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[Continued on next page]

(54) Title: MULTI FLUID DRILLING SYSTEM

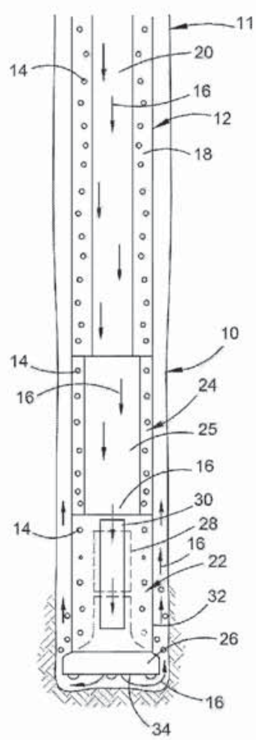

FIGURE 1

(57) Abstract: A multi-fluid drilling system (10) drilling is disclosed for drilling a hole or well (11). The system (10) is coupled to a dual wall drill string (12). The drill string (12) is configured to enable separate flow of a first fluid (14) and a second fluid (16). The system (10) has a hammer (22) and a downhole motor (24). Both the hammer (22) and the motor (24) are supported by and are coupled to the drill string (12). The motor (24) is uphole of the hammer (22). The hammer (22) is arranged so that when supported by the drill string (12) the first fluid (14) when flowing through the drill string (12) is able to flow to and power the hammer (22). As the motor (24) is disposed between the hammer (22) and the drill string (2) the first fluid (14) is also able to flow through the motor (24). To this end the motor (24) has a channel (25) to enable the first fluid to flow from the drill sting (12) to the hammer (22). The channel (25) acts as a part of a flow path or conduit for the first fluid (14).

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

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P97828.PCT	**FOR FURTHER ACTION** See Form PCT/IPEA/416	
International application No. **PCT/AU2016/000002**	International filing date *(day/month/year)* 08 January 2016	Priority date *(day/month/year)* 08 January 2015

International Patent Classification (IPC) or national classification and IPC

See Supplemental Box

Applicant

STRADA DESIGN LIMITED

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of **4** sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of **32** sheets, as follows:
      - [X] sheets of the description, claims and/or drawings which have been amended and/or sheets containing rectifications authorized by this Authority, unless those sheets were superseded or cancelled, and any accompanying letters (see Rules 46.5, 66.8, 70.16, 91.2, and Section 607 of the Administrative Instructions).
      - [ ] sheets containing rectifications not taken into account by this Authority because they were not available at the time when this Authority began to draw up this report, and any accompanying letters (Rules 66.4*bis*, 70.2(e), 70.16 and 91.2).
      - [ ] Superseded sheets and any accompanying letters, where this Authority either considers that the superseding sheets contain an amendment that goes beyond the disclosure in the international application as filed, or the superseding sheets were not accompanied by a letter indicating the basis for the amendments in the application filed, as indicated in item 4 of Box No. I and the Supplemental Box (see Rule 70.16(b)).

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see paragraph 3*bis* of Annex C of the Administrative Instructions).

4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
07 November 2016	14 March 2017
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	**Authorised officer** Matthew McTiernan AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262256103

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2016/000002

Box No. I **Basis of the report**

1. With regard to the **language**, this report has been established on the basis of:

[X] The international application in the language in which it was filed:

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of :

[ ] international search (under Rules 12.3(a) and 23.1 (b)).

[ ] publication of the international application (under Rule 12.4(a)).

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a) and (b)).

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished, or

[X] the description: pages , as originally filed/furnished

pages **1-11** , received by this Authority on **07 November 2016** with the letter of **07 November 2016**

[X] the claims: pages , as originally filed/furnished

pages , as amended (together with any statement) under Article 19,

pages **12-14** , received by this Authority on **14 February 2017** with the letter of **14 February 2017**

[X] the drawings: pages , as originally filed/furnished

pages **1/5-5/5** , received by this Authority on **12 February 2016** with the letter of **12 February 2016**

[ ] a sequence listing - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing (specify):

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since either they are considered to go beyond the disclosure as filed, or they were not accompanied by a letter indicating the basis for the amendments in the application as filed, as indicated in the Supplemental Box (Rules 70.2(c) and (*c-bis*)):

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing (specify):

5. [ ] This report has been established:

[ ] taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.1(d-*bis*) and 70.2(e)).

[ ] without taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rules 66.4*bis* and 70.2(e)).

6. With regard to top-up searches (Rules 66.1*ter* and 70.2(f)):

[X] A top-up search was carried out by this Authority on 19 December 2016.

[ ] Additional relevant documents have been discovered during the top-up search.

[ ] No top-up search was carried out by this Authority because it would serve no useful purpose.

7. [ ] Supplementary international search report(s) from Authority(ies)
has/have been received and taken into account in establishing this report (Rule 45*bis*.8(b) and (c)).

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims **1-19**	**YES**
	Claims **NONE**	**NO**
Inventive step (IS)	Claims **1-19**	**YES**
	Claims **NONE**	**NO**
Industrial applicability (IA)	Claims **1-19**	**YES**
	Claims **NONE**	**NO**

Note: Details of earlier searches conducted following the filing of a demand can be found on Patentscope.

2. CITATIONS AND EXPLANATIONS:

CITATIONS

D1: EP 0233038 A2 (BOART INTERNATIONAL LIMITED) 19 August 1987
D2: US 6742605 B2 (MARTINI) 01 June 2004
D3: US 4852669 A (WALKER) 01 August 1989
D4: US 6659202 B2 (RUNQUIST et al.) 09 December 2003
D5: US 4393944 A (GUGGER et al.) 19 July 1983
D6: US 5853052 A (BAIDEN et al.) 29 December 1998

NOVELTY (N)

Document D6 is considered to represent the closest prior art. D6 discloses a drilling system comprising a first fluid that powers the hammer and a second fluid that powers the motor; wherein the first and second fluids are separate and independent of each other, see col. 2, lines 19-24 & 41-45; col. 4, lines 3-8; and col. 7, line 64 to col. 8 line 10. However, none of the cited documents discloses that the second fluid flows into a hole being drilled by the drilling system. Claims 1, 2, & 13 are therefore novel and comply with PCT Article 33(2).

Appended claims 3-12 & 14-19 add further features to those defined in claims 1, 2 & 13 and are therefore also novel and comply with PCT Article 33(2).

INVENTIVE STEP (IS)

Document D6 is considered to represent the closest prior art. D6 discloses a drilling system comprising a first fluid that powers the hammer and a second fluid that powers the motor; wherein the first and second fluids are separate and independent of each other, see col. 2, lines 19-24 & 41-45; col. 4, lines 3-8; and col. 7, line 64 to col. 8 line 10, but does not disclose that the second fluid flows into a hole being drilled by the drilling system. This feature is not obvious to a person skilled in the art from the cited documents, when taken individually or in any combination. Claims 1, 2, & 13 therefore involve an inventive step and comply with PCT Article 33(3).

Claims 3-12 & 14-19 embody further aspects of the inventive concept and therefore also meet the requirements of Article 33(3) of the PCT.

INDUSTRIAL APPLICABILITY (IA)

The invention defined in the claims is considered to meet the requirements of Industrial Applicability under Article 33(4) of the PCT because it can be made by, or used in, industry.

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY **Supplemental Box – IPC marks**	International Application No. **PCT/AU2016/000002**

E21B 6/04 (2006.01)

E21B 6/08 (2006.01)

E21B 4/06 (2006.01)

E21B 4/02 (2006.01)

E21B 4/14 (2006.01)

E21B 1/00 (2006.01)

E21B 7/00 (2006.01)

E21B 7/04 (2006.01)

E21B 7/24 (2006.01)

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The Receiving Office

7 November 2016

Sir

IN THE MATTER OF International (PCT) Patent Application No. PCT/AU2016/000002
in the name of Strada Design Limited; Warren Strange; Ian Speer
- and -
IN THE MATTER OF Demand for International Preliminary Examination
Our Ref: P97828.PCT

We enclose:

1. Demand for International Preliminary Examination.
2. Prescribed fee of $879.00.
3. Fresh specification and working copy detailing amendments.

We request that the specification as originally filed be cancelled and replaced with the fresh specification as attached.

The effect of the above replacement of pages to the Claims is that claims 1 and 2 are now amended to specify that the drill string is configured to enable separate <u>and independent</u> flow of a first fluid and a second fluid. Claim 13, being a method claim, is amended to include the step of delivering first and second fluids separately <u>and independently</u> of each other through a drill string. New claim 18 is added defining characteristics of the first and second fluids. Corresponding amendments are proposed to the “Summary of the Disclosure” on pages 3 and 4.

Basis for the amendments relating to the “independent” flow can be found in the specification as filed at page 2 lines 12-13. Basis for the inclusion of new claim 18 can be found at page 2 lines 14-16.

It is submitted that the invention defined by the claims at least as amended (and in our view prior to amendment) is clearly distinguishable from each of the prior art documents cited in the ISR. A particularly creative, though with respect illegitimate and unsustainable, interpretation of the prior art has been required in order to support the view regarding novelty in the Written Opinion. It each instance the prior art documents D1-D4 disclose only a single fluid for driving a motor and a hammer.

The claims are directed to a <u>multi</u>-fluid system in which one fluid drives a motor and the other fluid drives a hammer. This means the claims require that there is more than one fluid. In contrast each of the prior art documents disclose only a <u>single</u> fluid drilling system insofar as driving a motor and a hammer are concerned.

Further the claims, before and after amendment, specify that the first and second fluids when in the drill string are separate. The word "separate" means that they do not come together. However in each of the prior art documents the streams considered to constitute the "first fluid" and the "second fluid" do not flow separately within the corresponding drill string. They flow together.

Additionally, at least by virtue of the amendment, the claims required that the first and second fluids are independent. Clearly they are not independent when they are the same fluid.

The benefits achievable by the invention defined by the current claims, such as the ability to selectively modify characteristics of one fluid to provide a desired downhole condition without changing the characteristics of the other fluid, and in which each fluid drives either the motor or the hammer, cannot be replicated by any of the systems described in the prior art references.

The specific differences between each of the prior art references in the claimed invention are set out below.

<u>D1: EP 0233038</u>
D1 describes a down the hole drill which is able to carry or conduct two fluids. Air is able to flow through a pipe 12 in the drill while the hydraulic oil is able to flow through the hoses 11 carried on the outside of the drill. The drill also has a rotary motor 16 and hammer bit driven by a piston 25. The motor 16 and piston 25 are driven by a single fluid only, namely the hydraulic oil flowing through hoses 11. This single fluid is drawn from the tank 32 and pumped by a pump 31 through both of the piston 25 and the motor 16. A tee in the hydraulic circuit forms a first stream of the hydraulic oil that drives the piston 25 while a second stream of the <u>same hydraulic oil</u> drives the motor 16. The streams merge into one and flow via hose 11 through a filter 35 and into tank 32 before being drawn by the pump 31 and delivered again through hose 11 to the tee where they split into the two separate streams. Clearly the two streams are not separate and not independent.

<u>D2: US6742605</u>
D2 describes a single fluid drilling system not a multi fluid drilling system. There is a single fluid only that drives both the motor 4 and subsequently the piston 9. D2 does not describe the system where two fluids flow separately and independently. The separation of the same fluid into two separate flows is an artificial fabrication distorting the teachings of the reference D2. No one of ordinary skill in the art would ever construe the document D2 in the manner suggested in the Written Opinion.

<u>D3: US4852669</u>
D3 describes an air driven drilling system attached to the end of the drill string 1. The drill string 1 has a single air passage 2. Accordingly D3 does not teach or disclose invention defined by any of the present claims. It is physically impossible for the drill string 1 in reference D3 to enable separate and independent flow of a first fluid and a second fluid. Also as with each of D1 and D2 in D3 there is only a single fluid flow that operates both the motor and the drill.

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D4: US6659202

D4 describes various embodiments of a drilling apparatus 10. It is only the embodiment in figure 1 which has both a hammer 12 and a motor 36. Contrary to the assertions in the Written Opinion the embodiments in figures 2 and 3 do not have a fluid operated motor. Reverting back to the embodiment shown in figure 1 as with the prior art documents D2 and D3 there is only a single fluid drives both the motor 36 and the hammer 12. The fluid that drives the motor 36 subsequently drives the hammer 12. There is no disclosure that the drill string 22 is configured to enable separate and independent flow of a first fluid and a second fluid. This is hardly surprising because the drilling apparatus 10 in D4 only requires a single fluid to operate.

The interpretation applied to the references D1-D4 in the Written Opinion is at best fanciful. An analogy is to consider an ordinary garden reticulation system connected to a mains water supply and having two sprinklers, either in series configuration and or in a parallel configuration. Turning ON the reticulation system will result in both sprinklers sprinkling water. Applying the interpretation set out in Written Opinion one would reach the bizarre conclusion that reticulation system is fed by two separate supplies of water because two sprinklers are sprinkling water.

From the above it is clear that the invention defined by present claims is novel over the disclosure in each and every one of the prior art references. As the inventive step opinion is based on the unsustainable interpretation used for the novelty opinion it necessarily follows that the inventive step opinion is also unsustainable.

Yours faithfully
GRIFFITH HACK

A. P. (Tony) Mizzi
Principal
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The Receiving Office

14 February 2017

Sir

IN THE MATTER OF International (PCT) Patent Application No. PCT/AU2016/000002
in the name of Strada Design Limited, Ian Speer and Mr Warren Strange
entitled Multi Fluid Drilling System
Our Ref: P97828.PCT

We write in response to the Written Opinion issued on the above application on 19 December 2016.

We appreciate the efforts of the IPEA in locating the new prior art document D6 (US 5853052) while this application is still in the international phase. It is of enormous benefit to be aware of the prior art before National phase entry.

In order to more clearly distinguish the present invention from the disclosure in D6 is proposed to amend the independent claims of the present application. To this end we request that current claim pages 12-14 be cancelled and replaced with fresh claim pages 12-14 attached.

The effect of the replacement of the claim pages is as follows:

a) Independent claims 1 and 2 are amended to specify that: "**the drilling system is arranged to enable the second fluid to flow into a hole being drilled by the drilling system**"

b) independent claims 13 is amended to include the step of: "**allowing the second fluid to flow into a hole being drilled by the drilling system**"

c) new dependent claim 18 is added defining the steps of "**coupling the down hole motor to a drill string which is arrange to enable the delivering of the first and second fluids to the hammer and the motor respectively; and transmitting torque to the hammer from a surface rotary table or rotation head via the drill string**".

The basis for the amendments a) and b) can be found from each of the accompanying Figures 1-5 which depict the second fluid 16 flowing into the hole 11 after providing power to the motor 24, see also page 6 lines 3-6 and 24-27; page 7 lines 1-2. The basis for amendment c) can be found at page 2 lines 11-12 and lines 20-23.

Prior to responding to the novelty and inventive step observations we make the following comments regard the reference D6. Reference D6 describes a rock drill used for very shallow holes (e.g. 70 to 140 m (column 1 lines 12-16)) commonly required for blast holes. The problems in the prior art discussed by D6 relate to the time taken to drill the holes. This is due to a combination of two factors. One is the use of a drill string made from individual drill rods. The problem here is that to progress hole depth or alternately pull the drill from the hole, for example to replace the drill bit, it is necessary to connect or disconnect the drill rods one by one. When the drill pipe is 1.64 m long this takes a considerable amount of time. A further disadvantage is that the single supply of hydraulic fluid is used to drive a rotary motor, drive the drill bit and remove cuttings from the drill hole (column 2 lines 18-21).

D6 seeks to overcome these problems by firstly replacing a drill string with a flexible conduit 22 and secondly by provision of a new hydraulic motor which has a central conduit 55 for conveying fluid (in this instance air) to a hammer 12. Due to the use of a flexible conduit 22 D6 also requires a tractor 18 to grip the inside of a hole being drilled to react against the drive torque and prevent twisting of the flexible conduit (column 4 lines 48-51).

The fluid supplied by the conduit 55 in the hydraulic drive unit 16 not only powers the hammer 12 but also is used to remove rock chips from the hole being drilled (column 7 lines 51-54). The hydraulic fluid used for driving the hydraulic drive unit 16 is returned via a conduit 150 and outlet 152 to a surface pump for continuous operation of the hydraulic motor (column 6 lines 30-33). Thus the hydraulic fluid is not fed into the drill hole.

D6 is not concerned with downhole pressure and in particular balancing pressure because the described motor and a drill rig are only required to drill to a depth of about 140 m. D6 is not describing a drilling system for oil and gas exploration or production where holes may be drilled to depths exceeding 5000 m. At these depths reservoir pressure can be extremely high and require careful management to comply with safety requirements while also ensuring optimum drilling rates. Further, one would never use a downhole motor and bit suspended from 5000 m of flexible conduit to drill a hole.

The invention defined by the claims as proposed to be amended clarifies that the second fluid, which is used for driving the rotational motor, is supplied or fed into the hole being drilled. This provides substantial benefits to the present invention because it allows control of downhole pressure at significant hole depths, as well as clearing of drill cuttings. For example the claimed invention by way of this feature enables a hole to be operated at: an under pressure, or an overpressure, or a balanced condition. It further enables a hole/well to be killed. This is not possible using the teachings of D6.

Not only does D6 not describe feeding the hydraulic fluid into the hole it specifically teaches against this by describing that the hydraulic fluid is returned to a surface pump for continuous operation of the hydraulic motor. It would not be obvious to therefore direct the hydraulic fluid into the hole. Further, as would be apparent to persons skilled in the art the hydraulic motor of D6 is clearly one driven by hydraulic oil as distinct from drilling mud. This follows from the description of the motor/drive unit itself. One would never use drilling mud for the motor of a type described because the solids in the drilling mud would very quickly wear the critical operating surfaces of the drive unit which would then require replacement thereby increasing drilling time which is counter to the object of D6. Further, one would never deliberately release hydraulic oil into a hole/well due to health and safety requirements. Indeed this would violate environmental protection laws in most countries of the world.

Additionally, the invention as claimed either implicitly or explicitly defines the use of a drill string which supports the hammer and enables the independent flow of the first and second fluids. The drill string by definition is one made from individual drill pipes. Use of the drill string also enables the delivery of torque from an at surface drive through the drill string to the drill bit. Reference D6 positively points away from use of a drill string and advocates the use of a flexible conduit 22.

For the above reasons it is submitted that the invention defined by the claims as amended defines a drilling system and associated method which are clearly novel and not obvious in the light of the reference D6.

Yours faithfully
GRIFFITH HACK

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Abstract

A multi-fluid drilling system 10 drilling is disclosed for drilling a hole or well 11. The system 10 is coupled to a dual wall drill string 12. The drill string 12 is configured to enable separate flow of a first fluid 14 and a second fluid 16. The system 10 has a hammer 22 and a downhole motor 24. Both the hammer 22 and the motor 24 are supported by and are coupled to the drill string 12. The motor 24 is uphole of the hammer 22. The hammer 22 is arranged so that when supported by the drill string 12 the first fluid 14 when flowing through the drill string 12 is able to flow to and power the hammer 22. As the motor 24 is disposed between the hammer 22 and the drill string 12 the first fluid 14 is also able to flow through the motor 24. To this end the motor 24 has a channel 25 to enable the first fluid to flow from the drill sting 12 to the hammer 22. The channel 25 acts as a part of a flow path or conduit for the first fluid 14.

Claims:

1. A multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate and independent flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer;

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when the second fluid flows through the motor; and

wherein the drilling system is arranged to enable the second fluid to flow into a hole being drilled by the drilling system.

2. A multi-fluid powered drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer;

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer; and

wherein the drilling system is arranged to enable the second fluid to flow into a hole being drilled by the drilling system.

3. The drilling system according to claim 1 wherein the hammer is provided with a hammer bit and first fluid is directed through the drilling system to exit the drilling system adjacent the hammer bit.

4. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system so as the flow across a bit face of the hammer bit.

5. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system up hole of a bit face of the hammer bit.

6. The drilling system according to claim 5 comprising a shroud located over the hammer and terminating up hole of the bit face and wherein the second fluid exits the drilling system from a down hole end of the shroud.

7. The drilling system according to any one of claims 1-3 comprising an arrangement of ports associated with the motor for selectively causing the second fluid to flow into the hole being drilled: prior to imparting substantive power to the motor, or, after imparting power to the motor.

8. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an annular flow path formed in the drill string and the second fluid flows in an inner flow path surrounded by the annular flow path.

9. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an inner path formed in the drill string and the second fluid flows in an annular flow path in the drill string, wherein the annular flow path surrounds the inner flow path.

10. The drilling system according to any one of claims 1-9 comprising a steering mechanism coupled between the drill string and the hammer.

11. The drilling system according to claim 10 wherein the steering mechanism is: located between the motor and the hammer; or incorporated in the motor.

12. The drilling system according to any one of the preceding claims comprising a topsides rotation system arranged to rotate the hammer by imparting torque to the drill string.

13. A method of drilling a hole comprising:

coupling a down hole motor to a hammer, the down hole motor being capable of rotating the hammer;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the first fluid powers the hammer to cyclically impact a toe of a hole being drilled; and

the second fluid powers the down hole motor, in isolation of the first fluid, to enable to the down hole motor to rotate the hammer; and

allowing the second fluid to flow into a hole being drilled by the drilling system.

14. The method according to claim 13 comprising directing the first fluid into the hole after operating the hammer.

15. The method according to claim 13 or 14 comprising directing the second fluid into the hole from at least one of the following locations: across a bit face of a bit of the hammer; up hole of the bit face; and, up hole of the hammer.

16. The method according to any one of claims 13-15 comprising using a steering mechanism coupled to hammer to cause a changing in direction of a hole being drilled.

17. The method according to claim 16 comprising operating the down hole motor to rotate the hammer when changing the direction of the hole being drilled.

18. The method according to any one of claims 13-17 comprising coupling the down hole motor to a drill string which is arrange to enable the delivering of the first and second fluids to the hammer and the motor respectively; and transmitting torque to the hammer from a surface rotary table or rotation head via the drill string

19. The system according to any one of claims 1-12 wherein the first and second fluids are in the form of respective liquids having at least one different characteristic. wherein the characteristics comprise: specific gravity, viscosity, rheology, pressure and flow rate.

MULTI FLUID DRILLING SYSTEM

Technical Field

A system and method are disclosed for drilling a hole in the ground. The hole may be for example, but not limited to, exploration or production holes for hydrocarbons or access to subterranean geothermal sources, or waste storage holes.

Background Art

Many types of ground drilling systems are available for drilling holes for particular purposes and in specific ground conditions. One range of downhole drill systems utilise a fluid under pressure to assist in advancing the drill. The fluid may act to either drive a drilling tool coupled to an associated drill string, or to flush drill cuttings from a hole being drilled, or both. The fluid can be a gas such as air or nitrogen, a liquid/slurry such as water or drilling mud, or a combination of a gas and liquid.

For oil and gas exploration and production it is common to use downhole motors which are driven by high specific gravity fluid such as drilling mud to provide rotation to an attached roller bit. The mud can also act to clear cuttings from the hole and provide downhole pressure control. Additionally the volumetric flow rate of mud through a mud motor may be sufficient to kill a well if required. However there is a limitation in terms of drilling in hard materials particularly with directional (i.e. non-vertical holes). This arises due to the inability to apply sufficient downhole pull-down or weight on bit ("WOB") to fracture rock and progress the drilling at an economical rate.

The limitation of penetration in hard materials can overcome by the use of a down the hole (DTH) hammer. DTH hammers are driven by a fluid. While air is a common driving fluid it does not enable control of downhole and ground pressure. Also it is often not possible to provide the air with the required pressure and volume to provide sufficient pressure differential with reference to the prevailing down hole environment to effectively drive the hammer.

Instead of air, water and additives such as drilling mud can used to drive the hammer. This enables higher drilling pressures to be provided to combat high ground pressures. However due to its inherent nature drilling mud rapidly wears the internal surfaces of the hammer leading to the need for frequent replacement. This involves the very time consuming process of tripping the drill string. Also conventional hammer drills do not enable a sufficient volumetric flow rate to kill a well (i.e. flood the well quickly to control or stop the flow of gas and other dangerous well conditions) in the event of a dangerous over pressure condition.

Summary of the Disclosure

In broad terms a drilling system and method are disclosed utilising a plurality of fluids to drive separate downhole devices. The separate downhole devices may comprising a hammer and downhole motor. A hammer bit is attached to the hammer and the hammer is downstream of the motor. The drilling system is coupled to a downhole end of a drill string. The drill string is arranged to enable the separate and independent flow of a first fluid and a second fluid. The first fluid is used to power the hammer. The second fluid is used to power the motor. Both fluids may be liquids. The liquids may, and often will, have different characteristics. The difference may be in terms of one or more of their specific gravity, viscosity, rheology, pressure and flow rate.

The downhole motor can be used to rotate the hammer. However it is also possible to stop flow of the second fluid to the downhole motor in which case the motor will not rotate the hammer. In that event rotation of the hammer can be provided by rotating the drill string for example by use of a surface rotary table or rotation head. In a further alternative torque can be provided to the bit by both the downhole motor and a surface rotary table or rotation head.

A steerable joint or sub may be provided between a downhole end of the drill string and the hammer. Thus the steerable joint or sub can be either between the end of the string and the motor, or between the motor and the hammer. However in an alternate embodiment the downhole motor may be steerable itself by the incorporation of an in-built adjustable bend.

The system is configured so that the second fluid can be discharged into the hole being drilled across the face of the hammer bit. Alternatively the second fluid may be discharged into the hole from a location close to the face of the bit; or from a location up hole of the hammer drill.

The use of multiple fluids makes it possible to optimise the system and method by appropriate selection of the fluids to meeting different their specific requirements. For example the first fluid can be optimised for operating the hammer in terms of power, speed, efficiency and longevity. On the other hand the second fluid may be optimised in terms of operating the motor and: clearing the hole of drill cuttings; hole stability; and, providing a desired downhole pressure condition, either by itself or when mixed with the first fluid in the event that the first fluid is into the hole exhausted after operating the hammer. The parameters or characteristic that may be selected for the second fluid include but are not limited to: up hole velocity, viscosity and specific gravity.

The first fluid may be denoted as a “power fluid” as this is the fluid that provides power to drive the down the hole hammer drill. It is the power fluid that flows through a porting arrangement of the hammer to reciprocate a piston which cyclically impacts the hammer bit of the hammer. In various embodiments the first fluid may comprise a liquid or a gas or combination thereof, such as but is not limited to: water, oil, air, nitrogen gas, or mixtures thereof.

The second fluid in addition to proving power to the motor has other functions which can be performed either simultaneously or separately in various circumstances. For example the second fluid may function as a flushing fluid to flush cuttings from the hole and in particular from near the bit face of the hammer bit. The second fluid may also be used to control downhole pressure. For this reason the second fluid may also be denoted as a “flushing fluid” or a “control fluid”. The second fluid in most instances is a liquid such as but not limited to: water, drilling mud or in, for example dangerous over pressure conditions, cement/grout. In the event that water is used as the second fluid it is not of great significance to the operational life of the hammer if the water carries with it significant fractions of particulate material. That is dirty water may be used to operate the motor. Whereas clean water is preferable used for the hammer.

In a first aspect there is disclosed a multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate and independent flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer drill; and

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when second fluid flows through the motor.

In a second aspect there is disclosed a multi-fluid drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer; and

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer.

In a third aspect there is disclosed a method of drilling a hole comprising:

coupling a motor to a hammer the motor being capable of rotating the hammer drill;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the first fluid powers the hammer to cyclically impact a toe of a hole being drilled; and

the second fluid powers the motor, in isolation of the first fluid, to enable to the motor to rotate the hammer.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the system and method as set forth in the Summary, a specific embodiment will now be described by way of example only with reference to the accompanying drawing in which:

Figure 1 is a schematic representation of a first embodiment of the disclosed multi-fluid drilling system;

Figure 2 is a schematic representation of a second embodiment of the disclosed multi-fluid drilling system;

Figure 3 is a schematic representation of a third embodiment of the disclosed multi-fluid drilling system;

Figure 4 is a schematic representation of a fourth embodiment of the disclosed multi-fluid drilling system; and,

Figure 5 is a schematic representation of a fifth embodiment of the disclosed multi-fluid drilling system.

Detailed Description of Specific Embodiments

Figure 1 illustrates one embodiment of the disclosed multi-fluid drilling system 10 drilling a hole or well 11. The system 10 is coupled to a dual wall drill string 12. The drill string 12 is configured to enable separate flow of a first fluid 14 depicted by circles and a second fluid 16 depicted by arrows. In this instance the first fluid 14 flows in an outer annular path or channel 18 of the drill string 12 while the second fluid 16 flows through an inner channel or flow path 20. The system 10 comprises a hammer 22 and a downhole motor 24. Both the hammer 22 and the motor 24 are supported by and are coupled to the drill string 12. The motor 24 is uphole of the hammer 22.

The hammer 22 is arranged so that when supported by the drill string 12 the first fluid 14 when flowing through the drill string 12 is able to flow to and power the hammer 22. As the motor 24 is disposed between the hammer 22 and the drill string 12 the first fluid 14 is also able to flow through the motor 24. To this end the motor 24 has a channel 25 to enable the first fluid to flow from the drill sting 12 to the hammer 22. The channel 25 acts as a part of a flow path or conduit for the first fluid 14.

The hammer 22 is of generally conventional construction and includes amongst other features, a hammer bit 26, a piston 28, and a central tube 30. The hammer 22 also includes a porting arrangement (not shown) through which the first fluid 14 flows. The porting arrangement comprises a plurality of surfaces formed on the piston 28 and on an inner circumferential surface of a porting sleeve (not shown). The piston 28 is caused to reciprocate along the central tube 30 by action of the fluid 14 passing through the porting arrangement. This provides impact force onto the bit 26. The fluid 14 is then exhausted generally between the outside of the bit 26 and an outer casing 32 of the hammer 22.

The motor 24 is driven by the flow of the second fluid 16. The second fluid 16 when passing through the motor 24 causes a rotor (not shown) in the motor 24 to rotate relative to the corresponding stator (not shown). The rotor is coupled to the hammer 22. Thus when fluid 16 passes through the motor 24, the hammer 22 including the associated hammer bit 26 rotate.

In this embodiment the second fluid 16 is caused to flow through the central tube 30 and subsequently through an internal passage in the hammer bit 26. This passage opens onto a bit face 34. The fluid 16 is then able to flow across the bit face 34 and subsequently back up the hole/well 11 being drilled by the system 10. The fluids 14 and 16 mix as they travel back up the hole/well 11.

Figure 2 illustrates a second embodiment of the disclosed system 10a. The same reference numbers used in Figure 1 to describe features of the system 10 above are used in Figure 2 to denote the same features of the system 10a. The system 10a is in substance the same as the system 10 however the first fluid 14 in this embodiment flows through the inner channel 20 while the second fluid 16 passes through the annular channel 18. As a result of this the system 10a also includes a crossover sub 35 between the drill string 12 and the motor 24. The crossover sub 35 crosses the flow paths of the first and second fluids 14 and 16 from the drill string 12 to the motor 24 so that: the second fluid 16 remains flowing through the channel 25 in the motor 24 and subsequently through the inner tube 30 of the hammer 22; and, the first fluid 14 is directed to the porting arrangement of the hammer 22.

Figure 3 illustrates a further embodiment of the disclosed system designated as 10b. The same reference numbers used in Figure 1 to describe features of the system 10 above are used in Figure 3 to denote the same features of the system 10b. The system 10b differs from the system 10 only by way of the outlet or exit points for the second fluid 16. In the system 10b the second fluid 16 exits the system 10 near but uphole of the hammer 22. This is achieved by the provision of ports 36 in the motor 24 which enable the second fluid 16 to flow out of the motor 24 uphole of the hammer 22 and into the hole being drilled. In this embodiment the first fluid 14 continues to flow through the motor 24 and to the hammer 22 to cause reciprocation of the piston 28 and thus provide the impact force for the hammer bit 26. The fluid 14 exits the system 10b from between the outer housing 32 and the bit 26. Again both fluids 14 and 16 will mix in the hole 11 and flow upward to bring drill cuttings to the surface.

Figure 4 depicts a further embodiment designated as system 10c. The system 10c is a variation of the system 10b. The variation lies in a minor reconfiguration of the ports 36 and the addition of an external shroud 38. The shroud 38 extends over the outer housing 32 of the hammer 22. The shroud 38 and outer housing 32 are configured so to form an annular flow path 40 there between. The port 36 is arranged to direct the fluid 16 to flow through the flow path 40. The second fluid 16 then exits the system 10c adjacent the head of the hammer bit 26 but upstream of the bit face 34. The first fluid 14 also exits the system 10c from between a lower end of the outer housing 32 and the hammer bit 26. Thus in this instance both the fluids 14 and 16 exit from substantially the same location on the drill system 10c and flow upwardly to carry drill cuttings to the surface.

Each of the systems 10b and 10c shown in Figures 3 and 4 respectively can be further modified in a manner so as to cause the fluid 16 to in essence bypass the motor 24 and thus be pumped directly into the hole being drilled rather than operate the motor 24. To modify the systems 10b and 10c to operate in this manner both require further exit ports 42. The ports 42 are upstream of the ports 36.

In these modified embodiments each of the ports 36 and 42 is also provided with valves 37 and 43 respectively. The valves 37 and 43 can be selectively and independently opened and closed.

By closing the valves 43 in the upstream ports 42 and opening the valves 37 in the downstream ports 36, the systems 10b and 10c operate as previously described. However if the valves 37 in the ports 36 are closed and the valves 43 in the ports 42 opened then the fluid 16 is caused to substantially bypass the motor 24 and flow directly in to the hole being drilled. Consequently the motor 24 will provide very little if any rotational torque to the hammer 22. In that event, rotation of the hammer 22 and the corresponding hammer bit 26 may be provided by an uphole rotation head or turntable coupled to the drill string 12. In both instances the fluid 16 will be pumped into the hole/well 11.

Figure 5 shows a further embodiment of a disclosed system designated here as 10d. The same reference numbers used in Figure 1 to describe features of the system 10 above are used in Figure 5 to denote the same features of the system 10d. The system 10d differs from the earlier systems 10-10c by the inclusion of a steering mechanism 50. The steering mechanism 50 is illustrated in this embodiment as being disposed between the hammer 22 and the motor 24. However in an alternate embodiment the steering mechanism 50 may be located between the end of the drill string 12 and the motor 24. It is however generally preferable to have the steering mechanism as close as possible to the bit face 34. In its simplest form the steering mechanism may be incorporated as a bent housing in the motor 24 or by using a bent sub or eccentric stabiliser. Thus although the steering mechanism 50 is shown as being separate from the motor 24 it may be incorporated as part of the motor 24.

The provision of the steering mechanism 50 enables the drilling system 10d to be used for directional drilling. In such when drilling a straight section of the hole (e.g. before and after a bend) the hammer 22/hammer bit 26 are rotated by rotating the drill string 12. In one embodiment when it is required to change the direction of drilling the second fluid 16 is delivered through the string 12 to the motor 24. This will activate the steering mechanism to deflect the line of drilling of the hammer 22 and associated bit 26 in comparison to the line of the drill string 12. Once the appropriate bend has been drilled, delivery of the second fluid 16 can cease and rotation is again provided by rotating the string 12 using for example a drill head or turntable. However other known bent subs or steerable subs/joints may be used to provide directional control of the hole/well 11 being drilled which are actived without the need to stop the flow of the second fluid 16. Indeed this is favoured in most circumstances so as to maintain a desired down hole pressure and continuous flushing and stabilisation of the hole/well 11.

The steering mechanism 50 may be introduced into each of the system 10a, 10b and 10c described above. In particular when used in conjunction with the modified forms of systems 10b or 10c having the valve controlled ports 36 and 42, it is possible to maintain a flow of the second fluid 16 into the hole/well 11 irrespective of whether while forming a bend or turn in the hole/well 11. The steering mechanism may be incorporated as part of the motor 24 in all of the embodiments.

In each of the above described embodiments the first fluid 14 can be a gas or a liquid (i.e. compressible or incompressible fluid). The first fluid 16 can be a gas such as air if the hole depths and pressure differentials are such that air can be delivered at sufficient pressure and flow rate/volume to operate the hammer 22. Alternately the first fluid 14 can be a liquid (i.e. incompressible fluid) such as but not limited to water. This may be beneficial when drilling deep holes in order to provide the pressure differential to operate the hammer 22. The term “water” in the context of the first fluid 14 in operating or powering the hammer 22 is intended to be reference to clean water or relatively clean water with an acceptably small fraction of small particulate matter. For example the water can have a purity of 5μ. This is to be distinguished from dirty water or muds which essentially are water mixed with significant fractions of relatively large particulate matter. It is indeed known to use mud to down hole hammers. However such hammers have a short service life as the mud has an abrasive effect on the internal workings of the hammer and in particular the porting surfaces. This leads to rapid degradation of performance and the necessity to change the hammer 22 on a regular basis.

The second fluid 16 which flows in isolation to the first fluid 14 can be chosen, in addition to providing power to drive the motor 24, to have characteristics to control downhole conditions, provide lubrication to the bit face 34 and flush cuttings from the hole/well 11. The fluid 16 may be but is not limited to gases, water, dirty water, drilling mud, drilling additives, lubricants and a combination of two or more of these.

Although the first fluid 14 is not crucial in terms of controlling downhole pressure conditions it's density and viscosity can be taken into account when selecting the second fluid 16 so that the mixture of the fluids 14 and 16 provide a desired downhole pressure condition. Thus, one can select or modify the characteristics of the second fluid 16 to provide the desired downhole conditions taking into account, but without requiring any change of, the first fluid 14.

In the event that dangerous conditions are detected it is possible to provide second fluid 16 at sufficient volume and flow rate to kill the well. This arises due to the manner in which the second fluid 16 is delivered which provides for a substantially greater volume of liquid than with a traditional down hole fluid hammer.

The above the systems 10-10d enable a method of drilling a hole or well in the ground using a fluid operated hammer 22 with an adjacent fluid operated motor providing torque. Separate fluids 14 and 16 are used to drive the hammer 22 and the motor 24. The fluids may be matched to the prevailing down hole conditions and/or for optimum operation of the hammer and/or the motor 24. The fluids 14 and 16 may be pumped into an up hole end of the drill string 12 using a dual circulation fluid inlet swivel.
The above described embodiments of the system and associated drilling method are particularly, but not exclusively, suited to drilling: oil and gas; or geothermal wells in hard ground formations, or drilling very deep holes, such as for example depth in excess of 5000m. In particular, embodiments of the disclosed system and method enable the use of down the hole drilling tools in the form of down the hole hammers which are very well suited to drilling in hard materials although do not find favour when drilling for oil/gas due to the trade-off between longevity of the drilling tool and the ability to control down hole pressure and maintain hole stability. For example to drill

with a marginal under pressure, when using a regular down hole hammer, it may be required to operate the hammer with a fluid of a relatively high specific gravity. This will entail using a mud or slurry to drive the hammer. However by its very nature the mud or slurry will contain particles that abrade and wear the hammer. As a result it becomes necessary to trip the drill string more regularly in order to replace the worn hammer. When a hole is several kilometres deep, the tripping of the drill string may take up to or exceed 24 hours. However if a hammer driving fluid of lower specific gravity is used then the ability to provide a specific pressure condition may be lost. Embodiments of the system and method enable separate provision and control of the parameters and characteristics of the working and flushing fluids thereby enabling maximum efficiency and longevity of the down hole tool while also providing control over down hole pressure and hole stability.

Embodiments of the presently disclosed system and method use two separate fluid flows all the way to the bottom of the drill string 12 and in many embodiments the well/hole 11. Consequently the fluids 14 and 16 will mix at or very close to the bit face 34 i.e. the bottom of the well 11. This allows for well control with maximum effect and safety and for the mixing of the both fluids at or very near the bit face.

The ratio between the first fluid 14 and the second fluid 16 may be between 10/90 and 30/70. That is 10% first fluid 16 and 90% second fluid 18. This means for example during the drilling of a 8.5 inch well using 5.5 inch drill pipe, an embodiment of the disclosed the hammer 22 will use 10% to 30% of the total well volume as a first fluid 16.

Looked at in terms of fluid volumes and pressures, say for example the total volume of fluid required to drill and lift drill cuttings is 1,000 litres per minute pumped at a pressure of 5,000 psi. The hammer 22 will use 100 to 300 litres per minute of that total volume. The second fluid will be pumped at around 4,000 psi and the flow rate will be 900 to 700 litters per minute.

Thus embodiments of the disclosed the system and method are very efficient in comparison to say a normally operated water hammer. In comparable downhole environment and depth, a normally operated water hammer would typically use over 1,000 litres per minute and up to 2,000 litres per minute. This is substantially more than the 100-300 litres per minute of embodiments of the disclosed system and method.

In the disclosed system and method the provision of separate fluid flows for the motor and hammer enables "tuning" of the drilling process wherein the rotation speed/torque and percussive energy of the hammer bit can be separately controlled. The rotation speed/torque of the hammer bit 26 can be controlled by controlling the flow and other characteristics of the second fluid 16 which drives the motor 24. The percussive energy of the hammer bit 26 can be controlled by controlling the flow and other characteristics of the first fluid 14. Thus for example it is possible drill with low bit rotation speed and high bit percussive energy impact speed; or high bit rotation speed and low bit percussive energy; or indeed more generally any combination of bit rotation speed and bit percussive energy.

The motor 24 may be in the form of a vane or turbine type motor. Such a motor has a central drive shaft that is coupled to the hammer 22 to rotate the hammer 22. The central drive shaft is provided with a bore which forms the channel 25. Alternatively the drive shaft may be provided with a bore and an inner rotationally decoupled sleeve that forms the channel 25.

Embodiments of the system and method may be used on either land or offshore rigs. In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the disclosed system and method.

Claims:

1. A multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate and independent flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer; and

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when the second fluid flows through the motor.

2. A multi-fluid powered drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer;

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer.

3. The drilling system according to claim 1 wherein the hammer is provided with a hammer bit and first fluid is directed through the drilling system to exit the drilling system adjacent the hammer bit.

4. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system so as the flow across a bit face of the hammer bit.

5. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system up hole of a bit face of the hammer bit.

6. The drilling system according to claim 5 comprising a shroud located over the hammer and terminating up hole of the bit face and wherein the second fluid exits the drilling system from a down hole end of the shroud.

7. The drilling system according to any one of claims 1-3 comprising an arrangement of ports associated with the motor for selectively causing the second fluid to flow into the hole being drilled: prior to imparting substantive power to the motor, or, after imparting power to the motor.

8. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an annular flow path formed in the drill string and the second fluid flows in an inner flow path surrounded by the annular flow path.

9. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an inner path formed in the drill string and the second fluid flows in an annular flow path in the drill string, wherein the annular flow path surrounds the inner flow path.

10. The drilling system according to any one of claims 1-9 comprising a steering mechanism coupled between the drill string and the hammer.

11. The drilling system according to claim 10 wherein the steering mechanism is: located between the motor and the hammer; or incorporated in the motor.

12. The drilling system according to any one of the preceding claims comprising a topsides rotation system arranged to rotate the hammer by imparting torque to the drill string.

13. A method of drilling a hole comprising:

coupling a down hole motor to a hammer, the down hole motor being capable of rotating the hammer;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the first fluid powers the hammer to cyclically impact a toe of a hole being drilled; and

the second fluid powers the down hole motor, in isolation of the first fluid, to enable to the down hole motor to rotate the hammer.

14. The method according to claim 13 comprising directing the first fluid into the hole after operating the hammer.

15. The method according to claim 13 or 14 comprising directing the second fluid into the hole from at least one of the following locations: across a bit face of a bit of the

hammer; up hole of the bit face; and, up hole of the hammer.

16. The method according to any one of claims 13-15 comprising using a steering mechanism coupled to hammer to cause a changing in direction of a hole being drilled.

17. The method according to claim 16 comprising operating the down hole motor to rotate the hammer when changing the direction of the hole being drilled.

18. The system according to any one of claims 1-12 wherein the first and second fluids are in the form of respective liquids having at least one different characteristic. wherein the characteristics comprise: specific gravity, viscosity, rheology, pressure and flow rate.

Claims:

1. A multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate and independent flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer; ~~and~~

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when the second fluid flows through the motor; and

wherein the drilling system is arranged to enable the second fluid to flow into a hole being drilled by the drilling system.

2. A multi-fluid powered drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer;

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer; and

wherein the drilling system is arranged to enable the second fluid to flow into a hole being drilled by the drilling system.

3. The drilling system according to claim 1 wherein the hammer is provided with a hammer bit and first fluid is directed through the drilling system to exit the drilling system adjacent the hammer bit.

4. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system so as the flow across a bit face of the hammer bit.

5. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system up hole of a bit face of the hammer bit.

6. The drilling system according to claim 5 comprising a shroud located over the hammer and terminating up hole of the bit face and wherein the second fluid exits the drilling system from a down hole end of the shroud.

7. The drilling system according to any one of claims 1-3 comprising an arrangement of ports associated with the motor for selectively causing the second fluid to flow into the hole being drilled: prior to imparting substantive power to the motor, or, after imparting power to the motor.

8. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an annular flow path formed in the drill string and the second fluid flows in an inner flow path surrounded by the annular flow path.

9. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an inner path formed in the drill string and the second fluid flows in an annular flow path in the drill string, wherein the annular flow path surrounds the inner flow path.

10. The drilling system according to any one of claims 1-9 comprising a steering mechanism coupled between the drill string and the hammer.

11. The drilling system according to claim 10 wherein the steering mechanism is: located between the motor and the hammer; or incorporated in the motor.

12. The drilling system according to any one of the preceding claims comprising a topsides rotation system arranged to rotate the hammer by imparting torque to the drill string.

13. A method of drilling a hole comprising:

coupling a down hole motor to a hammer, the down hole motor being capable of rotating the hammer;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the first fluid powers the hammer to cyclically impact a toe of a hole being drilled; and

the second fluid powers the down hole motor, in isolation of the first fluid, to enable to the down hole motor to rotate the hammer; and

allowing the second fluid to flow into a hole being drilled by the drilling system.

14. The method according to claim 13 comprising directing the first fluid into the hole after operating the hammer.

15. The method according to claim 13 or 14 comprising directing the second fluid into the hole from at least one of the following locations: across a bit face of a bit of the hammer; up hole of the bit face; and, up hole of the hammer.

16. The method according to any one of claims 13-15 comprising using a steering mechanism coupled to hammer to cause a changing in direction of a hole being drilled.

<u>17.</u> The method according to claim 16 comprising operating the down hole motor to rotate the hammer when changing the direction of the hole being drilled.

~~17.~~<u>18. The method according to any one of claims 13-17 comprising coupling the down hole motor to a drill string which is arrange to enable the delivering of the first and second fluids to the hammer and the motor respectively; and transmitting torque to the hammer from a surface rotary table or rotation head via the drill string</u>

~~18.~~<u>19.</u> The system according to any one of claims 1-12 wherein the first and second fluids are in the form of respective liquids having at least one different characteristic. wherein the characteristics comprise: specific gravity, viscosity, rheology, pressure and flow rate.

example the first fluid can be optimised for operating the hammer in terms of power, speed, efficiency and longevity. On the other hand the second fluid may be optimised in terms of operating the motor and: clearing the hole of drill cuttings; hole stability; and, providing a desired downhole pressure condition, either by itself or when mixed with the first fluid in the event that the first fluid is into the hole exhausted after operating the hammer. The parameters or characteristic that may be selected for the second fluid include but are not limited to: up hole velocity, viscosity and specific gravity.

The first fluid may be denoted as a “power fluid” as this is the fluid that provides power to drive the down the hole hammer drill. It is the power fluid that flows through a porting arrangement of the hammer to reciprocate a piston which cyclically impacts the hammer bit of the hammer. In various embodiments the first fluid may comprise a liquid or a gas or combination thereof, such as but is not limited to: water, oil, air, nitrogen gas, or mixtures thereof.

The second fluid in addition to proving power to the motor has other functions which can be performed either simultaneously or separately in various circumstances. For example the second fluid may function as a flushing fluid to flush cuttings from the hole and in particular from near the bit face of the hammer bit. The second fluid may also be used to control downhole pressure. For this reason the second fluid may also be denoted as a “flushing fluid” or a “control fluid”. The second fluid in most instances is a liquid such as but not limited to: water, drilling mud or in, for example dangerous over pressure conditions, cement/grout. In the event that water is used as the second fluid it is not of great significance to the operational life of the hammer if the water carries with it significant fractions of particulate material. That is dirty water may be used to operate the motor. Whereas clean water is preferable used for the hammer.

In a first aspect there is disclosed a multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate <u>and independent</u> flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer drill; and

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when second fluid flows through the motor.

In a second aspect there is disclosed a multi-fluid drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer; and

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer.

In a third aspect there is disclosed a method of drilling a hole comprising:

coupling a motor to a hammer the motor being capable of rotating the hammer drill;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the ~~a~~ first fluid ~~to the hammer to enable~~powers the hammer to cyclically impact a toe of a hole being drilled; and

~~delivering a~~the second fluid ~~to~~ powers the motor, in isolation of the first fluid, to enable to the motor to rotate the hammer.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the system and method as set forth in the Summary, a specific embodiment will now be described by way of example only with reference to the accompanying drawing in which:

Figure 1 is a schematic representation of a first embodiment of the disclosed multi-fluid drilling system;

Figure 2 is a schematic representation of a second embodiment of the disclosed multi-fluid drilling system;

Figure 3 is a schematic representation of a third embodiment of the disclosed multi-fluid drilling system;

Figure 4 is a schematic representation of a fourth embodiment of the disclosed multi-fluid drilling system; and,

Claims:

1. A multi-fluid drilling system capable of being coupled to an end of a drill string configured to enable separate and independent flow of a first fluid and a second fluid, the system comprising:

a hammer arranged so that when supported by the drill string a first fluid flowing through the drill string is able to power the hammer; and

a motor arranged so that when supported by the drill string a second fluid flowing through the drill string is able to flow through and power the motor;

the motor being coupled to the hammer and arranged to rotate the hammer when the second fluid flows through the motor.

2. A multi-fluid powered drilling system comprising:

a drill string configured to enable separate and independent flow of a first fluid and a second fluid;

a hammer supported by the drill string and in fluid communication with the drill string wherein the first fluid is able to power the hammer;

a motor supported by the drill string and in fluid communication with the drill string wherein the second fluid is able to flow through and power the motor, the motor arranged to rotate the hammer.

3. The drilling system according to claim 1 wherein the hammer is provided with a hammer bit and first fluid is directed through the drilling system to exit the drilling system adjacent the hammer bit.

4. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system so as the flow across a bit face of the hammer bit.

5. The drilling system according to any one of claims 1-3 wherein hammer is provided with a hammer bit and the second fluid is directed through the drilling system to exit the drilling system up hole of a bit face of the hammer bit.

6. The drilling system according to claim 5 comprising a shroud located over the hammer and terminating up hole of the bit face and wherein the second fluid exits the drilling system from a down hole end of the shroud.

7. The drilling system according to any one of claims 1-3 comprising an arrangement of ports associated with the motor for selectively causing the second fluid to flow into the hole being drilled: prior to imparting substantive power to the motor, or, after imparting power to the motor.

8. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an annular flow path formed in the drill string and the second fluid flows in an inner flow path surrounded by the annular flow path.

9. The drilling system according to any one of claims 1-7 wherein the first fluid flows in an inner path formed in the drill string and the second fluid flows in an annular flow path in the drill string, wherein the annular flow path surrounds the inner flow path.

10. The drilling system according to any one of claims 1-9 comprising a steering mechanism coupled between the drill string and the hammer.

11. The drilling system according to claim 10 wherein the steering mechanism is: located between the motor and the hammer; or incorporated in the motor.

12. The drilling system according to any one of the preceding claims comprising a topsides rotation system arranged to rotate the hammer by imparting torque to the drill string.

13. A method of drilling a hole comprising:

coupling a down hole motor to a hammer, the down hole motor being capable of rotating the hammer;

delivering first and second fluids separately and independently of each other through a drill string to the hammer and the motor respectively wherein the ~~a~~ first fluid ~~to the hammer to enable~~powers the hammer to cyclically impact a toe of a hole being drilled; and

~~delivering a~~the second fluid ~~to~~ powers the down hole motor, in isolation of the first fluid, to enable to the down hole motor to rotate the hammer.

14. The method according to claim 13 comprising directing the first fluid into the hole after operating the hammer.

15. The method according to claim 13 or 14 comprising directing the second fluid

into the hole from at ~~one~~ least one of the following locations: across a bit face of a bit of the hammer; up hole of the bit face; and, up hole of the hammer.

16. The method according to any one of claims 13-15 comprising using a steering mechanism coupled to hammer to cause a changing in direction of a hole being drilled.

17. The method according to claim 16 comprising operating the down hole motor to rotate the hammer when changing the direction of the hole being drilled.

18. The system according to any one of claims 1-12 wherein the first and second fluids are in the form of respective liquids having at least one different characteristic. wherein the characteristics comprise: specific gravity, viscosity, rheology, pressure and flow rate.

SISTEMA DE PERFORACIÓN MULTI FLUIDOS

Campo técnico

Se describe un sistema y un método para perforar un orificio en el suelo. El orificio puede estar, por ejemplo, pero no limitado a, orificios de exploración o producción para hidrocarburos o acceso a fuentes geotérmicas subterráneas, o orificios para almacenamiento de desechos.

Antecedentes de la técnica

Existen muchos tipos de sistemas de perforación de suelos para perforar orificios para propósitos particulares y en condiciones específicas del suelo. Una serie de sistemas de perforación de fondo de pozo utilizan un fluido a presión para ayudar a avanzar el taladro. El fluido puede actuar para impulsar una herramienta de perforación acoplada a una columna de perforación asociada, o para enjuagar los cortes de taladro desde un orificio perforado, o ambos. El fluido puede ser un gas tal como el aire o nitrógeno, un líquido/suspensión tal como el agua o lodo de perforación, o una combinación de gas y líquido.

Para la exploración y producción de petróleo y gas, es común el uso de motores de fondo de pozo que son accionados por un fluido de alta densidad específica tal como lodo de perforación para proporcionar rotación a una broca rotatoria de martillo adjunta. El lodo también puede actuar para despejar los cortes del orificio y proporcionar un control de presión en el fondo del pozo. Además, la tasa de flujo volumétrica del lodo a través de un motor de lodo puede ser suficiente para eliminar un pozo si es necesario. Sin embargo, hay una limitación en términos de perforación en materiales duros, particularmente con orificios direccionales (es decir, no verticales). Esto se debe a la incapacidad de aplicar suficiente empuje descendente o peso sobre la broca ("WOB") para fracturar la roca y avanzar la perforación a una tasa económica.

La limitación de la penetración en materiales duros puede superarse mediante el uso de un martillo de perforación (DTH). Los martillos DTH son accionados por un fluido. Aunque el aire es un fluido de conducción común, no permite el control de la presión del pozo y del suelo. También a menudo no es posible proporcionar aire con la presión y el volumen requeridos para proporcionar un diferencial de presión suficiente con referencia al ambiente prevaleciente del orificio descendente para accionar eficazmente el martillo.

En lugar de aire, se puede utilizar agua y aditivos como el lodo de perforación para impulsar el martillo. Esto permite presiones de perforación más altas proporcionadas para combatir las altas presiones del suelo. Sin embargo, debido a su naturaleza inherente, el lodo de la perforación rápidamente desgasta las superficies internas del martillo, lo que conduce a la necesidad de un reemplazo frecuente. Esto implica que el proceso requiera de mucho tiempo para activar la columna de perforación. Además, los taladros de martillo convencionales no permiten una tasa de flujo volumétrica suficiente para eliminar un pozo (es decir, inundar el pozo rápidamente para controlar o detener el flujo de gas y otras condiciones de pozo peligrosas) en el caso de una condición peligrosa de sobrepresión.

Resumen de la divulgación

En términos generales, se describe un sistema y un método de perforación que utilizan una pluralidad de fluidos para conducir dispositivos de fondo de pozo separados. Los dispositivos de fondo de pozo separados pueden comprender un martillo y un motor de fondo de pozo. Una broca de martillo está unida al martillo y el martillo está descendente del motor. El sistema de perforación está acoplado en un extremo descendente a una columna de perforación. La columna de perforación está dispuesta para permitir el flujo separado e independiente de un primer fluido y un segundo fluido. El primer fluido se utiliza para accionar el martillo. El segundo fluido se utiliza para accionar el motor. Ambos fluidos pueden ser líquidos. Los líquidos pueden, y muchas veces tendrán, características diferentes. La diferencia puede ser en términos de uno o más de su gravedad específica, viscosidad, reología, presión y tasa de flujo.

El motor del fondo del pozo se puede utilizar para girar el martillo. Sin embargo, también es posible detener el flujo del segundo fluido al motor de fondo de pozo, en cuyo caso el motor no girará el martillo. En ese caso, la rotación del martillo puede proporcionarse girando la columna de perforación, por ejemplo, mediante el uso de una mesa giratoria de superficie o cabezal de rotación. En otra realización, se puede proporcionar un torque alternativo a la broca tanto por el motor de fondo de pozo como por una mesa giratoria de superficie o cabezal de rotación.

Se puede proporcionar una unión o sub unión orientable entre un extremo de fondo de la columna de perforación y el martillo. De este modo, la unión o sub unión orientable puede estar entre el extremo de la columna y el motor, o entre el motor y el martillo. Sin embargo, en una realización alternativa, el motor de fondo de pozo puede ser dirigible por sí mismo mediante la incorporación de una curvatura ajustable incorporada.

El sistema está configurado de manera que el segundo fluido pueda ser descargado en el orificio que se está perforando a través de la cara de la broca del martillo. Alternativamente, el segundo fluido también se puede descargar en el orificio desde una ubicación cerca de la cara de la parte o desde una ubicación ascendente del taladro de martillo.

El uso de múltiples fluidos permite optimizar el sistema y el método mediante una selección adecuada de los fluidos para satisfacer sus necesidades específicas. Por ejemplo, el primer fluido puede ser optimizado para operar el martillo en términos de potencia, velocidad, eficiencia y longevidad. Por otra parte, el segundo fluido puede optimizarse en términos de funcionamiento del motor y: eliminación del orificio de las estacas de perforación; estabilidad del orificio; y, proporcionar una condición de presión de fondo deseada, ya sea por sí misma o cuando se mezcla con el primer fluido en el caso que el primer fluido se encuentre agotado dentro del orificio después de operar el martillo. Los parámetros o características que pueden seleccionarse para el segundo fluido incluyen, pero no se limitan a: la velocidad del orificio, la viscosidad y la gravedad específica.

El primer fluido puede ser denotado como un “fluido de potencia”, ya que este es el fluido que proporciona potencia para impulsar el taladro de martillo de fondo de pozo. Es el fluido de potencia que fluye a través de un dispositivo portador del martillo para alternar un pistón que choca cíclicamente una parte del martillo. En varias realizaciones, el primer fluido puede comprender un líquido o un gas o una combinación de estos, tal como, pero no limitado a: agua, aceite, aire, nitrógeno gaseoso o mezclas de estos.

El segundo fluido, además de probar la potencia al motor, tiene otras funciones que pueden realizarse simultáneamente o por separado en diversas circunstancias. Por ejemplo, el segundo fluido puede funcionar como un fluido de limpieza para limpiar los cortes del orificio y en particular desde cerca de la cara de la broca del martillo. El segundo fluido también se puede usar para controlar la presión de fondo de pozo. Por esta razón, el segundo fluido también se puede designar como un “fluido de limpieza” o un “fluido de control”. El segundo fluido, en la mayoría de los casos, es un líquido tal como, pero no limitado a: agua, lodo de perforación o, por ejemplo, condiciones peligrosas de sobrepresión, cemento/lechada. En el caso que se utilice agua como segundo fluido, no es de gran importancia para la vida operativa del martillo si el agua lleva consigo fracciones significativas de material particulado. Esta agua sucia se puede utilizarse para operar el motor. Aunque es preferible usar agua limpia para el martillo.

En un primer aspecto se describe un sistema de perforación multi-fluido capaz de ser acoplado a un extremo de una columna de perforación configurada para permitir el flujo separado e independiente de un primer fluido y un segundo fluido, comprendiendo el sistema:

un martillo dispuesto de modo que, cuando está soportado por la columna de perforación, un primer fluido que fluye a través de la columna de perforación es capaz de accionar el taladro de martillo; y

un motor dispuesto de modo que, cuando es soportado por la columna de perforación, un segundo fluido que fluye a través de la columna de perforación es capaz de fluir a través de y accionar el motor;

un motor estando acoplado al martillo y dispuesto para hacer girar la broca del martillo cuando el segundo fluido fluye a través del motor.

En un segundo aspecto se describe un sistema de perforación multi-fluido que comprende:

Una columna de perforación configurada para permitir el flujo separado e independiente de un primer fluido y un segundo fluido;

un martillo soportado por la columna de perforación y en comunicación fluida con la columna de perforación en la que el primer fluido es capaz de accionar el martillo; y

un motor soportado por la columna de perforación y en comunicación fluida con la columna de perforación, en el que el segundo fluido es capaz de fluir a través y accionar el motor, el motor dispuesto para hacer girar el martillo.

En un tercer aspecto, se describe un método de perforación de un orificio que comprende:

acoplar un motor a un martillo, siendo el motor capaz de hacer girar el taladro de martillo;

proporcionando un segundo fluido por separado e independientemente uno del otro a través de una columna de perforación al martillo y el motor, respectivamente, en el que el primer fluido acciona al martillo para que haga impacto cíclico en una punta del orificio que se está perforando; y

el segundo fluido acciona al motor en aislamiento del primer fluido para permitir que el motor haga girar el martillo.

Breve descripción de los gráficos

No obstante, cualquier otra forma que pueda caer dentro del alcance del sistema y método expuestos en el Resumen, se describirá ahora una forma de realización específica a modo de ejemplo, solamente con referencia al gráfico adjunto en el que:

La figura 1 es una representación esquemática de una primera realización del sistema de perforación multi-fluido descrito;

La figura 2 es una representación esquemática de una segunda realización del sistema de perforación multi-fluido descrito;

La Figura 3 es una representación esquemática de una tercera realización del sistema de perforación multi-fluido descrito;

La figura 4 es una representación esquemática de una cuarta realización del sistema de perforación multi-fluido descrito; y,

La figura 5 es una representación esquemática de una quinta realización del sistema de perforación multi-fluido descrito.

Descripción detallada de realizaciones específicas

La figura 1 ilustra una realización del sistema de perforación multi-fluido 10 que perfora un orificio o pozo 11. El sistema 10 está acoplado a una columna de perforación de doble pared 12. La columna de perforación 12 está configurada para permitir el flujo separado de un primer fluido 14 representado por círculos y un segundo fluido 16 representado por flechas. En este caso, el primer fluido 14 fluye en una trayectoria anular exterior o canal 18 de la columna de perforación 12 mientras que el segundo fluido 16 fluye a través de un canal interior o vía de flujo 20. El sistema 10 comprende un martillo 22 y un motor de fondo de pozo 24. El martillo 22 y el motor 24 están soportados por y están acoplados a la columna de perforación 12. El motor 24 es ascendente del martillo 22.

El martillo 22 está dispuesto de manera que cuando está soportado por la columna de perforación 12, el primer fluido 14, cuando fluye a través de la columna de perforación 12, es capaz de fluir hacia y accionar el martillo 22. Como el motor 24 está dispuesto entre el martillo 22 y la columna de perforación 12, el primer fluido 14 también es capaz de fluir a través del motor 24. Con este fin, el motor 24 tiene un canal 25 para permitir que el primer fluido fluya desde la columna de perforación 12 al martillo 22. El canal 25 actúa como parte de una vía de flujo o conducto para el primer fluido 14.

El martillo 22 es de construcción generalmente convencional e incluye, entre otras características, un martillo 26, un pistón 28 y un tubo central 30. El martillo 22 también incluye una disposición portante (no mostrada) a través de la cual fluye el primer fluido 14. La disposición portante comprende una pluralidad de superficies formadas sobre el pistón 28 y sobre una superficie circunferencial interior de una manga portante (no mostrado). El pistón 28 es obligado a moverse alternativamente a lo largo del tubo central 30 por acción del fluido 14 que pasa a través de la disposición de transporte. Esto proporciona fuerza de impacto sobre la broca 26. El fluido 14 se agota entonces generalmente entre el exterior de la broca 26 y una carcasa exterior 32 del martillo 22.

El motor 24 es accionado por el flujo del segundo fluido 16. El segundo fluido 16 cuando pasa a través del motor 24 hace que un rotor (no mostrado) en el motor 24 gire con relación al estator correspondiente (no mostrado). El rotor está acoplado al martillo 22. Así, cuando el fluido 16 pasa a través del motor 24, el martillo 22 que incluye la broca de martillo asociada 26 gira.

En esta realización, el segundo fluido 16 es obligado a fluir a través del tubo central 30 y subsiguientemente a través de un paso interno en la broca 26. Este paso se abre sobre una cara la broca 34. El fluido 16 puede entonces fluir a través de la cara de la broca 34 y subsiguientemente refuerza el orificio/pozo 11 perforado por el sistema 10. Los fluidos 14 y 16 se mezclan a medida que recorren el orificio/pozo 11.

La Figura 2 ilustra una segunda realización del sistema descrito 10a. Los mismos números de referencia utilizados en la figura 1 para describir las características del sistema 10 anterior se usan en la figura 2 para designar las mismas características del sistema 10a. El sistema 10a es sustancialmente el mismo que el sistema 10, sin embargo, el primer fluido 14 en esta realización fluye a través del canal interior 20 mientras que el segundo fluido 16 pasa a través del canal anular 18. Como resultado de esto, el sistema 10a incluye también un sub-cruce 35 entre la columna de perforación 12 y el motor 24. El sub-cruce 35 cruza las trayectorias de flujo del primer y segundo fluido 14 y 16 desde la columna de perforación 12 al motor 24 de modo que: el segundo fluido 16 permanece fluyendo a través del canal 25 en el motor 24 y posteriormente a través del tubo interior 30 del martillo 22; y el primer fluido 14 está dirigido al arreglo portante del martillo 22.

La figura 3 ilustra una realización adicional del sistema descrito designado como 10b. Los mismos números de referencia usados en la Figura 1 para describir las características del sistema 10 anterior se usan en la Figura 3 para designar las mismas características del sistema 10b. El sistema 10b difiere del sistema 10 sólo a través de la salida o puntos de salida para el segundo fluido 16. En el sistema 10b, el segundo fluido 16 sale del sistema 10 cerca, pero ascendente del martillo 22. Esto se consigue mediante la provisión de puertos 36 en el motor 24 que permiten que el segundo fluido 16 fluya fuera del motor de pozo de fondo 24 del martillo 22 y dentro del orificio que se perfora. En esta realización, el primer fluido 14 continúa fluyendo a través del motor 24 y al martillo 22 para provocar el movimiento alternativo del pistón 28 y así proporcionar la fuerza de impacto para la broca 26. El fluido 14 sale del sistema 10b desde entre la carcasa externa 32 y la broca 26. Nuevamente, ambos fluidos 14 y 16 se mezclarán en el orificio 11 y fluirán ascendentes para llevar los cortes del taladro a la superficie.

La figura 4 representa una realización adicional designada como sistema 10c. El sistema 10c es una variación del sistema 10b.

La variación radica en una reconfiguración menor de los orificios 36 y la adición de una envoltura externa 38. La envoltura 38 se extiende sobre la carcasa exterior 32 del martillo 22. La envoltura 38 y la carcasa exterior 32 están configuradas de modo que formen una vía de flujo anular 40 entre ellos. El puerto 36 está dispuesto para dirigir el fluido 16 para que fluya a través de la trayectoria de flujo 40. El segundo fluido 16 sale entonces del sistema 10c adyacente a la cabeza del martillo 26 pero ascendente de la cara de la broca 34. El primer fluido 14 también sale del sistema 10c entre un extremo inferior de la carcasa exterior 32 y la broca de martillo 26. Así, en este caso, tanto los fluidos 14 como 16 salen sustancialmente de la misma posición en el sistema de perforación 10c y fluyen ascendentes para transportar los cortes de taladro hacia la superficie.

Cada uno de los sistemas 10b y 10c ilustrados en las figuras 3 y 4, respectivamente, puede modificarse adicionalmente, de manera que haga que el fluido 16, en esencia, se desvíe del motor 24 y, de este modo, se bombee directamente al orificio que se perfora en lugar de accionar el motor 24. Para modificar los sistemas 10b y 10c para operar de esta manera, ambos requieren puertos de salida adicionales 42. Los puertos 42 están ascendentes de los puertos 36.

En estas realizaciones modificadas, cada uno de los puertos 36 y 42 está también provisto de válvulas 37 y 43 respectivamente. Las válvulas 37 y 43 pueden abrirse y cerrarse selectiva e independientemente.

Al cerrar las válvulas 43 en los puertos ascendentes 42 y abrir las válvulas 37 en los puertos descendentes 36, los sistemas 10b y 10c funcionan como se ha descrito anteriormente. Sin embargo, si las válvulas 37 en los orificios 36 están cerradas y las válvulas 43 en los orificios 42 se abren, entonces el fluido 16 se desvía sustancialmente del motor 24 y fluye directamente hacia el orificio perforado. En consecuencia, el motor 24 proporcionará muy poco o ningún torque de rotación al martillo 22. En ese caso, la rotación del martillo 22 y la broca correspondiente 26 puede estar proporcionada por un cabezal de giro ascendente o plataforma giratoria acoplada a la columna de perforación 12. En ambos casos, el fluido 16 será bombeado dentro del orificio/pozo 11.

La figura 5 muestra una realización adicional de un sistema descrito designado aquí como 10d. Los mismos números de referencia usados en la Figura 1 para describir las características del sistema 10 anterior se usan en la Figura 5 para designar las mismas características del sistema 10d. El sistema 10d difiere de los sistemas anteriores 10-10c por la inclusión de un mecanismo de dirección 50. El mecanismo de dirección 50 se ilustra en esta realización estando dispuesto entre el martillo 22 y el motor 24. Sin embargo, en una realización alternativa, el mecanismo de dirección 50 puede estar situado entre el extremo de la columna de perforación 12 y el motor 24. Sin embargo, es generalmente preferible tener el mecanismo de dirección lo más próximo posible a la cara de la broca 34. En su forma más simple, el mecanismo de dirección puede incorporarse como una carcasa doblada en el motor 24 o utilizando un estabilizador sub o excéntrico curvado. Así, aunque el mecanismo de dirección 50 se muestra separado del motor 24, puede incorporarse como parte del motor 24.

La provisión del mecanismo de dirección 50 permite que el sistema de perforación 10d se utilice para la perforación direccional. En tal caso, cuando se perfora una sección recta del orificio (por ejemplo, antes y después de un viraje), el martillo 22/ broca de martillo 26 se hace girar haciendo girar la columna de perforación 12. En una realización cuando se requiere cambiar la dirección de perforación, se suministra el segundo fluido 16 A través de la columna 12 hasta el motor 24. Esto activará el mecanismo de dirección para desviar la línea de perforación del martillo 22 y la broca asociada 26 en comparación con la línea de la columna de perforación 12. Una vez perforada la curvatura apropiada, el suministro del segundo fluido 16 puede cesar y la rotación se proporciona de nuevo girando la columna 12 utilizando, por ejemplo, una cabeza de taladro o una plataforma giratoria. Sin embargo, pueden usarse otras uniones dobladas u orientables conocidas para proporcionar control direccional del orificio/ pozo 11 perforado que se activan sin la necesidad de detener el flujo del segundo fluido 16. En efecto, esto es favorecido en la mayoría de las circunstancias para así mantener una presión descendente deseada y un lavado y estabilización continuos del orificio/pozo 11.

El mecanismo de dirección 50 puede introducirse en cada uno de los sistemas 10a, 10b y 10c descritos anteriormente. En particular, cuando se usa junto con las formas modificadas de los sistemas 10b o 10c que tienen los orificios controlados por las válvulas 36 y 42, es posible mantener un flujo del segundo fluido 16 dentro del orificio/ pozo 11, independientemente de si se forma una curva o giro en el orificio/pozo 11. El mecanismo de dirección puede incorporarse como parte del motor 24 en todas las realizaciones.

En cada una de las realizaciones descritas anteriormente, el primer fluido 14 puede ser un gas o un líquido (es decir, fluido compresible o incompresible). El primer fluido 16 puede ser un gas como el aire si las profundidades de orificio y los diferenciales de presión son tales que el aire pueda ser suministrado a una presión y tasa de flujo/volumen suficiente para operar el martillo 22. Alternativamente, el primer fluido 14 puede ser un líquido fluido incompresible) tal como, pero no limitado al agua. Esto puede ser beneficioso cuando se perforan orificios profundos con el fin de proporcionar la diferencia de presión para operar el martillo 22. El término "agua" en el contexto del primer fluido 14 al operar o accionar el martillo 22 está referido al agua limpia o relativamente limpia con una pequeña fracción aceptable de material particulado pequeño. Por ejemplo, el agua puede tener una pureza de 5 µ. Esto se debe distinguir de agua sucia o lodos que esencialmente son agua mezclada con fracciones significativas de materia particulada relativamente grande. De hecho, se sabe que se usa lodo para martillos de pozo de fondo. Sin embargo, tales martillos tienen una vida útil corta, ya que el lodo tiene un efecto abrasivo sobre el funcionamiento interno del martillo y, en particular, sobre las superficies portantes. Esto conduce a una degradación rápida del rendimiento y a la necesidad de cambiar el martillo 22 de una manera regular.

El segundo fluido 16 que fluye de forma aislada al primer fluido 14 puede ser elegido, además de proporcionar potencia para accionar el motor 24, para tener características para controlar las condiciones descendentes, proporcionar lubricación a la broca 34 y recortes del orificio/pozo 11. El fluido 16 puede ser, pero no está limitado a, gases, agua, agua sucia, lodo de perforación, aditivos de perforación, lubricantes y una combinación de dos o más de estos.

Aunque el primer fluido 14 no es crucial en términos de control de las condiciones de presión descendente, su densidad y viscosidad pueden tenerse en cuenta al seleccionar el segundo fluido 16, de modo que la mezcla de los fluidos 14 y 16 proporcione una condición de presión descendente deseada. De este modo, se pueden seleccionar o modificar las características del segundo fluido 16 para proporcionar las condiciones descendentes deseadas, teniendo en cuenta, pero sin requerir ningún cambio, del primer fluido 14.

En el caso que se detecten condiciones peligrosas, es posible proporcionar un segundo fluido 16 a un volumen y tasa de flujo suficientes para eliminar el pozo. Esto surge debido a la manera en la que se suministra el segundo fluido 16, que proporciona un volumen sustancialmente mayor de líquido que con un martillo de fluido tradicional de pozo de fondo.

Los anteriores sistemas 10-10d permiten un método de perforación de un orificio o pozo en el suelo utilizando un martillo accionado por fluido 22 con un motor accionado por fluido adyacente que proporciona torque. Se utilizan fluidos separados 14 y 16 para accionar el martillo 22 y el motor 24. Los fluidos pueden adaptarse a las condiciones predominantes descendentes y/o para un funcionamiento óptimo del martillo y/o del motor 24. Los fluidos 14 y 16 pueden ser bombeados en un extremo ascendente de la columna de perforación 12 usando un eslabón giratorio de entrada de fluido de circulación doble. Las realizaciones descritas anteriormente del sistema y el método de perforación asociado son particularmente, pero no exclusivamente, adecuados para perforar: petróleo y gas; o pozos geotérmicos en formaciones de suelo duro, o taladrando orificios muy profundos, como por ejemplo de una profundidad de más de 5000 m. En particular, las realizaciones del sistema y el método descritos permiten el uso de las herramientas de perforación de orificios en forma de martillos de perforación que son muy adecuados para perforar materiales duros, aunque no son favorables al perforar petróleo/ gas debido al equilibrio entre la longevidad de la herramienta de perforación y la capacidad de controlar la presión del orificio y mantener la estabilidad del orificio. Por ejemplo, para perforar con una subpresión marginal cuando se utiliza un martillo de orificio regular, puede ser necesario operar el martillo con un fluido de una gravedad específica relativamente alta. Esto implicará el uso de un lodo o lechada para impulsar el martillo. Sin embargo, por su propia naturaleza, el barro o lodo contendrá partículas que desgastan y agotan el martillo. Como resultado, se hace necesario activar la columna de perforación con más frecuencia para reemplazar el martillo desgastado. Cuando un orificio tiene varios kilómetros de profundidad, el disparo de la columna de perforación puede tardar hasta o exceder las 24 horas. Sin embargo, si se utiliza un fluido de accionamiento de martillo de menor gravedad específica, entonces se puede perder la capacidad de proporcionar una condición de presión específica.

Las realizaciones del sistema y del método permiten la provisión y el control separados de los parámetros y características de los fluidos de trabajo y de lavado, permitiendo así la máxima eficacia y longevidad de la herramienta de pozo de fondo, proporcionando también control sobre la presión descendente y la estabilidad de orificio.

Las realizaciones del sistema y método descritos en la presente usan dos flujos de fluido separados hasta el fondo de la columna de perforación 12 y en muchas realizaciones el pozo/orificio 11. En consecuencia, los fluidos 14 y 16 se mezclarán en o muy cerca de la cara de la broca 34, es decir, el fondo del pozo 11. Esto permite el control del pozo con el máximo efecto y seguridad y la mezcla de ambos fluidos en o muy cerca de la cara de la broca.

La relación entre el primer fluido 14 y el segundo fluido 16 puede estar entre 10/90 y 30/70. Esto es un 10% del primer fluido 16 y 90% del segundo fluido 18. Esto significa, por ejemplo, que durante la perforación de un pozo de 8.5 pulgadas usando una tubería de perforación de 5.5 pulgadas, una realización del martillo revelado 22 usará de 10% a 30% del volumen total del pozo como un primer fluido 16.

Considerados en términos de volúmenes y presiones de fluidos, digamos, por ejemplo, el volumen total de fluido requerido para taladrar y levantar cortes de taladro es de 1000 litros por minuto bombeado a una presión de 5000 psi. El martillo 22 utilizará de 100 a 300 litros por minuto de ese volumen total. El segundo fluido será bombeado a alrededor de 4000 psi y la tasa de flujo será de 900 a 700 litros por minuto.

Por tanto, las realizaciones del sistema y método descritos son muy eficaces en comparación con un martillo de agua accionado normalmente. En un entorno y una profundidad de pozo comparables, un martillo de agua normalmente operado usaría típicamente más de 1000 litros por minuto y hasta 2000 litros por minuto. Esto es sustancialmente más que los 100-300 litros por minuto de las realizaciones del sistema y método descritos.

En el sistema y método descritos, la provisión de flujos de fluido separados para el motor y el martillo permite “afinar” el proceso de perforación en el que la velocidad de rotación/ torque y la energía de percusión del martillo pueden controlarse por separado. La velocidad de rotación/torque de la broca del martillo 26 se puede controlar controlando el flujo y otras características del segundo fluido 16 que acciona el motor 24. La energía de percusión de la broca del martillo 26 puede ser controlada controlando el flujo y otras características del primer fluido 14. Así, por ejemplo, es posible taladrar con baja velocidad de rotación de broca y alta velocidad de impacto de percusión; o alta velocidad de rotación de broca y baja energía de percusión de broca; o incluso más generalmente cualquier combinación de velocidad de rotación de broca y energía de percusión de broca.

El motor 24 puede estar en forma de un motor de tipo paleta o turbinas. Un motor de este tipo tiene un eje de accionamiento central que está acoplado al martillo 22 para hacer girar el martillo 22. El eje de accionamiento central está provisto de un orificio que forma el canal 25. Alternativamente, el árbol de accionamiento puede estar provisto de un orificio y una rotación interna desacoplado que forma el canal 25.

Las realizaciones del sistema y método pueden ser usadas en plataformas terrestres o en alta mar. En las reivindicaciones que siguen y en la descripción anterior de la invención, excepto cuando el contexto requiere de otra manera debido a un lenguaje expreso o implicación necesaria, la palabra “comprende” o variaciones tales como “comprende” o “comprendiendo” se usa en un sentido inclusivo, es decir, para especificar la presencia de las características indicadas, pero no para excluir la presencia o adición de otras características en varias realizaciones del sistema y método descritos.

Reivindicaciones:

1. Un sistema de perforación multi-fluido capaz de ser acoplado a un extremo de una columna de perforación configurada para permitir el flujo separado e independiente de un primer fluido y un segundo fluido, comprendiendo el sistema:

un martillo dispuesto de modo que, cuando está soportado por la columna de perforación, un primer fluido que fluye a través de la columna de perforación es capaz de accionar el martillo; y

un motor dispuesto de modo que, cuando es soportado por la columna de perforación, un segundo fluido que fluye a través de la columna de perforación es capaz de fluir a través y accionar el motor;

el motor estando acoplado al martillo y dispuesto para hacer girar el martillo cuando el segundo fluido fluye a través del motor; y

en el que el sistema de perforación está dispuesto para permitir que el segundo fluido fluya dentro de un orificio perforado por el sistema de perforación.

2. Un sistema de perforación accionado por múltiples fluidos que comprende:

una columna de perforación configurada para permitir el flujo separado e independiente de un primer fluido y un segundo fluido;

un martillo soportado por la columna de perforación y en comunicación fluida con la columna de perforación, en la que el primer fluido es capaz de accionar el martillo;

un motor soportado por la columna de perforación y en comunicación fluida con la columna de perforación, en el que el segundo fluido es capaz de fluir a través de y accionar el motor, el motor dispuesto para hacer girar el martillo; y

en el que el sistema de perforación está dispuesto para permitir que el segundo fluido fluya dentro de un orificio perforado por el sistema de perforación

3. El sistema de perforación según la reivindicación 1, en el que el martillo es proporcionado con una broca de martillo y el primer fluido es dirigido a través del sistema de perforación para salir del sistema de perforación adyacente a la broca del martillo.

4. El sistema de perforación de acuerdo con cualquiera de las reivindicaciones 1 - 3, en el que el martillo es proporcionado con una broca de martillo y el segundo fluido es dirigido a través del sistema de perforación para salir del sistema de perforación, de modo que el flujo es a través de una cara de la broca del martillo.

5. El sistema de perforación, de acuerdo con cualquiera de las reivindicaciones 1 - 3, en el que el martillo es proporcionado con una broca de martillo y el segundo fluido es dirigido a través del sistema de perforación para salir del sistema de perforación ascendente de una cara de la broca de martillo.

6. El sistema de perforación, de acuerdo con la reivindicación 5, que comprende una envoltura situada sobre el martillo y el orificio de terminación de la cara de la broca y en el que el segundo fluido sale del sistema de perforación desde un extremo descendente de la envoltura.

7. El sistema de perforación, según cualquiera de las reivindicaciones 1 a 3, que comprende una disposición de puertos asociados con el motor para hacer que el segundo fluido fluya de forma selectiva al interior del orificio siendo perforado: antes de impartir potencia sustancial al motor o, después de impartir potencia al motor.

8. El sistema de perforación, de acuerdo con cualquiera de las reivindicaciones 1 a 7, en el que el primer fluido fluye en una trayectoria de flujo anular formada en la columna de perforación y el segundo fluido fluye en una trayectoria de flujo interno rodeada por la trayectoria de flujo anular.

9. El sistema de perforación, de acuerdo con cualquiera de las reivindicaciones 1 a 7, en el que el primer fluido fluye en una trayectoria interna formada en la columna de perforación y

el segundo fluido fluye en una trayectoria de flujo anular en la columna de perforación, donde la ruta de flujo anular rodea la ruta de flujo interno.

10. El sistema de perforación, de acuerdo con cualquiera de las reivindicaciones 1 - 9, que comprende un mecanismo de dirección acoplado entre la columna de perforación y el martillo.

11. El sistema de perforación de acuerdo con la reivindicación 10, en el que el mecanismo de dirección está situado entre el motor y el martillo o incorporado en el motor.

12. El sistema de perforación, de acuerdo con cualquiera de las reivindicaciones precedentes que comprende un sistema de rotación de lado superior dispuesto para hacer girar el martillo impartiendo torque a la columna de perforación.

13. Un método para perforar un orificio que comprende:

acoplar un motor de fondo de pozo a un martillo, siendo el motor de fondo de pozo capaz de girar el martillo;

suministrar un primer fluido y segundo fluido por separado e independientemente uno del otro a través de una columna de perforación al martillo y el motor respectivamente donde el primer fluido acciona al martillo para que haga impacto cíclico en una punta del orificio que se está perforando; y el segundo fluido acciona al motor de fondo de pozo en aislamiento del primer fluido para permitir que el motor de fondo de pozo haga girar el martillo; y

permitir que el segundo fluido fluya dentro de un orificio perforado por el sistema de perforación..

14. El método de acuerdo con la reivindicación 13, que comprende dirigir el primer fluido dentro del orificio después de operar el martillo.

15. El método según la reivindicación 13 ó 14, que comprende dirigir el segundo fluido dentro del orificio desde al menos una de las siguientes ubicaciones: a través de una cara de una broca del martillo; ascendente de la broca; y, ascendente del martillo.

16. El método de acuerdo con cualquiera de las reivindicaciones 13-15, que comprende el uso de un mecanismo de dirección acoplado al martillo para provocar un cambio en la dirección de un orificio que se está perforando.

17. El método de acuerdo con la reivindicación 16, que comprende hacer funcionar el motor de fondo de pozo para girar el martillo al cambiar la dirección del orificio que se está perforando.

18. El método de acuerdo con cualquiera de las reivindicaciones 13-17, que comprende acoplar el motor de pozo de fondo a una columna de perforación que está dispuesta para permitir la

liberación del primer y segundo fluido al martillo y al motor, respectivamente; y transmitir el torque al martillo desde una mesa giratoria de superficie o cabezal de rotación a través de la columna de perforación.

19. El sistema de acuerdo con cualquiera de las reivindicaciones 1 a 12, en el que el primer y el segundo fluido están en forma de líquidos respectivos que tienen al menos una característica diferente, en el que las características comprenden: gravedad específica, viscosidad, reología, presión y tasa de flujo.

Resumen

Se describe un sistema de perforación multi-fluido 10 para la perforación de un orificio o pozo 11. El sistema 10 está acoplado a una columna de perforación de doble pared 12. La columna de perforación 12 está configurada para permitir el flujo separado de un primer fluido 14 y un segundo fluido 16. El sistema 10 tiene un martillo 22 y un motor de fondo de pozo 24. Tanto el martillo 22 como el motor 24 están soportados por y están acoplados a la columna de perforación 12. El motor 24 es ascendente del martillo 22. El martillo 22 está dispuesto de modo que cuando está soportado por la columna de perforación 12, el primer fluido 14 cuando fluye a través de la columna de perforación 12 es capaz de fluir hacia y accionar el martillo 22. Cuando el motor 24 está dispuesto entre el martillo 22 y la columna de perforación 12, el primer fluido 14 también es capaz de fluir a través del motor 24. Para este fin, el motor 24 tiene un canal 25 para permitir que el primer fluido fluya desde la columna de perforación 12 al martillo 22. El canal 25 actúa como parte de un camino o conducto de flujo para el primer fluido 14.