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KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

- *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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5 March 2015



WO 2014/203245 A3

(54) **Title:** AN NMR/MRI-BASED INTEGRATED SYSTEM FOR ANALYZING DRILLING MUD FOR DRILLING MUD RECYCLING PROCESS

(57) **Abstract:** An NMR/MRI-based integrated system for analyzing and treating of a drilling mud for drilling mud recycling line; the system comprising drilling mud recycling equipment; an NMR/MRI device configured to provide at least one image of at least a portion of the drilling mud at least one characterized recycling step in the drilling mud recycling line; and a processor for analyzing and controlling the recycling of the drilling mud; wherein the NMR/MRI-based integrated system is operating in a method of analyzing the NMR/MRI image online; operatively communicating results of the analysis to the drilling mud recycling equipment; and on-line feedback controlling at least one step in the recycling of the drilling mud recycling equipment, thereby controlling automatically at least one step in the recycling of the drilling mud recycling.

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - IPC(8)- G01V 3/00 (2014.01)
 CPC - G01R 33/24; G01R 33/26; G01R 33/022
 According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
 Minimum documentation searched (classification system followed by classification symbols)
 USPC- 324/301

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 IPC(8)- G01V 3/00 (2014.01)
 USPC- 324/301,303,309,300; CPC-G01R 33/24; G01R 33/26; G01R 33/022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 PatBase (PGPB, USPT, USOC, EPAB, JPAB, DWPI, TDBD), FreePatentsOnline (US Pat, PgPub, EPO, JPO, WIPO, NPL),
 GoogleScholar (PL, NPL); search terms: NMR/MRI-based analyzing drilling mud recycling mud recycling equipment integrated system
 analyzing treating mud recycling process

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2012/0013335 A1 (Saasen et al.) 19 January 2012 (19.01.2012) Abstract, para [0001]-[0013], [0014]-[0063], Table 1	1-3, 14-33, 43-59 ----- 4-13, 34-42
Y	Shadday, 'Recommendations for Rheological Testing and Modeling of DWPF Melter Feed Slurries (U)', Technical Assistance Request Number: 94-DWPT-PMC-A0003, pg 1-45 (08.08.1994) available at: https://inis.iaea.org/search/search.aspx?orig_q=RN:26021403 ; accessed on 15 December 2014 (15.12.2014) Summary, pg 3, 27-29, 37-39, equations a1-12, c1-16, Fig A2	4-13, 34-42
X	US 6,215,304 B1 (Slade) 10 April 2001 (10.04.2001) Abstract, col 1-5	1-3, 14-33, 43-59
X	US 2012/0077707 A1 (Rapoport) 29 March 2012 (29.03.2012) Abstract, para [0022]	1-3, 14-33, 43-59
X	US 5,696,448 A (Coates et al.) 9 December 1997 (09.12.1997) Abstract, col 2-6	1-3, 14-33, 43-59
X	US 6,646,437 B1 (Chitale et al.) 11 November 2003 (11.11.2003) Abstract, col 4, ln 15 to col 7, ln 15	1-3, 14-33, 43-59
X	WO 2013/009299 A1 (Dirksen et al.) 17 January 2013 (17.01.2013) Abstract, pg 4, ln 15-23	1-3, 14-33, 43-59
X	US 2008/0136409 A1 (Sen et al.) 12 June 2008 (12.06.2008) Abstract, para [0011]-[0027]	1-3, 14-33, 43-59

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 15 December 2014 (15.12.2014)	Date of mailing of the international search report 07 JAN 2015
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL 14/50544

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0189456 A1 (Schmidt et al.) 7 August 2008 (07.08.2008) Abstract, para [0008]-[0029]	1-3, 14-33, 43-59
X	US 2005/0030020 A1 (Siess et al.) 10 February 2005 (10.02.2005) Abstract, para [0013]-[0021], [0044]-[0095]	1-3, 14-33, 43-59
X	Coussot et al., Rheological behavior of drilling muds, characterization using MRI visualization, Oil & Gas Sci. Tech. 59, 23-29 (2009)available at: ; accessed on 15 December 2014 (15.12.2014) Abstract, pg 24-26, sections 1.1, 2.1, 2.2, 3, figs 1-2	1-3, 14-33, 43-59
Y	US 2013/0060474 A1 (Venkataramanan et al.) 7 March 2013 (07.03.2013) Abstract, para [0007]-[0028], equations 1-66	4-13, 34-42
Y	US 2004/0090230 A1 (Appel et al.) 13 May 2004 (13.05.2004) Abstract, para [0001]-[0018], [0019]-[0025], [0069]-[0182], equations 1-41	4-13, 34-42
Y	US 5,784,333 A (Tang et al.) 21 July 1998 (21.07.1998) Abstract, col 2, ln 33-54; col 7, ln 50 to col 15, ln 65; equations 1-22	4-13, 34-42
Y	US 5,023,551 A (Kleinberg et al.) 11 June 1991 (11.06.1991) Abstract, col 1, ln 35 to col 9, ln 30; col 9, ln 32 to col 11, ln 13; col 13, ln 14 to col 21, ln 51, equations 1-30	4-13, 34-42

INTERNATIONAL SEARCH REPORT

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 60-65, 68-70
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 60-65, 68-70 lack antecedent basis, and are confusing and ambiguous, and lack clarity under PCT Article 6. In claims 60-65, 68-70, there is no antecedent basis for any of: ?said time-resolved imaged drilling mud within said drilling hole whilst drilling said hole, ..said inflowing mud,..said out flowing mud timed,..etc. Therefore claims 60-65, 68-70 are not included in this opinion.
-----See supplemental box-----

3. Claims Nos.: 66-67
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-----See Supplemental Box-----

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

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Box II, No 2: Claims Nos. 60-65, 68-70 because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claims 60-65, 68-70 lack antecedent basis, and are confusing and ambiguous; and lack clarity under PCT Article 6. Therefore claims 60-65, 68-70 are not included in this opinion.

In claims 60-65, 68-70, there is no antecedent basis for any of: "said time-resolved imaged drilling mud within said drilling hole whilst drilling said hole," "said inflowing mud," "said out flowing mud timed," etc.

Further, in claims 60-65, 68-70, the phrase "at least one step of imaging and timing" results in a selection between "imaging" and "timing," resulting in a confusing language, for example, ""at least one step of imaging and timing" a series of NMR or MRI images of drilling mud." It is impossible to have images without the step of imaging. The timing of images cannot be performed without the imaging step, and it is impossible to compare any parameter if the imaging step is not performed. In addition, the claim is indefinite and lacks clarity under PCT Article 6 due to use of abbreviations such as "i.e.," making the claims unsearchable.

In addition, in claims 60, 64, 69; the phrase "said parameter and analyzing parameters related with the drilling," is indefinite and ambiguous.

In addition, in claim 68, "thereby controlling automatically said at least one step in the recycling of said drilling mud recycling," is indefinite and ambiguous, and does not have antecedent basis for "said at least one step in the recycling of said drilling mud recycling." The method claimed in 68 is not "said at least one step in the recycling of said drilling mud recycling," but for "a method for analyzing and treating of a drilling mud " in drilling mud recycling process and the steps involved are in ?method for analyzing and treating of a drilling mud. "

In addition, claim 63 does not have antecedent basis for "said at least one characterized recycling step," "said NMR OR MRI image online," "said analysis to said drilling mud recycling equipment," "said at least one step in the recycling of said drilling mud recycling."

Therefore claims 60-65, 68-70 are not included in this opinion, because they are indefinite, ambiguous and unsearchable under PCT Article 6.

Box III: Observations where unity of invention is lacking:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

Group I, claims 1-31, directed to an NMR/MRI-based integrated system for analyzing and treating of a drilling mud for drilling mud recycling line.

Group II, claims 32-65 and 68-70, directed to a method of analyzing drilling parameters.

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features (Distinct Technical Features):

The special technical feature of Group II is a method of analyzing drilling parameters comprising various steps, not required in Group I

Common Technical Features (Features Do Not Make a Contribution Over the Prior Art):

Groups I and II are related as a system (Group I) and a method of using the system (Group II), and share the technical feature of claim 1. However, this technical feature is not a unifying technical feature as it does not make a contribution over the prior art in view of WO 2013/009299 A1 to Dirksen et al. (hereinafter Dirksen).

Dirksen discloses an NMR/MRI-based integrated system for analyzing and treating of a drilling mud (abstract: Formation testing systems and methods may inject fluids into a formation . . . the injection tools are further provided with nuclear magnetic resonance (NMR) sensors to monitor the injected fluids and provide measurements of near-borehole fracture orientations and volumes. . . magnetic resonance imaging (MRI) techniques may be employed) for drilling mud recycling line (pg 4, ln 15-23; a drill string 8; Figure 1, part 8); said system comprising drilling mud recycling equipment (Mud recirculation equipment 18, Fig 2, part 18); an NMR/MRI device (abstract: nuclear magnetic resonance (NMR) sensors . . . magnetic resonance imaging (MRI) techniques; pg 2, ln 9-10: If an NMR tool collects measurements as a function of three spatial dimensions, it is usually called a magnetic resonance imaging (MRI) tool = NMR/MRI-based integrated system) configured to provide at least one image of at least a portion of said drilling mud at said at least one characterized recycling step in said drilling mud recycling line (abstract, pg 4, ln 6-14: . . . nuclear magnetic resonance (NMR) . . . magnetic resonance imaging (MRI) techniques may be employed; pg 5, ln 27: The resulting telemetry data may be further analyzed and processed by computer 50 to generate a display of useful information); and a processor for analyzing and controlling the recycling of said drilling mud (pg 5, ln 26-27: data may be further analyzed and processed by computer 50); wherein said NMR/MRI-based integrated system is operating in a method of analyzing said NMR/MRI image online (Telemetry is a highly automated communications process by which measurements are made and other data collected at remote or inaccessible points and transmitted to receiving equipment for monitor, which encompasses data transferred over other media such as a telephone, computer network, optical link or other wired communications like phase line carriers. pg 5, ln 27: The resulting telemetry data may be further analyzed and processed by computer 50 to generate a display of useful information; Fig 8, step 808); operatively communicating results of said analysis to said drilling mud recycling equipment (pg 5, ln 15-19: commands to be communicated from the surface to the control = telemetry = online); and online feedback controlling at least one step in the recycling of said drilling mud recycling equipment (pg 5, ln 15-19: commands to be communicated from the surface to the control = telemetry = online; pg 11, ln 18-19: . . . can be performed with the assistance of software running in a processor in the downhole tool and/or software running in a processing system on the surface = by telemetry = online), thereby controlling automatically at least one step in the recycling of said drilling mud recycling (Fig 8, step 812 if Y, then START, if N, then step 814 and STOP). Although Dirksen discloses a mud recirculation equipment 18 and a drill string 8 for analyzing and treating of a drilling mud using NMR/MRI-based integrated system, using telemetry and a processor for analyzing and controlling the recycling of said drilling mud, and controlling automatically at least one step in the recycling of said drilling mud recycling; Dirksen does not explicitly teach that "the online feedback controlling automatically at least one step in the recycling of said drilling mud recycling" and "an NMR/MRI-based integrated system for analyzing and treating of a drilling mud." However, it would have been obvious to a person having ordinary skill in the art to use Dirksen's system comprising a mud recirculation equipment 18 and a drill string 8 and NMR/MRI-based integrated system for analyzing and treating of a drilling mud, because Dirksen's NMR/MRI integrated analytical system serves the same function and purpose of analyzing and treating of a drilling mud by controlling automatically at least one step in the recycling of said drilling mud recycling, and in addition, many such systems have automated shutdown protocols as a safety measure.

Therefore, inventions of Groups I-II lack unity under PCT Rule 13.

Note:

Claims 2, 33 and 43 are objected to as being ambiguous and have been interpreted for example, as follows for this invitation:

2. The system according to claim 1, wherein said drilling mud recycling steps are selected from a group consisting of adding [[ingredients and raw materials]], mixing, shaking, rotating, tumbling, aerating, heating, cooling, holding at a fixed temperature, emulsifying, adding water or water immiscible solutions, grinding, grounding, milling, shredding, pulvering, cutting, filtering, reducing particle size, de-emulsifying, kneading, decanting, settling, destiling, decentering, vacuuming and any combination thereof.

Claims 66-67, have been found to be unsearchable because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).