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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 July 2012 (19.07.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/096966 A3

(51) International Patent Classification:
H01L 31/055 (2006.01) *H01L 31/00* (2006.01)
H01L 21/00 (2006.01)

(21) International Application Number:
PCT/US2012/020789

(22) International Filing Date:
10 January 2012 (10.01.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/431,827 11 January 2011 (11.01.2011) US
61/431,830 7 February 2011 (07.02.2011) US

(71) Applicant *(for all designated States except US)*: **FORO ENERGY, INC.** [US/US]; 8020 Southpark Circle, Suite 500, Denver, CO 80120 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ZEDIKER, Mark, S.** [US/US]; 1896 Via De Los Pinons, Castle Rock, CO 80104 (US). **JONES-ALBERTUS, Rebecca** [US/US]; 505 Cypress Point Drive #108, Mountain View, CA 94043 (US). **FAIRCLOTH, Brian, O.** [US/US]; 7664 Brook Forest Lane, Evergreen, CO 80439 (US). **RINZLER, Charles, C.** [US/US]; 1015 21st Street, Apt. 105, Denver, CO 80205 (US). **MOXLEY, Joel, F.** [US/US]; 949 South Clayton Way, Denver, CO 80209 (US).

(74) Agent: **FREEMAN, John, C.**; Brinks Hofer Gilson & Lione, P.O. Box 10087, Chicago, IL 60610 (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.

[Continued on next page]

(54) Title: HIGH POWER LASER PHOTO-CONVERSION ASSEMBLIES, APPARATUSES AND METHODS OF USE

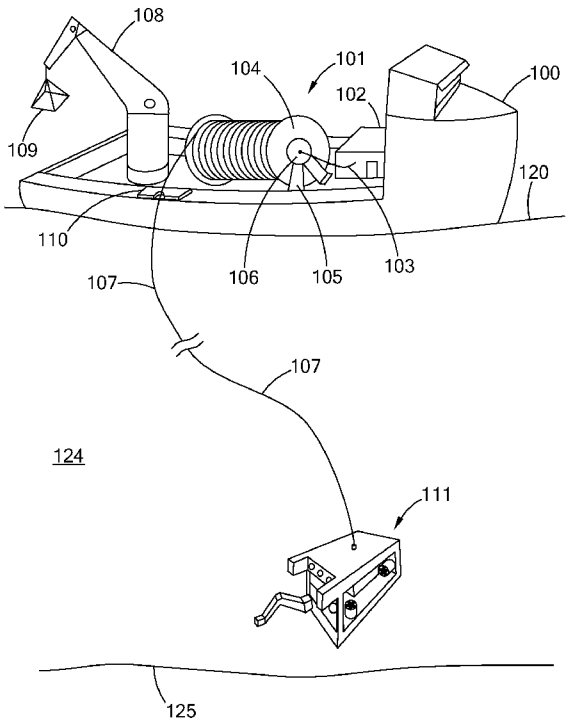


Fig. 1

(57) Abstract: There is provided a high power laser system for powering a remotely located laser device, such as an ROV, using a photo-conversion device, such as a laser photovoltaic assembly. Laser device systems, such as ROV systems that utilizes a high power laser cutting and/or cleaning tools are also provided.

WO 2012/096966 A3

(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).

Published:

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

(88) **Date of publication of the international search report**:
4 October 2012

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/20789

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01L 31/055; H01L 21/00; H01L 31/00 (2012.01)
USPC - 136/246; 136/262; 136/261; 136/256
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)
USPC -- 136/246; 136/262; 136/261; 136/256

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC -- 136/246; 136/262; 136/261; 136/256 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (USPT, PGPB, JPAB, EPAB); Google
Search Terms Used: laser, photovoltaic, assembly, cells, lens, shape, size, temperature, heat, heat sink, reflector, collimator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0272424 A1 (Ortabasi) 05 November 2009 (05.11.2009), entire document especially Abstract, para [0057], [0063], [0038] and [0060]	1-6
Y	US 2010/0215326 A1 (Zediker et al.) 26 August 2010 (26.08.2010), entire document especially Abstract, para [0033]	1-6

☐ Further documents are listed in the continuation of Box C. ☐

* 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 another 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	Date of mailing of the international search report
20 June 2012 (20.06.2012)	29 JUN 2012
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: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 12/20789

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.:
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:

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:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-6
Group II: Claims 7-21
Group III: Claims 22-33
Group IV: Claims 34

-- see extra sheet

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 additional fees, this Authority did not invite payment of additional fees.

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.:
1-6

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

International application No.
PCT/US 12/20789

Continuation of Box No. III -- Observations where unity of invention is lacking

Group I: is drawn to a high power laser photovoltaic assembly comprising: a. a photovoltaic assembly comprising a plurality of photovoltaic cells; b. a means to provide a predetermined high power laser beam distribution profile to the photovoltaic cells; and, c. the photovoltaic cells configured in a shape based at least in part upon the predetermined laser beam profile.

Group II: is drawn to a high power laser photovoltaic assembly comprising: a. a laser beam delivery means; b. a photovoltaic assembly comprising a housing; c. the housing having an opening for receiving the laser beam, the housing defining an optically active surface, the optically active surface comprising a plurality of photovoltaic cells; and, d. a cooling device.

Group III: is drawn to a high power laser photovoltaic cell comprising: a. a front for receiving a high power laser beam having a predetermined wavelength; b. a back; and, c. a layer between the front and back, comprising a photovoltaic material having a band gap tuned to a predetermined operating temperature and the predetermined laser wavelength.

Group IV: is drawn to a method of remotely converting power laser energy for use in a device, the method comprising: a. propagating a high power laser beam; b. transmitting the high power laser beam through the high power laser fiber to the device without substantial loss of power; c. directing the high power laser beam from the high power laser fiber into a laser photovoltaic assembly; d. converting at least a portion of the laser beam into electrical energy; and, e. utilizing the electrical energy to power an operation of the device.

The inventions listed in the above-mentioned groups do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Groups I-IV lack unity of invention, because even though the inventions of these groups require the technical feature of a providing a laser beam to a photovoltaic assembly, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US 2009/0272424 A1 (Ortabasi), which discloses providing a laser beam to a photovoltaic assembly (para [0015]-[0017]).

Groups I-IV therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.