling returns at the surface. Consequently, those wells cannot be efficiently cleaned out at an economic price.

[0004] It is, therefore, an object of the invention to alleviate the above-discussed shortcomings and to provide a clean-out tool and method for efficiently cleaning out oil, gas and uranium well bores in general, in particular well bores with lost circulation or formations with sub-hydrostatic pressure, where low reservoir pressure prevents debris or other material being circulated to the surface, where settling velocity of the particles exceeds the lifting velocity due to the ratio between well inside diameters and achievable fluid and/or gas pump rates or where the density of the debris or other material prevents such debris or other material being circulated to the surface. Another object of the present invention is to provide such a clean-out tool and method with which a well bore can be cleaned-out effectively without having a negative effect on the producing formation and without adding any fluid to the well bore.

SUMMARY OF THE INVENTION

[0005] Those and other objects are achieved by the present invention by providing a clean-out tool for cleaning out a well bore, said clean-out tool comprising:

- a helical displacing member comprising a central shaft and a helical blade flight with a longitudinal axis, said displacing member being secured against rotation about said longitudinal axis;
- a tubular barrel surrounding said displacing member, said tubular barrel being rotatably journalled in a first bearing and a second bearing spaced from the first bearing;
- a drive mechanism for rotatably driving said tubular barrel; and
- said tubular barrel comprising a hollow bit at a free end of the tubular barrel, said second bearing being provided within the hollow bit, and wherein said hollow bit is provided with scoop openings. The drive mechanism can be a down hole motor. Such a down hole motor can be driven hydraulically, by means of a compressed gas or air or a combination thereof. Further drive mechanism can be an electric drive (e.g. an electric motor with power supplied from down hole batteries or a surface source via a conductor cable) or a rotating drill string or tubing rotating the tubular barrel. Preferably, the hollow bit comprises a cylindrical part with substantially uniform diameter and a conical part with reducing diameter or a flat bottom. Please note, that the invention is not restricted to remove

debris from well bores but can also be used to remove other materials, such as uranium, from well bores or to deepen an existing well bore.

[0006] In an embodiment of a clean-out tool for cleaning out a well bore according to the invention the scoop openings are provided in the conical or bottom part so that - in use - debris or other material can be effectively removed from the well bore.

[0007] In a further embodiment of a clean-out tool for cleaning out a well bore according to the invention the helical blade flight extends to within the hollow bit, preferably up to the second bearing, for efficiently conveying debris or other material from the scoop openings into the tubular barrel and further displacing the debris into the tubular barrel.

[0008] In an advantageous embodiment of a clean-out tool for cleaning out a well bore according to the invention the hollow bit is removably connected to the tubular barrel. In this manner, maintenance and repair can be performed in a simple manner while it is also possible to remove debris or other material contained within the tubular barrel by removing the hollow bit from the tubular barrel.

[0009] Preferably, the clean-out tool comprises a first bearing and connection subassembly, said first bearing and connection subassembly comprising the first bearing and being connectable to the drive mechanism. It is then in particular advantageous when the drive mechanism comprises a down-hole motor comprising a static or hollow shaft, said static shaft being coupled to the central shaft of the helical displacing member in a rotationally fixed manner or the central shaft of the helical displacing member is extended through the hollow shaft of the down hole motor and rotationally fixed in the work string above the down hole motor. For facilitating maintenance and repair and allowing debris or other material contained

within the tubular barrel to be removed from the tubular barrel it is preferred that the first bearing and connection subassembly is removably connected to the tubular barrel.

[0010] In a further embodiment of a clean-out tool for cleaning out a well bore according to the invention the clean-out tool comprises an anchor extending in longitudinal direction from the hollow bit, said anchor comprising an anchor shaft extending through the hollow bit, said anchor shaft being coupled to the central shaft of the helical displacing member in a rotationally fixed manner. In this manner the helical displacing member can be held stationary by the anchor, which - in use - is pressed in the debris or other material. Such an anchor can be used in addition to or as an alternative to a down-hole motor comprising a static shaft coupled to the central shaft of the helical displacing member.

[0011] In a still further embodiment of a clean-out tool for cleaning out a well bore according to the invention the tubular barrel comprises at least one slot for passing fluids, gas or air within the tubular barrel to outside the tubular barrel. Such slots enable fluids, gas or air present in the debris or other material to be squeezed out of the tubular barrel through the slots to prevent pressure built up inside the tubular barrel. The dimensions, i.e. length and width, of the slots are preferably chosen in dependence of the size and kind of the debris or other material.

[0012] Preferably, in a still further embodiment the helical displacing member comprises an upper part in which the central shaft is free from helical blade flight which can provide more compacting of the debris. In particular when the slots are provided in an upper part of the tubular barrel, which upper part of the tubular barrel surrounds the upper part of the helical displacing member which is free from helical blade flight compacting can be performed very efficiently, as a result of which more debris or other material can be contained within the tubular barrel.

[0013] In a particular advantageous embodiment of a clean-out tool for cleaning out a well bore according to the invention a predefined working clearance between a cylindrical volume occupied by said helical displacing member and an inner surface of said tubular barrel is such that, in use, a stable layer of material is formed against said inner surface of said tubular barrel, said stable layer urging a mass of material within said tubular barrel along a helical path by frictional engagement between said stable layer and said mass of material. Such a clearance can provide an efficient fill of the tubular barrel and prevents wear of the inner wall of the tubular barrel through metal-on-metal contact and lock up of the tubular barrel against the helical displacing member in the tubular barrel. Due to the contact frictional engagement between the material and the inner wall of the tubular barrel the material is caused to rotate inside the tubular barrel where it encounters the static helical displacing member. The rotating tubular barrel pushes the debris or other material along the helical blade flight inward the tubular barrel and the tubular barrel can become completely filled with debris or other material. In addition because of said clearance between the rotating tubular barrel, it is then in particular advantageous that the material inside the rotating tubular barrel will only move by the same amount of debris or other material as is additional taken in via the scoop openings of the hollow bit.

[0014] For a person skilled in the art it is clear that the clean-out tool can be sized and extended with various diameters and lengths of screw and tube sections to accommodate the well bore and/or the well bore surface lubricator configurations.

[0015] The present invention further relates to a method for cleaning out a well bore using a clean-out tool according to the invention, comprising the steps of:

lowering said clean-out tool completely into a pre-formed well bore, such as by means of for example coiled tubing, jointed pipes, wire line or conductor line, until the hollow bit of said clean-out tool engages debris or other material within said pre-formed well bore;

activating the drive mechanism, causing the tubular barrel surrounding the helical displacing member to rotate about the longitudinal axis while the helical displacing member is kept stationary to convey debris or other material into the tubular barrel via the scoop openings and further into the tubular barrel;

pulling said clean-out tool from said well bore, such as by means of for example coiled tubing, jointed pipes, wire line or conductor line; and removing debris or other material out of the tubular barrel.

[0016] Preferably, the step of removing debris or other material out of the tubular barrel comprises the step of removing at least one of the hollow bit and the first bearing and connection subassembly from the tubular barrel. By disassembling the clean-out tool it is ensured that the components of the clean-out tool are damaged as less as possible when removing debris or other material from the tubular barrel, although it requires a relatively small amount of additional time. Thus the debris or other material can be cleaned out of the well bore through production tubing, casing or a combination of both. The inventive method can be used for cleaning out cased well bores as well as so called open hole well bores.

[0017] In a particularly advantageous embodiment of a method cleaning out a well bore according to the invention, said method comprises the steps of:

rotating said tubular barrel at a speed sufficient to urge debris or other material towards an inner wall of said tubular barrel;

providing a predefined working clearance between said helical displacing member and said inner wall of said tubular barrel, the predefined working clearance being such that, in use, a stable layer of debris or other material is formed against said inner wall of said tubular barrel;

urging a mass of debris or other material within said tubular barrel along a helical path by frictional engagement between said mass of debris or other material and said stable layer;
wherein preferably said working clearance between a cylindrical volume occupied by said helical displacing member and said inner wall of said tubular barrel is greater than a mean particle diameter of packable debris or other material. Preferably the tubular barrel is rotated at a speed sufficient to form a static layer of debris or other material in a clearance space between a cylindrical volume occupied by said helical displacing member and said inner wall of said tubular barrel. Furthermore, rotation of material inside the tubular barrel will automatically tend to centre the helical displacement member which is particular advantageous for extended cleanout tools.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In order that the invention may be more fully understood and put into practical effect, reference will now be made to preferred embodiments illustrated in the accompanying drawings in which:

FIG. 1A shows schematically a cross-sectional side elevation of an embodiment of a clean-out tool according to the invention;
FIG. 1B shows schematically a hollow bit of the clean-out tool in side elevation of Figure 1A;
FIG. 1C shows schematically the hollow bit of FIG. 1B seen from the free end of the tubular barrel;
FIGs. 2A and 2B show the clean-out tool of FIG. 1 in two positions during cleaning out debris from a well bore;
FIG. 3A shows schematically a cross-sectional side elevation of an alternative embodiment of a clean-out tool according to the invention comprising an anchor;
FIG. 3B shows schematically the clean-out tool of FIG. 3A seen from the free end of the tubular barrel;
FIGs. 4A and 4B show the clean-out tool of FIG. 3 in two positions during cleaning out debris from a well bore;
FIG. 5 shows yet another embodiment of a clean-out tool according to the invention comprising slots in the tubular barrel; and
FIG. 6 shows a further embodiment of a clean-out tool according to the invention in which an upper end of the helical displacing member is free from a helical blade flight.

DETAILED DESCRIPTION OF THE INVENTION

[0019] In FIG. 1A, the clean-out tool 1 comprises a tubular barrel 2 surrounding a helical displacing member 3 comprising a central shaft 4 with a helical blade flight 5 extending about the circumference of central shaft 4.

[0020] The shaft 4 is fixedly mounted (in a rotational manner) to a static shaft 6 of a down-hole motor 7 which forms the drive mechanism for the clean-out tool 1.

[0021] In FIG. 1A the positioning of the clean-out tool 1 is shown - in use - in which the helical displacing member is supported, with a longitudinal axis 8 in a substantially upright position. Please note, that the helical displacing member need not be placed substantially upright but operates as well when positioned horizontally or under an angle to the horizontal plane. The helical displacing member 3 is thus secured against rotation about the longitudinal axis 8.

[0022] The tubular barrel 2 surrounds the helical displacing member 3 and is rotatably journalled in a first bearing 9 and a second bearing 10, spaced from the first bearing 9. The first bearing 10 is included in a first bearing and connection subassembly 11, which in the shown embodiment is removably connectable to the drive mechanism 7 (schematically shown) and the tubular barrel 2.

[0023] The tubular barrel 2 further comprises a hollow bit 12 at a free end of the tubular barrel 2. The second bearing 10 is provided within the hollow bit 12. The hollow bit 12 comprises a cylindrical part 12A with substantially uniform diameter and a conical part 12B with reducing diameter. Please note that although the conical part 12B is shown as being pointed, it is in other - not shown - embodiments possible that the conical part is more flattened. Scoop openings 13 are provided in the conical part 12B for enabling debris to enter into the tubular barrel 2. In the shown embodiment there are two, almost triangular shaped scoop openings 13 in the conical part 12B.

[0024] As can be seen in FIG. 1A the helical blade flight 5 extends to within the hollow bit 12, preferably up to the second bearing 10, and thus has a reducing diameter in a direction toward the second bearing 10. In the shown embodiment the hollow bit 12 is removably connected to the tubular barrel 2, e.g. by a threaded connection as indicated in FIG. 1B.

[0025] In Figures 2A and 2B the clean-out tool 1 of FIG. 1 is shown in two positions during cleaning out debris D from a well bore WB which is pre-formed in a formation F (partly shown) . In Figure 2A the clean-out tool is lowered into the pre-formed well bore WB until the hollow bit 12 of said clean-out tool 1 engages debris D within said pre-formed well bore WB. Thereafter the drive mechanism 7 is activated causing the tubular barrel 2 surrounding the helical displacing member 3 to rotate (indicated by the arrow) about the longitudinal axis 8 while the helical displacing member 3 is kept stationary by the static shaft 6 of the down-hole motor 7 to convey debris D into the tubular barrel 2 via the scoop openings 13 and further into the tubular barrel 2 as indicated in Figure 2B. As a result of the hollow bit 12 the clean-out tool 1 is efficiently drilled into to debris D. Due to the first bearing 9 and the second bearing 10 the helical displacing member 3 will substantially not deform leading to a reproducible and constant operation of the clean-out tool 1. After the tubular barrel 2 is sufficiently filled the clean-out tool

1 is pulled from the well bore WB. The debris D can then be removed out of the tubular barrel 2 by e.g. disassembling the hollow bit 13 and the first bearing and connection subassembly 11. Please note, that the rotation direction is indicated as an example only and that it will be clear for a person skilled in the art that the rotation direction for displacing debris or other material into the tubular barrel depends on whether the helical blade flight 5 has a right hand or a left hand wound screw. Of course the down hole motor needs to be modified accordingly.

[0026] In FIG. 3A schematically a cross-sectional side elevation of an alternative embodiment of a clean-out tool 1 according to the invention is shown which comprises an anchor 14, which is shown in FIG. 3B as seen from the free end of the tubular barrel 2. The anchor 14 extends in longitudinal direction from the hollow bit 13 and comprises an anchor shaft 15 extending through the hollow bit 12. The anchor shaft 15 is coupled to the central shaft 4 of the helical displacing member 3 in a rotationally fixed manner and holds the helical displacing member static. In this embodiment the drive mechanism 7' (schematically shown) does not need to have a static shaft connected to the central shaft 4 but can be formed by any other known drive mechanism able to rotate the tubular barrel 2.

[0027] FIGs. 4A and 4B show the clean-out tool 1 of FIG. 3 in two positions during cleaning out debris D from a well bore WB which is pre-formed in a formation F (partly shown). In Figure 4A the clean-out tool is lowered into the pre-formed well bore WB until the anchor 14 of the hollow bit 12 of said clean-out tool 1 engages debris D within said pre-formed well bore WB. Thereafter the drive mechanism 7' is activated causing the tubular barrel 2 surrounding the helical displacing member 3 to rotate (indicated by the arrow) about the longitudinal axis 8 while the helical displacing member 3 is kept stationary by the anchor 14 to convey debris D into the tubular barrel 2 via the scoop openings 13 and further into the tubular barrel 2 as indicated in Figure 4B. As a result of the hollow bit 12 the clean-out tool 1 is efficiently drilled into to debris D. Due to the first bearing 9 and the second bearing 10 the helical displacing member 3 will substantially not deform leading to a reproducible and constant operation of the clean-out tool 1. After the tubular barrel 2 is sufficiently filled the clean-out tool 1 is pulled from the well bore WB. The debris D can then be removed out of the tubular barrel 2 by e.g. disassembling the hollow bit 13 and the first bearing and connection subassembly 11. Please note that in this embodiment it is not necessary to use a drive mechanism having a static shaft but any other available drive mechanism can be used.

[0028] FIG. 5 shows yet another embodiment of a clean-out tool 1 according to the invention comprising slots in the tubular barrel 2.

[0029] FIG. 6 shows a further embodiment of a clean-out tool 1 according to the invention in which an upper end 3A of the helical displacing member 3 is free from a helical blade flight 5. Please note, that in this embodiment the slots 16 are only provided in an upper part 2A of the tubular barrel, which upper part 2A of the tubular barrel surrounds the upper part 3A of the helical displacing member which is free from helical blade flight 5.

[0030] In the embodiments shown a predefined working clearance C between a cylindrical volume occupied by said helical displacing member 3 and an inner surface 20 of said tubular barrel 2 is such that, in use, a stable layer of material is formed against said inner surface 20 of said tubular barrel 2. The stable layer urges - in use a mass of material within said tubular barrel 2 along the helical path by frictional engagement between said stable layer and said mass of material.

Claims

1. A clean-out tool for cleaning out a well bore, said clean-out tool comprising:

   - a helical displacing member comprising a central shaft and a helical blade flight with a longitudinal axis, said displacing member being secured against rotation about said longitudinal axis;
   - a tubular barrel surrounding said helical displacing member, said tubular barrel being rotatably journalled in a first bearing and a second bearing spaced from the first bearing;
   - a drive mechanism for rotatably driving said tubular barrel; and
   - said tubular barrel comprising a hollow bit at a free end of the tubular barrel, said second bearing being provided within the hollow bit, and wherein said hollow bit is provided with scoop openings.

2. A clean-out tool for cleaning out a well bore according to claim 1, wherein the hollow bit comprises a cylindrical part with substantially uniform diameter and a conical part with reducing diameter.

3. A clean-out tool for cleaning out a well bore according to claim 2, wherein the scoop openings are provided in the conical part.

4. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the helical blade flight extends to within the hollow bit, preferably up to the second bearing.

5. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the hollow bit is removably connected to the tubular barrel.

6. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the clean-out tool comprises a first bearing and connec-

tion subassembly, said first bearing and connection subassembly comprising the first bearing and being connectable to the drive mechanism.

7. A clean-out tool for cleaning out a well bore according to claim 6, wherein the drive mechanism comprises a down-hole motor comprising a static shaft, said static shaft being coupled to the central shaft of the helical displacing member in a rotationally fixed manner.

8. A clean-out tool for cleaning out a well bore according to claim 6 or 7, wherein the first bearing and connection subassembly is removably connected to the tubular barrel.

9. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the clean-out tool comprises an anchor extending in longitudinal direction from the hollow bit, said anchor comprising an anchor shaft extending through the hollow bit, said anchor shaft being coupled to the central shaft of the helical displacing member in a rotationally fixed manner.

10. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the tubular barrel comprises at least one slot for passing fluids within the tubular barrel to outside the tubular barrel.

11. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, wherein the helical displacing member comprises an upper part in which the central shaft is free from helical blade flight.

12. A clean-out tool for cleaning out a well bore according to claims 10 and 11, wherein the slots are provided in an upper part of the tubular barrel, which upper part of the tubular barrel surrounds the upper part of the helical displacing member which is free from helical blade flight.

13. A clean-out tool for cleaning out a well bore according to any one of the preceding claims, **characterized in that** a predefined working clearance between a cylindrical volume occupied by said helical displacing member and an inner surface of said tubular barrel is such that, in use, a stable layer of material is formed against said inner surface of said tubular barrel, said stable layer urging a mass of material within said tubular barrel along a helical path by frictional engagement between said stable layer and said mass of material.

14. A method for cleaning out a well bore using a clean-out tool according to any one of the preceding claims, comprising the steps of:

lowering said clean-out tool completely into a pre-formed well bore until the hollow bit of said clean-out tool engages material within said pre-formed well bore;

activating the drive mechanism, causing the tubular barrel surrounding the helical displacing member to rotate about the longitudinal axis while the helical displacing member is kept stationary to convey material into the tubular barrel via the scoop openings and further into the tubular barrel;

pulling said clean-out tool from said well bore; and

removing material out of the tubular barrel.

15. A method for cleaning out a well bore according to claim 14, using a clean-out tool according to claim 5 or claim 8 or according to claims 5 and 8, wherein the step of removing material out of the tubular barrel comprises the step of removing at least one of the hollow bit and the first bearing and connection subassembly from the tubular barrel.

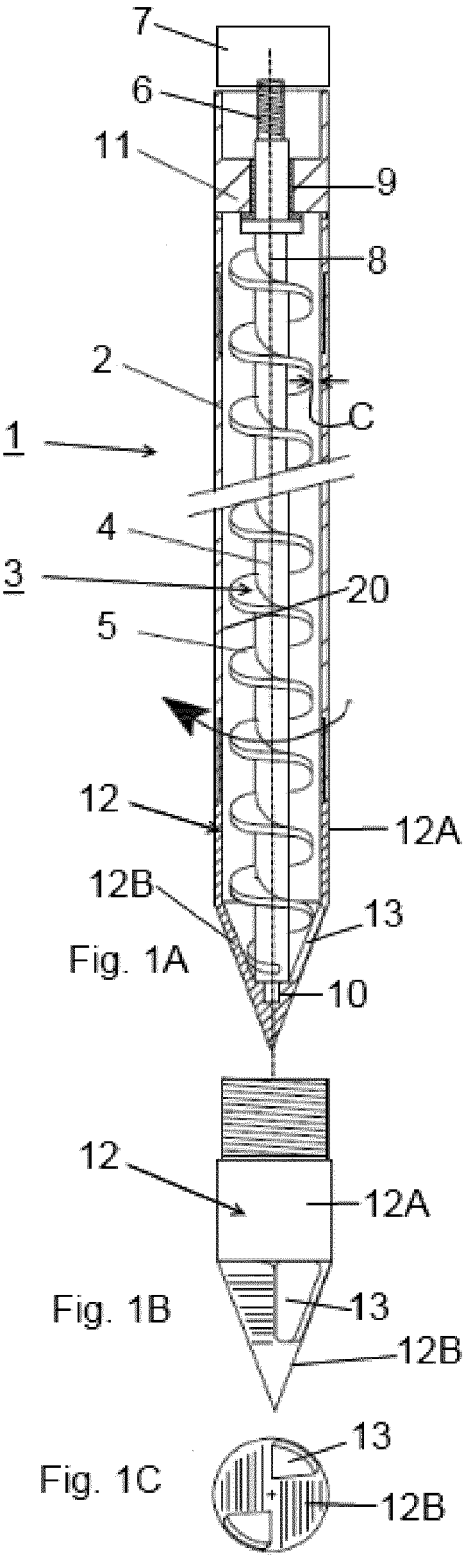

Fig. 1A

Fig. 1B

Fig. 1C

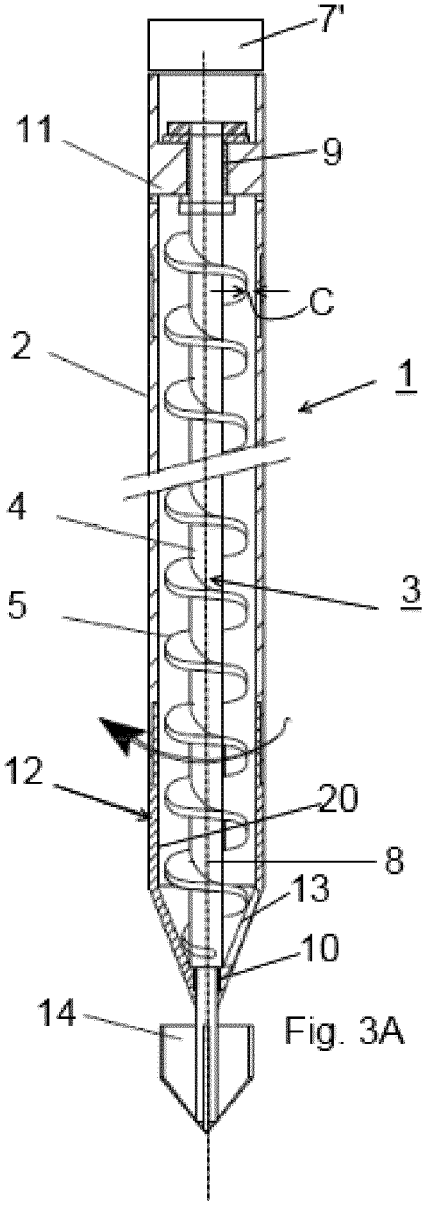

Fig. 3A

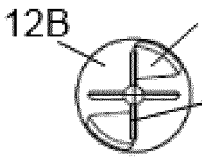

Fig. 3B

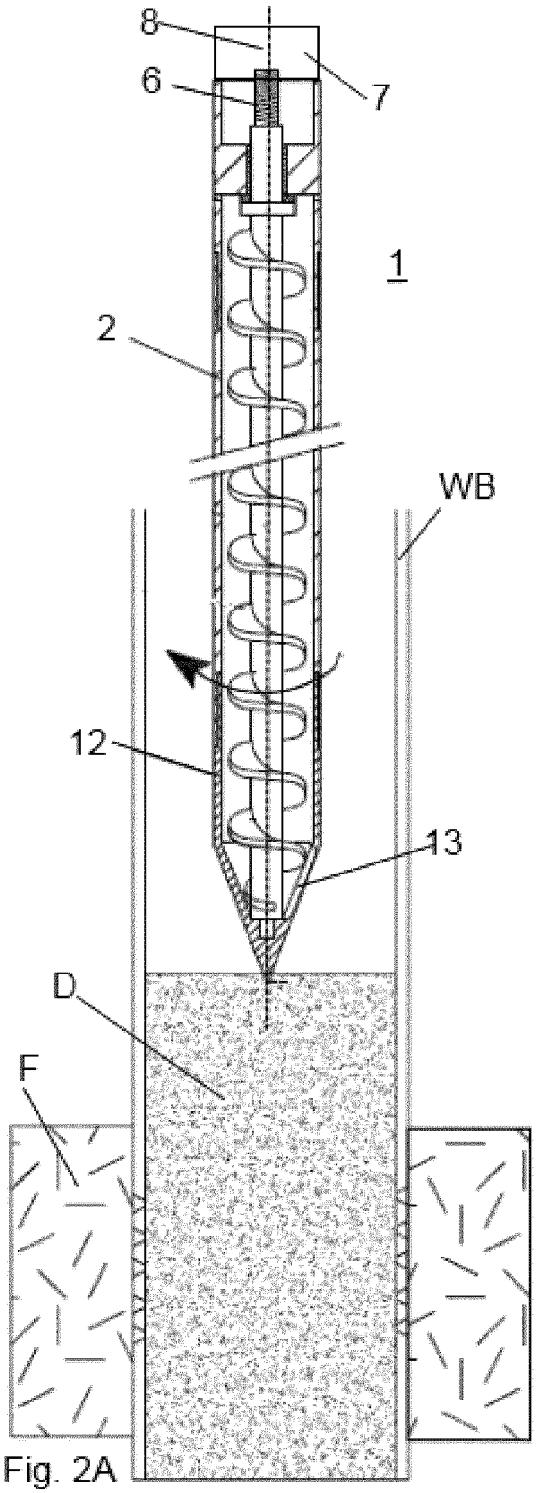

Fig. 2A

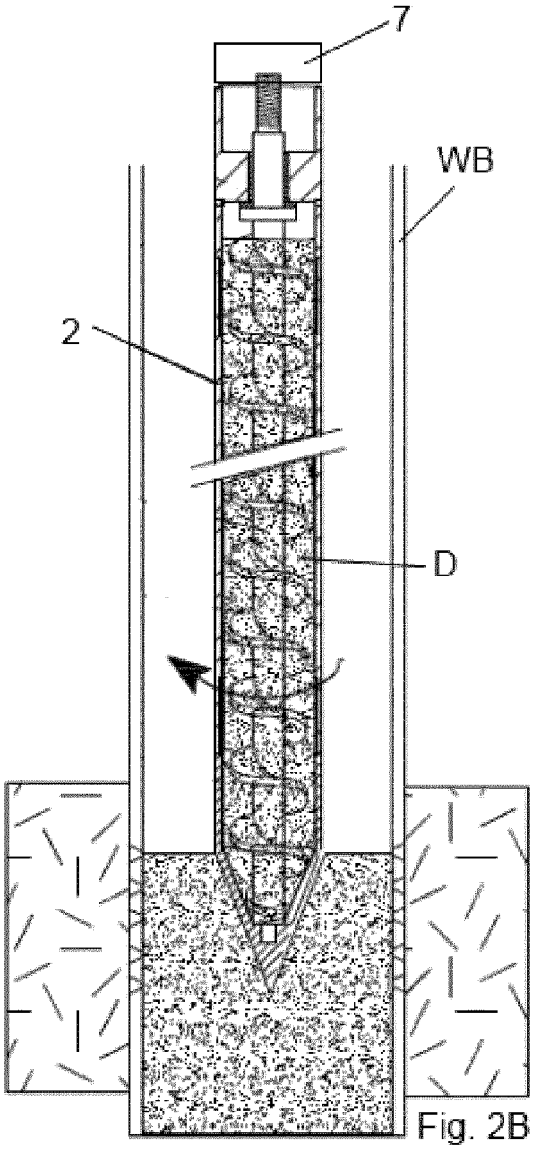

Fig. 2B

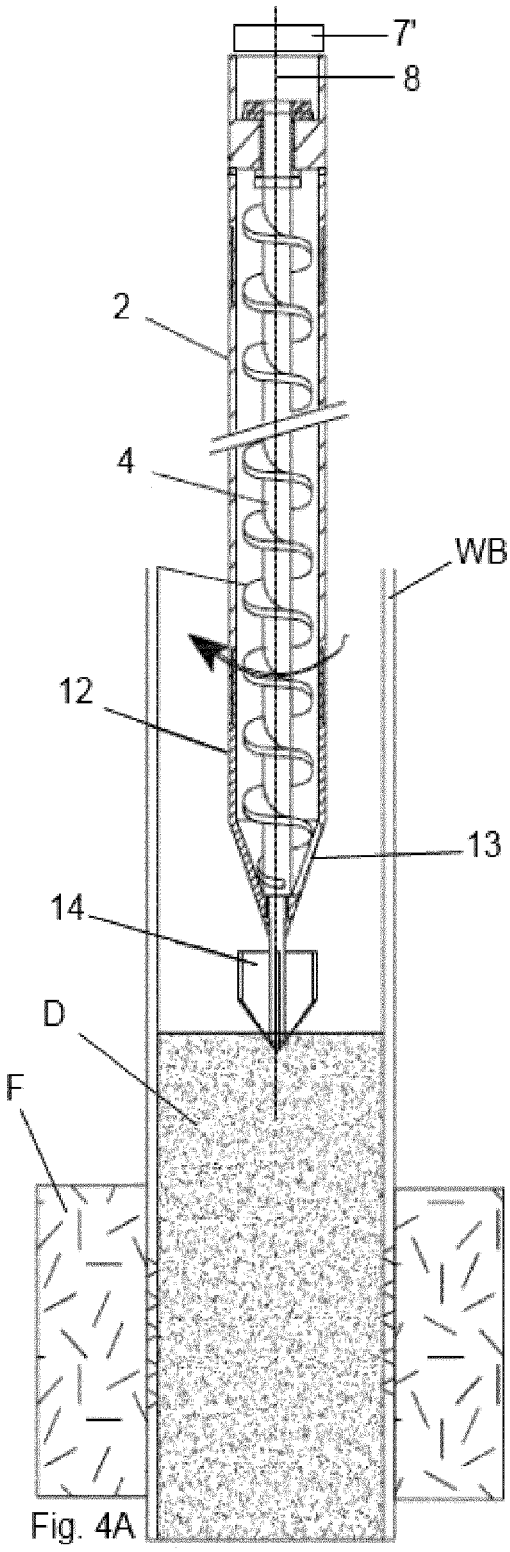

Fig. 4A

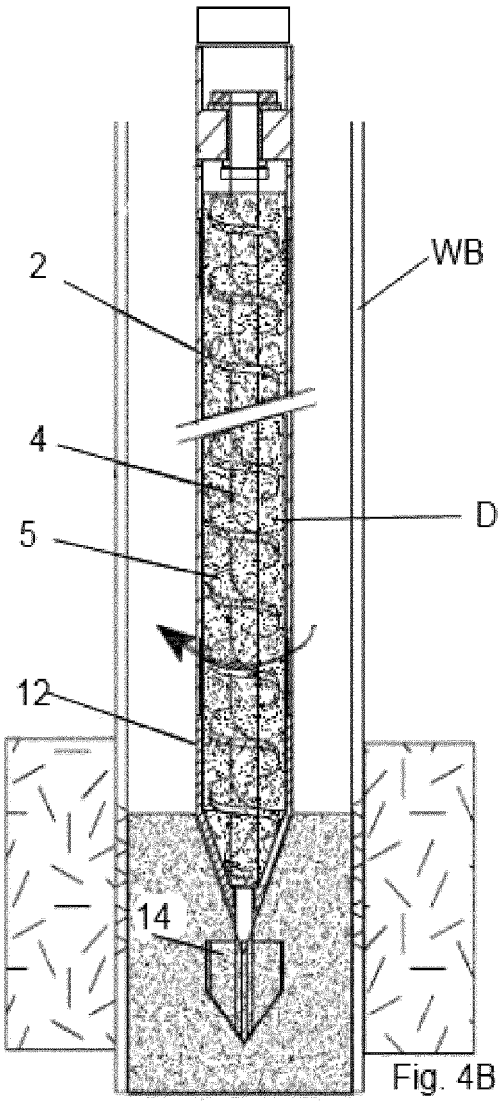

Fig. 4B

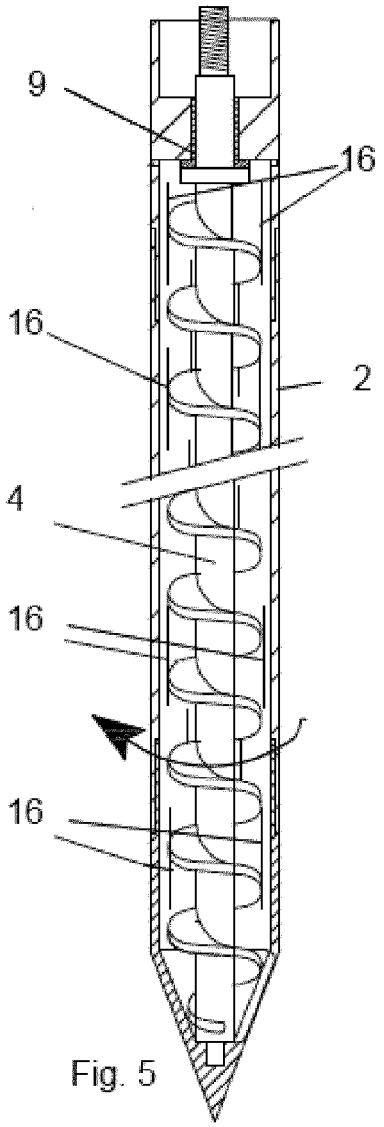

Fig. 5

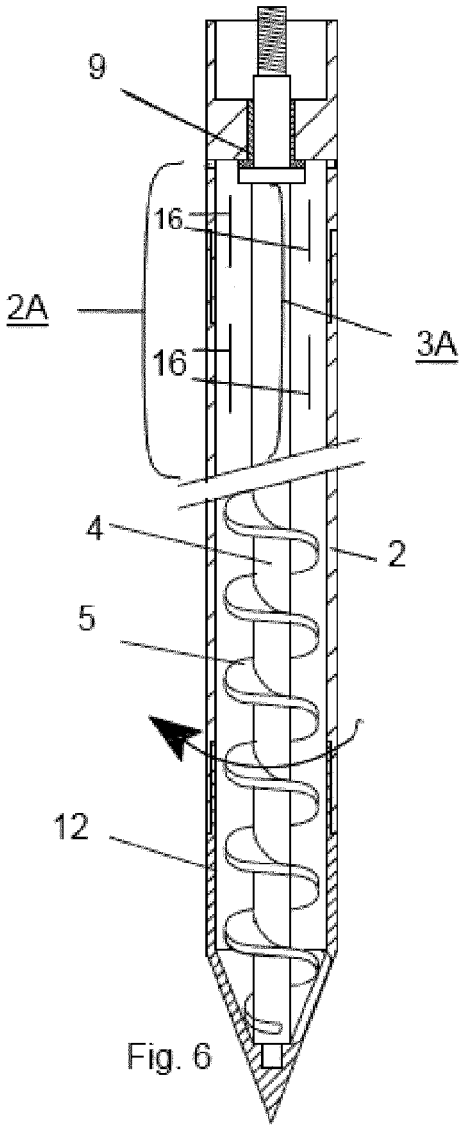

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 8757

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	WO 00/58602 A1 (FRENCH OILFIELD SERVICES LTD [BE]; FRENCH CLIVE JOHN [BE]) 5 October 2000 (2000-10-05) * the whole document * * pages 11-23 * * The drill string may remain rotationally stationary, and the sleeve and screw may rotate around the string, driven by a suitable downhole motor.; figures 1,2 *	1-15	INV. E21B27/04 E21B37/00 E21B10/44 E21B7/00
A	JP 2005 200841 A (OHBAYASHI CORP) 28 July 2005 (2005-07-28) * figures 1c-f,2 * * the whole document *	1	
A	US 2 915 288 A (EDMOND CRAPEZ LEON) 1 December 1959 (1959-12-01) * the whole document *	1	
A	DE 24 25 404 A1 (STIHL MASCHF ANDREAS) 4 December 1975 (1975-12-04) * figure 1 * * the whole document *	1	TECHNICAL FIELDS SEARCHED (IPC) E21B B23B
A	GB 2 114 185 A (MATSUZAWA KIKO KK; SANWA KIZAI CO LTD) 17 August 1983 (1983-08-17) * figure 7 * * the whole document *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28 October 2013	van Berlo, André

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 17 8757

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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28-10-2013

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