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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	03/29/2022	11287515	103033-P010US3C2-1252983	9133

20350 7590 03/09/2022

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

INVENTOR(s) (Please see PAIR WEB site http://pair.uspto.gov for additional inventors):

Angus Pacala, San Francisco, CA;
Mark Frichtl, San Francisco, CA;
Marvin Shu, Daly City, CA;
Eric Younge, Portola Valley, CA;

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Ouster, Inc., San Francisco, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 02/25/2022

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

NOTIFICATION DATE	DELIVERY MODE
02/25/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Corrected ***Notice of Allowability***	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.	
	Examiner QUE TAN LE	**Art Unit** 2878	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to the IDS filed 2/18/2022.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-25 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code [4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Application No 16/209,875, Notice of Allowance, Mailed On January 31, 2022, 8 pages.	
	2	Application No 16/209,879, Notice of Allowance, Mailed On January 31, 2022, 8 pages.	
	3	17/323,983, "Corrected Notice of Allowability", February 9, 2022, 2 pages.	

EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	02/23/2022

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2022-02-18
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/



United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :75320

Sale Accounting Date:02/22/2022

Sale Item Reference Number	Effective Date
17323987	02/18/2022

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I20222LG39474291	2806	SUBMISSION- INFORMATION DISCLOSURE STMT	$130.00	Deposit Account



United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :C46472

Sale Adjustment Accounting Date:02/22/2022

Effective Date	Sale Accounting Date	Sale Item Reference Number
02/18/2022	02/22/2022	17323987

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I20222LE17310887	2820	RCE- 2ND AND SUBSEQUENT REQUEST	$1,000.00	

United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :C46472

Refund Accounting Date:02/22/2022

Effective Date	Sale Item Reference Number	Refund Total
02/18/2022	17323987	$1,000.00

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method	Account Number
I20222LE17310887	2820	RCE- 2ND AND SUBSEQUENT REQUEST	$1,000.00		**********8410

Doc Code: QPIDS.REQ
Document Description: QuickPath Information Disclosure Statement

PTO/SB/09 (09-18)

CERTIFICATION AND REQUEST FOR CONSIDERATION OF AN INFORMATION DISCLOSURE STATEMENT FILED AFTER PAYMENT OF THE ISSUE FEE UNDER THE QPIDS PROGRAM

Non-Provisional Application Number: 17/323,987	Filing Date: May 18, 2021
First Named Inventor: Angus Pacala	Title of Invention: Rotating Compact Light Ranging System Comprising A Stator Driver Circuit Imparting An Electromagi

THE UNDERSIGNED HEREBY CERTIFIES AND REQUESTS THE FOLLOWING FOR THE ABOVE-IDENTIFIED APPLICATION.

1. Consideration is requested of the information disclosure statement (IDS) submitted herewith, which is being filed after payment of the issue fee.
2. Check the box next to the appropriate selection:

   ☐ Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(1).

   OR

   ☑ No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the IDS was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(2).

   OR

   ☐ See attached certification statement in compliance with 37 CFR 1.97(e).
3. Please charge the IDS fee set forth in 37 CFR 1.17(p) to Deposit Account No. 20-1430.
4. A Petition to Withdraw from Issue After Payment of the Issue Fee (37 CFR 1.313(c)(2)), including the petition fee set forth in 37 CFR 1.17(h), is submitted herewith as a **Web-based ePetition**. **WARNING:** Do not submit the petition as a follow-on paper via EFS-Web. Submit the petition as a Web-based ePetition by signing on to EFS-Web as a registered user, selecting the radio button next to "Existing application/patent," and then selecting the radio button next to "ePetition (for automatic processing and immediate grant, if all petitions requirements are met)." Failure to use the Web-based ePetition interface will result in automatic entry of the RCE.
5. A request for continued examination (RCE) under 37 CFR 1.114 and the RCE fee under 37 CFR 1.17(e) are submitted herewith.
6. The RCE will be treated as a "conditional" RCE. In the event the examiner determines that any item of information contained in the IDS necessitates the reopening of prosecution in the application, the undersigned understands that (i) the RCE will be processed and treated as an RCE under 37 CFR 1.114 and therefore (ii) the IDS fee under 37 CFR 1.17(p) will be returned in accordance with 37 CFR 1.97(b)(4). In the event that no item of information in the IDS necessitates reopening prosecution, the undersigned understands that the RCE will not be processed and the RCE fee under 37 CFR 1.17(e) will be returned.
7. This certification and request is being filed as a **Web-based ePetition** and is not accompanied by an amendment to the application. Inclusion of an amendment will result in automatic entry of the RCE.

Signature / William L. Shaffer /	Date Feb. 18, 2022
Name (Print/Typed) William L. Shaffer	Practitioner Registration Number (If applicable) 37,234

Note: *Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below.**

☑ *Total of 1 forms are submitted.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/SB/08a (01-10)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17/323,987
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	2878
	Examiner Name	Que Tan Le
	Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code [4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Application No 16/209,875, Notice of Allowance, Mailed On January 31, 2022, 8 pages.	
	2	Application No 16/209,879, Notice of Allowance, Mailed On January 31, 2022, 8 pages.	
	3	17/323,983, "Corrected Notice of Allowability", February 9, 2022, 2 pages.	

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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	Application Number	17/323,987
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	2878
	Examiner Name	Que Tan Le
	Attorney Docket Number	103033-P010US3C2-1252983

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2022-02-18
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Doc Code: PET.AUTO Document Description: Petition automatically granted by EFS-Web	PTO/SB/140 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**PETITION TO WITHDRAW AN APPLICATION FROM ISSUE AFTER PAYMENT OF THE ISSUE FEE UNDER 37 CFR 1.313(c)**
Application Number	17323987
Filing Date	18-May-2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	
Attorney Docket Number	103033-P010US3C2-1252983
Title	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

An application may be withdrawn from issue for further action upon petition by the applicant. To request that the Office withdraw an application from issue, applicant must file a petition under this section including the fee set forth in § 1.17(h) and a showing of good and sufficient reasons why withdrawal of the application from issue is necessary.

APPLICANT HEREBY PETITIONS TO WITHDRAW THIS APPLICATION FROM ISSUE UNDER 37 CFR 1.313(c).

A grantable petition requires the following items:
(1) Petition fee; and
(2) One of the following reasons:
(a) Unpatentability of one or more claims, which must be accompanied by an unequivocal statement that one or more claims are unpatentable, an amendment to such claim or claims, and an explanation as to how the amendment causes such claim or claims to be patentable;
(b) Consideration of a request for continued examination in compliance with § 1.114 (for a utility or plant application only); or
(c) Express abandonment of the application. Such express abandonment may be in favor of a continuing application, but not a CPA under 37 CFR 1.53(d).

Petition Fee

◉	Small Entity
○	Micro Entity
○	Regular Undiscounted

Reason for withdrawal from issue

◯ One or more claims are unpatentable ◉ Consideration of a request for continued examination (RCE) (List of Required Documents and Fees) ◯ Applicant hereby expressly abandons the instant application (any attorney/agent signing for this reason must have power of attorney pursuant to 37 CFR 1.32(b)).
RCE request,submission, and fee. ☐ I certify, in accordance with 37 CFR 1.4(d)(4) that : The RCE request ,submission, and fee have already been filed in the above-identified application on ☒ Are attached.
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application. ◯ An attorney or agent registered to practice before the Patent and Trademark Office, acting in a representative capacity. ◯ A sole inventor ◯ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ◯ A joint inventor; all of whom are signing this e-petition

Signature	/William L. Shaffer/
Name	William L. Shaffer
Registration Number	37234

Electronic Patent Application Fee Transmittal

Application Number:	17323987
Filing Date:	18-May-2021
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Filer:	William Leland Shaffer/Erica Rojas
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PETITION FEE-37CFR 1.17(H) (GROUP II)	2464	1	70	70
RCE- 2ND AND SUBSEQUENT REQUEST	2820	1	1000	1000
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1070**

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : February 18, 2022

In re Application of :

Angus Pacala

DECISION ON PETITION

UNDER CFR 1.313(c)(2)

Application No : 17323987

Filed : 18-May-2021

Attorney Docket No : 103033-P010US3C2-1252983

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed February 18, 2022 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2878 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

Electronic Acknowledgement Receipt

EFS ID:	45034107
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/Erica Rojas
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	18-FEB-2022
Filing Date:	18-MAY-2021
Time Stamp:	17:51:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1070
RAM confirmation Number	E20222HH51451725
Deposit Account	201430
Authorized User	Erica Rojas

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	2022-02-18_Request_for_Continued_Examination_103033-P010US3C2-1252983.pdf	1667262 63cbf0c3a58c2e3ab1b975ce736c8bb1bc3f4560	no	3
Warnings:					
Information:					
2	Quick Path Information Disclosure Statement	2022-02-18_QPIDS_103033-P010US3C2-1252983.pdf	178782 fc6ca5f3f1b89a786220939b68ed93768e4a4f08	no	2
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	2022-02-18_Supplemental_Information_Disclosure_Statement_103033-P010US3C2-1252983.pdf	215243 57b9f02ad890b5a1e6a1a77caf87e70441995a2f	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
4	Non Patent Literature	NPL_US_16209875_NOA_01312022.pdf	430237 0118a9ccf615f09d8fac6ec2a6b7a07157afe62c	no	8
Warnings:					
Information:					
5	Non Patent Literature	NPL_US_16209879_NOA_01312022.pdf	425720 97ea5745afb31effa9f579f996e634b8cfd8afe8	no	8
Warnings:					
Information:					
6	Non Patent Literature	NPL_US_17323983_CNOA_02092022.pdf	85225 df796d4160cd97d5445c30466221ef81393ed9b8	no	2
Warnings:					

Information:					
7	ePetition Request Form	petition-request.pdf	39815 2b5d304b32bbe5b76e5f29870208136812f9ab58	no	2
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	40732 5f9d43ee6e7f289f00372263b21be34bd99b7fd4	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	3083016	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 02/11/2022

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

NOTIFICATION DATE	DELIVERY MODE
02/11/2022	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Corrected ***Notice of Allowability***	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.	
	Examiner QUE TAN LE	**Art Unit** 2878	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to IDS filed 12/30/2021.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-25 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Pacala
Art Unit	3645
Examiner Name	James R Hulka
Attorney Docket Number	103033-P010US3C2-1252983

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20160117853	A1	2016-04-28	ZHONG, et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Pacala
	Art Unit	3645
	Examiner Name	James R Hulka
	Attorney Docket Number	103033-P010US3C2-1252983

	1	16/209,875, "Non-Final Office Action", September 20, 2021, 9 pages	☐
	2	16/209,879, "Non-Final Office Action", September 20, 2021, 15 pages	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	02/06/2022

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Pacala
	Art Unit	3645
	Examiner Name	James R Hulka
	Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-10-13
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	11131773		Sep 28, 2021	Pacala et al.	

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	2	20180329060		Nov 15, 2018	Pacala et al.	
	3	20200041613		Feb 6, 2020	Pacala et al.	
	4	20210278505		Sep 9, 2021	Pacala et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	02/06/2022

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
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Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-12-30
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/



United States Patent and Trademark Office

Office of the Chief Financial Officer

Document Code:WFEE

User :75320

Sale Accounting Date:02/01/2022

Sale Item Reference Number	Effective Date
17323987	10/13/2021

Document Number	Fee Code	Fee Code Description	Amount Paid	Payment Method
I202221G00252576	2806	SUBMISSION- INFORMATION DISCLOSURE STMT	$130.00	Deposit Account

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	11131773		Sep 28, 2021	Pacala et al.	

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	2	20180329060		Nov 15, 2018	Pacala et al.	
	3	20200041613		Feb 6, 2020	Pacala et al.	
	4	20210278505		Sep 9, 2021	Pacala et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number [3]	Country Code [2]	Kind Code [4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T [5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [5]

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	17/323,987
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Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-12-30
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
www.uspto.gov

ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/323,987	**12/30/2021 05:36:12 PM ET**	**103033-P010US3C2-1252983**

Title of Invention

ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9133	FILED BY	Erica Rojas
PATENT CENTER #	60467429	FILING DATE	05/18/2021
CUSTOMER #	20350	FIRST NAMED INVENTOR	Angus Pacala
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Bill Shaffer

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2021-12-30_Information_Dislcosure_Statement_103033-P010US3C2-1252983.pdf	2	Information Disclosure Statement (IDS) Form (SB08)	178 KB

Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)

2021-12-30_Information_Disclcosure_Statement_103033-P010US3C2-1252983.pdf	AD42DCF2CC8C5115D11E3B03A267EBE72744B91C71575345A49BF520E4A35EBB1278870D888C33851EAD496FE34BD151DA53F2365ECD249E4D2230B65D41BE66

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on November 16, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /Erica M. Rojas/
Erica M. Rojas

PATENT
Attorney Docket No.: 103033-P010US3C2-1252983
Client Ref. No.: P010US3C2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Angus Pacala et al.

Application No.: 17/323,987

Filed: May 18, 2021

For: ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

Customer No.: 20350

Confirmation No.: 9133

Examiner: Que Tan Le

Technology Center/Art Unit: 2878

STATEMENT OF THE SUBSTANCE OF AN INTERVIEW

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

Applicants thank the Examiner for discussing (on October 12, 2021) procedural questions related to the filing of a Quick Path IDS.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

75395952v.1

UNITED STATES
PATENT AND TRADEMARK OFFICE

P.O. Box 1450
Alexandria, VA 22313 - 1450
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #	RECEIPT DATE / TIME	ATTORNEY DOCKET #
17/323,987	**11/16/2021 05:11:12 PM ET**	**103033-P010US3C2-1252983**

Title of Invention

ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	9133	FILED BY	Erica Rojas
PATENT CENTER #	60402687	FILING DATE	05/18/2021
CUSTOMER #	20350	FIRST NAMED INVENTOR	Angus Pacala
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Bill Shaffer

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2021-11-16_Statement_of_Substance_of_an_Interview_103033-P010US3C2-1252983.pdf	1	Applicant summary of interview with examiner	74 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
2021-11-16_Statement_of_Substance_of_an_Interview_103033-	1F82F5B6E9DE83FF01CF8FDE23BE05D62B0C6D216D5D78488100C60FB9A60316AF13376C8B30FBB6237C8BB1A1A2EB3060243F59D59987AE9DA2A0E7EC547501

P010US3C2-1252983.pdf

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 10/20/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

NOTIFICATION DATE	DELIVERY MODE
10/20/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Applicant-Initiated Interview Summary	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.		
	Examiner QUE TAN LE	**Art Unit** 2878	**AIA (First Inventor to File) Status** Yes	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
QUE TAN LE	Primary Examiner	Telephonic
William L. Shaffer	Attorney	

Date of Interview: 12 October 2021

Issues Discussed:

Other

Consultation for submission of related documents

/QUE TAN LE/ Primary Examiner, Art Unit 2878	

Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04
Please further see:
MPEP 713.04
Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b)
37 CFR § 1.2 Business to be transacted in writing

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Pacala
Art Unit	3645
Examiner Name	James R Hulka
Attorney Docket Number	103033-P010US3C2-1252983

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20160117853	A1	2016-04-28	ZHONG, et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1							☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Pacala
	Art Unit	3645
	Examiner Name	James R Hulka
	Attorney Docket Number	103033-P010US3C2-1252983

	1	16/209,875, "Non-Final Office Action", September 20, 2021, 9 pages	☐
	2	16/209,879, "Non-Final Office Action", September 20, 2021, 15 pages	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Pacala
	Art Unit	3645
	Examiner Name	James R Hulka
	Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(c)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-10-13
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: PET.AUTO Document Description: Petition automatically granted by EFS-Web	PTO/SB/140 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**PETITION TO WITHDRAW AN APPLICATION FROM ISSUE AFTER PAYMENT OF THE ISSUE FEE UNDER 37 CFR 1.313(c)**
Application Number	17323987
Filing Date	18-May-2021
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	
Attorney Docket Number	103033-P010US3C2-1252983
Title	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

An application may be withdrawn from issue for further action upon petition by the applicant. To request that the Office withdraw an application from issue, applicant must file a petition under this section including the fee set forth in § 1.17(h) and a showing of good and sufficient reasons why withdrawal of the application from issue is necessary.

APPLICANT HEREBY PETITIONS TO WITHDRAW THIS APPLICATION FROM ISSUE UNDER 37 CFR 1.313(c).

A grantable petition requires the following items:
(1) Petition fee; and
(2) One of the following reasons:
(a) Unpatentability of one or more claims, which must be accompanied by an unequivocal statement that one or more claims are unpatentable, an amendment to such claim or claims, and an explanation as to how the amendment causes such claim or claims to be patentable;
(b) Consideration of a request for continued examination in compliance with § 1.114 (for a utility or plant application only); or
(c) Express abandonment of the application. Such express abandonment may be in favor of a continuing application, but not a CPA under 37 CFR 1.53(d).

Petition Fee

- (•) Small Entity
- ( ) Micro Entity
- ( ) Regular Undiscounted

Reason for withdrawal from issue

○ One or more claims are unpatentable ◉ Consideration of a request for continued examination (RCE) (List of Required Documents and Fees) ○ Applicant hereby expressly abandons the instant application (any attorney/agent signing for this reason must have power of attorney pursuant to 37 CFR 1.32(b)).	
RCE request,submission, and fee. ☐ I certify, in accordance with 37 CFR 1.4(d)(4) that : The RCE request ,submission, and fee have already been filed in the above-identified application on ☒ Are attached.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who has been given power of attorney in this application. ○ An attorney or agent registered to practice before the Patent and Trademark Office, acting in a representative capacity. ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this e-petition	
Signature	/William Shaffer/
Name	William Shaffer
Registration Number	37234

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Decision Date : October 13, 2021

In re Application of :

Angus Pacala

DECISION ON PETITION

UNDER CFR 1.313(c)(2)

Application No : 17323987

Filed : 18-May-2021

Attorney Docket No : 103033-P010US3C2-1252983

This is an electronic decision on the petition under 37 CFR 1.313(c)(2), filed October 13, 2021 , to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED.**

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid in this application cannot be refunded. If, however, this application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.

Telephone inquiries concerning this decision should be directed to the Patent Electronic Business Center (EBC) at 866-217-9197.

This application file is being referred to Technology Center AU 2878 for processing of the request for continuing examination under 37 CFR 1.114 .

Office of Petitions

Electronic Acknowledgement Receipt

EFS ID:	44024263
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/Kristina Alvarez
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	13-OCT-2021
Filing Date:	18-MAY-2021
Time Stamp:	18:38:13
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$750
RAM confirmation Number	E20210CI38050726
Deposit Account	201430
Authorized User	Kristina Alvarez

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	P010US3C2-RCE-transmittal.pdf	1351706 688e38ef2527c4a619ccbe5efd9bb894f70d72b1	no	-
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	P010US3C2-IDS.pdf	612096 60d824fbf88a2d1f6f4856bef573ecc80294bbff	no	4
Warnings:					
Information:					
3	Quick Path Information Disclosure Statement	P010US3C2-QPIDS-cert-request.pdf	174016 49a38f0a25e4f8e297f36fd6fc5bcc3e7aea38a2	no	2
Warnings:					
Information:					
4	Non Patent Literature	NPL_US_16209875_NFOA_09202021.pdf	350933 13af74c5a2744a9148c3b9c574fbd4ba9c754c7b	no	9
Warnings:					
Information:					
5	Non Patent Literature	NPL_US_16209879_NFOA_09202021.pdf	529743 8e94115d1d5fb23f4a67f17cce3b159e840a5cb4	no	15
Warnings:					
Information:					
6	ePetition Request Form	petition-request.pdf	39812 039eb1ac08388de3207956cfe0b204480e40087	no	2
Warnings:					
Information:					

7	Fee Worksheet (SB06)	fee-info.pdf	40733 1ca042b8240e23e7902b40127bd740d71a7bb938	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	3099039		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

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New International Application Filed with the USPTO as a Receiving Office

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Electronic Patent Application Fee Transmittal

Application Number:	17323987
Filing Date:	18-May-2021
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Filer:	William Leland Shaffer/Kristina Alvarez
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
PETITION FEE-37CFR 1.17(H) (GROUP II)	2464	1	70	70
RCE- 1ST REQUEST	2801	1	680	680
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**750**

Doc Code: QPIDS.REQ
Document Description: Quick Path Information Disclosure Statement

PTO/SB/09 (09-18)

CERTIFICATION AND REQUEST FOR CONSIDERATION OF AN INFORMATION DISCLOSURE STATEMENT FILED AFTER PAYMENT OF THE ISSUE FEE UNDER THE QPIDS PROGRAM

Non-Provisional Application Number: 17323987	Filing Date: 5/18/2021
First Named Inventor: Angus Pacala	Title of Invention: Rotating Compact Light Ranging System

THE UNDERSIGNED HEREBY CERTIFIES AND REQUESTS THE FOLLOWING FOR THE ABOVE-IDENTIFIED APPLICATION.

1. Consideration is requested of the information disclosure statement (IDS) submitted herewith, which is being filed after payment of the issue fee.
2. Check the box next to the appropriate selection:

   ☐ Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(1).

   OR

   ☑ No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the IDS was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the IDS. See 37 CFR 1.97(e)(2).

   OR

   ☐ See attached certification statement in compliance with 37 CFR 1.97(e).
3. Please charge the IDS fee set forth in 37 CFR 1.17(p) to Deposit Account No. 201430.
4. A Petition to Withdraw from Issue After Payment of the Issue Fee (37 CFR 1.313(c)(2)), including the petition fee set forth in 37 CFR 1.17(h), is submitted herewith as a **Web-based ePetition**. **WARNING:** Do not submit the petition as a follow-on paper via EFS-Web. Submit the petition as a Web-based ePetition by signing on to EFS-Web as a registered user, selecting the radio button next to "Existing application/patent," and then selecting the radio button next to "ePetition (for automatic processing and immediate grant, if all petitions requirements are met)." Failure to use the Web-based ePetition interface will result in automatic entry of the RCE.
5. A request for continued examination (RCE) under 37 CFR 1.114 and the RCE fee under 37 CFR 1.17(e) are submitted herewith.
6. The RCE will be treated as a "conditional" RCE. In the event the examiner determines that any item of information contained in the IDS necessitates the reopening of prosecution in the application, the undersigned understands that (i) the RCE will be processed and treated as an RCE under 37 CFR 1.114 and therefore (ii) the IDS fee under 37 CFR 1.17(p) will be returned in accordance with 37 CFR 1.97(b)(4). In the event that no item of information in the IDS necessitates reopening prosecution, the undersigned understands that the RCE will not be processed and the RCE fee under 37 CFR 1.17(e) will be returned.
7. This certification and request is being filed as a **Web-based ePetition** and is not accompanied by an amendment to the application. Inclusion of an amendment will result in automatic entry of the RCE.

Signature / William L. Shaffer /	Date Oct. 13, 2021
Name (Print/Typed) William Shaffer	Practitioner Registration Number (If applicable) 37234

***Note**: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required in accordance with 37 CFR 1.33 and 11.18. Please see 37 CFR 1.4(d) for the form of the signature. If necessary, submit multiple forms for more than one signature, see below.**

☑ *Total of 1 forms are submitted.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	10/19/2021	11150329	103033-P010US3C2-1252983	9133

20350 7590 09/29/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Ouster, Inc., San Francisco, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

Change(s) applied
to document,
/J.K.W./
8/6/2021

ROTATING COMPACT LIGHT RANGING SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application is a continuation of Non-Provisional Patent Application No. 16/209,875 filed December 4, 2018, which claims the benefit of U.S. Provisional Patent Application No. 62/596,018, filed December 7, 2017, the disclosure of each of which are incorporated herein by reference in their entirety for all purposes.

[0002] This application is related to the following commonly assigned and concurrently filed patents and patent applications, the disclosures of each of which are incorporated herein by reference in their entirety for all purposes: U.S. Patent Application No. 16/209,867 filed December 4, 2018; now U.S. Patent No. 10,481,269 issued November 19, 2019; U.S. Patent Application No. 16/209, 869 filed December 4, 2018, now U.S. Pat. No. 10/969,490 issued April 6, 2021; U.S. Patent Application No. 16/209,879 filed December 4, 2018; and concurrently filed U.S. Patent Application entitled "Rotating Cmopact Light Ranging System" (Attorney Docket No. 103033-P010US3C1-1244801). 17/323983

BACKGROUND

[0003] Light imaging, detection and ranging (LIDAR) systems measure distance to a target by illuminating the target with a pulsed laser light and measuring the reflected pulses with a sensor. Time-of-flight measurements can then be used to make a digital 3D-representation of the target. LIDAR systems can be used for a variety of applications where 3D depth images are useful including archaeology, geography, geology, forestry, mapping, construction, medical imaging and military applications, among others. Autonomous vehicles can also use LIDAR for obstacle detection and avoidance as well as vehicle navigation.

[0004] Many currently available LIDAR sensors that provide coverage and resolution sufficient for obstacle detection and avoidance in autonomous vehicles are both technologically complex and costly to manufacture. Such sensors can thus be too expensive to allow for wide deployment in mass-market automobiles, trucks and other vehicles. Overall component cost and manufacturing complexity of a particular type of LIDAR sensor is typically driven by the underlying complexities in the architecture of the LIDAR sensor itself. This can be further

PTO/SB/47 (03-09)
Approved for use through 05/31/2015. OMB 0651-0016
U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

"FEE ADDRESS" INDICATION FORM

Address to:
Mail Stop M Correspondence
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

- OR -

Fax to:
571-273-6500

INSTRUCTIONS: The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below**: If you have a Customer Number to represent the fee address. **When to check the second box below**: If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

☑ Customer Number: 00197

OR

☐ The attached Request for Customer Number (PTO/SB/125) form.

PATENT NUMBER (if known)	APPLICATION NUMBER
	17/323,987

Completed by (check one):

☐ Applicant/Inventor — / William L. Shaffer / (Signature)

☑ Attorney or Agent of record 37234 (Reg. No.) — William Shaffer (Typed or printed name)

☐ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96) — 415 576-0200 (Requester's telephone number)

☐ Assignee recorded at Reel _____ Frame _____ — September 16, 2021 (Date)

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.363. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1. 11 and 1.14. This collection is estimated to take 5 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313- 1450. DO NOT SEND COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Mail Stop M Correspondence, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
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Electronic Patent Application Fee Transmittal

Application Number:	17323987
Filing Date:	18-May-2021
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	600	600

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**600**

Electronic Acknowledgement Receipt

EFS ID:	43790061
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/LaRenda Meyer
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	16-SEP-2021
Filing Date:	18-MAY-2021
Time Stamp:	20:46:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$600
RAM confirmation Number	E20219FK46522699
Deposit Account	201430
Authorized User	LaRenda Meyer

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37 CFR 1.21 (Miscellaneous fees and charges)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.16 (National application filing, search, and examination fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	P010US3C2-issue-fee-transmittal.pdf	852381 0c29ce4ea4e326d1a48cb72e647d6cacf4c86097	no	1
Warnings:					
Information:					
2	Miscellaneous Incoming Letter	P010US3C2-Comments-reasons-allowance.pdf	152385 a5b25426fb6cd97789577f2828b075b6aa05056a	no	7
Warnings:					
Information:					
3	Maintenance Fee Address Change	P010US3C2-fee-address-indication-form.pdf	160064 08831c23a6dbd9eef000cc28f2adeb0232473ea8	no	2
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	38179 b11685289c1eb687c1d0dfca0bad28f6b5d02c53	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1203009		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

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National Stage of an International Application under 35 U.S.C. 371

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New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
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Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20350 7590 07/22/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

La Renda Meyer-Johnson	(Typed or printed name)
/La Renda Meyer-Johnson/	(Signature)
September 16, 2021	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

TITLE OF INVENTION: ROTATING COMPACT LIGHT RANGING SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	10/22/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
LE, QUE TAN	2878	356-004010

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☒ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Kilpatrick Townsend
2 & Stockton LLP
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Ouster, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): San Francisco, California

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

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☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 20-1430

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature / William L. Shaffer / Date September 16, 2021

Typed or printed name William Shaffer Registration No. 37234

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on September 16, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033-P010US3C2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Angus Pacala Application No.: 17/323,987 Filed: May 18, 2021 For: ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY	Confirmation No.: 9797 Examiner: James R. Hulka Art Unit: 3645 COMMUNICATION - COMMENTS ON STATEMENT OF REASONS FOR ALLOWANCE

Mail Stop: Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

Applicant would like to thank the Examiner for the Notice of Allowance dated September 10, 2021.

With respect to the Examiner's Reasons for Allowance articulated in the above-referenced Notice of Allowance, Applicant submits that the claims should be interpreted based on the claim language and not on the Examiner's reasons for allowance.

With such in mind, Applicants note that independent claim 1 recites:

1. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation;

a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;

a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;

a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;

a stator assembly disposed between the first and second planes and coupled to the stator circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core;

a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.

Applicants further note that independent claim 14 recites:

14. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation;

a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;

a support component comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;

one or more bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation;

a rotor circuit board coupled to rotate with the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;

a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil;

a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.

Applicants further note that independent claim 22 recites:

22. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation, the shaft including a hollow channel axially aligned with the axis of rotation and extending through a length of the shaft;

a stator circuit board assembly disposed within and coupled to the enclosure in a fixed relationship, the stator circuit board assembly comprising:

a first circuit board disposed along a plane perpendicular to the axis of rotation;

a second circuit board disposed parallel to and adjacent to the first circuit board and having a first aperture formed through a central portion of the second circuit board; and

a stator assembly comprising a plurality of stator elements arranged about the axis of rotation;

a rotor circuit board assembly disposed within the enclosure and rotationally coupled to the shaft, the rotor circuit board assembly comprising:

a support component having lower and upper surfaces, a sleeve extending away from the lower surface and fitted over the shaft, a plurality of arms extending away from the sleeve, and a plurality of alignment posts extending away from the upper surface;

a third circuit board coupled to the lower surface of the support component and disposed adjacent to and in an opposing relationship with the second circuit board;

a fourth circuit board coupled to the upper surface of the support component and arranged parallel with the third circuit board between the third circuit board and the top cover, the fourth circuit board having a plurality of alignment cutouts sized and shaped to accept the alignment posts; and

a rotor component coupled to the rotor circuit board assembly and spaced apart from and concentric with the stator assembly, the rotor component comprising an annular arrangement in which a plurality of magnetic segments surround the axis of rotation and are distributed along the annular arrangement in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles;

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module,

the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment,

the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment, wherein the detector circuitry comprises a plurality of pixels, each pixel comprising a plurality of single photon avalanche detectors (SPADs) and wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of the electromagnetic radiation pulses by the detector circuitry;

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the rotor component to drive a rotation of the second circuit board assembly and the light ranging device about the shaft;

a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement; and

a communication channel extending through the hollow channel in the shaft and operatively coupled to allow ranging data from the light ranging device to be transmitted to circuitry disposed within the enclosure in a fixed relationship to the stator circuit board assembly.

None of the cited prior art references teach or suggest, alone or in combination, the inventions as recited in any of the above claims or in the claims dependent on the above claims.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Reg. No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

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17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 09/10/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

NOTIFICATION DATE	DELIVERY MODE
09/10/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Corrected ***Notice of Allowability***	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.	
	Examiner QUE TAN LE	**Art Unit** 2878	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to the IDS filed 8/30/2021.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-25 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20150219763	A1	2015-08-06	NUBLING	

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	1	202014101753	DE	U1	2015-07-17	SICK AG	English Abstract submitted	X

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NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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First Named Inventor	Pacala
Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

	1	EP Application No. 18886096.9, "Extended European Search Report", dated July 21, 2021, 10 pages	

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EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	09/02/2021

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Art Unit	2878
Examiner Name	Que Tan Le
Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

X That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

X The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-08-30
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983

CONFIRMATION NO. 9133

20350
Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

PUBLICATION NOTICE

OC00000128291648

Title:ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

Publication No.US-2021-0278506-A1
Publication Date:09/09/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

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Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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	1	20150219763	A1	2015-08-06	NUBLING	

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	1	202014101753	DE	U1	2015-07-17	SICK AG	English Abstract submitted	X

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Pacala
	Art Unit	2878
	Examiner Name	Que Tan Le
	Attorney Docket Number	103033-P010US3C2-1252983

	1	EP Application No. 18886096.9, "Extended European Search Report", dated July 21, 2021, 10 pages

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Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-08-30
Name/Print	William L. Shaffer	Registration Number	37,234

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ABSTRACT DE202014101753U1

Optoelectronic sensor (10) for detecting objects in a monitoring area (20), in particular a laser scanner, with a light transmitter for emitting a transmitted light beam (26), a light receiver (34) for generating a received signal from the signal remitted by objects in the monitoring area (20) Light (30), a base unit (14), a scanning unit (12) which is movable relative to the base unit (14) for periodic scanning of the monitoring area (20) and an evaluation unit (46) for acquiring information about objects in the monitoring area (20) of the received signal, the base unit (14) having a first transmission unit (44, 54, 56) and the scanning unit (12) a second transmission unit (44, 54, 58) for the contactless transmission of energy between the base unit (14) and the scanning unit (12), characterized in that the base unit (14) has a first printed circuit card (50) with the first transmission unit (44, 54, 5 8) and the scanning unit (12) has a second printed circuit card (52) with the second transmission unit (44, 54, 58) so that the two printed circuit cards (50, 52) are arranged flat on top of one another and the second printed circuit card (52) with the scanning unit (12) is movable with respect to the first printed circuit card (50) and that the transmission units (44, 54, 56, 58) are each integrated in the printed circuit cards (50, 52) coils (56, 58) for supplying the scanning unit (12) by inductive Have coupling.

Hesai Exhibit 1002, page 81

Espacenet

Bibliographic data: DE202014101753 (U1) — 2015-07-17

Optoelektronischer Sensor zur Erfassung von Objekten in einem Überwachungsbereich

Inventor(s):

Applicant(s): SICK AG [DE] ± (SICK AG)

Classification: **- international:** ***G01S17/89; G01S7/481; H01F38/18***
- cooperative: G01S17/42 (EP); G01S7/4813 (EP); G01S7/4817 (EP); H01F38/18 (EP); G01S7/4815 (EP)

Application number: DE201420101753U 20140414

Priority number(s): DE201420101753U 20140414

Abstract of DE202014101753 (U1)

Optoelektronischer Sensor (10) zur Erfassung von Objekten in einem Überwachungsbereich (20), insbesondere Laserscanner, mit einem Lichtsender zum Aussenden eines Sendelichtstrahls (26), einem Lichtempfänger (34) zum Erzeugen eines Empfangssignals aus dem von Objekten in dem Überwachungsbereich (20) remittierten Licht (30), einer Sockeleinheit (14), einer gegenüber der Sockeleinheit (14) beweglichen Abtasteinheit (12) zur periodischen Abtastung des Überwachungsbereichs (20) sowie einer Auswertungseinheit (46) zur Erfassung von Informationen über Objekte in dem Überwachungsbereich (20) anhand des Empfangssignals, wobei die Sockeleinheit (14) eine erste Übertragungseinheit (44, 54, 56) und die Abtasteinheit (12) eine zweite Übertragungseinheit (44, 54, 58) zur kontaktlosen Übertragung von Energie zwischen der Sockeleinheit (14) und der Abtasteinheit (12) aufweisen, dadurch gekennzeichnet, dass die Sockeleinheit (14) eine erste Leiterkarte (50) mit der ersten Übertragungseinheit (44, 54, 58) und die Abtasteinheit (12) eine zweite Leiterkarte (52) mit der zweiten Übertragungseinheit (44, 54, 58) aufweist, dass die beiden Leiterkarten (50, 52) flächig übereinander angeordnet sind und die zweite Leiterkarte (52) mit der Abtasteinheit (12) gegenüber der ersten Leiterkarte (50) beweglich ist und dass die Übertragungseinheiten (44, 54, 56, 58) jeweils in die Leiterkarten (50, 52) integrierte Spulen (56, 58) zur Versorgung der Abtasteinheit (12) durch induktive Kopplung aufweisen.

Hesai Exhibit 1002, page 82

(19) Deutsches Patent- und Markenamt

(10) **DE 20 2014 101 753 U1** 2015.08.27

(12) # Gebrauchsmusterschrift

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G01S 17/89 (2006.01)
H01F 38/18 (2006.01)

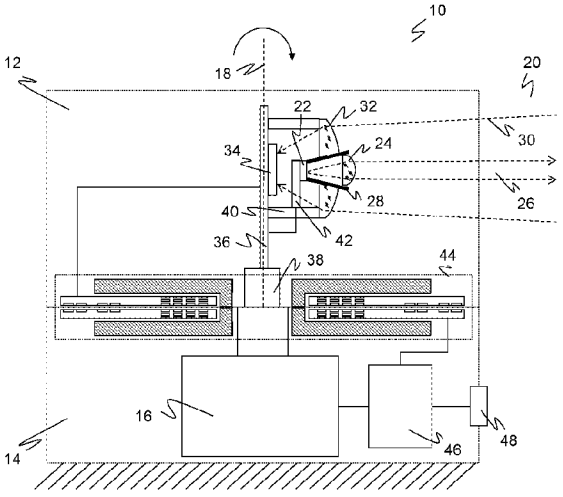
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(74) Name und Wohnsitz des Vertreters:
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Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Optoelektronischer Sensor zur Erfassung von Objekten in einem Überwachungsbereich**

(57) Hauptanspruch: Optoelektronischer Sensor (10) zur Erfassung von Objekten in einem Überwachungsbereich (20), insbesondere Laserscanner, mit einem Lichtsender zum Aussenden eines Sendelichtstrahls (26), einem Lichtempfänger (34) zum Erzeugen eines Empfangssignals aus dem von Objekten in dem Überwachungsbereich (20) remittierten Licht (30), einer Sockeleinheit (14), einer gegenüber der Sockeleinheit (14) beweglichen Abtasteinheit (12) zur periodischen Abtastung des Überwachungsbereichs (20) sowie einer Auswertungseinheit (46) zur Erfassung von Informationen über Objekte in dem Überwachungsbereich (20) anhand des Empfangssignals, wobei die Sockeleinheit (14) eine erste Übertragungseinheit (44, 54, 56) und die Abtasteinheit (12) eine zweite Übertragungseinheit (44, 54, 58) zur kontaktlosen Übertragung von Energie zwischen der Sockeleinheit (14) und der Abtasteinheit (12) aufweisen, dadurch gekennzeichnet, dass die Sockeleinheit (14) eine erste Leiterkarte (50) mit der ersten Übertragungseinheit (44, 54, 58) und die Abtasteinheit (12) eine zweite Leiterkarte (52) mit der zweiten Übertragungseinheit (44, 54, 58) aufweist, dass die beiden Leiterkarten (50, 52) flächig übereinander angeordnet sind und die zweite Leiterkarte (52) mit der Abtasteinheit (12) gegenüber der ersten Leiterkarte (50) beweglich ist und dass die Übertragungseinheiten (44, 54, 56, 58) jeweils in die Leiterkarten (50, 52) integrierte Spulen (56, 58) zur Versorgung der Abtasteinheit (12) durch induktive Kopplung aufweisen.



Beschreibung

[0001] Die Erfindung betrifft einen optoelektronischen Sensor zur Erfassung von Objekten in einem Überwachungsbereich nach dem Oberbegriff von Anspruch 1.

[0002] Für Abstandsmessungen, die einen großen horizontalen Winkelbereich des Messsystems erforderlich machen, eignen sich optoelektronische Systeme und besonders Laserscanner. In einem Laserscanner überstreicht ein von einem Laser erzeugter Lichtstrahl mit Hilfe einer Ablenkeinheit periodisch einen Überwachungsbereich. Das Licht wird an Objekten in dem Überwachungsbereich remittiert und in dem Scanner ausgewertet. Aus der Winkelstellung der Ablenkeinheit wird auf die Winkellage des Objektes und aus der Lichtlaufzeit unter Verwendung der Lichtgeschwindigkeit zusätzlich auf die Entfernung des Objektes von dem Laserscanner geschlossen.

[0003] Mit den Winkel- und Entfernungsangaben ist der Ort eines Objektes in dem Überwachungsbereich in zweidimensionalen Polarkoordinaten erfasst. Damit lassen sich die Positionen von Objekten ermitteln oder durch mehrere Antastungen desselben Objekts an verschieden Stellen dessen Kontur bestimmen. Die dritte Raumkoordinate kann durch eine Relativbewegung in Querrichtung ebenfalls erfasst werden, beispielsweise durch einen weiteren Bewegungsfreiheitsgrad der Ablenkeinheit in dem Laserscanner oder indem das Objekt relativ zu dem Laserscanner befördert wird. So können auch dreidimensionale Konturen ausgemessen werden.

[0004] Neben solchen Messanwendungen werden Laserscanner auch in der Sicherheitstechnik zur Überwachung einer Gefahrenquelle eingesetzt, wie sie beispielsweise eine gefährliche Maschine darstellt. Ein derartiger Sicherheitslaserscanner ist aus der DE 43 40 756 A1 bekannt. Dabei wird ein Schutzfeld überwacht, das während des Betriebs der Maschine vom Bedienpersonal nicht betreten werden darf. Erkennt der Laserscanner einen unzulässigen Schutzfeldeingriff, etwa ein Bein einer Bedienperson, so löst er einen Nothalt der Maschine aus. In der Sicherheitstechnik eingesetzte Sensoren müssen besonders zuverlässig arbeiten und deshalb hohe Sicherheitsanforderungen erfüllen, beispielsweise die Norm EN13849 für Maschinensicherheit und die Gerätenorm EN61496 für berührungslos wirkende Schutzeinrichtungen (BWS).

[0005] Die Abtastung der Überwachungsebene in einem Laserscanner wird üblicherweise dadurch erreicht, dass der Sendestrahl auf einen rotierenden Drehspiegel trifft. Lichtsender, Lichtempfänger sowie zugehörige Elektronik und Optik sind im Gerät fest montiert und vollziehen die Drehbewegung nicht mit. Durch den Spiegel ergeben sich sehr hohe Anforderungen an die Ausrichtung der Lichtsender und Lichtempfänger zur Drehachse. Abweichungen davon führen zu einer verbogenen Überwachungsebene. Außerdem sind solche Optikeinheiten baugroß, weil sich immer ein Teil der Objektweite über den Spiegel bis zur Empfangsoptik in das Gerät erstreckt. Streulichteffekte an der Frontscheibe durch die Frontscheibe selbst oder deren Verunreinigung führen zu einer Beeinträchtigung der Sensorfunktion.

[0006] Es ist auch bekannt, den Drehspiegel durch eine mitbewegte Abtasteinheit zu ersetzten. Beispielsweise rotiert in der DE 197 57 849 B4 der gesamte Messkopf mit Lichtsender und Lichtempfänger. Die EP 2 388 619 A1 sieht ebenfalls eine drehbare Sende-/Empfangseinheit vor. Diese Abtasteinheit wird beispielsweise nach dem Transformationsprinzip von den drehfesten Bereichen des Sensors mit Energie versorgt, während die Datenübertragung drahtlos per Funk oder auf optischem Wege erfolgt. Solche drahtlosen Schnittstellen erfordern aber einen hohen Aufwand und verursachen Störstrahlung.

[0007] Daher ist Aufgabe der Erfindung, den Aufbau eines Sensors mit mitbewegter Abtasteinheit zu vereinfachen.

[0008] Diese Aufgabe wird durch einen optoelektronischen Sensor zur Erfassung von Objekten in einem Überwachungsbereich nach Anspruch 1 gelöst. Dabei geht die Erfindung von dem Grundgedanken aus, den Sensor zweiteilig mit einer Sockeleinheit und einer Abtasteinheit aufzubauen. Die Abtasteinheit wird relativ zu der Sockeleinheit bewegt, um den Überwachungsbereich periodisch abzutasten, insbesondere in Drehbewegung versetzt. Die Sockeleinheit bleibt stationär und umfasst alle weiteren ruhenden Elemente des Sensors, beispielsweise ein Gehäuse. Dabei bezieht sich stationär oder ruhend auf ein übliches Bezugssystem des Sensors, der dennoch insgesamt bewegt werden kann, beispielsweise in mobilen Anwendungen an einem Fahrzeug, welches dann das hier als stationär bezeichnete Bezugssystem bildet. Die Erfindung geht dann von dem Grundgedanken aus, die Schnittstellen zwischen Sockeleinheit und Abtasteinheit in zwei Leiterkarten zu integrieren, von denen eine Leiterkarte mit der Sockeleinheit ruht und die andere Leiterkarte sich mit der Abtasteinheit bewegt. Die Leiterkarten sind flächig übereinander angeordnet und stehen vorzugsweise senkrecht zu einer Antriebswelle, welche die Abtasteinheit bewegt. Eine erste Funktion der Schnittstellen oder Übertragungseinheiten ist, die Abtasteinheit mit Energie beziehungsweise Strom oder Spannung zu versorgen. Dazu sind Spulen, insbesondere Planarspulen, in Form von gewundenen Leitungsstrukturen auf den beiden Außenflächen sowie möglicherweise auch in inneren Schichten der Leiterkarten in die Leiterkarten integriert, um die Abtasteinheit kontaktlos induktiv zu versorgen.

[0009] Die Erfindung hat den Vorteil, dass ermöglicht wird, die herkömmlichen Umlenkspiegel oder Spiegelräder durch eine mitbewegte Abtasteinheit zu ersetzen, ohne dadurch mechanisch anfällige Schleifkontakte oder sehr aufwändige drahtlose Schnittstellen zu benötigen. Es entsteht ein sehr kompakter, kostengünstiger und robuster Sensor.

[0010] Vorteilhafterweise ist die erste Leiterkarte in der Sockeleinheit und die zweite Leiterkarte an einer Welle eines Antriebs für die Abtasteinheit befestigt. Damit sind die Leiterkarten sicher fixiert, und wie gewünscht ruht die erste Leiterkarte in der Sockeleinheit, während die zweite Leiterkarte mit der Abtasteinheit rotiert.

[0011] Der Lichtsender und der Lichtempfänger sind bevorzugt in der Abtasteinheit angeordnet. Damit wird die Abtasteinheit zu einem weitgehend autarken Messkopf. Mit Lichtsender und Lichtempfänger sind vorzugsweise auch zugehörige Sende- und Empangsoptiken sowie zumindest ein Teil der Sende- und Empfangselektronik in der Abtasteinheit untergebracht. Lichtsender, Lichtempfänger und/oder deren Elektronik können je nach optischem Aufbau innerhalb der Abtasteinheit auf der zweiten Leiterplatte angeordnet sein. Alternativ wird mindestens eine weitere Leiterplatte in der Abtasteinheit angeordnet, die mit der zweiten Leiterplatte verbunden ist.

[0012] Die erste Leiterkarte weist bevorzugt eine Royer-Oszillator-Schaltung auf. Dadurch kann eine stabile, weitgehend oberwellenfreie Schwingung im Resonanzbereich der Spulen erzeugt werden. Dies minimiert Schaltverluste und elektromagnetische Abstrahlung und sorgt für einen hohen Wirkungsgrad der Energieübertragung.

[0013] Die zweite Leiterkarte ist bevorzugt kreisförmig ausgebildet. Dadurch wird ein Rotieren ohne Unwucht erleichtert. Die ruhende erste Leiterkarte weist mindestens die kreisförmige Ausdehnung der zweiten Leiterkarte auf, damit sich die beiden Leiterkarten vollständig mit ihren zueinander gerichteten Außenseiten flächig gegenüberstehen. Die erste Leiterkarte kann aber über diese Ausdehnung hinausragen, um beispielsweise weitere Elektronikbauteile oder Befestigungselemente unterzubringen.

[0014] Die Spulen sind bevorzugt als zentral angeordnete Windungen um eine Drehachse der Abtasteinheit auf den Leiterkarten ausgebildet. Die Spulen winden sich also innen eng um die Drehachse, insbesondere die Welle des Antriebs. Durch die zentrale Lage können die Spulen besonders wirkungsvoll abgeschirmt werden.

[0015] Die Spulen weisen bevorzugt gegenläufige Windungen auf. Es verläuft also mindestens eine Windung mit dem Uhrzeigersinn und eine Windung gegen den Uhrzeigersinn. Soweit möglich, umfassen die Windungen dennoch nahezu 360°, sind also so vollständig, wie das ohne Kurzschluss möglich ist. Eine besonders bevorzugte Ausprägung ist eine selbstkompensierende Doppelwicklung mit einer inneren Windung in der einen und einer äußeren Windung in der anderen Richtung. Die gegenläufigen Windungen ermöglichen einen symmetrischen Aufbau mit optimiertem Feldverlauf, wenn sich im Inneren ein elektrisch leitendes Objekt befindet, wie hier beispielsweise die Motorachse.

[0016] Die Übertragungseinheiten weisen bevorzugt einen Resonanzübertrager ohne primärseitige Hilfswicklung und Mittelpunktanzapfung auf. Der Resonanzübertrager soll funktional einem Royer-Oszillator entsprechen, d.h. möglichst oberwellenfrei schwingen. Ein Royer-Oszillator benötigt aber Hilfwicklungen und eine mittige Anzapfung der Spule. Das ist insbesondere bei einem vorteilhaften Spulenaufbau gemäß dem vorigen Absatz schwer oder gar nicht möglich. Durch die angepasste Schaltung können die Vorteile des Royer-Oszillators und des besagten Spulenaufbaus miteinander kombiniert werden.

[0017] Die Übertragungseinheiten weisen bevorzugt jeweils einander gegenüberliegende Leiterstrukturen auf den Leiterkarten auf, die mindestens einen Kondensator zur kapazitiven kontaktlosen Datenübertragung bilden. Die Leiterstrukturen sind vorzugsweise paarweise und innerhalb eines Paares gleichartig auf den beiden Leiterkarten vorgesehen. Jedes Paar einander gegenüberstehender Leiterstrukturen bildet dann mit dem Luftspalt zwischen den Leiterplatten beziehungsweise eventuell eingeschlossenem Leiterplattenmaterial oder sonstigem Dielektrikum einen Kondensator. Die gleichen Leiterkarten beziehungsweise die darauf angeordneten Übertragungseinheiten haben zusätzlich zur induktiven Versorgung eine zweite Funktion der kontaktlosen kapazitiven Datenübertragung. Die unterschiedlichen physikalischen Übertragungsprinzipien erleichtern es, gegenseitige Störungen zu verhindern.

[0018] Die Leiterstrukturen sind bevorzugt als Kreisringe ausgebildet. Der Mittelpunkt der Kreisringe ist die Drehachse. So stehen die Leiterstrukturen zweier Leiterplatten einander unabhängig von einer Drehstellung der Abtasteinheit bezüglich der Sockeleinheit immer in gleicher Weise gegenüber. Die Kapazität bleibt also während der Abtastbewegung gleich.

[0019] Bevorzugt sind mehrere zueinander konzentrische Kreisringe vorgesehen, um mehrere Kondensatoren für eine bidirektionale und/oder differentielle Datenübertragung zu bilden. So können zwei Kondensatoren für bidirektionale Datenübertragung, zwei Kondensatoren für eine robustere differentielle Datenübertragung oder sogar vier Kondensatoren für ei-

ne differentielle, bidirektionale Datenübertragung vorgesehen sein.

[0020] Die Kreisringe sind bevorzugt untereinander flächengleich. Die durch die unterschiedlichen Innenradien variierenden Kreisumfänge werden dabei durch unterschiedliche Dicken ausgeglichen, also radiale Ausdehnung der Kreisringe, damit die Kapazitäten der gebildeten Kondensatoren untereinander gleich bleiben.

[0021] Die Kreisringe der Kapazitäten und die Windungen der Induktivitäten sind bevorzugt konzentrisch um die Drehachse angeordnet, und zwar derart, dass die Kreisringe die Windungen umschließen. Dadurch sind zum einen Energie- und Datenübertragung örtlich entkoppelt. Außerdem wird Störstrahlung durch die innen angeordnete Energieübertragung von der außen liegenden Datenübertragung abgeschirmt.

[0022] Die Übertragungseinheiten sind vorzugsweise zumindest teilweise von einem Ferritmantel eingeschlossen. Der Ferritmantel oder Ferritkern schließt den Magnetkreis der Energieversorgung bis auf einen für die Drehbewegung notwendigen Luftspalt ein und erhöht damit den Wirkungsgrad der Übertragung. Im Bereich der Datenübertragung, die deutlich höhere Frequenzen nutzt, dient der Ferritmantel als Abschirmung. Gleichzeitig kann der Ferritmantel für die mechanische Halterung der Übertragungseinheiten genutzt werden.

[0023] Die Leiterkarten sind bevorzugt zumindest teilweise von einer magnetischen, schlecht leitenden Abschirmung umgeben. Das verringert etwaige Störstrahlung in beide Richtungen (EMV).

[0024] Die Abschirmung weist bevorzugt eine Bodenplatte und eine Deckplatte sowie einen inneren Zylinder auf, so dass eine Drehachse der Abtasteinheit innerhalb des Zylinders und die Leiterkarten konzentrisch zu dem Zylinder sowie zwischen Bodenplatte und Deckplatte angeordnet sind. Diese Geometrie umgibt die Übertragungseinheiten und schirmt die Übertragung damit wirksam nach außen und von außen ab. Da nur ein innerer Zylinder vorgesehen ist, bleibt eine äußere Mantelfläche frei, wo die Leiterplatten befestigt, frei bestückt und kontaktiert werden können. Zum gleichen Zweck ist vorzugsweise der Radius von Boden- beziehungsweise Deckplatte geringer als derjenige der Leiterplatten.

[0025] Die Erfindung wird nachstehend auch hinsichtlich weiterer Vorteile und Merkmale unter Bezugnahme auf die beigefügte Zeichnung anhand von Ausführungsbeispielen erläutert. Die Figuren der Zeichnung zeigen in:

[0026] **Fig.** 1 eine schematische Schnittdarstellung durch einen optoelektronischen Sensor;

[0027] **Fig.** 2 eine vergrößerte Darstellung einer kontaktlosen Anbindung des Sensors gemäß **Fig.** 1;

[0028] **Fig.** 3 eine Draufsicht auf eine Leiterplatte der kontaktlosen Anbindung gemäß **Fig.** 2;

[0029] **Fig.** 4 einen Ausschnitt einer Schaltskizze zur bidirektionalen und differentiellen kapazitiven Datenübertragung;

[0030] **Fig.** 5 eine Draufsicht auf eine weitere Ausführungsform einer Spulenanordnung zur kontaktlosen Anbindung;

[0031] **Fig.** 6 eine Schnittdarstellung zur Erläuterung des Feldverlaufs in einer zusätzlich abgeschirmten Spulenanordnung gemäß **Fig.** 5;

[0032] **Fig.** 7 eine Resonanzübertragerschaltung für die kontaktlose Anbindung insbesondere mit einer Spule gemäß **Fig.** 5; und

[0033] **Fig.** 8 beispielhafte Spannungs- und Ansteuerungsverläufe für die Schaltung gemäß **Fig.** 7.

[0034] **Fig.** 1 zeigt eine schematische Schnittdarstellung durch einen optoelektronischen Sensor in einer Ausführungsform als Laserscanner **10**. Der Laserscanner **10** umfasst in grober Aufteilung eine bewegliche Abtasteinheit **12** und eine Sockeleinheit **14**. Die Abtasteinheit **12** ist der optische Messkopf, während in der Sockeleinheit **14** weitere Elemente wie eine Versorgung, Auswertungselektronik, Anschlüsse und dergleichen untergebracht sind. Im Betrieb wird mit Hilfe eines Antriebs **16** der Sockeleinheit **14** die Abtasteinheit **12** in eine Drehbewegung um eine Drehachse **18** versetzt, um so einen Überwachungsbereich **20** periodisch abzutasten.

[0035] In der Abtasteinheit **12** erzeugt ein Lichtsender **22** mit Hilfe einer Sendeoptik **24** einen Sendelichtstrahl **26**, der in den Überwachungsbereich **20** ausgesandt wird. Zur Vermeidung von Streulicht innerhalb des Laserscanners **10** wird der interne Lichtweg des Sendelichtstrahls **26** von einem lichtundurchlässigen Tubus **28** abgeschirmt. Trifft der Sendelichtstrahl **26** in dem Überwachungsbereich **20** auf ein Objekt, so kehrt ein entsprechender Lichtstrahl als remittiertes Licht **30** zu dem Laserscanner **10** zurück. Das remittierte Licht **30** wird von einer Empfangsoptik **32** auf einen Lichtempfänger **34** geführt und dort in ein elektrisches Empfangssignal gewandelt.

[0036] Der Lichtempfänger **34** ist in dieser Ausführungsform auf einer Leiterkarte **36** angeordnet, die auf der Drehachse **18** liegt und mit der Welle **38** des Antriebs **16** verbunden ist. Die Empfangsoptik **32**

stützt sich durch Beinchen **40** auf der Leiterkarte **36** ab und hält eine weitere Leiterkarte **42** des Lichtsenders **22**. Die beiden Leiterkarten **36**, **42** sind untereinander verbunden und können auch als gemeinsame Flexprint-Leiterkarte ausgebildet sein.

[0037] Der in **Fig.** 1 gezeigte optische Aufbau mit zwei übereinander geschichteten Leiterkarten **36**, **42** oder Leiterkartenbereichen und einer zentral innerhalb der Empfangsoptik **32** angeordneten Sendeoptik **24** ist rein beispielhaft zu verstehen. So wäre alternativ jede andere an sich von einstrahligen optoelektronischen Sensoren oder Laserscannern bekannte Anordnung wie etwa eine Doppelaugenanordnung oder die Verwendung eines Strahlteilerspiegels möglich. Die Erfindung befasst sich weniger mit der konkreten Ausgestaltung von Lichtsender, Lichtempfänger und deren Optiken und Elektronik, sondern vielmehr mit einer kontaktlosen Anbindung **44** der beweglichen Abtasteinheit **12** an die Sockeleinheit **14** zur Energie- und/oder Datenübertragung. Die kontaktlose Anbindung **44** wird weiter unten im Zusammenhang mit den **Fig.** 2 bis **Fig.** 4 näher erläutert.

[0038] Die kontaktlose Anbindung **44** ist in der Abtasteinheit **12** mit der Elektronikkarte **36** und in der Sockeleinheit **14** mit einer Steuer- und Auswertungseinheit **46** verbunden. Auf diese Weise kann die Steuer- und Auswertungseinheit **46** den Lichtsender **22** steuern und erhält das Empfangssignal des Lichtempfängers **34** zur weiteren Auswertung. Die Steuer- und Auswertungseinheit **46** steuert außerdem den Antrieb **16** und erhält das Signal einer nicht gezeigten, von Laserscannern allgemein bekannten Winkelmesseinheit, welche die jeweilige Winkelstellung der Abtasteinheit **14** bestimmt.

[0039] Zur Auswertung wird vorzugsweise mit einem Lichtlaufzeitverfahren die Distanz zu einem angetasteten Objekt gemessen. Dazu wird in einem phasenbasierten System das Sendelicht des Lichtsenders **22** moduliert und eine Phasenbeziehung zu dem Empfangssignal des Lichtempfängers **34** ausgewertet. Alternativ werden in einem pulsbasierten System kurze Lichtpulse zu einem Sendezeitpunkt als Sendelicht ausgesandt und aus dem Empfangssignal deren Empfangszeitpunkt ermittelt. Dabei sind sowohl Einzelpulsverfahren, die jeweils aus einem einzigen Sendepuls eine Entfernung bestimmen, als auch Pulsmittelungsverfahren denkbar, in denen das Empfangssignal nach einer Vielzahl aufeinanderfolgender Sendepulse gesammelt und statistisch ausgewertet wird. Die jeweilige Winkelstellung, unter welcher der Sendelichtstrahl **26** jeweils ausgesandt wurde, ist von der Winkelmesseinheit ebenfalls bekannt. Somit stehen nach jeder Scanperiode über den Winkel und die Entfernung zweidimensionale Polarkoordinaten aller Objektpunkte in einer Abtastebene zur Verfügung. Durch eine zusätzliche Verkippung der Abtasteinheit **14** kann auch ein dreidimensionaler Überwachungsbereich **20** erfasst werden.

[0040] Damit sind die Objektpositionen beziehungsweise Objektkonturen bekannt und können über eine Sensorschnittstelle **48** ausgegeben werden. Die Sensorschnittstelle **48** oder ein weiterer, nicht gezeigter Anschluss dienen umgekehrt als Parametrierschnittstelle. Bei Anwendungen in der Sicherheitstechnik werden Schutzfelder, die in dem Überwachungsbereich **20** konfiguriert werden können, auf unzulässige Eingriffe überwacht, und daraufhin wird gegebenenfalls ein sicherheitsgerichtetes Abschaltsignal über die dann sicher ausgebildete Schnittstelle **48** (OSSD, Output Signal Switching Device) ausgegeben.

[0041] Der Lichtsender **22** kann als einfache Lichtquelle, etwa in Form einer Halbleiterdiode, aber auch als beispielsweise zeilen- oder matrixförmige Anordnung zahlreiche Lichtquellen aufgebaut sein. Entsprechend kann es sich bei dem Lichtempfänger **34** um eine einfache Empfangsfläche, etwa einer Photodiode, oder um eine beispielsweise zeilen- oder matrixförmige Anordnung von Lichtempfangselementen handeln, wie einen CCD- oder CMOS-Chip. Damit entsteht dann nicht nur ein einzelner Abtaststrahl, sondern eine entsprechende Vielzahl zur Aufnahme von zweidimensionalen Bilddaten oder dreidimensionalen Bilddaten mit Hilfe eines Lichtlaufzeitverfahrens. Prinzipiell können nahezu beliebige Sensoreinheiten in der Abtasteinheit **12** rotieren und so den Überwachungsbereich **20** erfassen, beispielsweise auch mehrere Sensoreinheiten in unterschiedlichen Winkelstellungen, die einander mit gleichen oder unterschiedlichen physikalischen Messprinzipien ergänzen. Es besteht auch die Möglichkeit, die Abtasteinheit zusätzlich zu verkippen oder mehrere übereinander angeordnete Lichtsender **22** beziehungsweise Lichtempfänger **34** oder eine insbesondere entfernungsmessende Kamerazeile rotieren zu lassen, um einen dreidimensionalen Raumbereich abzutasten.

[0042] **Fig.** 2 zeigt eine Ausschnittvergrößerung eines linken Bereichs der kontaktlosen Anbindung **44** aus **Fig.** 1. Der in **Fig.** 2 nicht gezeigte rechte Bereich der kontaktlosen Anbindung ist nur ein anderer Schnitt durch die insgesamt zylindrische kontaktlose Anbindung **44** und sieht bis auf Spiegelung gleich aus, wie auch aus **Fig.** 1 hervorgeht.

[0043] Die kontaktlose Anbindung **44** weist einen unteren Teil mit einer ersten Leiterkarte **50** in der Sockeleinheit **14** und einen oberen Teil mit einer zweiten Leiterkarte **52** in der Abtasteinheit **12** auf. Beispielsweise ist die erste Leiterkarte **50** an einem Gehäuse des Laserscanners **10** und die zweite Leiterkarte **52** an der Welle **38** befestigt. Demzufolge rotiert die zweite Leiterkarte **52** mit der Abtasteinheit **12** gegen die erste Leiterkarte **50** in der stationären Sockelein-

heit **14**, wobei die Leiterkarten **50**, **52** dabei in jeder Winkelstellung flächig übereinander angeordnet und nur durch einen kleinen Spalt getrennt sind.

[0044] In einem zentralen Bereich, also nahe der Drehachse **18**, weisen die Leiterplatten **50**, **52** eine kontaktlose Energieversorgung **54** auf. Dazu sind in die Leiterplatten **50**, **52** Spulen **56**, **58** vorzugsweise als mehrlagige Planarspulen mit Windungen um die Drehachse **18** integriert. Über die Spulen **56**, **58** kann die Abtasteinheit **12** induktiv kontaktlos versorgt werden. Die induktive Kopplung beeinflusst das Drehmoment nicht, da die Feldlinien vertikal zu der Drehachse **18** verlaufen. **Fig.** 3 zeigt eine ergänzende Draufsicht auf die erste Leiterkarte **50**, wobei in einer Unteransicht der zweiten Leiterkarte **52** vergleichbare Strukturen zu sehen wären.

[0045] Um die elektromagnetische Abstrahlung der Spulen **56**, **58** gering zu halten und die Schaltfrequenz zu optimieren, ist auf der ersten Leiterplatte **50** vorzugsweise eine nicht dargestellte Royer-Oszillator-Schaltung angeordnet. Diese an sich bekannte Schaltung sorgt für eine oberwellenfreie Ansteuerung der Spulen **56**, **58** im Resonanzbereich. Die Transistoren der Schaltung haben außerdem ein vorteilhaftes Schaltverhalten, die das Signal schnell und zuverlässig auf 0V bringen. Dadurch entstehen keine Schaltverluste oder störenden Oberwellen, und es wird ein sauberes sinusförmiges Signal bereitgestellt.

[0046] Zusätzlich zur kontaktlosen Versorgung hat die kontaktlose Anbindung **44** vorzugsweise auch die Aufgabe einer kontaktlosen Datenübertragung **60**. Dazu sind in einem äußeren Bereich der Leiterplatten **50**, **52**, also weiter von der Drehachse **18** beabstandet, leitende Kreisringe **62**, **64** vorgesehen, welche die Windungen der Spulen **56**, **58** umschließen. Jeweils einander gegenüberstehende Kreisringe **62**, **64** der beiden Leiterplatten **50**, **52** bilden einen Plattenkondensator, der für eine kapazitive Datenübertragung genutzt wird. Da die Kreisringe **62**, **64** konzentrisch sind, stehen sich die Kreisringe **62**, **64** in jeder Drehstellung der Abtasteinheit **14** weiterhin gegenüber, so dass die kapazitive Kopplung von der Drehbewegung nicht beeinträchtigt wird.

[0047] In der Draufsicht gemäß **Fig.** 3 ist eine Ausführungsform mit je zwei Kreisringen **62a**–b, in **Fig.** 2 sogar eine Ausführungsform mit je vier Kreisringen gezeigt. Dementsprechend werden mehrere Plattenkondensatoren gebildet, die dafür genutzt werden, Daten bidirektional und/oder differentiell zu übertragen. Eine differentielle Datenübertragung ist unempfindlich gegen Gleichtaktstörungen. Gleichspannungsfreie Datensignale werden beispielsweise durch eine 8B10B-Codierung erreicht.

[0048] **Fig.** 4 zeigt einen Ausschnitt einer Schaltskizze zur bidirektionalen und differentiellen kapazitiven Datenübertragung mit vier durch entsprechende Kreisringpaare gebildeten Kondensatoren **66a**–d. Der Vorteil einer differentiellen kapazitiven Datenübertragung liegt in dem robusten Störverhalten sowohl hinsichtlich Einstrahlung als auch Abstrahlung. Es lassen sich Datenraten von beispielsweise 2,5 GBit erreichen. Die Kondensatoren **66a**–d sollten die gleiche Kapazität haben, was durch Anpassung der Breite der Kreisringe **62**, **64** erreicht werden kann, damit diese untereinander flächengleich sind. Die Datenübertragung kann doppelt ausgebildet werden, um mehr Bandbreite oder eine redundante Datenübertragung beispielsweise für Sicherheitsanwendungen zu erzielen.

[0049] Wie in **Fig.** 2 zu erkennen, ist die kontaktlose Anbindung **44** von einer zweiteiligen Abschirmung **68**, **70** umgeben, beispielsweise einem Ferritmantel. Dies verbessert die induktive Kopplung und sorgt für eine Abschirmung gegen Störstrahlung. Die Abschirmung besteht aus einer Boden- beziehungsweise Deckplatte, welche die Leiterplatten **50**, **52** bis zu einem gewissen radialen Abstand zur Drehachse **18** abdecken sowie jeweils einem inneren Zylinder als Abschluss. Es ist denkbar, die Abschirmung **68**, **70** zumindest teilweise in die Leiterplatten **50**, **52** zu integrieren.

[0050] **Fig.** 5 zeigt eine Draufsicht auf eine weitere Ausführungsform einer Spulenanordnung, die sich durch die Gestaltung der Windungen **56**, **58** unterscheidet. Es verlaufen nämlich Windungen **56**, **58** in zueinander entgegengesetzter Richtung, also mit und gegen den Uhrzeigersinn, wobei **Fig.** 5 gerade die besonders vorteilhafte minimale Konfiguration mit einer derartigen selbstkompensierenden Doppelwindung darstellt. Der vorteilhafte Effekt ist, dass im Inneren der Windungen **56**, **58** das Magnetfeld zumindest partiell ausgelöscht wird. Dies ermöglicht einen verlustoptimierten symmetrischen Aufbau um ein elektrisch leitendes Objekt herum, wobei hier natürlich bei einem solchen Objekt im Inneren in erster Linie an die Welle **38** des Antriebs **16** zu denken ist.

[0051] **Fig.** 6 zeigt eine vereinfachende Schnittdarstellung des Feldverlaufs an einer solchen Spule gemäß **Fig.** 5 mit selbstkompensierender Doppelwindung **56**, **58**. Der Bereich der Welle **38** ist zumindest nahezu feldfrei. Als weitere optionale Ausgestaltung ist hier eine zweischichtige Abschirmung mit einer Ferritschicht **68a**, **70a** direkt über den Windungen **56**, **58** und darüber eine weitere leitende Abschirmschicht **68b**, **70b** beispielsweise aus Kupfer vorgesehen. Die Ferritschicht **68a**, **70a** beziehungsweise Ferritplatten sorgen für eine Ablenkung des magnetischen Feldes. Dadurch werden die Magnetfelder im Bereich der Energieübertragung konzentriert und die Abstrahlung gering gehalten. Die zusätzliche optionale Kupferschicht **68b**, **70b** verringert die Abstrahlung noch weiter. Felder, die in der abschirmenden

Kupferschicht **68b**, **70b** ankommen, werden durch Wirbelstromverluste absorbiert und in Wärme umgesetzt.

[0052] Über die in **Fig.** 6 gezeigte zweischichtige Abschirmung hinaus kann es sinnvoll sein, die Windungen **56**, **58** und gegebenenfalls auch die Kreisringe **62**, **64** nicht nur mit Ferrit abzudecken, sondern weitgehend mit Ferrit zu ummanteln. Dadurch wird der Magnetkreis bis auf einen für die Drehbewegung nötigen Luftspalt eingeschlossen. Die Kopplung über den Luftspalt kann durch entsprechende Isolierstoffe mit höherer dielektrischer Konstante verbessert werden. Die Schirmtechnik kann gleichzeitig für die mechanische Halterung von Primär- beziehungsweise Sekundärkreis genutzt werden.

[0053] Eine weitere Maßnahme zusätzlich zu der bereits erläuterten differentiellen kapazitiven Datenübertragung besteht in einer Spulentrennung, also dem Vorsehen einer radialen Lücke zwischen Windungen oder Doppelwindungen der Spulen **56**, **58**. Ähnliches ist auch für die Kreisringe **62**, **64** der kapazitiven Datenübertragung denkbar. Die Spulentrennung wird induktiv für eine weiter verbesserte Magnetfeldkonzentration auf den aktiven Bereich genutzt. Außerdem kann die Feldstreuung nach außen reduziert werden.

[0054] Der Frequenzbereich der Energieübertragung und der Datenübertragung unterscheidet sich vorteilhafterweise erheblich, und dieser Unterschied kann in einer Größenordnung von drei Zehnerpotenzen liegen. Der Ferritmantel hat in diesen beiden Frequenzbereichen ein sehr unterschiedliches Verhalten. Für die Energieübertragung kann die erhöhte Effizienz genutzt werden, für den Datenverkehr die hohe Abstrahlreduktion nach außen durch Dämpfung.

[0055] **Fig.** 7 zeigt eine Resonanzübertragerschaltung, mit der induktiv über die Spulen **56**, **58** Energie von der Sockeleinheit **14** in die Abtasteinheit **12** übertragen wird. Der obere Teil dieser Schaltung ist beispielsweise auf der Leiterkarte **52** beziehungsweise vor oder auf der Leiterkarte **52**, der untere Teil der Schaltung auf der Leiterkarte **50** beziehungsweise vor oder auf der Steuer- und Auswertungseinheit **46** untergebracht. Der Übergang vom stationären System der Sockeleinheit **14** auf das rotierende System der Abtasteinheit **12** bilden die Induktivität L3, welche der Spule **56**, und die Induktivität L4, welche der Spule **58** entspricht. Eine alternative Möglichkeit, diese Schaltung zu gestalten, ist ein an sich bekannter Royer-Oszillator oder Royer-Konverter. Das hat aber den Nachteil, dass es mit der speziellen Spulenform nach **Fig.** 5 nicht ohne Weiteres funktioniert, weil ein Royer-Oszillator Hilfswindungen und einen Mittenabgriff erfordert.

[0056] Die in **Fig.** 7 gezeigte Schaltung arbeitet als Resonanzübertrager. Die Ansteuerung über die Schalter S1 und S2 kann gezielt über eine externe Taktquelle oder gleichsam spontan durch Aufschwingen immer vorhandener kleiner Störungen erfolgen. Die Feedbackleitung kann dazu verwendet werden, den Schaltzeitpunkt gerade beim Nulldurchgang der Spannung und damit so festzulegen, dass in dem Schalter S1, S2 keine Schaltverluste entstehen. Als Schalter S1, S2 dienen beispielsweise bipolare Transistoren oder Feldeffekttransistoren.

[0057] Die Grundfrequenz der Schaltung ist die Resonanzfrequenz von L3 und C3 sowie L4 und C4 gemäß der üblichen Formel $f = 1/2\pi\sqrt{LC}$. Die Induktivitäten L1 und L2 werden benötigt, um den Schwingkreis von der Versorgungsspannung abzukoppeln. Die Energieübertragung erfolgt von L3 nach L4, und R1 entspricht der Last, also den mitdrehenden Verbrauchern in der rotierenden Ablenkeinheit **12**. Ein hinter den Serienschwingkreis aus L4 und C4 angeordneter Gleichrichter übernimmt gemeinsam mit der Kapazität C1 die Umwandlung der übertragenen Wechselspannung in eine Gleichspannung, die das mitdrehende System in der Ablenkeinheit **12** gewöhnlich benötigt.

[0058] Im Vergleich mit einem herkömmlichen Royer-Oszillator hat diese Schaltung den Vorteil, dass keine Mittelpunktanzapfung der Primärwicklung und keine Hilfswicklung der Primärwicklung nötig ist. Das macht die Schaltung gemäß **Fig.** 7 besonders geeignet für anhand der **Fig.** 5 beschriebene selbstkompensierende Spulen **56**, **58**.

[0059] **Fig.** 8 zeigt beispielhafte Spannungs- und Ansteuerungsverläufe für die soeben erläuterte Schaltung gemäß **Fig.** 7. Dabei ist der obere Verlauf **74** die Ansteuerung beispielsweise an S1 und der untere Verlauf **76** der zugehörige Spannungsverlauf. Die Schaltung insgesamt erzeugt somit einen sehr reinen, sinusförmigen Strom ohne Oberwellen durch die Induktivität L3, der dementsprechend bei korrekter Anordnung und räumlicher Nähe in der Induktivität L4 induziert wird.

[0060] Die bisherigen Ausführungsformen beschreiben eine Energie- und Datenübertragung auf Leiterkarten **50**, **52** mit einem zusätzlichen Antrieb **16**. Es ist aber auch denkbar, den Motor zu integrieren, und zwar auf zwei alternativen Wegen. In einer Ausführungsform werden Rotor- und Statorspulen des Motors ähnlich wie die Windungen **56**, **58** und die Kreisringe **62**, **64** ebenfalls auf die Leiterkarten **50**, **52** integriert. Dabei können die Abschirmungen **68**, **70** und insbesondere die Ferritkerne mit genutzt werden. In einer anderen Ausführungsform wird die Integration umgekehrt betrieben. Dabei werden die Leiterkarten **50**, **52** in den Antrieb **16** integriert. Der Antrieb stellt selbst dann mitbewegte Versorgungs- und Da-

tenanschlüsse zur Verfügung. Beim Aufbau des Laserscanners **10** selbst muss dann die drahtlose Übertragung nicht mehr geplant werden, sondern es können einfach die vorhandenen Anschlüsse des Antriebs **16** genutzt werden.

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ZITATE ENTHALTEN IN DER BESCHREIBUNG

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Hesai Exhibit 1002, page 91

Schutzansprüche

1. Optoelektronischer Sensor (**10**) zur Erfassung von Objekten in einem Überwachungsbereich (**20**), insbesondere Laserscanner, mit einem Lichtsender zum Aussenden eines Sendelichtstrahls (**26**), einem Lichtempfänger (**34**) zum Erzeugen eines Empfangssignals aus dem von Objekten in dem Überwachungsbereich (**20**) remittierten Licht (**30**), einer Sockeleinheit (**14**), einer gegenüber der Sockeleinheit (**14**) beweglichen Abtasteinheit (**12**) zur periodischen Abtastung des Überwachungsbereichs (**20**) sowie einer Auswertungseinheit (**46**) zur Erfassung von Informationen über Objekte in dem Überwachungsbereich (**20**) anhand des Empfangssignals, wobei die Sockeleinheit (**14**) eine erste Übertragungseinheit (**44**, **54**, **56**) und die Abtasteinheit (**12**) eine zweite Übertragungseinheit (**44**, **54**, **58**) zur kontaktlosen Übertragung von Energie zwischen der Sockeleinheit (**14**) und der Abtasteinheit (**12**) aufweisen, **dadurch gekennzeichnet,** dass die Sockeleinheit (**14**) eine erste Leiterkarte (**50**) mit der ersten Übertragungseinheit (**44**, **54**, **58**) und die Abtasteinheit (**12**) eine zweite Leiterkarte (**52**) mit der zweiten Übertragungseinheit (**44**, **54**, **58**) aufweist, dass die beiden Leiterkarten (**50**, **52**) flächig übereinander angeordnet sind und die zweite Leiterkarte (**52**) mit der Abtasteinheit (**12**) gegenüber der ersten Leiterkarte (**50**) beweglich ist und dass die Übertragungseinheiten (**44**, **54**, **56**, **58**) jeweils in die Leiterkarten (**50**, **52**) integrierte Spulen (**56**, **58**) zur Versorgung der Abtasteinheit (**12**) durch induktive Kopplung aufweisen.

2. Sensor (**10**) nach Anspruch 1, wobei die erste Leiterkarte (**50**) in der Sockeleinheit (**14**) und die zweite Leiterkarte (**52**) an einer Welle (**38**) eines Antriebs (**16**) für die Abtasteinheit (**12**) befestigt ist.

3. Sensor (**10**) nach Anspruch 1 oder 2, wobei der Lichtsender (**22**) und der Lichtempfänger (**34**) in der Abtasteinheit (**12**) angeordnet sind.

4. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die erste Leiterkarte (**50**) eine Royer-Oszillator-Schaltung aufweist.

5. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die zweite Leiterkarte (**52**) kreisförmig ausgebildet ist.

6. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Spulen als zentral angeordnete Windungen (**56**, **58**) um eine Drehachse (**18**) der Abtasteinheit (**12**) auf den Leiterkarten (**50**, **52**) ausgebildet sind.

7. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Spulen (**56**, **58**) gegenläufige Windungen aufweisen, insbesondere die Spulen (**56**, **58**) eine selbstkompensierende Doppelwicklung mit einer inneren Windung in der einen und einer äußeren Windung in der anderen Richtung aufweisen.

8. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Übertragungseinheiten einen Resonanzübertrager ohne primärseitige Hilfswicklung und Mittelpunktanzapfung aufweisen.

9. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Übertragungseinheiten (**44**, **54**, **56**, **58**) jeweils einander gegenüberliegende, insbesondere als Kreisringe ausgebildete, Leiterstrukturen (**62**, **64**) auf den Leiterkarten (**50**, **52**) aufweisen, die mindestens einen Kondensator zur kapazitiven kontaktlosen Datenübertragung (**60**) bilden.

10. Sensor (**10**) nach Anspruch 9, wobei mehrere zueinander konzentrische Kreisringe (**62a**–b) vorgesehen sind, um mehrere Kondensatoren für eine bidirektionale und/oder differentielle Datenübertragung (**60**) zu bilden.

11. Sensor (**10**) nach Anspruch 10, wobei die Kreisringe (**62**, **64**) untereinander flächengleich sind.

12. Sensor (**10**) nach Anspruch 6 oder 7 und einem der Ansprüche 9 bis 11, wobei die Kreisringe (**62**, **64**) und die Windungen (**56**, **58**) konzentrisch um die Drehachse (**18**) angeordnet sind, so dass die Kreisringe (**62**, **64**) die Windungen (**56**, **58**) umschließen.

13. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Übertragungseinheiten (**44**, **54**, **56**, **58**) zumindest teilweise von einem Ferritmantel (**68**, **70**) eingeschlossen sind.

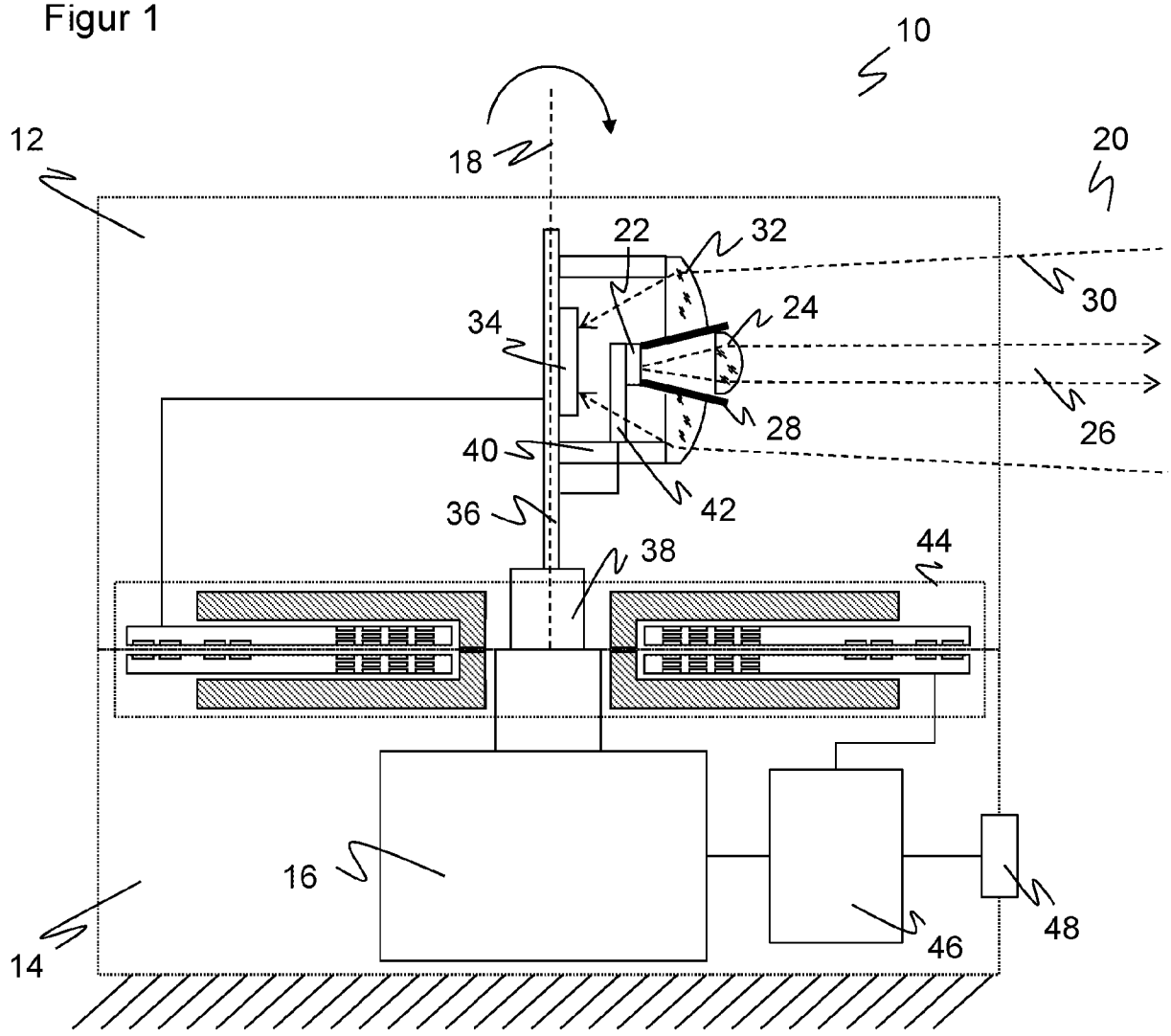
14. Sensor (**10**) nach einem der vorhergehenden Ansprüche, wobei die Leiterkarten (**50**, **52**) zumindest teilweise von einer magnetischen, schlecht leitenden Abschirmung (**68**, **70**) umgeben sind, wobei die Abschirmung (**68**, **70**) eine Bodenplatte und eine Deckplatte sowie einen inneren und/oder äußeren Zylinder aufweist, so dass eine Drehachse (**18**) der Abtasteinheit (**12**) innerhalb des Zylinders und die Leiterkarten (**50**, **52**) konzentrisch zu dem Zylinder sowie zwischen Bodenplatte und Deckplatte angeordnet sind.

Es folgen 4 Seiten Zeichnungen

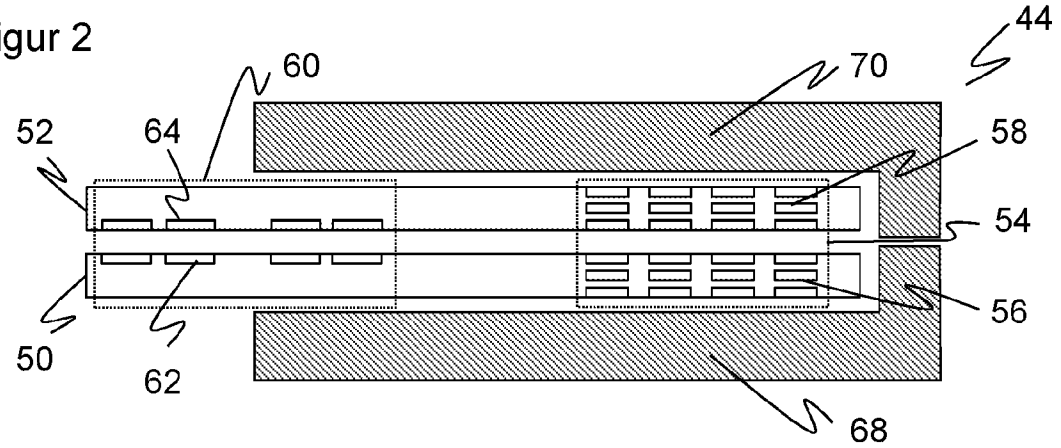
Hesai Exhibit 1002, page 92

Anhängende Zeichnungen

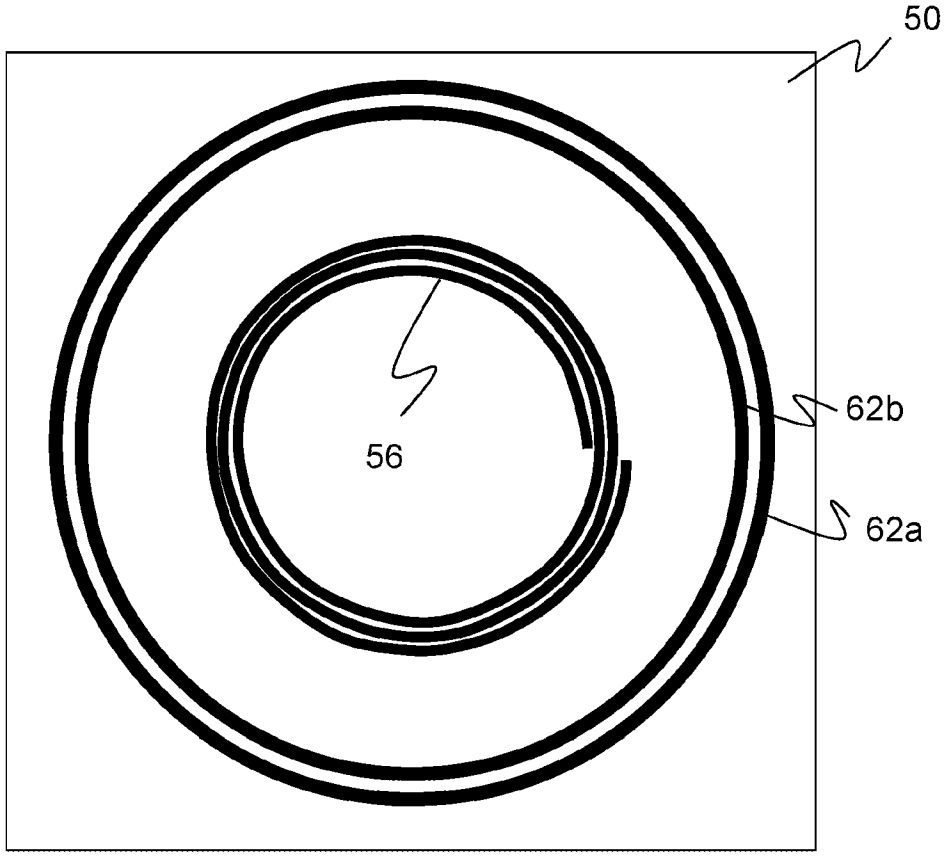
Figur 1



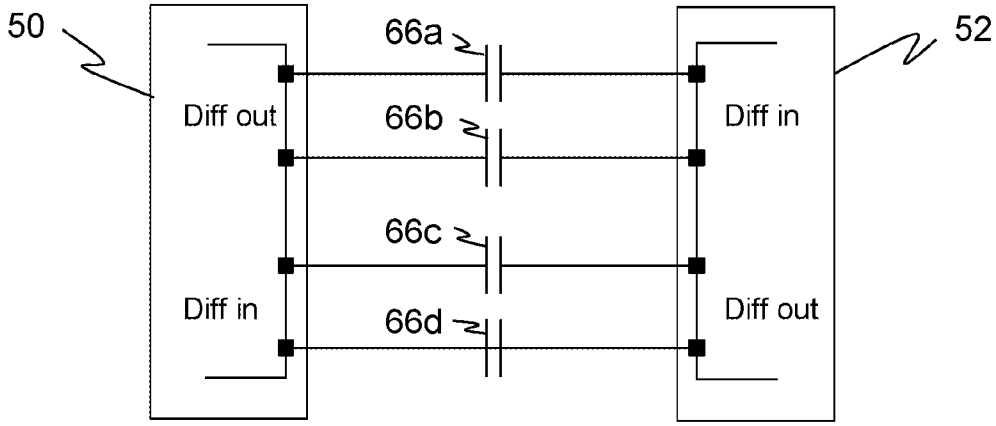
Figur 2



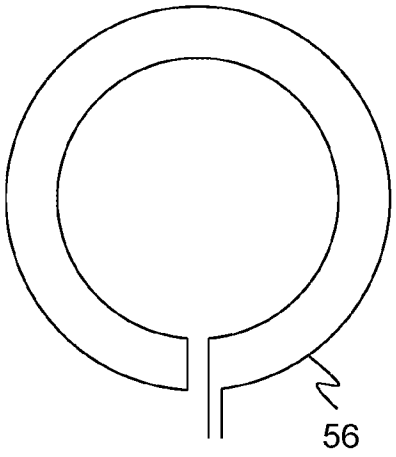
Figur 3



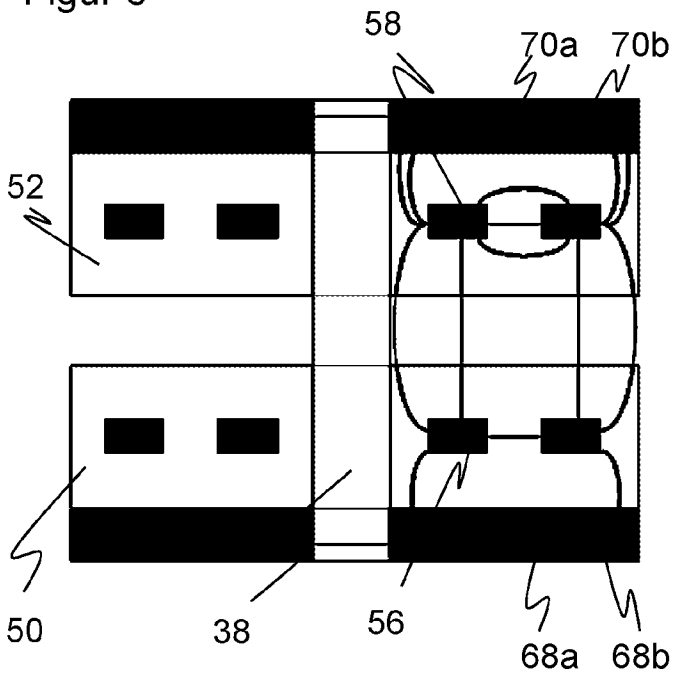
Figur 4



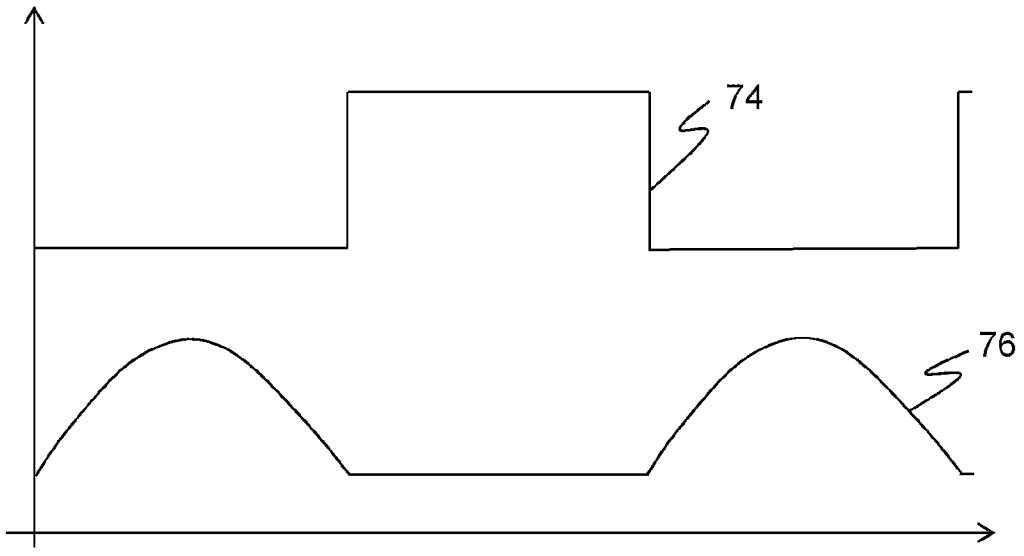
Figur 5



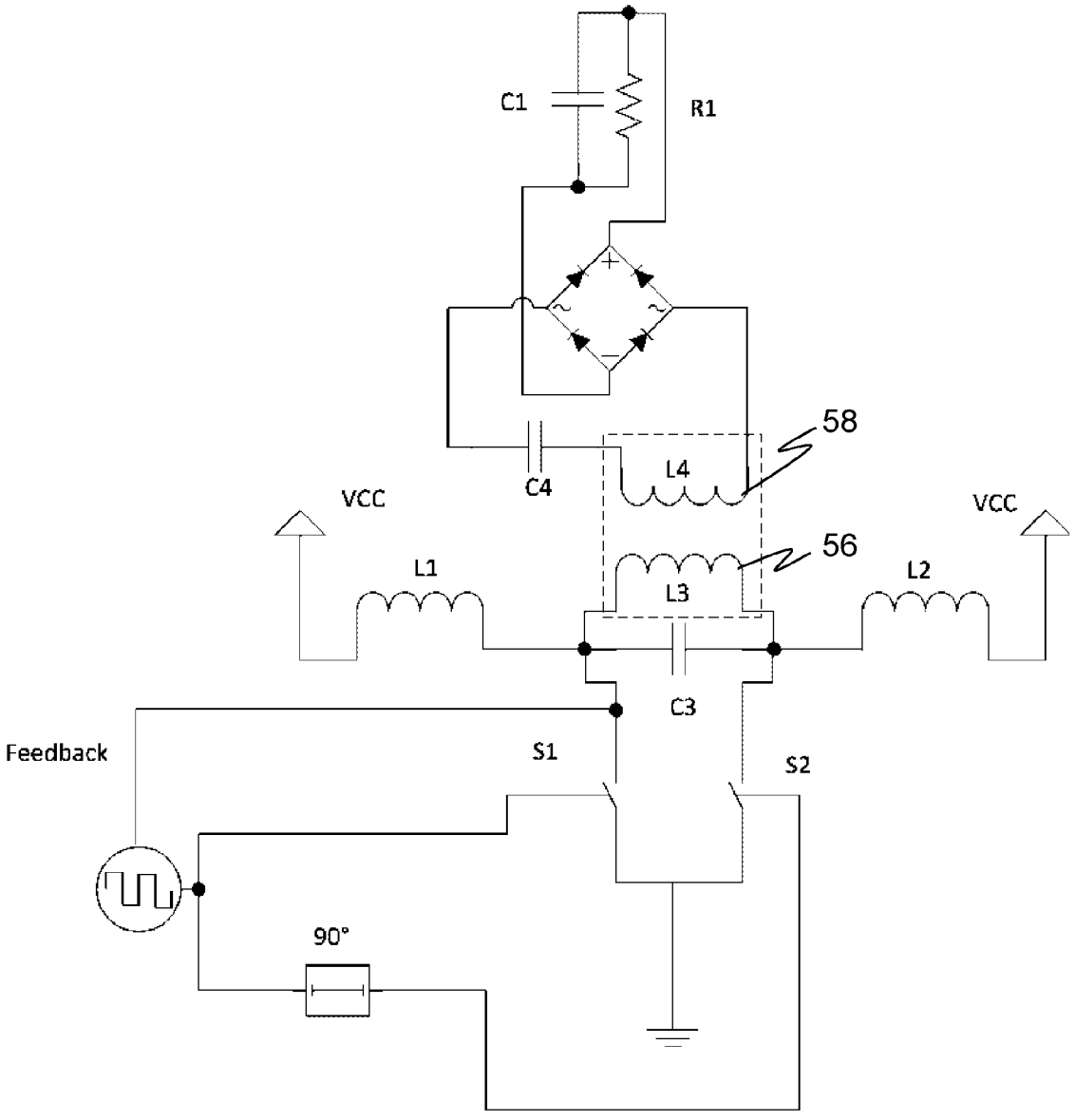
Figur 6



Figur 8



Figur 7



Electronic Patent Application Fee Transmittal

Application Number:	17323987
Filing Date:	18-May-2021
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Filer:	William Leland Shaffer/Megan McCoy
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	130	130
		Total in USD ($)		**130**

Electronic Acknowledgement Receipt

EFS ID:	43642062
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/Megan McCoy
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	30-AUG-2021
Filing Date:	18-MAY-2021
Time Stamp:	20:13:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$130
RAM confirmation Number	E20218TK13524359
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	_103033-1252983-P010US3C2_SuppIDS.pdf	1034404 ecdfcae2c874290be8f0bc9bf0973b174c8b28bd	no	4
Warnings:					
Information:					
2	Non Patent Literature	NPL_EP_18886096-9_EESR_07212021.pdf	388226 7d689bab80b621d78204e88e875b93fa8872594f	no	10
Warnings:					
Information:					
3	Foreign Reference	DE_202014101753_U1.pdf	2664628 12ffec8af762be4140dd03a098f4918b175094bd	no	16
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	38126 077b91e682f25c77b1111e6c60463864b76e9c1e	no	2
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 08/19/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

NOTIFICATION DATE	DELIVERY MODE
08/19/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Corrected ***Notice of Allowability***	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.	
	Examiner QUE TAN LE	**Art Unit** 2878	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to the IDS filed 8/11/2021.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-25 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some* c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6707230		2004-03-16	Smith et al.	
	2	6928386		2005-08-09	Hasser	
	3	6992630		2006-01-31	Parsche	
	4	7045833		2006-05-16	Campbell et al.	
	5	7049597		2006-05-23	Bodkin	
	6	7266248		2007-09-04	Matherson et al.	

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

	1	20030029989		2003-02-13	Stettner et al.	
	2	20040036007		2004-02-26	Wilson et al.	
	3	20040175183		2004-09-09	Willhoeft et al.	
	4	20040189787		2004-09-30	Hanina et al.	
	5	20060061869		2006-03-23	Fadel et al.	
	6	20060145062		2006-07-06	Boehlau et al.	
	7	20070017281		2007-01-25	Rodgers et al.	
	8	20070133924		2007-06-14	Yang et al.	
	9	20080309914		2008-12-18	Cantin et al.	
	10	20090115994		2009-05-07	Stettner et al.	
	11	20090168045		2009-07-02	Lin et al.	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Angus Pacala
	Art Unit	2878
	Examiner Name	LE, QUE TAN
	Attorney Docket Number	103033-P010US3C2-1252983

	12	20100284082		2010-11-11	Shpunt et al.	
	13	20100290698		2010-11-18	Freedman et al.	
	14	20100309288		2010-12-10	Stettner et al.	
	15	20110052004		2011-03-03	Lee et al.	
	16	20130279753		2013-10-24	Freedman et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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	1	Notice of Allowance for Application number 17/323,983, dated July 30, 2021, 10 pages	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	08/17/2021

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-08-11
Name/Print	William Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6707230		2004-03-16	Smith et al.	
	2	6928386		2005-08-09	Hasser	
	3	6992630		2006-01-31	Parsche	
	4	7045833		2006-05-16	Campbell et al.	
	5	7049597		2006-05-23	Bodkin	
	6	7266248		2007-09-04	Matherson et al.	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Art Unit	2878
	Examiner Name	LE, QUE TAN
	Attorney Docket Number	103033-P010US3C2-1252983

	1	20030029989		2003-02-13	Stettner et al.	
	2	20040036007		2004-02-26	Wilson et al.	
	3	20040175183		2004-09-09	Willhoeft et al.	
	4	20040189787		2004-09-30	Hanina et al.	
	5	20060061869		2006-03-23	Fadel et al.	
	6	20060145062		2006-07-06	Boehlau et al.	
	7	20070017281		2007-01-25	Rodgers et al.	
	8	20070133924		2007-06-14	Yang et al.	
	9	20080309914		2008-12-18	Cantin et al.	
	10	20090115994		2009-05-07	Stettner et al.	
	11	20090168045		2009-07-02	Lin et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
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	Art Unit	2878
	Examiner Name	LE, QUE TAN
	Attorney Docket Number	103033-P010US3C2-1252983

	12	20100284082		2010-11-11	Shpunt et al.			
	13	20100290698		2010-11-18	Freedman et al.			
	14	20100309288		2010-12-10	Stettner et al.			
	15	20110052004		2011-03-03	Lee et al.			
	16	20130279753		2013-10-24	Freedman et al.			

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Notice of Allowance for Application number 17/323,983, dated July 30, 2021, 10 pages	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17323987
	Filing Date	2021-05-18
	First Named Inventor	Angus Pacala
	Art Unit	2878
	Examiner Name	LE, QUE TAN
	Attorney Docket Number	103033-P010US3C2-1252983

EXAMINER SIGNATURE			
Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	17323987
Filing Date	2021-05-18
First Named Inventor	Angus Pacala
Art Unit	2878
Examiner Name	LE, QUE TAN
Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☒ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-08-11
Name/Print	William Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

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9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	17323987
Filing Date:	18-May-2021
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Filer:	William Leland Shaffer/Stephen Quast
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	260	260
		Total in USD ($)		**260**

Electronic Acknowledgement Receipt

EFS ID:	43485701
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/Stephen Quast
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	11-AUG-2021
Filing Date:	18-MAY-2021
Time Stamp:	16:15:58
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$260
RAM confirmation Number	E20218AG16260094
Deposit Account	
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	103033-P010US3C2-1252983_IDS-signed.pdf	1035035 132ec0d097a2d5c78e1d974738ba78a06f2bc67f	no	6
Warnings:					
Information:					
2	Non Patent Literature	NPL_US_17323983_NOA_07302021.pdf	542597 5e88d47139cbed04cf451fd3a75b4521298 94814	no	10
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	38441 492c1a214882c7170838119a76e2c6948eef 094c	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	1616073		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/323,987	05/18/2021	2878	1080	103033-P010US3C2-1252983	25	3

CONFIRMATION NO. 9133

CORRECTED FILING RECEIPT

20350
Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

OC000000127358714

Date Mailed: 07/30/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Angus Pacala, San Francisco, CA;
Mark Frichtl, San Francisco, CA;
Marvin Shu, Daly City, CA;
Eric Younge, Portola Valley, CA;

Applicant(s)

Ouster, Inc., San Francisco, CA;

Assignment For Published Patent Application

Ouster, Inc., San Francisco, CA

Power of Attorney: The patent practitioners associated with Customer Number 20350

Domestic Priority data as claimed by applicant

This application is a CON of 16/209,875 12/04/2018

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 06/03/2021
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/323,987**
Projected Publication Date: 09/09/2021
Non-Publication Request: No
Early Publication Request: No
**** SMALL ENTITY ****
Title

ROTATING COMPACT LIGHT RANGING SYSTEM COMPRISING A STATOR DRIVER CIRCUIT IMPARTING AN ELECTROMAGNETIC FORCE ON A ROTOR ASSEMBLY

Preliminary Class

356

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

20350 7590 07/22/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER
LE, QUE TAN

ART UNIT	PAPER NUMBER
2878	

DATE MAILED: 07/22/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

TITLE OF INVENTION: ROTATING COMPACT LIGHT RANGING SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	10/22/2021

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20350 7590 07/22/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

TITLE OF INVENTION: ROTATING COMPACT LIGHT RANGING SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$600	$0.00	$0.00	$600	10/22/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
LE, QUE TAN	2878	356-004010

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 07/22/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	
LE, QUE TAN	

ART UNIT	PAPER NUMBER
2878	

DATE MAILED: 07/22/2021

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 17/323,987	Applicant(s) Pacala et al.	
	Examiner QUE TAN LE	Art Unit 2878	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☐ This communication is responsive to _____.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-25 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The title of the invention has been changed to: --Rotating compact light ranging system comprising a stator driver circuit imparting an electromagnetic force on a rotor assembly--.

In the claim:

In claim 15, on line 4, "the lower" has been changed to --a lower--.

The following is an examiner's statement of reasons for allowance: The prior art of record fails to teach a light ranging system, among other features, comprising a shaft disposed within an enclosure; a stator circuit board disposed within the enclosure; a support component with a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve; a rotor circuit board to rotate with the support component; a stator assembly with a plurality of stator elements arranged annularly about the axis of rotation; a rotor assembly including an annular arrangement with a plurality of magnetic poles surround the axis of rotation; a light ranging device to detect reflected portion of electromagnetic radiation pulses reflected from

objects in a surrounding environment; and a stator driver circuit disposed within the enclosure to provide a drive signal to the stator elements to imparting an electromagnetic force on the rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

I) Satzky et al 8,300,215 disclose an optical system comprising a rotating device and a light pulse detection device.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to QUE TAN LE whose telephone number is (571)272-2438. The examiner can normally be reached on TUES-THURS 6:00-4:30.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, GEORGIA EPPS can be reached on 571-272-2328. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/QUE TAN LE/
Primary Examiner, Art Unit 2878

Notice of References Cited	Application/Control No. 17/323,987	Applicant(s)/Patent Under Reexamination Pacala et al.	
	Examiner QUE TAN LE	Art Unit 2878	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8300215-B2	10-2012	Satzky; Uwe	G01S17/42	356/5.01
	B					
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	Art Unit
	QUE TAN LE	2878

CPC - Searched*		
Symbol	Date	Examiner
G01S 17/42, G01S 7/4817, G01S 17/10, G01S 17/89, G01S 7/4813, G01S 2007/4975, G01S 7/003, B60L 3/0015, G05D 1/0231	07/12/2021	lq

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner
250	221, 239, 208.1, 214R	07/12/2021	lq

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
CPC and East search (attached)	07/12/2021	lq
Inventor and Assignee search	07/12/2021	lq

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
250	221; US-PGPUB; USPAT; Interference search (attached)	07/12/2021	lq
G01S	17/89	07/12/2021	lq
B60L	3/0015	07/12/2021	lq
G01S	17/42	07/12/2021	lq

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	Art Unit
	QUE TAN LE	2878

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	**Art Unit**
	QUE TAN LE	2878

CPC						
Symbol					**Type**	**Version**
G01S	/	7	/	4813	F	2013-01-01
G01S	/	17	/	89	I	2013-01-01
G01S	/	17	/	42	I	2013-01-01
G01S	/	7	/	486	I	2013-01-01
G01S	/	7	/	4816	I	2013-01-01
B60L	/	3	/	0015	I	2013-01-01
H01S	/	5	/	146	I	2013-01-01
H02J	/	7	/	025	I	2013-01-01
G01S	/	7	/	4817	I	2013-01-01
G01S	/	7	/	4863	I	2013-01-01
G01S	/	7	/	497	I	2013-01-01
G01S	/	7	/	4814	I	2013-01-01
G01S	/	17	/	931	I	2020-01-01
G01S	/	17	/	10	I	2013-01-01
H01F	/	38	/	14	I	2013-01-01
H05K	/	1	/	0274	I	2013-01-01
H05K	/	1	/	144	I	2013-01-01
H05K	/	1	/	181	I	2013-01-01
H05K	/	5	/	0004	I	2013-01-01
H04B	/	10	/	1143	I	2013-01-01
G02B	/	3	/	0006	I	2013-01-01
H02J	/	50	/	10	A	2016-02-01
G05D	/	1	/	0231	A	2013-01-01
H02K	/	11	/	0094	A	2013-01-01
H05K	/	2201	/	042	A	2013-01-01
H05K	/	2201	/	09027	A	2013-01-01
H05K	/	2201	/	1009	A	2013-01-01
H05K	/	2201	/	10121	A	2013-01-01
H05K	/	2201	/	10151	A	2013-01-01
H05K	/	2201	/	10409	A	2013-01-01

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/QUE TAN LE/ Primary Examiner, Art Unit 2878	12 July 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1B

U.S. Patent and Trademark Office — Part of Paper No.: 20210712

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	**Art Unit**
	QUE TAN LE	2878

CPC Combination Sets									
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/QUE TAN LE/ Primary Examiner, Art Unit 2878	12 July 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1B

U.S. Patent and Trademark Office — Part of Paper No.: 20210712

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	**Art Unit**
	QUE TAN LE	2878

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G01S	/	17	/	89

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
250	221

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 25	
/QUE TAN LE/ Primary Examiner, Art Unit 2878 (Primary Examiner)	12 July 2021 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1B

U.S. Patent and Trademark Office

Part of Paper No.: 20210712

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	17/323,987	Pacala et al.
	Examiner	**Art Unit**
	QUE TAN LE	2878

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		10		19										
	2		11		20										
	3		12		21										
	4		13		22										
	5		14		23										
	6		15		24										
	7		16		25										
	8		17												
	9		18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/QUE TAN LE/ Primary Examiner, Art Unit 2878	12 July 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1B

U.S. Patent and Trademark Office

Part of Paper No.: 20210712

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	Herewith
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	4358851		Nov 9, 1982	Scifres et al.	
	2.	4634272		Jan 6, 1987	Endo	
	3.	4676599		Jun 30, 1987	Cruz	
	4.	4702600		Oct 27, 1987	Handrich et al.	
	5.	4744667		May 17, 1988	Fay et al.	
	6.	4851664		Jul 25, 1989	Rieger	
	7.	5267016		Nov 30, 1993	Meinzer et al.	
	8.	5288992		Feb 22, 1994	Fohl	
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17/323,987
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	Not yet assigned
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number [3]	Country Code [2]	Kind Code [4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T [5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [5]
	1.	Application No. 17/323,983 filed May 18, 2021, 98 pages	

EXAMINER SIGNATURE

Examiner Signature	/QUE TAN LE/	Date Considered	07/12/2021

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Field

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Application Number	17/323,987
Filing Date	May 18, 2021
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-06-09
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /Q.L/

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	108	(((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 11:58
L2	0	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) same (((radiation or electromagnetic or light or laser) near3 (pulse)) with ((reflect$4) near4 (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:02
L3	0	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) and (((radiation or electromagnetic or light or laser) near3 (pulse)) with ((reflect$4) near4 (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:04
L4	0	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) and (((radiation or electromagnetic or light or laser) near3 (pulse)) same ((reflect$4) near4 (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:05

L5	0	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) and (((radiation or electromagnetic or light or laser) near3 (pulse or light)) same ((reflect$4) near4 (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:10
L6	13	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) and (((radiation or electromagnetic or light or laser) same (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:12
L7	260,016	(250/$7.ccls.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:14
L8	176,375	(356/$7.ccls.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:14
L9	0	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) same (((reflect$4) near4 (object or target or environment or surrounding)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:15
L10	1	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2021/07/12 12:17

		circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))) and (((reflect$4) near4 (object or target or environment or surrounding)))	DERWENT; IBM_TDB			
L11	0	(transparent adj3 window) and (stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (ranging adj3 device) and (electromagnetic adj3 radiation) and (detector adj3 circuitry) and (driver adj3 circuit)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:21
L12	0	(transparent adj3 window) and (stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (electromagnetic adj3 radiation) and (detector adj3 circuitry) and (driver adj3 circuit)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:22
L13	0	(stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (electromagnetic adj3 radiation) and (detector adj3 circuitry) and (driver adj3 circuit)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:23
L14	0	(stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (electromagnetic adj3 radiation) and (driver adj3 circuit)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:23
L15	11	(stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (driver adj3 circuit)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:24
L17	0	1 and 7	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:27
L18	0	1 and 8	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:28

L19	0	(((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity))) and ((electromagnetic) near3 (radiation or light))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:29
L20	0	(((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity))) and ((electromagnetic or laser or reflect$4) near3 (radiation or light))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:30
L22	108	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity))))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:39
L23	302	((((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) and (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity))))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:40
L24	2	7 and 23	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:42
L25	0	8 and 23	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2021/07/12 12:42

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L16	11	(stator adj3 circuit) and (rotor adj3 circuit) and (stator adj3 assembly) and (rotor adj3 assembly) and (driver adj3 circuit)	US-PGPUB; USPAT	OR	ON	2021/07/12 12:24
L21	82	(((stator) near3 (circuit$4 or module or device or unit or assembly)) with ((axis) near3 (rotation or rotating or rotatable))) same (((rotor) near3 (assembly or unit or device or circuit$4 or module)) with ((magnetic or magnet) near3 (element or component or pole or polarity)))	US-PGPUB; USPAT	OR	ON	2021/07/12 12:33

7/12/2021 12:43:23 PM
C:\Users\qle\Documents\EAST\Workspaces\Default EAST home.wsp

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Alexandria, Virginia 22313-1450
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BIB DATA SHEET

CONFIRMATION NO. 9133

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
17/323,987	05/18/2021	356	2878	103033-P010US3C2-1252983

APPLICANTS

Ouster, Inc., San Francisco, CA;

INVENTORS

Angus Pacala, San Francisco, CA;
Mark Frichtl, San Francisco, CA;
Marvin Shu, Daly City, CA;
Eric Younge, Portola Valley, CA;

**** CONTINUING DATA ***************************

This application is a CON of 16/209,875 12/04/2018

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **

06/03/2021

Foreign Priority claimed ❑ Yes ☑ No 35 USC 119(a-d) conditions met ❑ Yes ☑ No Verified and Acknowledged /QUE LE/ Examiner's Signature	❑ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	18	25	3

ADDRESS

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309
UNITED STATES

TITLE

ROTATING COMPACT LIGHT RANGING SYSTEM

FILING FEE RECEIVED		
1080	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _____ ❑ Credit

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983	9133

20350 7590 07/08/2021

Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

EXAMINER	

ART UNIT	PAPER NUMBER
3645	

NOTIFICATION DATE	DELIVERY MODE
07/08/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

KTSDocketing2@kilpatrick.foundationip.com
ipefiling@kilpatricktownsend.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 17/323,987	**Applicant(s)** Pacala et al.	
	Examiner CHERYL P GIBSON BAYLOR	**Art Unit** OPET	**AIA (FITF) Status** Yes

1. THE REQUEST FILED 18 May 2021 IS **GRANTED** .

   The above-identified application has met the requirements for prioritized examination
   - A. ☑ for an original nonprovisional application (Track I).
   - B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:
   - A. filing a **petition for extension of time** to extend the time period for filing a reply;
   - B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;
   - C. filing a **request for continued examination** ;
   - D. filing a notice of appeal;
   - E. filing a request for suspension of action;
   - F. mailing of a notice of allowance;
   - G. mailing of a final Office action;
   - H. completion of examination as defined in 37 CFR 41.102; or
   - I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to CHERYL GIBSON BAYLOR at (571)272-3213. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/CHERYL GIBSON BAYLOR/ Paralegal Specialist, OPET	

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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/323,987	05/18/2021	Angus Pacala	103033-P010US3C2-1252983

CONFIRMATION NO. 9133

20350
Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

POA ACCEPTANCE LETTER

OC000000126657633

Date Mailed: 07/02/2021

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 06/28/2021.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/zabraha/

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
17/323,987	May 18, 2021

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 20350

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Ouster, Inc.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature	Mark Frichtl	Date (Optional)	2017-10-04
Name	Mark Frichtl		
Title	CTO		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	43109124
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/LaRenda Meyer
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	28-JUN-2021
Filing Date:	18-MAY-2021
Time Stamp:	16:24:41
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	POA-ouster.pdf	122803 8d1410cfd13636b3f9346de57da8aa171c1f3b9d	no	1

Warnings:

Information:	
Total Files Size (in bytes):	122803

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T[5]

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1.	Application No. 17/323,983 filed May 18, 2021, 98 pages	

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.
[4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	17/323,987
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	Not yet assigned
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e) (2).

☐ See attached certification statement.

☐ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-06-09
Name/Print	William L. Shaffer	Registration Number	37,234

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Electronic Acknowledgement Receipt

EFS ID:	42945822
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM
First Named Inventor/Applicant Name:	Angus Pacala
Customer Number:	20350
Filer:	William Leland Shaffer/LaRenda Meyer
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	09-JUN-2021
Filing Date:	18-MAY-2021
Time Stamp:	18:21:24
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	IDS-P010USC32-1252983.pdf	188915 ed5800f88cb54fb8dcb177fc69ca3a8a09ed0201	no	2

Warnings:

Information:					
This is not an USPTO supplied IDS fillable form					
2	Non Patent Literature	Application-P010US3C1.pdf	4876546 4400dc21021e7820cd40c2a7d1361256a22cfc5e	no	98
Warnings:					
Information:					
			Total Files Size (in bytes):	5065461	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/323,987	05/18/2021	2834	1080	103033-P010US3C2-1252983	25	3

CONFIRMATION NO. 9133

FILING RECEIPT

20350
Kilpatrick Townsend & Stockton LLP - West Coast
Mailstop: IP Docketing - 22
1100 Peachtree Street
Suite 2800
Atlanta, GA 30309

OC000000128079338

Date Mailed: 06/04/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Angus Pacala, San Francisco, CA;
Mark Frichtl, San Francisco, CA;
Marvin Shu, Daly City, CA;
Eric Younge, Portola Valley, CA;

Applicant(s)

Ouster, Inc., San Francisco, CA;

Assignment For Published Patent Application

Ouster, Inc., San Francisco, CA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/209,875 12/04/2018

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 06/03/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/323,987**

Projected Publication Date: 09/09/2021

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

ROTATING COMPACT LIGHT RANGING SYSTEM

Preliminary Class

310

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/323,987

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	80		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	350		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	400		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	25 minus 20 =	* 5	x 50 =	250	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*	x 240 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1080		TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	Herewith
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	Not yet assigned
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

U.S. PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code [1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	4358851		Nov 9, 1982	Scifres et al.	
	2.	4634272		Jan 6, 1987	Endo	
	3.	4676599		Jun 30, 1987	Cruz	
	4.	4702600		Oct 27, 1987	Handrich et al.	
	5.	4744667		May 17, 1988	Fay et al.	
	6.	4851664		Jul 25, 1989	Rieger	
	7.	5267016		Nov 30, 1993	Meinzer et al.	
	8.	5288992		Feb 22, 1994	Fohl	
	9.	5982552		Nov 9, 1999	Nakama et al.	
	10.	6014232		Jan 11, 2000	Clarke	
	11.	6133989		Oct 17, 2000	Stettner et al.	
	12.	6252331		Jun 26, 2001	Mildice et al.	
	13.	6255133		Jul 3, 2001	Ormond et al.	
	14.	6374024		Apr 16, 2002	Iijima	
	15.	6414746		Jul 2, 2002	Stettner et al.	
	16.	6690019		Feb 10, 2004	Stettner et al.	
	17.	6721262		Apr 13, 2004	Jordache et al.	
	18.	7091462		Aug 15, 2006	Wilson et al.	
	19.	D531525		Nov 7, 2006	Dold et al.	
	20.	7170542		Jan 30, 2007	Hanina et al.	
	21.	7199947		Apr 3, 2007	Wang et al.	
	22.	7295298		Nov 13, 2007	Willhoeft et al.	
	23.	7345271		Mar 18, 2008	Boehlau et al.	
	24.	7421159		Sep 2, 2008	Yang et al.	
	25.	7433042		Oct 7, 2008	Cavanaugh et al.	
	26.	7570426		Aug 4, 2009	Rodgers et al.	
	27.	7808706		Oct 5, 2010	Fadel et al.	
	28.	7969558		Jun 28, 2011	Hall	
	29.	8013983		Sep 6, 2011	Lin et al.	
	30.	8089618		Jan 3, 2012	Yang	
	31.	8130367		Mar 6, 2012	Stettner et al.	
	32.	D659030		May 8, 2012	Anselment et al.	
	33.	8314612		Nov 20, 2012	Rodgers et al.	
	34.	8319949		Nov 27, 2012	Cantin et al.	
	35.	8330840		Dec 11, 2012	Lenchenkov	
	36.	8374405		Feb 12, 2013	Lee et al.	
	37.	8384997		Feb 26, 2013	Shpunt et al.	
	38.	8494252		Jul 23, 2013	Freedman et al.	
	39.	8675181		Mar 18, 2014	Hall	
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	41.	8742325		Jun 3, 2014	Droz et al.	
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	43.	8761495		Jun 24, 2014	Freedman et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	Not yet assigned
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

	44.	8767190		Jul 1, 2014	Hall	
	45.	8829406		Sep 9, 2014	Akerman et al.	
	46.	8836922		Sep 16, 2014	Pennecot et al.	
	47.	8848039		Sep 30, 2014	Spektor et al.	
	48.	9041915		May 26, 2015	Earhart et al.	
	49.	9063549		Jun 23, 2015	Pennecot et al.	
	50.	9071763		Jun 30, 2015	Templeton et al.	
	51.	9086273		Jul 21, 2015	Gruver et al.	
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	53.	9157790		Oct 13, 2015	Shpunt et al.	
	54.	9164511		Oct 20, 2015	Ferguson et al.	
	55.	9176051		Nov 3, 2015	Mappes et al.	
	56.	9229109		Jan 5, 2016	Stettner et al.	
	57.	9285464		Mar 15, 2016	Pennecot et al.	
	58.	9285477		Mar 15, 2016	Smith et al.	
	59.	9299731		Mar 29, 2016	Lenius et al.	
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	61.	9369689		Jun 14, 2016	Tran et al.	
	62.	9383753		Jul 5, 2016	Templeton et al.	
	63.	9425654		Aug 23, 2016	Lenius et al.	
	64.	9435891		Sep 6, 2016	Oggier	
	65.	9470520		Oct 18, 2016	Schwarz et al.	
	66.	9489601		Nov 8, 2016	Fairfield et al.	
	67.	9525863		Dec 20, 2016	Nawasra et al.	
	68.	9529079		Dec 27, 2016	Droz et al.	
	69.	9709699		Jul 18, 2017	Sunne et al.	
	70.	RE46672		Jan 16, 2018	Hall	
	71.	9882433		Jan 30, 2018	Lenius et al.	
	72.	9935514		Apr 3, 2018	Lenius et al.	
	73.	10036803		Jul 31, 2018	Pacala et al.	
	74.	10291319		May 14, 2019	Karplus et al.	
	75.	10481269		Nov 19, 2019	Pacala et al.	
	76.	10830892		Nov 10, 2020	Pacala et al.	
	77.	10969490		Apr 6, 2021	Pacala et al.	

U.S. PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code [1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	78.	20030006676		Jan 9, 2003	Smith et al.	
	79.	20030047752		Mar 13, 2003	Campbell et al.	
	80.	20040061502		Apr 1, 2004	Hasser	
	81.	20040119020		Jun 24, 2004	Bodkin	
	82.	20040223071		Nov 11, 2004	Wells et al.	
	83.	20050030409		Feb 10, 2005	Matherson et al.	
	84.	20050088342		Apr 28, 2005	Parsche	
	85.	20060139770		Jun 29, 2006	Wang et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	Herewith
	Filing Date	May 18, 2021
	First Named Inventor	Angus Pacala
	Art Unit	Not yet assigned
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P010US3C2-1252983

	86.	20060208193		Sep 21, 2006	Bodkin	
	87.	20060244851		Nov 2, 2006	Cartlidge	
	88.	20070007563		Jan 11, 2007	Mouli	
	89.	20070060806		Mar 15, 2007	Hunter et al.	
	90.	20070228262		Oct 4, 2007	Cantin et al.	
	91.	20080088818		Apr 17, 2008	Mori	
	92.	20080153189		Jun 26, 2008	Plaine et al.	
	93.	20090016642		Jan 15, 2009	Hart	
	94.	20090040629		Feb 12, 2009	Bechtel et al.	
	95.	20090179142		Jul 16, 2009	Duparre et al.	
	96.	20090295910		Dec 3, 2009	Mir et al.	
	97.	20100008588		Jan 14, 2010	Feldkhun et al.	
	98.	20100020306		Jan 28, 2010	Hall	
	99.	20100110275		May 6, 2010	Mathieu	
	100	20100123893		May 20, 2010	Yang	
	101	20100204964		Aug 12, 2010	Pack et al.	
	102	20100224768		Sep 9, 2010	Yoshida et al.	
	103	20110025843		Feb 3, 2011	Oggier et al.	
	104	20110032398		Feb 10, 2011	Lenchenkov	
	105	20110037849		Feb 17, 2011	Niclass et al.	
	106	20110116262		May 19, 2011	Marson	
	107	20110216304		Sep 8, 2011	Hall	
	108	20110285252		Nov 24, 2011	Hyde et al.	
	109	20120044476		Feb 23, 2012	Earhart et al.	
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I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on May 18, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

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Attorney Docket No.: 103033- P010US3C2 -1252983
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: Herewith
Angus Pacala	Examiner: Not yet assigned
Application No.: Herewith	Technology Center/Art Unit: Not yet assigned
Filed: May 18, 2021	
For: ROTATING COMPACT LIGHT RANGING SYSTEM	INFORMATION DISCLOSURE STATEMENT
Customer No.: 20350	

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

The references cited on attached form PTO/SB/08A are being called to the attention of the Examiner. In accordance with the provisions of 37 CFR §1.98(a)(2), copies of any cited U.S. Patents and U.S. Patent Application Publications are not provided. Copies of the references are not enclosed.

In accordance with 37 CFR §1.98(d), copies of the references can be found in 16/209,875 filed December 4, 2018.

The following applications are related to this application: U.S. Patent Application No. 16/209,867 filed December 4, 2018, now U.S. Patent No. 10,481,269 issued November 19, 2019; U.S. Patent Application No. 16/209,869 filed December 4, 2018, now U.S. Pat. No. 10,969,490 issued April 6, 2021; U.S. Application No. 16/209,875 filed December 4, 2018; U.S. Patent

Application No. 16/209,879 filed December 4, 2018; and concurrently filed U.S. Patent Appliation entitled "Rotating Compact Light Ranging System" Attorney Docket No. 103033-P010US3C1-1244801. Copies of any Office Actions in such Patent Applications are available via the USPTO's PAIR or electronic file wrapper system and are believed to be readily accessible to the Examiner. Thus, although Applicant may submit copies of some such Office Actions, Applicant does not represent that copies of all, or the most significant, Office Actions are being supplied. If the Examiner desires copies of all such Office Actions, the Examiner should contact the undersigned.

It is respectfully requested that the cited references be expressly considered during the prosecution of this application, and the references be made of record therein and appear among the "references cited" on any patent to issue therefrom.

As provided for by 37 CFR §1.97(g) and (h), no inference should be made that the information and references cited are prior art merely because they are in this statement and no representation is being made that a search has been conducted or that this statement encompasses all the possible relevant information.

This Information Disclosure Statement is being filed ***before*** the mailing date of the first Office Action on the merits.

Applicant believes that ***no fee*** is required for submission of this statement. However, if any additional fees are due for the submission of this Information Disclosure Statement, please deduct those fees from Deposit Account No. 20-1430.

Respectfully submitted,

/ William L. Shaffer /

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Attachment

ABSTRACT

A light ranging system including a shaft; a first circuit board assembly that includes a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly; a second circuit board assembly rotationally coupled to the shaft, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the shaft; and a light ranging device mechanically coupled to the second circuit board assembly such that the light ranging device rotates with the second circuit board assembly.

WHAT IS CLAIMED IS:

1. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation;

a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;

a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;

a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;

a stator assembly disposed between the first and second planes and coupled to the stator circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core;

a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on

rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.

2. The light ranging system of claim 1 wherein the shaft is hollow and the system further comprises a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board.

3. The light ranging system of claim 2 wherein the communication channel comprises an optical communication channel.

4. The light ranging system of claim 1 further comprising:

a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and

a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane.

5. The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second portion of the ranging device housing directly adjacent to the first portion.

6. The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation.

7. The light ranging system of claim 1 wherein the annular arrangement comprises a plurality of separate permanent magnets.

8. The light ranging system of claim 1 further comprising circuitry to compute ranging data based on the reflected portion of the electromagnetic radiation pulses.

9. The light ranging system of claim 1 wherein the stator driver circuit is configured to rotate the rotor assembly at a rate between 10 to 30 Hz.

10. The light ranging system of claim 1 wherein the support component comprises two arms extending away from the sleeve in an opposing relationship.

11. The light ranging system of claim 1 wherein a number of stator elements in the plurality of stator elements is a multiple of three and the stator driver circuit is configured to provide a 3-phase alternating signal to the plurality of stator elements.

12. The light ranging system of claim 1 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels.

13. The light ranging system of claim 12 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

14. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation;

a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;

a support component comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;

one or more bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation;

a rotor circuit board coupled to rotate with the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;

a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil;

a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.

15. The light ranging system of claim 14 wherein the shaft includes a hole extending through an entire length of the shaft along the axis of rotation, and wherein the light ranging system further comprises an optical communication channel extending through the hole in the shaft and operatively coupled to transmit data generated by the optical system to the lower circuit board assembly.

16. The light ranging system of claim 14 wherein the plurality of magnetic poles rotor in the annular arrangement of the rotor assembly comprise a plurality of separate permanent magnets.

17. The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement.

18. The light ranging system of claim 17 wherein:

the first annular transformer coil is disposed within a first annular channel formed from a magnetic material and having a bottom portion directly attached to an upper surface of the stator circuit board and first and second opposing sidewalls extending away from the bottom portion toward the rotor circuit board; and

the second annular transformer coil is disposed within a second annular channel formed from magnetic material in an opposing relationship with the first annular channel and having a bottom portion directly attached to a lower surface of the rotor circuit board and having first and second opposing sidewalls extending away from the bottom portion towards the stator circuit board.

19. The light ranging system of claim 14 wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry.

20. The light ranging system of claim 14 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and

wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels.

21. The light ranging system of claim 20 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).

22. A light ranging system comprising:

an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;

a shaft disposed within the enclosure and defining an axis of rotation, the shaft including a hollow channel axially aligned with the axis of rotation and extending through a length of the shaft;

a stator circuit board assembly disposed within and coupled to the enclosure in a fixed relationship, the stator circuit board assembly comprising:

a first circuit board disposed along a plane perpendicular to the axis of rotation;

a second circuit board disposed parallel to and adjacent to the first circuit board and having a first aperture formed through a central portion of the second circuit board; and

a stator assembly comprising a plurality of stator elements arranged about the axis of rotation;

a rotor circuit board assembly disposed within the enclosure and rotationally coupled to the shaft, the rotor circuit board assembly comprising:

a support component having lower and upper surfaces, a sleeve extending away from the lower surface and fitted over the shaft, a plurality of arms extending away from the sleeve, and a plurality of alignment posts extending away from the upper surface;

a third circuit board coupled to the lower surface of the support component and disposed adjacent to and in an opposing relationship with the second circuit board;

a fourth circuit board coupled to the upper surface of the support component and arranged parallel with the third circuit board between the third circuit board and the top cover, the fourth circuit board having a plurality of alignment cutouts sized and shaped to accept the alignment posts; and

a rotor component coupled to the rotor circuit board assembly and spaced apart from and concentric with the stator assembly, the rotor component comprising an annular arrangement in which a plurality of magnetic segments surround the axis of rotation and are distributed along the annular arrangement in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles;

a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module,

the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment,

the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment, wherein the detector circuitry comprises a plurality of pixels, each pixel comprising a plurality of single photon avalanche detectors (SPADs) and wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of the electromagnetic radiation pulses by the detector circuitry;

a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the rotor component to drive a rotation of the second circuit board assembly and the light ranging device about the shaft;

a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein

the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement; and

a communication channel extending through the hollow channel in the shaft and operatively coupled to allow ranging data from the light ranging device to be transmitted to circuitry disposed within the enclosure in a fixed relationship to the stator circuit board assembly.

23. The light ranging system of claim 22 wherein the plurality of stator elements and the annular arrangement of the plurality of magnetic segments are each disposed between a surface of the second circuit board and a surface of the third circuit board.

24. The light ranging system of claim 22 wherein each magnetic segment in the annular arrangement of the rotor component comprises a permanent magnet.

25. The light ranging system of claim 22 wherein the light source comprises a plurality of emitters configured to project a plurality of illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of pixels.

PATENT APPLICATION

ROTATING COMPACT LIGHT RANGING SYSTEM

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ROTATING COMPACT LIGHT RANGING SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application is a continuation of Non-Provisional Patent Application No. 16/209,875 filed December 4, 2018, which claims the benefit of U.S. Provisional Patent Application No. 62/596,018, filed December 7, 2017, the disclosure of each of which are incorporated herein by reference in their entirety for all purposes.

[0002] This application is related to the following commonly assigned and concurrently filed patents and patent applications, the disclosures of each of which are incorporated herein by reference in their entirety for all purposes: U.S. Patent Application No. 16/209,867 filed December 4, 2018; now U.S. Patent No. 10,481,269 issued November 19, 2019; U.S. Patent Application No. 16/209, 869 filed December 4, 2018, now U.S. Pat. No. 10/969,490 issued April 6, 2021; U.S. Patent Application No. 16/209,879 filed December 4, 2018; and concurrently filed U.S. Patent Application entitled "Rotating Cmopact Light Ranging System" (Attorney Docket No. 103033-P010US3C1-1244801).

BACKGROUND

[0003] Light imaging, detection and ranging (LIDAR) systems measure distance to a target by illuminating the target with a pulsed laser light and measuring the reflected pulses with a sensor. Time-of-flight measurements can then be used to make a digital 3D-representation of the target. LIDAR systems can be used for a variety of applications where 3D depth images are useful including archaeology, geography, geology, forestry, mapping, construction, medical imaging and military applications, among others. Autonomous vehicles can also use LIDAR for obstacle detection and avoidance as well as vehicle navigation.

[0004] Many currently available LIDAR sensors that provide coverage and resolution sufficient for obstacle detection and avoidance in autonomous vehicles are both technologically complex and costly to manufacture. Such sensors can thus be too expensive to allow for wide deployment in mass-market automobiles, trucks and other vehicles. Overall component cost and manufacturing complexity of a particular type of LIDAR sensor is typically driven by the underlying complexities in the architecture of the LIDAR sensor itself. This can be further

exacerbated in some modern LIDAR sensors which are a conglomeration of different internal sub-systems, each of which can be in itself quite complex, e.g., optoelectronic systems, electromechanical systems, computer control systems, high-speed communication systems, data processing systems, and the like.

[0005] To achieve the high positional accuracy, long distance range, and low power consumption that can be important to some modern sensing applications, stringent technical requirements for each one of these sub-systems have led to architectures and designs that are complex and difficult to build and often require expensive calibration and alignment procedures before individual LIDAR units can be used by a customer. For example, some LIDAR systems have internal architectures that employ one or more large motherboards and bulky, heavy optical systems that are mounted on a counter-balanced structural member, all within a turret that rotates at rates on the order of 1,000 RPM. In some of these systems, separate laser emitter/detector pairs are mounted to individual, separate circuit boards. Thus, each emitter board and receiver board can be required to be separately mounted to the motherboard, with each emitter/detector pair precisely aligned along a particular direction to ensure that the field of view of each detector overlaps with the field of view of the detector's respective emitter. As a result of the above architecture, precision alignment techniques are typically required during assembly to align each emitter board and each receiver board separately.

[0006] The above-described architecture becomes increasingly problematic when one desires to scale the resolution of the device. Increasing the resolution requires the addition of more laser emitter/detector pairs, again, each mounted on their own circuit board. Consequently, scaling the resolution linearly with this type of architecture can lead to exponential increases in manufacturing costs and also exponential reductions in reliability due to the sheer number of individual parts and boards involved. Once assembly and alignment is complete, great care must be taken that the precisely aligned multi-board arrangement is not disturbed or jolted out of alignment during shipping or at some other point over the design life of the system.

[0007] In addition to the complexities of alignment and assembly of the optical systems, most currently available LIDAR units have a relatively low overall degree of system integration. For example, control and drive circuits in many currently available LIDAR units are separate

modules mounted to custom boards. These custom boards may, in turn, need to be mounted to a motherboard within the LIDAR unit or may be mounted somewhere else on a structural element of the LIDAR unit by way of one or more mounting brackets. In some cases, each board can have one or more electrical interconnects that need to be routed through one or more internal volumes or passages within the enclosure to eventually connect with the motherboard.

[0008] For rotating LIDAR systems even more additional specialized mounts and interconnects may be required for the electric motor rotor and/or stator. In addition to power connections, data uplink and downlink lines are needed and typically accomplished by one or more inductive, capacitive, and/or metal slip ring rotary couplers, which can be difficult to implement and/or lead to low rates of data transfer. Some systems employ metal brushes within the rotary coupler and are thus potentially unreliable due to the requirement of mechanical contact of the brushes within the rotary mechanism. Other slip ring-type connectors can employ hazardous substances, such as mercury, causing these types of couplers to be non-compliant under the Restriction of Hazardous Substances Directive 2002/95/EC (ROHS) and thus disfavored or even banned in some jurisdictions.

[0009] With respect to the optoelectronic systems, the industry has experienced challenges in incorporating cost-effective single photon photodetectors such as CMOS-based single photon avalanche diodes (SPADs) due to their low quantum efficiency in the near infrared wavelengths and their low dynamic range. To improve quantum efficiency, some SPAD-based detectors employ InGaAs technology but such systems are more challenging to integrate in a cost-effective manner than CMOS devices. Therefore, the external/supporting circuitry (e.g., a quenching circuit that can sense the leading edge of the avalanche current, generate a standard output pulse synchronous with the avalanche build-up, quench the avalanche by lowering the bias back down to the breakdown voltage, and then restore the photodiode to the operative level) associated with the SPAD detectors manufactured using InGaAs technology is typically fabricated separately from the SPAD array, for example, in a package that is external to the SPAD array. In addition, InGaAs substrates are relatively expensive and the associated manufacturing processes typically have a lower yield than silicon substrate manufacturing processes further compounding the costs increase. To complicate matters further, InGaAs substrates typically need to be actively cooled

in order to reduce dark currents to suitable levels, which increases the amount of energy consumed during runtime, increasing cost and complexity even further.

[0010] Rather than employing SPAD-based detectors, many commercially available LIDAR solutions employ avalanche photodiodes (APDs). APDs are not binary detection devices, but rather, output an analog signal (e.g., a current) that is proportional to the light intensity incident on the detector and have high dynamic range as a result. However, APDs must be backed by several additional analog circuits including, for example, analog circuits such as transimpedance amplifiers and/or differential amplifiers, high-speed A/D converters, one or more digital signal processors (DSPs) and the like. Traditional APDs also require high reverse bias voltages not possible with standard CMOS processes. Without mature CMOS, it is difficult to integrate all this analog circuitry onto a single chip with a compact form factor and multiple external circuit modules located on a printed circuit board are usually employed which contributes to the high cost of these existing units.

[0011] Accordingly, to support growing markets for 3D sensing systems, there remains a need for more cost effective but still high performing LIDAR systems. Furthermore, there remains a need for improved and more elegant system architectures that enable streamlined assembly processes that can be effectively employed at scale.

SUMMARY

[0012] Embodiments of the disclosure pertain to a LIDAR unit that can, among other uses, be used for obstacle detection and avoidance in autonomous vehicles. Various embodiments of the disclosure can address one or more of the problems discussed above that are associated with some currently available LIDAR systems. Some specific embodiments pertain to LIDAR systems that include design features that enable the systems to be manufactured cheaply enough and with sufficient reliability and to have a small enough footprint to be adopted for use in mass-market automobiles, trucks and other vehicles.

[0013] In some embodiments, a spinning light ranging system according to the present disclosure can include a light ranging device (e.g., which emits light pulses and detects reflected pulses) that is connected to an upper circuit board assembly that rotates about an axis defined by a shaft. The upper circuit board assembly can cooperate with a lower circuit board assembly,

e.g., to provide power, data, and/or encoded positions, via respective circuit elements. The inclusion of cooperating wireless circuit elements on the rotating upper board assembly and the lower board assembly (e.g., as opposed to external, physical connections) can provide for a more compact design. Further, specific circuit elements (e.g., optical or power) can be positioned in a manner to enable efficient communication and/or to increase flux. For example, a wireless power receiver can be provided at a ring at an outer edge of the upper circuit board assembly, maximizing the amount of magnetic flux captured by an inductive ring or maximizing the area available in a capacitive system.

[0014] According to some embodiments, an optical communications subsystem can provide an optical communications channel between a rotating light ranging device and a base subsystem that does not rotate about a shaft. The optical communications channel can provide for fast communications, but also can provide for a compact and inexpensive design. For instance, a turret optical communication component can be positioned on a rotating assembly to communicate data (e.g., ranging data from the light ranging device) with a base optical communication component. Such positioning can alleviate the need for more bulky communication mechanisms. For example, downlink transmitter can be positioned to transmit optical ranging data through a hollow shaft used for rotation. As another example, one or more uplink transmitters of the base subsystem can transmit uplink signals to one or more uplink receivers that rotate on a rotating assembly, e.g., where these uplink elements are positioned in rings that align.

[0015] According to some embodiments, a rotation of an upper circuit board assembly can be driven by stator and rotor elements integrated on upper and lower circuit boards, thereby making the light ranging system compact. For example, the upper circuit board assembly can include a plurality of rotor elements symmetrically arranged about a rotation shaft, and a lower circuit board assembly can include a plurality of stator elements symmetrically arranged about the shaft. A driver circuit can drive the stator elements. Having such rotor and stator elements built onto the circuit boards themselves provides various advantages over products that use bulkier motors (e.g., stepper motors, brushed motors or unintegrated brushless motors).

[0016] According to some embodiments, a light ranging system includes a shaft having a longitudinal axis; a first circuit board assembly that includes a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly; a second circuit board assembly rotationally coupled to the shaft and spaced apart from and in an opposing relationship with the first circuit board assembly, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the longitudinal axis of the shaft; and a light ranging device mechanically coupled to the second circuit board assembly such that the light ranging device rotates with the second circuit board assembly.

[0017] In some embodiments a light ranging system includes a shaft; a first circuit board assembly that includes a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly; a second circuit board assembly rotationally coupled to the shaft, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a light ranging device coupled to rotate with the second circuit board assembly, the light ranging device including a light source configured to transmit light pulses to objects in a surrounding environment, and detector circuitry configured to detect reflected portions of the light pulses that are reflected from the objects in the surrounding environment and to compute ranging data based on the reflected portion of the light pulses; and a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the shaft.

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[0018] In some embodiments a light ranging system includes a stationary enclosure having an optically transparent window and a base; a hollow shaft disposed within the enclosure; a bearing system coupled to the hollow shaft; a first circuit board assembly disposed within the enclosure and parallel with a first plane perpendicular to the hollow shaft, the first circuit board assembly including a stator assembly comprising a plurality of evenly spaced stator elements arranged annularly about the shaft on a surface of the first circuit board assembly; a second circuit board assembly disposed within the enclosure parallel to the first plane and rotationally coupled to the shaft by the bearing system, wherein the second circuit board assembly includes a rotor assembly comprising a plurality of evenly spaced rotor elements arranged annularly about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements are aligned with and spaced apart from the plurality of stator elements; a light ranging device coupled to rotate with the second circuit board assembly within the stationary enclosure, the light ranging device including a light source configured to transmit light pulses through the window to objects in a surrounding environment, and detector circuitry configured to detect reflected portions of the light pulses received through the window that are reflected from the objects in the surrounding environment and to compute ranging data based on the reflected portion of the light pulses; and a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly and the light ranging device about the shaft.

[0019] According to some embodiments a light ranging system includes a housing; a shaft defining an axis of rotation; a first circuit board assembly disposed within and coupled to the housing in a fixed relationship such that the first circuit board assembly is aligned along a first plane perpendicular to the axis of rotation, the first circuit board assembly including a plurality of first circuit elements disposed on a first circuit board; a second circuit board assembly spaced apart from the first circuit board assembly within the housing in a second plane parallel to the first plane and rotationally coupled to the shaft such that the second circuit board assembly rotates about the axis of rotation, the second circuit board assembly including a plurality of second circuit elements disposed on a second circuit board and aligned with and configured to function in wireless cooperation with at least one of the first plurality of circuit elements; and a

light ranging device electrically connected to and coupled to rotate with the second circuit board assembly, the light ranging device configured to transmit light pulses to objects in a surrounding environment, to detect reflected portions of the light pulses that are reflected from the objects in the surrounding environment, and to compute ranging data based on the reflected portion of the light pulses.

[0020] In some embodiments, a light ranging system includes an enclosure having an optically transparent window; a shaft defining an axis of rotation through the enclosure; a first circuit board assembly disposed within and fixedly coupled to the enclosure and aligned perpendicular to the axis of rotation; a second circuit board assembly disposed within the enclosure and spaced apart from and in an opposing relationship with the first circuit assembly, the second circuit board assembly rotatably coupled to the shaft; a light ranging device coupled to the second circuit board assembly in a fixed relationship such that the light ranging device rotates with the second circuit board assembly around the shaft; an annular encoder comprising an annular encoder strip mounted on one of the first or second circuit boards and an encoder reader mounted on the other of the first or second circuit boards at a location facing and opposite the annular encoder strip; a wireless communication system comprising a first annular wireless communication component mounted to the first circuit board and a second annular wireless communication component mounted to the second circuit board at a location facing and opposite the first annular wireless communication component; and an annular wireless power transfer system comprising an annular wireless power transmitter mounted to the first circuit board and an annular wireless power receiver mounted to the second circuit board at a location facing and opposite the annular wireless power transmitter.

[0021] In some embodiments, a light ranging system includes an enclosure having an optically transparent window; a shaft defining an axis of rotation through the enclosure; a first circuit board assembly disposed within and fixedly coupled to the enclosure and aligned perpendicular to the axis of rotation; a second circuit board assembly disposed within the enclosure and spaced apart from and in an opposing relationship with the first circuit assembly, the second circuit board assembly rotatably coupled to the shaft; a light ranging device mounted to the second circuit board assembly such that the light ranging device rotates with the second circuit board assembly around the shaft, the light ranging device configured to transmit light pulses to objects

in a surrounding environment, to detect reflected portions of the light pulses that are reflected from the objects in the surrounding environment, and to compute ranging data based on the reflected portion of the light pulses; an annular encoder comprising an annular encoder strip mounted on one of the first or second circuit boards and an encoder reader mounted on the other of the first or second circuit boards at a location facing and opposite the annular encoder strip; a wireless communication system comprising a first annular wireless communication component mounted to the first circuit board and a second annular wireless communication component mounted to the second circuit board at a location facing and opposite the first annular wireless communication component; an electric motor including a stator assembly comprising a plurality of stator elements arranged about the shaft on a surface of the first circuit board assembly and a rotor assembly comprising a plurality of rotor elements arranged about the shaft on a surface of the second circuit board assembly such that the plurality of rotor elements disposed at a location facing and opposite the plurality of stator elements; a stator driver circuit disposed on either the second or the first circuit board assemblies and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the plurality of rotor elements to drive a rotation of the second circuit board assembly about the shaft; and an annular wireless power transfer system comprising an annular wireless power transmitter mounted to the first circuit board and an annular wireless power receiver mounted to the second circuit board at a location facing and opposite the annular wireless power transmitter.

[0022] According to some embodiments a light ranging system includes a shaft having a longitudinal axis; a light ranging device configured to rotate about the longitudinal axis of the shaft, the light ranging device including a light source configured to transmit light pulses to objects in a surrounding environment, and detector circuitry configured to detect reflected portions of the light pulses that are reflected from the objects in the surrounding environment and to compute ranging data based on the reflected portion of the light pulses; a base subsystem that does not rotate about the shaft; and an optical communications subsystem configured to provide an optical communications channel between the base subsystem and the light ranging device, the optical communications subsystem including one or more turret optical communication components connected to the detector circuitry and one or more base optical communication components connected to the base subsystem.

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[0023] In some embodiments a light ranging system includes a housing having an optically transparent window; a hollow shaft having a longitudinal axis disposed within the housing; a light ranging device disposed within the housing and configured to rotate about the longitudinal axis of the shaft, the light ranging device including a light source configured to transmit light pulses through the optically transparent window to objects in a surrounding environment, and detector circuitry configured to detect reflected portions of the light pulses through the optically transparent window reflected from the objects in the surrounding environment and to compute ranging data based on the reflected portion of the light pulses; a base subsystem disposed within the housing that does not rotate about the shaft; and an optical communications subsystem disposed within the housing and configured to provide an optical communications channel between the base subsystem and the light ranging device, the optical communications subsystem including a first optical channel disposed within the hollow shaft and a second optical channel arranged annularly outside the hollow shaft.

[0024] In some embodiments, a light ranging system includes a housing having an optically transparent window; a hollow shaft having a longitudinal axis disposed within the housing; a light ranging device disposed within the housing and configured to rotate about the longitudinal axis of the shaft, the light ranging device including a light source configured to transmit light pulses through the optically transparent window to objects in a surrounding environment, and detector circuitry configured to detect reflected portions of the light pulses through the optically transparent window reflected from the objects in the surrounding environment and to compute ranging data based on the reflected portion of the light pulses; a base subsystem disposed within the housing that does not rotate about the shaft; a first optical communication channel configured to optically transmit data between the light ranging device and the base subsystem through the hollow shaft, the first optical communication channel including a first optical component coupled to circuitry coupled to rotate with the light ranging device and a second optical component coupled to circuitry disposed on the base subsystem; and a second, annular optical communication channel surrounding the hollow shaft and configured to optically transmit data between the light ranging device and the base subsystem, the annular optical communication channel including a first annular optical component coupled to circuitry coupled to rotate with

the light ranging device and a second annular optical component coupled to circuitry disposed on the base subsystem.

[0025] According to some embodiments, a light ranging device can include a light emitting module and a light sensing module. The light emitting module can include a light source configured to transmit light pulses to objects in a surrounding environment. The light sensing module can include a lens housing; a bulk lens system coupled to the lens housing and configured to receive light from the surrounding environment and focus the received light to a focal plane, the bulk lens system comprising a first lens, a second lens, and a third lens mounted in the lens housing; wherein the first lens, the second lens, or the first lens and the second lens are plastic; and wherein the third lens is glass; an array of photosensors configured to receive light from the bulk lens system and detect reflected portions of the light pulses that are reflected from the objects in the surrounding environment; and a mount that mechanically couples the lens housing with the array of photosensors, wherein the lens housing, the bulk lens system, and the mount are configured to passively focus light from the bulk lens system onto the array of photosensors over a temperature range. In some instances the lens housing, the bulk lens system, and the mount are configured to match, as a function of temperature, a focal length of the lens system with an expansion coefficient of the lens housing and with an expansion coefficient of the mount so that light is passively focused onto the array of photosensors over the temperature range, such as -5 degrees C to 70 degrees C.

[0026] In some embodiments, a light ranging system includes an enclosure having an optically transparent window, a light ranging device disposed within the enclosure and circuitry configured to compute ranging data. The light ranging device can include an optical transmitter comprising a bulk transmitter lens system and a plurality of transmitter channels, each channel including a light emitter configured to generate and transmit pulses of narrowband light through the bulk transmitter optic and through the optically transparent window into a field external to the light ranging system; and an optical receiver comprising a bulk receiver lens system, a lens housing and a plurality of micro-optic receiver channels, each micro-optic channel including an aperture coincident with a focal plane of the bulk receiver optic, a collimating lens behind the aperture, an optical filter behind the collimating lens and a photosensor responsive to incident photons passed through the aperture into the collimating lens and through the filter. The bulk

receiver lens system can include a first lens, a second lens, and a third lens mounted in the lens housing; wherein the first lens, the second lens, or the first lens and the second lens are plastic; the third lens is glass; and a coefficient of thermal expansion (CTE) of the lens housing is matched, over a temperature range, with the bulk receiver lens system so that the focal plane is stable relative to each photosensor in the plurality of micro-optic receiver channels over the temperature range. In some instances the temperature range is from 20 degrees C to 70 degrees C and in some instances the temperature range is from -5 degrees C to 70 degrees C.

[0027] In some embodiments an image sensing device is provided. The image sensing device can include a lens housing; a bulk lens system mechanically coupled to the lens housing and configured to receive light from the surrounding environment and focus the received light to a focal plane. The bulk lens system can include a first lens, a second lens, and a third lens mounted in the lens housing, wherein the first lens, the second lens, or the first lens and the second lens are plastic and wherein the third lens is glass. The image sensing device can further include an array of photosensors configured to receive light from the bulk lens system, and a mount that mechanically couples the lens housing with the array of photosensors. The coefficient of thermal expansion (CTE) of the lens housing can be matched, over a temperature range, with the bulk lens system so that the focal plane is stable relative to the array of photosensors over the temperature range. In some instances the temperature range is from 20 degrees C to 70 degrees C and in some instances the temperature range is from -5 degrees C to 70 degrees C. And, in some embodiments, a CTE of the mount is matched with the CTE of the lens housing.

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[0028] These and other embodiments of the invention are described in detail below. Additionally, other aspects and advantages of various embodiments of the disclosure will become apparent from the following detailed description taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the described embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIGS. 1A-1B show a rotating light ranging system and a non-rotating, solid-state light ranging system, respectively, that can be used in automotive applications according to some embodiments;

[0030] FIGS. 2A-2B show high level block diagrams of rotating and solid-state LIDAR systems, respectively, according to some embodiments;

[0031] FIG. 3 illustrates a more detailed block diagram of a rotating LIDAR system 300 according to some embodiments like those described above in reference to FIG. 2A;

[0032] FIGS. 4A and 4B show an illustrative example of the light transmission and detection process for a light ranging system according to some embodiments, with a focus on the emitter array and sensor array that form an arrangement of emitter-sensor channels, as introduced above in reference to FIG. 2.

[0033] FIGS. 5A-5B show a rotating LIDAR system 500 in accordance with one or more embodiments;

[0034] FIGS. 6A-6C show cross-sectional views of a LIDAR system in accordance with one or more embodiments;

[0035] FIG. 6D shows a top view of a stator board in accordance with one or more embodiments;

[0036] FIG. 6E shows a bottom view of a rotor board in accordance with one or more embodiments;

[0037] FIG. 6F is a simplified cross-sectional view of a portion of a multi-coil wireless power receiver positioned within an annular ferrite channel according to some embodiments;

[0038] FIG. 7 shows an exploded view of the lower circuit board assembly to illustrate the assembly process of the compact LIDAR system according to certain embodiments;

[0039] FIGS. 8A and 8B show an exploded view of a LIDAR system according to some embodiments;

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[0040] FIGS. 9A-9C show a perspective view, a front view, and a zoomed front view, respectively, of a light ranging device 900 according to certain embodiments;

[0041] FIG. 10 shows an optical block diagram of a light ranging device 1000 showing both the optical systems for a Rx module 1001 and a Tx module 1003 according to certain embodiments;

[0042] FIG. 11A shows a top view of a micro-optics package according to certain embodiments;

[0043] FIG. 11B shows a cross-section of a single micro-optic receiver channel according to some embodiments;

[0044] FIG. 12A-12B shows top views of a SPAD-based detector according to some embodiments;

[0045] FIGS. 13A and B show simplified top and side views of a VCSEL chip transmitter according to some embodiments;

[0046] FIG. 14 depicts a simplified schematic of an embodiment of a LIDAR bulk optical system;

[0047] FIGS. 15A, 15B, and 15C depict an embodiment of a bulk optics lens assembly;

[0048] FIGS. 16A-16E depicts various views of an embodiment of a lens assembly;

[0049] FIG. 17A-17D, depict a cross sections of embodiment of the lenses of a lens assembly; and

[0050] FIG. 18 depicts an embodiment of a lens assembly with three lenses.

TERMS

[0051] Unless defined otherwise, technical and scientific terms used herein have the same meaning as commonly understood by a person of ordinary skill in the art. The following definitions, however, are provided to facilitate understanding of certain terms used frequently and are not meant to limit the scope of the present disclosure. Abbreviations used herein have their conventional meaning within the relevant arts.

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[0052] The term *ranging data* may refer to any data that can be transmitted from a laser ranging device, e.g., a turret component of a rotating LIDAR system. Examples of ranging data include range information, e.g. distance to a given target point at a certain angle (azimuth and/or zenith), range-rate or velocity information, e.g. the derivative of the ranging data with respect to time, and also operational information such as signal-to-noise ratio (SNR) of return or signal intensity, target reflectivity, ambient NIR levels coming from each pixel field of view, diagnostic information including temperature, voltage levels, etc. In some embodiments, ranging data can include RGB information from an RGB camera that is located in the turret, e.g., a high speed read-out camera such as a line scan camera or thermal imager.

[0053] The term *turret* can refer to the rotating part or portion of a rotating LIDAR system. *Turret components* include any rotating component or circuit boards in the turret portion of the LIDAR system and can include one or more components located in a light ranging device and/or one or more components located on a rotating circuit board of a rotary actuator.

[0054] In the context of a rotating LIDAR system (sometimes referred to herein as a "spinning LIDAR system"), the term *base* can refer to the non-rotating part or non-rotating portion of the rotating LIDAR system. *Base components* include any non-rotating component or circuit boards in the base portion of the LIDAR system and can include one or more components located in a base assembly and/or one or more components located on a non-rotating circuit board of a rotary actuator.

[0055] The terms *upper* and *lower* refer to the position, or relative position, of components along the axis of rotation of a LIDAR system. In some embodiments, *upper* components, also referred to as *turret* components, are located on the turret of the LIDAR system while *lower* components, also referred to as *base* components, are located on the base of the LIDAR system.

[0056] The term *ring* includes not just circular shapes but also shapes that are slightly non-circular, e.g., elliptical, and arranged circumferentially around a central axis, including perturbations or oscillations (e.g., wavy) at a circumference.

[0057] One or more shapes that are referred to as *symmetric* can include both perfectly symmetric shapes as well as shapes that are generally but not perfectly symmetric. Arrangements of electronic components described herein may operate most efficiently in a

symmetric configuration, however, the term symmetric does not exclude those configurations that are slightly asymmetric, or have a slight deviation from symmetric even if those configurations do not result in the optimal operational configuration.

[0058] The term *parallel* is not limited to perfectly parallel but includes also those geometrical arrangements and configurations that are substantially parallel as a result of manufacturing variations, e.g., two elements that are referred to herein as being *parallel* may have an angle between -5 and 5 degrees or -1 and 1 degrees between the two elements depending on the manufacturing tolerance employed.

[0059] The term *perpendicular* is not limited to perfectly perpendicular but includes also those geometrical arrangements and configurations that are substantially perpendicular as a result of manufacturing variations, e.g., two elements that are referred to herein as being *perpendicular* may have an angle between 85 and 95 degrees between the two elements.

[0060] The term *photosensor* (or just *sensor*) refers to a sensor that can convert light into an electrical signal (e.g., an analog electrical signal or binary electrical signal). An avalanche photodiode (APD) is one example of a photosensor. A single photosensor can include a plurality of smaller "*photodetectors*". Thus, a plurality of single-photon avalanche diodes (SPADs) can be another example of a photosensor where each individual SPAD in the plurality of SPADs (e.g., each SPAD in an array of SPADs) can be referred to as a photodetector. The term *sensor array* can sometimes refer to a sensor chip that includes an array of multiple sensors. Additionally, the term *pixel* is sometimes used interchangeably with photosensor or sensor.

[0061] The term *transmitter* can refer to a structure that includes one or more light transmitting elements, e.g., LED, laser, VCSEL, and the like. The term *transmitter* can also include a transmitter chip that includes an array of transmitters, sometimes referred to as an emitter array.

[0062] The term *bulk optic(s)* refers to single lenses and/or lens assemblies that include one or more macroscopically-sized optics, e.g., with diameters on the order of centimeters or greater, such as those used in commercially available camera lenses and microscope lenses. In this disclosure, the term *bulk optics* is contrasted with the term *micro-optics* which refers to optical elements or arrays of optical elements having individual element diameters that are on the order of a few micrometers to a few millimeters in size or smaller. In general, *micro-optics* can

modify light differently for different emitters and/or different detectors of an array of emitters or an array of detectors, whereas the *bulk optics* modify light for the entire array.

[0063] As used herein, the term *image space telecentric optics module* refers to an optical system (bulk or otherwise) where, at the image plane, all (or substantially all) of the chief rays from within the aperture of the lenses are incident on the image plane "straight on", or at a zero angle of incidence, within a specified tolerance (e.g., +/- 2 degrees).

DETAILED DESCRIPTION

[0064] According to certain embodiments, methods and systems disclosed herein relate to a compact light ranging and detection (LIDAR) system and methods of assembly of a compact LIDAR system. The LIDAR system can include a modular light ranging device and an optional highly compact and integrated rotary actuator. The modular light ranging device can operate as a stand-alone non-rotating solid state LIDAR or, if connected to the integrated rotary actuator, can operate as part of a turret of a rotating LIDAR. The light ranging device can include a light transmission module (sometimes referred to as a "light emitting module") for illuminating objects in a field located around the light ranging module and also includes a light sensing module for sensing reflected or scattered portions of the illuminating light pulses for use in computing a 3D depth image. The light ranging module can also include a detector chip (e.g., a CMOS chip) that includes an array of photosensors, each of which can be, for example, an array of SPADs.

[0065] In some embodiments, the rotary actuator includes an upper circuit board assembly (also referred to herein as a turret, or rotating circuit board assembly) and a base circuit board assembly (also referred to herein as a stationary circuit board assembly). The various circuit boards of the rotary actuator can be highly integrated in the sense that many of the functional and/or supporting electronic and optical components of the LIDAR system can be mounted directly to one or more boards of the rotary actuator. For example, the base controller of the LIDAR system that can control various emission parameters of the light transmission module can be mounted on a board of the base circuit board assembly of the rotary actuator. Furthermore, power can be provided to the light ranging module by way of a wireless power transmission system that is also integrated onto a board of the rotary actuator. Communication

between the base controller and the light ranging module and vice versa can be enabled by way of an optical uplink channel and an optical downlink channel where the electrical and optical components that support the optical uplink/downlink channels are also integrated onto one or more circuit boards of the rotary actuator.

[0066] In some embodiments, these same boards include electric motor components integrated onto one or more surfaces of the upper and lower circuit board assemblies of the rotary actuator. For example, an electric motor stator can be bonded directly to a surface of the lower circuit board assembly of the rotary actuator along with other electrical components, e.g., a group of optical uplink transmitters, an optical downlink receiver, and a wireless power transmitter. Likewise, an electric motor rotor can be bonded directly to a surface of the upper circuit board assembly of the rotary actuator along with other electrical components, e.g., a group of optical uplink receivers, an optical downlink transmitter, an optical or magnetic rotary encoder reader, and a wireless power receiver.

[0067] In some embodiments, the upper circuit board assembly can include one or more connectors, also bonded to a surface of the upper circuit board assembly, to connect the light ranging module to the upper circuit board assembly. Additionally, the rotary actuator can also include additional computational resources, one or more FPGAs, ASICs, microprocessors, and the like, that can be used by the light ranging module to perform data processing on the acquired data.

[0068] In view of the high level of systems integration in the compact LIDAR disclosed herein, a fully functioning system can be assembled by simply attaching the light ranging module to the rotary actuator. There is no need for a separate electric motor module, separate communications module, separate power modules, etc.

[0069] In some embodiments, the architecture of the rotary actuator lends itself to an elegant method of assembly. For example, the system can be architected such that the electrical components, including communications components, electric motor components, and wireless power components are arranged circumferentially and concentrically around a central axis of the system or even coaxially with the axis of the system. The central axis can also be collinear with the axis of rotation of the upper circuit board assembly, or turret. One or more boards of the

rotary actuator can include a central hole that is configured to receive a shaft that can be attached (directly or indirectly) to a lower portion, or base, of a fixed enclosure. In some embodiments, the shaft defines the axis of rotation of the system and one or more bearings attached thereto provide for rotational movement of the upper circuit board assembly relative to the lower circuit board assembly.

[0070] In view of the above architecture, assembly of the rotary actuator in some embodiments can be reduced to dropping successive boards in place on the shaft. Because a subset of the electrical components (such as the communications components, electric motor components, and wireless power components) are arranged circumferentially around a central axis of the system these systems can operate effectively without the need for complex alignment procedures once the assembly is complete.

[0071] In some embodiments, the system employs a thermally stable image-space telecentric optics module employed within the light transmission module or the light sensing module, or both. The thermally stable image-space telecentric optics module can be engineered to have an image plane that is stable in space relative to transmitter or sensor chip that includes an array of transmitters and/or sensors of the light transmission module or light sensing module, respectively. The coefficients of thermal expansion of a lens housing and of the optical elements within the lens housing, along with the change in refractive index with respect to temperature, can be chosen to provide for the thermally stable image plane. In various embodiments, the individual optics in the optical system may be glass and/or plastic to provide for an economical yet thermally stable design.

[0072] A modular light ranging device according to some embodiments of the disclosure includes a set of vertical-cavity surface-emitting lasers (VCSELs) as illumination sources that emit pulses of radiation into a field and includes arrays of single-photon avalanche diode (SPAD) detectors as a set of pixels (photosensors) that detect radiation reflected or scattered from a surface in the field. As stated above, SPADs have a relatively low dynamic range as compared to APDs that are used in some currently available LIDAR sensors. The low dynamic range inherent to SPADs is due, in part, to the physics of how a SPAD detects a photon – they are so-called Geiger mode devices that, for each photon detection event, produce a binary electrical

signal (photon detected or not detected) in the form of an avalanche current pulse. Using VCSELs as the emitters and SPADs as the detectors enables multiple measurements to be taken at the same time (i.e., the VCSEL emitters can be fired simultaneously) and also enables the set of emitters and the set of photosensors to each be fabricated using standard CMOS processes on a single chip, greatly simplifying the manufacturing and assembly process. Using VCSELs and SPADs in certain embodiments presents challenges, however, that various embodiments of the invention overcome. For example, VCSELs are much less powerful than the lasers used in some currently available LIDAR sensors and SPADs are much less efficient than the detectors used in some LIDAR sensors. To address these challenges, as well as challenges presented by firing multiple emitters simultaneously, certain embodiments of the disclosure can include optical components to enhance the brightness of the VCSEL emitter as well as various optical components (e.g., lenses, filters, and an aperture layer), which may work in concert with multiple arrays of SPADs, each array corresponding to a different photosensor, as described herein.

I. Illustrative Automotive LIDAR System

[0073] FIGS. 1A-1B show automotive light ranging devices, also referred to herein as LIDAR systems, according to some embodiments. The automotive application for the LIDAR systems is chosen here merely for the sake of illustration and the sensors described herein may be employed in other types of vehicles, e.g., boats, aircraft, trains, etc., as well as in a variety of other applications where 3D depth images are useful, such as medical imaging, geodesy, geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, atmospheric physics, laser guidance, airborne laser swath mapping (ALSM), and laser altimetry. According to some embodiments, a LIDAR system, e.g., scanning LIDAR system 100 and/or solid state LIDAR system 120, can be mounted on the roof of a vehicle 105 as shown in FIGS. 1A and 1B. In other embodiments one or more LIDAR sensors can be mounted on other locations of a vehicle including, but not limited to, the front or back of the vehicle, the sides of the vehicle and/or corners of the vehicle.

[0074] The scanning LIDAR system 100 shown in FIG. 1A can employ a scanning architecture, where the orientation of the LIDAR light transmission module 102 (e.g., light source for emitting laser pulses) and/or light sensing module 104 (e.g., detector circuitry for

detecting reflected pulses to determine distance to an object) can be scanned around one or more fields of view 110 within an external field or scene that is external to the vehicle 105. In the case of the scanning architecture, the emitted light 112 can be scanned over the surrounding environment as shown. For example, the output beam(s) of one or more light sources (such as infrared or near-infrared pulsed IR lasers, not shown) located in the scanning LIDAR system 100, can be scanned, e.g., rotated, to illuminate a scene around the vehicle. In some embodiments, the scanning, represented by rotation arrow 115, can be implemented by mechanical means, e.g., by mounting the light emitters to a rotating column or platform. In some embodiments, the scanning can be implemented through other mechanical means such as through the use of galvanometers. Chip-based steering techniques can also be employed, e.g., by using microchips that employ one or more MEMS based reflectors, e.g., such as a digital micro-mirror (DMD) device, a digital light processing (DLP) device, and the like. In some embodiments, the scanning can be effectuated through non-mechanical means, e.g., by using electronic signals to steer one or more optical phased arrays.

[0075] For a stationary architecture, like the solid state LIDAR system 120 shown in FIG. 1B, one or more solid state LIDAR subsystems (e.g., light transmission module 122 and light sensing module 124) can be mounted to the vehicle 105. Each solid state LIDAR unit can face a different direction (possibly with partially and/or non-overlapping fields of views between units) so as to capture a composite field of view that is larger than each unit is capable of capturing on its own.

[0076] In either the rotating or stationary architectures, objects within the scene can reflect portions of the light pulses that are emitted from the LIDAR light sources. One or more reflected portions then travel back to the LIDAR system and can be detected by the detector circuitry. For example, reflected portion 114 can be detected by detector circuitry 104. The light transmission module can be disposed in the same housing as the light sensing module. Aspects of the scanning system and stationary system are not mutually exclusive and thus can be used in combination. For example, the individual LIDAR subsystems 122 and 124 in FIG. 1B can employ steerable emitters such as a MEMS oscillating mirror or the whole composite unit may rotate through mechanical means thereby scanning the entire scene in front of the LIDAR system, e.g., from field of view 130 to field of view 132.

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[0077] FIGS. 2A-2B show high level block diagrams of a rotating LIDAR system 200 and a stationary solid state LIDAR system 230, respectively, according to some embodiments. Both systems employ a light ranging device 210 that includes a light transmission module 212 and a light sensing module 214. The light transmission and sensing modules 212 and 214 can each include bulk optics 215, e.g., a multi-element lens assembly positioned at the input/output of the sensing and transmission modules, respectively. Light transmission module 212 can further include a micro-optics array and optional notch filter element (not shown) that is located between the bulk optics 215 and light emitter circuitry 216. In some embodiments, light emitter circuitry 216 includes a chip-scale array of light sources, such as an array of vertical cavity surface emitting lasers (VCSELs) on an Indium Gallium Arsenide (InGAs) substrate. Light sensing module 214 can also include a micro-optics array and notch filter element (not shown) that is located between the bulk optics 215 and light detector circuitry 218. In some embodiments, light detector circuitry 218 can includes a chip-scale array of photon detectors, such as an array of single photon avalanche diodes (SPADS) fabricated in a CMOS technology. Other detector technologies can be employed as well, e.g., avalanche photodiodes, CCD image sensors, CMOS photodiode image sensors, cavity enhanced photodetectors, surface enhanced photodetectors, and the like.

[0078] Turning to FIG. 2A, in rotating LIDAR system 200, light ranging device 210 can be electrically connected to a turret circuit board assembly 222 (also referred to herein as an upper circuit board assembly or ranging circuit board assembly). Circuit board assembly 222 can be considered ranging to the extent that it is connected to light ranging device 210. As described in more detail in FIG. 3 below, the turret circuit board assembly 222 can include a number of circuit elements including one or more processors and memory. For example, the turret circuit board assembly 222 can include a field programmable gate array (FPGA) and or one or more application specific integrated circuits (ASICs) that are tailored to provide certain LIDAR functionality. In some embodiments, the light ranging device 210 can be hard wired to the turret circuit board assembly 222 via a multi-pin electrical connector or may be wirelessly connected, e.g., through a communication channel employing optical or RF connections, to the turret circuit board assembly 222.

[0079] Turret circuit board assembly 222 can be disposed directly above a base circuit board assembly 226. In some embodiments, the base circuit board assembly 226 can wirelessly transmit power to the turret circuit board assembly 222 to, for example, power light ranging device 210 and any other associated circuitry (e.g., ASICS, FPGAs, communications circuits and the like). In addition, optical, inductive, and/or capacitive communications channels can connect the base circuit board assembly 226 to turret circuit board assembly 222 thereby allowing for the light ranging device 210 to be controlled via contactless data transfer from the base circuit board assembly.

[0080] In the embodiment shown in FIG. 2A, turret circuit board assembly 222 is rotationally coupled to base circuit board assembly 226 through a rotational coupler 224. Rotational coupler 224 enables light ranging device 210 and turret circuit board assembly 222 to rotate a full 360 degrees within a housing 220 of LIDAR system 200. Rotation of the light ranging device 210 allows the system to acquire data that can be used to construct a full 360 field-of-view 3D map of a volume around the device. In some embodiments, the base circuit board assembly 226 can be coupled to the housing 220, for example, by way of a mechanical bracket and screws (not shown), such that base circuit board assembly 226 is held stationary and does not rotate relative to housing 220. Housing 220 can be a waterproof housing that protects light ranging device 210 and other internal components of LIDAR system 200 from moisture and various elements of the environment that LIDAR system 200 operates within.

[0081] Rotational coupler 224 can be implemented in a number of different ways in various embodiments. For example, some embodiments can employ a shaft and bearing structure. In some embodiments, rotational coupler 224 also includes one or more components for a rotary actuator that not only allows for rotational movement but also drives the rotational movement of the turret circuit board assembly 222. For example, an electric motor rotor assembly including an arrangement of rotor elements (e.g., permanent magnets), can be directly integrated into the turret circuit board assembly 222, and an electric motor stator assembly including an arrangement of stator elements, such as solenoid coils, can be directly integrated into the base circuit board assembly 226. In such embodiments, where one or more rotary actuation components are integrated into the base circuit board assembly 226 and/or the turret circuit board assembly 222, a separate module for rotary actuation is no longer needed. As a result,

embodiments of the LIDAR system disclosed herein can have a more compact form factor and much simplified assembly process than spinning LIDAR systems that employ a separate electric motor module.

[0082] FIG. 2B is a simplified block diagram of a stationary solid state LIDAR system 230 according to some embodiments. Like rotating LIDAR system 200 shown in FIG. 2A, stationary solid state LIDAR system 230 includes a light ranging device 210 housed within a waterproof housing 240. Light ranging device 210 can be directly connected to a base circuit board assembly 232 within housing 240. Since system 230 does not rotate light ranging device 210, there is no need for a separate rotating turret circuit board assembly or a rotational coupler. Accordingly, the circuitry that was previously distributed amongst the turret circuit board assembly 222 and the base circuit board assembly 226 can be integrated entirely into the single base circuit board assembly 232 and/or shared amongst the circuitry associated with the light sensing module 214 and/or transmission module 212.

[0083] In some embodiments, for either of the embodiment shown in FIGS. 2A-2B, the hardware and software/firmware for performing one or more LIDAR-specific operations (e.g., photon time series accumulation followed by peak detection and ranging data computation and output) can be incorporated into the circuitry of light ranging device 210 and/or one or more of the circuit board assemblies (e.g., turret circuit board assembly 222 and/or base circuit board assembly 226 for LIDAR system 200, or base circuit board assembly 232 for LIDAR system 230). For example, in some embodiments, the light detector circuitry 218 may also include an ASIC that is integrated onto the same substrate as the array of SPADs. In such a situation, the light ranging device 210 is modular in the sense that a reprogramming/reconfiguring of the software/firmware can allow the light ranging device 210 to operate as part of a rotating LIDAR system (like LIDAR system 200 shown in FIG. 2A) or as a stand-alone solid state LIDAR system (like LIDAR system 230 shown in FIG. 2B). As already mentioned above, circuitry can be employed (e.g., MEMS, DMD, optical phased arrays, and the like) that will also allow for beam steering without the need for a mechanical rotational actuator. Accordingly, the modular design of the system disclosed herein results in a highly adaptable system that can fit user needs without expensive and time consuming redesign of the overall hardware and mechanical architecture.

II. Detailed block diagram

[0084] FIG. 3 illustrates a more detailed block diagram of a rotating LIDAR system 300 according to some embodiments like those described above in reference to FIG. 2A. More specifically, rotating LIDAR system 300 can optionally employ a rotary actuator with wireless data and power transmission and reception capabilities. In some embodiments, the rotary actuator includes a rotor that is integrated onto a surface of a rotating circuit board and a stator that is integrated onto a surface of a stationary circuit board and both board assemblies are equipped with wireless power and data transfer capabilities.

[0085] Rotating LIDAR system 300 shown in FIG. 3 includes two main modules: a light ranging device 320 and a rotary actuator 315 described in detail below. Additionally, rotating LIDAR system 300 can interact with one or more instantiations of user interface hardware and software 305. The different instantiations of user interface hardware and software 305 can vary and may include, e.g., a computer system with a monitor, keyboard, mouse, CPU and memory; a touch-screen in an automobile; a handheld device with a touch-screen; or any other appropriate user interface. The user interface hardware and software 305 may be local to the object upon which rotating LIDAR system 300 is mounted but can also be a remotely operated system. For example, commands and data to/from rotating LIDAR system 300 can be routed through a cellular network (LTE, etc.), a personal area network (Bluetooth, Zigbee, etc.), a local area network (WiFi, IR, etc.), or a wide area network such as the Internet.

[0086] The user interface hardware and software 305 can present the LIDAR data from the device to the user but can also allow a user to control the rotating LIDAR system 300 with one or more commands. Example commands can include commands that activate or deactivate the LIDAR system, specify photo-detector exposure level, bias, sampling duration and other operational parameters (e.g., for emitted pulse patterns and signal processing), specify light emitters parameters such as brightness. In addition, commands can allow the user to select the method for displaying results. The user interface can display LIDAR system results which can include, e.g., a single frame snapshot image, a constantly updated video image, and/or a display of other light measurements for some or all pixels such as ambient noise intensity, return signal intensity, calibrated target reflectivity, target classification (hard target, diffuse target,

retroreflective target), range, signal to noise ratio, target radial velocity, return signal temporal pulse width, signal polarization, noise polarization, and the like. In some embodiments, user interface hardware and software 305 can track distances (proximity) of objects from the vehicle, and potentially provide alerts to a driver or provide such tracking information for analytics of a driver's performance.

[0087] In some embodiments, the LIDAR system can communicate with a vehicle control unit 310 and one or more parameters associated with control of a vehicle can be modified based on the received LIDAR data. For example, in a fully autonomous vehicle, the LIDAR system can provide a real time 3D image of the environment surrounding the car to aid in navigation. In other cases, the LIDAR system can be employed as part of an advanced driver-assistance system (ADAS) or as part of a safety system that, for example, can provide 3D image data to any number of different systems (e.g., adaptive cruise control, automatic parking, driver drowsiness monitoring, blind spot monitoring, collision avoidance systems, etc). When a vehicle control unit 310 is communicably coupled to light ranging device 320, alerts can be provided to a driver or the proximity of an object can be tracked and/or displayed.

[0088] Light ranging device 320 includes light sensing module 330, light transmission module 340 and light ranging system controller 350. The rotary actuator 315 includes at least two circuit board assemblies, a lower circuit board assembly 360 (also referred to herein as a base subsystem) and an upper circuit board assembly 380 (also referred to herein as a turret subsystem). The lower circuit board assembly 360 can be mechanically mounted to a fixed portion of an enclosure or housing (not shown) while the upper circuit board assembly 380 is free to rotate about an axis of rotation, usually defined by a shaft (not represented in FIG. 3) that is also mounted to the enclosure (directly or indirectly). The light ranging device 320 can be mechanically attached to the rotatable upper circuit board assembly 380 and therefore is free to rotate within the housing.

[0089] While FIG. 3 shows one particular arrangement of components within light ranging device 320 and rotary actuator 315, in some embodiments, certain components may be integrated into one, or the other, module differently than shown. As one example, ranging system controller 350, which can be, for example, an FPGA, ASIC, or a more general computing device,

like an embedded system or system-on-a-chip (SOC), can be mounted directly (e.g., soldered) to, a printed circuit board that is part of the upper circuit board assembly 380. In other words, in some embodiments, the parts of the rotary actuator can be integrated within the light ranging device 320 and *vice versa*.

[0090] The rotary actuator 315 includes a number of different systems that are integrated onto one or more printed circuit boards of the lower and upper circuit board assemblies 360 and 380. For example, rotary actuator 315 can include a brushless electric motor assembly, an optical communications subsystem, a wireless power transmission subsystem, and a base controller. These systems are formed by pairs of cooperating circuit elements with each pair including one or more circuit elements on the lower circuit board assembly 360 operating in cooperation with (e.g., having a function that is complementary to) one or more circuit elements on the upper circuit board assembly 380. Complementary functions include, for example, transmission (Tx) and reception (Rx) of power and/or data communication signals as is described in more detail below.

[0091] The brushless electric motor assembly includes a stator assembly 362 integrated onto a printed circuit board of the lower circuit board assembly 360 and a rotor assembly 382 integrated onto a printed circuit board of the upper circuit board assembly 380. The rotation of rotor assembly 382 is driven from a drive signal, for example, a three-phase drive current, that originates from a motor driver circuit 364. In some embodiments, one or more motor control lines connect the motor driver circuit to the coils of the stator assembly 362 to allow for the drive signal to be provided to the motor stator. Furthermore, the motor driver circuit 364 can be electrically connected to a base controller 366 such that the base controller 366 can control the rotation rate of the rotor assembly and thus the rotation rate (i.e., frame rate) of the light ranging device 320.

[0092] In some embodiments, rotor assembly 382 can rotate at a rate between 10-30 Hz. In some embodiments, the rotor assembly 382 can be a passive device that includes a series of permanent magnets that are attached to a circuit board of the upper circuit board assembly. These permanent magnets are either attracted to or repelled by an electromagnetic force, for example, a magnetic force, generated by the coils of the stator assembly to drive a rotation of the

upper circuit board assembly 380 relative to the lower circuit board assembly 360. The rotational orientation of the upper circuit board assembly 380 can be tracked by a rotary encoder receiver 394, which can track the angular position of the upper circuit board assembly by detecting the passage of one or more features on the rotary encoder 374. A variety of different rotary encoder technologies can be employed. In some embodiments, rotary encoder 374 is integrated directly onto a surface of a circuit board of the lower circuit board assembly 360.

[0093] Rotary actuator 310 can also include a wireless power system that includes a wireless power transmitter 372 and a wireless power receiver 392 in a configuration referred to herein as a rotary transformer. Power transmitted from transmitter 372 to wireless power receiver 392 can be consumed by light ranging device 320 and/or any circuitry needing power on the turret/upper circuit board assembly. In some embodiments, all power required by light ranging device 320 is provided through wireless power receiver 392 and thus there is no need for a rotary electric coupler like a slip ring or mercury based device thereby increasing reliability and decreasing cost of the overall system.

[0094] Rotary actuator 310 can also include an optical communication subsystem that includes a number of optical transmitters (e.g., optical transmitters 378 and 396) and a number of optical receivers (e.g., optical receivers 376 and 398) used for bi-directional contactless data transmission between rotary actuator 315 and light ranging device 320 (or to/from any other device or system that is mechanically connected to upper circuit board assembly 380 of the rotary actuator 315). More specifically, the optical communication subsystem can include a set of base optical communication components that are attached to (e.g., soldered to) lower circuit board assembly 360 that is part of the stationary base of LIDAR system 300, and can include a set of turret optical communication components that are attached to (e.g., soldered to) rotating upper circuit board assembly 380 that is part of the rotating turret of LIDAR system 300. These optical communication components provide an uplink data channel for providing optical signals, including control signals, to light ranging device 320 and also provide a downlink data channel for providing optical signals, including ranging and operational data, from light ranging device 320 to base controller 366, user interface hardware and software 305, and/or the vehicle control unit 310.

[0095] A downlink optical communication channel from the upper circuit board assembly 360 to the lower circuit board assembly 380 can be created between the optical downlink transmitter 396 and the optical downlink receiver 376. Light ranging device 320 can be connected directly to upper circuit board assembly 380 and therefore can access the downlink optical communication channel to pass ranging and operational data down to lower circuit board assembly 360 for further use. In some embodiments, the data passed down in the optical signals via the optical downlink can include range data for individual points (pixels) in the field (or possibly multiple ranges for a single pixel and angle, e.g. during fog/rain, when looking through glass windows, etc.), azimuth and zenith angle data, signal to noise ratio (SNR) of the return or signal intensity, target reflectivity, ambient near IR (NIR) levels coming from each pixel field of view, diagnostic operational information from the light ranging device such as temperature, voltage levels, etc. In addition, data from any other system connected to upper circuit board 380 of the rotary actuator can be passed down through the optical downlink. For example, data from high speed RGB or thermal cameras, line scan cameras and the like.

[0096] An uplink optical communication channel from lower circuit board assembly 360 can be created between optical uplink transmitter 378 and optical uplink receiver 398. In some embodiments, control signals from the base controller 366 can be passed to light ranging device 320 via the optical uplink communication channel. For example, in some embodiments, base controller 366 can monitor various temperatures in the device (as received from the downlink channel) and can, in the case of an overheat condition, send an emergency shutdown signal to light ranging device 320 via the uplink channel. In some embodiments, the base controller can be a mobile computer, e.g., a programmable system-on-a-chip employing an ARM + FPGA architecture with associated memory and I/O capability (e.g., Ethernet and the like).

[0097] Ranging data can be generated by light ranging device 320 by transmitting one or more light pulses from light transmission module 340 to objects in a field of view surrounding the light ranging device. Reflected portions of the transmitted light are then detected by light sensing module 330 after some delay time. Based on the delay time, commonly referred to as the "time of flight", the distance to the reflecting surface can be determined. Other ranging methods can be employed as well, for example, continuous wave, Doppler, and the like.

[0098] Light transmission module 340 can include an emitter array 342 and a Transmit (Tx) optical system 344. Emitter array 342 can be a one-dimensional or two-dimensional array of transmitters, which when combined with transmit optical system 344 form an array of transmitter channels behind a bulk imaging optic. These transmitter channels can optionally include micro-optic structures for beam-shaping, beam-steering, brightness enhancement, or the like. Light transmission module 340 can further include an optional processor 346 and memory 348, although in some embodiments these computing resources can be incorporated into ranging system controller 350. In some embodiments, a pulse coding technique can be used, e.g., Barker codes and the like. In such cases, memory 348 can store pulse-codes that indicate when light should be transmitted. In one embodiment the pulse-codes are stored as a sequence of integers stored in memory.

[0099] Light sensing module 330 can include a sensor array 332 and a receiver (Rx) optical system 334. Sensor array 332 can be a one-dimensional or two-dimensional array of photosensors. In some embodiments, each photosensor can include a collection of binary photon detectors (e.g., SPADs or the like), while in other embodiments each photosensor can be a linear photodetector (e.g., an APD). Receiver optical system 334 and sensor array 332 taken together can form an array of micro-optic receiver channels behind a bulk imaging optic as described in more detail below. Each micro-optic receiver channel measures light that corresponds to an image pixel in a distinct field of view of the surrounding volume. Each photosensor (e.g., a collection of SPADs) of sensor array 332 can correspond to a particular emitter of emitter array 342 as a result of a geometrical configuration of light sensing module 330 and light transmission module 340. In an alternative embodiment, each sensor of sensor array 332 can correspond to multiple emitters (e.g., a cluster of VCSELs) of emitter array 342. In yet another embodiment, a single large emitter (e.g., a laser diode bar) could in emitter array 342 could correspond to multiple sensors within sensor array 336.

[0100] In some embodiments, sensor array 332 of light sensing module 330 can be fabricated as part of a monolithic device on a single substrate using, for example, CMOS technology, that includes both an array of photosensors, a processor 336 and a memory 338 for signal processing the raw signals from the individual photosensors (or groups of photosensors) in the array. The monolithic structure including sensor array 332, processor 336, and memory 338 can be

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fabricated as a dedicated ASIC. In some embodiments, micro-optical components that are part of receiver optical system 334 can also be a part of the monolithic structure in which sensor array 332, processor 334, and memory 338 are a part. In such instances, the micro-optical components can be formed on the ASIC so that they become part of the monolithic structure with separate substrate layers for each layer of the receiver channel. For example, an aperture layer, a collimating lens layer, an optical filter layer and a photodetector layer can be stacked and bonded to multiple ASICs at the wafer level before dicing. The aperture layer can be formed by laying a non-transparent substrate on top of a transparent substrate or by coating a transparent substrate with an opaque film. In such an embodiment, the dicing step forms multiple ASICs, each with its own micro-optic structure bonded directly thereto. As another example, the micro-optical components can be formed as a separate monolithic structure that can be bonded directly to an ASIC after the ASIC is separated from a larger wafer via a dicing process. In this manner, the ASIC and micro-optic structure can be bonded together to form a single monolithic structure. Yet other embodiments one or more components of the Rx module 330 may be external to the monolithic structure. For example, the aperture layer may be implemented as a separate metal sheet with pin-holes.

[0101] As mentioned above, processor 336 and memory 338 (e.g., SRAM) can perform the signal processing. As an example of signal processing, for each photosensor or grouping of photosensors, memory 338 of light sensing module 330 can accumulate counts of detected photons over successive time bins and these time bins taken together can be used to recreate a time series of the reflected light pulse (*i.e.*, a count of photons vs. time). This time-series of aggregated photon counts is referred to herein as an intensity histogram (or just histogram). In addition, processor 336 can accomplish certain signal processing techniques, such as matched filtering, to help recover a photon time series that is less susceptible to pulse shape distortion that can occur due to SPAD saturation and quenching. In some embodiments, one or more components of ranging system controller 350 can also be integrated into the same ASIC as sensor array 332, processor 336 and memory 338, thereby eliminating the need for separate a ranging controller module.

[0102] In some embodiments, the output from processor 336 is sent to ranging system controller 350 for further processing. For example, the data can be encoded by one or more

encoders of ranging system controller 350 and then sent as data packets via the optical downlink to lower circuit board assembly 360. Ranging system controller 350 can be realized in multiple ways including, e.g., by using a programmable logic device such an FPGA, as an ASIC or part of an ASIC, using a processor 352 with a memory 354, and some combination of the above. Ranging system controller 350 can cooperate with base controller 366 or operate independently of the base controller (via pre-programed instructions) to control light sensing module 330 by sending commands that include start and stop light detection and adjust photo-detector parameters. Similarly, ranging system controller 350 can control the light transmission module 340 by sending commands, or relaying commands from the base controller 366, that include start and stop light emission controls and controls that can adjust other light-emitter parameters such as, emitter temperature control (for wavelength tuning), emitter drive power and/or voltage.

[0103] If emitter array 342 has multiple independent drive circuits, then there can be multiple on/off signals that can be properly sequenced by ranging system controller 350. Likewise, if the emitter array includes multiple temperature control circuits to tune different emitters in the array differently, the transmitter parameters can include multiple temperature control signals. In some embodiments, ranging system controller 350 has one or more wired interfaces or connectors (e.g., traces on a circuit board) for exchanging data with light sensing module 330 and with light transmission module 340. In other embodiments, ranging system controller 320 communicates with the light sensing module 330 and light transmission module 340 over a wireless interconnect such as an optical communication link.

III. Light Transmission and Detection

[0104] FIGS. 4A and 4B depict an illustrative example of the light transmission and detection process for a light ranging system according to some embodiments, with a focus on the emitter array and sensor array that form an arrangement of emitter-sensor channels, as introduced above in reference to FIG. 2. FIG. 4A depicts a light ranging system 400 (e.g., solid state or and/or scanning) collecting three-dimensional distance data of a volume or scene 450 external to light ranging system 400. FIG. 4B is an enlarged view of light ranging system 400 from FIG. 4A. Light ranging system 400 can be representative of any of light ranging systems 200, 220 or 300 discussed above, as well as the various light ranging devices discussed below. FIGS. 4A and 4B

are highly simplified drawings to highlight relationships between emitters and sensors, and thus other components are not shown.

[0105] As shown in FIGS. 4A and 4B, light ranging system 400 includes a light emitter array 410 and a light sensor array 420. Light emitter array 410 includes an array of light emitters (e.g., an array of VCELs or the like) that includes individual emitters, such as emitter 410(1) and emitter 410(9). Light sensor array 420 includes an array of photosensors that includes individual photo sensors, such as sensors 420(1) and 420(9). The photosensors can be pixelated light sensors that employ, for each pixel, a set of discrete photodetectors such as single photon avalanche diodes (SPADs) or the like. However, various embodiments can deploy other types of photosensors. In some embodiments, light ranging system 400 includes one or more sets of bulk optical elements (not shown), referred to herein as bulk optics, placed in front of light emitter array 410 and/or the light sensor array 420 for redirecting the beams in the directions shown.

[0106] Each emitter can be slightly offset from its neighbor and can be configured to transmit light pulses into a different field of view from its neighboring emitters, thereby illuminating a respective field of view associated with only that emitter. For example, emitter 410(1) emits an illuminating beam 415(1) (formed from one or more light pulses) into the circular field of view 452 (the size of which is exaggerated for the sake of clarity). Likewise, emitter 410(9) emits an illuminating beam 415(9) (also called an emitter channel) into the circular field of view 454. While not shown in FIGS. 4A and 4B to avoid complication, each emitter emits a corresponding illuminating beam into its corresponding field of view resulting in a 2D array of fields of view being illuminated (twenty one distinct fields of view in this example corresponding to the twenty one emitters, arranged in a 3 x 7 array, of light emitter array 410).

[0107] Each field of view that is illuminated by an emitter can be thought of as a pixel or spot in the corresponding 3D image that is produced from the ranging data. Each emitter channel can be distinct to each emitter and can be non-overlapping with other emitter channels, *i.e.*, there is a one-to-one mapping between the set of emitters and the set of non-overlapping fields of view. Thus, in the example of FIGS. 4A and 4B, the system can sample twenty one distinct points in the 3D space. A denser sampling of points can be achieved by having a denser array of emitters

or by scanning the angular positions of the emitter beams over time such that one emitter can sample several points in space.

[0108] Each sensor can be slightly offset from its neighbor and, like the emitters described above, each sensor can see a different field of view of the scene in front of the sensor. Furthermore, each sensor's field of view substantially coincides with, e.g., overlaps with and is the same size as a respective emitter channel's field of view. Similar to the emitters described above, the fields of view of the sensors can be scanned by rotation of the assembly. Scanning could also be accomplished using galvanometers, MEMS mirrors, or via some other method.

[0109] In FIGS. 4A and 4B, the distance between corresponding emitter-sensor channels is exaggerated relative to the distance to objects in the field of view. In practice, the distance to the objects in the field of view is much greater than the distance between corresponding emitter-sensor channels and thus the path of light from the emitter to the object is approximately parallel to the path of the reflected light back from the object to the sensor (i.e., it is almost "back reflected"). Accordingly, there is a range of distances in front of the system 400 over which the fields of view of individual sensors and emitters are overlapped and it is over this range of distances that the system can most accurately determine depth information.

[0110] Because the fields of view of the emitters are overlapped with the fields of view of their respective sensors, each sensor channel ideally can detect the reflected illumination beam that originates from its respective emitter channel with ideally no cross-talk, i.e., no reflected light from other illuminating beams is detected. For example, emitter 410(1) emits an illuminating beam 415(1) into the circular field of view 452 and some of the illuminating beam reflects from the object 460 as reflected beam 425(1). Ideally, reflected beam 425(1) is detected by sensor 420(1) only. Thus, emitter 410(1) and sensor 420(1) share the same field of view (i.e., field of view 452) and form an emitter-sensor pair. Likewise, emitter 410(9) and sensor 420(9) form an emitter-sensor pair, sharing field of view 454. In some embodiments emitter array 410 and sensor array 420 are designed and configured (in conjunction with the bulk optics) such that the fields of view of each emitter-sensor pair are non-overlapping (beyond a threshold distance) with the fields of view of other emitter-sensor pairs.

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[0111] While the emitter-sensor pairs are shown in FIGS. 4A and 4B as being in the same relative locations in their respective array, any emitter can be paired with any sensor depending on the design of the optics used in the system. In some embodiments, having identical bulk imaging optics in front of identically arranged emitter/sensor pairs can be advantageous from a design simplicity/cost perspective.

[0112] During a ranging measurement, the reflected light from the different fields of view distributed around the volume surrounding the LIDAR system is collected by the various sensors and processed, resulting in range information for any objects in each respective field of view. As described above, a time-of-flight technique can be used in which the light emitters emit precisely timed pulses, and the reflections of the pulses are detected by the respective sensors after some elapsed time. The elapsed time between emission and detection and the known speed of light is then used to compute the distance to the reflecting surface. In some embodiments, additional information can be obtained by the sensor to determine other properties of the reflecting surface in addition to the range. For example, the Doppler shift of a pulse can be measured by the sensor and used to compute the relative velocity between the sensor and the reflecting surface.

[0113] In some embodiments, the LIDAR system can be composed of a relatively large 2D array of emitter and sensor channels and operate as a solid state LIDAR, i.e., it can obtain frames of range data without the need to scan the orientation of the emitters and/or sensors. In other embodiments, the emitters and sensors can be scanned, e.g., rotated about an axis, to ensure that the fields of view of the sets of emitters and sensors sample a full 360 degree region (or some useful fraction of the 360 degree region) of the surrounding volume. The range data collected from the scanning system, e.g., over some predefined time period, can then be post-processed into one or more frames of data that can then be further processed into one or more depth images or 3D point clouds. The depth images and/or 3D point clouds can be further processed into map tiles for use in 3D mapping and navigation applications.

IV. LIDAR Unit with Integrated Architecture

[0114] FIGS. 5A-5B show a rotating LIDAR system 500 that employs a 360 scanning architecture, according to some embodiments of the disclosure. In some embodiments, LIDAR system 500 can spin in a clockwise or counter-clockwise direction to observe the surrounding

field around a vehicle. System 500 can include a stationary base housing 502, an optically transparent window 504, and a stationary lid 506 for providing protection for the internal components of LIDAR system 500. Window 504 can be made from a transparent material to allow for two-way transmission of near IR light . Stationary base housing 502, window 504 and lid 506 make up a water-resistant or waterproof system housing or enclosure 508 that fully encloses internal components of LIDAR system 500 to protect the components from the elements. Housing/enclosure 508 can be representative, for example, of housing 220 discussed above with respect to FIG. 2A. In some embodiments, the enclosure can have a generally cylindrical shape as shown in FIG. 5A.

[0115] In some embodiments, window 504 can extend fully around a periphery of enclosure 508 and be attached to base housing 502 and lid 506 in a fixed relationship. In such embodiments, a light ranging device 510 (shown in FIG. 5B), can rotate within enclosure 508 behind window 504. In other embodiments, window 504 can rotate with light ranging device 510. The configuration of base housing 502, window 504 and stationary lid 506 shown in FIG. 5A is just one example of an enclosure 508 according to embodiments of the disclosure. A person of skill in the art will recognize that other configurations of a suitable enclosure for LIDAR system 500 are possible. As one example of a different configuration, lid 506 can be part of window 504. As another example, in embodiments where window 504 rotates with light ranging device 510, window 504 can include two or more separate windows separated by an opaque region. For example, in some embodiments, LIDAR system 500 can include a first window aligned with an optical transmitter and a second window, spaced apart from the first window, aligned with an optical receiver. As used herein, "aligned" means that the optical transmitter or receiver transmits or receives light through the window.

[0116] The internal components (not shown in FIG. 5A) of system 500 can include a rotary actuator and light ranging device, such as actuator 310 and light ranging device 320 described with respect to FIG. 3. The light ranging device can be aligned with window 504 and can be spun by the rotary actuator to project pulsed beams of light through window 504 into a field surrounding LIDAR system 500 while the light ranging device is spinning continuously through 360 degrees in a clockwise or counter-clockwise direction. Light reflected from the field back

through window 504 can then be detected by the light ranging device to determine distance to objects in the field as described herein.

[0117] As described in more detail below, rotating LIDAR system 500 can employ a highly integrated architecture and enables a highly compact configuration for the internal mechanical elements and circuitry. Accordingly, the overall form factor of LIDAR systems according to some embodiments of the disclosure can be smaller than many existing systems, for example, with an overall volume that is similar to or smaller than that of a coffee mug 550 as can be seen in FIG. 5A.

[0118] FIG. 5B shows an embodiment of LIDAR system 500 with the outer enclosure/system housing 508 (including window 504 and lid 506) removed to highlight the integrated, stacked-board design according to some embodiments of the disclosure. As shown in FIG. 5B, rotating LIDAR system 500 includes a light ranging device 510 that includes an optical transmitter 512 and an optical receiver 514 mounted within a housing 515 that includes a first housing portion 516 for the optical transmitter and a second housing portion 518 for the optical receiver. Light ranging device 510 is mechanically connected in a fixed relationship to a printed circuit board 522 that forms the rotating end of stacked board rotary actuator 520. The fixed side of stacked board rotary actuator 520, including printed circuit board 524, is attached to base portion 502 of the enclosure.

[0119] As described in more detail below, embodiments of the LIDAR system possess a highly integrated design that makes them especially suitable for a highly compact rotating LIDAR system. The various functional elements of the LIDAR system (both mechanical and electronic) are integrated into a stacked circuit board assembly that includes the one or more circuit boards stacked in a parallel arrangement, as shown in FIG. 5B, *e.g.*, circuit boards 522, 524, 526 and 528. In some embodiments, the power system, electric motor, communication system, and LIDAR control system are all integrated into the one or more stacked planar circuit boards of the stacked board rotary actuator 520. Light ranging device 510 can be conveniently attached to the top board 522 by way of one or more multi-pin connectors or the like (not shown). As will be detailed below, the boards can include a central aperture through which a central shaft passes. The upper boards can be attached to the upper portion of the shaft via one or more bearings.

Each of the boards can be arranged with its planar surface perpendicular to the shaft and therefore the axis of rotation. As a result of this configuration, assembly and maintenance are much simpler relative to other systems that employ multiple boards in different orientations within the LIDAR system.

[0120] FIGS. 6A-6C show cross-sectional views of LIDAR systems 600, 650 and 660 in accordance with various embodiments of the disclosure. More specifically, the individual components shown in FIGS. 6A-6C correspond generally to those already described above in reference to FIG. 3, with the views shown FIGS. 6A-6C providing examples of the geometric placement of the various circuit elements according to different embodiments. FIGS. 6A and 6B each show embodiments that employ optical communication between the upper and lower circuit board assemblies while FIG. 6C shows an embodiment that employs inductive communication between the upper and lower circuit board assemblies. FIGS. 6D-6E provide views of surfaces of the individual circuit boards according to some embodiments to further illustrate the concentric circumferential arrangement of a number of individual circuit elements.

[0121] Referring now to FIG. 6A, LIDAR system 600, which can be representative of LIDAR system 500, can include a light ranging device 602 along with upper and lower circuit board assemblies 610 and 620, respectively, in which upper board assembly 610 rotates with respect to lower board assembly 620 around an axis 605 that is perpendicular to the board assemblies. Circuit board assemblies 610 and 620 are each structural components of LIDAR system 600 that holding all or essentially all of the components of the LIDAR system. The two piece design enables system 600 to have reduced size and increased reliability compared to many currently available LIDAR systems and enables system 600 to be manufactured at a reduced cost.

[0122] Light ranging device 602 can be mounted to one of the circuit boards in upper board assembly 610 enabling the light ranging device to rotate with upper board assembly 610 while lower board assembly 620 can be mounted to base 604 and or sidewall 606, each of which is a part of the stationary base of LIDAR system 600. Rotation of upper circuit board assembly 610 and light ranging device 602 is enabled by a bearing system 607 located on a hollow shaft 606 centered along the longitudinal axis or rotation 605.

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[0123] Each of the assemblies 610, 620 can include two or more stacked planar circuit boards arranged in a parallel relationship with each other. In the specific embodiment shown, upper assembly 610 includes a rotor communication board 612 and a rotor control board 614 while lower assembly 620 includes a stator communication board 622 and a stator control board 624. An electric motor can be integrated directly on the board assemblies, along with an encoder, a wireless power system and optical communication system as described in more detail below. Many or all of these same elements are also integrated on the board assemblies of LIDAR systems 650 and 660 shown in FIGS. 6B and 6C, respectively. Thus, to simplify the description of the FIGS. 6A-6C and avoid repetition, like reference numbers are used to indicate like elements and the description of such like elements is typically not repeated.

[0124] The highly integrated, stacked board design of LIDAR system 600 provides for a system that has a greatly simplified assembly process in comparison to systems that employ numerous stand-alone modules for each of the different functional elements of a LIDAR system. In alternative embodiments, LIDAR systems of the present disclosure can include upper and lower board assemblies that are each a single circuit board even further simplifying the stacked board design. For example, LIDAR system 650 shown in FIG. 6B includes a single lower circuit board 652 and a single upper circuit board 654.

[0125] While not shown explicitly in FIGS. 6A-6C, one or more supporting power circuits, drive/control circuits, and communication circuits can be paired with each of the systems discussed below and these supporting systems can also be integrated onto one or more circuit boards of the rotary actuator. For example, a motor driver for providing a three-phase drive current to the solenoids of the stator can be attached to a surface of a circuit board of the lower circuit board assembly 620. Power drive and conditioning circuits can be paired with the wireless power transmission components and mounted to the upper and/or lower board assemblies. Supporting circuitry for the digital communication system, such as buffers, LED/laser current drivers, encoders/decoders, clock recovery circuits, photodetector drive and conditioning circuits, etc., can also be mounted to one or more boards of the circuit board assemblies. Some of these elements will be discussed in further detail below but one or ordinary skill in the art will appreciate that any number of arrangements and configurations of standard circuit components can be employed without departing from the scope of the present disclosure.

In some embodiments, because of the nature of the rotationally symmetric optical uplink, wireless power rotary transformer, brushless dc motor, and rotary encoder, any concentric ordering of these subsystems about the shaft can be employed.

V. Optical Links

1. Integrated Central Optical Downlink

[0126] In some embodiments, hollow shaft 606 can serve not only as a central structural member that supports each of the board assemblies, but also serves as a housing for a downlink optical communications channel ("the downlink channel") for providing data, e.g., ranging and/or operational data, from the turret assembly to the control and processing circuitry located in the lower circuit board assembly 620 (also referred to as the base system). The optical downlink channel can include an optical downlink transmitter 626 and an optical downlink receiver 628 each of which can be centered along rotational axis 605. Optical downlink transmitter 626 can be attached (e.g., soldered) directly to a surface of a circuit board of upper circuit board assembly 610 and can be positioned such that it can transmit optical signals through a central hole or opening in the hollow shaft 606. Likewise, the optical downlink receiver 628 can be attached (e.g., soldered) directly to a surface of a circuit board of the lower circuit board assembly 620. The optical downlink receiver 628 can be positioned on the lower end of the shaft and aligned with the optical downlink transmitter 626 such that it is able to receive optical signals transmitted from the optical downlink transmitter 626.

[0127] The optical transmitters and receivers used for the optical downlink of the rotary actuator can be any suitable optical emitter or detector. For example IR LEDs, laser diodes, VCSELs, and the like can be used for the optical emitters. Likewise any suitable light detection technology can be used for the receivers, such as, photodiodes or the like.

2. Integrated Optical Uplink

[0128] An optical uplink channel can be formed between a circumferential arrangement of multiple optical uplink transmitters 642 and a complementary circumferential arrangement of multiple optical uplink receivers 632. As with the optical downlink transmitter/receiver pair, the individual optical uplink transmitters and optical uplink receivers can be directly attached (e.g.,

soldered) to respective circuit boards of the lower and upper circuit board assemblies, respectively. Optical communication components that are disposed on the lower circuit board assembly are also referred to herein as "base optical communication components". Optical communication components that are disposed on the upper circuit board assembly, or turret, are also referred to herein as "turret optical communication components." Advantageously, the wall of the hollow shaft 606 provides for optical isolation between the uplink and downlink channels and therefore minimizes crosstalk.

[0129] The individual emitter and receivers of the circumferential arrangements can be coupled together to act together as a single composite receiver and a single composite transmitter. For example, as the system rotates, the overall optical intensity of the uplink signal detected by the full arrangement of optical uplink receivers varies only slightly as the individual emitters/detectors pass each other. Furthermore, the number of individual transmitters in the composite transmitter can be the same as or different from the number of individual receivers in the composite receiver.

[0130] The optical transmitters and receivers used for the optical uplink of the rotary actuator can be any suitable type of optical emitter or detector. For example, a ring of IR LEDs, laser diodes, VCSELs, or the like can be used as the composite optical transmitter. Likewise any suitable type of light detection technology can be used for the receivers, e.g., a ring of photodiodes or the like can be used as the composite optical receiver. In addition, the optical transmitters and receivers used for the optical uplink can be the same or different type (e.g., power and wavelength) as those used for the downlink.

[0131] An example of a circumferential arrangement of optical uplink transmitters 642 is shown in FIG. 6D, which illustrates a top view of a stationary circuit board (e.g., circuit board 622 of FIG. 6A). In this example, there are six (6) optical uplink transmitters 642 that are circumferentially arranged around the central hole 672. The six (6) transmitters are evenly spaced around the circle 674 whose center is located at the center of the shaft (and thus the center of hole 672) and therefore overlapped with the axis of rotation.

[0132] The opposing surface of the rotating circuit board (e.g., circuit board 612 of FIG. 6A or circuit board 654 of FIG. 6B) includes a corresponding circumferential arrangement of optical

uplink receivers 632, as shown in FIG. 6E, which illustrates a bottom view of a rotating circuit board according to some embodiments. In this example, there are seven (7) optical uplink receivers that are circumferentially arranged around the central hole 672. The seven (7) receivers are evenly spaced around the circle 684 whose center is located at center of the shaft and therefore overlapped with the axis of rotation. Accordingly, as the board rotates, the arrangement of optical uplink receivers 632 rotates about the axis of rotation. Because the radius of circle 684 is same as the radius of circle 674, the transmitters are aligned with the receivers and the rotation merely results in a slight rise and fall of the average signal over time with a frequency being a multiple of the rotation frequency of the turret system. The number of transmitters needed for a reliable uplink channel depends on both the nominal power of the transmitters as well as the divergence of the light cone that is emitted from each transmitter. Ideally, the spot size of the transmitter light at the front surface of the rotating board is large enough that the individual spots overlap to such an extent that as the rotating board rotates, the overall variation in the average intensity seen by the collection of receivers is below a specified value.

[0133] While FIGS. 6D and 6E depict an embodiment in which an optical downlink channel is formed within hollow shaft 606 and an optical uplink channel is formed between a circumferential arrangement of multiple optical uplink transmitters and a complementary circumferential arrangement of multiple optical uplink receivers disposed outside the shaft, in other embodiments other arrangements of optical channels are possible. For example, in some embodiments an uplink channel can be formed within hollow shaft 606 and a downlink channel can be formed outside the shaft. In still other arrangements both a downlink and an uplink channel can be formed inside shaft 606 (e.g., using separate light guides) or both a downlink channel and an uplink channel can be formed outside the shaft in separate circumferential arrangements of optical components.

VI. Inductive Communication Links

[0134] Referring back to FIG. 6C, FIG. 6C shows an embodiment that employs an inductive communications system 666, 668 between the upper and lower circuit board assemblies. In this example, data uplink and downlink are provided by pairs of coils 666a-e and 668a-e respectively

mounted on the lower circuit board assembly and upper circuit board assembly, as shown. The coils can include both data lines and clock lines. Each coil can be embedded within a separate channel, e.g., a circular channel, of a housing, such as upper coil housing 666 and lower coil housing 668 that are themselves mounted to the surfaces of their respective circuit boards. In some embodiments, there can be several coils that are used for multiple inductive data lines, e.g., downlink channel 1 transmitter coil 666b and downlink channel 1 receiver coil 668b, downlink channel 2 transmitter coil 666c and downlink channel 2 receiver coil 668c. In some embodiments, the downlink clock signal can be transmitted via a separate coil pair, e.g., downlink clock transmit coil 666a and downlink clock receiver coil 668a. Likewise, data uplink channels can be formed from one or more pairs of coils, e.g., by uplink transmitter coil 668d and uplink receiver could 666d. Like the downlink, the data uplink clock signal can also have a dedicated channel formed from a pair of coils, e.g., uplink clock transmitter coil 668e and uplink clock receiver coil 666e.

[0135] In some embodiments, the use of an inductive communications links can provide a number of advantages over an optical configuration, including: (1) replacement of the hollow shaft 606 with a solid shaft 665 which is simpler and easier to construct; (2) in some situations, an inductive coil arrangement can require less stringent tolerances on mechanical alignment and thus have lower cost of manufacture; (3) an easier arrangement for passing multiple channels of information between the boards; (4) can enable passing a clock along with data, which removes the need for clock and data recovery (CDR) chips; (5) can allow for scaling bandwidth by providing a multichannel (parallel) data transmission lines arrangement; and (6) by distributing a separate clock signal between the boards, deterministic timing behavior can be achieved between the lower board assembly (stator) and upper board assembly/light ranging unit (rotor).

[0136] While FIG. 6C shows an embodiment with five coil pairs, any number of coil pairs can be implemented without departing from the scope of the present disclosure. For example, a two coil pair configuration having only one data uplink channel and one downlink channel can be implemented. In this case, the clock signal can be provided via the uplink channel and the downlink clock can be derived from this uplink clock signal. In other embodiments, three coil pairs can be employed, one for uplink data, one for downlink data and one for the uplink clock signal, again, with the downlink clock signal being derived from the uplink clock signal. Four

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coil pair configurations are also possible that provide for both uplink and downlink clock signal channels. In addition to all the above, any number of data cannels can be employed without departing from the scope of the present disclosure.

VII. Integrated Electric Motor

[0137] According to certain embodiments, an electric rotary motor can be integrated directly onto the circuit boards. The motor can have a "pancake" or "axial" design having a planar rotor assembly on a rotor board that opposes a planar stator assembly on an opposing stator board. The stator and rotor assemblies of the electric motor can be integrated onto the boards of the rotary actuator 608, i.e., the elements of the electric motor are one of many components on the surface of the printed circuit boards and thus a separate motor module is not required for LIDAR system 600. For example, referring back to FIG. 6D, stator assembly 644 can include an annular arrangement of multiple stator elements 644(i), e.g., vertically oriented solenoids (having their longitudinal axes perpendicular to the surface of the board) that are affixed (e.g., using an adhesive) to a board of the lower circuit board assembly 620 (e.g., board 622) or to a soft magnetic core that is then affixed to the lower circuit board assembly 620. Examples of the stator elements are shown in the top view of FIG. 6D. Each stator element 644(i) can include a solenoid coil 644a wound around a core 644b of magnetic material, e.g., ferrite or the like. The coils are oriented such that the magnetic field exiting the solenoid is substantially oriented in a direction that is substantially perpendicular to the plane of the circuit board. In the embodiment shown in FIG. 6D, stator assembly 644 includes eighteen (18) individual stator elements 644(i) evenly spaced apart from each other, but embodiments of the disclosure are not limited to a stator assembly with any particular number of stator elements and other embodiments can include fewer or more individual stator elements 644(i). For example, in some embodiments stator assembly 644 includes at least 12 individual stator elements 644(i) in an annular arrangement. Also, in some embodiments, the number of individual stator elements 644(i) in stator assembly 644 is a multiple of three and a motor driver circuit and controller (not shown in FIG. 6D) provide a three-phase alternating signal to stator assembly 644 to control the rotation rate of board 622 and thus the rotation rate of light ranging device 602.

[0138] Positioned directly opposite the motor stator assembly 644 and attached to a board of the upper circuit board assembly 610 is the motor rotor assembly 634. In some embodiments, motor rotor assembly 634 can be a passive element that includes an annular arrangement of permanent magnets 634(i), with their poles arranged in an alternating pattern to sequentially oppose and attract the opening of the various solenoid coils of the stator assembly, as shown in more detail in board view shown in FIG. 6E. Thus, as shown in FIG. 6E, each individual magnet 634a can have its poles arranged opposite to its adjacent magnets 634b, and each individual magnet 634b can have its poles arranged opposite to its adjacent magnets 634a. Additionally, while the embodiment of the stator assembly 644 shown in FIG. 6E includes twenty four (24) individual magnets 634(i) evenly spaced apart from each other, embodiments of the disclosure are not limited to a rotor assembly with any particular number of elements and other embodiments can include fewer or more individual magnets 634(i). Further, as can be seen in FIG. 6D and 6E, the motor stator assembly 644 and the motor rotor assembly 634 can have an overall circular ring shape with both stator and rotor circles having the same radius and center positions (e.g., both rings can be centered on the shaft).

[0139] While the embodiments shown in FIGS. 6D and 6E employ rotor elements that are permanent magnets and stator elements that are solenoid coils, the opposite configuration can also be employed without departing from the scope of the present disclosure. For example, solenoids can be employed as the rotor elements and permanent magnets can be employed as the stator elements, in which case, power to the stator elements can be provided by the wireless power transmission system described below. In addition, rather than employing permanent magnets as rotor/stator elements, electromagnets can be employed in certain embodiments. One of ordinary skill having the benefit of this disclosure will appreciate that any implementation of a PCB mounted brushless DC motor can be employed, for example, any non-contact configuration of solenoid coils and permanent magnet elements can be employed and any drive scheme that implements rotary motion of the underlying hardware can be employed without departing from the scope of the present disclosure.

VIII. Integrated Wireless Power Transmission System

[0140] To provide power to the circuit elements connected to the rotating upper circuit board assembly 610, the rotary actuator 608 includes a wireless power system, also referred to herein as a rotary transformer. The wireless power system includes a wireless power transmission subsystem including a wireless power transmitter 648 and a wireless power receiving subsystem including a wireless power receiver 638. The wireless power transmitter 648 can be a transmitter coil in the form of a circular loop antenna (e.g., a single turn or multi-turn coil) that is attached to a surface of a circuit board of the lower circuit board assembly 620 (e.g., board 622) as shown, for example, in FIG. 6D. Likewise, the wireless power receiver 638 can be a receiver coil in the form of a circular loop antenna (e.g., a single turn or multi-turn coil) that is attached to a surface of a circuit board of the upper circuit board assembly 610 (e.g., board 612) as shown in FIG. 6E. The centers of both the wireless power transmitter 648 and the wireless power receiver 638 are positioned at the center of the hollow shaft 606 and are therefore concentric with, the optical encoder ring, the electric motor assemblies, and the optical uplink receiver/transmitters. Advantageously, the wireless power transmitter and receiver can be positioned at the outermost region of the boards 622 and 612 to maximize the area (and therefore inductance) of the circular loops which maximizes power transfer efficiency and advantageously blocks light from the environment or the internals of the LIDAR system from reaching the optical encoder, uplink or downlink.

[0141] In some embodiments, the wireless power transmitter 648 and a wireless power receiver 638 can be placed within an annular region of their respective boards with the walls and bottom of the annular regions formed from a magnetic material, e.g., ferrite or the like. For example, FIG. 6E shows wireless power receiver 638 disposed within an annular region formed from ferrite walls 686 and 688 (not shown in FIGS. 6A-6C) and an occluded ferrite bottom. Such an arrangement of ferrite materials is depicted in FIG. 6F, which is a simplified cross-sectional view of a portion of a multi-coil wireless power receiver 638 positioned within an annular channel defined by ferrite walls 686, 688 and a bottom ferrite wall 690. The arrangement shown in FIG. 6F helps channel the magnetic fields between the transmitter and receiver to improve power transfer efficiency and reduce electromagnetic radiation leaking from the system.

IX. Integrated Optical Encoder

[0142] The rotary actuator 608 further includes an integrated optical encoder assembly that allows for readout of the angular position of the upper circuit board assembly 610 relative to the lower circuit board assembly 620. The optical encoder assembly includes a patterned annular optical encoder 646 and rotary encoder detector 636 for reading off the angular position of the assembly by, for example, detecting and counting the number of patterns that pass the rotary encoder detector 636 as the system rotates. In certain embodiments, rotary encoder detector 636 can include an illumination device, such as an LED and a detector, such as a photodiode or imaging detector for illuminating and detecting the patterned surface of the annular optical encoder. In some embodiments, the annular optical encoder can include a start code that occurs at a unique position on the annulus or provides absolute encoding patterns thereby enabling an absolute angular orientation measurement. In some embodiments, the encoder system is magnetic instead of optical in nature and relies on a similarly positioned magnetic encoder strip and magnetic encoder reader.

[0143] In some embodiments, the annular optical encoder 646 can be attached to a surface of a circuit board of the lower circuit board assembly 620 (e.g., board 622) and the rotary encoder detector 636 can be attached to a surface of the upper circuit board assembly 610 (e.g., board 612) as shown here, or vice versa. Regardless of which board it is placed on, the annular optical encoder 646 can be arranged to have its center at the center of the hollow shaft 606 and is therefore concentric with both the electric motor assemblies and the optical uplink receiver/transmitters as shown, for example, in FIG. 6D. In some embodiments, the rotary encoder detector 636 is positioned on the rotating circuit board, anywhere above the annular optical encoder 646, e.g., as shown in FIG. 6E.

[0144] Advantageously, the encoder assembly can be positioned between the wireless power transmission system and the electric motor assembly to maximize the optical isolation between the encoder detector and the transmitters of the optical uplink system. As shown in the example of FIG. 6A, in some embodiments the annular optical encoder 646 can be on the stator side of the rotary actuator 606 while the rotary encoder detector 636 on the rotor side. While this is a non-standard configuration for rotary actuators, this configuration is advantageous for a LIDAR

application. For example, by removing the rotary connection between the rotary encoder detector 636 and the light ranging device 602 in this manner, the implementation of a low latency connection between the two systems can be implemented. In LIDAR applications a low latency connection can be important for quickly ingesting the angular position measurements of the rotary encoder detector 636 and correlating the current ranging information with the current angular position of the rotor for increased spatial accuracy.

X. Method of assembly

[0145] FIGS. 7-8 show exploded views of a LIDAR system to illustrate the assembly process according to certain embodiments. FIG. 7 illustrates the mechanical assembly of the lower circuit board assembly (also referred to herein as the base assembly). FIG. 8 illustrates the mechanical assembly of the upper circuit board assembly and its attachments to both the lower circuit board assembly and the light ranging device, thereby forming the full LIDAR system.

1. Assembling the Lower Circuit Board Assembly

[0146] FIG. 7 shows an exploded view of a lower circuit board assembly 700 to illustrate an assembly process of the compact LIDAR system according to certain embodiments. In the embodiment shown in FIG. 7, lower circuit board assembly 700 is of a two-board configuration, similar to that described above in reference to FIG. 6A. Specifically, lower circuit board assembly 700 includes first and second sub-boards, referred to herein as the base control board 720 and the stator board 730. In some embodiments, base control board 720 and stator board 730 correspond to boards 643 and board 641, respectively, as shown in FIG. 6A.

[0147] The assembly of lower circuit board assembly 700 can begin with base control board 720 being mechanically attached to a base housing unit 710 by way of screws 728. As already described above in reference to FIGS. 3 and 6A, the base control board can include a number of circuit elements, including a base controller, similar to base controller 366. Supporting circuitry, e.g., drivers for, the elements of the optical communications systems, wireless power transmission system, and the rotary encoder system can also be included on the base control board. To enable the optical downlink communications channel, an optical downlink receiver 722 can be mounted to (e.g., soldered to) an upper surface of base control board 720 in a central region of the board as described above in reference to FIG. 6A.

[0148] In some embodiments (e.g., as described above in reference to FIG. 6B), optical downlink receiver 722 and the other supporting circuit elements are integrated directly onto stator board 730 thereby eliminating the need for a separate base control board 720. In such a case, assembly of lower circuit board assembly 700 can begin by attaching a heat spreading element 725 directly to the base 710 or in cases that do not employ the base or heat spreading element 725, the assembly can begin by installing stator board 730.

[0149] After base control board 720 is attached to base 710, shaft 715 can be attached to base control board 720, using screws 706. In some embodiments, shaft 715 can be attached directly to base 710 for improved thermal conduction of heat from the upper circuit board assembly to the base 710 via the bearing system (shown in more detail in FIGS. 8A and 8B below). As described above in reference to FIGS. 6A-6B, shaft 715 can include a central hole 716 through its length that provides an open optical path for an optical downlink channel. As such, shaft 715 can be placed directly on top of optical downlink receiver 722 located generally near the center of base 710. In some embodiments, regardless of the shape of the outer circumference of base control board 712 or base 710, shaft 715 defines the axis of rotation 705 of the system. Thus, the position of shaft 715 need not be directly in the center of base control board 720 or in the center of base 710.

[0150] After shaft 715 is attached to base control board 710, heat spreading element 725 can be attached to base control board 720 by one or more screws 716. In some embodiments, heat spreading element 725 can be made from a material having a high thermal conductivity (e.g., aluminum and the like). In addition, there may be one or more intervening thermal foam pads between heat spreading element 725 and the boards to prevent electrical shorts while providing a conductive heat path. In some embodiments, heat spreading element 725 makes thermal contact with one or more portions of the lower surface of stator board 730 and one or more portions of the upper surface of base control board 720 thereby providing a thermal path for concentrated heat from the circuit elements of these boards to more evenly distribute amongst the boards. On its periphery, heat spreading element 725 may also make thermal contact with the sides of base 710 and thus provide an improved thermal path for heat to be conducted from the boards to base 710 and eventually out of the system.

[0151] After securing heat spreading element 725, stator board 730 can be attached by way of screws 736. In some embodiments, stator board 730 can be electrically connected to base control board 720 by way of one or more multi-pin electrical connectors (e.g., lower connectors 724 and 726). In some embodiments, the physical connection between the boards is made by applying a mechanical connection pressure between stator board 730 and base control board 720 (e.g., by pressing the stator board onto the base control board after it has been attached to base 710). The connection pressure can be maintained over the life of the system by screws 736 used to secure stator board 730 to base control board 720.

[0152] Once assembled and secured to the base 710, one or more optional color cameras 732 can be positioned around the periphery of stator board 730 to have a clear visual path out of base 710 through one or more imaging apertures 712, which in some embodiments can be clear apertures or can contain one or more optical elements to assist with imaging. In other embodiments, the color cameras 732 can be mounted directly to base 710 rather than be mounted to stator board 730. Color cameras 732 enable LIDAR data that is accumulated by the LIDAR system to be supplemented by color imaging data such as still frames and/or video as described in U.S. Application No. 15/980,509 entitled "Augmenting Panoramic LIDAR Results with Color," which is incorporated herein by reference in its entirety for all purposes.

2. Assembling the Upper Circuit Board Assembly and Attaching to the Lower Circuit Board Assembly

[0153] FIG. 8A is an exploded view of a compact LIDAR system 800 to illustrate an assembly process of a LIDAR system according to some embodiments of the disclosure. LIDAR system 800 can be, for example, LIDAR system 500 shown in FIG. 5A. LIDAR system 800 includes lower circuit board assembly 700, described above with respect to FIG. 7, an upper circuit board assembly 810, a light ranging device 820, and an enclosure 830. As shown in FIG. 8A, LIDAR system 800 includes an upper circuit board assembly 8 that.

[0154] As shown in FIG. 8A, upper circuit board assembly 810 is of a two-board configuration, similar to that described above in reference to FIG. 6A and includes a ranging device control board 840 and the rotor board 850. In some embodiments, ranging device control

board 850 and rotor board 730 correspond to stator control board624 and rotor control board 614, respectively described above in reference to FIG. 6A.

[0155] Rotor board 850 includes a bearing assembly 860, shown in FIG. 8B, which is an exploded view of rotor board 850. Bearing assembly 860 includes bearings 862 and 864, which are inserted into either end of a t-shaped bearing housing 865. T-shaped bearing housing 865 can then attached to rotor board 850 with screws 866.

[0156] Rotor board 850 can be placed on top of assembled lower circuit board assembly 700 by fitting the central portion of T-shaped bearing housing 865 over shaft 715. A circular nut 852 can then be fitted into a circular central recess 854 in the top surface of the t-shaped bearing housing 86 and threaded onto the top of shaft 715 to securely attach rotor board 850 to lower circuit board assembly 700. As discussed above, rotor board 850 is able to rotate relative to lower circuit board assembly 700 due to the rotational coupling made between shaft 715 and bearings 862 and 864.

[0157] Ranging device control board 840 can then be joined to rotor board 850 by applying a downward pressure to the ranging device control board 840. To provide an electrical connection between ranging device control board 840 and rotor board 850, one or more electrical connectors can be attached to (e.g., soldered to) the lower surface of ranging device control board 840 (not visible in FIG. 8A) and the upper surface of rotor board 850 (e.g., connector 856). Ranging device control board 840 can then be secured to rotor board 850 using screws 846.

3. Attaching the Laser Ranging Device to the Rotary Actuator

[0158] Once the upper circuit board assembly has been assembled and secured to the lower circuit board assembly, light ranging device 820 can be electrically connected to the upper surface of ranging device control board 840, which mechanically connects the light ranging device to T-shape bearing housing 865. Light ranging device 820 includes a Tx module 822 and a Rx module 824 each of which can have dedicated electrical connectors that mate with corresponding connectors 844 and 846 disposed on the upper surface of light ranging device control board 840. As with the other boards in the system, connecting the light ranging device 820 to the rest of the assembled system can be achieved by applying a pressing force to the components. Once the connections are made, the pressing force can be maintained by screws

826 mounted on either side of light ranging device 820 as shown. In addition, a u-shaped bracket 828 can secured to light ranging device 820 with additional screws 826 to provide further structure to the assembly.

[0159] Once all the internal components are assembled, enclosure 830 can be dropped over the entire assembly and affixed to base 700, e.g., using one or more screws as well as adhesive, if required to achieve a more robust seal. Enclosure 830 can include an optically transparent window as described above with respect to FIG. 5 that enables laser pulses from Tx module 822 to be projected from the LIDAR system into the surrounding environment and enables reflected and scattered light from the pulses to be received by the LIDAR system via Rx module 824.

[0160] In the assembly process described above, various arrangements of screws and brackets are disclosed merely for the sake of example. Embodiments of the compact LIDAR system are not required to employ screw arrangements that are identical to that shown in FIGS. 7-8 and any number, arrangement, and type of fastener, including adhesive, deformable pins or latches, rivets, or welds, can be used without departing from the scope of the present disclosure.

XI. Optics and Optoelectronics

[0161] FIGS. 9A-9C show a perspective view, a front view, and a zoomed front view, respectively, of a light ranging device 900 according to certain embodiments. The light ranging device 900 can correspond to embodiments described above in reference to FIGS. 1-6, e.g., light ranging device 320 described above in reference to FIG. 3 or light ranging device 510 described with respect to FIG. 5. Light ranging device 900 includes two main modules: a light transmission (Tx) module 910 and a light sensing (Rx) module 920 spaced apart from each other within a common housing or mount 905 that includes two lens tubes, e.g., transmitter lens tube 912 and detector lens tube 922. The light Tx module and light Rx modules each include bulk optics modules (not shown) that are positioned in front of their respective sensors/emitters, e.g., by sliding the bulk optics module into the appropriate lens tube. The bulk optics modules are described in more detail below. On the transmission side, located behind the Tx-side bulk optics module is, optionally, a Tx-side micro-optics assembly. Details of the micro-optics assembly are set forth below in reference to FIGS. 10-11. Behind the optional transmit-side micro-optics assembly is an emitter array 914, e.g., a monolithic single-chip NIR VSCEL array fabricated on

InGaAs, or the like. On the detector side, located behind the Rx-side bulk optics module is a Rx-side micro-optics assembly, also described in more detail below in reference to FIGS. 10-11. Behind the Rx-side micro-optics assembly is a single chip detector array and ASIC combination 924, e.g., a monolithic single-chip NIR SPAD array fabricated on a CMOS process, or the like.

[0162] Both Rx module 920 and Tx module 910 are backed by circuit boards 926 and 916, respectively, that include additional supporting circuitry for the light ranging device, e.g., voltage regulators, VCSEL current drivers, and the like. For example, circuit board 926 can include circuitry for counting signals from SPADs to include in a histogram of time bins, which may be specified by a time-to-digital converter. Circuit board 926 can also include match filtering for analyzing the histogram to determine a received time. In some embodiments, a programmable computation element such as an FPGA (e.g., to perform advanced filtering, such as interpolation) may be operatively connected to the Rx module 920.

[0163] While not shown in FIG. 9A-9B, the FPGA can be located on one or more boards of the upper board assembly of the rotary actuator described above, that include, e.g., the rotor half of a brushless motor, the receive side of a rotary transformer power link, the receive side of a rotary optical uplink, and the transmit side of a rotary optical downlink. These elements taken together are referred to herein as the turret assembly of the LIDAR system. In certain embodiments, the turret assembly can spin at a frequency of 1Hz to 30Hz, taking range measurements at fixed angular intervals. In one embodiment, for any given full rotation ("frame"), a 64x2048 resolution depth image can be produced, although the user may select other resolutions by changing device operating parameters. In some embodiments, the LIDAR system can acquire 2,621,440 points (range measurements) per second.

1. Optical Systems for the Tx and Rx Modules

[0164] FIG. 10 shows an optical block diagram of a light ranging device 1000 according to some embodiments of the disclosure. As shown in FIG. 10, light ranging device 1000 includes a light transmission (Tx) module 1010 and a light sensing (Rx) module 1040. Light transmission module 1010 can be representative of Tx module 910 while light sensing module 1040 can be representative of Rx module 920. Embodiments of the disclosure are not limited to the specific optical configurations shown in FIG. 10. In other embodiments, light transmission module 1010

and light sensing module 1040 can include fewer, more or different optical components. Non-limiting examples of other configurations for light transmission module 1010 and light sensing module 1040 are set forth in U.S. Application No. 15/979,235 entitled "Optical Imaging Transmitter with Brightness Enhancement," filed on May 14, 2018, and U.S. Application No. 15/979,266 entitled "Spinning LIDAR Unit with Micro-optics Aligned behind Stationary Window," filed on May 14, 2018, the disclosures of each of which are incorporated herein by reference in their entirety for all purposes.

[0165] Embodiments of the light ranging device 1000 can be employed within the compact LIDAR system disclosed herein as described above in reference to, e.g., FIGS. 5A-5B. The Tx module 1010 provides active illumination of objects in the area around the LIDAR system by, e.g., transmitting pulses of narrow band light, e.g., NIR light having a spectral width of, e.g., 2nm, 1nm, 0.5nm, 0.25 nm or less, into one or more fields of view, as shown in FIGS. 1A-1B and 4 above. The Rx module 1040 detects reflected portions of the transmitted narrowband light that is reflected by the objects in the scene.

[0166] As shown in FIG. 10, Tx module 1010 can include a TX-side micro-optics package 1020 and a bulk optical element 1030. The TX-side micro-optics package 1020 includes a plurality of light emitters 1022, and optionally includes a micro-lens layer 1024 and an aperture layer 1026. Emitters 1022 can be arranged in a one or two-dimensional array of transmitter channels, e.g., channel 1025 shown in the boxed region. Each one of the transmitter channels has one or more light emitters 1022, e.g., NIR VCSELs or the like, capable of emitting narrowband light, and optionally, a micro-lens from lens layer 1024 and an aperture from aperture layer 1026.

[0167] Light emitted from each one of the transmitters diverges as it approaches one of the micro-optics of the Tx-side micro-optic lens layer 1024. Micro-lenses from micro-lens layer 1024 capture the diverging light and refocus it to a focal plane that is coincident with apertures in aperture layer 1026 that includes an array of apertures that correspond in position to the array of micro-optics and the array of emitters. Aperture array 1026 can reduce crosstalk in the system. After exiting the micro-lenses, the focused light again diverges in the form of cones that then

encounter the Tx-side bulk imaging optics module 1030. Details of the Tx-side bulk imaging optics module 1030 are discussed in more detail below.

[0168] In some embodiments, the separation between the micro-lens layer 1024 and the Tx-side bulk imaging optics module 1030 is equal to the sum of their focal lengths, such that light focused at the aperture array 1026 appears as collimated light at the output of the Tx-side bulk imaging optics module 1030 with each collimated bundle of rays exiting the Tx-side bulk imaging optics module 1030 at a different angle. Accordingly, the light from each emitter is directed to a different field of view ahead of the device. In some embodiments, the Tx-side bulk imaging optic 1030 is telecentric on the VCSEL side of the lens, i.e., in a ray diagram of the system, all the chief rays entering anywhere within the aperture of the bulk imaging optic 1030 leave the lens travelling parallel to each other and intersect the VCSEL (image) plane at an angle of incidence that is substantially perpendicular to the VCSEL (image) plane. In this configuration the VCSEL array advantageously operates as a telecentric source, i.e., the optics capture substantially all light produced by the emitter array, even light that is emitted from the emitters on the outer edges of the array. Without the telecentric design, light captured by the outer emitters may be reduced, scattered or refracted in an undesirable manner because of their highly oblique angle of incidence.

[0169] The Rx module 1040 includes an Rx-side bulk imaging optics module 1060 and an RX-side micro-optics package 1050. The RX-side micro-optics package 1050 has either a one or two-dimensional array arrangement that matches the TX-side micro-optics package 1020, with a micro-optic receiver channel 1055 for each corresponding micro-optic transmitter channel 1025. The RX-side micro-optics package 1050 includes an Rx-side aperture array layer 1056, an Rx-side micro-optics lens layer 1054, a narrow band optical filter layer 1028 and a sensor array layer 1052. The portions of the emitted light that reflect off of objects in the field, shown as light rays 1005, enter the Rx-side bulk imaging optics module 1060 from multiple directions. The Rx-side bulk imaging optics module 1060 focuses light rays at a plane that is coincident with the Rx-side aperture array layer 1056. The focused light then is captured by the micro-lenses of the Rx-side micro-optics lens layer 1054 and directed to a sensor array layer 1052 in a collimated fashion (i.e. having a divergence half angle of less than ten degrees).

[0170] In some embodiments, the sensor array layer 1052 includes a 1-D or 2-D array of light sensors or a one or two dimensional array of groups of light sensors, e.g., SPADS and the like. In some embodiments, each sensor or group of sensors in the array corresponds to an emitter in the emitter module and thus a "pixel" in the ranging data.

[0171] In some embodiments, to remove spurious background light, a narrow band optical filter layer 1028 can be disposed within the layered structure, e.g. between the micro-optics array and the sensor array layer 1052. The pass band of the narrow band optical filter layer 1028 can be chosen to correspond with the center wavelength of the emitters and the width of the pass band can be wide enough to accommodate any variation in the output wavelength across the emitter array. In some embodiments, where a very narrow pass band is desired, a control system can stabilize the wavelength of the emitters individually or as a whole. In some embodiments, where a very narrow pass band is desired, the collimation angle of the light passing through filter layer 1028 must be tightly controlled so that no angle-of-incidence shifts occur (as is common in thin-film interference filters); the collimation angle is primarily controlled by the size of apertures in RX-side aperture array layer 1056, the focal lengths of the lenses in RX-side micro-optic lens layer 1054, the relative positioning between RX-side aperture array layer 1056 and RX-side micro-optic lens layer 1054, and surface quality and form precision of RX-side micro-optic lens layer 1054. In some embodiments the narrow band optical filter layer 1028 is continuous planar layer across the entire array of sensors. In other embodiments, the narrow band optical filter layer 1028 can be fabricated as an array of micro-optical elements that correspond with the pixel geometry of the sensor array layer 1052.

[0172] As with the Tx side, the individual elements of the Rx module 1040 form micro-optic receiver channels, e.g., receiver channel 1055. According to certain embodiments, the array of micro-optics and receivers can have a layered monolithic structure. Each micro-optic receiver channel 1055 measures light for a different pixel in the sensor array layer 1052, i.e., the optics of the Rx module 1040 serve to map bundles of parallel rays entering the module from different angles to different corresponding spatial positions on the sensor array layer 1052. In some embodiments, the bulk imaging optics module 1060 is telecentric on the detector side of the system to avoid the non-idealities in the image plane in a manner similar to the TX side, as described above.

[0173] In some embodiments, the micro-optic receiver channels as formed by the cooperation between the micro-optic lens layer 1054, narrow band optical filter layer 1028, and Rx-side aperture array layer 1056 provide for increased isolation between different pixels on the sensor array layer. This is advantageous because in some situations, such as when the emitter light is reflected from a strong reflector in the field, such as a stop sign, the photon flux at the Rx side for each channel can be sizable, making the system susceptible to cross talk and blooming (i.e. the incoming light from one channel may be so bright that it is detectible by an adjacent channel). One solution to the booming problem is to employ a complex time multiplexing scheme such that only one emitter-detector pair (or a carefully chosen group of emitter-detector pairs) are triggered at any given time, therefore eliminating the risk of cross talk. Such an arrangement requires additional timing electronics and multiplexing software and hardware which adds additional cost and complexity to the system. In addition, time-multiplexing is an inefficient data collection method because each receiver emitter pair must be sequentially activated in series thereby increasing the overall acquisition time of the array as a whole. Advantageously, the design of the Rx side micro-optics assembly reduces cross-talk to such an extent that time multiplexing and sequential activation is not necessary, i.e., all channels can be employed at the same time to collect data points in parallel, in a manner similar to a flash LIDAR system.

[0174] The design of the micro-optical systems for the Rx module 1040 and the Tx module 1010 advantageously enable the conceptual LIDAR arrangement described above in reference to FIG. 3 where each transmitter element is paired with a sensor element such that the sensor element views light only from the field of view that the transmitter illuminates. This 1:1 pairing of fields of view helps eliminates cross-talk in the detector from adjacent or neighboring pixels. The additional micro-optical aperture layer also helps to eliminate cross-talk. The narrow band filter layer helps to remove background light which may contribute to spurious signal detection, eventually leading to ranging errors.

2. Micro-Optics

[0175] FIG. 11A shows a simplified top view of a micro-optics package 1100 according to certain embodiments. Micro-optics package 1100 can be applied on either or both the

transmitter or detector side of the light ranging device and includes a plurality of channels 1102. For example if implemented on the receiver side, each channel 1102 would correspond to a single micro optical receiver channel, such as channel 1055. Similarly, if implemented on the transmitter side, each channel 1102 would correspond to a single transmitter channel, such as channel 1025. In the example shown in FIG. 11A, the micro-optical channels are laid out as an m×n staggered array, e.g., laid out in 16×4 array. As an example, if FIG. 11A represents receiver channels, for a receiver channel size of 0.500 mm (diameter) the layout illustrated can be implemented in a chip of size 8.000 mm by 2.000 mm.

[0176] Other array patterns are possible without departing from the scope of the present disclosure. For example, rather than a staggered array, any of the following shaped arrays can be employed: a square array, a 1-D straight line array (m×1), a warped linear (m×1) array, a warped rectangular m×n array, or arrays having any arbitrary pattern. As used herein the term "warped" refers to embodiments where the spacing between receiver channels is uneven. For example, receiver channels near the center, are spaced closer together, while the exterior channels are spaced further apart. The warped layout has an advantage of being able to allow for correction of the distortion curve of a lens (i.e. the angles between the receiver channel fields of view are evenly spaced in the object space).

[0177] FIG. 11B shows a cross-section of a single micro-optic receiver channel 1120 according to some embodiments that can be representative of, for example, receiver channel 1055 shown in FIG. 10. Receiver channel 1120 serves to accept an input cone of light containing a wide range of wavelengths, filters out all but a narrow band of those wavelengths centered at the operating wavelength, and allows a pixel (photosensor) 1171 to detect only or substantially only photons within the aforementioned narrow band of wavelengths. Embodiments of the disclosure are not limited to any particular configuration for receiver channels and channel 1120 is just one example of a receiver channel that can be implemented as receiver channel 1055.

[0178] In some embodiments, the receiver channel 1132 includes an input aperture layer 1140 including an optically-transparent aperture 1144 and optically-non-transparent stop region 1146. Aperture 1144 is configured to define a narrow field of view when placed at the focal plane of an

imaging optic, such as bulk receiving optic 1060. As used herein, the term "optically-transparent" refers to a material that allows most or all incident light to pass through. As used herein, the term "optically non-transparent" refers to a material that allows little to no light to pass through, e.g., a reflecting or absorbing surface. The aperture layer 1140 is configured to receive the input marginal ray lines 1133. The aperture layer 1140 may include an array of optically-transparent apertures and optically-non-transparent stop regions built upon a single monolithic piece such as an optically-transparent substrate. In some embodiments, aperture layer 1140 can be formed from a optically non-transparent material that forms stop regions 1146 and apertures 1144 can be holes or openings in layer 1140.

[0179] In some embodiments, the receiver channel 1120 includes an optical lens layer 1150 including a collimating lens 1151 characterized by a focal length. The collimating lens can be offset from the plane of aperture 1144 and stop region 1146 by the focal length and aligned axially with aperture 1144 (i.e., the optical axis of the collimating lens is aligned with the center of the aperture). In this manner the collimating lens can be configured to collimate light rays passed by the aperture such that the light rays are travelling approximately parallel to the optical axis of collimating lens 1151. The optical lens layer 1150 may optionally include apertures, optically-non-transparent regions and tube structures to reduce cross talk.

[0180] In some embodiments, the receiver channel 1132 includes an optical filter layer 1160 including an optical filter 1161, e.g., a Bragg reflector type filter or the like. In some embodiments, the optical filter layer is disposed on a detector-side of the an optical lens layer 1150 (as opposed to the aperture side). The optical filter layer is configured to pass normally incident photons at a specific operating wavelength and passband. The optical filter layer 1160 may contain any number of optical filters 1161. The optical filter layer 1160 may optionally include apertures, optically-non-transparent regions and tube structures to reduce cross talk.

[0181] In some embodiments, receiver channel 1132 includes a photosensor layer 1170 including a pixel 1171 disposed behind the filter layer. The pixel can be a photosensor capable of detecting photons with a detector active area made of, e.g., a standard photodiode, an avalanche photodiode, an array of SPADs, RCPs (Resonant Cavity Photo-diodes), or other suitable photodetectors. Photosensor 1171 may be composed of several photon detector areas

(e.g., each a different SPAD) cooperating together to act as a single pixel, often with higher dynamic range, faster response time, or other beneficial properties as compared to a single large photon detection area. Photosensor layer 1170 refers to a layer made of pixels and can include optional structures to improve detection efficiency and reduce cross talk with neighboring receiver structures. Photosensor layer 1170 may optionally include diffusers, converging lenses, apertures, optically-non-transparent tube spacer structures, optically-non-transparent conical spacer structures, etc.

[0182] Stray light may be caused by roughness of optical surfaces, imperfections in transparent media, back reflections, and so on, and may be generated at many features within the receiver channel 1132 or external to receiver channel 1132. The stray light can be directed through the filter region 1161 along a path non-parallel to the optical axis of collimating lens 1151; reflecting between the aperture 1144 and the collimating lens 1151; and generally taking any other path or trajectory possibly containing many reflections and refractions. If multiple receiver channels are arrayed adjacent to one another, this stray light in one receiver channel may be absorbed by a pixel in another channel, thereby contaminating the timing, phase, or other information inherent to photons. Accordingly, the receiver channel 1120 may also feature several structures to reduce crosstalk and increase signal between receiver channels. Examples of such structures and other suitable receiver channels are described in U.S. Patent Application 15/979,295 entitled "Micro-optics for Imaging Module with Multiple Converging Lenses per Channel," filed on May 14, 2018, the disclosure of which is hereby incorporated by reference in its entirety for all purposes.

3. Detector Array (e.g., SPADs)

[0183] FIGS. 12A and 12B show a top view of a SPAD-based photosensor array layer 1200 according to certain embodiments. Photosensor array layer 1200 shown in FIG. 12A is a two-dimensional array of sensor channels 1210 where each individual sensor channel can correspond, for example, to receiver channel 1055. Thus, each sensor channel 1210 can include a group of SPADs as described above. In the example shown in FIG. 12A, photosensor array 1200 is an 18 x 4 array that includes a total of 72 individual sensor channels 1210. Photosensor array 1200 also includes 8 calibration pixels 1220 at the top of the array. Calibration pixels 1220 can be, for

example, covered by an opaque surface such that they are not exposed to any light and therefore can be used to measure dark counts.

[0184] FIG. 12B shows a magnified view of a subset of sensor channels 1210 illustrating that each sensor channel 1210 can be formed from a group (array) of individual SPADs 1212 cooperating together to act as a single pixel. Such an arrangement is advantageous when SPADs are used as the photodetectors because after a photon detection event, a SPAD suffers some deadtime during which external circuitry operates to quench the SPAD so that it is ready to detect again. Thus, a single SPAD has an upper limit to the light intensity (measured in photons/sec) that it can detect. That is, a single SPAD cannot detect a light intensity that is greater than one photon per quench time. Collecting multiple SPADs together as shown in FIG. 12B increases the overall intensity that can be detected because not all SPADs will be saturated at the same time. Thus, a collection of N SPADs may be able to detect with N-times the dynamic range of a single SPAD.

4. Emitter Array (e.g., VCSELs)

[0185] FIGS. 13A and 13B depict simplified top and side views, respectively, of an emitter array 1300 according to certain embodiments. The emitter array 1300 can include a two-dimensional array of VCSEL emitters 1310 that are fabricated on a single monolithic chip 1305 and whose pattern matches the photosensors pixels on a corresponding sensor chip. In this example, emitter array 1300 VCSEL array is 16 x 4 for a total of 64 emitter channels 1310 to match the middle 64 detector channels shown in FIG. 12A above. Emitter array 1300 can also include a plurality of leads 1320 over which signals to drive the various emitters in array 1300 can be transmitted to the emitters.

[0186] As was described in reference to FIG. 12A, the monolithic VCSEL array of optical emitters can be arranged behind the TX-side micro-optics package and behind the TX-side bulk optics module. Each VCSEL emitter can output an illuminating beam of an initial diameter that is substantially identical to (or slightly greater than) the diameter of a corresponding aperture defined either by the aperture layer or the numerical aperture of the micro-lenses of the micro-optics layer to ensure that all or substantially all of the light emitted by the VCSEL will be transmitted to objects in the field.

5. Bulk optics

[0187] In some embodiments, the present disclosure provides a telecentric light ranging device having a fast lens system (e.g., f-number = 1.0, 1.2, or 1.4) and/or a lens system that is passively athermal over a specified temperature range that is likely to be encountered when the light ranging device is used for obstacle detection and avoidance in autonomous navigation for automobiles, trucks or other vehicles. In addition, the bulk optical system possesses a low focal plane distortion and one or more of the optical elements may be AR coated to maximize optical throughput and reduce stray reflections, ghosting, and cross-talk amongst different sensor channels. Advantageously, the optical system is image-space telecentric and thus provides a "straight on" view (when viewed from the object side) of each of the detector channels of the sensor array (each chief ray arrives perpendicular to the focal plane), even those on the outer edges of the array.

[0188] As used herein, passively athermal describes an optics system, wherein the spot quality of light from an extended source with non-zero angular size focused by a lens system on an array does not change significantly as temperature changes. If the back focal length of the lens system changes, and the array remains in the same place relative to the rear lens element, then the spot quality of light on the array would change. As used herein, spot quality can be defined by a fraction of light from an extended source with angular size of 0.13 degrees that is focused onto the image plane and contained by a circle 25 μm in diameter. An opto-mechanical system is considered to be passively athermal over a temperature range if the spot quality remains above 50% for all temperatures in the temperature range. The diameters and angular sizes listed are exemplary and depend on the size of the apertures in the micro-optic array, the focal length of the system, etc.

[0189] FIG. 14 depicts a simplified schematic of a portion of an optical module 1400 that provides a thermally stable image plane over a wide range of temperatures according to some embodiments. Optical module 1400 includes an array 1410, a bulk lens system 1420, a lens housing 1430, and a mount 1440 to mechanically couple the housing with the array. Optical module 1400 can be representative of an embodiment of light sensing module 330 (in which case array 1410 can be an array of photosensors) or an embodiment of light emitting module 340 (in

which case array 1410 can be an array of emitters), and in some embodiments mount 1440 can representative of a portion of mount 905 shown in FIG. 9. A light ranging device according to some embodiments of the disclosure can include a first optical module 1400 as a light sensing module and a second module 1400 as a light emitting module.

[0190] Array 1410 can be planar (e.g., having irregularity from a perfect plane less than 1 mm peak-to-valley over a 10 mm diameter disc) for ease in manufacturing (e.g., forming arrays in bulk on a semiconductor substrate, wherein there are a plurality of emitters or detectors in one array). In some embodiments, array 1410 can include a micro-optics structure, such as transmitter micro-optics package 1020 or receiver micro-optics package 1050 discussed above with respect to FIG. 10 depending on optical module 1400 is implemented as a light sensing module or as a light emitting module.

[0191] As shown in FIG. 14, lens system 1420 can include a first lens 1422, a second lens 1424, a third lens 1426, and a fourth lens 1428. In some embodiments, the first lens, the second lens, the third lens, and the fourth lens are mounted in the lens housing 1430. When implemented as part of an imager sensor (i.e., array 1410 is an array of photosensors), lens housing 1430, lens system 1420, and mount 1440 are configured to passively focus light from the lens system to the photosensor array over a temperature range (e.g., from -40 Celsius to 85 Celsius, -50 Celsius to 95 Celsius, -35 Celsius to 60 Celsius, -40 Celsius to 105 Celsius, -45 Celsius to 110 Celsius, or -35 Celsius to 100 Celsius). In embodiments that include a micro-optics structure in the array, the lens system 1420 is configured to passively focus light from the lens system to the aperture layer of the micro-optics structure and the various micro-optic components in the micro-optic structure can then focus light received at each individual micro-optic channel to the corresponding photosensor for that channel.

[0192] The array can be kept at the image plane of the lens system for varying temperatures. Materials can be chosen to reduce cost, reduce weight, and/or maintain the image plane at the array. To reduce costs, first lens 1422, second lens 1424, the forth lens 1428 can be made of plastic (e.g., OKP-1), while third lens 1426 can be made of glass (e.g., to reduce temperature variations in the lens system). A nominal distance between an apex of the fourth lens and the image plane is 8 mm. In the lens assembly shown, the image plane moves toward the fourth lens

as temperature increases. This is perhaps counter intuitive given that the index of refraction for plastic decreases as temperature increases, which would usually push the image plane away from a plastic lens since a lens with a lower refractive index would refract light less sharply (i.e., longer focal length) than a convex plastic lens of similar shape with a higher refractive index (e.g., according to the Lensmaker's Equation where focal length is inversely proportional to a difference between the refractive index of the lens and air, where refractive index of air equals 1; see also Snell's Law). The combination of a glass lens with two or more plastic lenses may allow the effective focal length of the lens system to decrease with increase of temperature even though one or more plastic lenses in the lens system has a focal length that increases with temperature.

[0193] Lens housing 1430 (e.g., made of polycarbonate) can elongate as temperature increases. In some embodiments, mount 1440 attaches to lens housing 1430 near third lens 1426, so that fourth lens 1428 moves to the right as temperature of the housing increases. Material of mount 1440, which separates lens housing 1430 from array 1410, expands with increasing temperature, moving lens housing 1430 away (e.g., left) from array 1410. Simultaneously, lens housing 1430 expands with increasing temperature moving the fourth lens 1428 toward (e.g., right) array 1410. Also simultaneously, the back focal shift moves the image plane leftward, as described above. By choosing the housing material CTE, mount material CTE, and the housing-to-mount interface location appropriately, the back focal shift can be compensated by the aforementioned housing expansion and mount expansion such that the image plane remains approximately coincident with the array over the temperature range.

[0194] In some embodiments, mount 1440 can be coupled with lens housing 1430 near the glass lens (i.e., third lens 1426 in some embodiments). In some embodiments, mount 1440 can be coupled with lens housing 1430 near the glass lens so that a lens of lens system 1410 nearest array 1410 (e.g., fourth lens 1428) can move in relation to array 1410 (e.g., toward the array) as the focal length of lens system 1420 moves in relation to array 1410 (e.g., away from the array). In some embodiments, near can be a point or line on the outside of lens housing 1430, nearest the glass lens, and/or or within +/- 5 mm or +/- 10 mm from the point or line.

[0195] The spot quality of the lens system in FIG. 14 was experimentally verified for a temperature range from -5 degrees C to 70 degrees C using the Zemax optical design program. In some embodiments, the inside of the LIDAR unit can be deliberately heated when the environment gets below a specific temperature. For example, when the environment is -40 degrees C, internal components of the LIDAR unit can be heated to keep the lens system at a temperature of -5 degrees C or higher. In some embodiments a light ranging device can include a temperature sensor and a heating element (e.g., a resistive heater) that can heat the lens system when the temperature drops below a predetermined level as detected by the temperature sensor. Accordingly, system 1400 can be expected to perform well from at least temperatures ranging from -40 degrees C to 70 degrees C (a temperature range of 100 degrees). In various embodiments, system 1400 can provide a stable image plane over temperature ranging from 0 degrees C to 32 degrees C; from 0 degrees C to 55 degrees C; from -10 degrees C to 32 degrees C; from -10 degrees C to 55 degrees C; from -20 degrees C to 60 degrees C; from -40 degrees C to 85 degrees C; and combinations thereof. In some embodiments, the temperature range can be from -40 degrees C to 105 degrees C (a temperature range of 145 degrees).

[0196] It can be often desirable to make lens housing 1430 out of material with a comparable coefficient of thermal expansion (CTE) to the lenses to avoid stressing the lenses. Changing the housing material can also change how the lens elements are spread apart as temperature increases. In some embodiments, the material CTE of lens housing 1430 is not changed/tuned substantially to prevent reduction in optical performance. Thus, the lens housing material has a CTE close to that of the lenses; and not all possible materials for the housing are considered because some housing materials have CTEs that are sufficiently different from CTEs of lenses that stress in the lenses will occur, which can result in degradation of optical performance of the lenses.

[0197] The CTE of lens housing 1430 can be matched, over a temperature range, with lens system 1420 so that a focal plane of lens system 1420 is stable relative to lens housing 1430 over the temperature range. In some embodiments, a thermal coefficient of mount 1440 is matched with lens system 1420 and/or with thermal expansion of lens housing 1430 so that the focal plane is stable relative to a position of the detector (e.g., detector array) over the temperature range. As used herein, a focal plane is said to be "stable" over a range of temperatures if the focal plane

maintains a predetermined resolution at the detector for the system over the given temperature range. As an example, in some embodiments a predetermined resolution requires light focused to a point at the detector to have 50% of the light in a 25 micron circle, in other embodiments a predetermined resolution requires light focused to a point at the detector to have 80% of the light in a 20 micron circle . The CTE of the material of mount 1440 can be chosen with a caveat that material of mount 1440 is strong and/or mechanically rigid (lower CTE materials tend to be stronger). In this example, the fact that the back focal shift is negative (leftward) rather than positive (rightward) allows a very rigid glass filled polymer, or even a metal like magnesium or aluminum, to be used for the separating material of mount 1440.

[0198] FIGS. 15A, 15B, and 15C depict an optical module 1500 according to some embodiments of the disclosure. Optical module 1500 includes a lens system 1520 with four lenses (of which only two, lenses 1522 and 1528, are visible in FIGS. 15A-15C) and a housing 1530. Lens system 1520 can be, for example, lens system 1420, while housing 1530 can be, for example, lens housing 1430. Since image sensors are generally not circular, the lenses of assembly system 1500 generally do not need to be circular. For example, a photosensor array associated with lens assembly 1500 can be narrow and tall, so lenses can be clipped in a rectangular fashion. It is typically easier and less expensive to make rectangular molded polymer optics, while it can be more expensive to grind glass lenses into rectangular shapes. The diameter of the third lens (not shown in FIGS. 15A-15C) can define a minimum width of the lens system, thereby defining part of the rectangular shape. By using a circular glass element and rectangular molded polymer optics lens assembly 1500 can be relatively easy and cheap to manufacture.

[0199] In some embodiments, two housings are put as close together as possible (e.g., touching), which is another reason to keep the glass lens (e.g., lens 3) small. For example, the light ranging device can include a first lens system mounted in a first housing, a second lens system mounted in a second housing, a sensor array, and an emitter array. The first lens system, the first housing, and the sensor array can form a first unit. The second lens system, the second housing, and the emitter array can form a second unit. The first unit and the second unit can be placed side by side as close as possible (e.g., no more than 2.5 cm spaced apart in some embodiments and no more than 5.0 cm in other embodiments) so that light emitted from the

second unit and reflected/scattered is gathered by the first unit in similar field of views as the second lens system projected light from the emitter array.

[0200] Lens system 1520 can be designed to be a fast lens system. In some embodiments, the f-number of lens system 1520 is between 1.0 and 2.4 (e.g., 1.2). The spot sizes on the sensor array can have 80% of the light in a 20 μm circle. Further, lens system 1520 can have a track length equal to or less than 100 mm, 50 mm, 35 mm, and/or 20 mm, and/or equal to or greater than 5, 10, 15, 20, and/or 25 mm.

[0201] In various instances, bulk lens systems according to the present disclosure can include: two or more plastic lenses and at least one glass lens; two or more plastic lenses; and/or one or more glass lenses. In some embodiments, micro-optic structure can be included as part of the array as described above. The micro-optics can modify light differently for different emitters and/or detectors on the array, whereas the bulk lens system modifies light for the entire array. In some embodiments there is one or more micro-optic elements for each individual array element.

[0202] FIG. 16A depicts a top view of an embodiment of an optical module 1600 that can be, for example, optical module 1500. Cross section A-A is identified in FIG. 16A. FIG. 16B depicts an embodiment of cross section A-A. As shown in FIG. 16B, optical module 1600 includes four optical elements, including: element 1622 (e.g., lens 1), element 1624 (e.g., lens 2), element 1626 (e.g., lens 3), and element 1628 (e.g., lens 4); and a housing 1630. FIG. 16C shows a magnified portion of the cross section A-A. The magnified portion shows one example of how lens 1624 and lens 1626 can be mounted in housing 1630. The aperture stop 1625 of lens system 1600 is between lens 1624 and lens 1626. The aperture stop 1625 can be used to secure lens 1624 within the housing.

[0203] FIG. 16D depicts a side view of an embodiment of lens assembly 1600. Cross section B-B is identified in FIG. 16D. FIG. 16E depicts an embodiment of cross section B-B. Lens 1, lens 2, lens 3, lens 4, and the housing are shown.

[0204] FIG. 17A, depicts a cross section of an embodiment of first lens (lens 1522). The first lens has a first surface S1 and a second surface S2. The first surface S1 of lens 1522 and the second surface S2 of lens 1 are spherical. The first surface S1 of the first lens can be a convex surface. The second surface S2 of the first lens can be a concave surface. Light traveling from

left to right can be focused by the first lens. The first surface of the first lens can be larger than the second surface of the first lens to gather light (e.g., reduce the f-number of lens system) for the lens system.

[0205] FIG. 17B, depicts a cross section of an embodiment of the second lens (lens 1524). The second lens has a first surface S1 and a second surface S2. The first surface S1 of lens 1524 and the second surface S2 of lens 2 are aspherical. The first surface S1 of the second lens can be a convex surface. The second surface S2 of the second lens can be planar, slightly convex, or slightly concave. Light traveling from left to right can be defocused by the second lens.

[0206] FIG. 17C, depicts a cross section of an embodiment of the third lens (lens 1526). The third lens has a first surface S1 and a second surface S2. The first surface S1 of lens 1526 and the second surface S2 of lens 3 are spherical. As examples, the third lens can have a width (e.g., diameter) equal to or greater than 10 mm and equal to or less than 20 mm (e.g., 11, 11.5, 12, 12.5, 13, 13.5, 14, and/or 14.5 mm). In some embodiments, the third lens is a high-index glass. In some embodiments, an index of the glass does not change (e.g., change equal to or less than 0.05%) for the temperature range of 100 degrees. The first surface S1 of the third lens can be planar, slightly convex, or slightly concave. The second surface S2 of the third lens can be convex. Light traveling from left to right can be collimated or slightly focused by the third lens.

[0207] FIG. 17D, depicts a cross section of an embodiment of the fourth lens (lens 1528). The fourth lens has a first surface S1 and a second surface S2. The first surface S1 of lens 4 and the second surface S2 of lens 4 are aspherical. The first surface S1 of the fourth lens can be convex. The second surface S2 of the third lens can be convex. Light traveling from left to right can be focused to the array.

[0208] By mixing plastic and glass lenses, as well as mixing aspherical and spherical lenses, an economical, light, compact, and/or athermal light ranging device can be made for autonomous vehicles.

[0209] In some embodiments, the lens system has a fixed focal length (e.g., fixed focal length while at constant temperature; not a zoom lens). In some embodiments, the lens system has a fixed focal length to reduce size, weight, number of parts, and/or complexity of the lens system.

[0210] FIG. 18 depicts an embodiment of an optical module 1800 with three lenses: a first lens 1822; a second lens 1824; and a third lens 1826. The first lens, the second lens, and the third lens are mounted in a housing 1830. A connecter 1805 couples the housing with a sensor 1810 (e.g., a sensor in an array). The first lens, the second lens, and the third lens can be made of plastic (e.g., OKP-1). The first lens, the second lens, and the third lens are part of a lens system 1810. Lens system 1810 is estimated to have a focal shift of around 105 μm over a 50 degree C temperature range (e.g., from 0 to 50 degrees C). Housing 1830 can be made of a high CTE material, and/or the mount 1840 attaches near lens 1822, to hold the focal plane of lens system 1810 at the array. In the embodiment in FIG. 18, polycarbonate (CTE = 70 ppm/C) is used and mount 1840 is attached to housing 1830 25-35 mm away from the array. A combination of mount 1840 attached to the housing 30 mm away from array 1810, a movement of lenses of the lens system 1810 due to thermal expansion of housing 1830, a movement of housing 1830 due to thermal expansion of mount 1840, and/or a focal shift of lens system 1810 due to temperature change are matched to align the focal plane of the lens system with the array.

[0211] The above description of exemplary embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form described, and many modifications and variations are possible in light of the teaching above. The embodiments were chosen and described in order to explain the principles of the invention and its practical applications to thereby enable others skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

[0212] As an example, while various embodiments and examples described above have focused primarily on the application of light ranging within the context of 3D sensing for automotive or other road vehicle use cases, systems disclosed herein can be used in any application without departing from the scope of the present disclosure. The small, or even miniature, form factor of a LIDAR system according to the present disclosure enables a number of additional use cases, e.g., for solid-state light ranging systems. As specific examples, systems can be used in 3D cameras and/or depth sensors within devices, such as mobile phones, tablet PCs, laptops, desktop PCs, or within other peripherals and/or user-interface devices. As other examples, one or more embodiments could be employed within a mobile device to support facial recognition and facial tracking capabilities, eye tracking capabilities, and/or for 3D scanning of objects. Other use cases include forward-facing depth cameras for augmented and virtual reality applications in mobile devices.

[0213] Other applications include deployment of one or more systems on airborne vehicles, such as airplanes, helicopters, drones, and the like. Such examples could provide 3D sensing and depth imaging to assist with navigation (autonomous or otherwise) and/or to generate 3D maps for later analysis, e.g., to support geophysical, architectural, and/or archeological analyses. Systems can also be mounted to stationary objects and structures, such as buildings, walls, poles, bridges, scaffolding, and the like. In such cases, the systems can be used to monitor outdoor areas, such as manufacturing facilities, assembly lines, industrial facilities, construction sites, excavation sites, roadways, railways, bridges, etc. Furthermore, systems can be mounted indoors and used to monitor movement of persons and or objects within a building, such as the movement of inventory within a warehouse or the movement of people, luggage, or goods within an office building, airport, train station, etc.

[0214] As another example, while various examples above included lasers in the IR or near-IR wavelengths as the emitters in LIDAR systems according to some embodiments of the disclosure, embodiments of the disclosure are not limited to any particular wavelength of light or other types of radiation for the emitters. For example, in some embodiments, the emitters can be lasers that generate pulses having any suitable known operating wavelength including a green (532 nm) wavelength, which can be particularly well-suited for underwater applications, or UV

wavelengths that can be particularly useful for atmospheric LIDAR systems. As would be appreciated by one of ordinary skill in the art with the benefit of this disclosure, many different applications of light ranging systems are possible and, as such, the examples provided herein are provided for illustrative purposes only and shall not be construed to limit the uses of such systems to only the examples explicitly disclosed.

[0215] The specific details of particular embodiments described above may be combined in any suitable manner without departing from the spirit and scope of embodiments of the invention. However, other embodiments of the invention may be directed to specific embodiments relating to each individual aspect, or specific combinations of these individual aspects. For example, to reduce a spot size on the array, more than four lenses could be used, using more aspheric surfaces, and/or using multiple types of plastics could be used. As another example, in some embodiments a curved detector and/or emitter can be used. Additionally, in some embodiments three lenses are used instead of four (e.g., two lenses plastic and one lens glass). These examples and others are included within the scope of the present disclosure.

Hesai Exhibit 1002, page 261

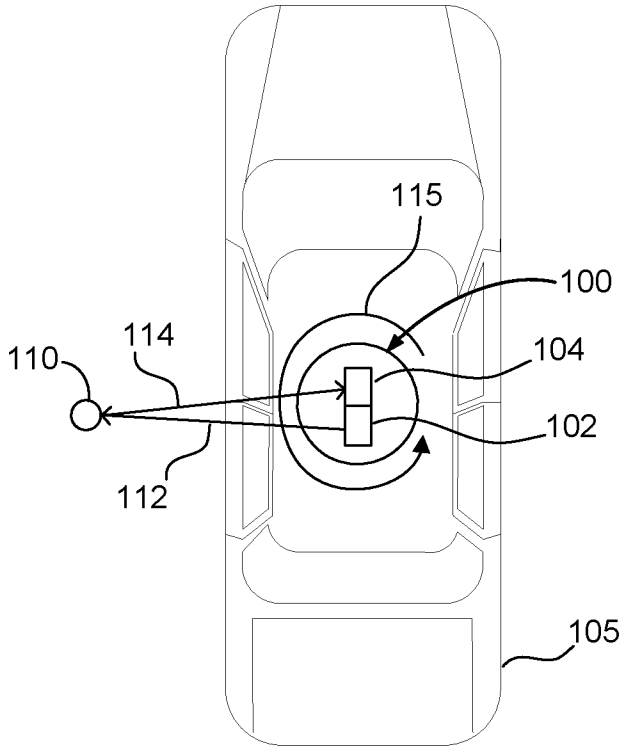


FIG. 1A

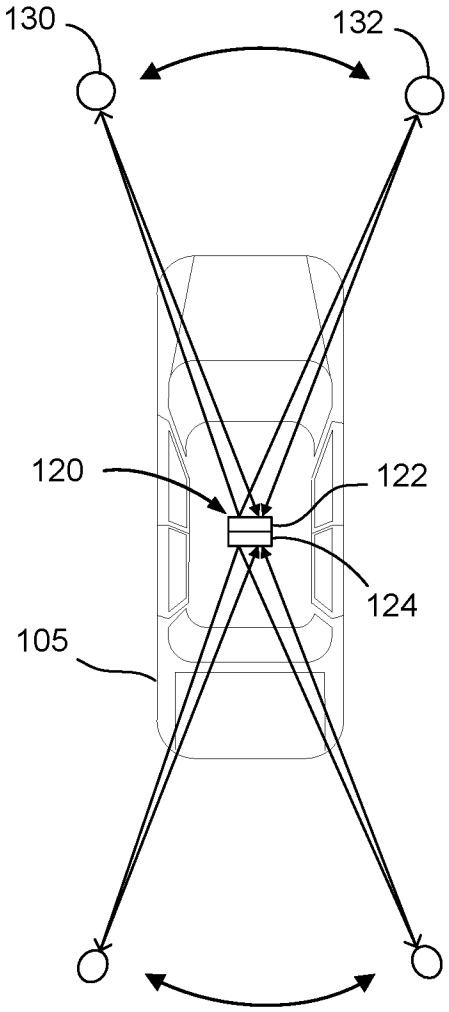


FIG. 1B

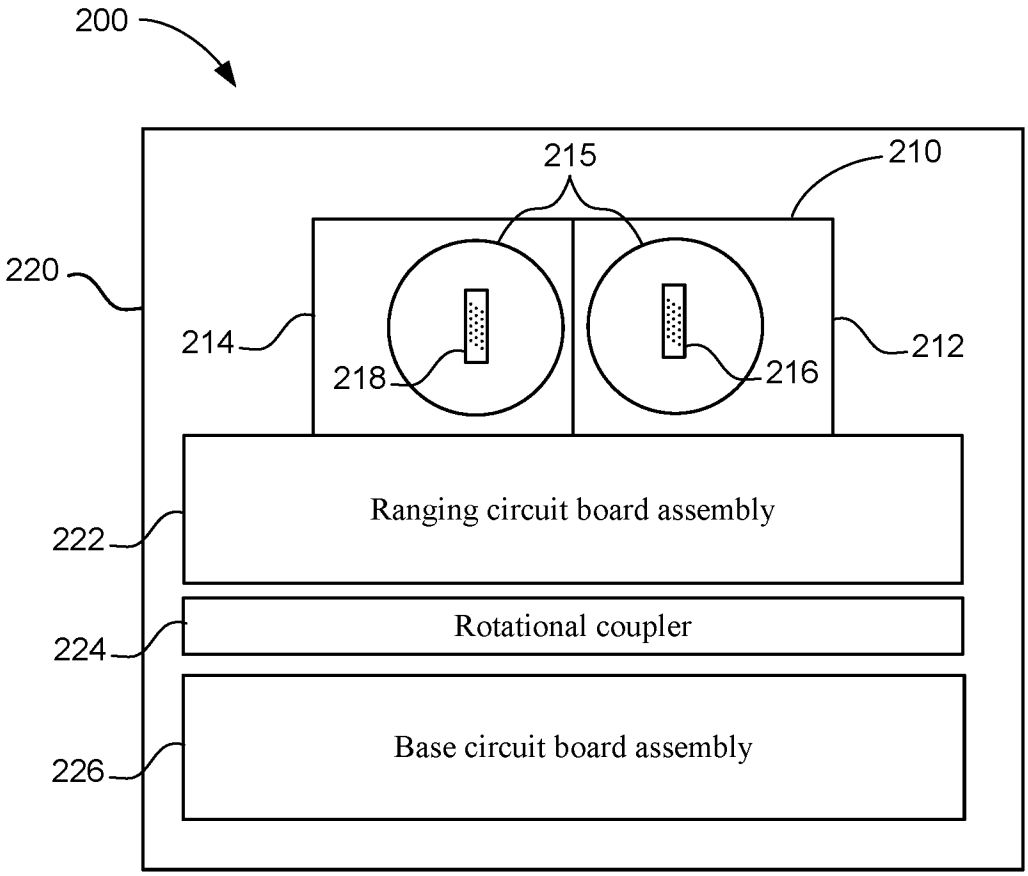

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Ranging circuit board assembly
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Rotational coupler
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Base circuit board assembly
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FIG. 2A

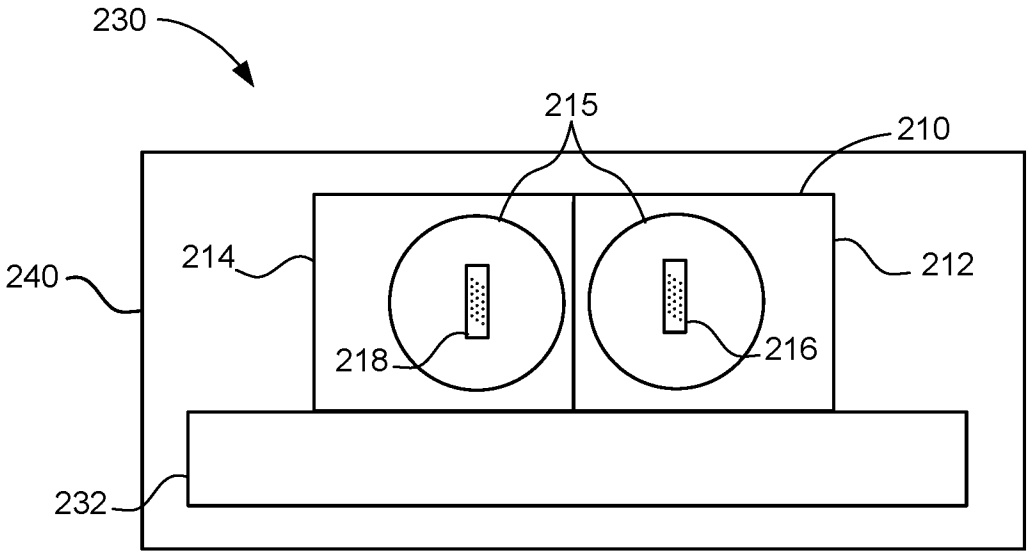

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FIG. 2B

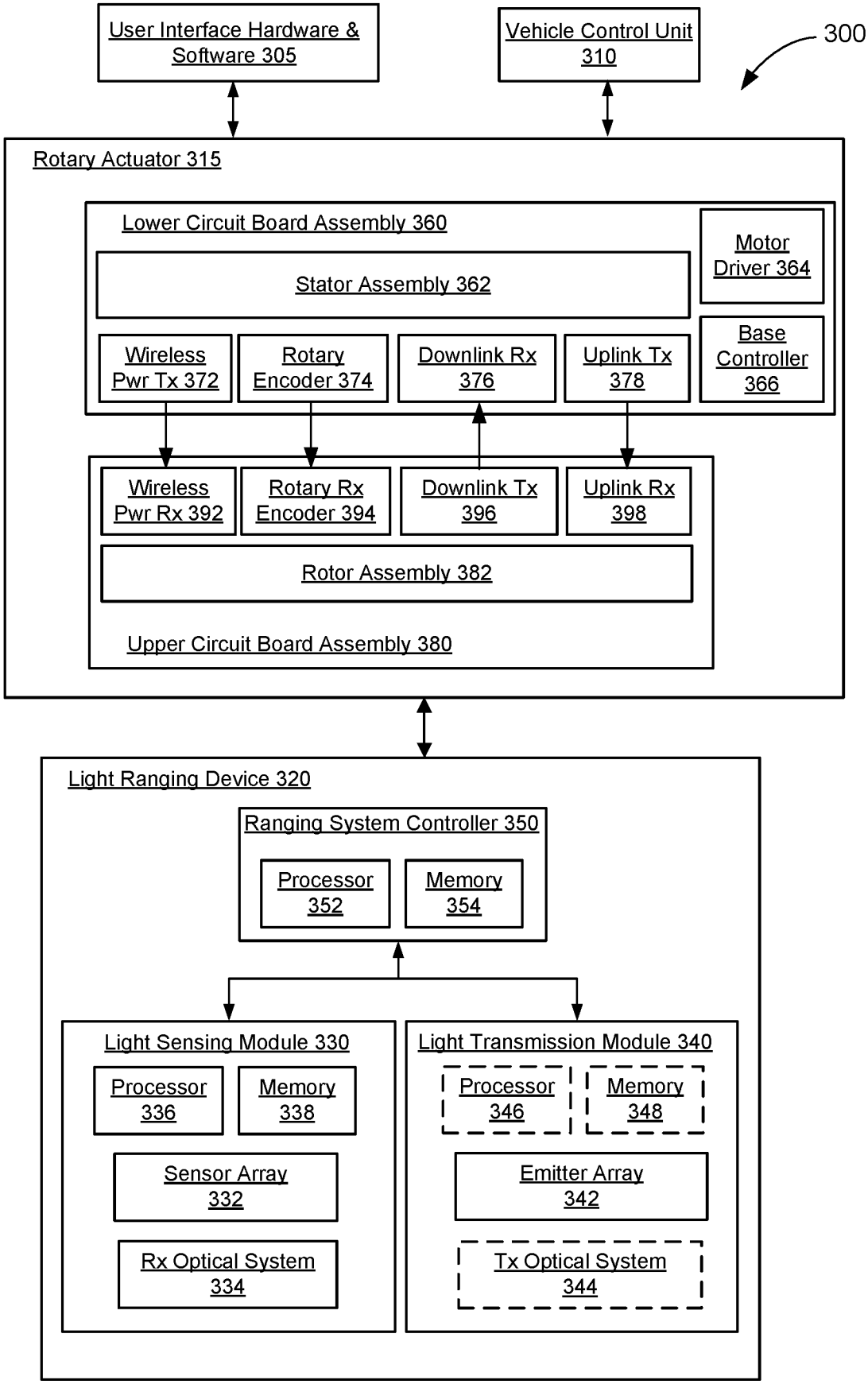

User Interface Hardware & Software 305
Vehicle Control Unit 310
300
Rotary Actuator 315
Lower Circuit Board Assembly 360
Motor Driver 364
Stator Assembly 362
Base Controller 366
Wireless Pwr Tx 372
Rotary Encoder 374
Downlink Rx 376
Uplink Tx 378
Wireless Pwr Rx 392
Rotary Rx Encoder 394
Downlink Tx 396
Uplink Rx 398
Rotor Assembly 382
Upper Circuit Board Assembly 380
Light Ranging Device 320
Ranging System Controller 350
Processor 352
Memory 354
Light Sensing Module 330
Processor 336
Memory 338
Sensor Array 332
Rx Optical System 334
Light Transmission Module 340
Processor 346
Memory 348
Emitter Array 342
Tx Optical System 344

FIG. 3

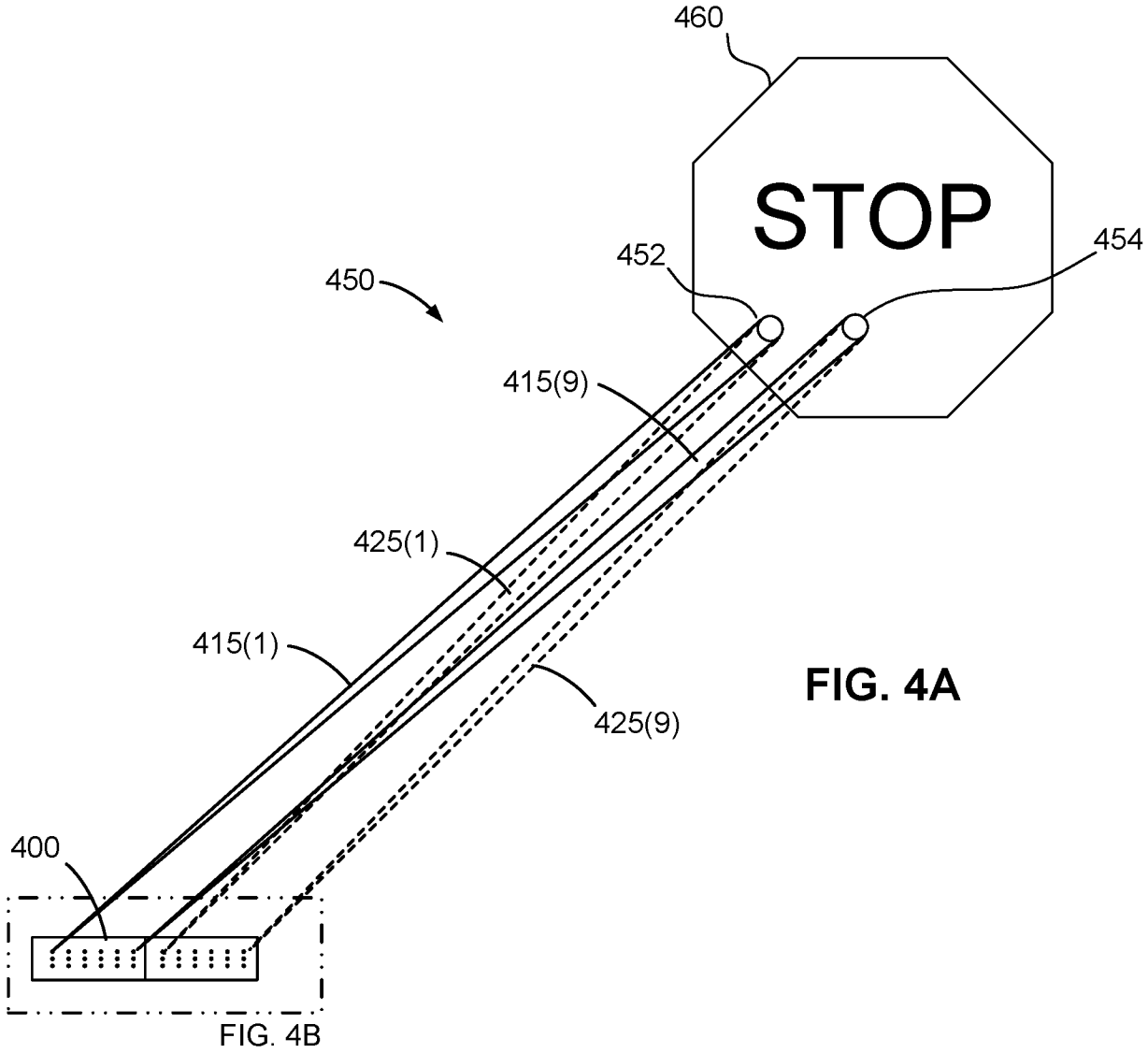


FIG. 4A

FIG. 4B

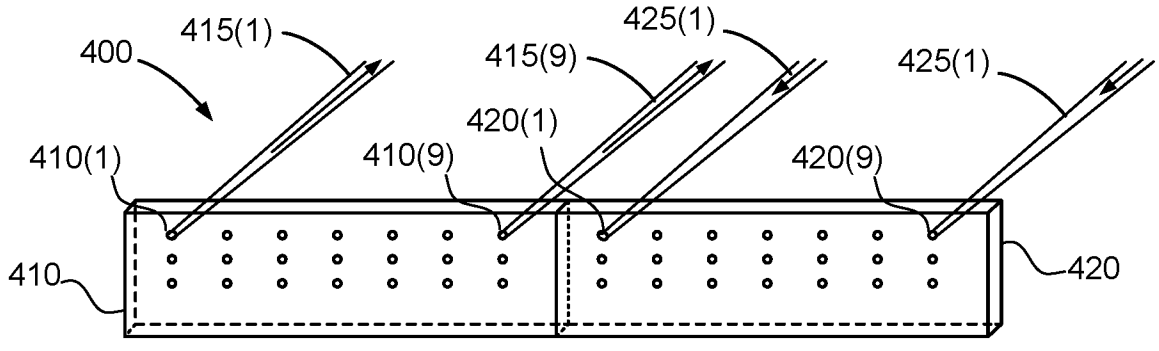


FIG. 4B

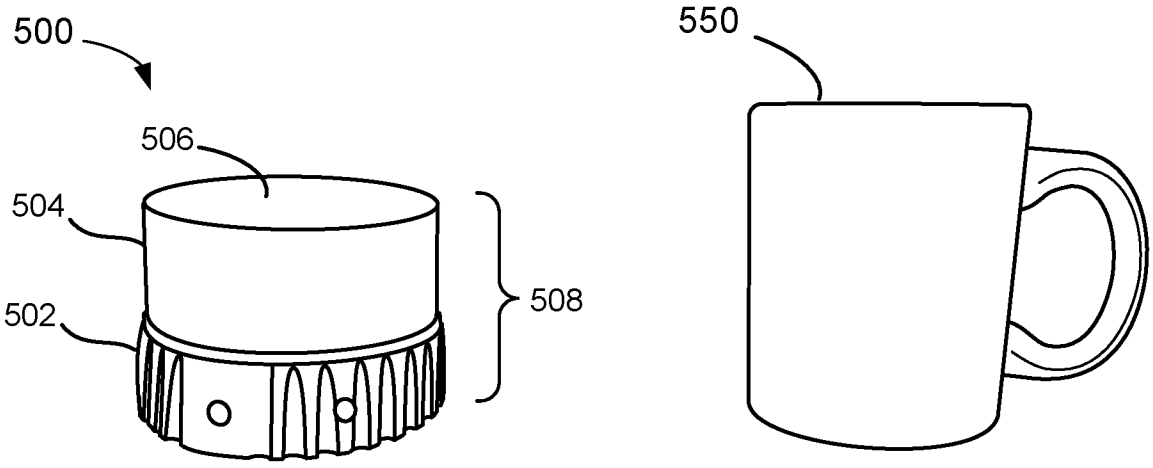

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FIG. 5A

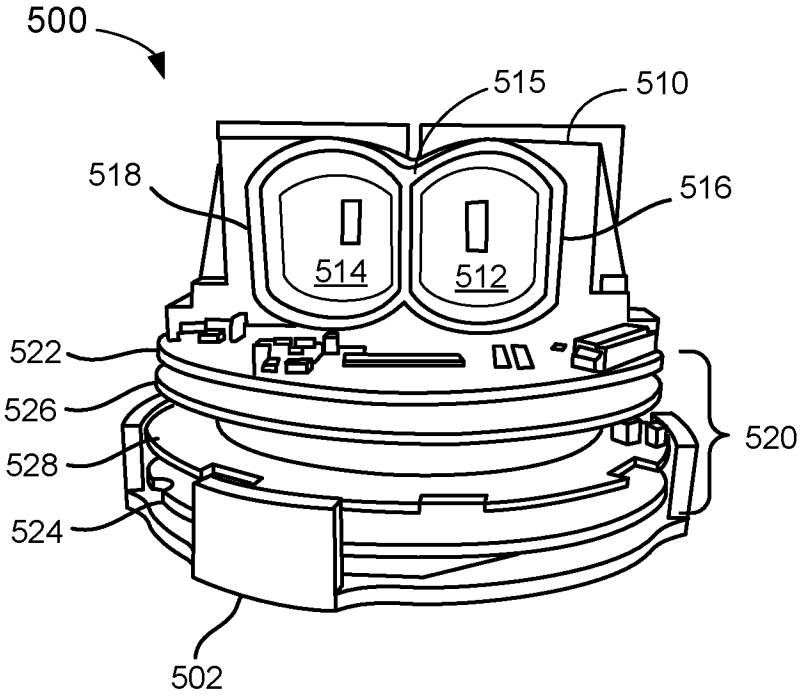

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FIG. 5B

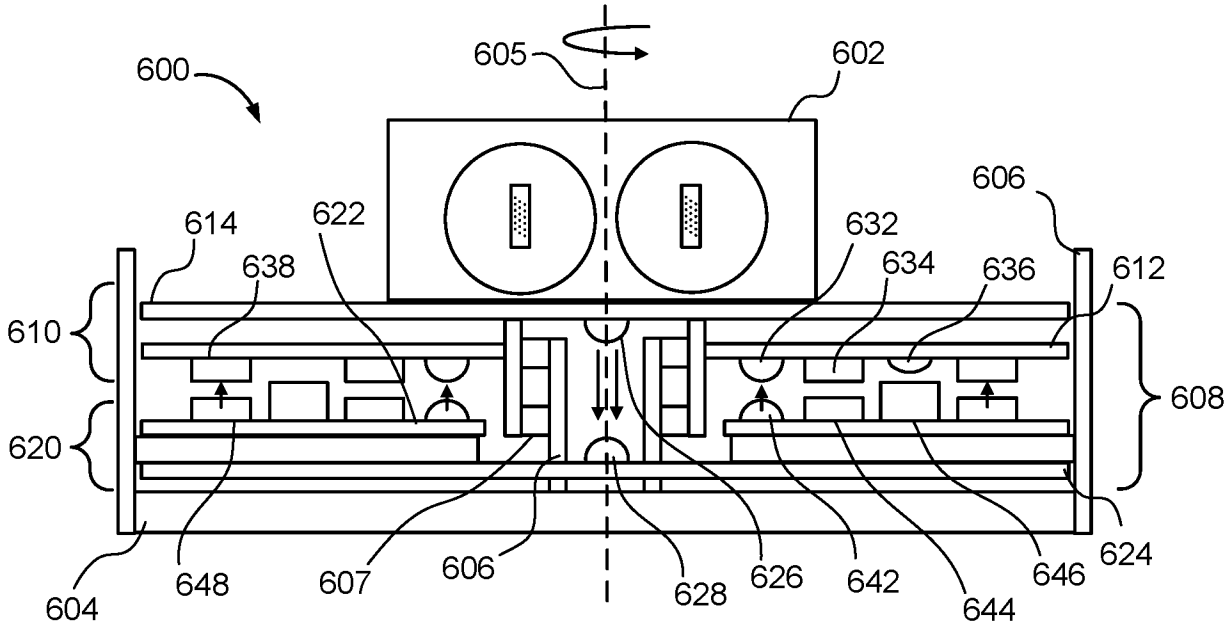


FIG. 6A

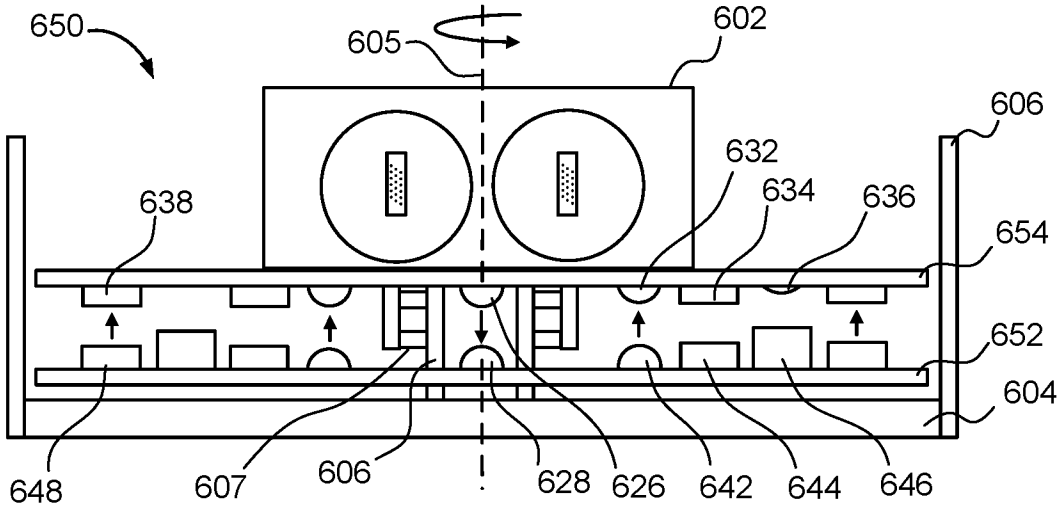


FIG. 6B

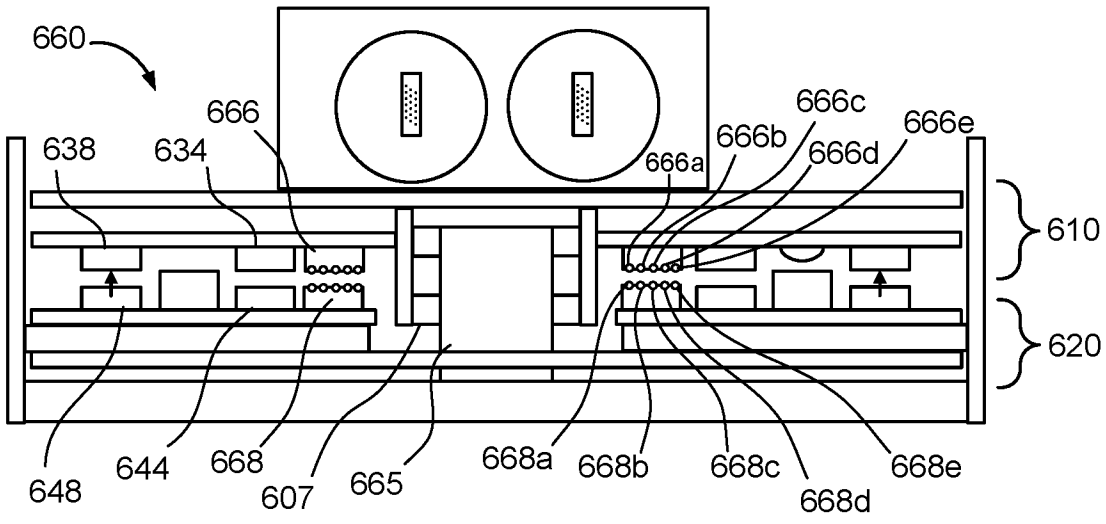
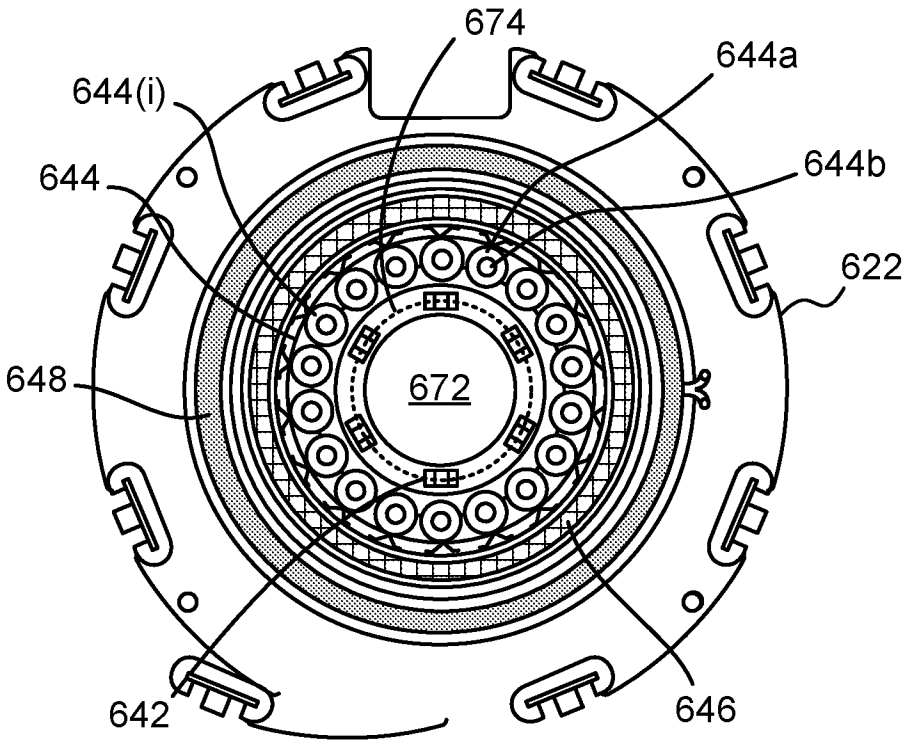


FIG. 6C

FIG. 6D



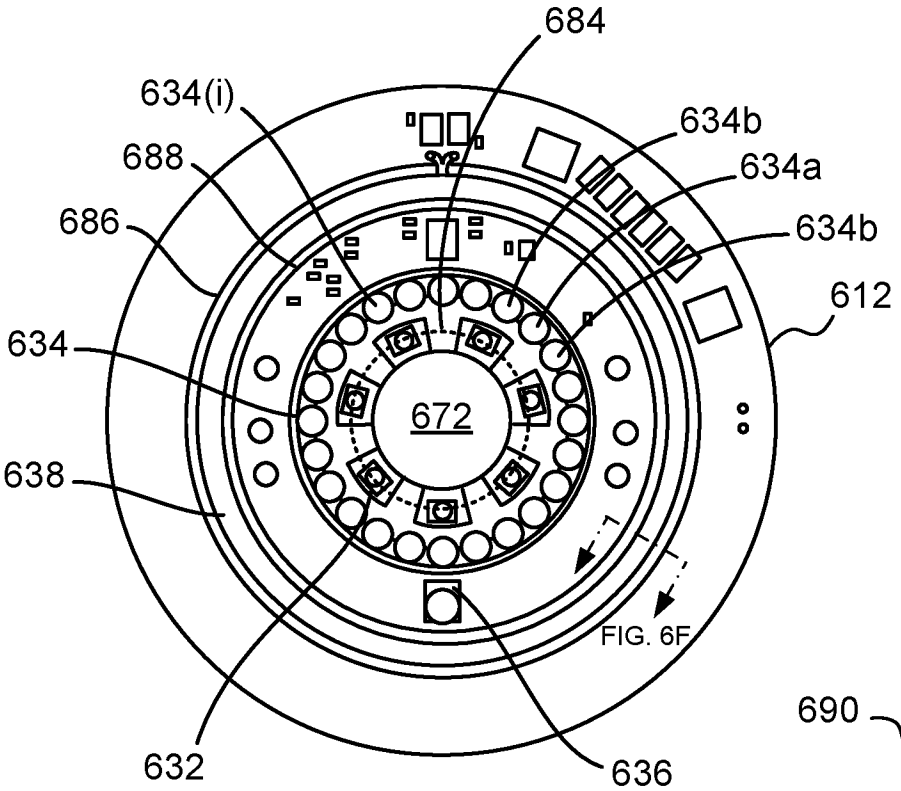


FIG. 6E

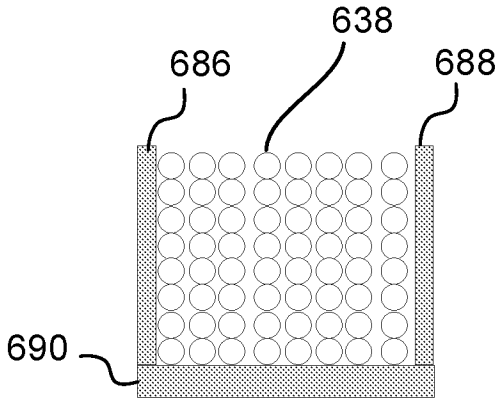


FIG. 6F

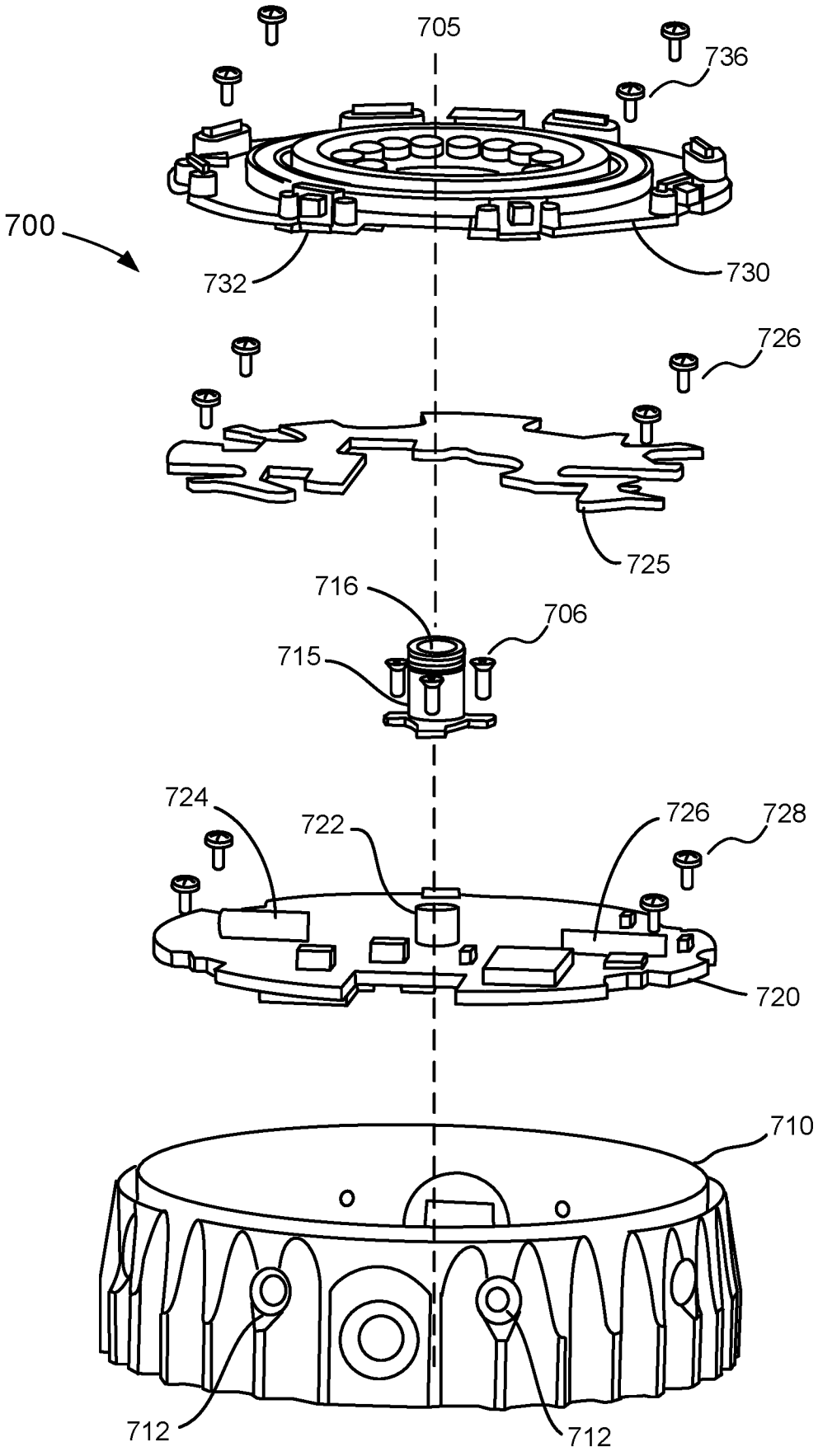

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FIG. 7

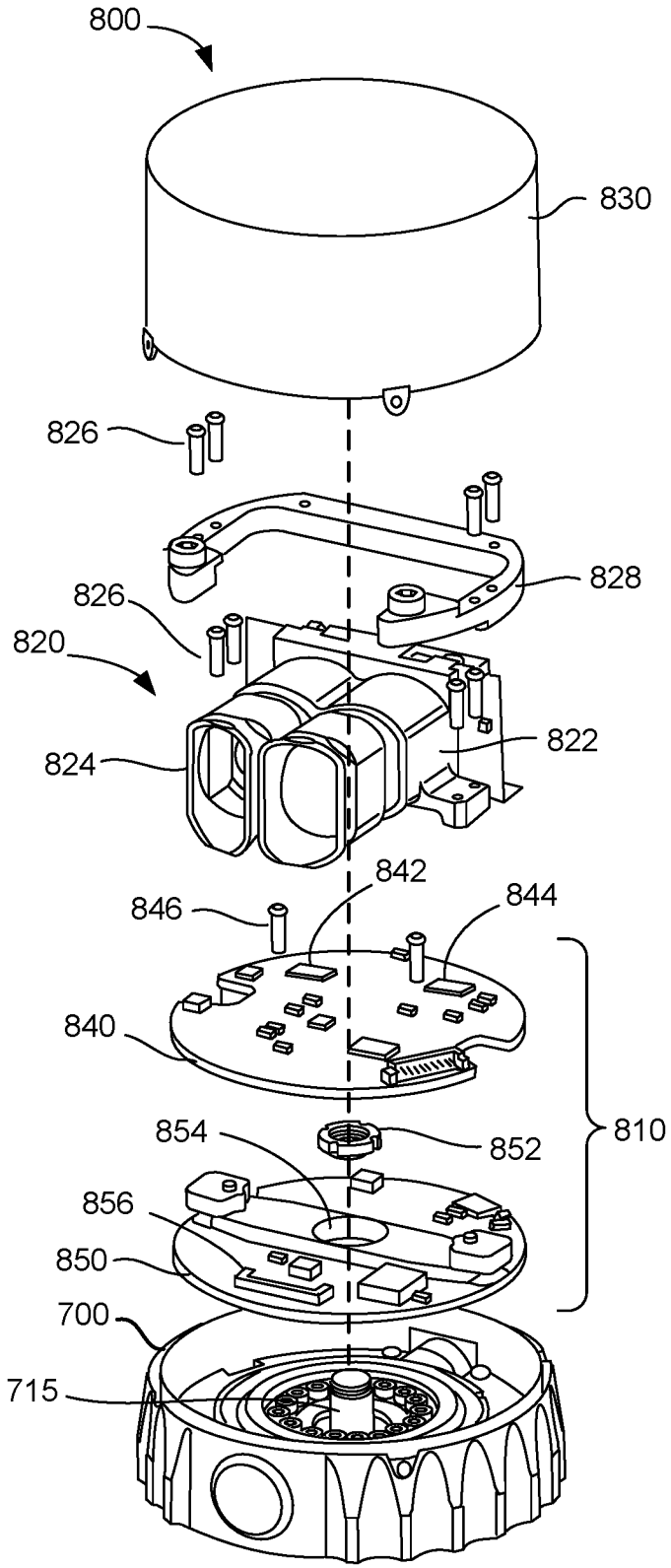

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FIG. 8A

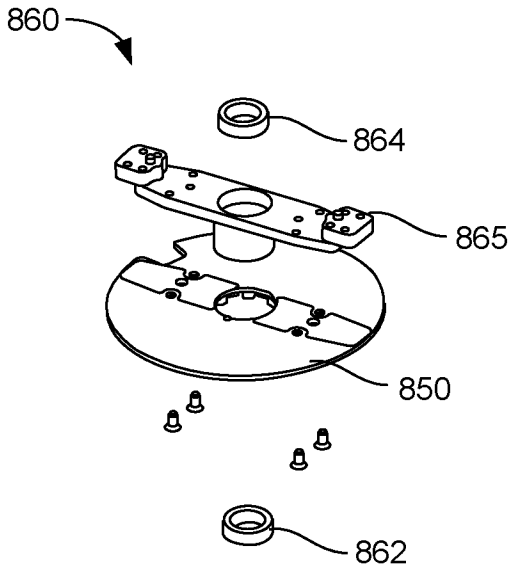

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FIG. 8B

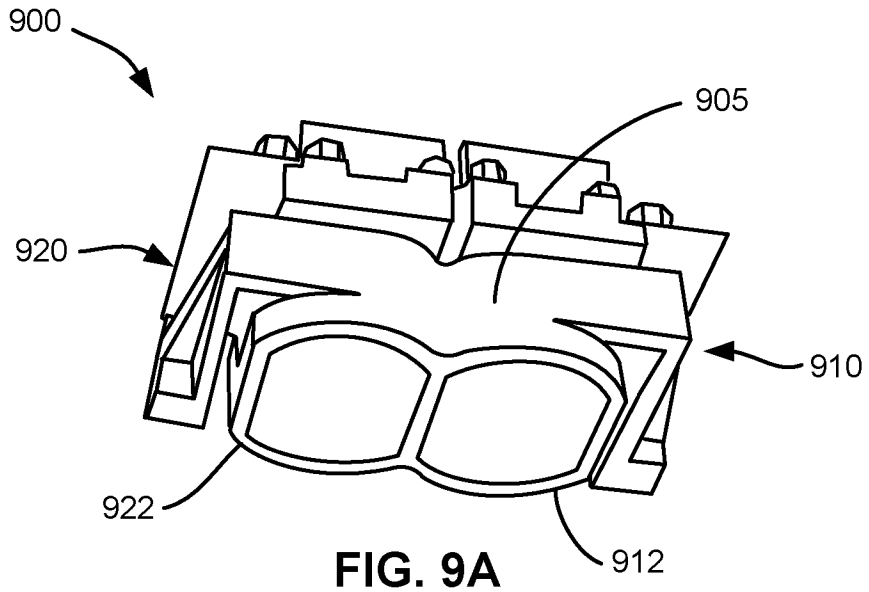


FIG. 9A

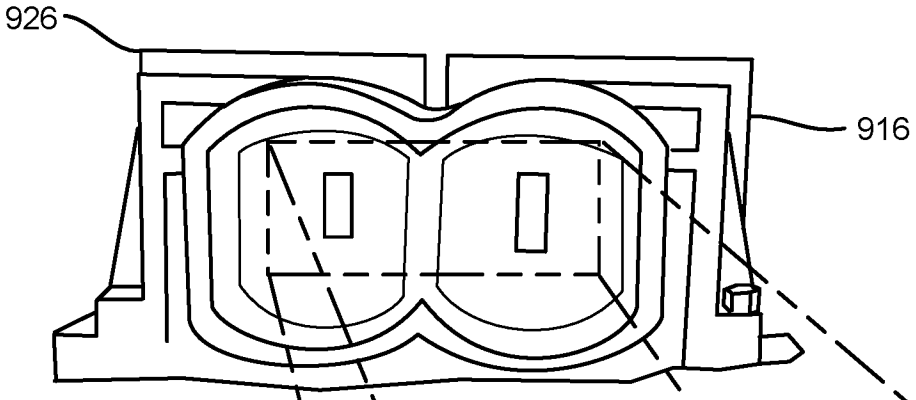


FIG. 9B

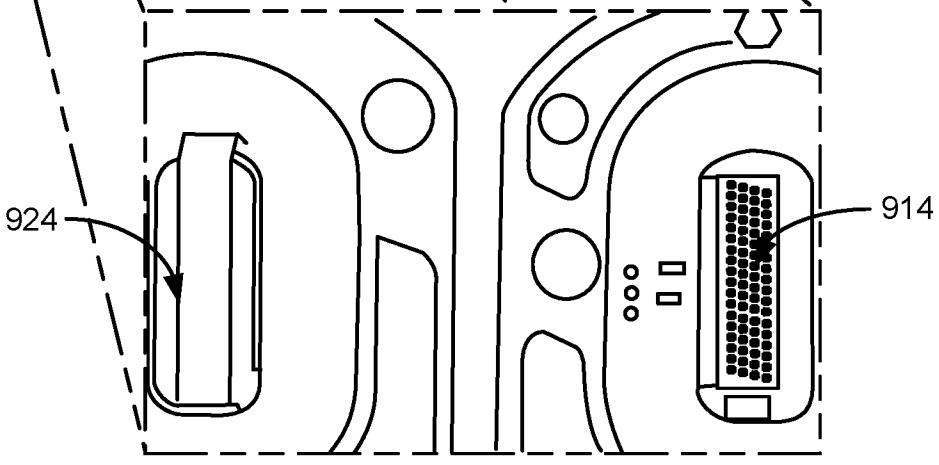


FIG. 9C

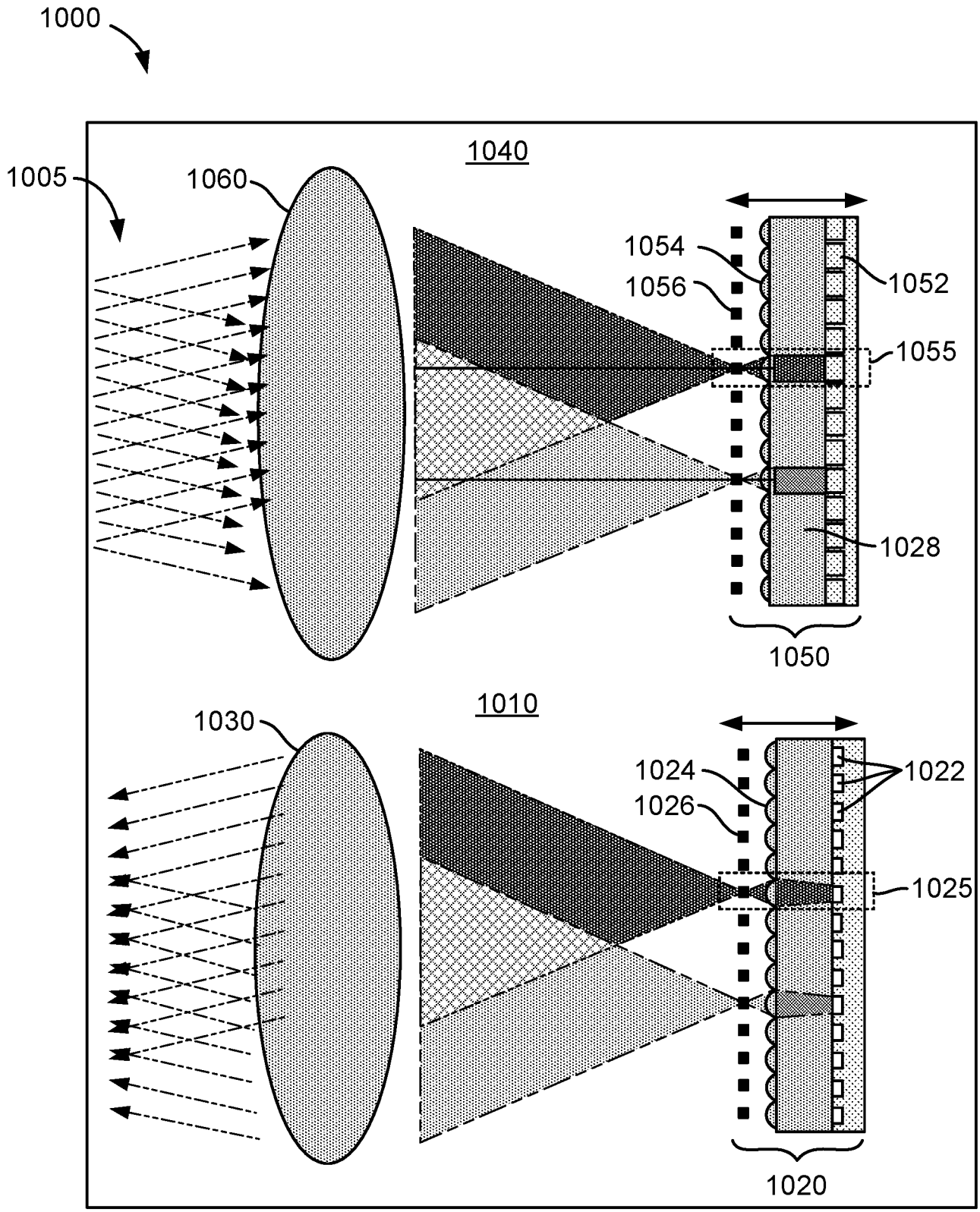

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FIG. 10

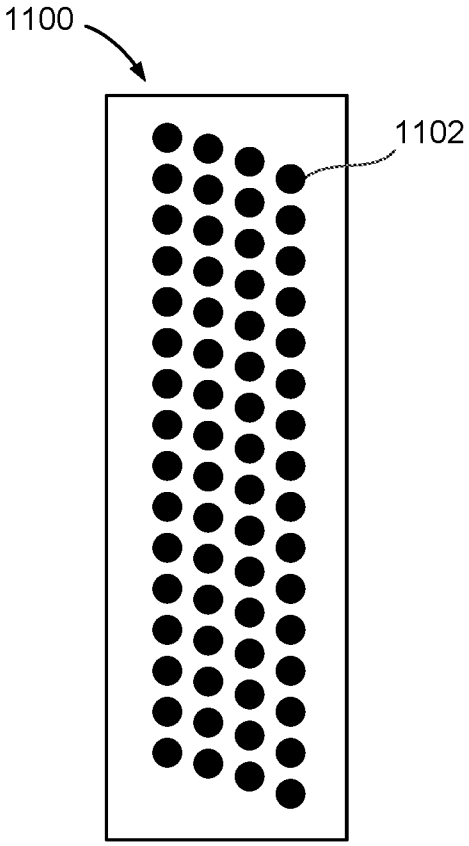


FIG. 11A

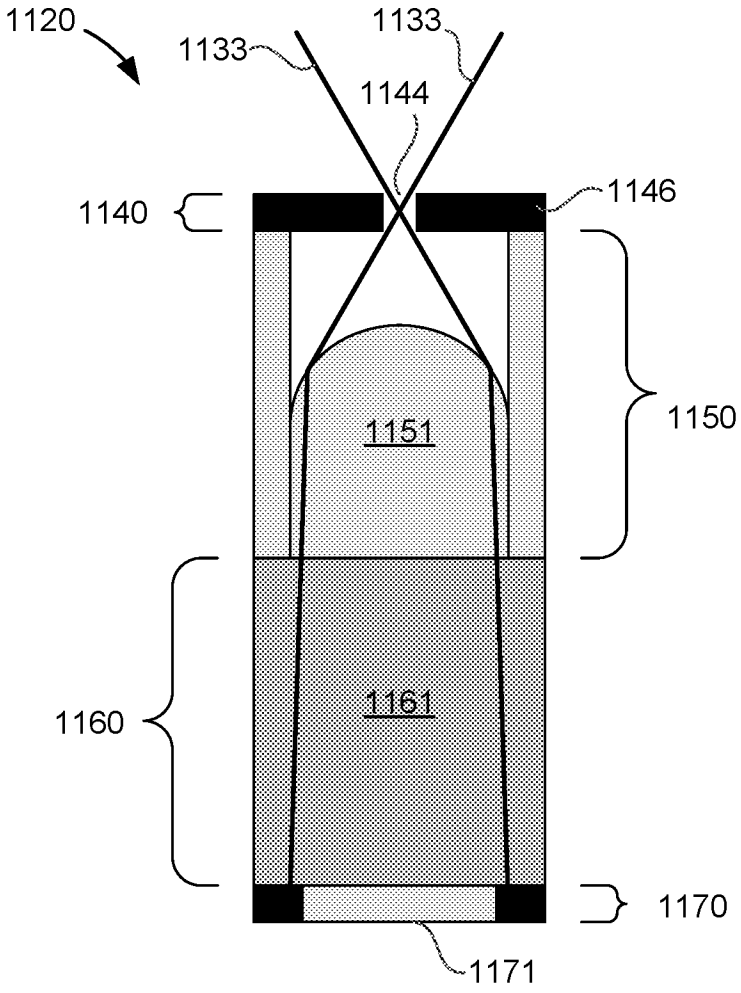


FIG. 11B

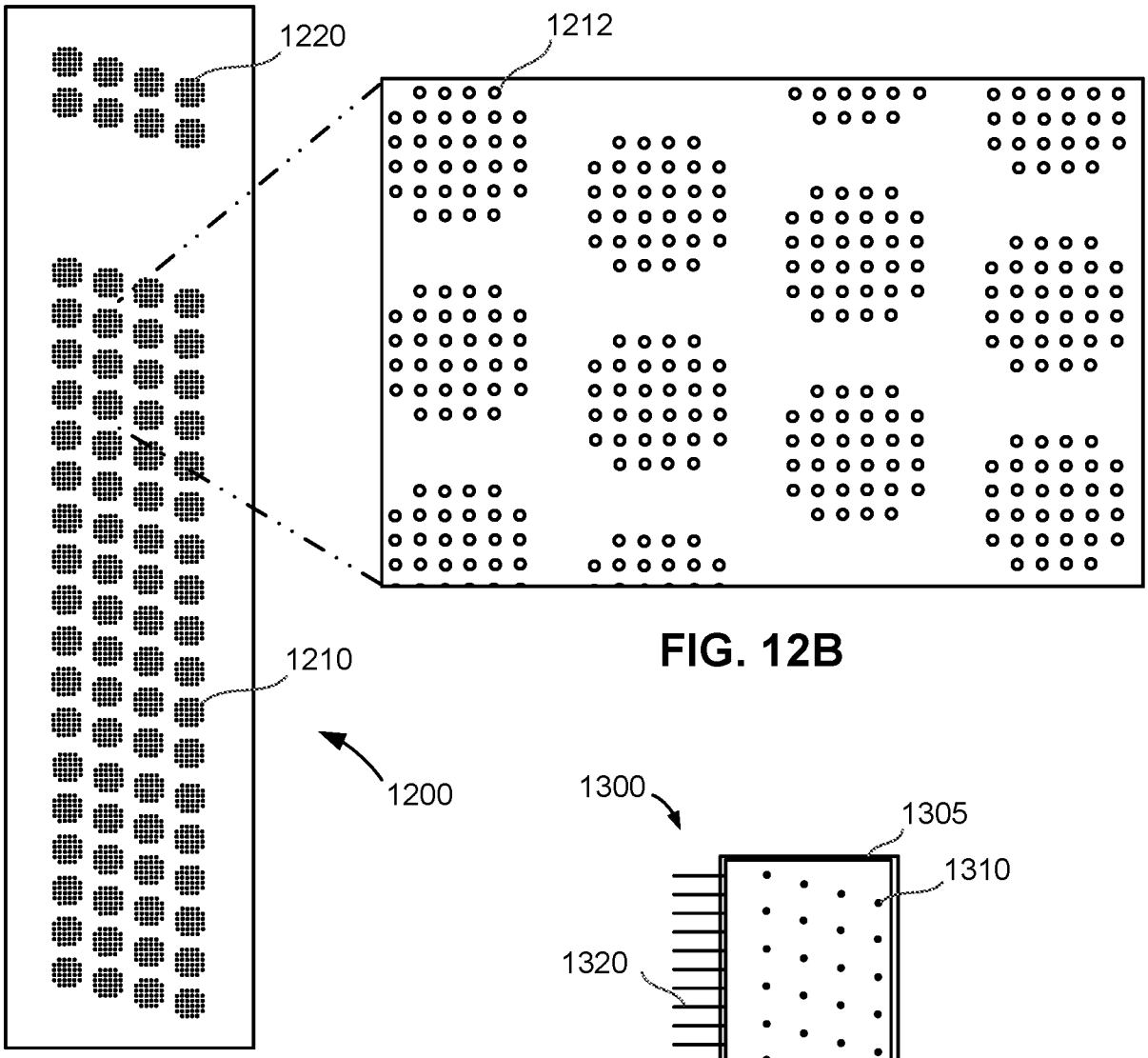


FIG. 12A

FIG. 12B

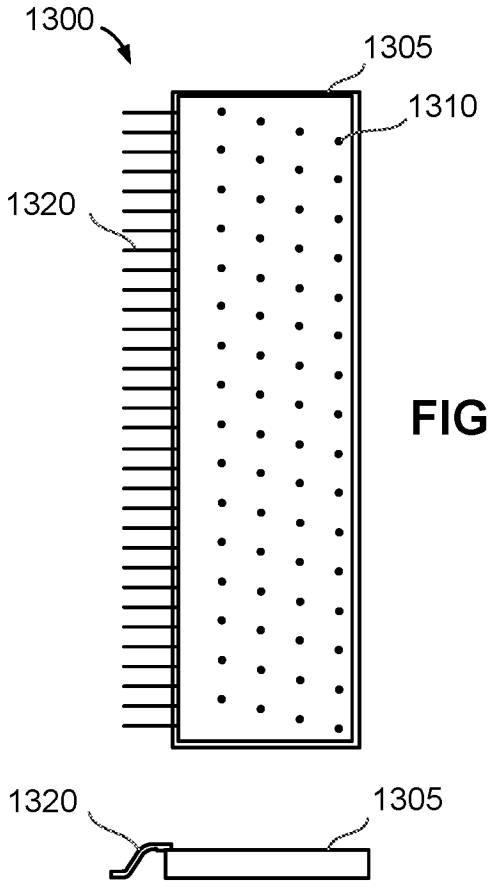


FIG. 13A

FIG. 13B

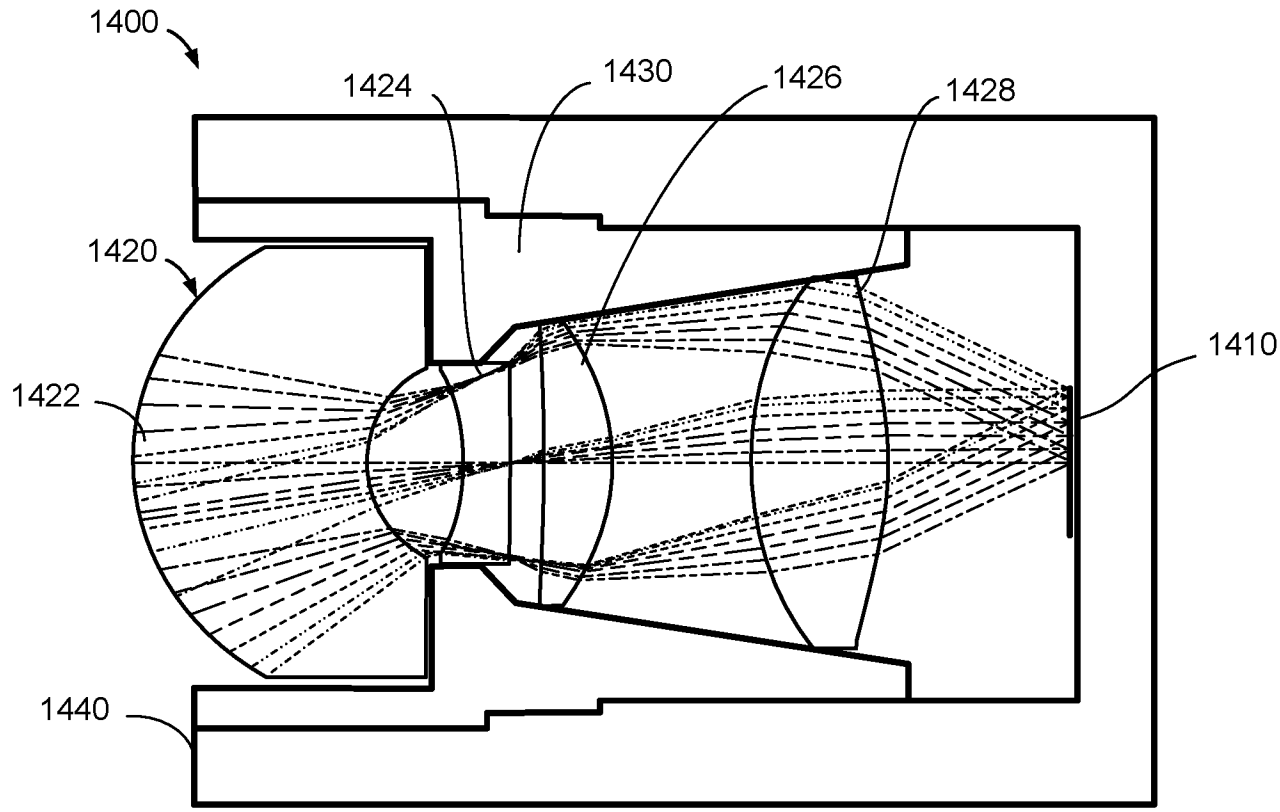


FIG. 14

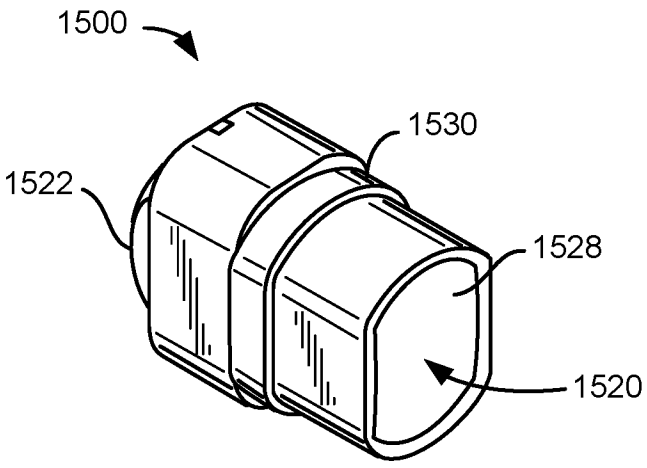


FIG. 15A

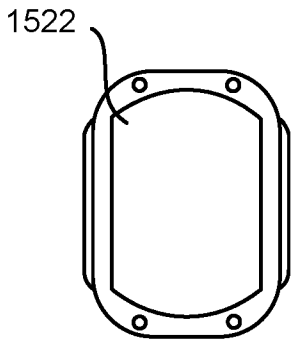


FIG. 15B

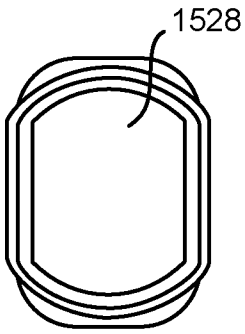


FIG. 15C

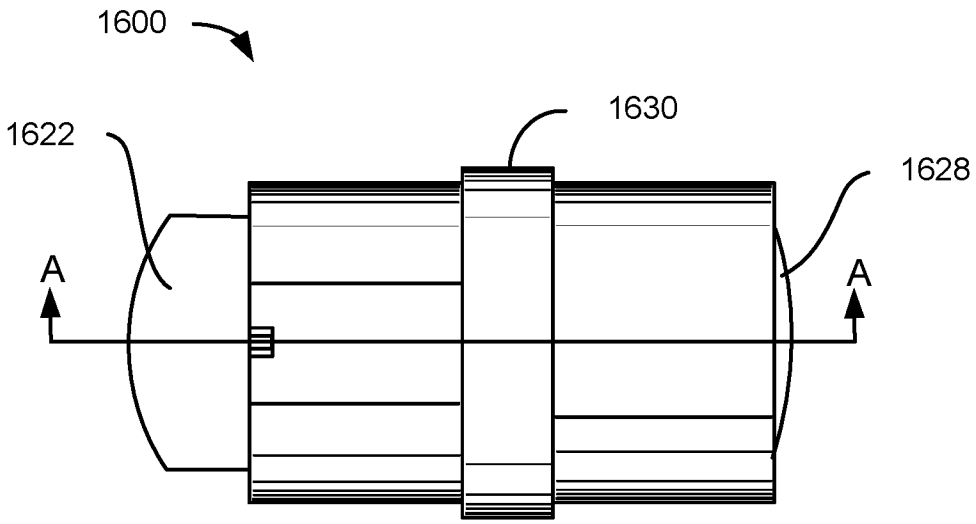


FIG. 16A

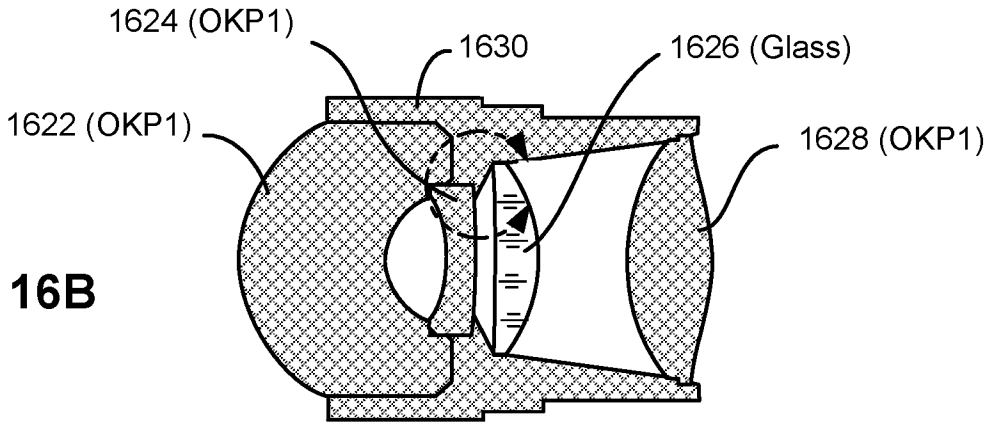


FIG. 16B

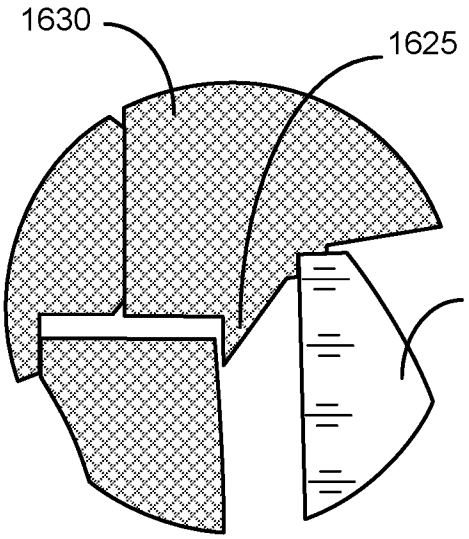


FIG. 16C

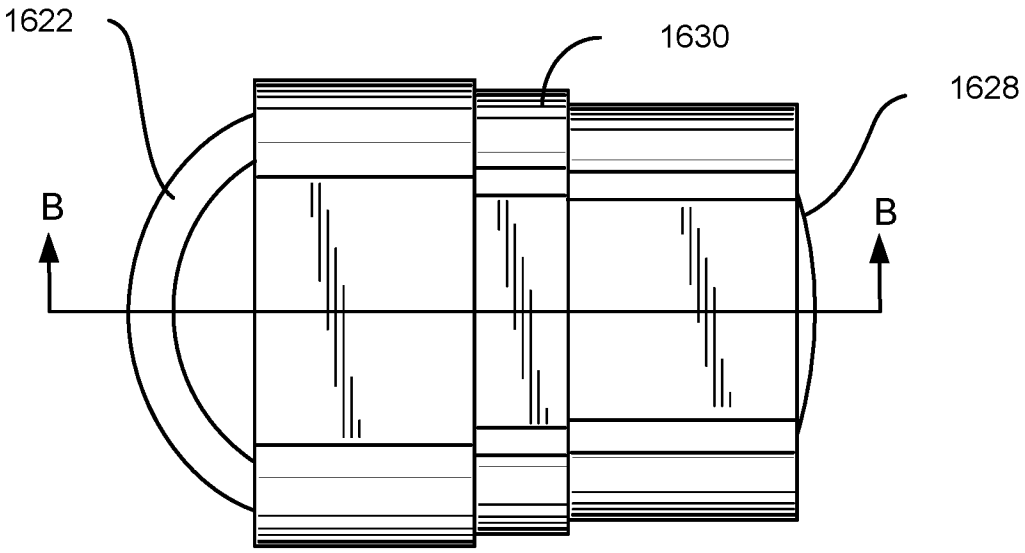
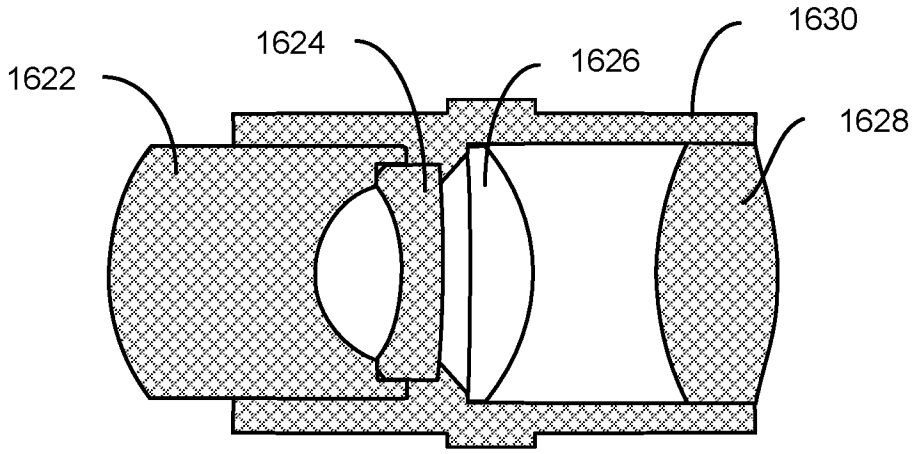


FIG. 16D



SECTION B-B

FIG. 16E

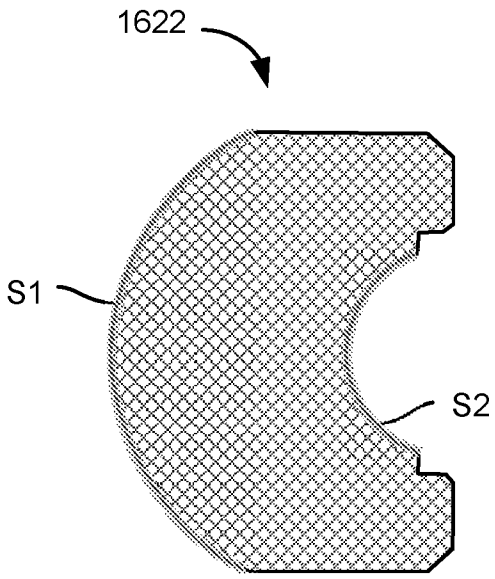


FIG. 17A

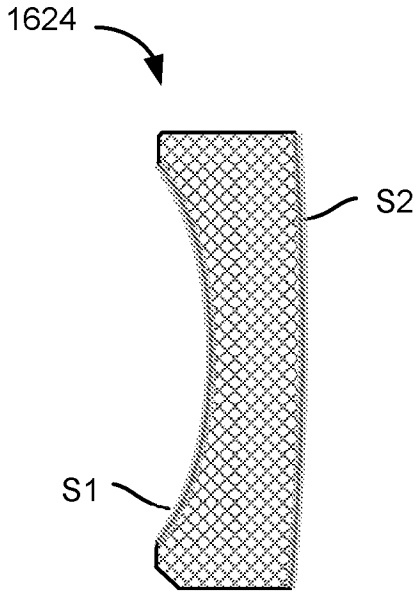


FIG. 17B

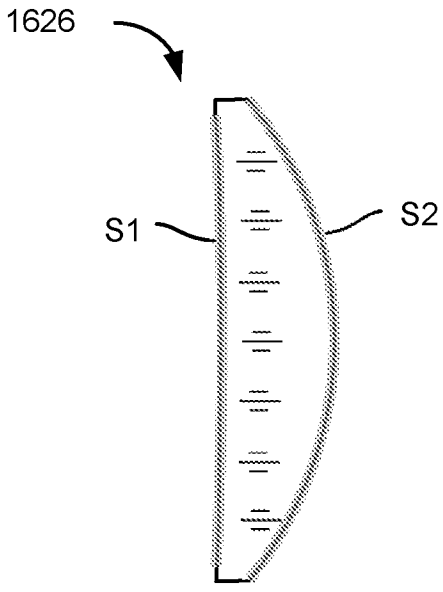


FIG. 17C

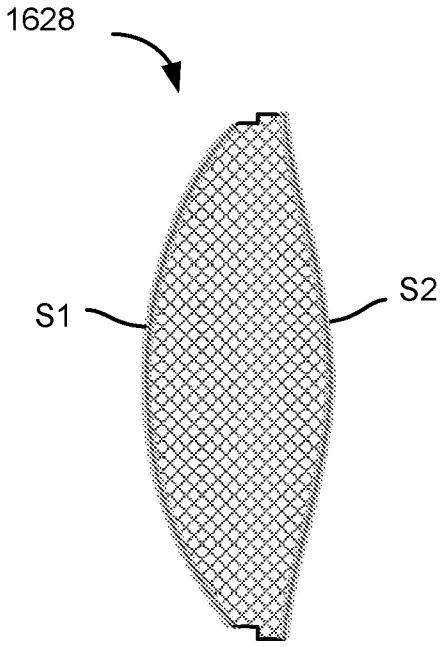


FIG. 17D

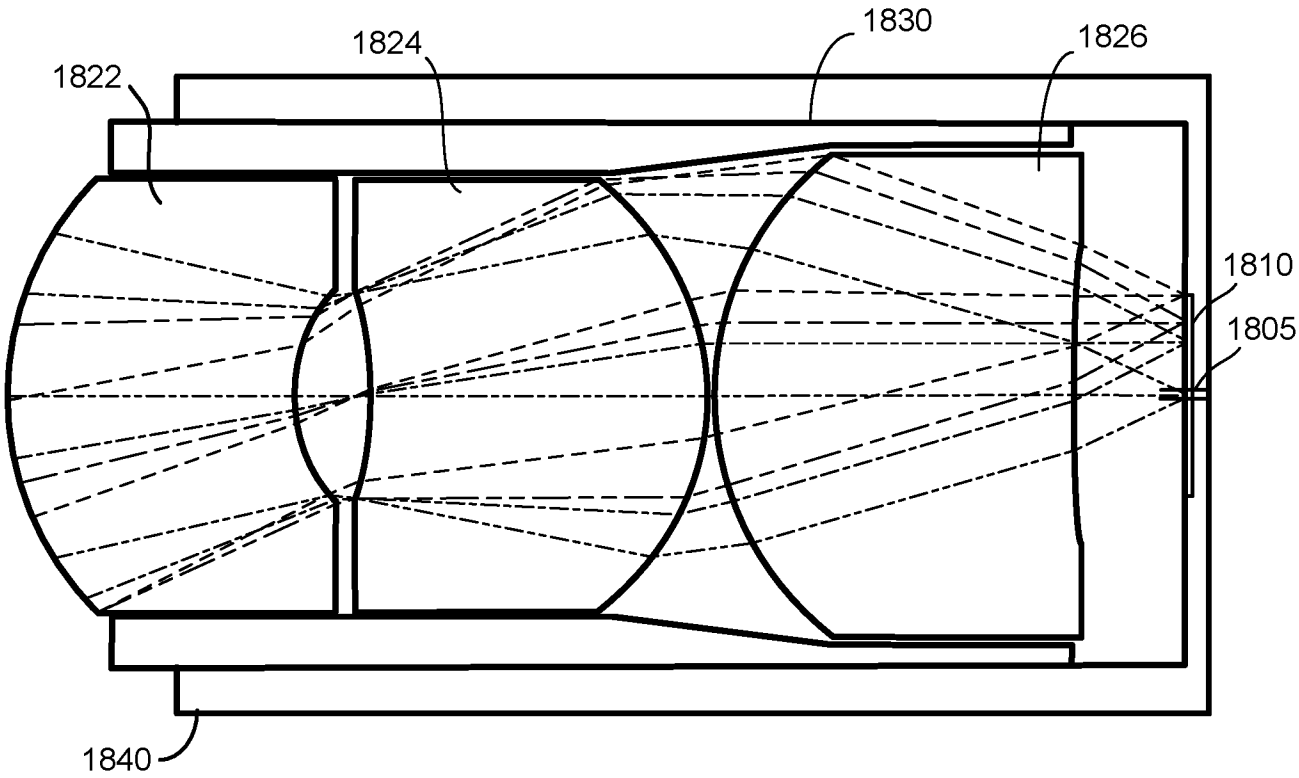


FIG. 18

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ROTATING LIGHT RANGING SYSTEM WITH OPTICAL COMMUNICATION UPLINK AND DOWNLINK CHANNELS

As the below named inventor, I hereby declare that:

This declaration is directed to:

- [■] The attached application, or
- [ ] United States application or PCT international application number _____

  filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

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LEGAL NAME OF INVENTOR

Inventor: Angus PACALA Date (Optional): 12/3/2018

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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- [x] The attached application, or
- [ ] United States application or PCT international application number _____

  filed on _____.

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LEGAL NAME OF INVENTOR

Inventor: Mark FRICHTL Date (Optional): 2018-12-03

Signature: Mark Frichtl

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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LEGAL NAME OF INVENTOR

Inventor: Marvin SHU Date (Optional): 12/3/2018

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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This declaration is directed to:

- [■] The attached application, or
- [ ] United States application or PCT international application number _____ filed on _____.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Eric YOUNGE Date (Optional): 2018-12-4

Signature: Eric Younge

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM
First Named Inventor/Applicant Name:	ANGUS PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P010US3C2-1252983

Filed as Small Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	80	80
UTILITY SEARCH FEE	2111	1	350	350
UTILITY EXAMINATION FEE	2311	1	400	400
REQUEST FOR PRIORITIZED EXAMINATION	2817	1	2100	2100
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	2202	5	50	250
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	2830	1	70	70

Petition:	
Patent-Appeals-and-Interference:	
Post-Allowance-and-Post-Issuance:	
Extension-of-Time:	
Miscellaneous:	
Total in USD ($)	**3250**

Electronic Acknowledgement Receipt

EFS ID:	42757877
Application Number:	17323987
International Application Number:	
Confirmation Number:	9133
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM
First Named Inventor/Applicant Name:	ANGUS PACALA
Customer Number:	20350
Filer:	William Leland Shaffer/LaRenda Meyer
Filer Authorized By:	William Leland Shaffer
Attorney Docket Number:	103033-P010US3C2-1252983
Receipt Date:	18-MAY-2021
Filing Date:	
Time Stamp:	20:15:42
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$3250
RAM confirmation Number	E20215HK16210047
Deposit Account	201430
Authorized User	LaRenda Meyer

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS-P010US3C2-1252983.pdf	1792201 0eb91d9d112c70f4eb8146dced1d935b6ebb47ff	no	9
Warnings:					
Information:					
2	TrackOne Request	TrackOneRequest.pdf	146374 ca5f0d0ada855a4e37dcfb132a7f3d2eb2e9f64e	no	2
Warnings:					
Information:					
3		IDS-P010US3C2-1252983.pdf	311427 a0cb513defc6d68be79dd4e3a71fc70ea939f2e3	yes	11

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Information Disclosure Statement (IDS) Form (SB08)	4	11
	Transmittal Letter	1	3

Warnings:					
Information:					
4		patent-application-P010US3C2.pdf	359419 f623018fc634ad101d55a9d3f61037bd85a0b47d	yes	81

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Abstract	81	81
	Claims	73	80

	Specification		1	72	
Warnings:					
Information:					
5	Drawings-other than black and white line drawings	Drawings-as-filed-parent.pdf	278520 aba0d8a36429eaafdd6bf2eb36555aca23639493	no	18
Warnings:					
Information:					
6	Oath or Declaration filed	SIGNED-Declarations-from-parent.pdf	5498399 1a79927b32f3f4268d89061d498b646c7f6979cd	no	5
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	41449 33f7eec62fb00e82e635c520009d6e87d687b6c5	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	8427789		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Angus		Pacala	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
San Francisco	CA	US

Mailing Address of Inventor:

Address 1	350 Treat Avenue
Address 2	
City	San Francisco
State/Province	CA
Postal Code	94103
Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Mark		Frichtl	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	State/Province	Country of Residence
San Francisco	CA	US

Mailing Address of Inventor:

Address 1	350 Treat Avenue
Address 2	
City	San Francisco
State/Province	CA
Postal Code	94103
Country	US

Inventor 3 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Marvin		Shu	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

City	Daly City	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	350 Treat Avenue
Address 2	

City	San Francisco	State/Province	CA
Postal Code	94103	Country	US

Inventor 4 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Eric		Younge	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Portola Valley	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	350 Treat Avenue
Address 2	

City	San Francisco	State/Province	CA
Postal Code	94103	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	20350		
Email Address	ipefiling@kilpatricktownsend.com	Add Email	Remove Email

Application Information:

Title of the Invention	ROTATING COMPACT LIGHT RANGING SYSTEM		
Attorney Docket Number	103033-P010US3C2-1252983	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	18	Suggested Figure for Publication (if any)	

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Approved for use through 04/30/2017. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	20350		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16/209,875	2018-12-04

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Ouster, Inc.		
Mailing Address Information For Applicant:			
Address 1	350 Treat Avenue		
Address 2			
City	San Francisco	**State/Province**	CA
Country	US	Postal Code	94103
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

PTO/AIA/14 (11-15)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Ouster, Inc.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	350 Treat Avenue		
Address 2			
City	San Francisco	**State/Province**	CA
Country i	US	Postal Code	94103
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/ William L. Shaffer /			Date (YYYY-MM-DD)	2021-05-18
First Name	William	Last Name	Shaffer	Registration Number	37234

Additional Signature may be generated within this form by selecting the Add button. Add

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	103033-P010US3C2-1252983
	Application Number	
Title of Invention	ROTATING COMPACT LIGHT RANGING SYSTEM	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Angus PACALA	Nonprovisional Application Number (if known):	
Title of Invention:	ROTATING COMPACT LIGHT RANGING SYSTEM		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ **Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)**

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, or the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ **Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)**

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature / William L. Shaffer /	Date 2021-05-18
Name (Print/Typed) William Shaffer	Practitioner Registration Number 37234

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☐ *Total of _____ forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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SCORE Placeholder Sheet for IFW Content

Application Number: 17323987 Document Date: 05/18/2021

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

- Drawing

At the time of document entry (noted above):

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Form Revision Date: March 1, 2019