



- (51) International Patent Classification:
G01V 1/04 (2006.01)
- (21) International Application Number:
PCT/US2012/028544
- (22) International Filing Date:
9 March 2012 (09.03.2012)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
61/485,437 12 May 2011 (12.05.2011) US
- (71) Applicant (for all designated States except US): **EXXON-MOBIL UPSTREAM RESEARCH COMPANY** [US/US]; CORP-URC-SW359, P.O. Box 2189, Houston, TX 77252-2189 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **MEIER, Mark, A.** [US/US]; 3133 Buffalo Speedway, #2201, Houston, TX 77098 (US). **DUREN, Richard, E.** [US/US]; 10 Claridge Ct., Conroe, TX 77304 (US).
- (74) Agents: **PLUMMER, J. Paul** et al.; ExxonMobil Upstream Research Company, Corp-URC-SW 359, P.O. Box 2189, Houston, TX 77252-2189 (US).

- (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.
- (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, 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, RS, SE, SI, SK, SM, 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))

[Continued on next page]

(54) Title: TWO COMPONENT SOURCE SEISMIC ACQUISITION AND SOURCE DE-GHOSTING

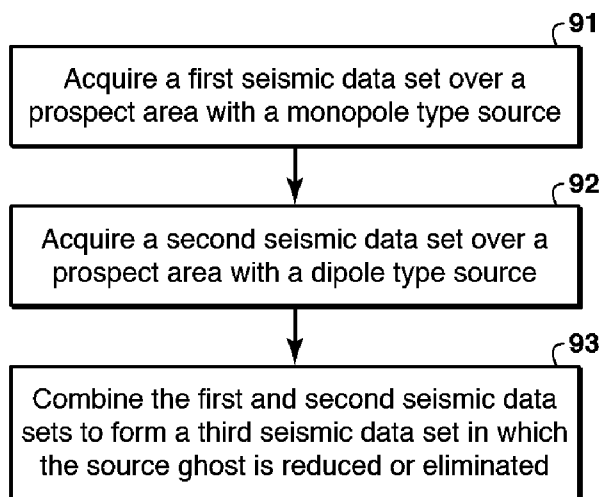


FIG. 9

(57) Abstract: Method for marine seismic acquisition using both monopole (91) and dipole (92) source types. Through a combination of source design and operation and/or combination or summing of the data in a processing step, the source ghost is either attenuated or, if desired, enhanced (93). The properties of the two different source types allow them to be adjusted so that the first down going wave from each has either opposite polarity or the same polarity, whereas the source-ghost wave will have, respectively same polarity or opposite polarity. This allows cancellation or enhancement of the source ghost. If the survey also employs two-component sensor acquisition, then the combined data sets may be both sensor de-ghosted and source de-ghosted.

WO 2012/154294 A4

Published:

- *with international search report (Art. 21(3))*
- *with amended claims (Art. 19(1))*

(88) Date of publication of the international search report:
24 January 2013

Date of publication of the amended claims: 14 March 2013

AMENDED CLAIMS

received by the International Bureau on 20 July 2012 (20.07.2012)

AMENDED CLAIMS

1. A marine seismic survey method comprising acquiring seismic data over a subsurface region using a monopole-type source and acquiring seismic data over the subsurface region using a dipole-type source, with the seismic survey conducted so that combined down-going waves from the two sources exhibit reduced or eliminated source ghosting or exhibit enhanced source ghosting, or the seismic data processed so that combined seismic data from the two sources exhibit reduced or eliminated source ghosting or exhibit enhanced source ghosting.
2. The method of claim 1, wherein the seismic survey is conducted so as to reduce or eliminate or so as to enhance source ghosting by operating the monopole-type source and the dipole-type source co-locally, simultaneously, and with equalized outputs.
3. The method of claim 1, wherein the monopole-type source and the dipole-type source are operated during the seismic survey with enough time between their respective activations to prevent overlap between their recorded seismic data, which seismic data are processed so as to reduce or eliminate or so as to enhance source ghosting by combining the seismic data acquired using the monopole-type source with the seismic data acquired using the dipole-type source.
4. The method of claim 3, further comprising adjusting the seismic data for different power outputs and different frequency and phase characteristics between the monopole-type source and the dipole-type source by applying weights or filters to the seismic data for each source type before the combining.
5. The method of claim 4, wherein the weights or filters are found by deterministic means, by statistical means, or by a combination of deterministic and statistical means.
6. The method of claim 3, wherein deviation of the monopole-type source from a perfect monopole or deviation of the dipole-type source from a perfect dipole, or both, are compensated for by applying weights or filters to the seismic data for each source type before the combining.
7. The method of claim 1, wherein in order to conduct a seismic survey or process the seismic data so as to reduce or eliminate source ghosting, the monopole-type source and the dipole-type source are designed so that a first down-going wave from the monopole type source is the same amplitude and polarity as a first down-going wave from the dipole source, and a second down-going wave, i.e. a source ghost, from the monopole-type source is the same

amplitude and opposite polarity as a second down-going wave, i.e. a source ghost, from the dipole-type source.

8. The method of claim 1, wherein in order to conduct a seismic survey or process the seismic data so as to enhance source ghosting, the monopole-type source and the dipole-type source are designed so that a first down-going wave from the monopole type source is the same amplitude and opposite polarity as a first down-going wave from the dipole source, and a second down-going wave, i.e. a source ghost, from the monopole-type source is the same amplitude and same polarity as a second down-going wave, i.e. a source ghost, from the dipole-type source.

9. The method of claim 1, further comprising using at least one or more additional monopole-type sources, or arrays of such sources, and one or more additional dipole-type sources, or arrays of such sources, in conducting the seismic survey.

10. The method of claim 1, wherein all of said acquiring seismic data employs two-component seismic acquisition.

11. A method for producing hydrocarbons from a subsurface region and a Marine environment, comprising:

performing a seismic survey of the subsurface region using a method of claim 1 to produce source de-ghosted seismic data;

drilling a well into the subsurface region based at least partly on analysis of the source de-ghosted seismic data, and producing hydrocarbons from the well.