(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization

International Bureau



(10) International Publication Number WO 2011/007229 A3

(43) International Publication Date 20 January 2011 (20.01.2011)

(51) International Patent Classification: E21B 47/022 (2006.01) G01C 21/16 (2006.01)

(21) International Application Number:

PCT/IB2010/001671

(22) International Filing Date:

8 July 2010 (08.07.2010)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

12/503,075

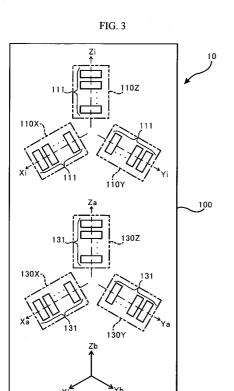
15 July 2009 (15.07.2009) US

- (71) Applicant (for AL, AU, AZ, BG, CO, CZ, DE, DK, GQ, GR, HU, ID, IE, IL, IT, KR, KZ, LT, MX, NO, NZ, OM, PL, RO, RU, SI, SK, TM, TN, TR, TT, UA, UZ, ZA only): SCHLUMBERGER TECHNOLOGY B.V. [NL/NL]; PARKSTRAAT 83-89, NL-2514 JG THE HAGUE (NL).
- (71) Applicant (for FR only): SERVICES PETROLIERS SCHLUMBERGER [FR/FR]; 42 rue Saint Dominique, F-75007 Paris (FR).

- (71) Applicant (for CA only): SCHLUMBERGER CANA-DA LIMITED [CA/CA]; 525-3RD Avenue S.W., Calgary, Alberta (CA).
- (71) Applicant (for GB, JP, NL only): SCHLUMBERGER HOLDINGS LIMITED; P.O. Box 71 Craigmuir Chambers, Road Town, Tortola (VG).
- (71) Applicant (for all designated States except AL, AU, AZ, BG, CA, CO, CZ, DE, DK, FR, GB, GQ, GR, HU, ID, IE, IL, IT, JP, KR, KZ, LT, MX, NL, NO, NZ, OM, PL, RO, RU, SI, SK, TM, TN, TR, TT, UA, US, UZ, ZA): PRAD RESEARCH AND DEVELOPMENT LIMITED; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola (VG).
- (72) Inventors; and
- Inventors/Applicants (for US only): SATO, Shigeru [JP/ JP]; 1-15-4, Koyodai, Inagi-shi, Tokyo 206-0803 (JP). IGARASHI, Juei [JP/JP]; 3-9-1-A803, NISHITERAO, YOKOHAMA-SHI, KANAGAWA-KU, JP-KANA-GAWA-KEN 221-0001 (JP). YAMATE, Tsutomu [JP/JP]; 6-1-E-406 NAKAGAWA, TSUZUKI-KU, YOKOHAMA-SHI, JP-224-0001 Kanagawa-ken (JP).

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR WELLBORE SURVEY USING INERTIAL SENSORS



(57) Abstract: A sensor apparatus comprising a housing, two or three gyroscope units and three accelerometer units. The gyroscope units are oriented orthogonally respective to each other and mounted within the housing. Each gyroscope unit includes a plurality of gyroscopes with input axes parallel to each other. The accelerometer units are oriented orthogonally respective to each other and mounted within the housing. Each accelerometer unit includes a plurality of accelerometers with detection axes parallel to each other.



- **WOODBURN, Charles** [GB/FR]; 1, RUE HENRI BEC-QUEREL, BP 202, BATIMENT 1, F-92142 CLAMART CEDEX1FR (FR).
- (74) Agent: MATSUDA, Kiichiro; Schlumberger K.K., 2-2-1 Fuchinobe, Chuo-ku, Sagamihara-shi, Kanagawa-ken 252-0206 (JP).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, 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, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- (88) Date of publication of the international search report: 21 April 2011

INTERNATIONAL SEARCH REPORT

International application No PCT/IB2010/001671

A. CLASSIFICATION OF SUBJECT MATTER INV. E21B47/022 G01C21/16 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

| C. DOCUM | ENTS CONSIDERED TO BE RELEVANT | | | |
|---|--|---|-----------------------|--|
| Category* | Citation of document, with indication, where appropriate, of the re | elevant passages | Relevant to claim No. | |
| X | US 6 315 062 B1 (ALFT KEVIN L [U 13 November 2001 (2001-11-13) column 27, line 12 - column 36, figures 6-9 | | 1-57 | |
| X | WO 2005/100916 A1 (GYRODATA INC 27 October 2005 (2005-10-27) paragraph [0025] - paragraph [00 | 1,4,5,45 | | |
| A | US 2006/253253 A1 (REYNOLDS CHRISTOPHER I [US] ET AL) 9 November 2006 (2006-11-09) paragraph [0017] - paragraph [0018] | | 1,4,5,45 | |
| A | US 6 453 239 B1 (SHIRASAKA ICHII AL) 17 September 2002 (2002-09-1 cited in the application the whole document | | 1,4,5,45 | |
| X Furti | ner documents are listed in the continuation of Box C. | X See patent family annex. | | |
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| | actual completion of the international search | Date of mailing of the international sea | • | |
| 13 January 2011 | | 01/02/2011 | | |
| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | | Authorized officer Hoekstra, Frank | | |
| DOT!!OA! | 210 (second sheet) (April 2005) | 1 | | |

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2010/001671

| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT | | | | | | |
|--|--|-----------------------|--|--|--|--|
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. | | | | |
| | | Relevant to claim No. | | | | |
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2010/001671

| Patent document cited in search report | Publication date | Patent family member(s) | 1 | Publication date |
|---|---------------------|---|----------------------------------|--|
| US 6315062 B1 | 13-11-2001 | US 200200529 | 97 A1 | 17-01-2002 |
| WO 2005100916 A1 | 27-10-2005 | AT 4531 CA 25587 EP 17355 EP 21614 US 20070171 US 20052242 | 97 A1 92 A1 97 A2 96 A1 | 15-01-2010 27-10-2005 27-12-2006 10-03-2010 25-01-2007 13-10-2005 |
| US 2006253253 A1 | 09-11-2006 | US 20101144 WO 20061215 | | 06-05-2010 16-11-2006 |
| US 6453239 B1 | 17-09-2002 | GB 23518 NO 200029 | | 10-01-2001 11-12-2000 |
| US 6882964 B2 | 19-04-2005 | US 20031876 | 23 A1 | 02-10-2003 |