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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, 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, 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.

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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))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

[Continued on next page]

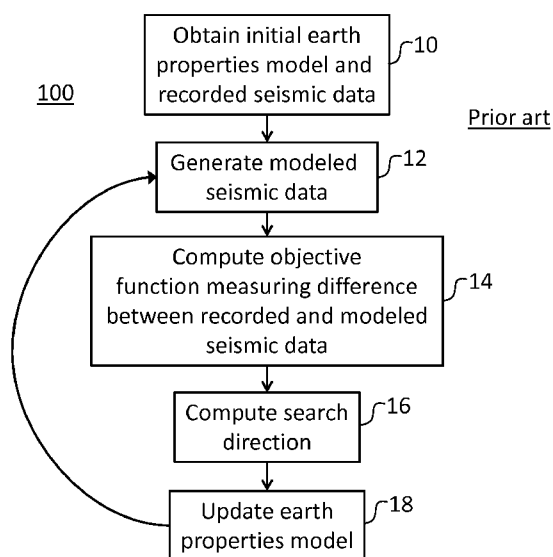
(54) **Title:** SYSTEM AND METHOD FOR SEISMIC DATA INVERSION BY NON-LINEAR MODEL UPDATE

Figure 1

(57) **Abstract:** A system and computer-implemented method for determining properties of a subsurface region of interest from seismic data is disclosed. An embodiment of the method performs full waveform inversion by non-linear model update to compute a velocity model. The method includes obtaining actual seismic data representative of the subsurface region and an initial earth property model for the subsurface region, performing forward modeling using the initial earth property model to create modeled seismic data with similar acquisition specifications as the actual seismic data, calculating a residual between the actual seismic data and the modeled seismic data in a time or transform domain, and inverting the residual to generate a model produced by non-linear model update components. The system includes a data source, user interface, and processor configured to execute computer modules that implement the method.

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

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## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2012/039057****A. CLASSIFICATION OF SUBJECT MATTER****G01V 1/30(2006.01)i, G06F 19/00(2011.01)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 1/30; G06F 19/00; G01V 1/28

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 practicable, search terms used)

eKOMPASS(KIPO internal) &amp; Keywords: seismic, earth, property, forward, model, residual, invert, update, non-linear, scattering and similar terms.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages      | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------|-----------------------|
| A         | US 2011-0090760 A1 (RICKETT, J. & CHILDS, P.) 21 April 2011<br>See the whole document.  | 1-3,5,6               |
| A         | US 05995905 A (IKELLE, L. T. & ROBERTS, G.) 30 November 1999<br>See the whole document. | 1-3,5,6               |
| A         | US 6594585 B1 (GERSZTENKORN, A.) 15 July 2003<br>See the whole document.                | 1-3,5,6               |
| A         | US 7373252 B2 (SHERRILL, F. G. & MALLICK, S.) 13 May 2008<br>See the whole document.    | 1-3,5,6               |



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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

28 DECEMBER 2012 (28.12.2012)

Date of mailing of the international search report

**02 JANUARY 2013 (02.01.2013)**

Name and mailing address of the ISA/KR

Korean Intellectual Property Office  
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan  
City, 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

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**INTERNATIONAL SEARCH REPORT**

International application No.

**PCT/US2012/039057****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.: 4  
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 4 is referring to itself. Additionally, although claim 4 is worded in reference to the step of phase unwrapping, said the step of phase unwrapping has not been worded in any preceeding claims.
3. ☐ Claims Nos.:  
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/US2012/039057**

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| US 2011-0090760 A1                        | 21.04.2011          | WO 2011-049885 A2          | 28.04.2011          |
| US 05995905 A                             | 30.11.1999          | EP 0799429 A1              | 08.10.1997          |
|                                           |                     | GB 2296567 A               | 03.07.1996          |
|                                           |                     | WO 96-20417 A1             | 04.07.1996          |
| US 6594585 B1                             | 15.07.2003          | AU 2001-53887 A1           | 24.12.2001          |
|                                           |                     | WO 01-96905 A1             | 20.12.2001          |
| US 7373252 B2                             | 13.05.2008          | None                       |                     |