

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
13 September 2007 (13.09.2007)

PCT

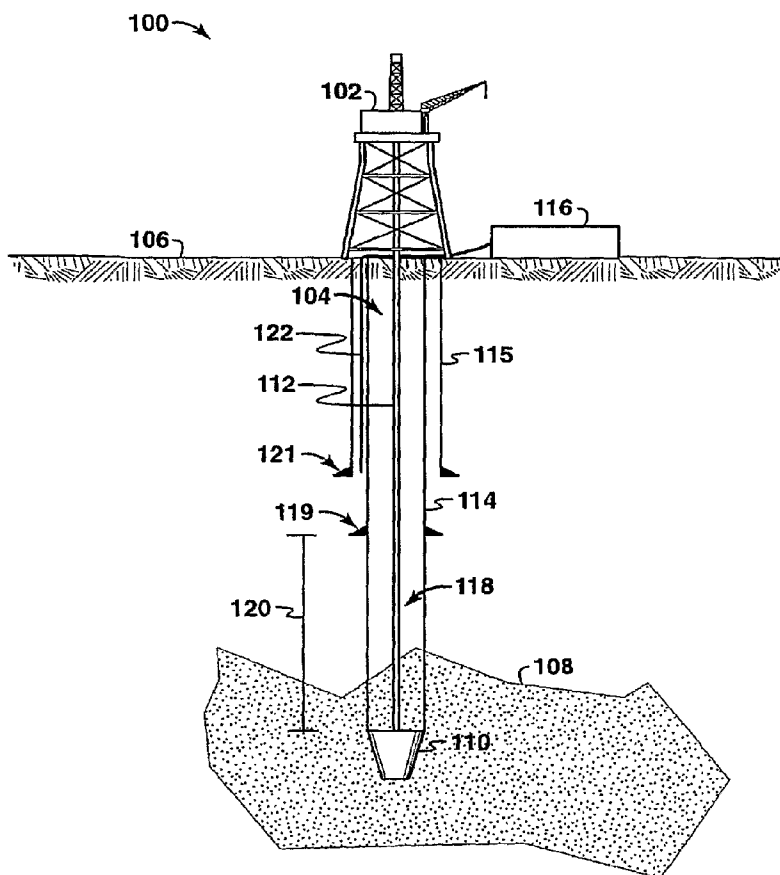
(10) International Publication Number  
**WO 2007/102971 A3**

- (51) International Patent Classification:  
E21B 21/01 (2006.01) E21B 21/08 (2006.01)  
E21B 21/06 (2006.01)
- (21) International Application Number:  
PCT/US2007/003691
- (22) International Filing Date:  
13 February 2007 (13.02.2007)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
60/779,679 6 March 2006 (06.03.2006) US
- (71) Applicant (for all designated States except US): **EXXON-MOBIL UPSTREAM RESEARCH COMPANY** [US/US]; P.O. Box 2189, Corp-Urc-Sw348, Houston, TX 77252-2189 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **SPIECKER, P., Matthew** [US/US]; 3303 Waters Edge Drive, Manvel, TX

- 77578 (US). **ENTCHEV, Pavlin, B.** [BE/US]; 3133 Buffalo Speedway #7303, Houston, TX 77098 (US). **GUPTA, Ramesh** [US/US]; 57 Lawrence Drive, Berkley Heights, NJ 07922 (US). **POLIZZOTTI, Richard** [US/US]; 30 Little York-Mount Pleasant Road, Milford, NJ 08848-2153 (US). **CARSTENSEN, Barbara** [US/US]; 32 Michael Lane, Annandale, NJ 08801 (US). **PEIFFER, Dennis, G.** [US/US]; 3333 John Drive, Annandale, NJ 08801 (US). **POKUTYLOWICZ, Norman** [CA/US]; 2525 Nantucket Apt. 11, Houston, TX 77057 (US).
- (74) Agents: **KNIGHT, Brent, R.** et al.; Exxonmobil Upstream Research Company, P.O. Box 2189, Corp-Urc-Sw348, Houston, TX 77252-2189 (US).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS,

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR MANAGING VARIABLE DENSITY DRILLING MUD



(57) Abstract: A method and system for drilling a wellbore is described. The system includes a wellbore with a variable density drilling mud, drilling pipe, a bottom hole assembly disposed in the wellbore and a drilling mud processing unit in fluid communication with the wellbore. The variable density drilling mud has compressible particles and drilling fluid. The bottom hole assembly is coupled to the drilling pipe while the drilling mud processing unit is configured to separate the compressible particles from the variable density drilling mud. The compressible particles in this embodiment may include compressible hollow objects filled with pressurized gas and configured to maintain the mud weight between the fracture pressure gradient and the pore pressure gradient. In addition, the system and method may also manage the use of compressible particles having different characteristics, such as size, during the drilling operations.

WO 2007/102971 A3



RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN,  
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

**(84) Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

**Published:**

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

**(88) Date of publication of the international search report:**

21 February 2008

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US07/03691

**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC: **E21B 21/01( 2006.01),21/06( 2006.01),21/08( 2006.01)**  
  
 USPC: 175/40,48,65,206,207,324;210/257.1,258,787,804;507/906  
 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)  
 U.S. : 175/40, 48, 65, 206, 207, 324; 210/257.1, 258, 787, 804; 507/117, 143, 906

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
 NONE

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

**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 2005/0284641 A (WATKINS et al) 29 December 2005 (29.12.2005), Figures 1A-1C, 2A-2C; Para's [0027], [0033], [0047], [0048].	1-11 ----- 12, 15, 16
Y	US 5,881,826 A (BROOKEY) 16 March 1999 (16.03.1999), col. 5, lines 60-64.	12, 15, 16
A	US 2005/0113262 A (RAVI et al) 26 May 2005 (26.05.2005), see entire document	1-49
A	US 6,953,097 A (SEYFFERT), 11 October 2005 (11.10.2005), see entire document.	1-27
A	US 3,231,030 A (BLOM) 25 January 1966 (25.01.1966), see entire document.	28-49
A	US 3,174,561 A (STERRETT) 23 March 1965 (23.03.1965), see entire document.	28-49

Further documents are listed in the continuation of Box C.  See patent family annex.

* 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 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: 21 September 2007 (21.09.2007)  
 Date of mailing of the international search report: 28 DEC 2007

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:  
 George Suchfield *J. Suchfield*  
 Telephone No. 571-272-3600

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US07/03691

## C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/0161262 A (JAMISON) 28 July 2005 (28.07.2005), see entire document.	1-49
A	US 6,530,437 A (MAURER et al) 11 March 2003 (11.03.2003), see entire document.	23-27

**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/US07/03691

Continuation of B. FIELDS SEARCHED Item 3:

EAST, DERWENT

search terms: variable density drilling fluid, compressible particles, maintain density, separating, hydrocyclone, centrifuge, diverting, monitoring