



(43) International Publication Date
20 December 2012 (20.12.2012)

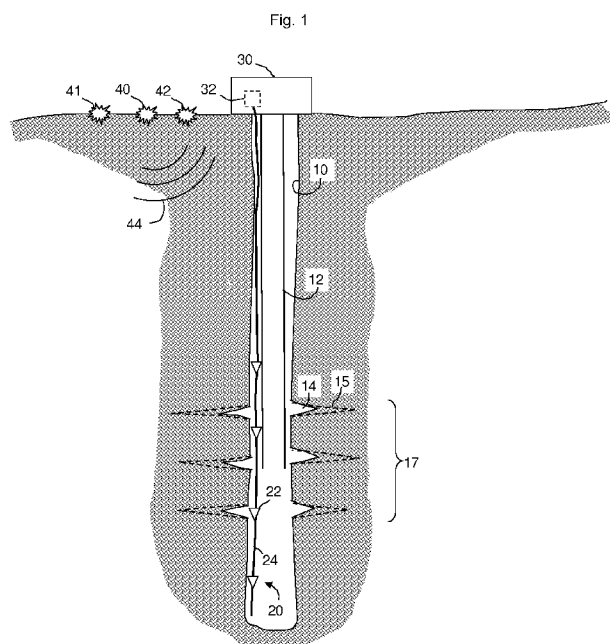
- (51) **International Patent Classification:**
G01V 1/40 (2006.01) *G01V 1/42* (2006.01)
- (21) **International Application Number:**
PCT/US2012/041880
- (22) **International Filing Date:**
11 June 2012 (11.06.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/496,280 13 June 2011 (13.06.2011) US
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- (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, 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, QA, RO, RS, RU, RW, 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, RW, SD, SL, SZ, TZ,

[Continued on next page]

(54) Title: HYDRAULIC FRACTURE MONITORING USING ACTIVE SEISMIC SOURCES WITH RECEIVERS IN THE TREATMENT WELL



(57) Abstract: A method for obtaining information about a hydraulic fracturing operation in a fracture zone in a well, comprises a) providing at least one acoustic sensor in the well and at least one acoustic source, b) injecting fracturing fluid into the well so as to cause fractures in a fracture zone in the surrounding formation, c) using the acoustic source to send an acoustic signal and using the acoustic receiver to receive the signal, d) repeating step c) at least once, and e) processing the received signals using a microprocessor so as to obtain information about the fractures. The source may be at the earth's surface or in a second well. Step e) may comprise measuring first-arriving acoustic waves or measuring reflected or diffracted acoustic waves. The information gained in step e) may be used to control the injection of fracturing fluid or detect out-of-zone water injection.



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

— *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))*

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

25 April 2013

Published:

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/041880**A. CLASSIFICATION OF SUBJECT MATTER*****G01V 1/40(2006.01)i, G01V 1/42(2006.01)i***

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)

G01V 1/40; E21B 17/14; E21B 47/00; E21B 47/02; E21B 49/00; E21B 47/01; G01S 1/72; G01V 8/00; G01V 1/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: fracturing, hydraulic, acoustic, sensor, source, second well, deconvolution, virtual source processing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20100157737 A1 (MILLER et al.) 24 JUNE 2010 See paragraphs 0029,0033,0035,0053,0054, claim 1, and figures 1,6.	1-3
A	EP 1335107 B1 (HALLIBURTON ENERGY SERVICES INC.) 8 October 2008 See claims 1,9,10.	1-3
A	US 2010-0200743 A1 (FORSTER et al.) 12 August 2010 See claim 1 and figure 2.	1-3
A	US 2007-0215345 A1 (LAFFERTY et al.) 20 September 2007 See claim 1 and figure 1.	1-3
A	US 5619475 A (WINKLER, KENNETH W.) 8 April 1997 See claim 1 and figure 1.	1-3

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

14 FEBRUARY 2013 (14.02.2013)

Date of mailing of the international search report

18 FEBRUARY 2013 (18.02.2013)

Name and mailing address of the ISA/KR

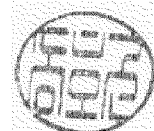


Facsimile No. 82-42-472-7140

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2012/041880**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.: 6
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:
Claim 6 is unclear because it refers to multiple dependent claim 5 which does not comply with PCT Rule 6.4(a).
3. ☒ Claims Nos.: 4,5,7-15
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:

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 an additional fee, this Authority did not invite payment of any additional fee.
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

Information on patent family members

International application No.

PCT/US2012/041880

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2012/041880

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