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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	11/16/2021	11175405	103033-P006US3-1086284	9761

20350 7590 10/27/2021

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 612 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 Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) 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, San Francisco, CA;

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

Ouster, Inc., San Francisco, CA;

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

PTOSB08a (01-10)
Approved for use through 07312012. 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	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

	121	20160047897	A1	02-18-2016	Dussan	
	122	20160047898	A1	02-18-2016	Dussan	
	123	20160047899	A1	02-18-2016	Dussan	
	124	20160047900	A1	02-18-2016	Dussan	
	125	20160047903	A1	02-18-2016	Dussan	
	126	20160097858	A1	04-07-2016	Mundhenk, et al.	
	127	20160218727	A1	07-28-2016	Maki	
	128	20160265902	A1	09-15-2016	Nawasra, et al.	
	129	201602911434	A1	10-16-2016	Droz, et al.	
	130	20160306032	A1	10-20-2016	Schwarz, et al.	
	131	20160328619	A1	11-10-2016	Yi, et al.	
Change(s) applied to document, /K.S.S./ 6/18/2021	132	20170219426	A1	08-03-2017	~~Ouster, Inc.~~ Pacala et al.	
	133	20090295910	A1	12/03/2009	Mir Jose et al.	
	134	20100020306	A1	01/28/2010	Hall David S.	
	135	20100123893	A1	05/20/2010	YanQ DezhonQ	
	136	20110032398	A1	02/10/2011	Lenchenkov Victor	
	137	20110216304	A1	09/08/2011	Hall David S.	
	138	20120154914	A1	06/21/2012	MoriQuchi Chihiro et al.	
	139	20120182464	A1	07/19/2012	Shpunt Alexander et al.	
	140	20140211194	A1	07/31/2014	Pacala Angus et al.	
	141	20150192677	A1	07/09/2015	Yu Tianyue et al.	
	142	20150293224	A1	10/15/2015	Eldada Louay et al.	
	143	20150378241	A1	12/31/2015	Eldada Louay	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

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	Application Number	15/979,266
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	Attorney Docket Number	103033-P006US3-1086284

	75	20030047752	A1	03-2003	Campbell Joe C.	
	76	20040223071	A1	11-2004	Wells David	
	77	20050030409	A1	02-2005	Matherson Kevin J.	
	78	20060244851	A1	11-2006	Cartlidge; Andrew G.	
	79	20070007563	A1	01-2007	Mouli; Chandra	
	80	20080153189	A1	06-2008	Plaine; Glenn-Yves	
	81	20090016642	A1	01-2009	Hart; Douglas P.	
	82	20090040629	A1	02-2009	Bechtel; Jon H.	
	83	20100110275	A1	05-2010	Mathieu; Gilles	
Change(s) applied to document, /K.S.S./ 6/18/2021	84	20110037849	A1	02-2011	~~NICLA88; Cristiano~~	Niclass
	85	20130300840	A1	11-2013	Borowski; Andre	
	86	20140269796	A1	09-2014	Geske; Jonathan	
	87	20160327779	A1	11-2016	Hillman; Elizabeth	
	88	20170289524	A1	10-2017	Pacala Angus	
	89	20070060806	A1	~~07-03-15~~	Hunter et al.	03/2007
	90	20070228262	A1	~~07-10-04~~	Cantin et al.	10/2007
	91	20100204964	A1	08-12-2010	Pack, et al.	
	92	20110025843	A1	02-03-2011	Oggier, et al.	
	93	20110116262	A1	05-19-2011	Marson	
	94	20120044476	A1	02-23-2012	Earnhart, et al.	
	95	20120140109	A1	06-07-2012	Shpunt, et al.	
	96	20120287417	A1	11-15-2012	Mimeault	
	97	20130044310	A1	02-21-2013	Mimeault	

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Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

Change(s) applied to document, /K.S.S./ 6/18/2021

	26	7969558	B2	~~01/03/2012~~ 06/2011	Hall, David S.	
	27	8089618	B2	12/11/2012	Yang, Dezhong	
	28	8330840	B2	~~05/06/2014~~ 12/2012	Lenchenkov, Victor	
	29	8717488	B2	~~03/15/2016~~ 05/2014	Shpunt, Alexander, et al.	
	30	9285477	B1	07/05/2016	Smith, Scott T., et al.	
	31	9383753	B1	~~11/09/1982~~ 07/2016	Templeton, Bradley, et al.	
	32	6721262	B1	Apr 13 2004	Jordache et al.	
	33	7433042	B1	Oct 7 2008	Cavanaugh et al.	
	34	8384997	B2	02-26-2013	Shpunt, et al.	
	35	8494252	B2	07-23-2013	Freedman, et al.	
	36	8675181	B2	03-18-2014	Hall	
	37	8742325	B1	06-03-2014	Droz, et al.	
	38	8743176	B2	06-03-2014	Stettner, et al.	
	39	8761495	B2	06-14-2014	Freedman, et al.	
	40	8767190	B2	07-01-2014	Hall	
	41	8829406	B2	09-09-2014	Akerman, et al.	
	42	8836922	B1	09-16-2014	Pennecot, et al.	
	43	8848039	B2	09-30-2014	Spektor, et al.	
	44	9041915	B2	05-26-2015	Earnhart, et al.	
	45	9063549	B1	06-23-2015	Pennecot, et al.	
	46	9071763	B1	06-30-2015	Templeton, et al.	
	47	9086273	B1	07-21-2015	Gruver, et al.	
	48	9111444	B2	08-18-2015	Kaganovich	
	49	9157790	B2	10-13-2015	Shpunt, et al.	
	50	9164511	B1	10-20-2015	Ferguson, et al.	
	51	9176051	B2	11-03-2015	Mappes, et al.	
	52	9229109	B2	01-05-2016	Stettner, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

PTOSB08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

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	4634272	A	1987-01-06	Endo	
	2	4676599	A	1987-06-30	Cruz	
	3	4702600	A	1987-10-27	Handrich, et al.	
	4	4358851	A	07-25-1989	Scifres, Donald R., et al.	
	5	4744667	A	1988-05-17	Fay, et al.	
	6	5982552	A	Nov 9, 1999	Nakama et al.	
	7	6133989	A	2000-10-17	Stettner, et al.	
	8	6414746	B1	2004-02-10	Stettner, et al.	
	9	6690019	B2	2004-02-10	Stettner, et al.	
	10	6721262	B1	Apr 13, 2004	Jordache et al.	
	11	7433042	B1	Oct 7, 2008	Cavanaugh et al.	
	12	7091462	B2	2006-08-15	Wilson, et al.	
	13	D531525	S1	11-07-2006	Dold, et al.	
	14	7170542	B2	01-30-2007	Hanina, et al.	
	15	7295298	B2	11-13-2007	Willhoeft, et al.	
	16	7345271	B2	03-18-2008	Boehlau, et al.	
	17	7421159	B2	09-02-2008	Yang, et al.	
	18	7808706	B2	10-05-2010	Fadel, et al.	
	19	8013983	B2	09-06-2011	Lin, et al.	
	20	8130367	B2	03-06-2012	Stettner, et al.	
	21	D659030	S1	05-08-2012	Anselment, et al.	
	22	8319949	B2	11-27-2012	Cantin, et al.	
	23	8374405	B2	02-12-2013	Lee, et al.	
	24	4851664		~~02-22-1994~~ 07/1989	Rieger, Harry	
	25	5288992	A	~~08/23/2011~~ 02/1994	Fohl, Timothy	

Change(s) applied to document,
/K.S.S./
6/18/2021

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PTO/SB/47 (03-09)
Approved for use through 05/31/2015. OMB 0651-0016
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Fax to:
571-273-6500

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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
	15/979,266

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)

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Requester's telephone number

☐ Assignee recorded at Reel _____ Frame_____

October 12, 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.
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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.
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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.
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:	15979266
Filing Date:	14-May-2018
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
First Named Inventor/Applicant Name:	Angus PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P006US3-1086284

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:	44024348
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	13-OCT-2021
Filing Date:	14-MAY-2018
Time Stamp:	18:30:11
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	E20210CI30580628
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	Issue Fee Payment (PTO-85B)	P006US3-Issue-fee-transmittal.pdf	95226 bfb65806d0297c1e9450509bb6509e35060ba2ee	no	1
Warnings:					
Information:					
2	Maintenance Fee Address Change	P006US3-Fee-address-form.pdf	205970 1bc738e6b08d0873b6bf1c74f0aa4481dc906d54	no	2
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	38088 280ee62e9abf2eb09baf6a1087540484fd6318bd	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	339284		

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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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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 09/30/2021

Kilpatrick Townsend & Stockton LLP - West Coast
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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)
/LMeyerJ/	(Signature)
10-13-2021	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

TITLE OF INVENTION: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

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	12/30/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
ASKARIAN, AMIR J	3645	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 & Stockton LLP
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)
OUSTER, INC.	SAN FRANCISCO, CA

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. 201430

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 October 12, 2021

Typed or printed name William L Shaffer Registration No. 37,234

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

20350 7590 09/30/2021

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

EXAMINER
ASKARIAN, AMIR J

ART UNIT	PAPER NUMBER
3645	

DATE MAILED: 09/30/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

TITLE OF INVENTION: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

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	12/30/2021

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 09/30/2021

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.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

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nonprovisional	SMALL	$600	$0.00	$0.00	$600	12/30/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
ASKARIAN, AMIR J	3645	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)

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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
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Suite 2800
Atlanta, GA 30309

EXAMINER	
ASKARIAN, AMIR J	
ART UNIT	PAPER NUMBER
3645	

DATE MAILED: 09/30/2021

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.

HESAI EX1002, P.15

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. 15/979,266	Applicant(s) PACALA et al.	
	Examiner AMIR J ASKARIAN	Art Unit 3645	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 Claims filed 09/21/2021.
   ☐ 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 See Continuation Sheet . 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. 20210602.
5. ☑ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/A.J.A./ Examiner, Art Unit 3645	/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645

Continuation of 3. The allowed claim(s) is/are: 1-5,7-12,14-17 and 19-37

DETAILED ACTION

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.

Examiner's Amendment

Authorization for this examiner's amendment was given by Bill Shaffer on September 22, 2021.

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 application has been amended as follows:

In Claim 35, Line 4, "having non-overlapping the fields of view" has been changed to:

--having non-overlapping fields of view--.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMIR J ASKARIAN whose telephone number is (571)272-1246. The examiner can normally be reached on M-Th 7:30am-5:30pm.

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, Yuqing Xiao can be reached on (571) 270-3603. 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.

/A.J.A./
Examiner, Art Unit 3645

/YUQING XIAO/
Supervisory Patent Examiner, Art Unit 3645

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

CPC - Searched*		
Symbol	**Date**	**Examiner**
G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801 limited with text	02/12/2021	aa
		aa

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P.31

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR G02B19/0014 OR G02B19/0019 OR G02B19/0052 OR G02B19/0057 OR G02B19/0061 OR G02B19/0066 OR G02B21/0032 OR G02B21/0052 OR G02B21/0096 OR G02B21/361 OR G02B21/367 OR G02B23/04 OR G02B26/00 OR G02B26/085 OR G02B26/127 OR G02B27/0025 OR G02B27/0075 OR G02B27/09 OR G02B27/0966 OR G02B27/0977 OR G02B27/10 OR G02B27/1066 OR G02B27/12 OR G02B27/123 OR G02B27/143 OR G02B27/4244 OR G02B27/425 OR G02B27/4272 OR G02B27/4277 OR G02B3/0037 OR G02B3/06 OR G02B5/021 OR G02B5/09 OR G02B5/10 OR G02B5/1814 OR G02B5/1819 OR G02B5/1842 OR G02B6/003 OR G02B6/0036 OR G02B6/0046 OR G02B6/005 OR G02B6/04 OR G02B6/06 OR G02B6/12007 OR G02B6/29356 OR G02B6/29368 OR G02B6/368 OR G02B6/4214 OR G02B6/4225 OR G02B6/4298 OR G02B7/026 OR G02B9/64 OR G06T7/521 OR G06T2207/10004 OR G06T2207/10028 OR G06T2207/10024 OR G06T7/194 OR G06T15/00 OR G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204	02/12/2021	

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P.32

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285) limited with text		
updated search	06/04/2021	aa
updated search	09/22/2021	aa

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* 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**
ip.com search, google patents search, npl search: google scholar, ieee explore, inventor/assignee search, classification search limited with text	02/12/2021	aa
updated search, consulted Luke Ratcliffe re allowable subject matter	06/04/2021	aa
updated search	09/22/2021	aa

/A.J.A./ Examiner, Art Unit 3645	

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	((((hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross))) AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)).clm.	09/22/2021	aa

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1003 P.34

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

CPC						
Symbol					**Type**	**Version**
G01S	/	17	/	10	F	2013-01-01
G02B	/	27	/	30	I	2013-01-01
G01S	/	7	/	486	I	2013-01-01
G02B	/	27	/	0037	I	2013-01-01
G02B	/	27	/	0955	I	2013-01-01
G01S	/	17	/	42	I	2013-01-01
G01S	/	7	/	4816	I	2013-01-01
G01S	/	7	/	4863	I	2013-01-01
G01S	/	7	/	4865	I	2013-01-01
H01L	/	31	/	02325	I	2013-01-01
H01L	/	31	/	02162	I	2013-01-01
H01L	/	31	/	02164	I	2013-01-01
G01S	/	17	/	931	I	2020-01-01
G01S	/	17	/	89	I	2013-01-01
H01L	/	27	/	14643	I	2013-01-01
H01L	/	31	/	02027	I	2013-01-01
G01S	/	7	/	4813	I	2013-01-01
G01S	/	7	/	4815	I	2013-01-01
G01S	/	7	/	4817	I	2013-01-01
G01S	/	17	/	08	I	2013-01-01
H04B	/	10	/	503	I	2013-01-01
H04B	/	10	/	675	I	2013-01-01
H04B	/	10	/	6973	I	2013-01-01
H04B	/	10	/	801	I	2013-01-01
H01L	/	27	/	1446	I	2013-01-01
H01L	/	31	/	02165	I	2013-01-01
H01L	/	31	/	02327	I	2013-01-01
H01L	/	31	/	107	I	2013-01-01
G02B	/	5	/	205	A	2013-01-01

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	22 September 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	24 September 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

CPC Combination Sets					
Symbol		**Type**	**Set**	**Ranking**	**Version**
	/		/					

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	22 September 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	24 September 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G01S	/	17	/	10

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	22 September 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	34	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	24 September 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

☐ 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	1	9	10	18	19	25	28	34	37						
2	2	10	11	19	20	26	29								
3	3	11	12	20	21	27	30								
4	4	-	13	15	22	28	31								
5	5	12	14	16	23	29	32								
-	6	13	15	21	24	30	33								
6	7	14	16	22	25	31	34								
7	8	17	17	23	26	32	35								
8	9	-	18	24	27	33	36								

/AMIR J ASKARIAN/ Examiner, Art Unit 3645 (Assistant Examiner)	22 September 2021 (Date)	**Total Claims Allowed:** 34	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645 (Primary Examiner)	24 September 2021 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 2

Search History

Report Run Date: 2021-09-22 UTC
Queries: 2
Markers: 0

Query #	Timestamp	Results	Page
1	2021-09-22 19:01 UTC	38,396,229	3
2	2021-09-22 19:02 UTC	1,527,894	4

Content: Patents + NPL (187)

US Patents | US Designs | US Applications | EPO Patents | EPO Applications | China Patents | China Applications | Japan Patents | Japan Applications | Korea Patents | Korea Applications | WIPO Applications | Argentina Patents | Argentina Applications | Brazil Patents | Brazil Applications | Canada Patents | Canada Applications | Chile Patents | Chile Applications | Colombia Applications | Costa Rica Applications | Cuba Patents | Cuba Applications | Dominican Republic Applications | Ecuador Patents | Ecuador Applications | El Salvador Applications | Guatemala Applications | Honduras Applications | Mexico Patents | Mexico Applications | Nicaragua Patents | Panama Applications | Peru Applications | Trinidad & Tobago Patents | Uruguay Applications | Austria Patents | Austria Applications | Belarus Patents | Belgium Patents | Belgium Applications | Bosnia & Herzegovina Patents | Bosnia & Herzegovina Applications | Bulgaria Patents | Bulgaria Applications | Croatia Patents | Croatia Applications | Czech Republic Patents | Czech Republic Applications | Czechoslovakia Patents | Czechoslovakia Applications | Denmark Patents | Denmark Applications | Estonia Patents | Estonia Applications | EUIPO Patents | Finland Patents | Finland Applications | France Patents | France Applications | Germany Patents | Germany Applications | Great Britain Patents | Great Britain Applications | Greece Patents | Greece Applications | Hungary Patents | Hungary Applications | Iceland Patents | Iceland Applications | Ireland Patents | Ireland Applications | Italy Patents | Italy Applications | Latvia Patents | Latvia Applications | Lithuania Patents | Lithuania Applications | Luxembourg Patents | Malta Patents | Monaco Patents | Montenegro Patents | Montenegro Applications | Netherlands Patents | Netherlands Applications | Norway Patents | Norway Applications | Poland Patents | Poland Applications | Portugal Patents | Portugal Applications | Republic of Moldova Patents | Republic of Moldova Applications | Romania Patents | Romania Applications | San Marino Patents | San Marino Applications | Serbia Patents | Serbia Applications | Slovakia Patents | Slovakia Applications | Slovenia Patents | Spain Patents | Spain Applications | Sweden Patents | Sweden Applications | Switzerland Patents | Switzerland Applications | Ukraine Patents | Yugoslavia/Serbia and Montenegro Patents | Yugoslavia/Serbia and Montenegro Applications | Armenia Patents | Australia Patents | Australia Applications | Cyprus Patents | Gulf Cooperation Council Patents | Hong Kong Patents | India Patents | India Applications | Indonesia Patents | Indonesia Applications | Israel Applications | Jordan Patents | Kyrgyzstan Patents | Macao Applications | Malaysia Patents | Mongolia Patents | New Zealand Patents | Philippines Patents | Philippines Applications | Saudi Arabia Patents | Singapore Patents | Singapore Applications | Taiwan Patents | Taiwan Applications | Tajikistan Patents | Tajikistan Applications | Thailand Applications | Uzbekistan Patents | Vietnam Patents | Algeria Patents | ARIPO Patents | ARIPO Applications | Egypt Patents | Kenya Patents | Malawi Patents | Morocco Patents | Morocco Applications | OAPI Patents | South Africa Patents | Tunisia Applications | Zambia Patents | Zimbabwe Patents | EAPO Patents | EAPO Applications | Georgia Patents | Georgia Applications | Kazakhstan Patents | Kazakhstan Applications | Russia Patents | Russia Applications | Turkey Patents | Turkey Applications | IEEE Xplore Publications: IEEE Periodicals | IEEE Xplore Publications: IEEE Conferences | IEEE Xplore Publications: IEEE Standards | IEEE Xplore Publications: IEEE Early Access | IEEE Xplore Publications: SMPTE Periodicals | IEEE Xplore Publications: SMPTE Conferences | IEEE Xplore Publications: SMPTE Standards | IEEE Xplore Publications: MIT Press eBooks | IEEE Xplore Publications: Wiley-IEEE eBooks | IEEE Xplore Publications: IBM Periodicals | IEEE Xplore Publications: URSI Periodicals | IEEE Xplore Publications: VDE Conferences | IEEE Xplore Publications: Periodicals from China | IP.com Prior Art Database: The IP.com Journal | IP.com Prior Art Database: Internet Society RFC | IP.com Prior Art Database: IBM TDB Archive | IP.com Prior Art Database: Legacy Journals | IP.com Prior Art Database: Software Patent Institute | OnePetro.org: Periodicals at OnePetro.org | OnePetro.org: Conferences at OnePetro.org | Other Literature: IBM Redbooks | Other Literature: PubMed Central | Other Literature: arXiv.org

1 **2021-09-22 19:01 UTC | 38,396,229 results from**

De-Dup: None | **Cut-off:** None | **Sort:** Relevance

Main Concept: Document

US20180329061 Spinning lidar unit with micro-optics aligned behind stationary window (view)

Concept Modifiers: None

Filters: None

2 **2021-09-22 19:02 UTC | 1,527,894 results from**

De-Dup: None | **Cut-off:** None | **Sort:** Relevance

Main Concept: Same as Query 1

Concept Modifiers (1):
1. More Like Text: aperture layer

Filters: None

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 pages	

EXAMINER SIGNATURE

Examiner Signature /AMIR J ASKARIAN/		Date Considered 09/22/2021	

*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. /A.J.A./

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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Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284

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.

☐ 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)	2021-09-21
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. /A.J.A./

Bibliographic Data

Application No: 15/979,266

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /AMIR J ASKARIAN/ Examiner's Signature | Initials

Title: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
05/14/2018	356	3645	103033-P006US3-1086284
RULE			

APPLICANTS

Ouster, Inc., San Francisco, CA, UNITED STATES

INVENTORS

Angus PACALA, San Francisco, CA, UNITED STATES

Mark FRICHTL, San Francisco, CA, UNITED STATES

Marvin SHU, San Francisco, CA, UNITED STATES

CONTINUING DATA

This application has PRO of 62515291 06/05/2017

This application has PRO of 62506437 05/15/2017

This application has PRO of 62506449 05/15/2017

This application has PRO of 62506445 05/15/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

06/12/2018

** SMALL ENTITY **

STATE OR COUNTRY

UNITED STATES

ADDRESS

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

FILING FEE RECEIVED

$865

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on August 19, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033-1086284-P006US3
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Amir J Askarian
Application No.: 15/979,266	Technology Center/Art Unit: 3645
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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 of a first Office Action (after or concurrently with) the filing of a Request for Continued Examination under 37 CFR §1.114. Therefore, under 37 CFR §1.97(b)(4), Applicant believes that ***no fee*** is required for submission of this statement. However, if any 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 /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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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First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284

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	11086013		Aug 10, 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

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]
	2	Application No 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 pages	
	3	Application No 15/979,277, Notice of Allowance, May 24, 2021, 7 pages	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	09/22/2021

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

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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.

☐ 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)	2021-08-19
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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Search Strategy

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Set#	Searched for	Results
S1	(((hole or opening or aperture or gap or slit) near/5 (layer or array)) near/15 (stop or opaque)) near/40 ((reduc[*3] or decreas[*3]) near/4 ((crosstalk or cross) or noise or background or back pre/0 ground or ambient))	1°
S2	(hole or opening or aperture or gap or slit) near/5 (layer or array) and (reduc[*3] or decreas[*3]) near/4 ((crosstalk or cross) or noise or background or back pre/0 ground or ambient)	19631*
S3	S2 and (lidar or ladar)	605°
S4	((((array or multiple or plurality) near/15 (laser or source or transmitter)) near/15 corresponding) near/15 (receiver or detector)) near/40 (hole or opening or aperture or gap or slit)	72°
S5	((((array or multiple or plurality) near/15 (laser or source or transmitter)) near/15 corresponding) near/15 (receiver or detector))	1415°

S6	S3 and S5	3°

* Duplicates are removed from the search, but included in the result count.

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First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284

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 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 pages	

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

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L148	2	"20180329061".pn.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
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L150	2117	("OUSTER, INC.".ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L151	2117	(OUSTER.ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2021/09/21 03:16 PM

		OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	IBM_TDB)				
L152	192	("20120170029" OR "20130325241" OR "20140111812" OR "20160282468" OR "20180180720" OR "20180284228" OR "20180286909" OR "20180191967" OR "20180136321" OR "10066990" OR "10222475" OR "10663586" OR "20150260830" OR "20180109061" OR "20180118041" OR "20180123412" OR "6433934" OR "7196301" OR "9366573" OR "9882433" OR "9917423" OR "9935514" OR "D531525" OR "20110266022" OR "20140224792" OR "5084596" OR "8633384" OR "10063849" OR "10183541" OR "10222458" OR "20180299554" OR "20190041498" OR "9551791" OR "9989406" OR "9992477" OR "20050035474" OR "20150055117" OR "5745153" OR "20180059222" OR "20180152691" OR "20180209841" OR "20180217236" OR "20030006676" OR "20030047752" OR "20040061502" OR "20040223071" OR "20050030409" OR "20060244851" OR "20070007563" OR "20070060806" OR "20070228262" OR "20080153189" OR "20090016642" OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		"20090040629" OR "20090179142" OR "20090295910" OR "20100008588" OR "20100020306" OR "20100110275" OR "20100123893" OR "20100204964" OR "20110025843" OR "20110032398" OR "20110037849" OR "20110116262" OR "20110216304" OR "20120044476" OR "20120140109" OR "20120154914" OR "20120182464" OR "20120287417" OR "20120320164" OR "20130044310" OR "20130141549" OR "20130206967" OR "20130294089" OR "20130300840" OR "20140118335" OR "20140118493" OR "20140153001" OR "20140158900" OR "20140168631" OR "20140176933" OR "20140211194" OR "20140269796" OR "20140285628" OR "20140291491" OR "20140313519" OR "20140375977" OR "20140376092" OR "20150002636" OR "20150131080" OR "20150184999" OR "20150192677" OR "20150292948" OR "20150293224" OR "20150316473" OR "20150355470" OR "20150358601" OR "20150378241" OR "20150379371" OR "20160003946" OR "20160047895" OR "20160047896" OR "20160047897" OR "20160047898" OR "20160047899" OR "20160047900" OR "20160047901" OR "20160047903" OR "20160049765" OR					

		"20160097858" OR "20160150963" OR "20160161600" OR "20160218727" OR "20160265902" OR "20160291134" OR "201602911434" OR "20160306032" OR "20160327779" OR "20160328619" OR "20170146640" OR "20170219426" OR "20170219695" OR "20170269197" OR "20170269198" OR "20170269209" OR "20170269215" OR "20170289524" OR "20170350983" OR "4358851" OR "4634272" OR "4676599" OR "4702600" OR "4744667" OR "4851664" OR "5267016" OR "5288992" OR "5982552" OR "6014232" OR "6133989" OR "6255133" OR "6374024" OR "6414746" OR "6690019" OR "6721262" OR "7091462" OR "7170542" OR "7295298" OR "7345271" OR "7421159" OR "7433042" OR "7808706" OR "7969558" OR "8013983" OR "8089618" OR "8130367" OR "8319949" OR "8330840" OR "8374405" OR "8384997" OR "8494252" OR "8675181" OR "8717488" OR "8742325" OR "8743176" OR "8761495" OR "8767190" OR "8829406" OR					

		"8836922" OR "8848039" OR "9041915" OR "9063549" OR "9071763" OR "9086273" OR "9111444" OR "9157790" OR "9164511" OR "9176051" OR "9229109" OR "9285464" OR "9285477" OR "9299731" OR "9368936" OR "9369689" OR "9383753" OR "9425654" OR "9435891" OR "9470520" OR "9489601" OR "9525863" OR "9529079" OR "D659030").pn.					
L153	1148	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L154	29	(3 OR 4) AND 6	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L155	82	(3 OR 4) AND 2	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L156	188	2 AND 6	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L157	19	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L158	54	(array OR multiple OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21

		plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) AND ((Micro ADJ optical OR micro ADJ lens OR microlens) near2 array)					03:16 PM
L159	269087	(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR					

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		G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204 OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285).cpc.					
L160	10731	((light OR laser OR beam OR optic$2) NEAR3 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3 OR diode)) WITH (bulk common) near3 (optic$3 lens collimat$3)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L161	768	13 AND (multiple plurality different second) near4 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3) near4	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		(channel route band)					
L162	184	14 AND 12	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L163	134	15 NOT (9 OR 8 OR 7 OR 5)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L164	53	14 AND ((bulk common) near3 (optic$3 lens collimat$3)) near6 (coincident$3 coincid$3 match$3)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L165	1	"20180267148".pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L166	16	((US-10183541-B2 OR US-9917423-B2).did. AND USPT.dbnm.) OR ((US-20180191967-A1 OR US-20180180720-A1 OR US-20180136321-A1 OR US-20180267151-A1 OR US-20190369258-A1 OR US-20190312636-A1 OR US-20190223729-A1 OR US-20180167602-A1 OR US-20140320843-A1 OR US-20130182320-A1 OR US-20070273957-A1 OR US-20070013872-A1 OR US-20040061917-A1 OR US-20180267148-A1).did. AND PGPB.dbnm.)	(USPAT; US-PGPUB; FPRS; USOCR; IBM_TDB; EPO; JPO; DERWENT; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO))	OR	ON	ON	2021/09/21 03:16 PM
L167	169	((hemispheric$3 (hemi ADJ spheric$3)) near2 lens) near5 filter	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L168	28	20 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L169	428	((biconic$3 cylindr$4) near2 lens) near5 aberration$2 near5 (correct$3 compensat$4)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L170	115	22 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2021/09/21 03:16 PM

			IBM_TDB)				
L171	248	(detect$3 sens$4) WITH apertur$3 WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L172	119	22 AND (12 OR 2)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L173	49	24 AND (12 OR 2)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L174	23	(detect$3 sens$4) WITH apertur$3 WITH filter WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L175	267	(detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L176	8	(positive near5 value near5 pulse near5 code) WITH (intensity power)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L177	46	14 AND (filter WITH micro WITH lens WITH (aperture openning window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L178	47	14 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L179	65	6 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L180	76	6 AND (control near5 (start begin initiat$3) near5 (stop end shut))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L181	2	"20180329061".pn.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR,	OR	ON	ON	2021/09/21 03:16 PM

			WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L182	254164	(G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801).cpc. OR (G01S17/10 OR G01S7/486 OR G02B27/00 OR G02B27/09 OR G02B27/30).ipc.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L183	2117	("OUSTER, INC.".ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L184	2117	(OUSTER.ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L185	192	("20120170029" OR "20130325241" OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		"20140111812" OR "20160282468" OR "20180180720" OR "20180284228" OR "20180286909" OR "20180191967" OR "20180136321" OR "10066990" OR "10222475" OR "10663586" OR "20150260830" OR "20180109061" OR "20180118041" OR "20180123412" OR "6433934" OR "7196301" OR "9366573" OR "9882433" OR "9917423" OR "9935514" OR "D531525" OR "20110266022" OR "20140224792" OR "5084596" OR "8633384" OR "10063849" OR "10183541" OR "10222458" OR "20180299554" OR "20190041498" OR "9551791" OR "9989406" OR "9992477" OR "20050035474" OR "20150055117" OR "5745153" OR "20180059222" OR "20180152691" OR "20180209841" OR "20180217236" OR "20030006676" OR "20030047752" OR "20040061502" OR "20040223071" OR "20050030409" OR "20060244851" OR "20070007563" OR "20070060806" OR "20070228262" OR "20080153189" OR "20090016642" OR "20090040629" OR "20090179142" OR "20090295910" OR "20100008588" OR "20100020306" OR "20100110275" OR "20100123893" OR					

		"20100204964" OR "20110025843" OR "20110032398" OR "20110037849" OR "20110116262" OR "20110216304" OR "20120044476" OR "20120140109" OR "20120154914" OR "20120182464" OR "20120287417" OR "20120320164" OR "20130044310" OR "20130141549" OR "20130206967" OR "20130294089" OR "20130300840" OR "20140118335" OR "20140118493" OR "20140153001" OR "20140158900" OR "20140168631" OR "20140176933" OR "20140211194" OR "20140269796" OR "20140285628" OR "20140291491" OR "20140313519" OR "20140375977" OR "20140376092" OR "20150002636" OR "20150131080" OR "20150184999" OR "20150192677" OR "20150292948" OR "20150293224" OR "20150316473" OR "20150355470" OR "20150358601" OR "20150378241" OR "20150379371" OR "20160003946" OR "20160047895" OR "20160047896" OR "20160047897" OR "20160047898" OR "20160047899" OR "20160047900" OR "20160047901" OR "20160047903" OR "20160049765" OR "20160097858" OR "20160150963" OR "20160161600" OR "20160218727" OR "20160265902" OR "20160291134" OR "201602911434" OR					

		"20160306032" OR "20160327779" OR "20160328619" OR "20170146640" OR "20170219426" OR "20170219695" OR "20170269197" OR "20170269198" OR "20170269209" OR "20170269215" OR "20170289524" OR "20170350983" OR "4358851" OR "4634272" OR "4676599" OR "4702600" OR "4744667" OR "4851664" OR "5267016" OR "5288992" OR "5982552" OR "6014232" OR "6133989" OR "6255133" OR "6374024" OR "6414746" OR "6690019" OR "6721262" OR "7091462" OR "7170542" OR "7295298" OR "7345271" OR "7421159" OR "7433042" OR "7808706" OR "7969558" OR "8013983" OR "8089618" OR "8130367" OR "8319949" OR "8330840" OR "8374405" OR "8384997" OR "8494252" OR "8675181" OR "8717488" OR "8742325" OR "8743176" OR "8761495" OR "8767190" OR "8829406" OR "8836922" OR "8848039" OR "9041915" OR "9063549" OR "9071763" OR "9086273" OR "9111444" OR					

		"9157790" OR "9164511" OR "9176051" OR "9229109" OR "9285464" OR "9285477" OR "9299731" OR "9368936" OR "9369689" OR "9383753" OR "9425654" OR "9435891" OR "9470520" OR "9489601" OR "9525863" OR "9529079" OR "D659030").pn.					
L186	1148	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L187	29	(3 OR 4) AND 6	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L188	82	(3 OR 4) AND 2	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L189	188	2 AND 6	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L190	19	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L191	54	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		OR gap OR slit) AND ((Micro ADJ optical OR micro ADJ lens OR microlens) near2 array)					
L192	269087	(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM

		G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR G02B19/0014 OR G02B19/0019 OR G02B19/0052 OR G02B19/0057 OR G02B19/0061 OR G02B19/0066 OR G02B21/0032 OR					

		G02B21/0052 OR G02B21/0096 OR G02B21/361 OR G02B21/367 OR G02B23/04 OR G02B26/00 OR G02B26/085 OR G02B26/127 OR G02B27/0025 OR G02B27/0075 OR G02B27/09 OR G02B27/0966 OR G02B27/0977 OR G02B27/10 OR G02B27/1066 OR G02B27/12 OR G02B27/123 OR G02B27/143 OR G02B27/4244 OR G02B27/425 OR G02B27/4272 OR G02B27/4277 OR G02B3/0037 OR G02B3/06 OR G02B5/021 OR G02B5/09 OR G02B5/10 OR G02B5/1814 OR G02B5/1819 OR G02B5/1842 OR G02B6/003 OR G02B6/0036 OR G02B6/0046 OR G02B6/005 OR G02B6/04 OR G02B6/06 OR G02B6/12007 OR G02B6/29356 OR G02B6/29368 OR G02B6/368 OR G02B6/4214 OR G02B6/4225 OR G02B6/4298 OR G02B7/026 OR G02B9/64 OR G06T7/521 OR G06T2207/10004 OR G06T2207/10028 OR G06T2207/10024 OR G06T7/194 OR G06T15/00 OR G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR					

		G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204 OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285).cpc.					
L193	10731	((light OR laser OR beam OR optic$2) NEAR3 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3 OR diode)) WITH (bulk common) near3 (optic$3 lens collimat$3)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L194	768	13 AND (multiple plurality different second) near4 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3) near4 (channel route band)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L195	184	14 AND 12	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L196	134	15 NOT (9 OR 8 OR 7 OR 5)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L197	53	14 AND ((bulk common)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21

		near3 (optic$3 lens collimat$3)) near6 (coincident$3 coincid$3 match$3)					03:16 PM
L198	1	"20180267148".pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L199	16	((US-10183541-B2 OR US-9917423-B2).did. AND USPT.dbnm.) OR ((US-20180191967-A1 OR US-20180180720-A1 OR US-20180136321-A1 OR US-20180267151-A1 OR US-20190369258-A1 OR US-20190312636-A1 OR US-20190223729-A1 OR US-20180167602-A1 OR US-20140320843-A1 OR US-20130182320-A1 OR US-20070273957-A1 OR US-20070013872-A1 OR US-20040061917-A1 OR US-20180267148-A1).did. AND PGPB.dbnm.)	(USPAT; US-PGPUB; FPRS; USOCR; IBM_TDB; EPO; JPO; DERWENT; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO))	OR	ON	ON	2021/09/21 03:16 PM
L200	169	((hemispheric$3 (hemi ADJ spheric$3)) near2 lens) near5 filter	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L201	28	20 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L202	428	((biconic$3 cylindr$4) near2 lens) near5 aberration$2 near5 (correct$3 compensat$4)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L203	115	22 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L204	248	(detect$3 sens$4) WITH apertur$3 WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L205	119	22 AND (12 OR 2)	(US-PGPUB; USPAT;	OR	ON	ON	2021/09/21

			USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:16 PM
L206	49	24 AND (12 OR 2)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L207	23	(detect$3 sens$4) WITH apertur$3 WITH filter WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L208	267	(detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L209	8	(positive near5 value near5 pulse near5 code) WITH (intensity power)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L210	46	14 AND (filter WITH micro WITH lens WITH (aperture openning window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L211	47	14 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L212	65	6 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L213	76	6 AND (control near5 (start begin initiat$3) near5 (stop end shut))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L214	962	((pixel detect$3 sens$3) near7 micro ADJ lens near7(aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L215	247	L67 AND (L2 L12 L35 L45)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM

L216	11	L68 AND ((pixel detect$3 sens$3) near7 align$3 near7(aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L217	1148	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L218	29	(3 OR 4) AND 6	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L219	82	(3 OR 4) AND 2	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L220	188	2 AND 6	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L221	19	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L222	68	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L223	30	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L224	77	(hole OR opening OR	(US-PGPUB; USPAT;	OR	ON	ON	2021/09/21

		aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)				03:16 PM
L225	1099	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L226	362	L142 AND (L2 L12 L35 L45)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L227	30	L143 AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L228	4	("10809359" OR "11025885" OR "20180359460" OR "20200036959").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L229	1	("20180106900").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:16 PM
L230	4	"11025885".pn.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/21 03:16 PM
L231	30	L143 AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:20 PM
L232	36	(((hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque substrate matte) AND (reduc$3 decreas$3) near4 (crosstalk cross)) AND (L2 L12 L35 L45))	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/21 03:22 PM

		AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiv$3 OR detect$4) SAME (hole OR open$4 OR aperture OR gap OR slit)					
L233	77	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/22 12:01 PM
L234	68	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/22 02:08 PM
L235	114	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 ((crosstalk cross) noise background back ADJ ground ambient)	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/22 03:00 PM
L236	46	L235 NOT L234	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/22 03:00 PM
L237	286	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 ((crosstalk cross) noise background back ADJ ground ambient)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/22 03:03 PM
L238	72	L237 AND (L2 L12 L35 L45)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/22 03:03 PM
L239	0	L238 NOT (L236 L234)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/09/22 03:03 PM

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N3	0	((((hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross))) AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/22 03:04 PM
N4	4	((detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/09/22 03:04 PM

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 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
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	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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.

☐ 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)	2021-09-21
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:	43830662
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	22-SEP-2021
Filing Date:	14-MAY-2018
Time Stamp:	11:49:12
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)	P006US3-1086284-IDS.pdf	201480 73206070e644e24a81bf27f33aa011ea72833afc	no	2

Warnings:

Information:	
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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.

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on September 21, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033- P006US3-1086284

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Angus Pacala, *et al.*

Application No.: 15/979,266

Filed: May 14, 2018

For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

Customer No.: 20350

Confirmation No.: 9761

Examiner: Amir J Askarian

Technology Center/Art Unit: 3645

PRELIMINARY AMENDMENT

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

Commissioner:

Prior to examination of the above-referenced application, please enter the following amendments and consider the following remarks:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 12 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings of claims in the application.

Listing of Claims:

1. (Previously presented) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having an optically transparent window;

a spinning light ranging device disposed within the housing, the light ranging device comprising:

a platform;

an optical transmitter coupled to the platform, the optical transmitter comprising a bulk transmitter optic and a plurality of transmitter channels, each transmitter channel including a light emitter configured to generate and transmit a narrowband light through the bulk transmitter optic into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising a bulk receiver optic, an aperture layer coincident with a focal plane of the bulk receiver optic and comprising a plurality of apertures separated by a stop region, and a plurality of micro-optic receiver channels, each micro-optic channel including an aperture from the plurality of apertures, an optical filter positioned along a path of light from the bulk receiver optic and axially aligned with the aperture, and a photosensor responsive to incident photons passed through the aperture and the optical filter;

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform, optical transmitter, and optical receiver within the housing; and

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

2. (Original) The optical system set forth in claim 1 wherein the optical receiver further includes a collimating lens behind the aperture and directly coupled to the optical filter, the optical filter positioned behind the collimating lens.

3. (Original) The optical system set forth in claim 1 wherein the optical filter is a filter layer on a hemispherical lens positioned directly on a top or bottom side of the aperture.

4. (Original) The optical system set forth in claim 1 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

5. (Original) The optical system set forth in claim 4 further comprising a corrective optical structure to correct for optical aberrations caused by the transparent window.

6. (Canceled)

7. (Original) The optical system set forth in claim 1 wherein the optical transmitter and optical receiver are configured such that each transmitter channel is paired with a receiver channel and the centers of their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system.

8. (Original) The optical system set forth in claim 1 wherein the plurality of micro-optic receiver channels are part of a monolithic ASIC constructed on a common substrate, within which photosensors are fabricated, and separate layers for the aperture layer, and the optical filter are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC.

9. (Previously presented) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having a base, a top and an optically transparent window disposed between the base and the top;

a spinning light ranging device disposed within the housing and aligned with the optically transparent window, the light ranging device comprising:

a platform;

an optical transmitter coupled to the platform, the optical transmitter comprising an image-space telecentric bulk transmitter optic and a plurality of transmitter channels, each channel including a light emitter configured to generate and transmit a narrowband light through the bulk transmitter optic into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising an image-space telecentric bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, and a plurality of micro-optic receiver channels, each micro-optic channel including an aperture from the plurality of apertures 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;

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform, optical transmitter and optical receiver within the housing;

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

10. (Original) The optical system set forth in claim 9 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

11. (Original) The optical system set forth in claim 9 wherein the optical transmitter and optical receiver are configured such that each transmitter channel is paired with a receiver channel and the centers of their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system.

12. (Original) The optical system set forth in claim 9 wherein the plurality of micro-optic receiver channels are part of a monolithic ASIC constructed on a common substrate, within which photosensors are fabricated, and separate layers for the aperture layer, and the optical filter are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC.

13. (Canceled)

14. (Previously presented) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having a base, a top and an optically transparent window disposed between the base and the top;

a light ranging device disposed within the housing and aligned with the optically transparent window, the light ranging device comprising:

a platform;

a plurality of vertical-cavity surface emitting lasers (VCSELs) arranged in an array, each VCSEL in the plurality of VCSELs being configured to generate and transmit discrete pulses of light into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors, each photosensor comprising a plurality of single-photon avalanche diodes (SPADs) responsive to incident photons, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of light to pass through the filter to the plurality of photosensors while blocking light outside the band from reaching the plurality of photosensors;

wherein the plurality of apertures comprises at least first and second apertures, the plurality of photosensors comprises at least first and second photosensors, and the optical receiver includes a first optical path extending between the bulk receiver optic and the first photosensor through the first aperture and a second optical path extending between the bulk receiver optic and the second photosensor through the second aperture;

a motor disposed within the housing and operatively coupled to spin the light ranging device within the housing; and

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

15. (Original) The optical system set forth in claim 14 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

16. (Previously presented) The optical system set forth in claim 14 wherein the plurality of VCSELs are arranged to form a plurality of emitter channels having non-overlapping fields of view at a certain distance from the optical system and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping fields of view at a certain distance from the optical system, and wherein each transmitter channel is paired with a separate one of the receiver channels.

17. (Previously presented) The optical system set forth in claim 14 wherein the plurality of photosensors are fabricated within, and form part of, a monolithic ASIC constructed on a common substrate.

18. (Canceled)

19. (Previously presented) The optical system set forth in claim 14 wherein the first and second apertures are pinhole apertures.

20. (Original) The optical system set forth in claim 14 wherein the discrete pulses of light are each coded with an embedded positive-value pulse-code formed by an intensity of its respective pulse of light.

21. (Previously presented) The optical system set forth in claim 14 wherein the plurality of apertures further comprises third and fourth apertures, the plurality of photosensors further comprises third and fourth photosensors, and the optical receiver includes a third optical path extending between the bulk receiver optic and the third photosensor through the third aperture and a fourth optical path extending between the bulk receiver optic and the fourth photosensor through the fourth aperture.

22. (Previously presented) The optical system set forth in claim 16 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of emitter channels and detection of photons from the pulses of light by the plurality of photosensors.

23. (Currently Amended) The optical system set forth in claim 16 further comprising a bulk transmitter optic and wherein:

the bulk transmitter optic and the bulk receiver optic are each image-space telecentric optics; and

the plurality of emitter channels are configured to project a plurality of illuminating beams in the field external to 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 photosensors.

24. (Currently Amended) An optical system for performing distance measurements, the optical system comprising:

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

a light ranging device disposed within the housing and comprising:

a platform;

a light transmission module coupled to the platform and comprising a bulk transmitter optic and a plurality of optical emitters, each optical emitter in the plurality of optical emitters configured to generate and transmit pulses of radiation through the bulk transmitter optic and through the optically transparent window into a field external to the optical system; and

a light sensing module coupled to the platform and comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the filter to the plurality of photosensors while blocking radiation outside the band from reaching the plurality of photosensors; and

a motor disposed within the housing and operatively coupled to spin the platform and the light ranging device within the housing;

wherein:

each photosensor in the plurality of photosensors comprises a plurality of single photon ~~avalance~~ avalanche diodes (SPADs);

the plurality of apertures comprises at least first, second, third and fourth apertures;

the plurality of photosensors comprises at least first, second, third and fourth photosensors; and

the light sensing module includes a first optical path to the first photosensor through the first aperture, a second optical path to the second photosensor through the second aperture, a third optical path to the third photosensor through the third aperture, and a fourth optical path to the fourth photosensor through the fourth aperture.

25. (Previously presented) The optical system for performing distance measurements according to claim 24 wherein the bulk transmitter optic and the bulk receiver optic are each image-space telecentric optics.

26. (Previously presented) The optical system for performing distance measurements according to claim 24 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.

27. (Previously presented) The optical system for performing distance measurements according to claim 24 wherein the plurality of optical emitters are arranged to form a plurality of emitter channels having non-overlapping fields of view, and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping the fields of view and having a one-to-one relationship with the plurality of emitter channels such that the field of view for each receiver channel is coincident with the field of view of a corresponding emitter channel.

28. (Previously presented) The optical system for performing distance measurements according to claim 24 wherein the plurality of emitters are configured to project a plurality of illuminating beams in the field external to 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 photosensors.

29. (New) An optical system for performing distance measurements, the optical system comprising:

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

a light ranging device disposed within the housing and comprising:

a platform;

a light transmission module coupled to the platform and comprising a bulk transmitter optic and a plurality of optical emitters, each optical emitter in the plurality of optical emitters configured to generate and transmit pulses of radiation through the bulk transmitter optic and through the optically transparent window into a field external to the optical system; and

a light sensing module coupled to the platform and comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and one or more optical filters disposed between the bulk receiver optic and the plurality of photosensors, each of the one or more optical filters configured to allow a set of wavelengths of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the one or more optical filters while blocking radiation outside that set; and

a motor disposed within the housing and operatively coupled to spin the platform and the light ranging device within the housing;

wherein:

each photosensor in the plurality of photosensors comprises a plurality of single photon avalanche diodes (SPADs);

the plurality of apertures comprises at least first, second, third and fourth apertures;

the plurality of photosensors comprises at least first, second, third and fourth photosensors; and

the light sensing module includes a first optical path to the first photosensor through the first aperture, a second optical path to the second photosensor through the second aperture, a third optical path to the third photosensor through the third aperture, and a fourth optical path to the fourth photosensor through the fourth aperture.

30. (New) The optical system for performing distance measurements set forth in claim 29 wherein the one or more optical filters comprise a bandpass filter.

31. (New) The optical system for performing distance measurements set forth in claim 29 wherein the one or more optical filters comprise a plurality of optical filters.

32. (New) The optical system for performing distance measurements set forth in claim 31 wherein each of the plurality of optical filters is supported by an optically transparent substrate.

33. (New) The optical system for performing distance measurements set forth in claim 32 wherein the plurality of optical filters are disposed in the first optical path.

34. (New) The optical system for performing distance measurements according to claim 29 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.

35. (New) The optical system for performing distance measurements according to claim 29 wherein the plurality of optical emitters are arranged to form a plurality of emitter channels having non-overlapping fields of view, and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping the fields of view and having a one-to-one relationship with the plurality of emitter channels such that the field of view for each receiver channel is coincident with the field of view of a corresponding emitter channel.

36. (New) The optical system for performing distance measurements according to claim 29 wherein the plurality of emitters are configured to project a plurality of illuminating beams in the field external to 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 photosensors.

37. (New) The optical system for performing distance measurements according to claim 29 wherein the one or more optical filters comprises a first optical filter disposed in the first optical path between the first photosensor and the first aperture, a second optical filter disposed in the second optical path between the second photosensor and the second aperture, a third optical filter disposed in the third optical path between the third photosensor and the third aperture, and a fourth optical filter disposed in the fourth optical path between the fourth photosensor and the fourth aperture.

REMARKS/ARGUMENTS

Upon entry of the present amendment, claims 1-5, 7-12, and 14-17 and 19-37 will be pending in this application. Claims 23 and 24 have been amended, no claims have been canceled, and new claims 29-37 have been added. No new matter is added.

Allowed Claims

Applicants note with appreciation the receipt of the Notice of Allowance dated June 15, 2021 indicating that claims 1-5, 7-12, 14-17 and 19-28 have been allowed. Rather than pay the Issue Fee, Applicants submitted a Request for Continuing Examination to add additional claims as noted below.

Please note that while Applicants file a Preliminary Amendment that included all the amendments made herein with the RCE on July 29, 2021, it is believed that the previously filed Preliminary Amendment was not processed properly by the Patent Office and had not been entered into the record. Accordingly, Applicants have submitted the present Preliminary Amendment in its place.

Claims 23 and 24

Claim 23 has been amended to correct a potential antecedent basis issue that was previously not recognized.

Claim 24 has been amended to correct a minor typographical error.

New Claims

New claims 29-37 have been added to secure an appropriate scope of protection for the present invention. Applicants respectfully assert that the new claims are supported by the application as originally filed and that no new matter is added. Examination and allowance of the new claims is respectfully requested.

CONCLUSION

In view of the foregoing, Applicant believes all claims now pending in this application are in condition for examination.

Except for the issue fees payable under 37 C.F.R. § 1.18, the Director is authorized to charge any additional fees during pendency of this application, including any required extension of time fees, or credit any overpayment to Deposit Account Number 20-1430. This paragraph is intended to be a constructive petition for extension of time in accordance with 37 C.F.R. § 1.136(a)(3).

If the Examiner believes a telephone conference would expedite prosecution of this application, please contact the undersigned at 858-350-6104 or wshaffer@kilpatricktownsend.com.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

`I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on September 21, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033-1086284-P006US3
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Amir J Askarian
Application No.: 15/979,266	Technology Center/Art Unit: 3645
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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 of a first Office Action after or concurrently with the filing of a Request for Continued Examination under 37 CFR §1.114. Therefore, under 37 CFR §1.97(b)(4), Applicant believes that ***no fee*** is required for submission of this statement. However, if any 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 /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 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

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	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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.

☐ 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		Date (YYYY-MM-DD)	
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:	43825942
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	21-SEP-2021
Filing Date:	14-MAY-2018
Time Stamp:	18:17:38
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		P006US3-PrelimAmend.pdf	132405 a3cad604249f11f73b6107b952834f2ba9cded95	yes	13

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Claims	2	11
	Applicant Arguments/Remarks Made in an Amendment	12	13

Warnings:					
Information:					
2		P006US3-July_29_2021_IDS-resubmitted-09-21-21.pdf	269796 f1b6ced8f2ee25e541dca7c781ecfdcf92303e34	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2
	Information Disclosure Statement (IDS) Form (SB08)	3	4

Warnings:	
Information:	
Total Files Size (in bytes):	402201

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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.

Doc Code: ECOMM.AUTH/ECOMM.WTDW
Doc Description: Internet Communications Authorized/Internet Communications Authorization Withdrawn

PTO/SB/439 (11-15)

AUTHORIZATION FOR INTERNET COMMUNICATIONS IN A PATENT APPLICATION OR REQUEST TO WITHDRAW AUTHORIZATION FOR INTERNET COMMUNICATIONS		
	Application No.	15979266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J. Askarian
	Practitioner Docket No.	103033-P006US3-1086284

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

I. To authorize permission for Internet Communications.

☑ Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via video conferencing, instant messaging, or electronic mail. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03)

II. To withdraw authorization for Internet Communications.

☐ The authorization given on _____, to the USPTO to communicate with the undersigned and any practitioner in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via Internet communications such as video conferencing, instant messaging, or electronic mail is hereby withdrawn. I understand that the withdrawal is effective when approved rather than when received.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 37234.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/ William L. Shaffer /
Signature

September 20, 2021
Date

William Shaffer
Typed or printed name

858-350-6104
Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Juristic entities must be represented by a patent practitioner (see 37 CFR 1.31, which is applicable to any paper filed on or after September 16, 2012, that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 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).
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 Acknowledgement Receipt

EFS ID:	43810828
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	20-SEP-2021
Filing Date:	14-MAY-2018
Time Stamp:	15:44:50
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	Internet Communications Authorized	Internet-Auth-Form-P006US3-1086284.pdf	75258 4571c3b54db8b9bb5a51b651f80741095f947423	no	2

Warnings:

Information:	
Total Files Size (in bytes):	75258

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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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

7590 08/24/2021

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

EXAMINER	
ASKARIAN, AMIR J	

ART UNIT	PAPER NUMBER
3645	

NOTIFICATION DATE	DELIVERY MODE
08/24/2021	ELECTRONIC

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed *8/19/2021* in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

☑ The IDS lacks a statement as specified in 37 CFR 1.97(e).

☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).

☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

N. Horne, for

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

Electronic Acknowledgement Receipt

EFS ID:	43556070
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	19-AUG-2021
Filing Date:	14-MAY-2018
Time Stamp:	17:39:26
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	Non Patent Literature	NPL_2021-05-24_NOA.PDF	421293 595722eab6918b0ea889a31256a4d22e68cc99d6	no	7

Warnings:

Information:					
2	Non Patent Literature	NPL_2021-07-22-NOA.PDF	593640 2790e86d3b7b1baa21fac3da6e7ad174135187e6	no	11
Warnings:					
Information:					
3		P006US3-103033-1086284_IDS.pdf	404878 fba734d1700f9c8ddb4cb42c3e156a3de0448b61	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
	Information Disclosure Statement (IDS) Form (SB08)	2	4

Warnings:	
Information:	
Total Files Size (in bytes):	1419811

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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 August 19, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033-1086284-P006US3
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Amir J Askarian
Application No.: 15/979,266	Technology Center/Art Unit: 3645
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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representation is being made that a search has been conducted or that this statement encompasses all the possible relevant information.

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Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

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	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284

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	11086013		Aug 10, 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

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]
	2	Application No 15/979,253 , Notice of Allowance, Mailed On July 22, 2021, 7 pages	
	3	Application No 15/979,277, Notice of Allowance, May 24, 2021, 7 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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284

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.

☐ 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)	2021-08-19
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:	43383887
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	29-JUL-2021
Filing Date:	14-MAY-2018
Time Stamp:	19:34:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$680
RAM confirmation Number	E20217SJ35140452
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	Request for Continued Examination (RCE)	RCE-Transmittal-. P006US3-1086284.pdf	1351710 f5fc71d0a26ec5c2523f82ae3f9c5d56df9a9b38	no	-
Warnings:					
Information:					
2		Amendment-submitted-with-RCE-P006US3-1086284.pdf	127346 a8ab91f0ec1a99c5fe2751a2780ee7f30f0e6e51	yes	13

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
Claims	2	11
Applicant Arguments/Remarks Made in an Amendment	12	13

Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	IDS-P006US3-1086284.pdf	212461 d67dece532dd551943b663b831db2bc9fd230da6	no	4
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
4	Non Patent Literature	NPL-NOA-7-22-21_P006.pdf	593671 728c19735571 4eca15896a5e3e99753209c14dd3	no	11
Warnings:					
Information:					

5	Fee Worksheet (SB06)	fee-info.pdf	38295 0692199421Ba4ab01d57c5763e14ea2857c7c99a	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	2323483	

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.
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Best Available Copy

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Warnings:					
Information:					
2		Amendment-submitted-with-RCE-P006US3-1086284.pdf	127346 a8ab91f0ec1a99c5fe2751a2780ee7f30f0e6e51	yes	13

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
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Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	IDS-P006US3-1086284.pdf	212461 d67dece532dd551943b663b831db2bc9fd230da6	no	4
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
4	Non Patent Literature	NPL-NOA-7-22-21_P006.pdf	593671 728c197355714eca15896a5e3e99753209c14dd3	no	11
Warnings:					
Information:					

Best Available Copy

5	Fee Worksheet (SB06)	fee-info.pdf	38295 06921994218a4ab01d57c5763e14ea2857e7c99a	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2323483		

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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

20350 7590 07/12/2021

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

EXAMINER	
ASKARIAN, AMIR J	

ART UNIT	PAPER NUMBER
3645	

NOTIFICATION DATE	DELIVERY MODE
07/12/2021	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

Supplemental ***Notice of Allowability***	**Application No.** 15/979,266	**Applicant(s)** PACALA et al.	
	Examiner AMIR J ASKARIAN	**Art Unit** 3645	**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 06/16/2021.
   ☐ 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 See Continuation Sheet . 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 _____.

/A.J.A./ Examiner, Art Unit 3645	/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645

Continuation of 3. The allowed claim(s) is/are: 1-5,7-12,14-17 and 19-28

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-P006US3-1086284

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.	U.S. Patent Application No. 15/979,277 , Notice of Allowance, dated May 24, 2021, 7 pages.	

EXAMINER SIGNATURE			
Examiner Signature /AMIR J ASKARIAN/		Date Considered 07/07/2021	

*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. /A.J.A./

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

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	2875
Examiner Name	Not yet assigned
Attorney Docket Number	103033- P006US3-1086284

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
07/07/2021 /A.J.A./	1	11025885	~~A1~~ B2	06-01-2021	Pacala et al.	
	2	10809359	B2	10-20-2020	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
	3	20200036959	A1	01-30-2020	Pacala, et al.	
	4	20180359460	A1	07-26-2018	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]

1

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]
	5	U.S. Patent Application No. 17/317,809 filed May 11, 2021; 81 pages.	
	6	U.S. Patent Application No. 17/323,962, filed May 18, 2021; 78 pages.	
	7	U.S. Patent Application No. 17/194,068, filed May March 5, 2021; 69 pages.	
	8	U.S. Patent Application No. 17/323,983, filed May May 18, 2021; 80 pages.	
	9	U.S. Patent Application No. 17/323,987, filed May May 18, 2021; 81 pages.	

EXAMINER SIGNATURE

Examiner Signature /AMIR J ASKARIAN/		Date Considered 06/04/2021	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

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Electronic Acknowledgement Receipt

EFS ID:	43005034
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	16-JUN-2021
Filing Date:	14-MAY-2018
Time Stamp:	15:14:36
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	Non Patent Literature	NPL-NOA-P006US4.pdf	421293 5a9190b9bb76976c14304320455a45a7dd5f037d	no	7

Warnings:

Information:	
Total Files Size (in bytes):	421293

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Examiner Signature		Date Considered	

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Electronic Patent Application Fee Transmittal

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First Named Inventor/Applicant Name:	Angus PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P006US3-1086284

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:	43004923
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	16-JUN-2021
Filing Date:	14-MAY-2018
Time Stamp:	15:10:32
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	E20216FF11144508
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		IDS-P006US3-1086284.pdf	233936 02af737fa07f7976bf3b4de241337769f4578461	yes	3

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2
	Information Disclosure Statement (IDS) Form (SB08)	3	3

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30632 dea34ec825a416fcfc33c8bff7898a1c1ac0717c	no	2

Warnings:

Information:

Total Files Size (in bytes):	264568

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.

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

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033- P006US3-1086284
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Amir J Askarian
Application No.: 15/979,266	Technology Center/Art Unit: 3645
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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 ***after*** an action closing prosecution, but before the payment of the Issue Fee.

I hereby certify under 37 CFR §1.97(e)(2) 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 §1.56(c) more than three months prior to the filing of the Information Disclosure Statement.

The Commissioner is authorized to charge the fee set forth in §1.17(p) to the firm's credit card for consideration of this paper. The Commissioner is authorized to charge any additional fee due to Deposit Account No. 20-1430.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

20350 7590 06/15/2021

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

EXAMINER
ASKARIAN, AMIR J

ART UNIT	PAPER NUMBER
3645	

DATE MAILED: 06/15/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

TITLE OF INVENTION: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

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	09/15/2021

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 06/15/2021

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.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

TITLE OF INVENTION: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

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	09/15/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
ASKARIAN, AMIR J	3645	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.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

20350 7590 06/15/2021

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

EXAMINER	
ASKARIAN, AMIR J	

ART UNIT	PAPER NUMBER
3645	

DATE MAILED: 06/15/2021

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.

HESAI EX1002, P.130

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. 15/979,266	Applicant(s) PACALA et al.	
	Examiner AMIR J ASKARIAN	Art Unit 3645	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 Remarks - 05/24/2021 - Applicant Arguments/Remarks Made in an Amendment.
   ☐ 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 See Continuation Sheet . 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. 20210602.
5. ☑ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/A.J.A./ Examiner, Art Unit 3645	/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645

Continuation of 3. The allowed claim(s) is/are: 1-5,7-12,14-17 and 19-28

DETAILED ACTION

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.

Examiner's Amendment

Authorization for this examiner's amendment was given in a telephone interview with Bill Shaffer on Monday, June 7, 2021.

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 application has been amended as follows:

In Claim 8, Lines 3-4, "within which the array of photosensors are fabricated, and the separate layers for the aperture layer, and the filter layer are formed" has been changed to:

--within which photosensors are fabricated, and separate layers for the aperture layer, and the optical filter are formed--.

In Claim 9, Lines 14-15, "a plurality of apertures" has been changed to:

--a plurality of apertures separated by a stop region--.

In Claim 12, Lines 3-4, "within which the array of photosensors are fabricated, and the separate layers for the aperture layer, and the filter layer are formed" has been changed to:

--within which photosensors are fabricated, and separate layers for the aperture layer, and the optical filter are formed--.

In Claim 22, Line 1, "The optical system set forth in claim 14" has been changed to:

--The optical system set forth in claim 16--.

In Claim 22, Lines 2-3, "the plurality of optical emitters" has been changed to:

--the plurality of emitter channels--.

In Claim 23, Line 1, "The optical system set forth in claim 14" has been changed to:

--The optical system set forth in claim 16--.

In Claim 23, Line 4, "the plurality of emitters" has been changed to:

--the plurality of emitter channels--.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMIR J ASKARIAN whose telephone number is (571)272-1246. The examiner can normally be reached on M-Th 7:30am-5:30pm.

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, Yuqing Xiao can be reached on (571) 270-3603. 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.

/A.J.A./
Examiner, Art Unit 3645

/YUQING XIAO/
Supervisory Patent Examiner, Art Unit 3645

Examiner-Initiated Interview Summary	**Application No.** 15/979,266	**Applicant(s)** PACALA et al.		
	Examiner AMIR J ASKARIAN	**Art Unit** 3645	**AIA (First Inventor to File) Status** Yes	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
AMIR J ASKARIAN	Examiner	Telephonic
Bill Shaffer	Attorney of Record	

Date of Interview: 07 June 2021

Issues Discussed:

35 U.S.C. 112

Amendments were discussed and agreed on to ensure compliance with 35 U.S.C. 112.

Proposed Amendment(s)

The Examiner proposed amendments and obtained authorization to enter the amendments under Examiner's amendments to prevent final rejection under 35 U.S.C. 103.

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645

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: It is not necessary for applicant to provide a separate record of the substance of 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.

Notice of References Cited	Application/Control No. 15/979,266	Applicant(s)/Patent Under Reexamination PACALA et al.	
	Examiner AMIR J ASKARIAN	Art Unit 3645	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-20070058981-A1	03-2007	Tamanuki; Takemasa	G02B6/423	398/141
*	B	US-20200060550-A1	02-2020	PESACH; Benny	G06T7/0012	1/1
	C					
	D					
	E					
	F					
	G					
	H					
	I					
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	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.

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

CPC						
Symbol					**Type**	**Version**
G01S	/	17	/	10	F	2013-01-01
G02B	/	27	/	30	I	2013-01-01
G01S	/	7	/	486	I	2013-01-01
G02B	/	27	/	0037	I	2013-01-01
G02B	/	27	/	0955	I	2013-01-01
G01S	/	17	/	42	I	2013-01-01
G01S	/	7	/	4816	I	2013-01-01
G01S	/	7	/	4863	I	2013-01-01
G01S	/	7	/	4865	I	2013-01-01
H01L	/	31	/	02325	I	2013-01-01
H01L	/	31	/	02162	I	2013-01-01
H01L	/	31	/	02164	I	2013-01-01
G01S	/	17	/	931	I	2020-01-01
G01S	/	17	/	89	I	2013-01-01
H01L	/	27	/	14643	I	2013-01-01
H01L	/	31	/	02027	I	2013-01-01
G01S	/	7	/	4813	I	2013-01-01
G01S	/	7	/	4815	I	2013-01-01
G01S	/	7	/	4817	I	2013-01-01
G01S	/	17	/	08	I	2013-01-01
H04B	/	10	/	503	I	2013-01-01
H04B	/	10	/	675	I	2013-01-01
H04B	/	10	/	6973	I	2013-01-01
H04B	/	10	/	801	I	2013-01-01
H01L	/	27	/	1446	I	2013-01-01
H01L	/	31	/	02165	I	2013-01-01
H01L	/	31	/	02327	I	2013-01-01
H01L	/	31	/	107	I	2013-01-01
G02B	/	5	/	205	A	2013-01-01

/AMIR J ASKARIAN/ Examiner, Art Unit 3645 (Assistant Examiner)	04 June 2021 (Date)	**Total Claims Allowed:** 25	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645 (Primary Examiner)	07 June 2021 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

CPC Combination Sets									
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	04 June 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	07 June 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G01S	/	17	/	10

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	04 June 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	07 June 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	**Art Unit**
	AMIR J ASKARIAN	3645

☐ 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	1	9	10	18	19	25	28								
2	2	10	11	19	20										
3	3	11	12	20	21										
4	4	-	13	15	22										
5	5	12	14	16	23										
-	6	13	15	21	24										
6	7	14	16	22	25										
7	8	17	17	23	26										
8	9	-	18	24	27										

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	04 June 2021	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	25	
/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645	07 June 2021	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

U.S. Patent and Trademark Office Part of Paper No.: 20210602

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

CPC - Searched*		
Symbol	**Date**	**Examiner**
G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801 limited with text	02/12/2021	aa
		aa

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P.143

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR G02B19/0014 OR G02B19/0019 OR G02B19/0052 OR G02B19/0057 OR G02B19/0061 OR G02B19/0066 OR G02B21/0032 OR G02B21/0052 OR G02B21/0096 OR G02B21/361 OR G02B21/367 OR G02B23/04 OR G02B26/00 OR G02B26/085 OR G02B26/127 OR G02B27/0025 OR G02B27/0075 OR G02B27/09 OR G02B27/0966 OR G02B27/0977 OR G02B27/10 OR G02B27/1066 OR G02B27/12 OR G02B27/123 OR G02B27/143 OR G02B27/4244 OR G02B27/425 OR G02B27/4272 OR G02B27/4277 OR G02B3/0037 OR G02B3/06 OR G02B5/021 OR G02B5/09 OR G02B5/10 OR G02B5/1814 OR G02B5/1819 OR G02B5/1842 OR G02B6/003 OR G02B6/0036 OR G02B6/0046 OR G02B6/005 OR G02B6/04 OR G02B6/06 OR G02B6/12007 OR G02B6/29356 OR G02B6/29368 OR G02B6/368 OR G02B6/4214 OR G02B6/4225 OR G02B6/4298 OR G02B7/026 OR G02B9/64 OR G06T7/521 OR G06T2207/10004 OR G06T2207/10028 OR G06T2207/10024 OR G06T7/194 OR G06T15/00 OR G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204	02/12/2021	

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P.144

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285) limited with text		
updated search	06/04/2021	aa

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* 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**
ip.com search, google patents search, npl search: google scholar, ieee explore, inventor/assignee search, classification search limited with text	02/12/2021	aa
updated search, consulted Luke Ratcliffe re allowable subject matter	06/04/2021	aa

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P 145

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
	Examiner	Art Unit
	AMIR J ASKARIAN	3645

Interference Search			
US Class/CPC Symbol	**US Subclass/CPC Group**	**Date**	**Examiner**
	((((hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross))) AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)).clm.	06/04/2021	aa

/A.J.A./ Examiner, Art Unit 3645	

HESAI EX1002, P.146

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

Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284-P006US3

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	15/979,253 , "Non-Final Office Action", February 19, 2021, 7 pages	
	2	15/979,295 , "Notice of Allowance", January 27, 2021, 5 pages	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	06/04/2021

*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.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

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First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284-P006US3

[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)	2021-03-23
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. /A.J.A./

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

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Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284-P006US3

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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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
	1.	20180106900		Apr 19, 2018	Droz 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]
	2.	Application No 15/979,277 , Final Office Action, Mailed On March 30, 2021, 7 pages	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	06/04/2021

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[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. /A.J.A./

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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	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284-P006US3

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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).

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Signature	/ William L. Shaffer /	Date (YYYY-MM-DD)	2021-04-20
Name/Print	William L. Shaffer	Registration Number	37,234

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

https://ieeexplore.ieee.org/search/searchresult.jsp?action=search&newsearch=true&matchBoolean=true&queryText=(%22Full%20Text%20.AND.%20Metadata%22:aperture%20layer%20lidar%20aligned%20with%20transmitter%20receiver)

https://ieeexplore.ieee.org/search/searchresult.jsp?action=search&matchBoolean=true&queryText=(%22Full%20Text%20.AND.%20Metadata%22:aperture%20layer%20lidar%20aligned%20with%20transmitter%20receiver)&highlight=true&returnFacets=ALL&returnType=SEARCH&matchPubs=true&searchWithin=reduce%20crosstalk

https://ieeexplore.ieee.org/search/searchresult.jsp?action=search&matchBoolean=true&queryText=(%22Full%20Text%20.AND.%20Metadata%22:aperture%20layer%20lidar%20aligned%20with%20transmitter%20receiver)&highlight=true&returnType=SEARCH&matchPubs=true&returnFacets=ALL&searchWithin=crosstalk

Web Search History

date, time	web site	search string
6/4/2021 3:54:00 PM	Google Scholar	aperture layer lidar aligned with transmitter receiver
6/4/2021 3:56:43 PM	Google Scholar	aperture layer aligned with transmitter receiver reducing crosstalk lidar

Main Concept Document
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US20180329061
Title: Spinning lidar unit with micro-optics aligned behind stationary window

Concept Modifiers (1)
==========
1. More Like Text: aperture layer align transmitter receiver

(No Filters)
==========

Options
=======
De-dup: None
Cut-off: None
Sort: Relevance

Content: Patents + NPL (187)
==========
US Patents
US Designs
US Applications
EPO Patents
EPO Applications
China Patents
China Applications
Japan Patents
Japan Applications
Korea Patents
Korea Applications
WIPO Applications
Argentina Patents
Argentina Applications
Brazil Patents
Brazil Applications
Canada Patents
Canada Applications
Chile Patents
Chile Applications
Colombia Applications
Costa Rica Applications
Cuba Patents
Cuba Applications
Dominican Republic Applications
Ecuador Patents
Ecuador Applications
El Salvador Applications

Guatemala Applications
Honduras Applications
Mexico Patents
Mexico Applications
Nicaragua Patents
Panama Applications
Peru Applications
Trinidad & Tobago Patents
Uruguay Applications
Austria Patents
Austria Applications
Belarus Patents
Belgium Patents
Belgium Applications
Bosnia & Herzegovina Patents
Bosnia & Herzegovina Applications
Bulgaria Patents
Bulgaria Applications
Croatia Patents
Croatia Applications
Czech Republic Patents
Czech Republic Applications
Czechoslovakia Patents
Czechoslovakia Applications
Denmark Patents
Denmark Applications
Estonia Patents
Estonia Applications
EUIPO Patents
Finland Patents
Finland Applications
France Patents
France Applications
Germany Patents
Germany Applications
Great Britain Patents
Great Britain Applications
Greece Patents
Greece Applications
Hungary Patents
Hungary Applications
Iceland Patents
Iceland Applications
Ireland Patents
Ireland Applications
Italy Patents
Italy Applications
Latvia Patents
Latvia Applications
Lithuania Patents
Lithuania Applications
Luxembourg Patents
Malta Patents
Monaco Patents

Montenegro Patents
Montenegro Applications
Netherlands Patents
Netherlands Applications
Norway Patents
Norway Applications
Poland Patents
Poland Applications
Portugal Patents
Portugal Applications
Republic of Moldova Patents
Republic of Moldova Applications
Romania Patents
Romania Applications
San Marino Patents
San Marino Applications
Serbia Patents
Serbia Applications
Slovakia Patents
Slovakia Applications
Slovenia Patents
Spain Patents
Spain Applications
Sweden Patents
Sweden Applications
Switzerland Patents
Switzerland Applications
Ukraine Patents
Yugoslavia/Serbia and Montenegro Patents
Yugoslavia/Serbia and Montenegro Applications
Armenia Patents
Australia Patents
Australia Applications
Cyprus Patents
Gulf Cooperation Council Patents
Hong Kong Patents
India Patents
India Applications
Indonesia Patents
Indonesia Applications
Israel Applications
Jordan Patents
Kyrgyzstan Patents
Macao Applications
Malaysia Patents
Mongolia Patents
New Zealand Patents
Philippines Patents
Philippines Applications
Saudi Arabia Patents
Singapore Patents
Singapore Applications
Taiwan Patents
Taiwan Applications

Tajikistan Patents
Tajikistan Applications
Thailand Applications
Uzbekistan Patents
Vietnam Patents
Algeria Patents
ARIPO Patents
ARIPO Applications
Egypt Patents
Kenya Patents
Malawi Patents
Morocco Patents
Morocco Applications
OAPI Patents
South Africa Patents
Tunisia Applications
Zambia Patents
Zimbabwe Patents
EAPO Patents
EAPO Applications
Georgia Patents
Georgia Applications
Kazakhstan Patents
Kazakhstan Applications
Russia Patents
Russia Applications
Turkey Patents
Turkey Applications
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IEEE Xplore Publications: IEEE Early Access
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IEEE Xplore Publications: SMPTE Standards
IEEE Xplore Publications: MIT Press eBooks
IEEE Xplore Publications: Wiley-IEEE eBooks
IEEE Xplore Publications: IBM Periodicals
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IP.com Prior Art Database: The IP.com Journal
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OnePetro.org: Periodicals at OnePetro.org
OnePetro.org: Conferences at OnePetro.org
Other Literature: IBM Redbooks
Other Literature: PubMed Central
Other Literature: arXiv.org

PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L34	2	"20180329061".pn.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L35	243026	(G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801).cpc. OR (G01S17/10 OR G01S7/486 OR G02B27/00 OR G02B27/09 OR G02B27/30).ipc.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L36	1975	("OUSTER, INC.".ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L37	1975	(OUSTER.ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine.	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2021/05/28 03:27 PM

		OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	IBM_TDB)				
L38	192	("20120170029" OR "20130325241" OR "20140111812" OR "20160282468" OR "20180180720" OR "20180284228" OR "20180286909" OR "20180191967" OR "20180136321" OR "10066990" OR "10222475" OR "10663586" OR "20150260830" OR "20180109061" OR "20180118041" OR "20180123412" OR "6433934" OR "7196301" OR "9366573" OR "9882433" OR "9917423" OR "9935514" OR "D531525" OR "20110266022" OR "20140224792" OR "5084596" OR "8633384" OR "10063849" OR "10183541" OR "10222458" OR "20180299554" OR "20190041498" OR "9551791" OR "9989406" OR "9992477" OR "20050035474" OR "20150055117" OR "5745153" OR "20180059222" OR "20180152691" OR "20180209841" OR "20180217236" OR "20030006676" OR "20030047752" OR "20040061502" OR "20040223071" OR "20050030409" OR "20060244851" OR "20070007563" OR "20070060806" OR "20070228262" OR "20080153189" OR "20090016642" OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM

		"20090040629" OR "20090179142" OR "20090295910" OR "20100008588" OR "20100020306" OR "20100110275" OR "20100123893" OR "20100204964" OR "20110025843" OR "20110032398" OR "20110037849" OR "20110116262" OR "20110216304" OR "20120044476" OR "20120140109" OR "20120154914" OR "20120182464" OR "20120287417" OR "20120320164" OR "20130044310" OR "20130141549" OR "20130206967" OR "20130294089" OR "20130300840" OR "20140118335" OR "20140118493" OR "20140153001" OR "20140158900" OR "20140168631" OR "20140176933" OR "20140211194" OR "20140269796" OR "20140285628" OR "20140291491" OR "20140313519" OR "20140375977" OR "20140376092" OR "20150002636" OR "20150131080" OR "20150184999" OR "20150192677" OR "20150292948" OR "20150293224" OR "20150316473" OR "20150355470" OR "20150358601" OR "20150378241" OR "20150379371" OR "20160003946" OR "20160047895" OR "20160047896" OR "20160047897" OR "20160047898" OR "20160047899" OR "20160047900" OR "20160047901" OR "20160047903" OR "20160049765" OR					

		"20160097858" OR "20160150963" OR "20160161600" OR "20160218727" OR "20160265902" OR "20160291134" OR "201602911434" OR "20160306032" OR "20160327779" OR "20160328619" OR "20170146640" OR "20170219426" OR "20170219695" OR "20170269197" OR "20170269198" OR "20170269209" OR "20170269215" OR "20170289524" OR "20170350983" OR "4358851" OR "4634272" OR "4676599" OR "4702600" OR "4744667" OR "4851664" OR "5267016" OR "5288992" OR "5982552" OR "6014232" OR "6133989" OR "6255133" OR "6374024" OR "6414746" OR "6690019" OR "6721262" OR "7091462" OR "7170542" OR "7295298" OR "7345271" OR "7421159" OR "7433042" OR "7808706" OR "7969558" OR "8013983" OR "8089618" OR "8130367" OR "8319949" OR "8330840" OR "8374405" OR "8384997" OR "8494252" OR "8675181" OR "8717488" OR "8742325" OR "8743176" OR "8761495" OR "8767190" OR "8829406" OR					

		"8836922" OR "8848039" OR "9041915" OR "9063549" OR "9071763" OR "9086273" OR "9111444" OR "9157790" OR "9164511" OR "9176051" OR "9229109" OR "9285464" OR "9285477" OR "9299731" OR "9368936" OR "9369689" OR "9383753" OR "9425654" OR "9435891" OR "9470520" OR "9489601" OR "9525863" OR "9529079" OR "D659030").pn.					
L39	1126	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L40	26	(3 OR 4) AND 6	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L41	75	(3 OR 4) AND 2	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L42	175	2 AND 6	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L43	17	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L44	51	(array OR multiple OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28

		plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) AND ((Micro ADJ optical OR micro ADJ lens OR microlens) near2 array)					03:27 PM
L45	258580	(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM

		G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR					

		G02B19/0014 OR G02B19/0019 OR G02B19/0052 OR G02B19/0057 OR G02B19/0061 OR G02B19/0066 OR G02B21/0032 OR G02B21/0052 OR G02B21/0096 OR G02B21/361 OR G02B21/367 OR G02B23/04 OR G02B26/00 OR G02B26/085 OR G02B26/127 OR G02B27/0025 OR G02B27/0075 OR G02B27/09 OR G02B27/0966 OR G02B27/0977 OR G02B27/10 OR G02B27/1066 OR G02B27/12 OR G02B27/123 OR G02B27/143 OR G02B27/4244 OR G02B27/425 OR G02B27/4272 OR G02B27/4277 OR G02B3/0037 OR G02B3/06 OR G02B5/021 OR G02B5/09 OR G02B5/10 OR G02B5/1814 OR G02B5/1819 OR G02B5/1842 OR G02B6/003 OR G02B6/0036 OR G02B6/0046 OR G02B6/005 OR G02B6/04 OR G02B6/06 OR G02B6/12007 OR G02B6/29356 OR G02B6/29368 OR G02B6/368 OR G02B6/4214 OR G02B6/4225 OR G02B6/4298 OR G02B7/026 OR G02B9/64 OR G06T7/521 OR G06T2207/10004 OR G06T2207/10028 OR G06T2207/10024 OR G06T7/194 OR G06T15/00 OR					

		G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204 OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285).cpc.					
L46	10541	((light OR laser OR beam OR optic$2) NEAR3 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3 OR diode)) WITH (bulk common) near3 (optic$3 lens collimat$3)	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L47	751	13 AND (multiple plurality different second) near4 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3) near4	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM

		(channel route band)					
L48	173	14 AND 12	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L49	128	15 NOT (9 OR 8 OR 7 OR 5)	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L50	48	14 AND ((bulk common) near3 (optic$3 lens collimat$3)) near6 (coincident$3 coincid$3 match$3)	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L51	1	"20180267148".pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/05/28 03:27 PM
L52	16	((US-10183541-B2 OR US-9917423-B2).did. AND USPT.dbnm.) OR ((US-20180191967-A1 OR US-20180180720-A1 OR US-20180136321-A1 OR US-20180267151-A1 OR US-20190369258-A1 OR US-20190312636-A1 OR US-20190223729-A1 OR US-20180167602-A1 OR US-20140320843-A1 OR US-20130182320-A1 OR US-20070273957-A1 OR US-20070013872-A1 OR US-20040061917-A1 OR US-20180267148-A1).did. AND PGPB.dbnm.)	(USPAT; US-PGPUB; FPRS; USOCR; IBM_TDB; EPO; JPO; DERWENT; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO))	OR	ON	ON	2021/05/28 03:27 PM
L53	162	((hemispheric$3 (hemi ADJ spheric$3)) near2 lens) near5 filter	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L54	26	20 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L55	416	((biconic$3 cylindr$4) near2 lens) near5 aberration$2 near5 (correct$3 compensat$4)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L56	109	22 AND 12	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2021/05/28 03:27 PM

			IBM_TDB)				
L57	241	(detect$3 sens$4) WITH apertur$3 WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L58	113	22 AND (12 OR 2)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L59	45	24 AND (12 OR 2)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L60	22	(detect$3 sens$4) WITH apertur$3 WITH filter WITH monolithic	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L61	260	(detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L62	7	(positive near5 value near5 pulse near5 code) WITH (intensity power)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L63	43	14 AND (filter WITH micro WITH lens WITH (aperture openning window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L64	44	14 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L65	61	6 AND (filter WITH micro WITH lens WITH (aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L66	70	6 AND (control near5 (start begin initiat$3) near5 (stop end shut))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:27 PM
L67	920	((pixel detect$3 sens$3) near7 micro ADJ lens	(US-PGPUB; USPAT; USOCR; FIT (CN, FR,	OR	ON	ON	2021/05/28 03:28 PM

		near7(aperture opening window))	WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)				
L68	232	L67 AND (L2 L12 L35 L45)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:29 PM
L69	11	L68 AND ((pixel detect$3 sens$3) near7 align$3 near7(aperture opening window))	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/05/28 03:29 PM
L75	1126	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/01 12:01 PM
L76	26	(3 OR 4) AND 6	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/01 12:01 PM
L77	76	(3 OR 4) AND 2	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/01 12:01 PM
L78	175	2 AND 6	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/06/01 12:01 PM
L79	17	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/01 12:01 PM
L139	65	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/02 02:52 PM
L140	28	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/06/02 02:52 PM

		corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)					
L141	74	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) SAME (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/06/02 03:26 PM
L142	1071	(hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/06/04 03:04 PM
L143	325	L142 AND (L2 L12 L35 L45)	(US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2021/06/04 03:04 PM
L144	27	L143 AND (array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/04 03:05 PM
L145	4	("10809359" OR "11025885" OR "20180359460" OR "20200036959").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/04 03:32 PM
L146	1	("20180106900").pn.	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/04 03:32 PM

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N1	0	((((hole OR opening OR aperture OR gap OR slit) near5 (layer array) WITH (stop opaque) AND (reduc$3 decreas$3) near4 (crosstalk cross))) AND (array OR multiple OR	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/04 03:36 PM

		plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)).clm.					
N2	4	((detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2021/06/04 03:38 PM

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	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	2875
Examiner Name	Not yet assigned
Attorney Docket Number	103033- P006US3-1086284

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	11025885	A1	06-01-2021	Pacala et al.	
	2	10809359	B2	10-20-2020	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
	3	20200036959	A1	01-30-2020	Pacala, et al.	
	4	20180359460	A1	07-26-2018	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]

1

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]
	5	U.S. Patent Application No. 17/317,809 filed May 11, 2021; 81 pages.	
	6	U.S. Patent Application No. 17/323,962, filed May 18, 2021; 78 pages.	
	7	U.S. Patent Application No. 17/194,068, filed May March 5, 2021; 69 pages.	
	8	U.S. Patent Application No. 17/323,983, filed May May 18, 2021; 80 pages.	
	9	U.S. Patent Application No. 17/323,987, filed May May 18, 2021; 81 pages.	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	06/04/2021

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033- P006US3-1086284

*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. /A.J.A./

Bibliographic Data

Application No: 15/979,266

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☑ No ☐ Met After Allowance

Verified and Acknowledged: /AMIR J ASKARIAN/ Examiner's Signature | Initials

Title: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
05/14/2018	356	3645	103033-P006US3-1086284
RULE			

APPLICANTS

Ouster, Inc., San Francisco, CA, UNITED STATES

INVENTORS

Angus PACALA, San Francisco, CA, UNITED STATES

Mark FRICHTL, San Francisco, CA, UNITED STATES

Marvin SHU, San Francisco, CA, UNITED STATES

CONTINUING DATA

This application has PRO of 62515291 06/05/2017

This application has PRO of 62506449 05/15/2017

This application has PRO of 62506437 05/15/2017

This application has PRO of 62506445 05/15/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

06/12/2018

** SMALL ENTITY **

STATE OR COUNTRY

UNITED STATES

ADDRESS

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

FILING FEE RECEIVED

$865

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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 NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

20350 7590 05/24/2021

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

EXAMINER	
ASKARIAN, AMIR J	

ART UNIT	PAPER NUMBER
3645	

NOTIFICATION DATE	DELIVERY MODE
05/24/2021	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.** 15/979,266	**Applicant(s)** PACALA et al.		
	Examiner AMIR J ASKARIAN	**Art Unit** 3645	**AIA (First Inventor to File) Status** Yes	**Page** 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	**Title**	**Type**
AMIR J ASKARIAN	Examiner	Telephonic
Bill Shaffer	Attorney of Record	
Luke Ratcliffe	Primary Examiner	

Date of Interview: 19 May 2021

Issues Discussed:

35 U.S.C. 103

Claim 1 and the prior art was discussed. Examiner described why the cited art teaches the claimed feature (particularly the claimed aperture) and suggested that the applicant amend the claims to positively claim the structure of an aperture layer as comprising a non-transparent stop region and plurality of pinholes and the particular arrangements of the apertures in the aperture layer with respect to each detector pixel. It is also noted that further search and consideration would be required.

/AMIR J ASKARIAN/ Examiner, Art Unit 3645	/YUQING XIAO/ Supervisory Patent Examiner, Art Unit 3645

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.

Askarian, Amir

From: Shaffer, Bill <wshaffer@kilpatricktownsend.com>
Sent: Friday, May 14, 2021 12:47 PM
To: Askarian, Amir
Subject: US 15/979,266

CAUTION: This email has originated from a source outside of USPTO. **PLEASE CONSIDER THE SOURCE** before responding, clicking on links, or opening attachments.

Hello Examiner Askarian,

Thank you for agreeing to discuss this application by telephone on Wednesday, May 19 at 12:00 pm EDT.

Below is the agenda that I would like to cover during the interview.

- Overview of invention
- Claim 1 rejected under 103 in view of Pennecot + Streuber
- Brief description of Pennecot (primary reference)
    - OA admits that Pennecot does not teach/suggest the claimed micro-optic channels including the aperture array coincident with the focal plane of the bulk receiver
- Explanation on why Streuber (secondary reference) does not teach/suggest such and thus does not make up for the deficiency of Pennecot

I will call you on the 19th and look forward to discussing this application with you then.

Best regards,



Bill Shaffer
Kilpatrick Townsend & Stockton LLP
Suite 250 | 12255 El Camino Real | San Diego, CA 92130
office 858 350 6104 | fax 858 350 6111
wshaffer@kilpatricktownsend.com | My Profile | vCard

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033- P006US3-1086284

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	11025885	A1	06-01-2021	Pacala et al.	
	2	10809359	B2	10-20-2020	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
	3	20200036959	A1	01-30-2020	Pacala, et al.	
	4	20180359460	A1	07-26-2018	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]

1

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]
	5	U.S. Patent Application No. 17/317,809 filed May 11, 2021; 81 pages.	
	6	U.S. Patent Application No. 17/323,962, filed May 18, 2021; 78 pages.	
	7	U.S. Patent Application No. 17/194,068, filed May March 5, 2021; 69 pages.	
	8	U.S. Patent Application No. 17/323,983, filed May May 18, 2021; 80 pages.	
	9	U.S. Patent Application No. 17/323,987, filed May May 18, 2021; 81 pages.	

EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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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	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033- P006US3-1086284

*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.

Electronic Patent Application Fee Transmittal

Application Number:	15979266
Filing Date:	14-May-2018
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
First Named Inventor/Applicant Name:	Angus PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P006US3-1086284

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:				
CLAIMS IN EXCESS OF 20	2202	5	50	250
INDEPENDENT CLAIMS IN EXCESS OF 3	2201	1	240	240
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	130	130
		Total in USD ($)		**620**

Electronic Acknowledgement Receipt

EFS ID:	42804999
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	24-MAY-2021
Filing Date:	14-MAY-2018
Time Stamp:	18:29:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$620
RAM confirmation Number	E20215NI29321522
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		Response-NFOA_with_TD_P006US3-10862284.pdf	140542 0c1794c644d47e6bbde40b3ed0c3e1abba306731	yes	14

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	9
	Applicant summary of interview with examiner	10	10
	Applicant Arguments/Remarks Made in an Amendment	11	14

Warnings:

Information:

2		P006US3_IDS.pdf	185424 88967ebf2138a78cb9aa77da9f901f767f54c025	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	2
	Information Disclosure Statement (IDS) Form (SB08)	3	4

Warnings:

Information:

3	Non Patent Literature	NPL-P001USC4-patent-application.pdf	1784585 dce9a7acc7156429bc97e8b9fc1139eb88606fff	no	40

Warnings:

Information:

4	Non Patent Literature	NPL_P001USC5-patent-application.pdf	1700351 bd697f7a880f7827d1f5f8c108b92ce3d75861a3	no	39
Warnings:					
Information:					
5	Non Patent Literature	NPL_P004USC3-patent-application.pdf	1468805 afc4d70849e69d8342c01c675fcf9b3b9847060b	no	35
Warnings:					
Information:					
6	Non Patent Literature	NPL_P010US3C1_patent-application.pdf	4346141 79a2949cee70c40c4a1f45d51dd99ea3d6270249	no	81
Warnings:					
Information:					
7	Non Patent Literature	NPL_P010US3C2-patent-application.pdf	4364029 26bb381ea3d00f6a1eb12deb51db63036d7e4a6e	no	82
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	33784 36a3f1e73e5db84afc0d0ed1ab24102abff67d45	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	14023661	

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.

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on May 24, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033-P006US3-1086284
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Angus Pacala et al.

Application No.: 15/979,266

Filed: May 14, 2018

For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

Customer No.: 20350

Confirmation No.: 9761

Examiner: Amir J. Askarian

Art Unit: 3645

AFTER NON-FINAL AMENDMENT

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

Commissioner:

In response to the Non-Final Office Action mailed February 22, 2021, please enter the following amendments and consider the following remarks:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Applicant Summary of Interview with the Examiner begins on page 10 of this paper.

Remarks/Arguments begin on page 11 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings of claims in the application.

Listing of Claims:

1. (Currently Amended) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having an optically transparent window;

a spinning light ranging device disposed within the housing, the light ranging device comprising:

a platform;

an optical transmitter coupled to the platform, the optical transmitter comprising a bulk transmitter optic and a plurality of transmitter channels, each transmitter channel including a light emitter configured to generate and transmit a narrowband light through the bulk transmitter optic into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising a bulk receiver optic, an aperture layer coincident with a focal plane of the bulk receiver optic and comprising a plurality of apertures separated by a stop region, 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~~from the plurality of apertures, an optical filter positioned along a path of light from the bulk receiver optic and axially aligned with the aperture, and a photosensor responsive to incident photons passed through the aperture and the optical filter;

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform, optical transmitter, and optical receiver within the housing; and

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

2. (Original) The optical system set forth in claim 1 wherein the optical receiver further includes a collimating lens behind the aperture and directly coupled to the optical filter, the optical filter positioned behind the collimating lens.

3. (Original) The optical system set forth in claim 1 wherein the optical filter is a filter layer on a hemispherical lens positioned directly on a top or bottom side of the aperture.

4. (Original) The optical system set forth in claim 1 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

5. (Original) The optical system set forth in claim 4 further comprising a corrective optical structure to correct for optical aberrations caused by the transparent window.

6. (Canceled)

7. (Original) The optical system set forth in claim 1 wherein the optical transmitter and optical receiver are configured such that each transmitter channel is paired with a receiver channel and the centers of their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system.

8. (Original) The optical system set forth in claim 1 wherein the plurality of micro-optic receiver channels are part of a monolithic ASIC constructed on a common substrate, within which the array of photosensors are fabricated, and the separate layers for the aperture layer, and the filter layer are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC.

9. (Currently Amended) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having a base, a top and an optically transparent window disposed between the base and the top;

a spinning light ranging device disposed within the housing and aligned with the optically transparent window, the light ranging device comprising:

a platform;

an optical transmitter coupled to the platform, the optical transmitter comprising an image-space telecentric bulk transmitter optic and a plurality of transmitter channels, each channel including a light emitter configured to generate and transmit a narrowband light through the bulk transmitter optic into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising an image-space telecentric bulk receiver optic, an aperture layer comprising a plurality of apertures, and a plurality of micro-optic receiver channels, each micro-optic channel including an aperture from the plurality of apertures 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;

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform, optical transmitter and optical receiver within the housing;

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

10. (Original) The optical system set forth in claim 9 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

11. (Original) The optical system set forth in claim 9 wherein the optical transmitter and optical receiver are configured such that each transmitter channel is paired with a receiver channel and the centers of their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system.

12. (Original) The optical system set forth in claim 9 wherein the plurality of micro-optic receiver channels are part of a monolithic ASIC constructed on a common substrate, within which the array of photosensors are fabricated, and the separate layers for the aperture layer, and the filter layer are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC.

13. (Canceled)

14. (Currently Amended) An optical system for performing distance measurements, the optical system comprising:

a stationary housing having a base, a top and an optically transparent window disposed between the base and the top;

a light ranging device disposed within the housing and aligned with the optically transparent window, the light ranging device comprising:

a platform;

a plurality of vertical-cavity surface emitting lasers (VCSELs) arranged in an array, each VCSEL in the plurality of VCSELs being configured to generate and transmit discrete pulses of light into a field external to the optical system; and

an optical receiver coupled to the platform, the optical receiver comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors, each photosensor comprising a plurality of single-photon avalanche diodes (SPADs) responsive to incident photons, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of light to pass through the filter to the plurality of photosensors while blocking light outside the band from reaching the plurality of photosensors;

wherein the plurality of apertures comprises at least first and second apertures, the plurality of photosensors comprises at least first and second photosensors, and the optical receiver includes a first optical path extending between the bulk receiver optic and the first photosensor through the first aperture and a second optical path extending between the bulk receiver optic and the second photosensor through the second aperture;

a motor disposed within the housing and operatively coupled to spin the light ranging device within the housing; and

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device.

15. (Original) The optical system set forth in claim 14 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing.

16. (Currently Amended) The optical system set forth in claim 14 wherein the plurality of VCSELs are arranged to form a plurality of emitter channels having non-overlapping fields of view at a certain distance from the optical system and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping fields of view at a certain distance from the optical system, and wherein ~~optical transmitter and optical receiver are configured such that~~ each transmitter channel is paired with a separate one of the receiver channel~~s and the centers of their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system~~.

17. (Currently Amended) The optical system set forth in claim 14 wherein the plurality of photosensors are fabricated within, and form part of, a monolithic ASIC constructed on a common substrate~~, and wherein the separate layers for the aperture layer, and the filter layer are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC~~.

18. (Canceled)

19. (Currently Amended) The optical system set forth in claim 14 wherein ~~each of the separate layers for~~ the first and second apertures are pinhole apertures~~, the filter layer, and the photosensors is bonded to its adjacent layer~~.

20. (Original) The optical system set forth in claim 14 wherein the discrete pulses of light are each coded with an embedded positive-value pulse-code formed by an intensity of its respective pulse of light.

21. (New) The optical system set forth in claim 14 wherein the plurality of apertures further comprises third and fourth apertures, the plurality of photosensors further comprises third and fourth photosensors, and the optical receiver includes a third optical path extending between the bulk receiver optic and the third photosensor through the third aperture and a fourth optical path extending between the bulk receiver optic and the fourth photosensor through the fourth aperture.

22. (New) The optical system set forth in claim 14 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.

23. (New) The optical system set forth in claim 14 wherein:

the bulk transmitter optic and the bulk receiver optic are each image-space telecentric optics; and

the plurality of emitters are configured to project a plurality of illuminating beams in the field external to 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 photosensors

24. (New) An optical system for performing distance measurements, the optical system comprising:

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

a light ranging device disposed within the housing and comprising:

a platform;

a light transmission module coupled to the platform and comprising a bulk transmitter optic and a plurality of optical emitters, each optical emitter in the plurality of optical emitters configured to generate and transmit pulses of radiation through the bulk transmitter optic and through the optically transparent window into a field external to the optical system; and

a light sensing module coupled to the platform and comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the filter to the plurality of photosensors while blocking radiation outside the band from reaching the plurality of photosensors; and

a motor disposed within the housing and operatively coupled to spin the platform and the light ranging device within the housing;

wherein:

each photosensor in the plurality of photosensors comprises a plurality of single photon avalance diodes (SPADs);

the plurality of apertures comprises at least first, second, third and fourth apertures;

the plurality of photosensors comprises at least first, second, third and fourth photosensors; and

the light sensing module includes a first optical path to the first photosensor through the first aperture, a second optical path to the second photosensor through the second aperture, a third optical path to the third photosensor through the third aperture, and a fourth optical path to the fourth photosensor through the fourth aperture.

25. (New) The optical system for performing distance measurements according to claim 24 wherein the bulk transmitter optic and the bulk receiver optic are each image-space telecentric optics.

26. (New) The optical system for performing distance measurements according to claim 24 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.

27. (New) The optical system for performing distance measurements according to claim 24 wherein the plurality of optical emitters are arranged to form a plurality of emitter channels having non-overlapping fields of view, and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping the fields of view and having a one-to-one relationship with the plurality of emitter channels such that the field of view for each receiver channel is coincident with the field of view of a corresponding emitter channel.

28. (New) The optical system for performing distance measurements according to claim 24 wherein the plurality of emitters are configured to project a plurality of illuminating beams in the field external to 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 photosensors.

APPLICANT SUMMARY OF INTERVIEW WITH THE EXAMINER

Applicants thank the Examiner for the courtesy of an interview conducted on May 19, 2021, with Applicant's representative, William L. Shaffer. During the interview, claim 1 and the prior art was discussed and the Examiner suggested a relatively minor amendment that would overcome the current rejection. Applicants thank the Examiner for this suggestion and present this response, which is in line with what was discussed during the interview.

REMARKS/ARGUMENTS

Upon entry of the present amendment, claims 1-5, 7-12, 14-17 and 19-28 will be pending in this application. Claims 1, 9, 14, 16-17 and 19 have been amended, claims 6, 13 and 18 have been canceled, and new claims 21-28 have been added. No new matter is added.

Claims 1-2, 7, 9, and 11 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Publication No. 2016/0282453 (Pennecot) in view of U.S. Publication No. 2014/0320843 (Streuber).

Claim 3 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, and further in view of U.S. Patent No. 4,275,950 (Meyer).

Claims 4 and 10 were rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, and further in view of U.S. Publication No. 2017/0269215 (Hall).

Claim 5 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, further in view of Hall, and further in view of U.S. Publication No. 2018/0267148 (Buettner).

Claim 6 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, further in view of Hall, further in view of Buettner, and further in view of U.S. Publication No. 2007/0002434 (Juskaitis).

Claims 8 and 12 were rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, and further in view of U.S. Patent No. 4,003,660 (Christie).

Claim 13 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, and further in view of U.S. Publication No. 2016/0254312 (Lee).

Claims 14-18 were rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, and further in view of U.S. Publication No. 2018/0284228 (LaChapelle).

Claim 19 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, further in view of LaChapelle, and further in view of Lee.

Claim 20 was rejected under 35 U.S.C. § 103 as being unpatentable over Pennecot in view of Streuber, further in view of LaChapelle, and further in view of U.S. Publication No. 2017/0078026 (Brilman).

Claims 1-3, 7-9, 11-12, and 14-18 stand rejected on the grounds of alleged nonstatutory double patenting as being unpatentable over claims 1, 3-9, 11-15, and 17-20 of U.S. Application No. 15/979,277.

Based on the following remarks, Applicant respectfully requests reconsideration and allowance of the pending claims.

The Rejections under 35 USC §103

Claims 1-20 stand rejected under 35 U.S.C. 103 as being unpatentable over Pennecot in view of Streuber alone or in combination with one or more additional references.

While Applicants disagree with the rejections set forth in the Office Action, as discussed during the above mentioned Examiner Interview and in order to expedite prosecution of the present application, Applicants have amended claim 1 as suggested by the Examiner to clarify that the plurality of apertures have a stop region formed between them. Applicants respectfully assert that that the cited prior art does not teach or suggest, among other limitations, the claimed aperture layer and that claim 1 is patentable over the cited art.

Applicants further note that independent claims 9 and 14 include a similar limitation as the limitation discussed with the Examiner and are thus believed to be patentable over the cited art for at least the same reasons as claim 1 as well as for the additional limitations recited in each such claim.

Furthermore, Applicants note that each of the dependent claims 2-5, 7-8, 10-12, 15, and 19-20 depend in one manner or another from one of independent claims 1, 9 or 14 and are thus believed to be patentable over the cited art for at least the same reasons as their parent claim as well as for the additional limitations recited in each such claim.

Double Patenting

Claims 1-3, 7-9, 11-12, and 14-18 stand rejected on the grounds of alleged nonstatutory double patenting as being unpatentable over claims 1, 3-9, 11-15, and 17-20 of U.S. Application No. 15/979,277. The '277 patent application has published as U.S. Publication 2018-0329060.

Without agreeing with this rejection and in the interest of expediting allowance of the present application, a terminal disclaimer has been obtained and included with this Amendment to alleviate the double patenting rejection. In view of the Terminal Disclaimer and the comments set forth herein, Applicants respectfully assert that the pending claims are now in condition for allowance.

New Claims

New claims 21-28 have been added to secure an appropriate scope of protection for the present invention. Applicants respectfully assert that the new claims are supported by the application as originally filed and that no new matter is added.

New claims 21-23 depend from claim 14, which as noted above, is believed to be in condition for allowance. Thus, each of claims 21-23 are believed to be allowable for at least the same reasons as their parent claim as well as for the additional limitations recited in each dependent claim.

New claim 24 is an independent claim that is believed to be patentable over the cited art for reasons similar to those discussed above with respect to independent claims 1, 9 and 14, and claims 25-28 each depend from claim 24 and are thus believed to be allowable for at least the same reasons as their parent as well as for the additional limitations recited in each such claim.

CONCLUSION

In view of the foregoing, Applicant believes all claims now pending in this application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

Except for the issue fees payable under 37 C.F.R. § 1.18, the Director is authorized to charge any additional fees during pendency of this application, including any required extension

of time fees, or credit any overpayment to Deposit Account Number 20-1430. This paragraph is intended to be a constructive petition for extension of time in accordance with 37 C.F.R. § 1.136(a)(3).

If the Examiner believes a telephone conference would expedite prosecution of this application, please contact the undersigned at 858-350-6104 or wshaffer@kilpatricktownsend.com.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

I hereby certify that this correspondence is being filed via EFS-Web with the United States Patent and Trademark Office on May 24, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033- P006US3-1086284
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Not yet assigned
Application No.: 15/979,266	Technology Center/Art Unit: 2875
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	**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 remaining cited references are provided.

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 *after* the mailing of the first Office Action on the merits, but before the mailing date of the final Office Action, Notice of Allowance, or any other action that closes prosecution.

The Commissioner is authorized to charge the fee set forth in §1.17(p) to the firm's credit card for consideration of this paper. The Commissioner is authorized to charge any additional fee due to Deposit Account No. 20-1430.

Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/25 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A PROVISIONAL DOUBLE PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION**
Application Number	15979266
Filing Date	14-May-2018
First Named Inventor	Angus PACALA
Attorney Docket Number	103033-P006US3-1086284
Title of Invention	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
Ouster, Inc.	100%

The owner(s) of percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of any patent granted on pending reference Application Number(s)

15979277 filed on 05/14/2018

as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and any patent granted on the reference application are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term of any patent granted on said reference application, "as the term of any patent granted on said reference application may be shortened by any terminal disclaimer filed prior to the grant of any patent on the pending reference application," in the event that any such patent granted on the pending reference application: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims canceled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as shortened by any terminal disclaimer filed prior to its grant.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request.

○	I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.

Applicant claims the following fee status:

- ◉ Small Entity
- ○ Micro Entity
- ○ Regular Undiscounted

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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 is of record in this application

  Registration Number 37234

- ○ 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 request

Signature	/William L. Shaffer/
Name	William L. Shaffer

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	15979266
Filing Date:	14-May-2018
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
First Named Inventor/Applicant Name:	Angus PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P006US3-1086284

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	170	170
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**170**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 15979266

Filing Date: 14-May-2018

Applicant/Patent under Reexamination: PACALA

Electronic Terminal Disclaimer filed on May 24, 2021

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt

EFS ID:	42804817
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	24-MAY-2021
Filing Date:	14-MAY-2018
Time Stamp:	16:59:22
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$170
RAM confirmation Number	E20215NG59174834
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	Terminal Disclaimer-Filed (Electronic)	eTerminal-Disclaimer.pdf	34044 e5d19aefac01e1030959f7620a2dbfc8c6619e52	no	2
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30481 c6f3582a5d5bda7024591ccbdf73717522d8bb45	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	64525		

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/06 (09-11)
Approved for use through 1/31/2014. 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 displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/979,266	Filing Date 05/14/2018	☐ To be Mailed

ENTITY: ☐ LARGE ☑ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $50 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $230 =	
☐ 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).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	05/24/2021	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 25	Minus	** 20	= 5		x $50 =	250
	Independent (37 CFR 1.16(h))	* 4	Minus	*** 3	= 1		x $240 =	240
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	490

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/TARA A WASHINGTON/
*** 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 number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. 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 12 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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284-P006US3

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
	1.	20180106900		Apr 19, 2018	Droz 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]
	2.	Application No 15/979,277 , Final Office Action, Mailed On March 30, 2021, 7 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

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284-P006US3

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)	2021-04-20
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 Patent Application Fee Transmittal

Application Number:	15979266
Filing Date:	14-May-2018
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
First Named Inventor/Applicant Name:	Angus PACALA
Filer:	William Leland Shaffer/LaRenda Meyer
Attorney Docket Number:	103033-P006US3-1086284

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:	42509655
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	21-APR-2021
Filing Date:	14-MAY-2018
Time Stamp:	12:06:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$130
RAM confirmation Number	E20214KC08294963
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	Information Disclosure Statement (IDS) Form (SB08)	IDS-P006US3.pdf	130711 e349d9a258877a83c52cd9c57d727719cfcda0fb	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
2	Non Patent Literature	P006US4-Final-OA.pdf	687325 a867c42491f37aa34f05f97c83e7b67a2bfd8cec	no	18
Warnings:					
Information:					
3	Fee Worksheet (SB06)	fee-info.pdf	30443 d4ee605e15b48490f390287131d4c566f210bc25	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	848479		

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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.

PTO/SB/08a (01-10)
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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	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	3645
Examiner Name	Amir J Askarian
Attorney Docket Number	103033-1086284-P006US3

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

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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	15/979,253 , "Non-Final Office Action", February 19, 2021, 7 pages	
	2	15/979,295 , "Notice of Allowance", January 27, 2021, 5 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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[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

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☐ 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)	2021-03-23
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.**

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	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	3645
	Examiner Name	Amir J Askarian
	Attorney Docket Number	103033-1086284-P006US3

Electronic Acknowledgement Receipt

EFS ID:	42256933
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	23-MAR-2021
Filing Date:	14-MAY-2018
Time Stamp:	15:02:14
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)	P006US3-IDS.pdf	133191 d403009bfa5e8927c79e91d48263dd5b6418cbdf	no	3

Warnings:

Information:	
This is not an USPTO supplied IDS fillable form	
Total Files Size (in bytes):	133191

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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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UNITED STATES PATENT AND TRADEMARK OFFICE

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/979,266	05/14/2018	Angus PACALA	103033-P006US3-1086284	9761

20350 7590 02/22/2021

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

EXAMINER	
ASKARIAN, AMIR J	

ART UNIT	PAPER NUMBER
3645	

NOTIFICATION DATE	DELIVERY MODE
02/22/2021	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

Office Action Summary	Application No. 15/979,266	Applicant(s) PACALA et al.	
	Examiner AMIR J ASKARIAN	Art Unit 3645	AIA (FITF) Status Yes

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

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 05/14/2018.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ 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.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, 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.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 05/14/2018 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ 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)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

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.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

Claim(s) 1, 2, 7, 9, 11 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber).

1, 9. Pennecot discloses An optical system for performing distance measurements (Title, ¶78), the optical system comprising:

a stationary housing (Fig. 1: 102; ¶41, 42) [having a base and a top *as recited in claim 9* (Fig. 1: 102 necessarily has a base and a top, also Fig. 2A: 260, 210; ¶61-64)] having an optically transparent window (Fig, 2A: the opening for emitted and reflected light 204, 206; ¶61) [disposed between the base and the top *as recited in claim 9* (Fig. 2A, 2B; ¶60-67)];

a spinning light ranging device disposed within the housing (Fig. 2B: 290; ¶63, 65, 79) [and aligned with the optically transparent window *as recited in claim 9* (Fig. 2A, 2B; ¶60-67)], the light ranging device comprising:

a platform (Fig. 2B: 210; ¶62);

an optical transmitter coupled to the platform (Fig. 2B: 222a-c; ¶67-69), the optical transmitter comprising a bulk transmitter optic (Fig. 2B: lens 250; ¶70-72) and a

plurality of transmitter channels (Fig. 2B: 202a-c; ¶70-72), each transmitter channel including a light emitter configured to generate and transmit a narrowband light through the bulk transmitter optic into a field external to the optical system (Fig. 2B: 204a-c; ¶67-68, 70-74); and

an optical receiver coupled to the platform (Fig. 2B: 232a-c), …

a motor disposed within the housing and operatively coupled to spin the light ranging device including the platform, optical transmitter, and optical receiver within the housing (Fig. 6A: motor 670; ¶93, 98); and

a system controller disposed within the housing, the system controller configured to control the motor and to start and stop light detection operations of the light ranging device (Fig. 1: controller 180; ¶57-59, 63, 140, 118, 152).

While not explicitly disclosing, Pennecot in view of Streuber teaches

the optical receiver comprising a bulk receiver optic (Streuber Fig. 5: relay optics 112; ¶44) and a plurality of micro-optic receiver channels (Streuber Fig. 5: e.g. 124, 114; ¶47-48, 52), each micro-optic channel including an aperture coincident with a focal plane of the bulk receiver optic (Streuber Fig. 5: array 114, elements 124, which necessarily has aperture for the beam to pass through, is positioned on focal plane 116; ¶44), an optical filter positioned along a path of light from the bulk receiver optic and axially aligned with the aperture (Streuber Fig. 5: filter 138, Fig. 4: filters 92; ¶41-44, 50), and a photosensor responsive to incident photons passed through the aperture and the optical filter (Streuber Fig. 5: detector 140; ¶51);

with respect to claim 9, Pennecot in view of Streuber teaches

image-space telecentric optic (Streuber ¶47) …

a collimating lens behind the aperture (Streuber Fig. 5: elements 118; ¶46-49), an optical filter behind the collimating lens (Streuber Fig. 5; ¶49-50).

It would have been obvious to one of ordinary skill in the art to modify Pennecot by replacing the receiver as taught by Pennecot with the receiver as taught by Streuber because doing so is a substitution of a known receiver with another known receiver and in doing so, "by spatially multiplexing the different sub-channels into different sub-regions on the detector, the electrical signals for those sub-channels can be read out simultaneously" as taught by Streuber in ¶51 and may provide "high detection sensitivity to maintain high SNR and a multi-filtered optical channel that provides detection in different measurement bands" and may "detect high spatial resolution images with low resolution detectors" as taught by Streuber in Abstract. Further it would have been obvious to one of ordinary skill in the art to modify Pennecot to use telecentric configuration of optics so that "each sub-field would contain a displaced, but identical spread of rays" (Streuber ¶47).

2. Pennecot in view of Streuber teaches The optical system set forth in claim 1 wherein the optical receiver further includes a collimating lens behind the aperture and directly coupled to the optical filter (Streuber Fig. 5: elements 118; ¶46-49), the optical filter positioned behind the collimating lens (Streuber Fig. 5; ¶49-50).

It would have been obvious to one of ordinary skill in the art to combine Pennecot and Streuber for the same reasons described above.

7, 11. Pennecot in view of Streuber teaches The optical system set forth in claim 1 wherein the optical transmitter and optical receiver are configured such that each transmitter channel is paired with a receiver channel (Pennecot Figs. 2B, 21; ¶159-162) and the centers of

their fields-of-view are aligned to be non-overlapping at a certain distance from the optical system (Pennecot Figs. 2B, 21; ¶155, 156).

Claim(s) 3 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US 4275950 A (Meyer).

3. While not explicitly disclosing, Pennecot in view of Streuber further in view of Meyer teaches The optical system set forth in claim 1 wherein the optical filter is a filter layer on a hemispherical lens positioned directly on a top or bottom side of the aperture (Meyer Figs. 20, 21, 300; col. 3, lns 55-63, col. 14 lns 24-26).

It would have been obvious to one of ordinary skill in the art to modify Pennecot in view of Streuber such that the filter is on a hemispherical lens as taught by Meyer because doing so is a simple design modification and may reduce the spacing of the components.

Claim(s) 4, 10 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20170269215A1 (Hall).

4, 10. While not explicitly disclosing, Pennecot in view of Streuber further in view of Hall teaches The optical system set forth in claim 1 wherein the stationary housing is cylindrical in shape and the optically transparent window extends fully around a periphery of the stationary housing (Hall Fig. 2: 12, 17, 18; ¶52-57).

It would have been obvious to one of ordinary skill in the art to modify Pennecot such that the window extends fully around a periphery because doing so is a well-known and routine design choice and it may provide uninterrupted 360 degree view while providing more protection for the transmitter and receiver components.

Claim(s) 5 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20170269215A1 (Hall) further in view of US20180267148A1 (Buettner).

5. While not explicitly disclosing, Pennecot in view of Streuber further in view of Hall further in view of Buettner teaches The optical system set forth in claim 4 further comprising a corrective optical structure to correct for optical aberrations caused by the transparent window (Buettner ¶[14, 31-33).

It would have been obvious to one of ordinary skill in the art to modify Pennecot to include correction of optical aberrations as taught by Buettner because doing so may enhance detection.

Claim(s) 6 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20170269215A1 (Hall) further in view of US20180267148A1 (Buettner) further in view of US 20070002434 A1 (Juskaitis).

6. While not explicitly disclosing, Pennecot in view of Streuber further in view of Hall further in view of Buettner teaches further in view of Juskaitis teaches The optical system set forth in claim 5 wherein the corrective optical structure is constructed as a cylindrical lens included as part of the bulk receiver optic, a cylindrical lens included as part of the bulk transmitter optic, an array of cylindrical lenses included as part of the micro-optic receiver channels, or an array of biconical lenses included as part of the plurality of transmitter channels (Juskaitis ¶[12).

It would have been obvious to one of ordinary skill in the art to modify Pennecot in view of Streuber further in view of Hall further in view of Buettner to include a cylindrical lens for

compensating aberration as taught by Juskaitis because using a cylindrical lens is a common method of aberration compensation which may enhance detection accuracy.

Claim(s) 8, 12 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US 4003660 A (Christie).

8, 12. While not explicitly disclosing, Pennecot in view of Streuber further in view of Janson teaches The optical system set forth in claim 1 wherein the plurality of micro-optic receiver channels are part of a monolithic ASIC constructed on a common substrate (Janson ¶10, 23), within which the array of photosensors are fabricated, and the separate layers for the aperture layer, and the filter layer are formed on the monolithic ASIC such that they become part of the monolithic structure of the ASIC (Christie Fig. 3A; col. 9 ln 26-50).

It would have been obvious to one of ordinary skill in the art to modify Pennecot in view of Streuber to manufacture the detectors and filter and aperture on a monolithic circuit because doing so is a "well known microminiature semiconductor integrated circuit fabrication techniques" as taught by Christie and may reduce the space requirement. Further, integrating components using known manufacturing technique is an obvious modification to one of ordinary skill in the art, because as e.g. taught by Christie doing so is well known.

Claim(s) 13 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US 20160254312 A1 (Lee).

13. While not explicitly disclosing, Pennecot in view of Streuber further in view of Lee teaches The optical system set forth in claim 9 wherein each of the separate layers for the apertures, the filter layer, and the photosensors is bonded to its adjacent layer (Lee ¶83, 85, 89).

It would have been obvious to one of ordinary skill in the art to modify Pennecot to include the attached layers of aperture sensors and filter because bonding is a common manufacturing process and may reduce the size of the equipment or provide stability to the components.

Claim(s) 14, 15, 16, 17, 18 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20180284228A1 (LaChapelle).

14. Pennecot in view of Streuber teaches features of claim 14 as shown above with respect to claims 1, 9.

Pennecot further discloses

a plurality of vertical-cavity surface emitting lasers (VCSELs) (¶68).

While not explicitly teaching, Pennecot in view of Streuber further in view of LaChapelle teaches

plurality of photosensors, each photosensor comprising a plurality of single-photon avalanche diodes (SPADs) (LaChapelle ¶33, 64, 108).

It would have been obvious to one of ordinary skill in the art to modify Pennecot to use SPADs photo sensors because using SPADs is routine and common in the art and they may provide high sensitivity (LaChapelle ¶33).

Claims 15, 16 , 17, 18 are taught by Pennecot in view of Streuber further in view of LaChapelle for the same reasons as described above with respect to claims 2, 7, 8, 14.

Claim(s) 19 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20180284228A1 (LaChapelle) further in view of US 20160254312 A1 (Lee).

Claim 19 is taught by Pennecot in view of Streuber further in view of LaChapelle further in view of Lee for the same reasons as described above with respect to claims 13 and 14.

Claim(s) 20 is/are rejected under 35 U.S.C. 103 as being unpatentable over US20160282453A1 (Pennecot) in view of US20140320843A1 (Streuber) further in view of US20180284228A1 (LaChapelle) further in view of US20170078026A1 (Brilman).

20. While not explicitly disclosing, Pennecot in view of Streuber further in view of LaChapelle further in view of Brilman teaches The optical system set forth in claim 14 wherein the discrete pulses of light are each coded with an embedded positive-value pulse-code formed by an intensity of its respective pulse of light (Brilman Fig. 4-6; ¶43, 58, 62).

It would have been obvious to one of ordinary skill in the art to modify Pennecot such that the pulses of light is encoded as taught by Brilman because doing so may increase security or reduce noise or susceptibility "to inter-symbol interference" as taught by Brilman in ¶10.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van*

Ornum, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 1-3, 7-9, 11-12, 14-18 of the instant application are provisionally rejected on the ground of obviousness nonstatutory double patenting as being unpatentable over claims of copending Application No. 15/979,277 in view of Pennecot because the copending application recites similar subject matter as shown in the table below except for start and stop of light detection by the controller, which is taught by Pennecot as discussed above. It would have been

obvious to one of ordinary skill in the art to use the controller as claimed by the copending application to also start and stop detection operation because doing so is well-known to provide further control over the device and may provide power saving advantage. Therefore, although the claims at issue are not identical, they are not patentably distinct from each other.

Claims of the instant application	Similar claims of application 15/979,277
1, 9, 14	1, 7, 8, 9, 15
2, 9, 15	3, 11, 17
3	4, 12, 18
7, 11, 16	5, 13, 19
8, 12, 17, 18	6, 14, 20

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been issues as a patent.

Conclusion

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

Examiner's Note: examiner has cited particular columns/paragraph and line numbers in the references applied to the claims above for the convenience of the applicant. Although the specified citations are representative of the teachings of the art and are applied to specific limitations within the individual claim, other passages and figures may apply as well. It is respectfully requested from the applicant in preparing responses, to fully consider the references

in entirety as potentially teaching all or part of the claimed invention, as well as the context of the passage as taught by the prior art or disclosed by the examiner.

In the case of amending the claimed invention, Applicant is respectfully requested to indicate the portion(s) of the specification which dictate(s) the structure relied on for proper interpretation and also to verify and ascertain the metes and bounds of the claimed invention. This will assist in expediting compact prosecution. MPEP 714.02 recites: "Applicant should also specifically point out the support for any amendments made to the disclosure. See MPEP §2163.06. An amendment which does not comply with the provisions of 37 CFR 1.121(b), (c), (d), and (h) may be held not fully responsive. See MPEP § 714." Amendments not pointing to specific support in the disclosure may be deemed as not complying with provisions of 37 C.F.R. 1.131(b), (c), (d), and (h) and therefore held not fully responsive. Generic statements such as "no new matter has been introduced" may be deemed insufficient.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMIR J ASKARIAN whose telephone number is (571)272-1246. The examiner can normally be reached on M-Th 7:30am-5:30pm.

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, Yuqing Xiao can be reached on (571) 270-3603. 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 http://pair-direct.uspto.gov. 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.

/A.J.A./
Examiner, Art Unit 3645

/YUQING XIAO/
Supervisory Patent Examiner, Art Unit 3645

Notice of References Cited	Application/Control No. 15/979,266	Applicant(s)/Patent Under Reexamination PACALA et al.	
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U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20160282453-A1	09-2016	Pennecot; Gaetan	G01S17/42	1/1
*	B	US-20140320843-A1	10-2014	Streuber; Casey T.	F41G7/2253	356/4.01
*	C	US-4275950-A	06-1981	Meyer; Stanley A.	G02B3/00	126/698
*	D	US-20170269215-A1	09-2017	Hall; David S.	G01S7/4811	1/1
*	E	US-20180267148-A1	09-2018	Buettner; Axel	G01S7/4814	1/1
*	F	US-20070002434-A1	01-2007	Juskaitis; Rimbydas	G02B27/0031	359/368
*	G	US-4003660-A	01-1977	Christie, Jr.; John S.	B41F33/0036	356/407
*	H	US-20180284228-A1	10-2018	LaChapelle; Joseph G.	G01S7/4817	1/1
*	I	US-20160254312-A1	09-2016	Lee; Young Seen	G02B27/30	382/125
*	J	US-20170078026-A1	03-2017	BRILMAN; JOOST JACOB	H04B10/524	1/1
*	K	US-20160282468-A1	09-2016	Gruver; Daniel	H05K999/99	1/1
*	L	US-20180003823-A1	01-2018	Yan; Jason	G01S17/08	1/1
*	M	US-20160274221-A1	09-2016	WU; Ming-Cho	G01S7/4817	1/1

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
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U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20140293263-A1	10-2014	Justice; James	G01S17/42	356/4.01
*	B	US-20180123412-A1	05-2018	Karplus; Paul	H02K1/2793	1/1
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FOREIGN PATENT DOCUMENTS

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	AMIR J ASKARIAN	3645

CPC - Searched*		
Symbol	**Date**	**Examiner**
G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801 limited with text	02/12/2021	aa
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15/979,266	PACALA et al.
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	AMIR J ASKARIAN	3645

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
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OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285) limited with text		

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Application Number	15/979,266
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First Named Inventor	Angus Pacala
Art Unit	2875
Examiner Name	Alsomiri, Isam A.
Attorney Docket Number	103033-P006US3-1086284

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.	5084596	A	01-28-1992	Borsh	
	2.	8633384	B1	01-21-2014	Shotey, 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
	3.	20110266022	A1	11-03-2011	Jafari	
	4.	20140224792	A1	08-14-2014	Beneke	

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

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	5.	EUROPEAN PATENT OFFICE; Extended European Search Report received in European Application No. 16865297.2, mailed June 11, 2019; 9 pages.	

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[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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Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

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	4634272	A	1987-01-06	Endo	
	2	4676599	A	1987-06-30	Cruz	
	3	4702600	A	1987-10-27	Handrich, et al.	
	4	4358851	A	07-25-1989	Scifres, Donald R., et al.	
	5	4744667	A	1988-05-17	Fay, et al.	
	6	5982552	A	Nov 9, 1999	Nakama et al.	
	7	6133989	A	2000-10-17	Stettner, et al.	
	8	6414746	B1	2004-02-10	Stettner, et al.	
	9	6690019	B2	2004-02-10	Stettner, et al.	
	10	6721262	B1	Apr 13, 2004	Jordache et al.	
	11	7433042	B1	Oct 7, 2008	Cavanaugh et al.	
	12	7091462	B2	2006-08-15	Wilson, et al.	
	13	D531525	S1	11-07-2006	Dold, et al.	
	14	7170542	B2	01-30-2007	Hanina, et al.	
	15	7295298	B2	11-13-2007	Willhoeft, et al.	
	16	7345271	B2	03-18-2008	Boehlau, et al.	
	17	7421159	B2	09-02-2008	Yang, et al.	
	18	7808706	B2	10-05-2010	Fadel, et al.	
	19	8013983	B2	09-06-2011	Lin, et al.	
	20	8130367	B2	03-06-2012	Stettner, et al.	
	21	D659030	S1	05-08-2012	Anselment, et al.	
	22	8319949	B2	11-27-2012	Cantin, et al.	
	23	8374405	B2	02-12-2013	Lee, et al.	
	24	4851664		02-22-1994	Rieger, Harry	
	25	5288992	A	06/28/2011	Fohl, Timothy	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

Doc code: IDS
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	26	7969558	B2	01/03/2012	Hall, David S.	
	27	8089618	B2	12/11/2012	Yang, Dezhong	
	28	8330840	B2	05/06/2014	Lenchenkov, Victor	
	29	8717488	B2	03/15/2016	Shpunt, Alexander, et al.	
	30	9285477	B1	07/05/2016	Smith, Scott T., et al.	
	31	9383753	B1	11/09/1982	Templeton, Bradley, et al.	
	32	6721262	B1	Apr 13 2004	Jordache et al.	
	33	7433042	B1	Oct 7 2008	Cavanaugh et al.	
	34	8384997	B2	02-26-2013	Shpunt, et al.	
	35	8494252	B2	07-23-2013	Freedman, et al.	
	36	8675181	B2	03-18-2014	Hall	
	37	8742325	B1	06-03-2014	Droz, et al.	
	38	8743176	B2	06-03-2014	Stettner, et al.	
	39	8761495	B2	06-14-2014	Freedman, et al.	
	40	8767190	B2	07-01-2014	Hall	
	41	8829406	B2	09-09-2014	Akerman, et al.	
	42	8836922	B1	09-16-2014	Pennecot, et al.	
	43	8848039	B2	09-30-2014	Spektor, et al.	
	44	9041915	B2	05-26-2015	Earnhart, et al.	
	45	9063549	B1	06-23-2015	Pennecot, et al.	
	46	9071763	B1	06-30-2015	Templeton, et al.	
	47	9086273	B1	07-21-2015	Gruver, et al.	
	48	9111444	B2	08-18-2015	Kaganovich	
	49	9157790	B2	10-13-2015	Shpunt, et al.	
	50	9164511	B1	10-20-2015	Ferguson, et al.	
	51	9176051	B2	11-03-2015	Mappes, et al.	
	52	9229109	B2	01-05-2016	Stettner, et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

PTOSB08a (01-10)
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	53	9285464	B2	03-15-2016	Pennecot, et al.	
	54	9299731	B1	03-29-2016	Lenius, et al.	
	55	9368936	B1	06-14-2016	Lenius, et al.	
	56	9369689	B2	06-14-2016	Tran, et al.	
	57	9425654	B2	08-23-2016	Lenius, et al.	
	58	9435891	B2	09-06-2016	Oggier	
	59	9470520	B2	10-18-2016	Schwarz, et al.	
	60	9489601	B2	11-08-2016	Fairfield, et al.	
	61	9525863	B2	12-20-2016	Nawasra, et al.	
	62	9529079	B1	12-27-2016	Droz, et al.	
	63	6374024	B1	04-16-2002	Iijima	
	64	6014232	A	01-11-2000	Clarke	
	65	6255133	B1	07-03-2001	Ormond	
	66	5267016	A	11-30-1993	Meinzer, 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
	67	20040061502	A1	Apr 1, 2004	Hasser	
	68	20100008588	A1	Jan 14 2010	Feldkhun et al.	
	69	20120320164	A1	Dec 20 2012	Lipton	
	70	20150292948	A1	Oct 15 2015	Goldring et al.	
	71	20150131080	A1	May 2015	Retterath, et al.	
	72	20160150963	A1	Jun 2 2016	Roukes et al.	
	73	20160291134	A1	Oct 6, 2016	Droz, et al.	
	74	20170289524	A1	Oct 5 2017	Pacala et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	75	20030047752	A1	03-2003	Campbell Joe C.	
	76	20040223071	A1	11-2004	Wells David	
	77	20050030409	A1	02-2005	Matherson Kevin J.	
	78	20060244851	A1	11-2006	Cartlidge; Andrew G.	
	79	20070007563	A1	01-2007	Mouli; Chandra	
	80	20080153189	A1	06-2008	Plaine; Glenn-Yves	
	81	20090016642	A1	01-2009	Hart; Douglas P.	
	82	20090040629	A1	02-2009	Bechtel; Jon H.	
	83	20100110275	A1	05-2010	Mathieu; Gilles	
	84	20110037849	A1	02-2011	NICLA88; Cristiano	
	85	20130300840	A1	11-2013	Borowski; Andre	
	86	20140269796	A1	09-2014	Geske; Jonathan	
	87	20160327779	A1	11-2016	Hillman; Elizabeth	
	88	20170289524	A1	10-2017	Pacala Angus	
	89	20070060806	A1	07-03-15	Hunter et al.	
	90	20070228262	A1	07-10-04	Cantin et al.	
	91	20100204964	A1	08-12-2010	Pack, et al.	
	92	20110025843	A1	02-03-2011	Oggier, et al.	
	93	20110116262	A1	05-19-2011	Marson	
	94	20120044476	A1	02-23-2012	Earnhart, et al.	
	95	20120140109	A1	06-07-2012	Shpunt, et al.	
	96	20120287417	A1	11-15-2012	Mimeault	
	97	20130044310	A1	02-21-2013	Mimeault	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	98	20130141549	A1	06-06-2013	Beers, et al.	
	99	20130206967	A1	08-15-2013	Shpunt, et al.	
	100	20130294089	A1	11-07-2013	Freedman, et al.	
	101	20140118335	A1	05-01-2014	Gurman	
	102	20140158900	A1	06-12-2014	Dae-Kun, Yoon	
	103	20140118493	A1	05-01-2014	Sali, et al.	
	104	20140153001	A1	06-05-2014	Chayat, et al.	
	105	20140168631	A1	06-19-2014	Haslim, et al.	
	106	20140176933	A1	06-26-2014	Haslim, et al.	
	107	20140285628	A1	09-25-2014	Shpunt, et al.	
	108	20140291491	A1	10-02-2014	Shpunt, et al.	
	109	20140313519	A1	10-23-2014	Shpunt, et al.	
	110	20140375977	A1	12-25-2014	Ludwig, et al.	
	111	20140376092	A1	12-25-2014	Mor	
	112	20150002636	A1	01-01-2015	Brown, et al.	
	113	20150184999	A1	07-02-2015	Stettner	
	114	20150316473	A1	11-05-2015	Kester, et al.	
	115	20150355470	A1	12-10-2015	Herschbach	
	116	20150358601	A1	12-10-2015	Oggier	
	117	20150379371	A1	12-31-2015	Yoon, et al.	
	118	20160003946	A1	01-07-2016	Gilliland, et al.	
	119	20160047895	A1	02-18-2016	Dussan	
	120	20160047896	A1	02-18-2016	Dussan	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	121	20160047897	A1	02-18-2016	Dussan	
	122	20160047898	A1	02-18-2016	Dussan	
	123	20160047899	A1	02-18-2016	Dussan	
	124	20160047900	A1	02-18-2016	Dussan	
	125	20160047903	A1	02-18-2016	Dussan	
	126	20160097858	A1	04-07-2016	Mundhenk, et al.	
	127	20160218727	A1	07-28-2016	Maki	
	128	20160265902	A1	09-15-2016	Nawasra, et al.	
	129	201602911434	A1	10-16-2016	Droz, et al.	
	130	20160306032	A1	10-20-2016	Schwarz, et al.	
	131	20160328619	A1	11-10-2016	Yi, et al.	
	132	20170219426	A1	08-03-2017	Ouster, Inc.	
	133	20090295910	A1	12/03/2009	Mir Jose et al.	
	134	20100020306	A1	01/28/2010	Hall David S.	
	135	20100123893	A1	05/20/2010	YanQ DezhonQ	
	136	20110032398	A1	02/10/2011	Lenchenkov Victor	
	137	20110216304	A1	09/08/2011	Hall David S.	
	138	20120154914	A1	06/21/2012	MoriQuchi Chihiro et al.	
	139	20120182464	A1	07/19/2012	Shpunt Alexander et al.	
	140	20140211194	A1	07/31/2014	Pacala Angus et al.	
	141	20150192677	A1	07/09/2015	Yu Tianyue et al.	
	142	20150293224	A1	10/15/2015	Eldada Louay et al.	
	143	20150378241	A1	12/31/2015	Eldada Louay	

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	144	20160047901	A1	02/18/2016	Pacala Angus et al.		
	145	20160049765	A1	02/18/2016	Eldada Louay		
	146	20160161600	A1	06/09/2016	Eldada Louay et al.		
	147	20170350983	A1	Dec 7, 2017	Hall, et al.		
	148	2017269215	A1	Sept 21, 2017	Hall, et al.		
	149	2017269209	A1	Sept 21, 2017	Hall, et al.		
	150	2017269198	A1	Sept 21, 2017	Hall, et al.		
	151	2017269197	A1	Sept 21, 2017	Hall, et al.		
	152	2017219695	A1	Aug 3, 2017	Hall, et al.		
	153	2017146640	A1	May 25, 2017	Hall, et al.		
	154	20090179142	A1	July 16 2009	Duparre, et al.		
	155	20030006676	A1	Jan 09, 2003	Smith, 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	PagesColumnsLines where Relevant Passages or Relevant Figures Appear	T[5]
	156	2016125165	WO	A1	Aug 11 2016	Verifood Ltd		
	157	2124069	EP	A1	2009-11-25	Ibeo Automobile Sensor Gmbh		
	158	07-049417	JP	A	02-22-2007	Onaka Sueo		
	159	3002548	EP	A1	2016-09-14	Sick AG		

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

Doc code: IDS
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	160	2015052616	WO	A1	2015-04-16	Koninklijke Philips N.V.		
	161	2016116733	WO	A1	2016-07-28	Momcilo, et al.		
	162	2017132704	WO	A1	Aug 3, 2017	Velodyne Lidar, Inc.		
	163	H3-6407	JP		Jan 11, 1991	Daido Steel Co. Ltd.		

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 andor country where published.	T[5]
	164	PCTUS2017039306 "International Search Report and Written Opinion" November 7 2017 21 pages	
	165	PCTUS2017039306 "Invitation to Pay Add'l Fees and Partial Search Report" August 31 2017 2 pages	
	166	PCTUS2017/048379 "International Search Report and Written Opinion" November 2, 2017, 15 pages	
	167	VELODYNE LIDAR, INC., HDL-32E Data Sheet 2010, 2017.	
	168	VELODYNE LIDAR, INC., HDL-32E, User's Manual 2010.; August 2016.	
	169	VELODYNE LIDAR, INC., HDL-32E, HDL-32E, webpage: http://www.velodynelidar.com/hdl-32e.html; retrieved December 6, 2017.	
	170	VELODYNE LIDAR, INC., HDL-64E Data Sheet, 2017.	
	171	VELODYNE LIDAR, INC., HDL-64E S2 and S2.1; User's Manual and Programming Guide 2007; Firmware version 4; 2007, revision November 2012.	
	172	VELODYNE LIDAR, INC., HDL-64E, S3; User's Manual and Programming Guide revision J; 2007.; December 2017.	
	173	VELODYNE LIDAR, INC., HDL-64E; webpage: http://www.velodynelidar.com/hdl-64e.html; retrieved December 6, 2017.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	Attorney Docket Number	103033-P006US3-1086284

	174	VELODYNE LIDAR, INC., VLP-16 data sheet, Puck, Real Time 3D Lidar Sensor, 2014.	
	175	VELODYNE LIDAR INC., Velodyne Lidar Puck; User's Manual and Programming Guide; 2014.	
	176	VELODYNE LIDAR, INC., VLP-16; retrieved via website: http://www.velodynelidar.com/vlp-16.html; December 6, 2017.	
	177	VELODYNE, LIDAR, INC.; Puck Hi-Res Data Sheet; Sept 2016.	
	178	VELODYNE LIDAR, INC.; Puck Hi-Res User Manual; Sept. 2016.	
	179	VELODYNE LIDAR, INC.; Puck Hi-Res retrieved via website: http://www.velodynelidar.com/vlp-16-hi-res.html; December 13, 2017.	
	180	VELODYNE LIDAR, INC.; Puck Lite Data Sheet; February 2016.	
	181	VELODYNE LIDAR, INC.; Puck Lite User Manual; February 2016.	
	182	VELODYNE LIDAR, INC.; Puck Lite, Our Lightest Sensor Ever, April 2016; retrieved via website: http://www.velodynelidar.com/vlp-16-lite.html; December 13, 2017.	
	183	VeLODYNE LIDAR, INC.,; Ultra Puck VLP-32C; November 2017; retrieved via website: http://www.velodynelidar.com/vlp-32c.html; December 13, 2017.	
	184	BRONZI, Danilo, "100 000 Frames/s 64x32 Single Photon Detector Array for 2-D Imaging and 3-D Ranging", IEEE Journal of Selected Topic in Quantum Electronics, Vol. 20, No. 6, November/December 2014; 10 pages	
	185	QUANERGY SYSTEMS EX, 1005, Review of Scientific Instruments; Volume 72, Number 4, April 2001, 13 pages.	
	186	ITZLER, Mark A., "Geiger-mode avalance photodiode focal plane arrays for three-dimensional imaging LADAR"; Princeton LIghtwave, Inc., Proc of SPIE Vol 7808 780890C-, 14 pages.	
	187	COVA, Sergio D.; "Single-Photon Counting Detectors, IEEE Photonics Journal; Vol. 3, Number 2, April 2011, 5 pages.	
	188	GUERRIERI, Fabrizio, "Two-Dimensional SPAD Imaging Camera for Photon Counting, Volume 2, Number 5, October 2010, 17 pages.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	Attorney Docket Number	103033-P006US3-1086284

	189	CHARBON, Edoardo, et al. "SPAD-Based Sensors"; TOF Range-Imaging Cameras, Remondino, F.,; Stoppa D. (Eds.), 2013, V, 240 p. 138 Illus., 85 Illus. In color., Hardcover ISBN 978-3-642-27522-7, 2013.	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	02/12/2021

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[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.

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

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

Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	Not yet assigned
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

☒ 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	/Stephen A. Mao/	Date (YYYY-MM-DD)	2018-06-15
Name	Stephen A. Mao	Registration Number	73418

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 andor 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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Art Unit	2875
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

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.	10183541	B2	01-22-2019	Van Den Bossche, et al.	
	2.	9551791	B2	01-24-2017	Van Den Bossche, et al.	
	3.	9992477	B2	06-05-2018	Pacala	
	4.	10063849	B2	08-28-2018	Pacala	
	5.	9989406	B2	06-05-2018	Pacala	
	6.	10222458	B2	03-05-2019	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
	7.	20180299554	A1	10-18-2018	Dirk van Dyck	
	8.	20190041498	A1	02-07-2019	Pierre-Yves Droz, 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]
	9	3045935	EP	A1	07-20-2016	Xenomatix Nv		
	10	3316000	EP	A1	05-02-2018	Xenomatix Nv		
	11	2018065428	WO	A3	04-12-2018	Xenomatix Nv		
	12	2018065427	WO	A1	04-12-2018	Xenomatix Nv		

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	13	2018065429	WO	A1	04-12-2018	Xenomatix Nv		
	14	2018065426	WO	A1	04-12-2018	Xenomatix Nv		
	15	2018122415	WO	A1	07-05-2018	Xenomatix Nv		
	16	2018197441	WO	A1	11-01-2018	Xenomatix Nv		

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]

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Examiner Signature	/AMIR J ASKARIAN/	Date Considered	02/12/2021

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U.S. PATENTS

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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.	20120170029	A1	Jul 5, 2012	Azzazy et al.	
	2.	20130325241	A1	Dec 5, 2013	Lombrozo et al.	
	3.	20140111812	A1	Apr 24, 2014	Baeg et al.	
	4.	20160282468	A1	Sep 29, 2016	Gruver et al.	
	5.	20180180720	A1	Jun 28, 2018	Pei et al.	
	6.	20180284228	A1	Oct 4, 2018	LaChapelle	
	7.	20180286909	A1	Oct 4, 2018	Eichenholz et al.	

FOREIGN PATENT DOCUMENTS

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NON-PATENT LITERATURE DOCUMENTS

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	8.	15/979,253 , "Corrected Notice of Allowability", December 1, 2020, 2 pages	
	9.	15/979,253 , "Corrected Notice of Allowability", December 22, 2020, 2 pages	
	10.	15/979,253 , "Corrected Notice of Allowability", January 15, 2021, 2 pages	
	11.	15/979,253 , "Corrected Notice of Allowability", January 8, 2021, 2 pages	
	12.	15/979,277 , "Non-Final Office Action", January 12, 2021, 8 pages	

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Examiner Signature	/AMIR J ASKARIAN/	Date Considered	02/12/2021

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Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	2875
Examiner Name	Not yet assigned
Attorney Docket Number	103033-1086284-P006US3

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.	6433934	B1	Aug 13, 2002	Reznichenko et al.	
	2.	D531525	S	Nov 7, 2006	Dold et al.	
	3.	7196301	B2	Mar 27, 2007	Thomas et al.	
	4.	9366573	B2	Jun 14, 2016	Geelen et al.	
	5.	9882433	B2	Jan 30, 2018	Lenius et al.	
	6.	9917423	B2	Mar 13, 2018	Song	
	7.	9935514	B1	Apr 3, 2018	Lenius et al.	
	8.	10066990	B2	Sep 4, 2018	Rosen et al.	
	9.	10222475	B2	Mar 5, 2019	Pacala et al.	
	10.	10663586	B2	May 26, 2020	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
	11.	20150260830	A1	Sep 17, 2015	Ghosh et al.	
	12.	20180109061	A1	Apr 19, 2018	Pardhan et al.	
	13.	20180118041	A1	May 3, 2018	Lenius et al.	
	14.	20180123412	A1	May 3, 2018	Karplus 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]
	15.	3002548	EP		Sep 14, 2016	Sick AG		

1

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]
	16.	AU2018269000 , "First Examination Report", June 22, 2020, 5 pages	
	17.	SG11201910605R , "Written Opinion", May 16, 2020, 6 pages	

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	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-1086284-P006US3

EXAMINER SIGNATURE			
Examiner Signature/AMIR J ASKARIAN/		Date Considered02/12/2021	

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	1.	20180136321	A1	May 17, 2018	Verghese et al.	

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	2.	16/245,909 , "Notice of Allowance", January 14, 2020, 5 pages	
	3.	15/979,235 , "Non-Final Office Action", July 23, 2018, 5 pages	
	4.	15/979,235 , "Notice of Allowance", December 19, 2018, 5 pages	
	5.	15/979,253 , "Final Office Action", August 4, 2020, 9 pages	
	6.	15/979,253 , "Non-Final Office Action", March 20, 2020, 10 pages	
	7.	15/979,295 , "Non-Final Office Action", August 4, 2020, 15 pages	
	8.	16/245,909 , "Non-Final Office Action", September 18, 2019, 6 pages	

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L1	2	"20180329061".pn.	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/08 12:10 PM
L2	224169	(G01S17/08 OR G01S17/10 OR G01S17/42 OR G01S17/89 OR G01S7/4813 OR G01S7/4815 OR G01S7/4816 OR G01S7/4817 OR G01S7/486 OR G01S7/4863 OR G01S7/4865 OR G01S17/931 OR G02B27/0037 OR G02B27/0955 OR G02B27/30 OR G02B5/205 OR G02B27/46 OR H01L27/1446 OR H01L27/14643 OR H01L31/02027 OR H01L31/02165 OR H01L31/02327 OR H01L31/107 OR H01L31/02162 OR H01L31/02164 OR H01L31/02325 OR H04B10/503 OR H04B10/675 OR H04B10/6973 OR H04B10/801).cpc. OR (G01S17/10 OR G01S7/486 OR G02B27/00 OR G02B27/09 OR G02B27/30).ipc.	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/08 12:11 PM
L3	1850	("OUSTER, INC.".ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/08 12:11 PM

L4	1850	(OUSTER.ase.) OR ("FRICHTL M".ine. OR "FRICHTL; MARK".ine. OR "PACALA A".ine. OR "PACALA; ANGUS".ine. OR "SHU M".ine. OR "SHU; MARVIN".ine.)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/08 12:12 PM
L5	192	("20120170029" OR "20130325241" OR "20140111812" OR "20160282468" OR "20180180720" OR "20180284228" OR "20180286909" OR "20180191967" OR "20180136321" OR "10066990" OR "10222475" OR "10663586" OR "20150260830" OR "20180109061" OR "20180118041" OR "20180123412" OR "6433934" OR "7196301" OR "9366573" OR "9882433" OR "9917423" OR "9935514" OR "D531525" OR "20110266022" OR "20140224792" OR "5084596" OR "8633384" OR "10063849" OR "10183541" OR "10222458" OR "20180299554" OR "20190041498" OR "9551791" OR "9989406" OR "9992477" OR "20050035474" OR "20150055117" OR "5745153" OR "20180059222" OR "20180152691" OR "20180209841" OR "20180217236" OR "20030006676" OR "20030047752" OR "20040061502" OR "20040223071" OR "20050030409" OR "20060244851" OR "20070007563" OR "20070060806" OR "20070228262" OR "20080153189" OR "20090016642" OR	US-PGPUB; USPAT	OR	ON	ON	2021/02/08 12:31 PM

		"20090040629" OR "20090179142" OR "20090295910" OR "20100008588" OR "20100020306" OR "20100110275" OR "20100123893" OR "20100204964" OR "20110025843" OR "20110032398" OR "20110037849" OR "20110116262" OR "20110216304" OR "20120044476" OR "20120140109" OR "20120154914" OR "20120182464" OR "20120287417" OR "20120320164" OR "20130044310" OR "20130141549" OR "20130206967" OR "20130294089" OR "20130300840" OR "20140118335" OR "20140118493" OR "20140153001" OR "20140158900" OR "20140168631" OR "20140176933" OR "20140211194" OR "20140269796" OR "20140285628" OR "20140291491" OR "20140313519" OR "20140375977" OR "20140376092" OR "20150002636" OR "20150131080" OR "20150184999" OR "20150192677" OR "20150292948" OR "20150293224" OR "20150316473" OR "20150355470" OR "20150358601" OR "20150378241" OR "20150379371" OR "20160003946" OR "20160047895" OR "20160047896" OR "20160047897" OR "20160047898" OR "20160047899" OR "20160047900" OR "20160047901" OR "20160047903" OR					

		"20160049765" OR "20160097858" OR "20160150963" OR "20160161600" OR "20160218727" OR "20160265902" OR "20160291134" OR "201602911434" OR "20160306032" OR "20160327779" OR "20160328619" OR "20170146640" OR "20170219426" OR "20170219695" OR "20170269197" OR "20170269198" OR "20170269209" OR "20170269215" OR "20170289524" OR "20170350983" OR "4358851" OR "4634272" OR "4676599" OR "4702600" OR "4744667" OR "4851664" OR "5267016" OR "5288992" OR "5982552" OR "6014232" OR "6133989" OR "6255133" OR "6374024" OR "6414746" OR "6690019" OR "6721262" OR "7091462" OR "7170542" OR "7295298" OR "7345271" OR "7421159" OR "7433042" OR "7808706" OR "7969558" OR "8013983" OR "8089618" OR "8130367" OR "8319949" OR "8330840" OR "8374405" OR "8384997" OR "8494252" OR "8675181" OR "8717488" OR "8742325" OR "8743176" OR "8761495" OR "8767190" OR "8829406" OR "8836922" OR "8848039" OR "9041915" OR "9063549" OR "9071763" OR "9086273" OR "9111444" OR "9157790" OR "9164511" OR "9176051" OR "9229109" OR "9285464" OR "9285477" OR "9299731" OR "9368936" OR "9369689" OR "9383753"						

		OR "9425654" OR "9435891" OR "9470520" OR "9489601" OR "9525863" OR "9529079" OR "D659030").pn.					
L6	1090	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit)	US-PGPUB; USPAT	OR	ON	ON	2021/02/08 03:05 PM
L7	24	(3 OR 4) AND 6	US-PGPUB; USPAT	OR	ON	ON	2021/02/08 03:05 PM
L8	72	(3 OR 4) AND 2	US-PGPUB; USPAT	OR	ON	ON	2021/02/08 03:06 PM
L9	147	2 AND 6	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/08 03:07 PM
L10	16	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) SAME (Micro ADJ optical OR micro ADJ lens OR microlens)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 11:03 AM
L11	46	(array OR multiple OR plurality) WITH (laser OR source OR transmitter) WITH corresponding WITH (receiver OR detector) SAME (hole OR opening OR aperture OR gap OR slit) AND ((Micro ADJ optical OR micro ADJ lens OR microlens) near2 array)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 11:04 AM
L12	248763	(G01S17/89 OR G01S17/42 OR G01S7/4817 OR G01S17/931 OR G01S17/10 OR G01S7/4815 OR G01S7/4816 OR	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:30 PM

		G01S7/4814 OR G01S17/86 OR G01S17/87 OR G01S7/4813 OR G01S7/484 OR G01S17/894 OR G01S7/4865 OR G01S7/4863 OR G01S7/4861 OR G01S7/4812 OR G01S17/06 OR G01S7/499 OR G01S7/481 OR G01S7/4818 OR G01S7/497 OR G01S7/003 OR G01S7/4811 OR G01S17/08 OR G01S17/93 OR G01S7/4808 OR G01S7/486 OR G01S7/4868 OR G01S17/32 OR G01S7/4802 OR G01S7/487 OR G01S13/865 OR G01S17/02 OR G01S17/04 OR G01S17/14 OR G01S17/66 OR G01S17/88 OR G01S7/4972 OR G01S13/867 OR G01S13/931 OR G01S17/36 OR G01S17/46 OR G01S17/48 OR G01S17/58 OR G01S17/933 OR G01S3/7867 OR G01S7/483 OR G01S13/02 OR G01S13/88 OR G01S15/88 OR G01S17/18 OR G01S19/13 OR G01S2007/4975 OR G01S2013/9316 OR G01S2013/932 OR G01S2013/9327 OR G01S2013/93271 OR G01S2013/93272 OR G01S2013/93273 OR G01S2013/93274 OR G01S3/784 OR G01S3/789 OR G01S7/4873 OR					

		G01S7/491 OR G02B3/0056 OR G02B5/208 OR G02B27/0961 OR G02B27/46 OR G02B30/27 OR G02B27/30 OR G02B5/005 OR G02B5/28 OR G02B26/105 OR G02B27/0037 OR G02B27/0955 OR G02B3/0018 OR G02B13/14 OR G02B26/101 OR G02B27/0018 OR G02B27/0944 OR G02B27/1086 OR G02B27/42 OR G02B27/4205 OR G02B3/0012 OR G02B3/0031 OR G02B3/005 OR G02B3/0068 OR G02B3/0087 OR G02B5/201 OR G02B5/205 OR G02B5/285 OR G02B6/0055 OR G02B6/262 OR G02B6/29361 OR G02B6/32 OR G02B6/4215 OR G02B6/4249 OR G02B13/0025 OR G02B13/006 OR G02B13/0085 OR G02B13/04 OR G02B13/18 OR G02B13/20 OR G02B19/0014 OR G02B19/0019 OR G02B19/0052 OR G02B19/0057 OR G02B19/0061 OR G02B19/0066 OR G02B21/0032 OR G02B21/0052 OR G02B21/0096 OR G02B21/361 OR G02B21/367 OR G02B23/04 OR G02B26/00 OR G02B26/085 OR G02B26/127 OR G02B27/0025 OR G02B27/0075 OR G02B27/09 OR					

		G02B27/0966 OR G02B27/0977 OR G02B27/10 OR G02B27/1066 OR G02B27/12 OR G02B27/123 OR G02B27/143 OR G02B27/4244 OR G02B27/425 OR G02B27/4272 OR G02B27/4277 OR G02B3/0037 OR G02B3/06 OR G02B5/021 OR G02B5/09 OR G02B5/10 OR G02B5/1814 OR G02B5/1819 OR G02B5/1842 OR G02B6/003 OR G02B6/0036 OR G02B6/0046 OR G02B6/005 OR G02B6/04 OR G02B6/06 OR G02B6/12007 OR G02B6/29356 OR G02B6/29368 OR G02B6/368 OR G02B6/4214 OR G02B6/4225 OR G02B6/4298 OR G02B7/026 OR G02B9/64 OR G06T7/521 OR G06T2207/10004 OR G06T2207/10028 OR G06T2207/10024 OR G06T7/194 OR G06T15/00 OR G06T2207/10021 OR G06T2207/20032 OR G06T2207/30196 OR G06T5/50 OR G06T7/12 OR G06T7/593 OR G06T15/30 OR G06T17/05 OR G06T19/006 OR G06T19/20 OR G06T2200/04 OR G06T2200/28 OR G06T2207/20036 OR G06T2207/30181 OR G06T2207/30204 OR G06T2207/30256 OR G06T2207/30261 OR G06T5/002 OR G06T7/11 OR G06T7/162 OR G06T7/174 OR G06T7/254 OR					

		G06T7/292 OR G06T7/38 OR G06T7/40 OR G06T7/50 OR G06T7/60 OR G06T7/73 OR G06T7/74 OR G01B11/24 OR G01B11/026 OR G01B11/25 OR G01B11/00 OR G01B11/2513 OR G01B11/005 OR G01B11/04 OR G01B11/2518 OR G01B11/2527 OR G01B11/2536 OR G01B11/254 OR G01B11/2545 OR G01B11/285).cpc.					
L13	10357	((light OR laser OR beam OR optic$2) NEAR3 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3 OR diode)) WITH (bulk common) near3 (optic$3 lens collimat$3)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:31 PM
L14	730	13 AND (multiple plurality different second) near4 (emit OR emitt$3 OR transmit$3 OR source OR radiat$3) near4 (channel route band)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:33 PM
L15	162	14 AND 12	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:33 PM
L16	119	15 NOT (9 OR 8 OR 7 OR 5)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:33 PM
L17	46	14 AND ((bulk common) near3 (optic$3 lens collimat$3)) near6 (coincident$3 coincid$3 match$3)	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 02:49 PM
L18	1	"20180267148".pn.	US-PGPUB; USPAT	OR	ON	ON	2021/02/09 03:09 PM
L19	16	((US-10183541-B2 OR US-9917423-B2).did. AND USPT.dbnm.) OR ((US-20180191967-A1 OR US-20180180720-A1 OR US-20180136321-A1 OR US-20180267151-A1 OR US-20190369258-A1	USPAT; US-PGPUB; FPRS; USOCR; IBM_TDB; EPO; JPO; DERWENT; FIT (AU, AP, AT, CA, CH, CN, DD, DE, EA, EP, ES, FR, GB, JP, KR, OA, RU, SU, WO)	OR	ON	ON	2021/02/09 03:10 PM

		OR US-20190312636-A1 OR US-20190223729-A1 OR US-20180167602-A1 OR US-20140320843-A1 OR US-20130182320-A1 OR US-20070273957-A1 OR US-20070013872-A1 OR US-20040061917-A1 OR US-20180267148-A1).did. AND PGPB.dbnm.)					
L20	157	((hemispheric$3 (hemi ADJ spheric$3)) near2 lens) near5 filter	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 03:16 PM
L21	25	20 AND 12	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 03:19 PM
L22	396	((biconic$3 cylindr$4) near2 lens) near5 aberration$2 near5 (correct$3 compensat$4)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 04:14 PM
L23	97	22 AND 12	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 04:14 PM
L24	228	(detect$3 sens$4) WITH apertur$3 WITH monolithic	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 04:57 PM
L25	101	22 AND (12 OR 2)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 04:57 PM
L26	43	24 AND (12 OR 2)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 04:58 PM
L27	20	(detect$3 sens$4) WITH apertur$3 WITH filter WITH monolithic	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 05:15 PM
L28	242	(detect$3 sens$4) WITH apertur$3 WITH filter WITH bond$3	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/11 05:40 PM

L29	5	(positive near5 value near5 pulse near5 code) WITH (intensity power)	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/12 01:21 PM
L30	37	14 AND (filter WITH micro WITH lens WITH (aperture openning window))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/14 09:50 AM
L31	39	14 AND (filter WITH micro WITH lens WITH (aperture opening window))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/14 09:50 AM
L32	53	6 AND (filter WITH micro WITH lens WITH (aperture opening window))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/14 09:51 AM
L33	61	6 AND (control near5 (start begin initiat$3) near5 (stop end shut))	US-PGPUB; USPAT; USOCR; FIT (CN, FR, WO); FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	ON	2021/02/14 09:52 AM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

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

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033- P006US3-1086284

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]
	1	20130111130	KR		Oct 10, 2013	Samsung Electronics Co., Ltd.		
	2	2015025497	WO		Feb 26, 2015	Panasonic Intellectual Property Management Co., Ltd		

1

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]
	3	IN201947048756 , "First Examination Report", December 2, 2020, 6 pages	

EXAMINER SIGNATURE

Examiner Signature	/AMIR J ASKARIAN/	Date Considered	02/12/2021

*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.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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	Examiner Name	Not yet assigned
	Attorney Docket Number	103033- P006US3-1086284

[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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Doc description: Information Disclosure Statement (IDS) Field

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U.S. PATENTS

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	1.	20180191967	A1	Jul 5, 2018	Kester	

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]
	2	1193539	EP		Apr 3, 2002	Agfa Corporation		
	3	1918427	CN		Feb 21, 2007	Schott AG		
	4	101413905	CN		Apr 22, 2009	Shenzhen University		
	5	2110699	EP		Oct 21, 2009	Diehl Defence GmbH & Co. KG		
	6	102640037	CN		Aug 15, 2012	Eastman Kodak Co.		
	7	102015217908	DE		Mar 23, 2017	Robert Bosch GmbH		
	8	1193539	EP		Apr 3, 2002	Agfa Corporation		

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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]
	9.	15/979,253 , "Non-Final Office Action", October 23, 2020, 12 pages	
	10	15/979,253 , "Notice of Allowance", November 13, 2020, 7 pages	
	11.	CN202010078057.9 , "Office Action", November 9, 2020, 9 pages	
	12	EP18802192.7 , "Extended European Search Report", November 12, 2020, 11 pages	

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Doc description: Information Disclosure Statement (IDS) Field

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	13	PCT/US2018/032601 , "International Preliminary Report on Patentability", November 28, 2019, 13 pages	

EXAMINER SIGNATURE			
Examiner Signature /AMIR J ASKARIAN/		Date Considered 02/12/2021	

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[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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	1.	5745153	A	Apr 28, 1998	Kessler 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
	2.	20050035474	A1	Feb 17, 2005	Itoh	
	3.	20150055117	A1	Feb 26, 2015	Pennecot et al.	
	4.	20150260830	A1	Sep 17, 2015	Ghosh et al.	

FOREIGN PATENT DOCUMENTS

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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, page(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	5	PCT/US2018/032601 , "International Search Report and Written Opinion", September 21, 2018, 16 pages	
	6	PCT/US2018/032601 , "Invitation to Pay Additional Fees and, Where Applicable, Protest Fee", July 26, 2018, 2 pages	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	15/979,266
	Filing Date	May 14, 2018
	First Named Inventor	Angus Pacala
	Art Unit	2875
	Examiner Name	Not yet assigned
	Attorney Docket Number	103033-P006US3-1086284

EXAMINER SIGNATURE			
Examiner Signature /AMIR J ASKARIAN/		Date Considered 02/12/2021	

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[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.
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https://ieeexplore.ieee.org/search/searchresult.jsp?action=search&newsearch=true&matchBoolean=true&queryText=(%22Full%20Text%20.AND.%20Metadata%22:micro%20lens%20array%20lidar%20aperture%20filter%20monolithic)

Web Search History

date, time	web site	search string
2/12/2021 9:23:51 PM	Google Scholar	micro lens array lidar aperture filter monolithic

Main Concept Document
==========
US20180329061
Title: Spinning lidar unit with micro-optics aligned behind stationary window

(No Concept Modifiers)
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(No Filters)
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Options
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De-dup: None
Cut-off: None
Sort: Relevance

Content: Patents + NPL (188)
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US Patents
US Designs
US Applications
EPO Patents
EPO Applications
China Patents
China Applications
Japan Patents
Japan Applications
Korea Patents
Korea Applications
WIPO Applications
Argentina Patents
Argentina Applications
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Canada Applications
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India Applications
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Jordan Patents
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OnePetro.org: Periodicals at OnePetro.org
OnePetro.org: Conferences at OnePetro.org
OnePetro.org: Standards at OnePetro.org
Other Literature: IBM Redbooks
Other Literature: PubMed Central
Other Literature: arXiv.org

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

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

Application Number	15/979,266
Filing Date	May 14, 2018
First Named Inventor	Angus Pacala
Art Unit	2875
Examiner Name	Not yet assigned
Attorney Docket Number	103033-P006US3-1086284

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.	10063849	B2	08-28-2018	Pacala, Angus	
	2.	9989406	B2	06-05-2018	Pacala, Angus	
	3.	9992477	B2	06-05-2018	Pacala, Angus	
	4.	10063849	B2	08-28-2018	Pacala, Angus	

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
	5.	20180209841	A1	07-26-2018	Pacala, Angus	
	6.	20180152691	A1	05-31-2018	Pacala, Angus	
	7.	20180059222	A1	03-01-2018	Pacala, Angus	
	8.	20180217236	A1	08-02-2018	Pacala, Angus	

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	/AMIR J ASKARIAN/	Date Considered	02/12/2021

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.J.A./

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[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).

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☐ 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.

☐ 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	/Stephen A. Mao/	Date (YYYY-MM-DD)	2018-09-18
Name/Print	Stephen A. Mao	Registration Number	73418

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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Attorney Docket Number	103033- P006US3-1086284

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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.	20120170029	A1	Jul 5, 2012	Azzazy et al.	
	2.	20130325241	A1	Dec 5, 2013	Lombrozo et al.	
	3.	20140111812	A1	Apr 24, 2014	Baeg et al.	
	4.	20160282468	A1	Sep 29, 2016	Gruver et al.	
	5.	20180180720	A1	Jun 28, 2018	Pei et al.	
	6.	20180284228	A1	Oct 4, 2018	LaChapelle	
	7.	20180286909	A1	Oct 4, 2018	Eichenholz 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]

1

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]
	8.	15/979,253 , "Corrected Notice of Allowability", December 1, 2020, 2 pages	
	9.	15/979,253 , "Corrected Notice of Allowability", December 22, 2020, 2 pages	
	10.	15/979,253 , "Corrected Notice of Allowability", January 15, 2021, 2 pages	
	11.	15/979,253 , "Corrected Notice of Allowability", January 8, 2021, 2 pages	
	12.	15/979,277 , "Non-Final Office Action", January 12, 2021, 8 pages	

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	Attorney Docket Number	103033- P006US3-1086284

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Examiner Signature		Date Considered	

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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 January 21, 2021.

KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033- P006US3-1086284
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Not yet assigned
Application No.: 15/979,266	Technology Center/Art Unit: 2875
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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 /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

Electronic Acknowledgement Receipt

EFS ID:	41711239
Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
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-P006US3-1086284
Receipt Date:	22-JAN-2021
Filing Date:	14-MAY-2018
Time Stamp:	11:38:57
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		IDS-P006US3-1086284.pdf	185862 3bdd8a476922c996905c814b2d9dc5980f1044cb	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
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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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	First Named Inventor	Angus Pacala
	Art Unit	2875
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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]
	1	20130111130	KR		Oct 10, 2013	Samsung Electronics Co., Ltd.		
	2	2015025497	WO		Feb 26, 2015	Panasonic Intellectual Property Management Co., Ltd		

1

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]
	3	IN201947048756 , "First Examination Report", December 2, 2020, 6 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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[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.

(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(11) 공개번호 10-2013-0111130
(43) 공개일자 2013년10월10일

(51) 국제특허분류(Int. Cl.)
G01S 17/08 (2006.01)
(21) 출원번호 10-2012-0034115
(22) 출원일자 2012년04월02일
심사청구일자 없음
(30) 우선권주장
13/434,381 2012년03월29일 미국(US)

(71) 출원인
삼성전자주식회사
경기도 수원시 영통구 삼성로 129 (매탄동)
(72) 발명자
오브세아니코프 일리아
미국 캘리포니아주 91101 스튜디오 시티 바네타 디알 4184
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서울특별시 마포구 창전동 태영데시앙아파트 101-1301
노요환
경기도 안산시 상록구 본오2동 742-3 201호
(74) 대리인
윤재석, 한지희, 권영규

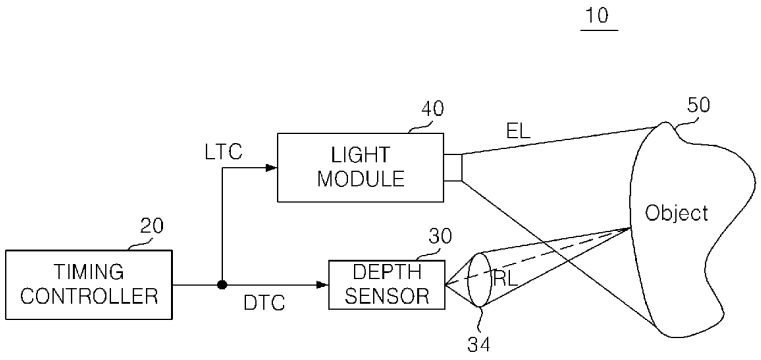
전체 청구항 수 : 총 10 항

(54) 발명의 명칭 **거리 측정 장치와 이의 동작 방법**

(57) 요 약

거리 측정 장치는 광신호를 피사체로 출력하는 광원과, 상기 피사체로부터 반사된 반사광에 응답하여 거리 정보를 측정하는 거리 센서와, 상기 광원으로 광 방사 제어 신호를 전송하고, 상기 거리 센서로 광 검출 제어 신호를 전송하여 상기 거리 센서의 동작 타이밍을 제어하는 타이밍 컨트롤러를 포함하며, 상기 광신호는 복수 개의 시퀀스들을 포함하고, 펄스의 위상은 상기 복수 개의 시퀀스들 각각마다 랜덤하게 변한다.

대 표 도 - 도1



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특허청구의 범위

청구항 1

거리 측정 장치의 동작 방법에 있어서,

광원으로부터 광신호를 피사체로 출력하는 단계; 및

게이트 신호와 상기 피사체로부터 반사된 반사광 신호에 응답하여 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 단계를 포함하며,

상기 광신호는 복수의 시퀀스들을 포함하며, 상기 광신호의 펄스의 위상은 상기 복수의 시퀀스들 각각 마다 랜덤하게 변하는 거리 측정 장치의 동작 방법.

청구항 2

제1항에 있어서,

상기 광신호는 상기 복수의 시퀀스들 사이마다 상기 펄스의 파장의 배수에 해당하는 지연 시간을 포함하는 거리 측정 장치의 동작 방법.

청구항 3

제2항에 있어서,

상기 지연 시간 동안, 상기 펄스의 구간은 필터링되는 거리 측정 장치의 동작 방법.

청구항 4

제1항에 있어서, 상기 광신호를 상기 피사체로 출력하는 단계는,

펄스 생성기로부터 펄스 신호를 출력하고, 난수 생성기로부터 위상 지정 신호를 출력하는 단계;

상기 위상 지정 신호에 기초하여 상기 펄스 신호의 일정 간격마다 서로 다른 위상들을 갖는 광 방사 제어 신호를 생성하는 단계; 및

상기 광 방사 제어 신호에 기초하여 상기 광원으로부터 상기 광신호를 출력하는 단계를 포함하는 거리 측정 장치의 동작 방법.

청구항 5

제4항에 있어서,

상기 난수 생성기는 복수의 위상 지정 신호들 중에서 어느 하나를 상기 위상 지정 신호로서 출력하는 거리 측정 장치의 동작 방법.

청구항 6

제1항에 있어서,

하나의 프레임 전체에 대하여 복수의 게이트 신호들은 상기 거리 측정 장치로 순차적으로 입력되고, 상기 복수의 게이트 신호들 각각의 위상은 미리 정해진 위상만큼 가변하는 거리 측정 장치의 동작 방법.

청구항 7

제1항에 있어서, 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 단계는,

상기 반사광 신호와 상기 게이트 신호에 응답하여 복수의 시퀀스 픽셀 신호들을 출력하는 단계; 및

상기 복수의 시퀀스 픽셀 신호들에 기초하여 계산된 상기 반사광 신호와 상기 게이트 신호의 위상 차이를 통해 거리 정보를 측정하는 단계를 포함하는 거리 측정 장치의 동작 방법.

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청구항 8

광신호를 피사체로 출력하는 광원;

상기 피사체로부터 반사된 반사광에 응답하여 거리 정보를 측정하는 거리 센서; 및

상기 광원으로 광 방사 제어 신호를 전송하고, 상기 거리 센서로 광 검출 제어 신호를 전송하여 상기 거리 센서의 동작 타이밍을 제어하는 타이밍 컨트롤러를 포함하며,

상기 광신호는 복수 개의 시퀀스들을 포함하고, 펄스의 위상은 상기 복수 개의 시퀀스들 각각마다 랜덤하게 변하는 거리 측정 장치.

청구항 9

제8항에 있어서, 상기 타이밍 컨트롤러는,

펄스 신호를 출력하는 펄스 생성기;

난수를 생성하고, 상기 난수에 의해 결정된 위상 지정 신호를 출력하는 난수 생성기; 및

상기 펄스 신호와 상기 위상 지정 신호를 수신하고, 상기 위상 지정 신호에 기초하여 상기 펄스 신호의 일정 간격마다 서로 다른 위상이 되도록 펄스의 일부를 지연시키는 지연 유닛을 포함하는 거리 측정 장치.

청구항 10

제8항에 있어서, 상기 거리 센서는,

적어도 하나의 거리 픽셀을 포함하는 감지 어레이;

상기 적어도 하나의 거리 픽셀로부터 출력된 복수의 이미지 픽셀 신호들을 디지털 픽셀 신호들로 전환하고 상기 디지털 픽셀 신호들을 출력하는 회로; 및

수신된 디지털 픽셀 신호들에 기초하여 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 거리 측정기를 포함하는 거리 측정 장치.

명 세 서

기 술 분 야

[0001] 본 발명의 개념에 따른 실시 예는 거리 센서에 관한 것으로, 특히 거리 센서의 TOF(time-of-flight) 원리를 이용한 거리 측정 장치와 이의 동작 방법에 관한 것이다.

배 경 기 술

[0002] 센서는 대상물의 상태를 파악하여 이를 전기 신호로 변환하여 전달하는 소자이다.

[0003] 센서의 종류로는 빛 센서, 온도 센서, 압력 센서, 자기 센서, 및 거리 센서 (depth sensor) 등 다양하다. 그 중 거리 센서는 광원으로부터 투사된 광신호가 피사체(예컨대, 측정 대상물)에 의해, 반사되어 되돌아 왔을 때의 지연 시간을 측정하여 피사체까지의 거리를 산출한다.

발명의 내용

해결하려는 과제

[0004] 본 발명이 이루고자 하는 기술적 과제는 3차원 거리 측정 데이터의 정확성을 높일 수 있는 거리 측정 장치, 이의 동작 방법, 및 외부 광신호의 간섭 제거 방법을 제공하는 것이다.

과제의 해결 수단

[0005] 본 발명의 실시 예에 따른 거리 측정 장치의 동작 방법은 광원으로부터 광신호를 피사체로 출력하는 단계와, 게이트 신호와 상기 피사체로부터 반사된 반사광 신호에 응답하여 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 단계를 포함하며, 상기 광신호는 복수의 시퀀스들을 포함하며, 상기 광신호의 펄스의 위상은 상

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기 복수의 시퀀스들 각각 마다 랜덤하게 변한다.

[0006] 상기 광신호는 상기 복수의 시퀀스들 사이마다 상기 펄스의 파장의 배수에 해당하는 지연 시간을 포함한다.

[0007] 상기 지연 시간 동안, 상기 펄스의 구간은 필터링된다.

[0008] 상기 광신호를 상기 피사체로 출력하는 단계는 펄스 생성기로부터 펄스 신호를 출력하고, 난수 생성기로부터 위상 지정 신호를 출력하는 단계와, 상기 위상 지정 신호에 기초하여 상기 펄스 신호의 일정 간격마다 서로 다른 위상들을 갖는 광 방사 제어 신호를 생성하는 단계와, 상기 광 방사 제어 신호에 기초하여 상기 광원으로부터 상기 광신호를 출력하는 단계를 포함한다.

[0009] 상기 난수 생성기는 복수의 위상 지정 신호들 중에서 어느 하나를 상기 위상 지정 신호로서 출력한다.

[0010] 하나의 프레임 전체에 대하여 복수의 게이트 신호들은 상기 거리 측정 장치로 순차적으로 입력되고, 상기 복수의 게이트 신호들 각각의 위상은 미리 정해진 위상만큼 가변한다.

[0011] 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 단계는 상기 반사광 신호와 상기 게이트 신호에 응답하여 복수의 시퀀스 픽셀 신호들을 출력하는 단계와, 상기 복수의 시퀀스 픽셀 신호들에 기초하여 계산된 상기 반사광 신호와 상기 게이트 신호의 위상 차이를 통해 거리 정보를 측정하는 단계를 포함한다.

[0012] 본 발명의 실시 예에 따른 거리 측정 장치는 광신호를 피사체로 출력하는 광원과, 상기 피사체로부터 반사된 반사광에 응답하여 거리 정보를 측정하는 거리 센서와, 상기 광원으로 광 방사 제어 신호를 전송하고, 상기 거리 센서로 광 검출 제어 신호를 전송하여 상기 거리 센서의 동작 타이밍을 제어하는 타이밍 컨트롤러를 포함하며, 상기 광신호는 복수 개의 시퀀스들을 포함하고, 펄스의 위상은 상기 복수 개의 시퀀스들 각각마다 랜덤하게 변한다.

[0013] 상기 타이밍 컨트롤러는 펄스 신호를 출력하는 펄스 생성기와, 난수를 생성하고, 상기 난수에 의해 결정된 위상 지정 신호를 출력하는 난수 생성기와, 상기 펄스 신호와 상기 위상 지정 신호를 수신하고, 상기 위상 지정 신호에 기초하여 상기 펄스 신호의 일정 간격마다 서로 다른 위상이 되도록 펄스의 일부를 지연시키는 지연 유닛을 포함한다.

[0014] 상기 거리 센서는 적어도 하나의 거리 픽셀을 포함하는 감지 어레이와, 상기 적어도 하나의 거리 픽셀로부터 출력된 복수의 이미지 픽셀 신호들을 디지털 픽셀 신호들로 전환하고 상기 디지털 픽셀 신호들을 출력하는 회로와, 수신된 디지털 픽셀 신호들에 기초하여 상기 피사체와 상기 거리 측정 장치 사이의 거리를 측정하는 거리 측정기를 포함한다.

발명의 효과

[0015] 본 발명의 실시 예에 따른 거리 측정 장치는 복수의 거리 측정 장치들에 의한 광신호들의 간섭 현상을 제거하여 피사체와의 거리를 명확하게 측정할 수 있는 효과가 있다.

도면의 간단한 설명

[0016] 본 발명의 상세한 설명에서 인용되는 도면을 보다 충분히 이해하기 위하여 각 도면의 상세한 설명이 제공된다.

도 1은 본 발명의 일 실시 예에 따른 거리 측정 장치를 나타내는 개념도이다.

도 2는 도 1에 도시된 타이밍 컨트롤러를 나타내는 블록도이다.

도 3은 도 2에 도시된 광 방사 제어 신호의 파형과 광 검출 제어 신호의 파형을 나타내는 타이밍 도이다.

도 4는 본 발명의 다른 실시 예에 따른 거리 측정 장치를 나타내는 블록도이다.

도 5는 도 1 또는 도 4에 도시된 거리 측정 장치의 동작 방법을 나타내는 순서도이다.

도 6은 도 4에 도시된 타이밍 컨트롤러의 일 예를 나타내는 블록도이다.

도 7은 도 6에 도시된 난수 생성기의 일 예를 나타내는 블록도이다.

도 8은 도 7에 도시된 난수 생성기를 통해 생성되는 진리 표의 일 예를 나타낸다.

도 9는 도 5에 도시된 전체 순서도에서 난수 생성기의 동작을 상세하게 나타내는 순서도이다.

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도 10은 도 4에 도시된 광원의 출력 신호인 광신호의 파형과 포토 게이트 컨트롤러의 출력 신호인 제1게이트 신호부터 제4게이트 신호의 파형을 나타내는 타이밍 도이다.

도 11은 도 5에 도시된 전체 순서 도에서, 도 4에 도시된 1-탭 거리 픽셀에 게이트 신호를 전송하는 포토 게이트 컨트롤러의 동작을 상세하게 나타내는 부분 순서도이다.

도 12a는 도 4에 도시된 감지 어레이에 포함된 1-탭 픽셀 구조를 가지는 거리 픽셀의 레이아웃을 나타낸다.

도 12b는 도 12a에 도시된 1-탭 픽셀 구조를 가지는 거리 픽셀에서 순차적으로 검출된 픽셀 신호들과 이들에 의한 위상 차를 설명하기 위한 타이밍 도이다.

도 13a부터 도 13d는 도 12a에 도시된 액티브 영역에 구현된 광전 변환 소자와 트랜지스터들을 나타내는 회로도들이다.

도 14는 도 12a에 도시된 1-탭 구조의 거리 센서에서 롤링 셔터 방식으로 수행되는 하나의 프레임을 나타내는 개념도이다.

도 15a는 도 4에 도시된 감지 어레이에 포함된 2-탭 픽셀 구조를 가지는 거리 픽셀의 레이아웃을 나타낸다.

도 15b는 도 15a에 도시된 2-탭 픽셀 구조를 가지는 거리 픽셀에서 순차적으로 검출된 픽셀 신호들과 이들에 의한 위상 차를 설명하기 위한 타이밍 도이다.

도 16은 도 5에 도시된 전체 순서도에서 2-탭 픽셀 구조를 가지는 거리 픽셀에 게이트 신호를 전송하는 도 4에 도시된 포토 게이트 컨트롤러의 동작을 상세하게 나타내는 부분 순서도이다.

도 17은 도 16a에 도시된 2-탭 구조 거리 픽셀에 구현된 복수의 포토 게이트들과 복수의 트랜지스터들을 포함하는 회로도이다.

도 18은 도 16a에 도시된 2-탭 구조의 거리 센서에서 롤링 셔터 방식으로 수행되는 하나의 프레임을 나타내는 개념도이다.

도 19a부터 도 19e는 도 4에 도시된 감지 어레이에 포함되는 단위 픽셀의 일 예를 나타낸다.

도 20은 서로 인접하게 위치한 복수의 거리 측정 장치들의 동작을 나타내는 도면이다.

도 21a는 도 20에 도시된 제 1 거리 측정 장치의 광 방사 제어신호의 파형과 제 1 거리 측정 장치의 광 검출 제어신호의 파형을 나타내는 타이밍 도이다.

도 21b는 도 20에 도시된 제 2 거리 측정 장치의 광 방사 제어신호의 파형과 제 1 거리 측정 장치의 광 검출 제어신호의 파형을 나타내는 타이밍 도이다.

도 22는 본 발명의 일 실시 예에 따른 영상 처리 시스템을 나타내는 도면이다.

도 23은 본 발명의 다른 실시 예에 따른 영상 처리 시스템을 나타내는 도면이다.

도 24는 도 1 또는 도 4에 도시된 거리 측정 장치를 포함하는 전자 시스템 및 인터페이스를 나타낸다.

발명을 실시하기 위한 구체적인 내용

[0017] 본 명세서에 개시되어 있는 본 발명의 개념에 따른 실시 예들에 대해서 특정한 구조적 또는 기능적 설명은 단지 본 발명의 개념에 따른 실시 예들을 설명하기 위한 목적으로 예시된 것으로서, 본 발명의 개념에 따른 실시 예들은 다양한 형태들로 실시될 수 있으며 본 명세서에 설명된 실시 예들에 한정되지 않는다.

[0018] 본 발명의 개념에 따른 실시 예들은 다양한 변경들을 가할 수 있고 여러 가지 형태들을 가질 수 있으므로 실시 예들을 도면에 예시하고 본 명세서에서 상세하게 설명하고자 한다. 그러나, 이는 본 발명의 개념에 따른 실시 예들을 특정한 개시 형태들에 대해 한정하려는 것이 아니며, 본 발명의 사상 및 기술 범위에 포함되는 모든 변경, 균등물, 또는 대체물을 포함한다.

[0019] 제1 또는 제2 등의 용어는 다양한 구성 요소들을 설명하는데 사용될 수 있지만, 상기 구성 요소들은 상기 용어들에 의해 한정되어서는 안 된다. 상기 용어들은 하나의 구성 요소를 다른 구성 요소로부터 구별하는 목적으로만, 예컨대 본 발명의 개념에 따른 권리 범위로부터 벗어나지 않은 채, 제1구성 요소는 제2구성 요소로 명명될 수 있고 유사하게 제2구성 요소는 제1구성 요소로도 명명될 수 있다.

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[0020] 어떤 구성 요소가 다른 구성 요소에 "연결되어" 있다거나 "접속되어" 있다고 언급된 때에는, 그 다른 구성 요소에 직접적으로 연결되어 있거나 또는 접속되어 있을 수도 있지만, 중간에 다른 구성 요소가 존재할 수도 있다고 이해되어야 할 것이다. 반면에, 어떤 구성 요소가 다른 구성 요소에 "직접 연결되어" 있다거나 "직접 접속되어" 있다고 언급된 때에는 중간에 다른 구성 요소가 존재하지 않는 것으로 이해되어야 할 것이다. 구성 요소들 간의 관계를 설명하는 다른 표현들, 즉 "~사이에"와 "바로 ~사이에" 또는 "~에 이웃하는"과 "~에 직접 이웃하는" 등도 마찬가지로 해석되어야 한다.

[0021] 본 명세서에서 사용한 용어는 단지 특정한 실시 예를 설명하기 위해 사용된 것으로서, 본 발명을 한정하려는 의도가 아니다. 단수의 표현은 문맥상 명백하게 다르게 뜻하지 않는 한, 복수의 표현을 포함한다. 본 명세서에서, "포함하다" 또는 "가지다" 등의 용어는 본 명세서에 기재된 특징, 숫자, 단계, 동작, 구성 요소, 부분품 또는 이들을 조합한 것이 존재함을 지정하려는 것이지, 하나 또는 그 이상의 다른 특징들이나 숫자, 단계, 동작, 구성 요소, 부분품 또는 이들을 조합한 것들의 존재 또는 부가 가능성을 미리 배제하지 않는 것으로 이해되어야 한다.

[0022] 다르게 정의되지 않는 한, 기술적이거나 과학적인 용어를 포함해서 여기서 사용되는 모든 용어들은 본 발명이 속하는 기술 분야에서 통상의 지식을 가진 자에 의해 일반적으로 이해되는 것과 동일한 의미를 나타낸다. 일반적으로 사용되는 사전에 정의되어 있는 것과 같은 용어들은 관련 기술의 문맥상 가지는 의미와 일치하는 의미를 갖는 것으로 해석되어야 하며, 본 명세서에서 명백하게 정의하지 않는 한, 이상적이거나 과도하게 형식적인 의미로 해석되지 않는다.

[0023] 이하, 본 명세서에 첨부된 도면들을 참조하여 본 발명의 실시 예들을 상세히 설명한다.

[0024] 도 1은 본 발명의 실시 예에 따른 거리 측정 장치를 나타내는 개념도를 나타내며, 도 2는 도 1에 도시된 타이밍 컨트롤러를 나타내는 블록도이다. 도 3은 도 2에 도시된 광 방사 제어 신호(LTC)의 파형과 광 검출 제어 신호(DTC)의 파형을 나타내는 타이밍 도이다.

[0025] 도 1부터 도 3을 참조하면, 거리 측정 장치(10)는 타이밍 컨트롤러(20), 광 모듈(40), 거리 센서(또는 깊이 센서; 30), 및 렌즈(34)를 포함한다.

[0026] 타이밍 컨트롤러(20)는 거리 센서(30)와 광 모듈(40) 각각의 동작 타이밍을 제어한다. 이를 위해, 타이밍 컨트롤러(20)는 광 방사 제어 신호(LTC)를 광 모듈 (40)로 전송하고 광 검출 제어 신호(DTC)를 거리 센서(30)로 전송한다.

[0027] 광 모듈(40)은 광 방사 제어신호(LTC)에 기초하여 생성된 광 신호(EL)를 피사체(Object; 50)를 향해 방사한다. 피사체(50)에 의하여 반사된 반사 광신호(RL)는 렌즈(34)를 통해 거리 센서(30)에 입사한다. 이때, 거리 측정 장치(10)는 광 신호(EL)의 방사 시간과 반사 광신호(RL)의 입사 시간의 시간 차(t_{Δ})를 나타내는 수학식 1을 이용하여 거리를 측정할 수 있다.

[0028] [수학식 1]

[0029] $$t_{\Delta} = \frac{2d}{c}$$

[0030] 여기서, d는 거리 측정 장치(10)와 피사체(50) 사이의 거리를 나타내고, c는 광속을 나타낸다.

[0031] 실시 예에 따라, 거리 센서(30)는 하나의 칩(chip)으로 구현되어 거리 정보를 계산할 수 있다. 또한 거리 센서(30)는 컬러 이미지 센서 칩과 함께 사용되어 3차원 이미지 정보와 거리 정보를 동시에 측정하는 데 이용될 수 있다.

[0032] 이때, 3차원 이미지 센서에서 거리 정보를 검출하기 위한 거리 픽셀과 이미지 정보를 검출하기 위한 컬러 픽셀들은 하나의 감지 어레이(sensing array)에 함께 구현될 수 있다.

[0033] 도 2 및 도 3을 참조하면, 타이밍 컨트롤러(20)는 펄스 생성기(21), 위상 지연 유닛(22), 난수 생성기(25), 및 펄스 지연 유닛(23)을 포함한다.

[0034] 펄스 생성기(21)에서 생성된 펄스(PULSE)는 위상 지연 유닛(22)으로 전송된다. 또한 난수 발생기(25)에서 생성

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된 난수(Li)는 위상 지연 유닛(22)으로 전송된다.

[0035] 상기 위상 지연 유닛(22)은 수신된 펄스(PULSE)를 복수 개의 시퀀스들(S(N-1), S(N) 및 S(N+1))로 구분하고, 수신된 난수(Li)에 기초하여 각 시퀀스(S(N-1), S(N), 및 S(N+1)) 마다 다른 위상 차이가 생기도록 펄스의 일부(d_r)를 지연시킨다.

[0036] 위상 지연 유닛(22)으로부터 출력된 펄스 형태의 광 검출 제어 신호(DTC)는 거리 센서(30)로 출력된다. 또한, 광 검출 제어 신호(DTC)는 펄스 지연 유닛(23)으로 전송된다.

[0037] 펄스 지연 유닛(23)은, 광 검출 제어 신호(DTC)에 기초하여, 인접하는 두 개의 시퀀스들(S(N-1), S(N), 및 S(N+1)) 사이마다 각각 지연 시간(delay time; Tw)을 갖는 광 방사 제어 신호(LTC)를 생성한다. 펄스 지연 유닛(23)은 펄스 신호를 필터링하거나 억제기(Suppressor)를 이용하여 구현될 수 있다. 광 방사 제어 신호 (LTC)는 광 모듈(40)로 출력된다.

[0038] 도 4는 본 발명의 다른 실시 예에 따른 거리 측정 장치를 나타내는 블록도이고, 도 5는 도 1 및 도 4에 도시된 거리 측정 장치의 동작 방법을 나타내는 순서도이다. 도 6은 도 4에 도시된 타이밍 컨트롤러의 일 예를 나타내는 블록도이다.

[0039] 도 4를 참조하면, 거리 측정 장치(100)는 타이밍 컨트롤러(20A), 거리 센서 (30A), 광 모듈(40A), 및 렌즈(34)를 포함한다.

[0040] 도 6을 참조하면, 도 4에 도시된 타이밍 컨트롤러(20A)는 컨트롤 로직(24), 펄스 생성기(21), 위상 지연 유닛(22), 난수 발생기(25), 및 펄스 필터 유닛(23A)을 포함한다.

[0041] 컨트롤 로직(24)은 펄스 생성기(21)를 제어하고, 로우 디코더(31)로 로우 어드레스(X-ADD)를 전송하거나, CDS(correlated double sampling)/ADC(analog-to-digital converting) 회로(36)로 CDS 제어 신호(CDSC)를 전송할 수 있다.

[0042] 도 3, 도 5, 및 도 6을 참조하면, 타이밍 컨트롤러(20A)의 펄스 생성기(21)는 펄스 신호(PULSE)를 생성한다(S501). 위상 지연 유닛(22)은 난수 발생기(25)에 의해 생성된 난수(Li)에 기초하여 시퀀스(S(N-1), S(N), 및 S(N+1)) 마다 다른 위상 차이가 되도록 펄스의 일부(d_r)를 지연시킨다(S502). 위상 지연 유닛(22)에서 생성된 광 검출 제어 신호(DTC)는 포토 게이트 컨트롤러(32)로 전송된다.

[0043] 펄스 필터 유닛(23A)은 위상 지연 유닛(22)으로부터 출력된 광 검출 제어 신호(DTC)와 동일한 파형의 펄스 신호를 수신하면, 인접하는 두 개의 시퀀스들(S(N-1), S(N) 및 S(N+1)) 사이마다 각각 지연 시간(Tw)을 두어 광 방사 제어 신호(LTC)를 생성한다(S503). 광 방사 제어 신호(LTC)는 광원 드라이버(41)로 전송된다.

[0044] 다시 도 4 및 도 5를 참조하면, 광 모듈(40A)은 광원 드라이버(41)와 광원 (42)을 포함한다.

[0045] 광원 드라이버(41)는, 타이밍 컨트롤러(20A)로부터 출력된 광 방사 제어 신호 (LTC)에 기초하여, 광원(42)을 드라이빙할 수 있는 클럭 신호를 생성할 수 있다.

[0046] 광원(42)은, 상기 클럭 신호에 응답하여, 광 신호(EL)를 피사체(50)로 방사한다(S504). 광원(42)은 LED(Light Emitting Diode), OLED(Organic Light Emitting Diode), AMOLED(Active-matrix Organic Light Emitting Diode) 또는 레이저 다이오드(Laser Diode)로 구현될 수 있다. 설명의 편의를 위하여, 광 신호(EL)의 파형은 광 방사 제어 신호(LTC)의 파형과 동일하다고 가정한다. 광 신호(EL)는 정현파 또는 구형파일 수 있다.

[0047] 반사 광 신호(RL)는 렌즈(34)를 통하여 감지 어레이(35)로 입사된다(S505). 여기서, 렌즈(34)는 렌즈와 적외선 통과 필터를 포함하는 의미로 사용될 수 있다.

[0048] 거리 센서(30A)는 반사 광 신호(RL)를 전기 신호로 변환하여 출력한다. 거리 센서(30A)는 포토 게이트 컨트롤러(32), 로우 디코더(31), 감지 어레이(35), CDS/ADC 회로(36), 메모리 유닛(37), 및 거리 추정기(또는 거리 측정기; 38)를 포함한다.

[0049] 로우 디코더(31)는 타이밍 컨트롤러(20A)로부터 출력된 로우 어드레스(X-ADD)에 응답하여 복수의 로우들 중에서 어느 하나의 로우를 선택한다. 여기서, 로우(row)란 감지 어레이(35)에서 가로-방향으로 배치된 복수의 거리 픽셀들의 집합을 나타낸다.

[0050] 포토 게이트 컨트롤러(32)는 타이밍 컨트롤러(20A)로부터 전송된 광 검출 제어 신호(DTC)에 기초하여 게이트 신호들(G0 내지 G3)을 생성한다(S506). 또한 포토 게이트 컨트롤러(32)는 게이트 신호들(G0 내지 G3)을 순차적으

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로 감지 어레이(35)로 공급할 수 있다(S507).

[0051] 감지 어레이(35)는 복수의 거리 픽셀들을 포함한다. 감지 어레이(35)에 포함된 복수의 거리 픽셀들은 렌즈(34)를 통하여 감지 어레이(35)로 입사된 복수의 반사광 신호들(RL)에 응답하여 반사광 신호(RL)의 위상과 광신호(EL)의 위상 차이를 검출한다(S508). 이를 통해, 감지 어레이(35)는 입사된 반사 광 신호들(RL)에 기초하여 이미지 픽셀 신호를 출력할 수 있다.

[0052] 이때, 출력된 이미지 픽셀 신호가 제4이미지 픽셀 신호(A'3)일 때까지 복수의 단계들(S501 내지 S508)을 반복한다(S509). 실시 예에 따라 상기 복수의 단계들 (S501 내지 S508) 중 적어도 하나의 단계가 반복될 수 있다.

[0053] CDS/ADC 회로(36)는 타이밍 컨트롤러(20A)로부터 출력된 CDS 제어 신호 (CDSC)에 기초하여 복수의 거리 픽셀들로부터 각각 출력된 이미지 픽셀 신호에 CDS (Correlated Double Sampling) 동작과 ADC(Analog to Digital Converting)동작을 수행하여 디지털 픽셀 신호들(A0 내지 A3)을 출력한다. 디지털 픽셀 신호들(A0 내지 A3)은 도 12b 및 도 15b에서 상세히 설명된다.

[0054] 버퍼로 구현될 수 있는 메모리 유닛(37)은 CDS/ADC회로(36)로부터 출력된 디지털 픽셀 신호들(A0 내지 A3)을 프레임 단위로 저장할 수 있다.

[0055] 거리 추정기(38)는 메모리 유닛(37)으로부터 출력된 각 디지털 픽셀 신호(A0 내지 A3)에 기초하여 위상 차이($\hat{\theta}$)를 측정한다. 거리 추정기(38)에 의하여 측정된 위상 차이($\hat{\theta}$)는 수학식 2과 같다.

[0056] [수학식 2]

$$\hat{\theta} = 2\pi f_m t_\Delta = \tan^{-1}\frac{A_1 - A_3}{A_0 - A_2}$$

[0057]

[0058] 거리 추정기(38)는 수학식 2에 따라서 측정된 위상 차이($\hat{\theta}$)를 이용하여 수학식 3에 따라 거리 정보를 측정하고, 측정된 거리 정보($\hat{d}$)를 출력한다.

[0059] [수학식 3]

$$\hat{d} = \frac{c}{4\pi f_m}\hat{\theta}$$

[0060]

[0061] 여기서, c는 광속을 나타내고, f_m은 광신호(EL)의 주파수를 나타낸다.

[0062] 본 발명의 실시 예에 따르면, 거리 센서(30A)는 CCD(Charge Coupled Device) 형태 또는 CIS(CMOS Image Sensor) 형태로 구현될 수 있다. 도 4의 구조는 CIS 형태의 거리 센서(30A)에서 구조의 변경 없이 적용이 가능하다. 거리 센서가 CCD 형태일 경우에는 CDS/ADC(36)의 구조가 일부 변경될 수 있다.

[0063] ADC는 CDS(Correlated Double Sampling) 방식의 적용에 따라 아날로그 CDS, 디지털 CDS 또는 듀얼 CDS(Dual CDS) 방식별로 그 구조가 변경될 수 있다. 또한, ADC는 거리 센서(30A)의 컬럼 별로 배치되는 컬럼 ADC(Column ADC) 또는 하나의 ADC가 배치되는 싱글 ADC(Single ADC)로 구현될 수 있다.

[0064] 거리 센서(30A)는 타이밍 컨트롤러(20A)와 하나의 칩으로 구현될 수 있다. 또한 거리 센서(30A)와 타이밍 컨트롤러(20A) 및 렌즈(34)가 하나의 모듈로 구성되고 광 모듈(40A)은 별도의 모듈로 구성될 수 있다.

[0065] 도 7은 도 6에 도시된 난수 생성기의 일 예를 나타내는 블록도이고, 도 8은 도 6에 도시된 난수 생성기의 진리표를 나타낸다. 도 9는 도 5에 도시된 전체 순서도에서 난수 생성기의 동작을 상세하게 나타내는 순서도이다.

[0066] 난수 생성기는 X(X는 2 이상의 정수)개의 시프트 레지스터들(shift register)을 포함하는 LFSR(Linear feedback shift Register)로 구현될 수 있다.

[0067] LFSR은 시프트 레지스터들로 입력되는 값들이 이전 상태 값들의 선형 함수로 계산되는 구조를 가지고 있다.

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LFSR은 피보나치 구현(Fibonacci implementation) 또는 갈루아 구현(Galois implementation)을 적용할 수 있다.이때, LFSR에 사용되는 선형 함수는 배타적 논리합일 수 있다.

[0068] 도 7을 참조하면, 난수 발생기(25)는 X(X는 2 이상의 정수)개의 레지스터들 (1~X)을 포함한다. 논리합 게이트(215-3)는 레지스터들(215-1 및 215-2)의 출력 신호들을 배타 논리합하여 첫 단의 레지스터(215-4)로 출력한다. 이를 통해, 난수 생성기(25)는 난수(Li)를 구성하는 복수의 비트들(A 및 B)을 출력할 수 있다.

[0069] 도 8을 참조하면, 난수 생성기(25)에서 출력된 비트들(A 및 B)에 따라 진리 표에 대응하여 위상 지정 신호(Li)가 발생한다. 예를 들어, 난수 발생기(25)에서 출력된 비트들(A와 B)이 00, 01, 10 또는 11 일 때, 위상 지정 신호(Li)는 제1위상 지정 신호(L0), 제2위상 지정 신호(L1), 제3위상 지정 신호(L2) 또는 제4위상 지정 신호(L3)가 된다.

[0070] 도 10은 도 4에 도시된 광 신호(EL)의 파형과 제1게이트 신호 내지 제4게이트 신호의 파형을 나타내는 타이밍도이다.

[0071] 도 6, 도 9, 및 도 10을 참조하면, 타이밍 컨트롤러(20A)에 포함되어 있는 난수 생성기(25)는 랜덤하게 발생된 위상 지정 신호(Li)를 생성한다(S910). 위상 지정 신호(Li)는 위상 지연 유닛(22)으로 전달되어 복수 시퀀스들 각각의 위상들을 각각 제어할 수 있다.

[0072] 예를 들어, 위상 지연 유닛(22)은 제1위상 지정 신호(L0)에 기초하여 본래 펄스의 파형을 가지는 시퀀스의 파형을 생성할 수 있다(S920 및 S930). 또는 위상 지연 유닛(22)은 제2위상 지정 신호(L1)에 기초하여 본래 펄스의 파형보다 90° 의 위상 차이를 가지는 시퀀스의 파형을 생성할 수 있다(S940 및 S950).

[0073] 또는, 위상 지연 유닛(22)은 제3위상 지정 신호(L2)에 기초하여 본래 펄스의 파형보다 180° 의 위상 차이를 가지는 시퀀스의 파형을 생성할 수 있다(S960 및 S970). 또는 위상 지연 유닛(22)은 제4위상 지정 신호(L3)에 기초하여 본래 펄스의 파형보다 270° 의 위상 차이를 가지는 시퀀스의 파형을 생성할 수 있다(S980).

[0074] 설명의 편의를 위해, 광 신호(EL)의 파형은 도 3의 광 방사 제어 신호(LTC)의 파형과 동일하다고 가정한다.

[0075] 도 10을 참조하면, 광 신호(EL)는 복수의 시퀀스들(S1 내지 S4)을 포함하며, 시퀀스들(S1 내지 S4) 사이마다 각각 일정 딜레이 타임(T_W)을 가진다. 복수의 시퀀스들(S1 내지 S4) 각각 사이의 위상 차이는 0° , 90° , 180° 또는 270° 중 하나가 될 수 있다. 광 신호(EL)는 정현파 또는 구형파일 수 있다.

[0076] 제1게이트 신호 내지 제4게이트 신호(G0 내지 G3)는 포토 게이트 컨트롤러 (32)로부터 감지 어레이(35)로 출력된다. 각각의 게이트 신호(G0 내지 G3)는 광신호(EL)의 파형처럼 각각 서로 다른 위상 차이를 가지는 복수의 시퀀스들(S1 내지 S4) 을 포함한다.

[0077] 이때, 광신호(EL)의 위상과 제1게이트 신호(G1)의 위상은 동일하다. 또한, 제1게이트 신호(G0)의 위상과 제2게이트 신호(G1)의 위상과의 차는 90° 이고, 제1게이트 신호(G1)의 위상과 제3게이트 신호(G2)의 위상과의 차는 180° 이고, 제1게이트 신호(G1)의 위상과 제4게이트 신호(G3)의 위상과의 차는 270° 이다. 게이트 신호들(G0 내지 G3)은 광신호(EL)와 다르게 딜레이 타임(T_W)을 포함하지 않는다.

[0078] 광원(42)으로부터 출력된 광신호(EL)가 피사체(50)에 반사되어 입사되기까지 시간 간격이 존재하기 때문이다. 예를 들어, 제1시퀀스(S1)는 제1위상 지정 신호 (L0)를 가지고 제2시퀀스(S2)는 제2위상 지정 신호를 가지므로, 두 시퀀스(S1 과 S2)의 위상 차이는 90° 이다.

[0079] 만약, 광신호(EL)에 딜레이 타임(T_W)이 없다면, 피사체(50)에 반사되어 입사되는 반사광 신호(RL)의 제1시퀀스(S1)와 게이트 신호(G0)의 제2시퀀스(S2)가 동기화되어 거리 측정 시 오류가 날 수 있다. 그러나, 이 오류의 수치가 무시할 수 있을 만큼 미미하다면, 다른 실시 예에 따라 광신호(EL)의 딜레이 타임(T_W)이 생략될 수도 있다.

[0080] 본 발명의 일 실시 예에 따르면, 도 4에 도시된 감지 어레이(35)는 1-탭(1-tap) 픽셀 구조의 거리 픽셀을 포함할 수 있다. 도 11 내지 도 14는 1-탭 거리 픽셀의 구조 및 동작을 설명하기 위한 도면들이다.

[0081] 도 11은 도 5에 도시된 전체 순서도에서 도 4에 도시된 1-탭 거리 픽셀에 게이트 신호를 전송하는 포토 게이트 컨트롤러(32)의 동작을 나타내는 부분 순서도이다.

[0082] 도 5, 도 10, 및 도 11을 참조하면, 포토 게이트 컨트롤러(32)는 거리를 감지하기 위한 이미지 픽셀 신호의 출

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력 단계 정보를 체크한다(S1110).

[0083] 체크된 이미지 픽셀 신호의 출력 단계 정보가 제1이미지 픽셀 신호(A0)를 출력하는 단계이면, 포토 게이트 컨트롤러(32)는 광신호(EL)의 위상과 동일한 위상을 가지는 제1게이트 신호(G0)를 감지 어레이(35)로 출력한다(S1120 및 S1130).

[0084] 또는, 체크된 이미지 픽셀 신호의 출력 단계 정보가 제2이미지 픽셀 신호 (A1)를 출력하는 단계이면, 포토 게이트 컨트롤러(32)는 광신호(EL)와 90° 위상 차를 갖는 제2게이트 신호(G1)를 감지 어레이(35)로 출력한다(S1140 및 S1150).

[0085] 또는, 체크된 이미지 픽셀 신호의 출력 단계 정보가 제3이미지 픽셀 신호 (A2)를 출력하는 단계이면, 포토 게이트 컨트롤러(32)는 광신호(EL)와 180° 위상 차를 갖는 제3게이트 신호(G2)를 감지 어레이(35)로 출력한다(S1160 및 S1170).

[0086] 또는, 체크된 이미지 픽셀 신호의 출력 단계 정보가 제4이미지 픽셀 신호 (A3)를 출력하는 단계이면, 포토 게이트 컨트롤러(32)는 광신호(EL)와 270° 위상 차를 갖는 제4게이트 신호(G3)를 감지 어레이(35)로 출력한다(S1180).

[0087] 도 12a는 도 4에 도시된 센싱 어레이에 포함된 1-탭 픽셀 구조를 갖는 거리 픽셀의 레이아웃을 나타내고, 도 12b는 도 12a에 도시된 1-탭 픽셀 구조를 갖는 거리 픽셀에서 순차적으로 검출된 픽셀 신호들과 이들에 의한 위상 차를 설명하기 위한 타이밍 도이다.

[0088] 1-탭 픽셀 구조를 갖는 거리 픽셀(60)은 액티브 영역(61)에 구현된 광전 변환 소자(62)를 포함한다. 액티브 영역(61)에는 도 13a 내지 도 13d 각각에 도시된 바와 같이 광전 변환 소자(62)와 T-개의 트랜지스터들이 구현된다. 여기서, T는 자연수로서, T는 3, 4 또는 5일 수 있다. 도 12a에 도시된 바와 같이 0° , 90° , 180° 및 270° 의 위상 차를 갖는 각 게이트 신호(G0내지 G3)가 광전 변환 소자(62)로 순차적으로 공급된다.

[0089] 광전 변환 소자(62)는 각 게이트 신호(G0 내지 G3)가 하이 레벨을 갖는 동안 반사광(RL)에 따라 광전 변환 동작을 수행한다. 광전 변환 소자(62)에 의하여 생성된 광 전하들은 플로팅 디퓨전 노드(FD)로 전송된다.

[0090] 도 12a와 도 12b를 참조하면, 1-탭 픽셀 구조를 갖는 거리 픽셀(60)은 제1시점(t0)에서 0° 의 위상 차를 갖는 제1게이트 신호(G0)에 응답하여 제1디지털 픽셀 신호(A0)를 출력하고, 제2시점(t1)에서 90° 의 위상 차를 갖는 제2게이트 신호(G1)에 응답하여 제2디지털 픽셀 신호(A1)를 출력하고, 제3시점(t2)에서 180° 의 위상 차를 갖는 제3게이트 신호(A2)에 응답하여 제3디지털 픽셀 신호(G2)를 출력하고, 제4시점(t3)에서 270° 의 위상 차를 갖는 제4게이트 신호(G3)에 응답하여 제4디지털 픽셀 신호(A3)를 출력한다.

[0091] 도 13a 내지 도 13d는 도 12a에 도시된 액티브 영역에 구현된 광전 변환 소자와 트랜지스터들을 나타내는 다양한 회로들이다.

[0092] 도 13a에 도시된 바와 같이 액티브 영역(61)에는 광전 변환 소자(62)와 4개의 트랜지스터들(RX, TX, DX 및 SX)이 구현된다. 도 13a를 참조하면, 광전 변환 소자(62)에는 도 12a에 도시된 게이트 신호들(G0내지 G3)과 반사광(RL)에 기초하여 광 전하들을 생성할 수 있다.

[0093] 예컨대, 광전 변환 소자(62)는 타이밍 컨트롤러(20A)로부터 출력되는 게이트 신호(G0)에 응답하여 온/오프 될 수 있다. 예컨대, 게이트 신호(G0)가 하이 레벨일 때, 광전 변환 소자(62)는 반사광(RL)에 기초하여 광 전하들을 생성할 수 있고, 게이트(G0)가 로우 레벨일 때 광전 변화 소자(62)는 반사광(RL)에 기초하여 광 전하들을 생성하지 않는다.

[0094] 광전 변화 소자(62)는 광 감지 소자로서 포토 다이오드(Photo diode), 포토 트랜지스터(Photo transistor), 포토 게이트(Photo gate) 또는 핀드 포토 다이오드(PPD; Pinned Photo diode)로 구현될 수 있다.

[0095] 리셋 트랜지스터(RX)는 타이밍 컨트롤러(20A)로부터 출력된 리셋 신호(RS)에 응답하여 상기 플로팅 디퓨전 영역(FD)를 리셋할 수 있다.

[0096] 전송 트랜지스터(TX)는 타이밍 컨트롤러(20A)로부터 출력된 제어 신호(TG)에 응답하여 광전 변환 소자(62)에 의하여 생성된 광 전하들을 플로팅 디퓨전 영역 (FD)으로 전송할 수 있다.

[0097] 소스 팔로워 버퍼 증폭기(Source Follower Buffer Amplifier) 역할을 수행하는 드라이브 트랜지스터(DX)는 플로팅 디퓨전 영역(FD)에 충전된 광 전하들에 응답하여 버퍼링 동작을 수행할 수 있다.

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[0098] 선택 트랜지스터(SX)는 타이밍 컨트롤러(20A)로부터 출력된 제어 신호(SEL)에 응답하여 드라이브 트랜지스터(DX)로부터 출력된 이미지 픽셀 신호(A0')를 컬럼 라인으로 출력할 수 있다.

[0099] 도 13a에는 하나의 광전 변환 소자(62)와 4개의 트랜지스터들(TX, RX, DX 및 SX)을 포함하는 액티브 영역(61)이 도시되어 있으나 이는 예시적인 것에 불과하다.

[0100] 도 13b에 도시된 바와 같이 액티브 영역(61)에는 광전 변환 소자(62)와 3개의 트랜지스터들(RX, DX 및 SX)이 구현된다. 도 13a와 도 13b를 참조하면, 도 13b의 액티브 영역(61)에는 전송 트랜지스터(TX)가 구현되지 않는다.

[0101] 도 13c에 도시된 바와 같이 액티브 영역(61)에는 광전 변환 소자(62)와 5개의 트랜지스터들(RX, TX, DX, SX 및 GX)이 구현된다. 도 13c를 참조하면, 전송 트랜지스터(TX)의 동작을 제어하기 위한 제어 신호(TF)는 제어신호(SEL)에 응답하여 온/오프 되는 트랜지스터(GX)를 통하여 전송 트랜지스터(TX)의 게이트로 공급된다.

[0102] 도 13d에 도시된 바와 같이 액티브 영역(61)에는 광전 변환 소자(62)와 5개의 트랜지스터들(RX, TX, DX, SX 및 PX)이 구현될 수 있다. 트랜지스터(PX)는 타이밍 컨트롤러(20A)로부터 출력된 제어 신호(PG)에 응답하여 동작한다.

[0103] 도 14는 도 12a에 도시된 1-탭 구조의 거리 센서에서 롤링 셔터 방식으로 수행되는 하나의 프레임을 나타내는 개념도이다. 이때, 광원(42)으로부터 광 신호(EL)의 위상은 0° 라고 가정한다.

[0104] 도 14를 참조하면, 하나의 프레임에 대한 0° 위상을 갖는 게이트 신호(G0)에 기초한 리드 동작이 수행 중인 동안에도 리드 동작 수행이 완료된 열들에 대해서는 90° 위상을 갖는 게이트 신호(G1)에 기초한 광 전하 축적이 시작된다. 이는 게이트 신호의 위상이 90° 에서 180° 로 가변되는 경우, 또는 180° 에서 270° 로 가변되는 경우에도 마찬가지이다.

[0105] 본 발명의 일 실시 예에 따르면, 도 4에 도시된 감지 어레이(35)는 2-탭(2-tap) 픽셀 구조의 거리 픽셀을 포함할 수 있다. 도 15a 내지 도 18은 2-탭 거리 픽셀의 구조 및 동작을 설명하기 위한 도면들이다.

[0106] 도 15a는 도 4에 도시된 감지 어레이에 포함된 2-탭 픽셀 구조를 갖는 거리 픽셀의 레이아웃을 나타내고, 도 15b는 도 15a에 도시된 2-탭 픽셀 구조를 갖는 거리 픽셀에서 검출된 픽셀 신호들과 이미지 픽셀 신호의 위상차를 설명하기 위한 타이밍도 이다.

[0107] 2-탭 픽셀 구조를 갖는 거리 픽셀(70)은 제1포토 게이트(71), 브리징 디퓨전 영역(75), 및 전송 트랜지스터(TX1; 73)를 포함하고, 제2포토 게이트(72), 브리징 디퓨전 영역(76), 및 전송 트랜지스터(74)를 포함한다.

[0108] 도 15a 및 도 15b를 참조하면, 2-탭 거리 픽셀(70)은 제1시점(t0)에서 제1게이트 신호(G0)와 제2게이트 신호(G2)에 응답하여 제1디지털 픽셀 신호(A0)와 제3디지털 픽셀 신호(A2)를 검출하고, 제2시점(t1)에서 제3게이트 신호(G1)와 제4게이트 신호(G3)에 응답하여 제2디지털 픽셀 신호(A1)와 제4디지털 픽셀 신호(A3)를 검출한다.

[0109] 도 16은 도 5에 도시된 전체 순서도에서 2-탭 거리 픽셀에 게이트 신호를 전송하는 포토 게이트 컨트롤러의 동작을 상세하게 나타내는 부분 순서도이다.

[0110] 도 5, 도 10 도 15 및 도 16을 참조하면, 포토 게이트 컨트롤러(32)는 거리를 감지하기 위한 이미지 픽셀 신호의 출력 단계 정보를 체크한다(S1510).

[0111] 이때, 체크된 이미지 픽셀 신호의 출력 단계 정보가 제1이미지 픽셀 신호 (A0)를 출력하는 단계이면(S1520), 포토 게이트 컨트롤러(32)는 광신호(EL)의 위상과 동일한 위상을 가지는 제1게이트 신호(G0)를 제1포토 게이트(71)에 출력하고, 광신호(EL)와 180° 의 위상 차를 갖는 제3게이트 신호(G2)를 제2포토 게이트(72)로 출력한다(S1530).

[0112] 또는, 포토 게이트 컨트롤러(32)는 체크된 이미지 픽셀 신호의 출력 단계 정보가 제1이미지 픽셀 신호(A0)를 출력하는 단계가 아니라면, 포토 게이트 컨트롤러 (32)는 광신호(EL)와 90° 의 위상 차를 갖는 제2게이트 신호(G1)를 2-탭 픽셀 신호의 제1포토 게이트(71)에 출력하고, 포토 게이트 컨트롤러(32)는 광신호(EL)와 270° 위상 차를 갖는 제4게이트 신호(G3)를 2-탭 픽셀 신호의 제2포토 게이트(72)로 출력한다(S1540).

[0113] 도 17은 도 16a에 도시된 2-탭 구조 거리 픽셀에 구현된 복수의 포토 게이트들과 복수의 트랜지스터들을 포함하는 회로도이다.

[0114] 도 17을 참조하면, 2-탭 구조를 갖는 거리 픽셀은 제1포토 게이트(PG1; 71)를 통과한 반사광(RL)에 의하여 생성된 광 전하들을 처리하는 제1회로 영역과, 제2포토 게이트(PG2; 72)를 통과한 반사광(RL)에 의하여 생성된 광

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전하들을 처리하는 제2회로 영역을 포함한다.

[0115] 예컨대, 제1회로 영역은 광 전하들을 수집 또는 전송할 수 있는 제1포토 게이트(71)와 복수의 트랜지스터들(TX1, RX1, DX1 및 SX1)을 포함한다. 또한, 제2회로 영역은 광 전하들을 수집 또는 전송할 수 있는 제2포토 게이트(72)와 복수의 트랜지스터들(TX2, RX2, DX2 및 SX2)을 포함한다.

[0116] 전송 게이트(transfer gate)로 구현될 수 있는 제1전송 회로(TX1; 73)는, 제어 신호(TG1)에 응답하여, 생성된 광 전하들을 제1플로팅 확산 영역(FD1)으로 전송한다. 적절한 타이밍으로 가해지는 제어 신호(TG1)의 전압 레벨을 조절하여 전송된 광 전하들이 제1플로팅 확산 영역(FD1)으로부터 제1포토 게이트(71) 쪽으로의 역행 (Back diffusion)을 막을 수 있다.

[0117] 또한, 전송 게이트로 구현될 수 있는 제2전송 회로(TX2; 74)는, 제어 신호 (TG2)에 응답하여, 생성된 광 전하들을 제2플로팅 확산 영역(FD2)으로 전송한다. 적절한 타이밍으로 가해지는 제어 신호(TG2)의 전압 레벨을 조절하여 전송된 광 전하들이 제2플로팅 확산 영역(FD2)으로부터 제2포토 게이트(72) 쪽으로의 역행을 막을 수 있다.

[0118] 포토 게이트 컨트롤러(32)로부터 출력된 게이트 신호들(G0과 G2) 각각에 응답하여, 제1포토 게이트(71)와 제2포토 게이트(72) 각각은 반사 광신호(RL)에 의하여 반도체 기판 내에서 생성된 광 전하들을 수집하는 수집 동작과 수집된 광 전하들을 각 플로팅 확산 영역(FD1과 FD2)으로 전송하는 전송 동작을 반복적으로 수행할 수 있다.

[0119] 두 개의 포토 게이트들(71과 72) 각각에 수신되는 두 개의 게이트 제어 신호들(G0과 G2)의 위상 차이는 180° 이다. 그러나 광신호(EL)의 위상과 두 개의 포토 게이트 제어 신호들 중에서 어느 하나의 신호의 위상의 차이는 0°, 90°, 180° 또는 270°가 될 수 있다.

[0120] 각 전송 트랜지스터(TX1과 TX2)는 타이밍 컨트롤러(20A)로부터 출력된 각 제어 신호(TG1과 TG2)에 응답하여 각 포토 게이트(71 및 72)의 하부에 축적된 광 전하들을 각 플로팅 확산 영역(FD1과 FD2)으로 전송할 수 있다.

[0121] 소스 팔로워 버퍼 증폭기 역할을 수행할 수 있는 각 드라이브 트랜지스터 (DX1과 DX2)는 각 플로팅 확산 영역(FD1과 FD2)에 충전된 광 전하들에 응답하여 버퍼링 동작을 수행할 수 있다.

[0122] 각 선택 트랜지스터(SX1과 SX2)는 타이밍 컨트롤러(20A)로부터 출력된 제어 신호(SEL)에 응답하여 각 드라이브 트랜지스터(DX1과 DX2)에 의하여 버퍼링된 신호(A0'와 A2')를 각 컬럼 라인으로 출력할 수 있다.

[0123] 도 18은 도 16a에 도시된 2-탭(2-Tap) 구조의 거리 센서에서 롤링 셔터 방식으로 수행되는 하나의 프레임을 나타내는 개념도이다. 이때, 광원(42)으로부터 방사되는 광 신호(EL)의 위상은 0°라고 가정한다.

[0124] 도 18을 참조하면, 하나의 프레임에 대한 각각이 0° 및 180° 위상을 갖는 게이트 신호들(G0 및 G2) 각각에 기초한 리드 동작이 수행 중인 동안에도, 리드 동작 수행이 완료된 열들에 대해서는 각각이 90° 및 270° 위상을 갖는 게이트 신호들(G1와 G3) 각각에 기초한 광 전하 축적이 시작된다.

[0125] 도 19a부터 도 19e는 감지 어레이(35)에 포함되는 단위 픽셀의 일 예를 나타낸다.

[0126] 도 19a를 참조하면, 도 4의 감지 어레이(35)의 일부를 구성하는 단위 픽셀 어레이는 레드 픽셀(R), 그린 픽셀(G), 블루 픽셀(B), 및 거리 픽셀(Z)을 포함할 수 있다.

[0127] 거리 픽셀(Z)의 구조는 도 12에 도시된 바와 같이 1-탭 픽셀 구조를 갖는 거리 픽셀이거나, 또는 도 16에 도시된 2-탭 픽셀 구조를 갖는 거리 픽셀일 수 있다.

[0128] 거리 픽셀(Z)은 적외선 영역에 속하는 파장들에 상응하는 거리 픽셀 신호를 생성한다.

[0129] 레드 픽셀(R), 그린 픽셀(G), 및 블루 픽셀(B)은 컬러 픽셀(C)이라고 불릴 수 있다. 레드 픽셀(R)은 가시광 영역 중에서 레드 영역에 속하는 파장들에 상응하는 레드 픽셀 신호를 생성하고, 그린 픽셀(G)은 상기 가시광 영역 중에서 그린 영역에 속하는 파장들에 상응하는 그린 픽셀 신호를 생성하고, 블루 픽셀(B)은 상기 가시광 영역 중에서 블루 영역에 속하는 파장들에 상응하는 블루 픽셀 신호를 생성한다.

[0130] 실시 예에 따라, 컬러 픽셀(C)들은 마젠타 픽셀(magenta pixel), 사이언 픽셀(cyan pixel), 및 옐로우 픽셀(yellow pixel)로 대체될 수 있다.

[0131] 도 19a 내지 19e에 도시된 단위 픽셀 어레이는 설명의 편의를 위하여 예시적으로 도시한 것으로서 단위 픽셀 어레이의 패턴과 상기 패턴을 구성하는 픽셀들은 실시 예에 따라 다양한 변형이 가능하다. 특히, 도 19d와 도 19e는 컬러 픽셀(C) 및 거리 픽셀(Z)들이 3차원 구조로 적층 될 수 있음을 나타낸다.

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[0132] 도 20은 서로 인접하게 위치한 복수의 거리 측정 장치들(620과 640)이 있을 때 광 신호들의 간섭 상황을 나타내는 도면이다. 도 21a 및 도 21b는 본 발명의 일 실시 예에 따른 거리 측정 장치들(620과 640)에서 각각의 광 방사 제어신호(LTC)의 파형과 광 검출 제어 신호(DTC)의 파형을 나타내는 타이밍 도이다.

[0133] 공간상 인접하게 위치한 복수의 거리 측정 장치들(620 과 640)은 동일한 피사체(650)에 향해 각각의 광 신호(EL1 및 EL2)를 방사할 수 있다.

[0134] 도 20을 참조하면, 제1거리 측정 장치(620)의 광원(624)은 피사체(650)를 향해 제1광 신호(EL1)를 방사하고, 제2거리 측정 장치(640)의 광원(644)은 피사체(650)를 향해 제2광 신호(EL2)를 방사할 수 있다. 이후, 제1거리 측정 장치(620)의 거리 센서(623)에 제1반사 광신호(RL1)와 제2반사 광신호(RL2)가 함께 입력될 수 있다.

[0135] 이때, 제1반사 광신호(RL1)는 제1광 신호(EL1)에 의해 피사체(650)에 반사되어 입사되는 광신호이고, 제2반사 광신호(RL2)는 제2광 신호(EL2)에 의해 피사체(650)에 반사되어 입사되는 광신호이다.

[0136] 이 경우, 각 반사 광신호(RL1 및 RL2)의 파형이 서로 간섭을 일으키거나, 혹은 제1반사 광신호(RL1)가 아닌 제2반사 광신호(RL2)를 기초로 하여 거리를 계산하는 오류가 발생할 수 있다. 그러나, 본 발명의 실시 예에 따르면, 제1거리 측정 장치(620)는 서로 다른 위상 차를 가지는 복수의 시퀀스들을 포함하는 광신호를 이용하여, 상기 광신호의 간섭 현상을 극복할 수 있다.

[0137] 상술한 바와 같이, 각 거리 측정 장치(620과 640)의 거리 센서(623과 643)에 포함된 복수의 거리 픽셀들은 복수의 게이트 신호들(G0 내지 G3)에 따라 광 전자들(또는 광 전하)을 일정시간, 예컨대 적분 시간(integration time) 동안 축적하고, 축적 결과에 따라 생성된 이미지 픽셀 신호들(A0 내지 A3)을 출력한다.

[0138] 이때, 복수의 게이트 신호들(G0 내지 G3)에 기초하여 출력되는 이미지 픽셀 신호들(A0 내지 A3) 각각은 각 시퀀스 픽셀 신호(P0 내지 P3)를 포함한다. 즉, 광 신호(EL)를 제어하는 광 방사 제어 신호(LTC)와 게이트 신호를 제어하는 광 검출 신호(DTC)들 각각은 서로 다른 위상 차를 가지는 시퀀스들을 포함하고 있기 때문에, 복수의 시퀀스들마다 각각 다른 위상 차로 인한 시퀀스 픽셀 신호들(P0 내지 P3)이 출력될 수 있다.

[0139] 복수의 거리 픽셀들 각각에 의하여 생성된 각 이미지 픽셀 신호(A_k)는 수학식 4와 같다.

[0140] [수학식 4]

[0141] $$A_k = \sum_{n=0}^{N} P_{m,n}$$

[0142] 여기서, 거리 픽셀의 포토 게이트로 입력되는 신호가 제1게이트 신호(G0)일 때, k는 0이고, 제2게이트 신호(G1)일 때 k는 1이고, 제3게이트 신호(G2)일 때 k는 2이고, 제4게이트 신호(G3)일 때 k는 3이다.

[0143] 또한, P는 시퀀스 픽셀 신호이며, n(n은 자연수)은 시퀀스의 순서를 나타낸다. m은 광 방사 제어 신호의 시퀀스 파형과 광 검출 제어 신호의 시퀀스 파형의 위상 차를 나타낸다.

[0144] 예를 들어, 광 방사 제어 신호의 시퀀스 위상과 광 방출 제어 신호의 시퀀스 위상이 동일하면 제1시퀀스 픽셀 신호(P0)가 출력되고, 광 방사 제어 신호의 시퀀스 위상과 광 방출 제어 신호의 시퀀스 위상과의 차가 90° 면 제2시퀀스 픽셀 신호 (P1)가 출력되고, 광 방사 제어 신호의 시퀀스 위상과 광 방출 제어 신호의 시퀀스 위상과의 차가 180° 면 제3시퀀스 픽셀 신호(P2)가 출력되고, 광 방사 제어 신호의 시퀀스 위상과 광 방출 제어 신호의 시퀀스 위상과의 차가 270° 면 제4시퀀스 픽셀 신호(P3)가 출력된다.

[0145] 시퀀스 픽셀 신호들(P0 내지 P3)은 각각 수학식 5, 수학식 6, 수학식 7, 수학식 8로 표현된다.

[0146] [수학식 5]

[0147] $$P_0 = \alpha + \beta \cos\theta$$

[0148] [수학식 6]

[0149] $$P_1 = \alpha + \beta \sin\theta$$

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[0150] [수학식 7]

[0151] $$P_2 = \alpha + \beta\cos\theta$$

[0152] [수학식 8]

[0153] $$P_3 = \alpha + \beta\sin\theta$$

[0154] 여기서, 수학식 5, 수학식 6, 수학식 7 및 수학식 8 각각의 알파(α)는 오프셋을, 베타(β)는 진폭을 의미한다. 상기 오프셋은 배경 강도(Background intensity)를 나타낸다.

[0155] 도 21a는 도 20의 제1거리 측정 장치(620)에서 방사되는 제1광 방사 제어신호(LTC1)의 파형과 제1거리 측정 장치(620)에서 출력되는 제1광 검출 제어신호 (DTC1)의 파형을 나타내는 타이밍 도이다.

[0156] 도 20 및 도 21a를 참조하면, 제1거리 측정 장치(620)의 타이밍 컨트롤러 (622)는 제1광 방사 제어 신호(LTC1)를 광원(624)에 전송하고, 제1광 검출 제어 신호(DTC1)를 거리 센서(643)에 전송한다. 설명의 편의를 위하여, 제1광 방사 제어신호(LTC1)에 기초하여 광원(624)에서 출력되는 광 신호(EL1)의 파형은 제1광 방사 제어 신호(LTC1)의 파형과 동일하다고 가정한다.

[0157] 따라서, 제1광 방사 제어 신호(LTC1) 파형과 제1광 검출 제어 신호(DTC1)의 파형을 비교하면, 제1시퀀스(S1) 동안 제1광 반사 제어 신호(LTC1)의 위상과 제1광 검출 제어 신호(DTC1)의 위상이 동일하므로 제1시퀀스 픽셀 신호(P0)가 도출된다.

[0158] 더불어 제2시퀀스, 제3시퀀스, 제4시퀀스에서도 각각 제1시퀀스 픽셀 신호 (P0)가 도출된다. 이때, 제1시퀀스 픽셀 신호(P0)는 수학식 5와 동일하다. 따라서 제1거리 측정 장치(620)에서 방사되는 광신호(EL1)가 피사체(650)에 반사되어 거리 센서(623)에 도달되면 수학식 9를 이용하여 거리를 측정할 수 있다.

[0159] [수학식 9]

[0160] $$LTC\ 1_{4_0} = P_0 + P_2 + P_3 + P_0 = 4\alpha + 4\beta\cos\hat{\theta}$$

[0161] 여기서, 각각의 알파(α)는 오프셋을, 베타(β)는 진폭을 의미한다. 상기 오프셋은 배경 강도를 나타낸다. 이때, 제1거리 측정 장치(620)는 위상 차($\hat{\theta}$)에 기초하여 거리 정보를 측정할 수 있다.

[0162] 도 21b는 도 20에 도시된 제2거리 측정 장치(640)의 제2광 방사 제어신호 (LTC1)의 파형과 제1거리 측정 장치(620)의 제1광 검출 제어신호(DTC1)의 파형을 나타내는 타이밍 도이다.

[0163] 도 20 및 도 21a를 참조하면, 제2거리 측정 장치(640)의 타이밍 컨트롤러 (642)가 제2광 방사 제어 신호(LTC2)를 광원(644)에 전송한다. 광원(644)은 제2광 방사 제어 신호(LTC2)에 기초하여, 광신호(EL2)를 피사체(50)로 방사한다.

[0164] 방사된 광신호(EL2)는 반사되어 제1거리 측정 장치(620)의 거리 센서(623)로 입사한다. 설명의 편의를 위하여, 광신호(EL2)의 파형은 제2광 방사 제어 신호(LTC 2)의 파형과 동일하다고 가정한다.

[0165] 제2거리 측정 장치(620)의 제2광 방사 제어 신호(LTC2)의 파형과 제1거리 측정 장치(640)의 제1광 검출 제어 신호(DTC1) 파형을 비교하여 시퀀스 픽셀 신호가 도출될 수 있다.

[0166] 제1시퀀스(S1) 동안 제1광 검출 제어 신호(DTC1)의 위상과 제2광 방사 제어 신호의 위상(LTC2)이 동일하므로, 제1시퀀스 픽셀 신호(P0)가 도출된다. 또한, 제3시퀀스(S2) 동안 제1광 검출 제어 신호(DTC1)의 위상과 제2광 방사 제어 신호 (LTC2)의 위상은 180° 차이가 나므로, 제3시퀀스 픽셀 신호(P2)가 도출된다.

[0167] 또한, 제4시퀀스(S3) 동안 제1광 검출 제어 신호(DTC1)의 위상과 제2광 방사 제어 신호(LTC2)의 위상은 270° 차이가 나므로, 제4시퀀스 픽셀 신호(P2)가 도출된다. 또한, 제2시퀀스(S2) 동안 제1광 검출 제어 신호(DTC1)의 위상과 제2광 방사 제어 신호(LTC2)의 위상은 180° 차이가 나므로, 제2시퀀스 픽셀 신호(P1)가 도출된다. 따라서, 제2거리 측정 장치에서 방사되는 광신호(EL2)가 피사체(650)에서 반사되면, 제1거리 측정 장치의 거리 센서에서 감지하여, 수학식 10을 이용하여 파형 간섭이 제거된다.

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[0168] [수학식 10]

[0169] $$LTC\ S_{A\alpha} = P'_0 + P'_2 + P'_3 + P'_1 = S\alpha$$

[0170] 수학식 10에서와 같이 제1내지 제4시퀀스 픽셀 신호들을 모두 더하면, $S\alpha$ 만 남는다. 여기서, 알파(α)는 오프셋을 의미하므로, 제2거리 측정 장치에서 방사되는 광신호(EL2)가 제1거리 측정 장치의 거리 센서에서 감지되어도, 배경 신호로 처리하여 거리를 측정하는데 간섭이 일어나지 않게 된다.

[0171] 상기 예의 거리 측정 장치는 제1내지 제4시퀀스 픽셀 신호들만을 더하여 간섭 효과를 상쇄하였지만, 실제로는 더 많은 수의 시퀀스 픽셀 신호들을 더하여 간섭 현상을 제거할 수도 있다.

[0172] 도 22는 본 발명의 일 실시 예에 따른 영상 촬영 장치를 나타내는 도면이다.

[0173] 도 4 및 도 22를 참조하면, 본 발명의 실시 예에 따른 이미지 처리 장치 또는 이미지 픽업 장치(1300)는 광원(LS)로부터 출력되는 출력 광이 피사체에 반사되는 반사 광을 렌즈(LE)를 통해 수신하여, 피사체에 대한 영상 정보(IMG)로 감지하는 이미지 센서(1310)를 포함할 수 있다.

[0174] 본 발명의 실시 예에 따른 이미지 처리 장치(1300)는 이미지 센서(1310)를 제어하는 컨트롤러(1322) 및 이미지 센서(1310)에 의해 감지된 영상 정보에 대한 신호 처리를 수행하는 신호 처리 회로(1321)를 구비하는 프로세서(1320)를 더 구비할 수 있다.

[0175] 도 23은 본 발명의 다른 실시 예에 따른 이미지 처리 시스템을 나타내는 도면이다.

[0176] 도 23을 참조하면 본 발명의 실시 예에 따른 이미지 처리 시스템(1400)은 이미지 처리 장치(1410) 및 이미지 처리 장치(1410)로부터 수신되는 이미지를 디스플레이하는 표시 장치(1440)를 포함할 수 있다. 이를 위해, 프로세서(1430)는 이미지 센서(1420)로부터 수신되는 이미지 정보를 표시 장치(1440)로 전송하는 인터페이스(1433)를 더 포함할 수 있다.

[0177] 도 24는 도 1 또는 도 4에 도시된 거리 측정 장치를 포함하는 전자 시스템 및 인터페이스를 나타낸다.

[0178] 도 24를 참조하면, 전자 시스템(2000)은 MIPI®(mobile industry processor interface)를 사용 또는 지원할 수 있는 데이터 처리 장치, 예컨대 이동 전화기, PDA(personal digital assistant), PMP(portable multimedia player), 테블릿 PC (tablet personal computer) 또는 스마트 폰으로 구현될 수 있다. 전자 시스템 (2000)은 애플리케이션 프로세서(2110), 이미지 센서 모듈(2140), 및 디스플레이 (2150)를 포함한다.

[0179] 애플리케이션 프로세서(2110)에 구현된 CSI 호스트(2112)는 카메라 시리얼 인터페이스(Camera Serial Interface; CSI)를 통하여 이미지 센서 모듈(2140)의 CSI 장치(2141)와 시리얼 통신을 수행할 수 있다. CSI 호스트(2112)는 디시리얼라이저(DES)를 포함할 수 있고, CSI 장치(2141)는 시리얼라이저(SER)를 포함할 수 있다.

[0180] DSI 호스트(2212)는 디스플레이 시리얼 인터페이스(Display Serial Interface; DSI)를 통하여 디스플레이(2150)의 DSI 장치(2151)와 시리얼 통신을 수행할 수 있다.

[0181] 일 실시 예에서, DSI 호스트(2212)는 시리얼라이저(SER)를 포함할 수 있고, DSI 장치(2151)는 디시리얼라이저(DES)를 포함할 수 있다. 나아가, 전자 시스템 (2000)은 애플리케이션 프로세스(2110)와 통신을 수행할 수 있는 RF(Radio Frequency) 칩(2160)을 더 포함할 수 있다.

[0182] 전자 시스템(2000)의 PHY(2113)와 RF 칩(2160)는 MIPI® Dig RF에 따라 데이터 송수신을 수행할 수 있다.

[0183] 또한, 애플리케이션 프로세서(2110)는 PHY(2113)의 MIPI® Dig RF에 따른 데이터 송수신을 제어하는 Dig RF MASTER(2114)를 더 포함할 수 있다. 한편, 전자 시스템(2000)은 GPS(Global Positioning System, 2120), 스토리지(2170), 마이크 (2180), DRAM(Dynamic Random Access Memory, 2185) 및 스피커(2190)를 포함할 수 있다. 또한 전자 시스템(2000)은 UWB(Ultra WideBand, 2210), WLAN(Wireless Local Area Network, 2220) 및 WIMAX(Worldwide Interoperability for Microwave Access, 2230) 등을 이용하여 통신을 수행할 수 있다. 다만, 전자 시스템(2000)의 구조 및 인터페이스는 하나의 예시로서 이에 한정되는 것이 아니다.

[0184] 본 발명은 도면에 도시된 실시 예를 참고로 설명되었으나 이는 예시적인 것에 불과하며, 본 기술 분야의 통상의 지식을 가진 자라면 이로부터 다양한 변형 및 균등한 타 실시 예가 가능하다는 점을 이해할 것이다. 따라서, 본 발명의 진정한 기술적 보호 범위는 첨부된 등록청구범위의 기술적 사상에 의해 정해져야 할 것이다.

HESAI EX1002, P.309

부호의 설명

[0185] 10; 거리 측정 장치

20, 20A; 타이밍 컨트롤러

21; 펄스 생성기

22; 지연 유닛

23; T_W 생성기

25; 난수 생성기

30, 30A; 거리 센서

36; CDS/ ADC 회로

37; 메모리 유닛

38; 거리 추정기

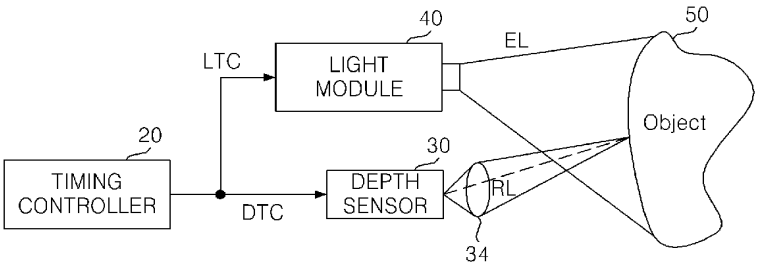
40, 40A; 광 모듈

34; 렌즈

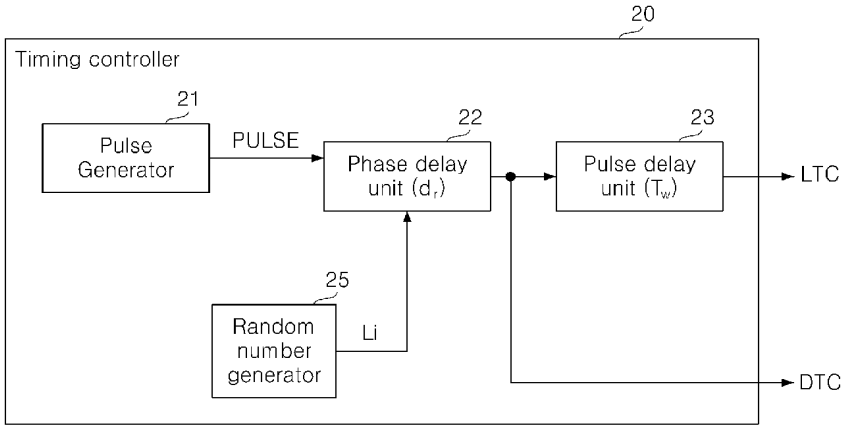
50; 피사체

도면

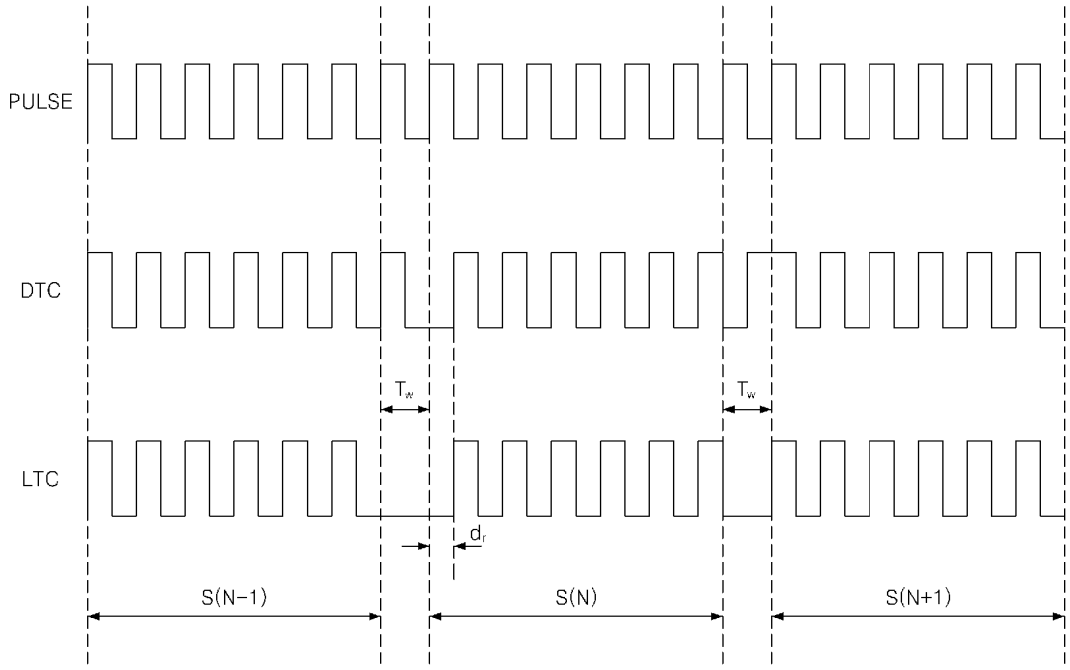
도면1



도면2

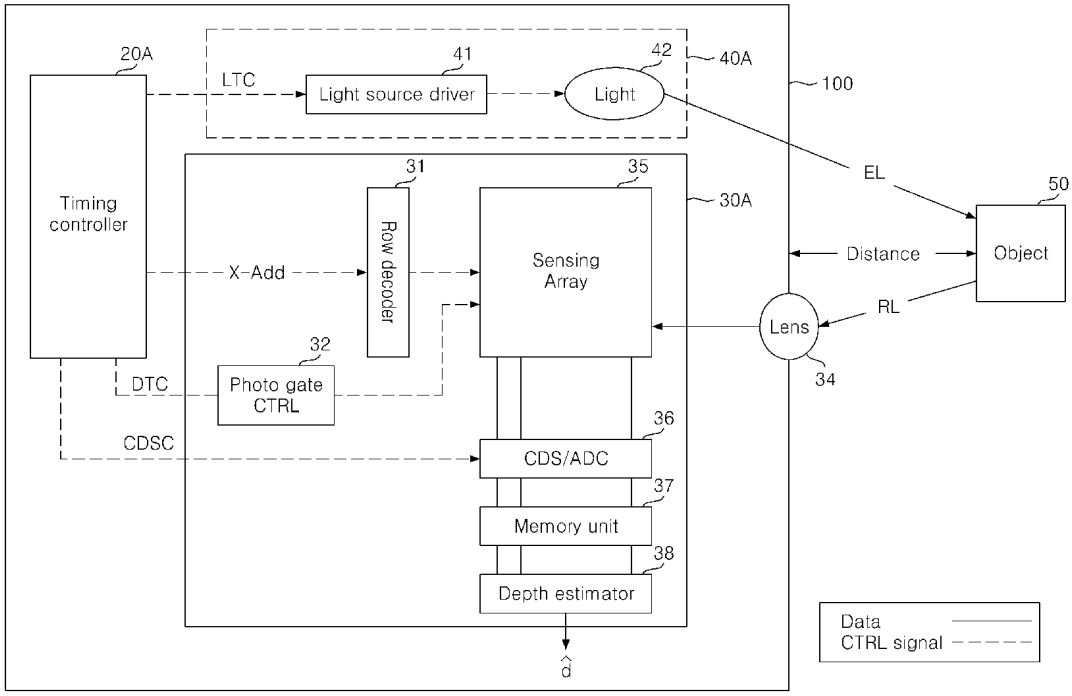


도면3



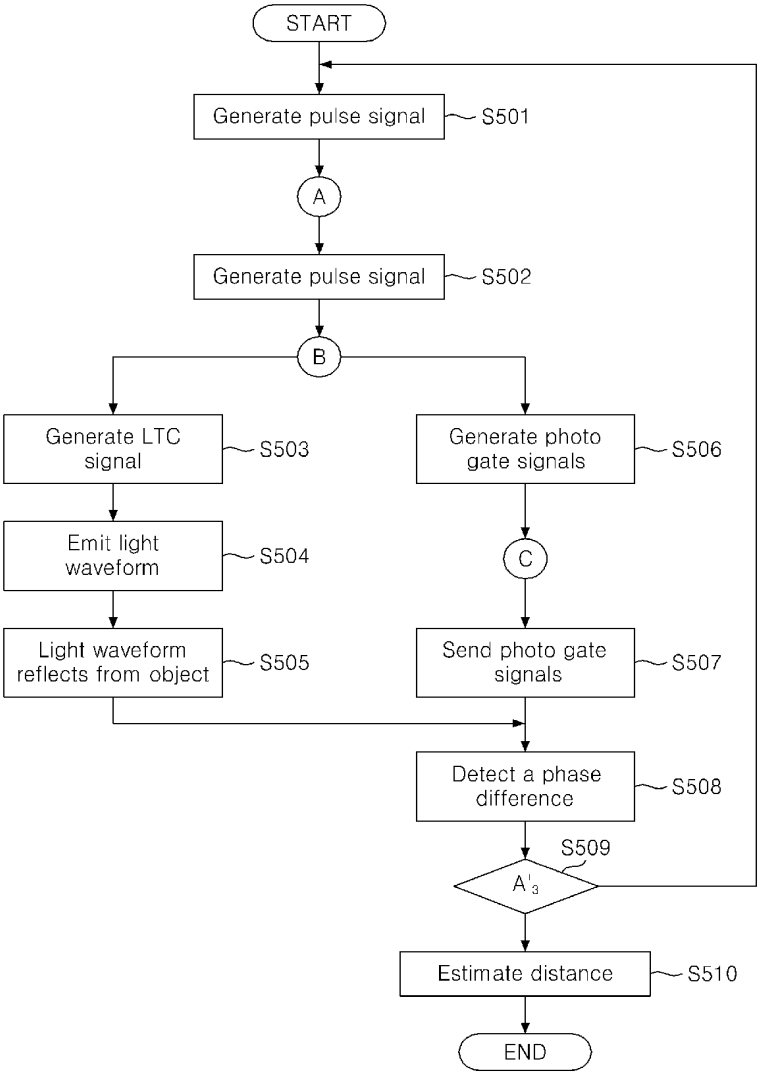
HESAI EX1002, P.311

도면4

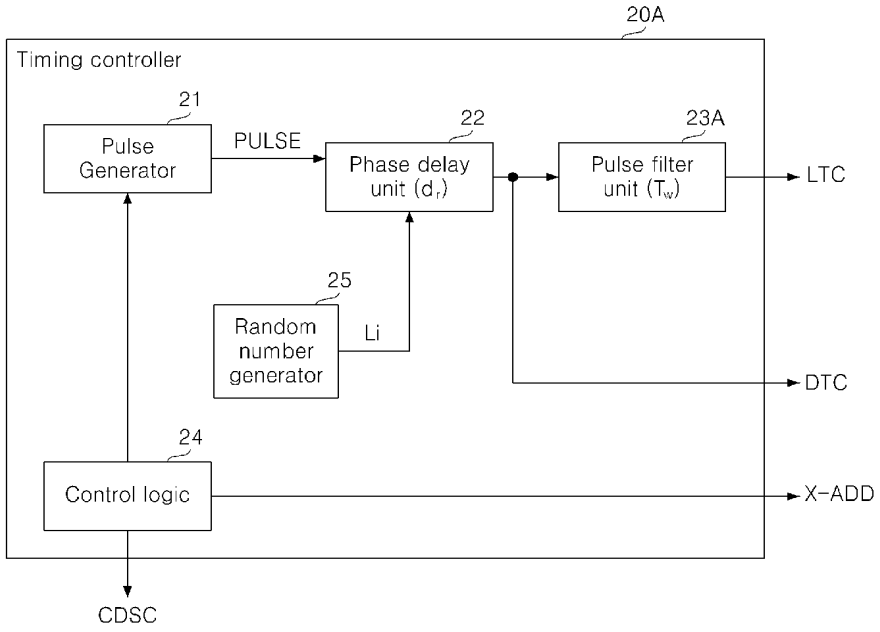


HESAI EX1002, P.312

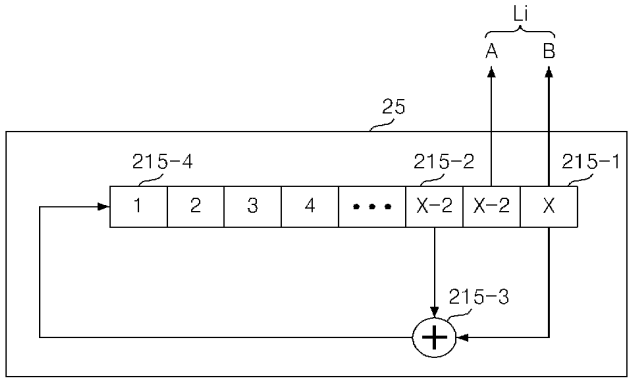
도면5


START
Generate pulse signal
S501
A
Generate pulse signal
S502
B
Generate LTC signal
S503
Emit light waveform
S504
Light waveform reflects from object
S505
Generate photo gate signals
S506
C
Send photo gate signals
S507
Detect a phase difference
S508
S509
A'3
Estimate distance
S510
END

도면6



도면7

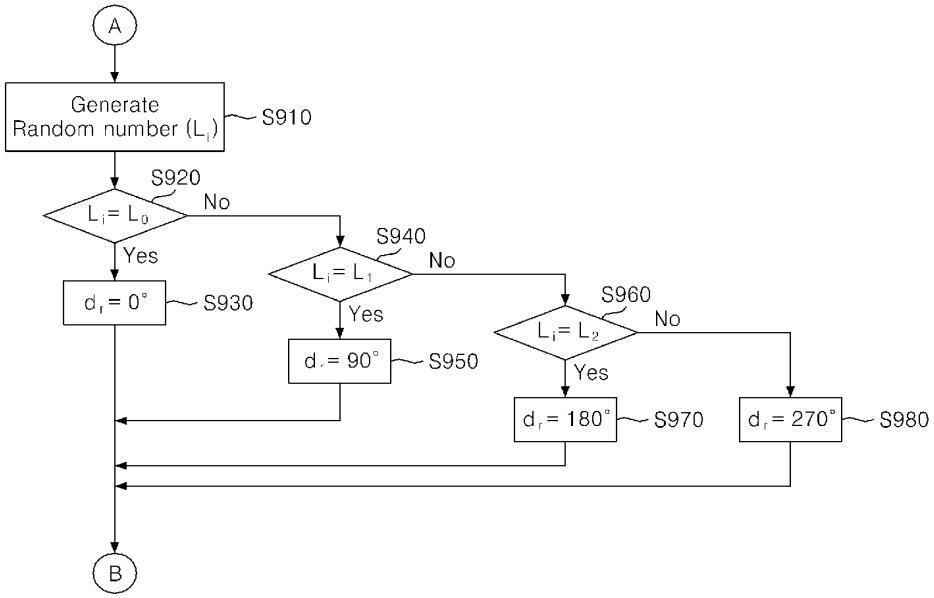


도면8

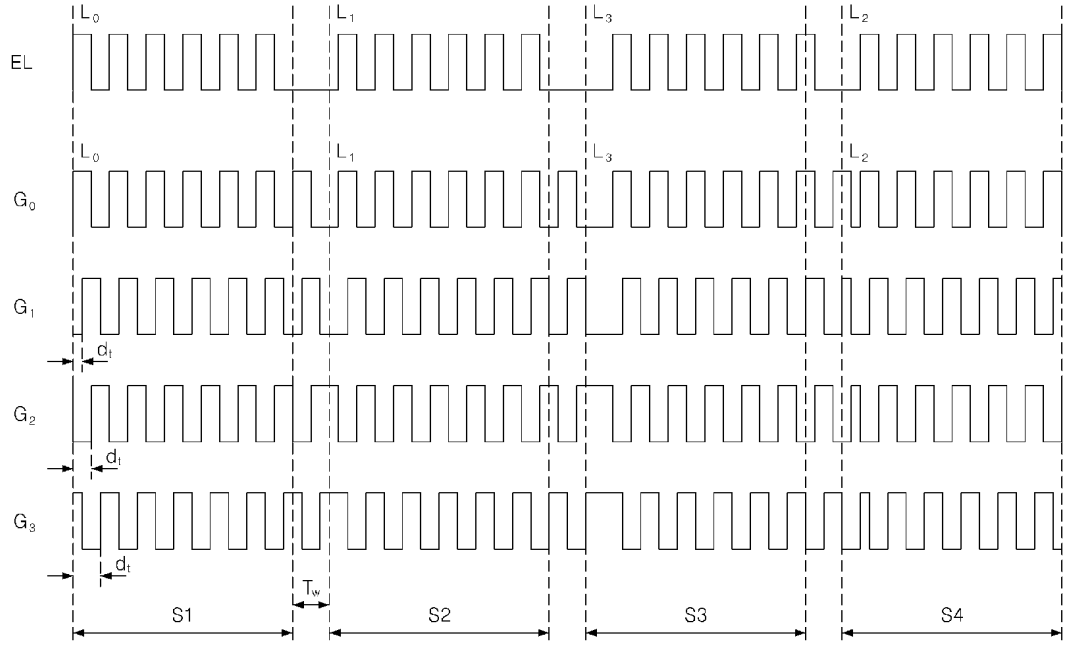
A	B	L_i
0	0	L_0
0	1	L_1
1	0	L_2
1	1	L_3

HESAI EX1002, P.314

도면9

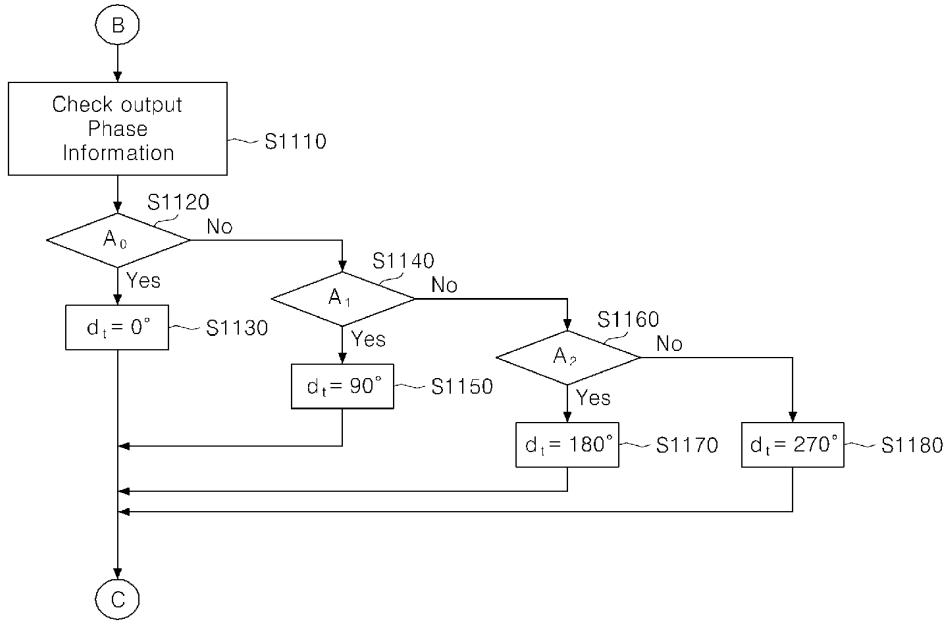


도면10

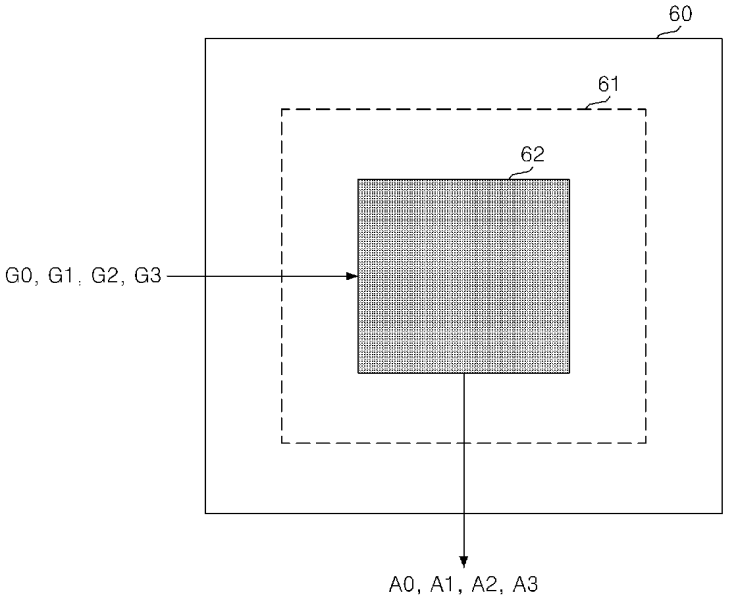


HESAI EX1002, P.315

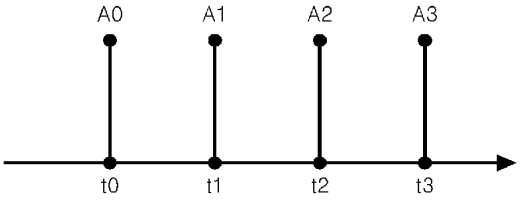
도면11


B
Check output Phase Information
S1110
S1120
A0
No
Yes
dt = 0°
S1130
S1140
A1
No
Yes
dt = 90°
S1150
S1160
A2
No
Yes
dt = 180°
S1170
dt = 270°
S1180
C

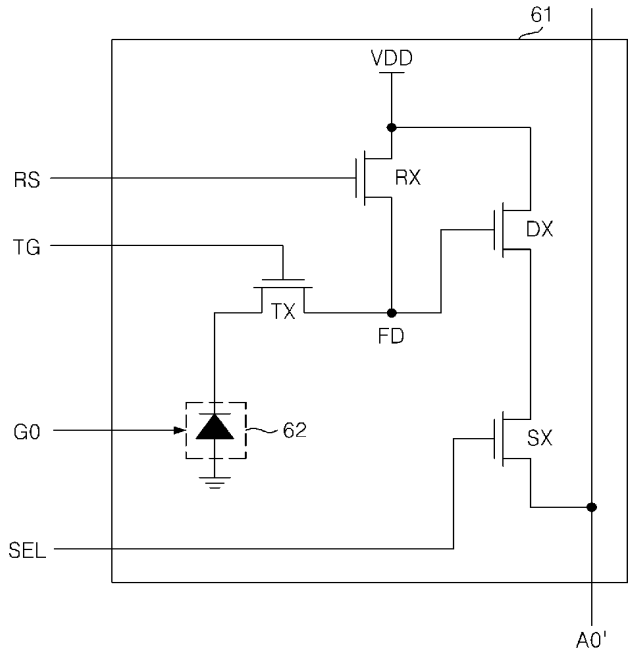
도면12a


60
61
62
G0, G1, G2, G3
A0, A1, A2, A3

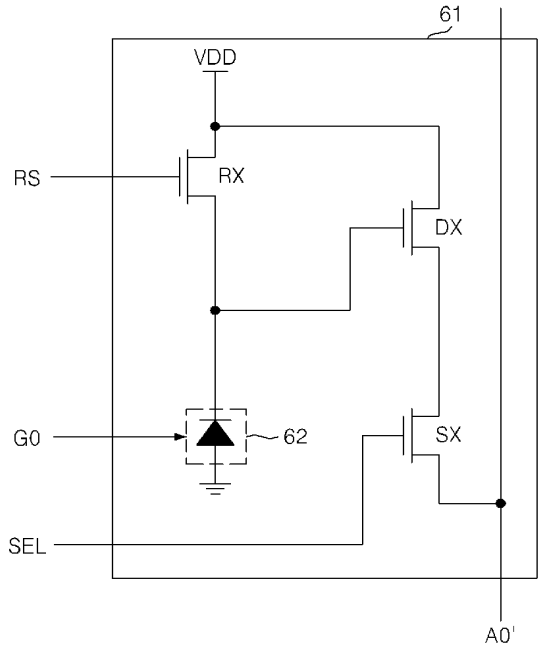
도면12b



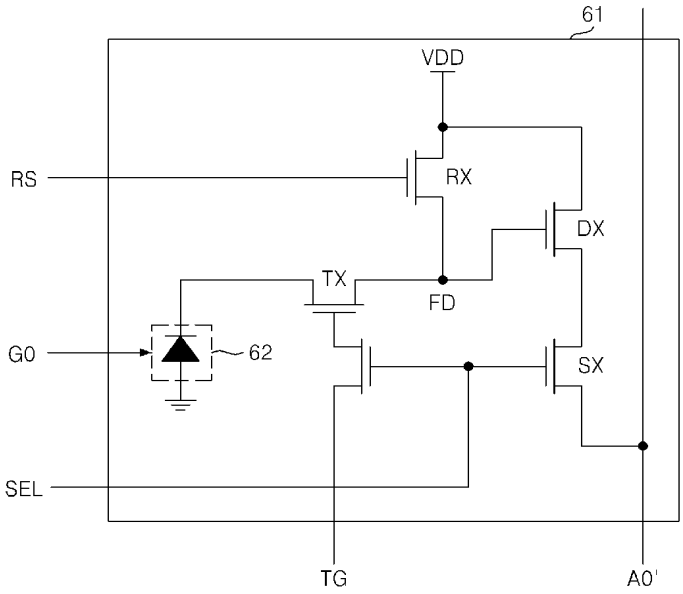
도면13a



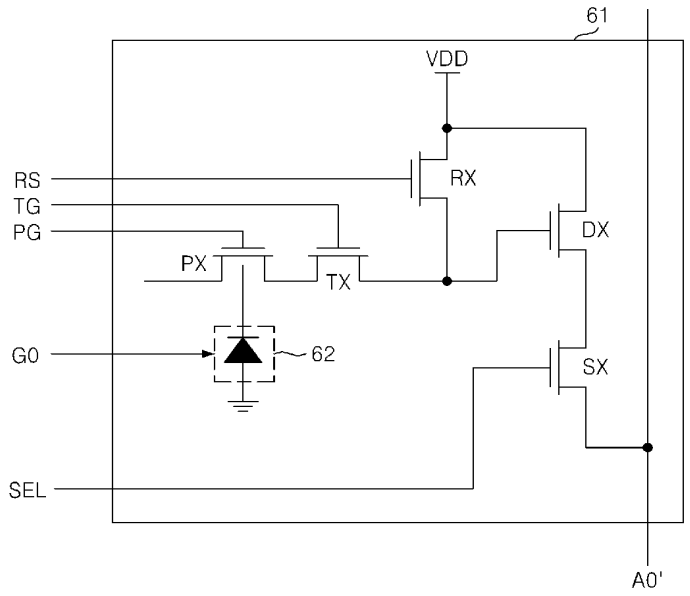
도면13b


61
VDD
RS
RX
DX
G0
62
SX
SEL
A0'

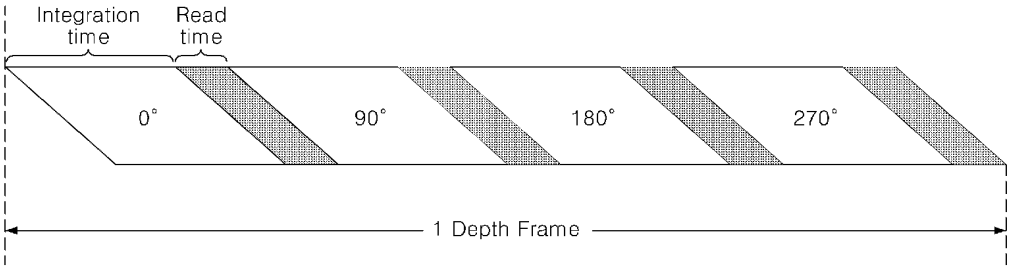
도면13c


61
VDD
RS
RX
DX
TX
FD
G0
62
SX
SEL
TG
A0'

도면13d

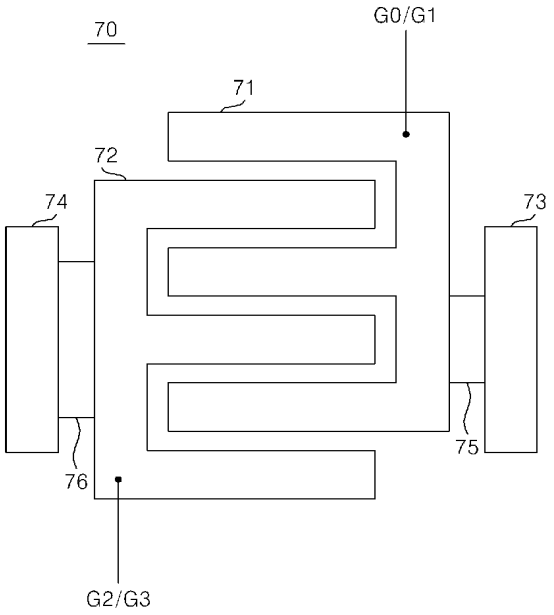


도면14

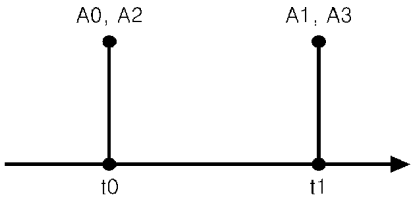


HESAI EX1002, P.319

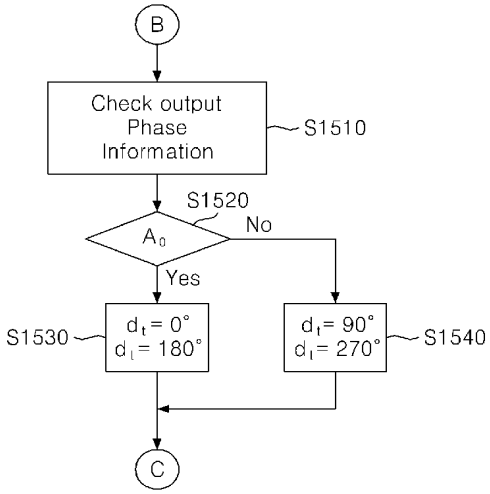
도면15a



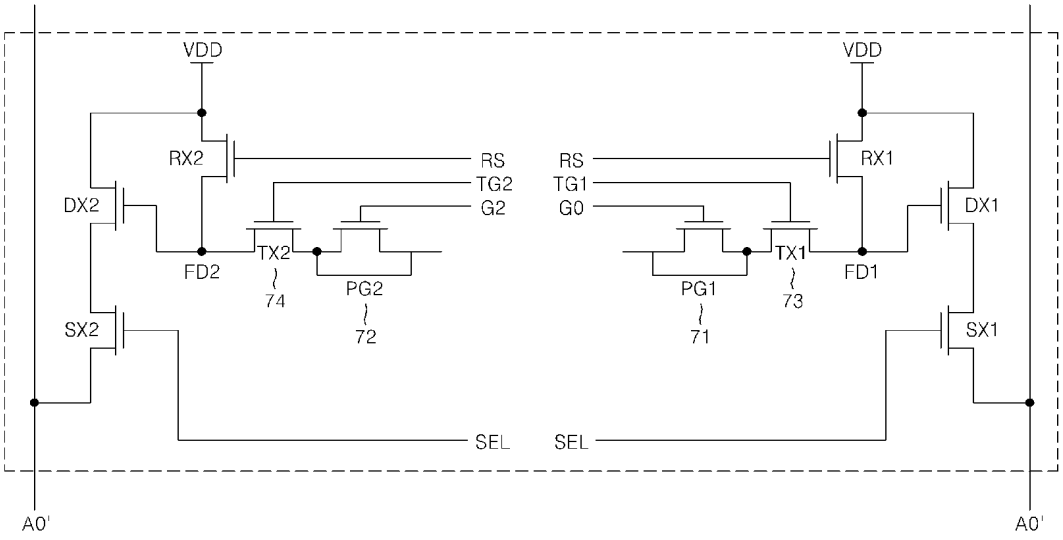
도면15b



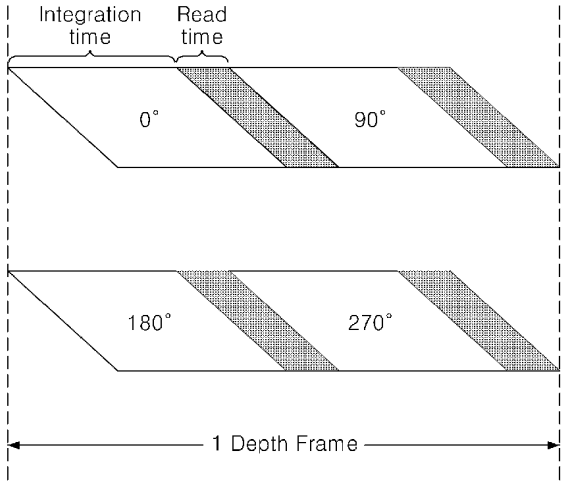
도면16



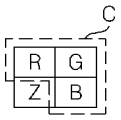
도면17



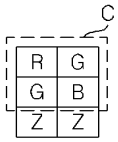
도면18



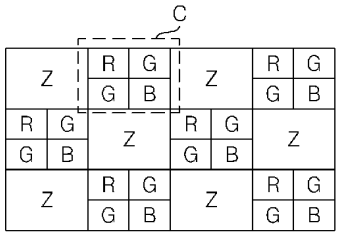
도면19a



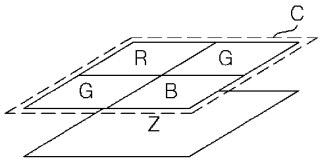
도면19b



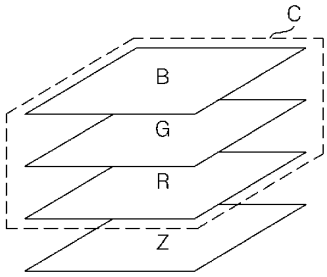
도면19c



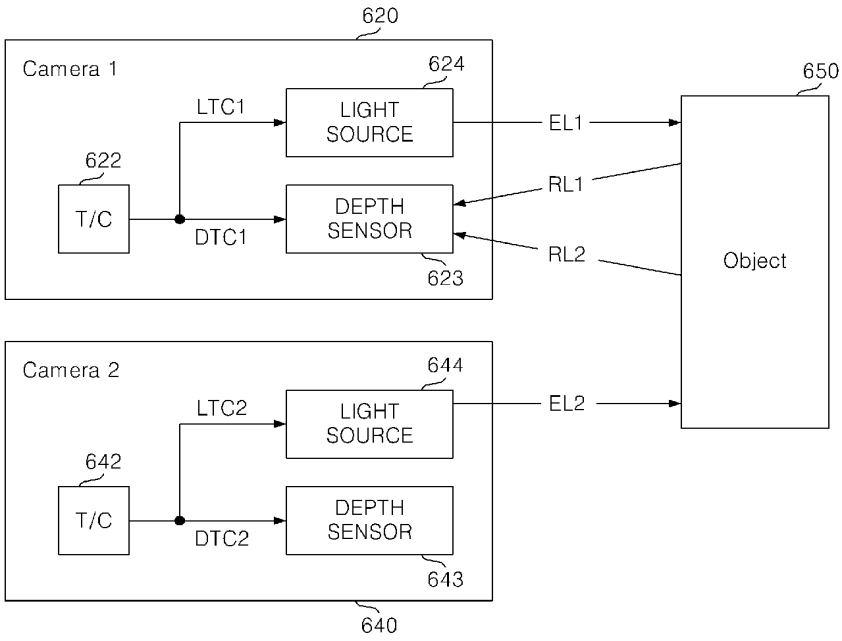
도면19d



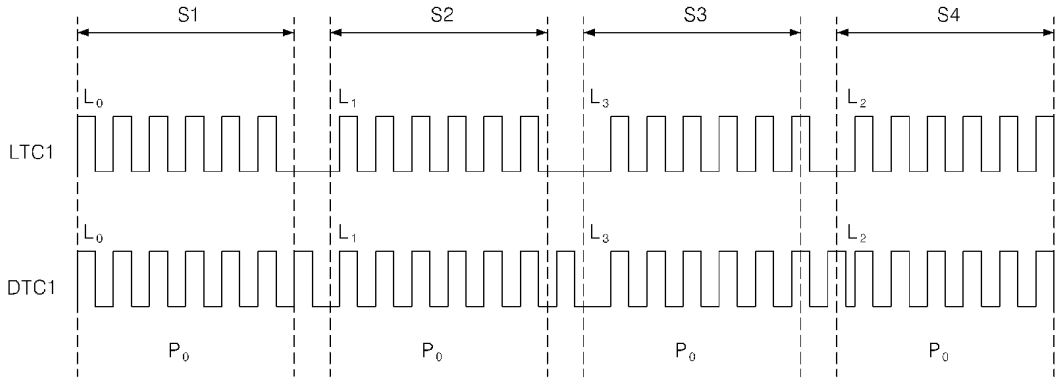
도면19e



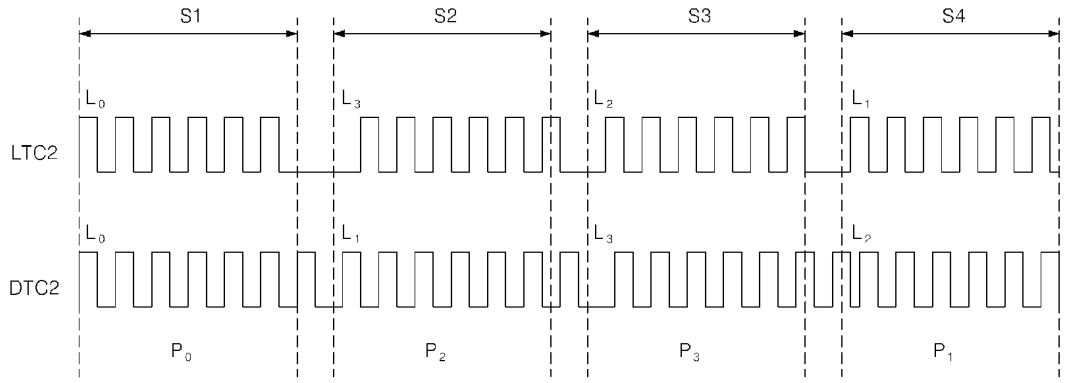
도면20



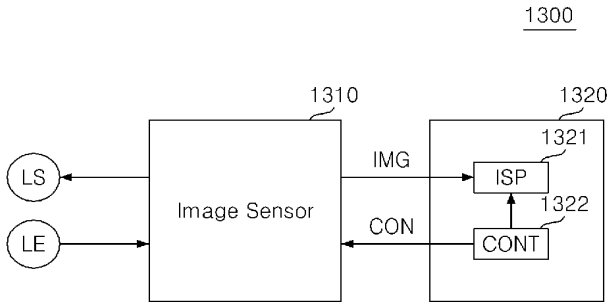
도면21a



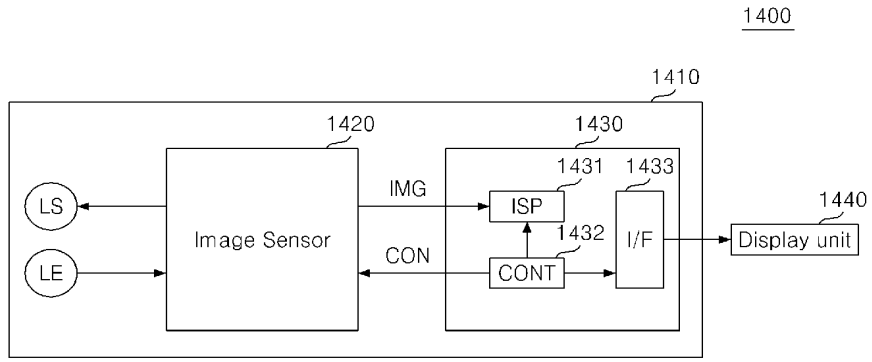
도면21b



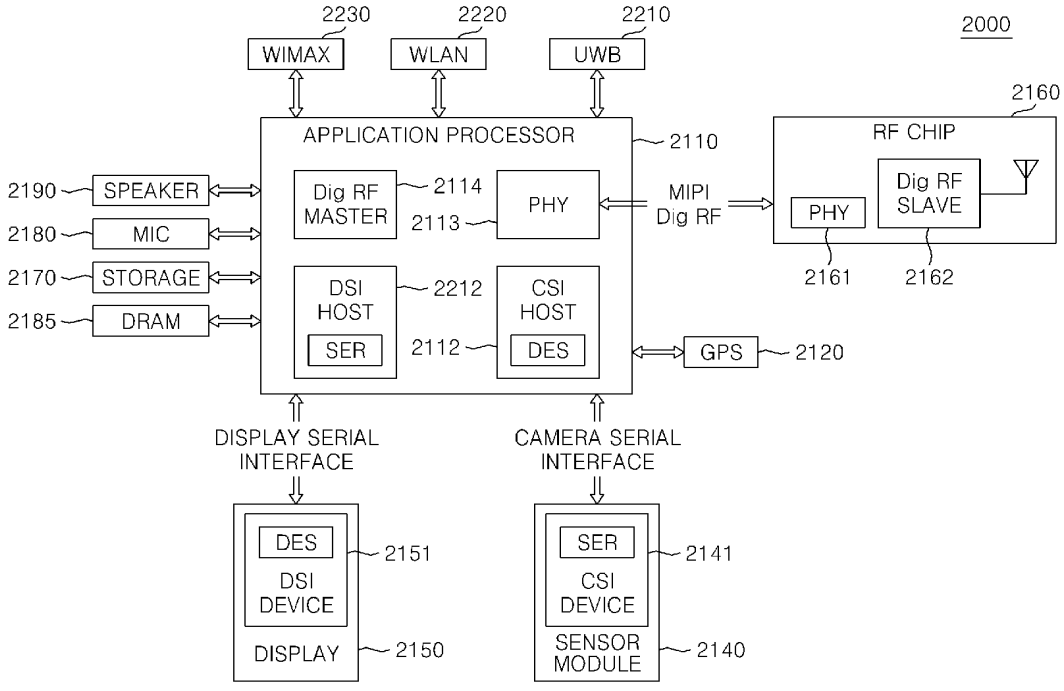
도면22



도면23



도면24



Espacenet

Bibliographic data: KR20130111130 (A) — 2013-10-10

DEPTH ESTIMATION DEVICE AND METHOD THEROF

Inventor(s): OVSIANNIKOV ILIA [US]; MIN DONG KI [KR]; NOH YO HWAN [KR] ± (OVSIANNIKOV ILIA, ; MIN, DONG KI, ; NOH, YO HWAN)

Applicant(s): SAMSUNG ELECTRONICS CO LTD [KR] ± (SAMSUNG ELECTRONICS CO., LTD)

Classification: **- international:** ***G01S17/08***
- cooperative: G01B11/026 (EP, US); G01S17/10 (EP, US); G01S17/894 (EP, US); G01S7/4865 (EP, US)

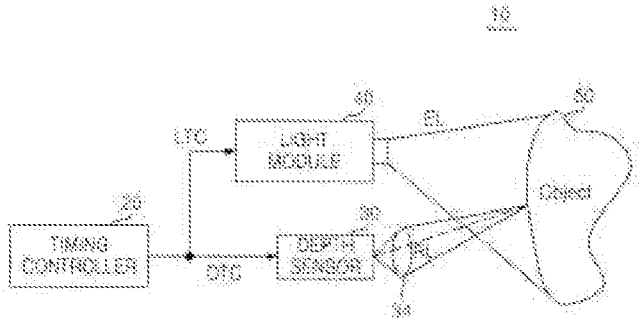
Application number: KR20120034115 20120402 Global Dossier

Priority number(s): US201213434381 20120329

Also published as: US2013258099 (A1)

Abstract of KR20130111130 (A)

PURPOSE: A distance measurement device and an operation method are provided to accurately measure a distance with an object. CONSTITUTION: A distance measurement device (10) includes a timing controller (20), an optical module (40), and a distance sensor (30). A light source outputs an optical signal to an object. The distance sensor measures a set of distance information in response to a reflective light which is reflected from the object. The timing controller controls the operation timing of the distance sensor by transmitting an optical radiation control signal to the light source and transmitting an optical detection control signal to the distance sensor. The optical signal includes a plurality of sequences. A phase of a pulse is randomly changed per sequence.



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DESCRIPTION KR20130111130A

Distance measuring device and its operation method (DEPTH ESTIMATION DEVICE AND METHOD THEREOF)

[0001]

An embodiment according to the concept of the present invention relates to a distance sensor, and more particularly, to a distance measuring apparatus using a time-of-flight (TOF) principle of the distance sensor and an operating method thereof.

[0002]

A sensor is a device that detects the state of an object, converts it into an electrical signal, and transmits it.

[0003]

There are various types of sensors such as light sensors, temperature sensors, pressure sensors, magnetic sensors, and depth sensors.

Among them, the distance sensor measures a delay time when an optical signal projected from a light source is reflected and returned by a subject (eg, an object to be measured) to calculate a distance to the subject.

[]

An object of the present invention is to provide a distance measurement apparatus capable of increasing the accuracy of 3D distance measurement data, an operation method thereof, and a method of removing interference from external optical signals. The operating method of the distance measuring apparatus according to an embodiment of the present invention includes the steps of outputting an optical signal from a light source to a subject, and determining a distance between the subject and the distance measuring device in response to a gate signal and a reflected light signal reflected from the subject. Measuring, the optical signal includes a plurality of sequences, and a phase of the pulse of the optical signal randomly changes for each of the plurality of sequences. The optical signal includes a delay time corresponding to a multiple of the wavelength of the pulse between the plurality of sequences. During the delay time, the period of the pulse is filtered. The outputting of the optical signal to the subject includes outputting a pulse signal from a pulse generator and outputting a phase designation signal from a random number generator, and different phases at predetermined intervals of the pulse signal based on the phase designation signal. Generating a light emission control signal having a light emission control signal, and outputting the optical signal from the light source based on the light emission control signal. The random number generator outputs any one of a plurality of phase designation signals as the phase designation signal. A plurality of gate signals are sequentially input to the distance measuring device for the entire frame, and a phase of each of the plurality of gate signals is varied by a predetermined phase. Measuring the distance between the subject and the distance measuring device includes: outputting a plurality of sequence pixel signals in response to the reflected light signal and the gate signal, and the reflected light calculated based on the plurality of sequence pixel signals And measuring distance information through a phase difference between the signal and the gate signal. A distance measuring apparatus according to an exemplary embodiment of the present invention includes a light source that outputs an

optical signal to a subject, a distance sensor that measures distance information in response to reflected light reflected from the subject, and transmits a light emission control signal to the light source, And a timing controller for controlling an operation timing of the distance sensor by transmitting a light detection control signal to the distance sensor, wherein the optical signal includes a plurality of sequences, and a phase of a pulse is randomly assigned to each of the plurality of sequences. Changes.

The timing controller includes a pulse generator that outputs a pulse signal, a random number generator that generates a random number and outputs a phase designation signal determined by the random number, and receives the pulse signal and the phase designation signal, and receives the phase designation signal. And a delay unit for delaying a part of the pulse so that the pulse signal has a different phase for each predetermined interval. The distance sensor includes a sensing array including at least one distance pixel, a circuit for converting a plurality of image pixel signals output from the at least one distance pixel into digital pixel signals and outputting the digital pixel signals, and received And a distance meter measuring a distance between the subject and the distance measuring device based on digital pixel signals.

The distance measuring apparatus according to an exemplary embodiment of the present invention has an effect of clearly measuring a distance to a subject by removing interference between optical signals caused by a plurality of distance measuring apparatuses.

[0016]

A detailed description of each drawing is provided in order to more fully understand the drawings cited in the detailed description of the present invention.

1 is a conceptual diagram illustrating a distance measuring apparatus according to an embodiment of the present invention.

2 is a block diagram illustrating the timing controller shown in FIG. 1.

FIG. 3 is a timing diagram showing waveforms of the light emission control signal and the light detection control signal shown in FIG. 2.

4 is a block diagram illustrating a distance measuring device according to another exemplary embodiment of the present invention.

5 is a flowchart illustrating a method of operating the distance measuring apparatus shown in FIG. 1 or 4.

6 is a block diagram illustrating an example of the timing controller shown in FIG. 4.

7 is a block diagram illustrating an example of the random number generator shown in FIG. 6.

8 shows an example of a truth table generated through the random number generator shown in FIG. 7.

9 is a flow chart showing in detail the operation of the random number generator in the overall flow chart shown in FIG. 5.

FIG. 10 is a timing diagram showing waveforms of an optical signal that is an output signal of a light source shown in FIG. 4 and a waveform of a first gate signal to a fourth gate signal that is an output signal of a photo gate controller.

FIG. 11 is a partial flow chart showing in detail an operation of a photo gate controller for transmitting a gate signal to a 1-tap distance pixel shown in FIG. 4 in the overall flow chart shown in FIG. 5.

12A shows a layout of a distance pixel having a 1-tap pixel structure included in the sense array shown in FIG. 4.

FIG. 12B is a timing diagram illustrating pixel signals sequentially detected in a distance pixel having a 1-tap pixel structure shown in FIG. 12A and a phase difference caused by the pixel signals.

13A to 13D are circuit diagrams illustrating photoelectric conversion elements and transistors implemented in the active region illustrated in FIG. 12A.

FIG. 14 is a conceptual diagram illustrating one frame performed by a rolling shutter method in the 1-tap structure distance sensor shown in FIG. 12A.

15A shows a layout of a distance pixel having a 2-tap pixel structure included in the sense array shown in FIG. 4.

FIG. 15B is a timing diagram illustrating pixel signals sequentially detected in a distance pixel having a 2-tap pixel structure shown in FIG. 15A and a phase difference caused by the pixel signals.

FIG. 16 is a partial flow chart showing in detail an operation of the photo gate controller shown in FIG. 4 for transmitting a gate signal to a distance pixel having a 2-tap pixel structure in the overall flow chart shown in FIG. 5.

FIG. 17 is a circuit diagram including a plurality of photo gates and a plurality of transistors implemented in the 2-tap structure distance pixel illustrated in FIG. 16A.

18 is a conceptual diagram illustrating one frame performed by a rolling shutter method in the distance sensor of the 2-tap structure shown in FIG. 16A.

19A to 19E illustrate an example of a unit pixel included in the sensing array illustrated in FIG. 4.

20 is a diagram illustrating an operation of a plurality of distance measuring devices located adjacent to each other.

FIG. 21A is a timing diagram illustrating waveforms of a light emission control signal of the first distance measuring device shown in FIG. 20 and a waveform of a light detection control signal of the first distance measuring device.

FIG. 21B is a timing diagram showing waveforms of a light emission control signal of the second distance measuring device shown in FIG. 20 and a waveform of a light detection control signal of the first distance measuring device.

22 is a diagram illustrating an image processing system according to an embodiment of the present invention.

23 is a diagram illustrating an image processing system according to another embodiment of the present invention.

24 shows an electronic system and an interface including the distance measuring device shown in FIG. 1 or 4.

[0017]

A specific structural or functional description of the embodiments according to the concept of the present invention disclosed in the present specification is exemplified only for the purpose of describing the embodiments according to the concept of the present invention, and the embodiments according to the concept of the present invention are It may be implemented in various forms and is not limited to the embodiments described herein.

[0018]

Since the embodiments according to the concept of the present invention can apply various changes and have various forms, the embodiments will be illustrated in the drawings and described in detail herein.

However, this is not intended to limit the embodiments according to the concept of the present invention to specific disclosed forms, and includes all changes, equivalents, or substitutes included in the spirit and scope of the present invention.

[0019]

Terms such as first or second may be used to describe various components, but the components should not be limited by the terms.

These terms are only for the purpose of distinguishing one component from other components, for example, without departing from the scope of the rights according to the concept of the present invention, the first component may be named as the second component and similarly the second component. The component may also be referred to as a first component.

[0020]

When a component is referred to as being "connected" or "connected" to another component, it is understood that it may be directly connected or connected to the other component, but other components may exist in the middle. Should be.

On the other hand, when a component is referred to as being "directly connected" or "directly connected" to another component, it should be understood that there is no other component in the middle.

Other expressions describing the relationship between components, such as "between" and "directly between" or "adjacent to" and "directly adjacent to" should be interpreted as well.

[0021]

The terms used in the present specification are only used to describe specific embodiments, and are not intended to limit the present invention.

Singular expressions include plural expressions unless the context clearly indicates otherwise.

In the present specification, terms such as "comprise" or "have" are intended to designate the presence of features, numbers, steps, actions, components, parts, or combinations thereof described herein, but one or more other features. It is to be understood that it does not preclude the possibility of presence or addition of elements or numbers, steps, actions, components, parts, or combinations thereof.

[0022]

Unless otherwise defined, all terms used herein, including technical or scientific terms, have the same meaning as commonly understood by one of ordinary skill in the art to which the present invention belongs.

Terms as defined in a commonly used dictionary should be interpreted as having a meaning consistent with the meaning in the context of the related technology, and should not be interpreted as an ideal or excessively formal meaning unless explicitly defined in the present specification. Does not.

[0023]

Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0024]

1 is a conceptual diagram illustrating a distance measuring apparatus according to an embodiment of the present invention, and FIG. 2 is a block diagram illustrating a timing controller shown in FIG.

3 is a timing diagram showing a waveform of a light emission control signal LTC and a waveform of a light detection control signal DTC shown in FIG. 2.

[0025]

Referring to FIGS. 1 to 3, the distance measuring apparatus 10 includes a timing controller 20, an optical module 40, a distance sensor (or depth sensor) 30, and a lens 34.

[0026]

The timing controller 20 controls operation timings of the distance sensor 30 and the optical module 40, respectively.

To this end, the timing controller 20 transmits the light emission control signal LTC to the optical module 40 and transmits the light detection control signal DTC to the distance sensor 30.

[0027]

The optical module 40 emits an optical signal EL generated based on the light emission control signal LTC toward the object 50.

The reflected optical signal RL reflected by the subject 50 is incident on the distance sensor 30 through the lens 34.

In this case, the distance measuring apparatus 10 may measure the distance by using Equation 1 representing a time difference (tΔ) between the radiation time of the optical signal EL and the incident time of the reflected optical signal RL.

[0028]

[Equation 1]

[0030]

Here, d denotes the distance between the distance measuring device 10 and the subject 50, and c denotes the light flux.

[0031]

Depending on the embodiment, the distance sensor 30 may be implemented as a single chip to calculate distance information.

Also, the distance sensor 30 may be used together with a color image sensor chip to simultaneously measure 3D image information and distance information.

[0032]

In this case, a distance pixel for detecting distance information and a color pixel for detecting image information in the 3D image sensor may be implemented together in one sensing array.

[0033]

2 and 3, the timing controller 20 includes a pulse generator 21, a phase delay unit 22, a random number generator 25, and a pulse delay unit 23.

[0034]

The pulse PULSE generated by the pulse generator 21 is transmitted to the phase delay unit 22.

Also, the random number Li generated by the random number generator 25 is transmitted to the phase delay unit 22.

[0035]

The phase delay unit 22 divides the received pulse PULSE into a plurality of sequences (S(N-1), S(N), and S(N+1)), and the received random number Li Based on this, a part (dr) of the pulse is delayed so that a different phase difference occurs for each sequence (S(N-1), S(N), and S(N+1)).

[0036]

The pulsed light detection control signal DTC output from the phase delay unit 22 is output to the distance sensor 30.

Further, the light detection control signal DTC is transmitted to the pulse delay unit 23.

[0037]

The pulse delay unit 23 delays each of the two adjacent sequences S(N-1), S(N), and S(N+1) based on the light detection control signal DTC. A light emission control signal (LTC) having a delay time (Tw) is generated.

The pulse delay unit 23 may be implemented by filtering a pulse signal or using a suppressor.

The light emission control signal LTC is output to the optical module 40.

[0038]

4 is a block diagram illustrating a distance measuring apparatus according to another exemplary embodiment of the present invention, and FIG. 5 is a flowchart illustrating a method of operating the distance measuring apparatus illustrated in FIGS. 1 and 4.

6 is a block diagram illustrating an example of the timing controller shown in FIG. 4.

[0039]

Referring to FIG. 4, the distance measuring apparatus 100 includes a timing controller 20A, a distance sensor 30A, an optical module 40A, and a lens 34.

[0040]

6, the timing controller 20A illustrated in FIG. 4 includes a control logic 24, a pulse generator 21, a phase delay unit 22, a random number generator 25, and a pulse filter unit 23A. Include.

[0041]

The control logic 24 controls the pulse generator 21 and transmits a row address (X-ADD) to the row decoder 31, or a correlated double sampling (CDS)/analog-to-digital converting (ADC) circuit (36) can transmit a CDS control signal (CDSC).

[0042]

3, 5, and 6, the pulse generator 21 of the timing controller 20A generates a pulse signal PULSE (S501).

The phase delay unit 22 has a different phase difference for each sequence (S(N-1), S(N), and S(N+1)) based on the random number Li generated by the random number generator 25. Part of the pulse (dr) is delayed so as to be possible (S502).

The light detection control signal DTC generated by the phase delay unit 22 is transmitted to the photo gate controller 32.

[0043]

When the pulse filter unit 23A receives a pulse signal of the same waveform as the light detection control signal DTC output from the phase delay unit 22, two adjacent sequences S(N-1) and S(N) And S(N+1)) to generate a light emission control signal LTC by placing a delay time Tw, respectively (S503).

The light emission control signal LTC is transmitted to the light source driver 41.

[0044]

Referring back to FIGS. 4 and 5, the optical module 40A includes a light source driver 41 and a light source 42.

[0045]

The light source driver 41 may generate a clock signal capable of driving the light source 42 based on the light emission control signal LTC output from the timing controller 20A.

[0046]

The light source 42 emits an optical signal EL to the subject 50 in response to the clock signal (S504).

The light source 42 may be implemented as a Light Emitting Diode (LED), an Organic Light Emitting Diode (OLED), an Active-matrix Organic Light Emitting Diode (AMOLED), or a laser diode.

For convenience of explanation, it is assumed that the waveform of the optical signal EL is the same as the waveform of the optical emission control signal LTC.

The optical signal EL may be a sine wave or a square file.

[0047]

The reflected light signal RL is incident on the sensing array 35 through the lens 34 (S505).

Here, the lens 34 may be used to include a lens and an infrared pass filter.

[0048]

The distance sensor 30A converts the reflected light signal RL into an electric signal and outputs it.

The distance sensor 30A includes a photo gate controller 32, a row decoder 31, a sensing array 35, a CDS/ADC circuit 36, a memory unit 37, and a distance estimator (or a range finder; 38). Include.

[0049]

The row decoder 31 selects any one of the plurality of rows in response to the row address X-ADD output from the timing controller 20A.

Here, a row represents a set of a plurality of distance pixels arranged in the horizontal-direction in the sense array 35.

[0050]

The photo gate controller 32 generates gate signals G0 to G3 based on the photo detection control signal DTC transmitted from the timing controller 20A (S506).

In addition, the photo gate controller 32 may sequentially supply the gate signals G0 to G3 to the sensing array 35 (S507).

[0051]

The sense array 35 includes a plurality of distance pixels.

The plurality of distance pixels included in the sensing array 35 are in response to the plurality of reflected light signals RL incident on the sensing array 35 through the lens 34, and the phase of the reflected light signal RL and the optical signal EL A phase difference of) is detected (S508).

Through this, the sensing array 35 may output an image pixel signal based on the incident reflected light signals RL.

[0052]

At this time, a plurality of steps (S501 to S508) are repeated until the output image pixel signal is the fourth image pixel signal A'3 (S509).

According to an embodiment, at least one of the plurality of steps (S501 to S508) may be repeated.

[0053]

The CDS/ADC circuit 36 performs a CDS (Correlated Double Sampling) operation and an ADC (Analog to ADC) on the image pixel signal output from a plurality of distance pixels based on the CDS control signal (CDSC) output from the timing controller 20A. Digital Converting) operation is performed to output digital pixel signals A0 to A3.

The digital pixel signals A0 to A3 are described in detail in FIGS. 12B and 15B.

[0054]

The memory unit 37, which may be implemented as a buffer, may store digital pixel signals A0 to A3 output from the CDS/ADC circuit 36 in a frame unit.

[0055]

The distance estimator 38 measures the phase difference φ on the basis of each digital pixel signal A0 to A3 output from the memory unit 37.

The phase difference () measured by the distance estimator 38 is shown in Equation 2.

[0056]

[Equation 2]

[0058]

The distance estimator 38 measures the distance information according to Equation 3 by using the phase difference () measured according to Equation 2, and outputs the measured distance information ().

[0059]

[Equation 3]

[0061]

Here, c represents the luminous flux, and fm represents the frequency of the optical signal EL.

[0062]

According to an embodiment of the present invention, the distance sensor 30A may be implemented in the form of a charge coupled device (CCD) or a CMOS image sensor (CIS).

The structure of FIG. 4 can be applied without changing the structure in the CIS-type distance sensor 30A.

When the distance sensor is a CCD type, the structure of the CDS/ADC 36 may be partially changed.

[0063]

The ADC structure may be changed for each analog CDS, digital CDS, or dual CDS method according to the application of the CDS (Correlated Double Sampling) method.

Further, the ADC may be implemented as a column ADC (Column ADC) arranged for each column of the distance sensor 30A or a single ADC (Single ADC) on which one ADC is arranged.

[0064]

The distance sensor 30A may be implemented with the timing controller 20A and one chip.

In addition, the distance sensor 30A, the timing controller 20A, and the lens 34 may be configured as one module, and the optical module 40A may be configured as a separate module.

[0065]

7 is a block diagram showing an example of the random number generator shown in FIG. 6, and FIG. 8 is a truth table of the random number generator shown in FIG. 6.

9 is a flow chart showing in detail the operation of the random number generator in the overall flow chart shown in FIG. 5.

[0066]

The random number generator may be implemented with a linear feedback shift register (LFSR) including X shift registers (where X is an integer greater than or equal to 2).

[0067]

LFSR has a structure in which values input to shift registers are calculated as a linear function of previous state values.

LFSR can be applied with Fibonacci implementation or Galois implementation.

In this case, the linear function used in the LFSR may be an exclusive OR.

[0068]

Referring to FIG. 7, the random number generator 25 includes X (X is an integer greater than or equal to 2) registers (1 to X).

The OR gate 215-3 performs an exclusive OR on the output signals of the registers 215-1 and 215-2 and outputs it to the first register 215-4.

Through this, the random number generator 25 may output a plurality of bits A and B constituting the random number Li.

[0069]

Referring to FIG. 8, a phase designation signal Li is generated according to the truth table according to bits A and B output from the random number generator 25.

For example, when the bits (A and B) output from the random number generator 25 are 00, 01, 10 or 11, the phase designation signal Li is the first phase designation signal L0 and the second phase designation. It becomes a signal L1, a third phase designation signal L2, or a fourth phase designation signal L3.

[0070]

10 is a timing diagram showing waveforms of the optical signal EL shown in FIG. 4 and waveforms of the first to fourth gate signals.

[0071]

6, 9, and 10, the random number generator 25 included in the timing controller 20A generates a randomly generated phase designation signal Li (S910).

The phase designation signal Li is transmitted to the phase delay unit 22 to control phases of each of the plurality of sequences, respectively.

[0072]

For example, the phase delay unit 22 may generate a sequence waveform having an original pulse waveform based on the first phase designation signal L0 (S920 and S930).

Alternatively, the phase delay unit 22 may generate a sequence waveform having a phase difference of 90° from the original pulse waveform based on the second phase designation signal L1 (S940 and S950).

[0073]

Alternatively, the phase delay unit 22 may generate a sequence waveform having a phase difference of 180° from the original pulse waveform based on the third phase designation signal L2 (S960 and S970).

Alternatively, the phase delay unit 22 may generate a sequence waveform having a phase difference of 270° from the original pulse waveform based on the fourth phase designation signal L3 (S980).

[0074]

For convenience of explanation, it is assumed that the waveform of the optical signal EL is the same as the waveform of the optical emission control signal LTC of FIG. 3.

[0075]

Referring to FIG. 10, the optical signal EL includes a plurality of sequences S1 to S4, and each has a predetermined delay time TW between the sequences S1 to S4.

The phase difference between each of the plurality of sequences S1 to S4 may be one of 0°, 90°, 180°, or 270°.

The optical signal EL may be a sine wave or a square file.

[0076]

The first to fourth gate signals G0 to G3 are output from the photo gate controller 32 to the sensing array 35.

Each of the gate signals G0 to G3 includes a plurality of sequences S1 to S4 each having a different phase difference like a waveform of the optical signal EL.

[0077]

At this time, the phase of the optical signal EL and the phase of the first gate signal G1 are the same.

In addition, the difference between the phase of the first gate signal G0 and the phase of the second gate signal G1 is 90°, and the difference between the phase of the first gate signal G1 and the phase of the third gate signal G2 is It is 180°, and the difference between the phase of the first gate signal G1 and the phase of the fourth gate signal G3 is 270°.

Unlike the optical signal EL, the gate signals G0 to G3 do not include a delay time TW.

[0078]

This is because a time interval exists until the optical signal EL output from the light source 42 is reflected and incident on the subject 50.

For example, since the first sequence S1 has a first phase designation signal L0 and the second sequence S2 has a second phase designation signal, the phase difference between the two sequences S1 and S2 is 90°. to be.

[0079]

If there is no delay time TW in the optical signal EL, the first sequence S1 of the reflected light signal RL reflected and incident on the subject 50 and the second sequence S2 of the gate signal G0 is synchronized, and an error may occur when measuring distance.

However, if the value of this error is negligible, the delay time TW of the optical signal EL may be omitted according to another embodiment.

[0080]

According to an embodiment of the present invention, the sensing array 35 illustrated in FIG. 4 may include distance pixels having a 1-tap pixel structure.

11 to 14 are diagrams for explaining the structure and operation of a 1-tap distance pixel.

[0081]

FIG. 11 is a partial flow chart showing an operation of the photo gate controller 32 for transmitting a gate signal to the 1-tap distance pixel shown in FIG. 4 in the overall flow chart shown in FIG. 5.

[0082]

5, 10, and 11, the photo gate controller 32 checks information on an output step of an image pixel signal for sensing a distance (S1110).

[0083]

If the output step information of the checked image pixel signal is the step of outputting the first image pixel signal A0, the photo gate controller 32 is a first gate signal G0 having the same phase as that of the optical signal EL. Is output to the sense array 35 (S1120 and S1130).

[0084]

Alternatively, if the output step information of the checked image pixel signal is the step of outputting the second image pixel signal (A1), the photo gate controller 32 is a second gate signal having a 90° phase difference from the optical signal EL G1) is output to the sense array 35 (S1140 and S1150).

[0085]

Alternatively, if the output step information of the checked image pixel signal is the step of outputting the third image pixel signal (A2), the photo gate controller 32 is a third gate signal having a phase difference of 180° from the optical signal EL (G2) is output to the sense array 35 (S1160 and S1170).

[0086]

Alternatively, if the output step information of the checked image pixel signal is the step of outputting the fourth image pixel signal (A3), the photo gate controller 32 is a fourth gate signal having a phase difference of 270° from the optical signal EL (G3) is output to the sense array 35 (S1180).

[0087]

12A shows a layout of a distance pixel having a 1-tap pixel structure included in the sensing array shown in FIG. 4, and FIG. 12B is a pixel sequentially detected from a distance pixel having a 1-tap pixel structure shown in FIG. 12A It is a timing diagram for explaining the signals and the phase difference caused by them.

[0088]

1

The distance pixel 60 having a tap pixel structure includes a photoelectric conversion element 62 implemented in the active region 61.

In the active region 61, as shown in each of FIGS. 13A to 13D, a photoelectric conversion element 62 and T-numbers of transistors are implemented.

Here, T is a natural number, and T may be 3, 4, or 5.

As shown in FIG. 12A, each gate signal G0 to G3 having a phase difference of 0°, 90°, 180°, and 270° is sequentially supplied to the photoelectric conversion element 62.

[0089]

The photoelectric conversion element 62 performs a photoelectric conversion operation according to the reflected light RL while each of the gate signals G0 to G3 has a high level.

Photoelectric charges generated by the photoelectric conversion element 62 are transferred to the floating diffusion node FD.

[0090]

12A and 12B, a distance pixel 60 having a 1-tap pixel structure is a first digital pixel in response to a first gate signal G0 having a phase difference of 0° at a first time point t0. Outputs a signal A0, outputs a second digital pixel signal A1 in response to a second gate signal G1 having a phase difference of 90° from the second time point t1, and outputs a third time point t2 In response to the third gate signal A2 having a phase difference of 180°, the third digital pixel signal G2 is output, and the fourth gate signal G3 having a phase difference of 270° at the fourth time point t3 In response to), a fourth digital pixel signal A3 is output.

[0091]

13A to 13D are various circuits illustrating photoelectric conversion elements and transistors implemented in the active region illustrated in FIG. 12A.

[0092]

As shown in FIG. 13A, a photoelectric conversion element 62 and four transistors RX, TX, DX, and SX are implemented in the active region 61.

Referring to FIG. 13A, photoelectric charges may be generated in the photoelectric conversion element 62 based on gate signals G0 to G3 and reflected light RL shown in FIG. 12A.

[0093]

For example, the photoelectric conversion element 62 may be turned on/off in response to the gate signal G0 output from the timing controller 20A.

For example, when the gate signal G0 is at a high level, the photoelectric conversion element 62 may generate photoelectric charges based on the reflected light RL, and when the gate G0 is at a low level, the photoelectric conversion element 62 Does not generate photo charges based on the reflected light RL.

[0094]

The photoelectric change device 62 is a photo-sensing device and may be implemented as a photo diode, a photo transistor, a photo gate, or a pinned photo diode (PPD).

[0095]

The reset transistor RX may reset the floating diffusion region FD in response to the reset signal RS output from the timing controller 20A.

[0096]

The transfer transistor TX may transfer photo charges generated by the photoelectric conversion element 62 to the floating diffusion region FD in response to the control signal TG output from the timing controller 20A.

[0097]

The drive transistor DX, which serves as a source follower buffer amplifier, may perform a buffering operation in response to photocharges charged in the floating diffusion region FD.

[0098]

The selection transistor SX may output the image pixel signal A0' output from the drive transistor DX to the column line in response to the control signal SEL output from the timing controller 20A.

[0099]

13A illustrates an active region 61 including one photoelectric conversion element 62 and four transistors TX, RX, DX, and SX, but this is only exemplary.

[0100]

As shown in FIG. 13B, a photoelectric conversion element 62 and three transistors RX, DX, and SX are implemented in the active region 61.

13A and 13B, the transfer transistor TX is not implemented in the active region 61 of FIG. 13B.

[0101]

As shown in FIG. 13C, a photoelectric conversion element 62 and five transistors RX, TX, DX, SX, and GX are implemented in the active region 61.

13C, a control signal TF for controlling the operation of the transfer transistor TX is supplied to the gate of the transfer transistor TX through the transistor GX turned on/off in response to the control signal SEL. do.

[0102]

As shown in FIG. 13D, a photoelectric conversion element 62 and five transistors RX, TX, DX, SX, and PX may be implemented in the active region 61.

The transistor PX operates in response to the control signal PG output from the timing controller 20A.

[0103]

FIG. 14 is a conceptual diagram illustrating one frame performed by a rolling shutter method in the 1-tap structure distance sensor shown in FIG. 12A.

In this case, it is assumed that the phase of the optical signal EL from the light source 42 is 0°.

[0104]

Referring to FIG. 14, even while a read operation based on a gate signal G0 having a 0° phase for one frame is being performed, columns for which a read operation has been completed are based on a gate signal G1 having a 90° phase.

Photocharge accumulation begins.

This is the same even when the phase of the gate signal is changed from 90° to 180° or from 180° to 270°.

[0105]

According to an embodiment of the present invention, the sensing array 35 illustrated in FIG. 4 may include a distance pixel having a 2-tap pixel structure.

15A to 18 are diagrams for explaining the structure and operation of a 2-tap distance pixel.

[0106]

FIG. 15A shows a layout of a distance pixel having a 2-tap pixel structure included in the sensing array shown in FIG. 4, and FIG. 15B shows pixel signals detected in a distance pixel having a 2-tap pixel structure shown in FIG. 15A. This is a timing diagram for explaining the phase difference between the and image pixel signals.

[0107]

2The distance pixel 70 having a tapped pixel structure includes a first photo gate 71, a bridging diffusion region 75, and a transfer transistor TX1; 73, and a second photo gate 72, a bridging diffusion region 76, and a transfer transistor 74.

[0108]

15A and 15B, the 2-tap distance pixel 70 is a first digital pixel signal A0 in response to a first gate signal G0 and a second gate signal G2 at a first time point t0.) And the third digital pixel signal (A2), and in response to the third gate signal (G1) and the fourth gate signal (G3) at a second time point (t1), the second digital pixel signal (A1) and the fourth The digital pixel signal A3 is detected.

[0109]

16 is a partial flow chart showing in detail an operation of a photo gate controller that transmits a gate signal to a 2-tap distance pixel in the overall flow chart shown in FIG. 5.

[0110]

5, 10, 15 and 16, the photo gate controller 32 checks information on an output step of an image pixel signal for detecting a distance (S1510).

[0111]

In this case, if the output step information of the checked image pixel signal is the step of outputting the first image pixel signal A0 (S1520), the photo gate controller 32 is a first having the same phase as that of the optical signal EL. The gate signal G0 is output to the first photo gate 71, and a third gate signal G2 having a phase difference of 180° from the optical signal EL is output to the second photo gate 72 (S1530).).

[0112]

Alternatively, if the information on the output step of the checked image pixel signal is not the step of outputting the first image pixel signal A0, the photo gate controller 32 is at 90° to the optical signal EL. The second gate signal G1 having a phase difference is output to the first photo gate 71 of the 2-tap pixel signal, and the photo gate controller 32 is a fourth gate signal having a phase difference of 270° from the optical signal EL. The gate signal G3 is output to the second photo gate 72 of the 2-tap pixel signal (S1540).

[0113]

FIG. 17 is a circuit diagram including a plurality of photo gates and a plurality of transistors implemented in the 2-tap structure distance pixel illustrated in FIG. 16A.

[0114]

Referring to FIG. 17, a distance pixel having a 2-tap structure includes a first circuit region processing photocharges generated by reflected light RL passing through a first photo gate PG1; 71, and a second photo gate. A second circuit region for processing photo charges generated by the reflected light RL passing through (PG2; 72) is included.

[0115]

For example, the first circuit region includes a first photo gate 71 capable of collecting or transferring photoelectric charges and a plurality of transistors TX1, RX1, DX1, and SX1. In addition, the second circuit region includes a second photo gate 72 capable of collecting or transferring photoelectric charges and a plurality of transistors TX2, RX2, DX2, and SX2.

[0116]

The first transfer circuit TX1 73, which may be implemented as a transfer gate, transfers the generated photo charges to the first floating diffusion region FD1 in response to the control signal TG1.

By controlling the voltage level of the control signal TG1 applied at an appropriate timing, the transmitted photocharges may prevent back diffusion from the first floating diffusion region FD1 toward the first photo gate 71.

[0117]

In addition, the second transfer circuit TX2 74, which may be implemented as a transfer gate, transfers the generated photo charges to the second floating diffusion region FD2 in response to the control signal TG2.

By controlling the voltage level of the control signal TG2 applied at an appropriate timing, it is possible to prevent the transmitted photo charges from going backward from the second floating diffusion region FD2 toward the second photo gate 72.

[0118]

In response to each of the gate signals G0 and G2 output from the photo gate controller 32, each of the first photo gate 71 and the second photo gate 72 is formed in the semiconductor substrate by the reflected optical signal RL. A collection operation for collecting photocharges generated from and a transfer operation for transferring the collected photocharges to each of the floating diffusion regions FD1 and FD2 may be repeatedly performed.

[0119]

The phase difference between the two gate control signals G0 and G2 received by each of the two photo gates 71 and 72 is 180°.

However, the difference between the phase of the optical signal EL and the phase of any one of the two photo gate control signals may be 0°, 90°, 180°, or 270°.

[0120]

Each of the transfer transistors TX1 and TX2 transfers the photo charges accumulated under each of the photo gates 71 and 72 in response to the control signals TG1 and TG2 output from the timing controller 20A, respectively, to the floating diffusion region FD1. And FD2).

[0121]

Each of the drive transistors DX1 and DX2 that can function as a source follower buffer amplifier may perform a buffering operation in response to photo charges charged in each of the floating diffusion regions FD1 and FD2.

[0122]

Each of the selection transistors SX1 and SX2 transfers the signals A0' and A2' buffered by the respective drive transistors DX1 and DX2 to each column line in response to the control signal SEL output from the timing controller 20A. Can be printed.

[0123]

18 is a conceptual diagram illustrating one frame performed by a rolling shutter method in the distance sensor of the 2-tap structure shown in FIG. 16A.

In this case, it is assumed that the phase of the optical signal EL emitted from the light source 42 is 0°.

[0124]

Referring to FIG. 18, even while a read operation based on each of the gate signals G0 and G2 each having a phase of 0° and 180° for one frame is being performed, each column for which the read operation has been performed is Photocharge accumulation is started based on each of the gate signals G1 and G3 having 90° and 270° phases.

[0125]

19A to 19E show an example of a unit pixel included in the sense array 35.

[0126]

Referring to FIG. 19A, a unit pixel array constituting a part of the sense array 35 of FIG. 4 includes a red pixel (R), a green pixel (G), a blue pixel (B), and a distance pixel (Z). I can.

[0127]

The structure of the distance pixel Z may be a distance pixel having a 1-tap pixel structure as shown in FIG. 12 or a distance pixel having a 2-tap pixel structure shown in FIG. 16.

[0128]

The distance pixel Z generates a distance pixel signal corresponding to wavelengths belonging to the infrared region.

[0129]

The red pixel (R), the green pixel (G), and the blue pixel (B) may be referred to as a color pixel (C).

The red pixel R generates a red pixel signal corresponding to wavelengths belonging to the red region of the visible light region, and the green pixel G generates a green pixel signal corresponding to wavelengths belonging to the green region of the visible light region. , The blue pixel B generates a blue pixel signal corresponding to wavelengths belonging to the blue region of the visible light region.

[0130]

According to an embodiment, the color pixels C may be replaced with magenta pixels, cyan pixels, and yellow pixels.

[0131]

The unit pixel arrays illustrated in FIGS. 19A to 19E are illustratively illustrated for convenience of description, and a pattern of the unit pixel array and pixels constituting the pattern may be variously modified according to exemplary embodiments.

In particular, FIGS. 19D and 19E show that the color pixels C and the distance pixels Z may be stacked in a three-dimensional structure.

[0132]

20 is a diagram illustrating an interference situation of optical signals when there are a plurality of distance measuring devices 620 and 640 located adjacent to each other.

21A and 21B are timing diagrams illustrating waveforms of a light emission control signal LTC and a light detection control signal DTC in the distance measuring devices 620 and 640 according to an embodiment of the present invention. .

[0133]

A plurality of distance measuring devices 620 and 640 located adjacent to each other in space may emit respective optical signals EL1 and EL2 toward the same subject 650.

[0134]

Referring to FIG. 20, a light source 624 of a first distance measuring device 620 emits a first optical signal EL1 toward a subject 650, and a light source 644 of the second distance measuring device 640 May emit a second optical signal EL2 toward the subject 650.

Thereafter, the first reflected optical signal RL1 and the second reflected optical signal RL2 may be input together to the distance sensor 623 of the first distance measuring device 620.

[0135]

At this time, the first reflected optical signal RL1 is an optical signal that is reflected and incident on the subject 650 by the first optical signal EL1, and the second reflected optical signal RL2 is applied to the second optical signal EL2. This is an optical signal reflected by the subject 650 and incident thereon.

[0136]

In this case, the waveforms of each of the reflected optical signals RL1 and RL2 interfere with each other, or an error in calculating the distance based on the second reflected optical signal RL2 instead of the first reflected optical signal RL1 may occur. Can occur.

However, according to an embodiment of the present invention, the first distance measuring apparatus 620 may overcome the interference phenomenon of the optical signal by using an optical signal including a plurality of sequences having different phase differences.

[0137]

As described above, the plurality of distance pixels included in the distance sensors 623 and 643 of the distance measuring devices 620 and 640 are photoelectrons (or photocharges) according to the plurality of gate signals G0 to G3. Is accumulated for a predetermined period of time, for example, an integration time, and image pixel signals A0 to A3 generated according to the accumulation result are output.

[0138]

In this case, each of the image pixel signals A0 to A3 output based on the plurality of gate signals G0 to G3 includes respective sequence pixel signals P0 to P3.

That is, since each of the light emission control signal LTC for controlling the optical signal EL and the light detection signal DTC for controlling the gate signal contain sequences having different phase differences, each of the plurality of sequences Sequence pixel signals P0 to P3 due to different phase differences may be output.

[0139]

Each image pixel signal (A) generated by each of the plurality of distance pixels is shown in Equation (4).

[0140]

[Equation 4]

[0142]

Here, when the signal input to the photo gate of the distance pixel is the first gate signal (G0), k is 0, when the second gate signal (G1), k is 1, and when the third gate signal (G2) k is 2, and k is 3 for the fourth gate signal G3.

[0143]

In addition, P is a sequence pixel signal, and n (n is a natural number) indicates the sequence of the sequence. m represents the phase difference between the sequence waveform of the light emission control signal and the sequence waveform of the light detection control signal.

[0144]

For example, If the sequence phase of the light emission control signal and the sequence phase of the light emission control signal are the same, the first sequence pixel signal P0 is output, and the sequence phase of the light emission control signal and the sequence phase of the light emission control signal are When the difference of is 90°, the second sequence pixel signal P1 is output, and when the difference between the sequence phase of the light emission control signal and the sequence phase of the light emission control signal is 180°, the third sequence pixel signal P2 is output, When the difference between the sequence phase of the light emission control signal and the sequence phase of the light emission control signal is 270°, the fourth sequence pixel signal P3 is output.

[0145]

The sequence pixel signals P0 to P3 are represented by Equation 5, Equation 6, Equation 7, and Equation 8, respectively.

[0146]

[Equation 5]

[0148]

[Equation 6]

[0150]

[Equation 7]

[0152]

[Equation 8]

[0154]

Here, in Equation 5, Equation 6, Equation 7, and Equation 8, alpha () represents an offset, and beta () represents an amplitude.

The offset represents the background intensity.

[0155]

21A illustrates a waveform of a first light emission control signal LTC1 radiated from the first distance measuring device 620 of FIG. 20 and a first light detection control signal DTC1 output from the first distance measuring device 620 It is a timing diagram showing the waveform.

[0156]

20 and 21A, the timing controller 622 of the first distance measuring device 620 transmits the first light emission control signal LTC1 to the light source 624, and the first light detection control signal DTC1) To the distance sensor 643.

For convenience of explanation, it is assumed that the waveform of the optical signal EL1 output from the light source 624 based on the first light emission control signal LTC1 is the same as the waveform of the first light emission control signal LTC1.

[0157]

Therefore, when comparing the waveform of the first light emission control signal LTC1 and the waveform of the first light detection control signal DTC1, the phase and the first light of the first light reflection control signal LTC1 during the first sequence S1 are compared. Since the phase of the detection control signal DTC1 is the same, a first sequence pixel signal P0 is derived.

[0158]

In addition, the first sequence pixel signal P0 is derived from the second sequence, the third sequence, and the fourth sequence, respectively.

In this case, the first sequence pixel signal P0 is the same as in Equation 5.

Accordingly, when the optical signal EL1 radiated from the first distance measuring device 620 is reflected by the subject 650 and reaches the distance sensor 623, the distance may be measured using Equation 9.

[0159]

[Equation 9]

[0161]

Here, each alpha () represents an offset and beta () represents an amplitude.

The offset represents the background intensity.

In this case, the first distance measuring device 620 may measure distance information based on the phase difference ().

[0162]

21B is a waveform of the second light emission control signal LTC1 of the second distance measuring device 640 shown in FIG. 20 and the waveform of the first light detection control signal DTC1 of the first distance measuring device 620 It is a timing diagram shown.

[0163]

20 and 21A, the timing controller 642 of the second distance measuring device 640 transmits a second light emission control signal LTC2 to the light source 644.

The light source 644 emits an optical signal EL2 to the subject 50 based on the second light emission control signal LTC2.

[0164]

The radiated optical signal EL2 is reflected and enters the distance sensor 623 of the first distance measuring device 620.

For convenience of explanation, it is assumed that the waveform of the optical signal EL2 is the same as the waveform of the second light emission control signal LTC2.

[0165]

A sequence pixel signal can be derived by comparing the waveform of the second light emission control signal LTC2 of the second distance measuring device 620 with the waveform of the first light detection control signal DTC1 of the first distance measuring device 640. have.

[0166]

Since the phase of the first light detection control signal DTC1 and the phase LTC2 of the second light emission control signal are the same during the first sequence S1, the first sequence pixel signal P0 is derived.

Also, during the third sequence S2, the phase of the first light detection control signal DTC1 and the phase of the second light emission control signal LTC2 differ by 180°, so that the third sequence pixel signal P2 is derived. .

[0167]

Also, during the fourth sequence S3, the phase of the first light detection control signal DTC1 and the phase of the second light emission control signal LTC2 differ by 270°, so a fourth sequence pixel signal P2 is derived. .

Also, during the second sequence S2, the phase of the first light detection control signal DTC1 and the phase of the second light emission control signal LTC2 are 180° different from each other, so that the second sequence pixel signal P1 is derived. .

Therefore, when the optical signal EL2 radiated from the second distance measuring device is reflected from the subject 650, it is detected by the distance sensor of the first distance measuring device, and waveform interference is removed using Equation 10.

[0168]

[Equation 10]

[0170]

When all of the first to fourth sequence pixel signals are added as in Equation 10, only remains.

Here, alpha () means an offset, so even if the optical signal EL2 emitted from the second distance measuring device is detected by the distance sensor of the first distance measuring device, it is processed as a background signal to prevent interference in measuring the distance. do.

[0171]

The distance measuring apparatus of the above example cancels the interference effect by adding only the first to fourth sequence pixel signals, but may actually remove the interference phenomenon by adding a larger number of sequence pixel signals.

[0172]

22 is a diagram illustrating an image capturing apparatus according to an embodiment of the present invention.

[0173]

4 and 22, the image processing device or image pickup device 1300 according to an embodiment of the present invention transmits reflected light from which the output light output from the light source LS is reflected to the subject through the lens LE. It may include an image sensor 1310 that receives and senses the subject as image information (IMG).

[0174]

The image processing apparatus 1300 according to an embodiment of the present invention includes a controller 1322 that controls the image sensor 1310 and a signal processing circuit 1321 that performs signal processing on image information detected by the image sensor 1310. A processor 1320 having) may be further provided.

[0175]

23 is a diagram illustrating an image processing system according to another embodiment of the present invention.

[0176]

Referring to FIG. 23, an image processing system 1400 according to an embodiment of the present invention may include an image processing device 1410 and a display device 1440 that displays an image received from the image processing device 1410.

To this end, the processor 1430 may further include an interface 1433 for transmitting image information received from the image sensor 1420 to the display device 1440.

[0177]

24 shows an electronic system and an interface including the distance measuring device shown in FIG. 1 or 4.

[0178]

Referring to FIG. 24, the electronic system 2000 is a data processing device capable of using or supporting a mobile industry processor interface (MIPI®), such as a mobile phone, a personal digital assistant (PDA), a portable multimedia player (PMP), and a tablet. It can be implemented as a PC (tablet personal computer) or a smart phone.

The electronic system 2000 includes an application processor 2110, an image sensor module 2140, and a display 2150.

[0179]

The CSI host 2112 implemented in the application processor 2110 may perform serial communication with the CSI device 2141 of the image sensor module 2140 through a camera serial interface (CSI).

The CSI host 2112 may include a deserializer (DES), and the CSI device 2141 may include a serializer (SER).

[0180]

The DSI host 2212 may perform serial communication with the DSI device 2151 of the display 2150 through a display serial interface (DSI).

[0181]

In an embodiment, the DSI host 2212 may include a serializer (SER), and the DSI device 2151 may include a deserializer (DES).

Furthermore, the electronic system 2000 may further include a radio frequency (RF) chip 2160 capable of communicating with the application process 2110.

[0182]

The PHY 2113 and the RF chip 2160 of the electronic system 2000 may perform data transmission/reception according to MIPI® Dig RF.

[0183]

In addition, the application processor 2110 may further include a Dig RF MASTER 2114 that controls data transmission/reception according to the MIPI® Dig RF of the PHY 2113.

Meanwhile, the electronic system 2000 may include a Global Positioning System (GPS) 2120, a storage 2170, a microphone 2180, a Dynamic Random Access Memory (DRAM) 2185, and a speaker 2190.

In addition, the electronic system 2000 may perform communication using an Ultra WideBand (UWB) 2210, a Wireless Local Area Network (WLAN) 2220, and a Worldwide Interoperability for Microwave Access (WIMAX) 2230 (WIMAX).

However, the structure and interface of the electronic system 2000 are illustrative and are not limited thereto.

[0184]

The present invention has been described with reference to the embodiments shown in the drawings, but these are only exemplary, and those of ordinary skill in the art will understand that various modifications and other equivalent embodiments are possible therefrom.

Therefore, the true technical protection scope of the present invention should be determined by the technical idea of the attached registration claims.

[0185]

10; Distance measuring devices 20, 20A; Timing controller 21; Pulse generator 22; Delay unit 23; TW generator 25; Random number generator 30, 30A; Distance sensor 36; CDS/ADC circuit 37; Memory unit 38; Distance estimator 40, 40A; Optical module 34; Lens 50; Subject

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CLAIMS KR20130111130A

1.

A method of operating a distance measuring apparatus, comprising: outputting an optical signal from a light source to a subject; And measuring a distance between the subject and the distance measuring device in response to a gate signal and a reflected light signal reflected from the subject, wherein the optical signal includes a plurality of sequences, and the phase of the pulse of the optical signal Is a method of operating a distance measuring apparatus that randomly changes for each of the plurality of sequences.

2.

The method of claim 1, wherein the optical signal includes a delay time corresponding to a multiple of a wavelength of the pulse between the plurality of sequences.

3.

The method of claim 2, wherein during the delay time, a section of the pulse is filtered.

4.

The method of claim 1, wherein the outputting the optical signal to the subject comprises: outputting a pulse signal from a pulse generator and outputting a phase designation signal from a random number generator; Constant of the pulse signal based on the phase designation signal Generating a light emission control signal having different phases for each interval; And outputting the optical signal from the light source based on the light emission control signal.

5.

The method of claim 4, wherein the random number generator outputs any one of a plurality of phase designation signals as the phase designation signal.

6.

The method of claim 1, wherein a plurality of gate signals are sequentially input to the distance measuring device for an entire frame, and a phase of each of the plurality of gate signals is varied by a predetermined phase.

7.

The method of claim 1, wherein measuring a distance between the subject and the distance measuring device comprises: outputting a plurality of sequence pixel signals in response to the reflected light signal and the gate signal; And measuring

distance information through a phase difference between the reflected light signal and the gate signal calculated based on the plurality of sequence pixel signals.

8.

A light source that outputs an optical signal to a subject; A distance sensor that measures distance information in response to reflected light reflected from the subject; And a timing controller that transmits a light emission control signal to the light source and transmits a light detection control signal to the distance sensor to control an operation timing of the distance sensor, wherein the optical signal includes a plurality of sequences, and The phase of the distance measuring device randomly changes for each of the plurality of sequences.

9.

The apparatus of claim 8, wherein the timing controller comprises: a pulse generator configured to output a pulse signal; a random number generator configured to generate a random number and output a phase designation signal determined by the random number; And a delay unit that receives the pulse signal and the phase designation signal, and delays a part of the pulse so as to have different phases at predetermined intervals of the pulse signal based on the phase designation signal.

10.

The method of claim 8, wherein the distance sensor comprises: a sensing array including at least one distance pixel; converts a plurality of image pixel signals output from the at least one distance pixel into digital pixel signals and outputs the digital pixel signals Circuit; And a distance measuring device configured to measure a distance between the subject and the distance measuring device based on received digital pixel signals.

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(71) 出願人: パナソニック ＩＰマネジメント株式会社 **(PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.)** [JP/JP]; 〒5406207 大阪府大阪市中央区城見２丁目１番６１号 Osaka (JP).

(72) 発明者: 伊藤　順治 **(ITO, Junji)**. 山田　徹 **(YAMADA, Tohru)**. 藤井　俊哉 **(FUJII, Toshiya)**.

(74) 代理人: 新居　広守, 外 **(NII, Hiromori** et al.); 〒5320011 大阪府大阪市淀川区西中島５丁目３番１０号タナカ・イトーピア新大阪ビル６階新居国際特許事務所内 Osaka (JP).

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[続葉有]

(54) **Title**: DISTANCE MEASUREMENT SYSTEM AND SIGNAL GENERATION DEVICE

(54) 発明の名称 : 測距システム及び信号発生装置

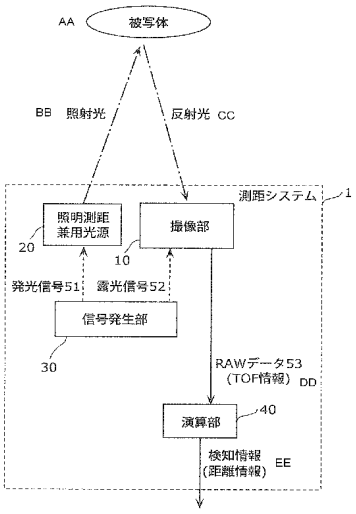


FIG. 1:
1 Distance measurement system
10 Imaging unit
20 Light source unit for illumination and distance measurement
30 Signal generation unit
40 Calculation unit
51 Light emission signal
52 Exposure signal
53 Raw data
AA Subject
BB Irradiated light
CC Reflected light
DD (TOF information)
EE Detection information (distance information)

(57) Abstract: A distance measurement system (1) is provided with: a signal generation unit (30) for generating a light emission signal instructing that light be irradiated and an exposure signal instructing that exposure to reflected light be carried out; a first light source unit for illumination and distance measurement (20) that carries out, upon receiving the light emission signal, illumination not intended for distance measurement and carries out light irradiation for distance measurement using reflected light; an imaging unit (10) for receiving the exposure signal, carrying out exposure, and acquiring a reflected light exposure amount; and a calculation unit (40) for using the exposure amount to calculate and output distance information. The distance measurement system (1) has, as operation modes, an illumination mode for making the first light source unit for illumination and distance measurement carry out illumination and a first distance measurement mode for carrying out first distance measurement by making the first light source unit for illumination and distance measurement irradiate light and making the imaging unit operate.

(57) 要約: 測距システム（１）は、光照射を指示する発光信号と反射光の露光を指示する露光信号とを発生する信号発生部（３０）と、発光信号を受信して、測距を目的としない照明と、反射光による測距のための光照射とを行う第１の照明測距兼用光源部（２０）と、露光信号を受信して露光を行い、反射光の露光量を取得する撮像部（１０）と、露光量を用いて、距離情報を演算して出力する演算部（４０）とを備え、第１の照明測距兼用光源部に照明を行わせる照明モードと、第１の照明測距兼用光源部に光照射をさせて撮像部を動作させることにより第１の測距を行う第１の測距モードとを動作モードとして有する。

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NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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明　細　書

発明の名称 ： 測距システム及び信号発生装置

技術分野

[0001] 本開示は、測距システム及び信号発生装置に関する。

背景技術

[0002] 図２１は、これまで提案された様々な検知システムのなかで、特許文献１に開示された従来技術の検知システムである。

[0003] この検知システムは、自動車用途であり、自動車の前部に設けられた赤外光源としてのＬＥＤランプ１２と、撮像手段としてのカメラ１３と、自動車の内部に設けられた制御手段としての制御回路１４と、表示手段としてのモニタ１５と、から構成されている。

[0004] また、ＬＥＤランプ１２は暗闇を照らす目的のヘッドライト光源とは別の光源であり、自動車のバンパーの端付近に設けられ、例えば波長８８０ｎｍの近赤外光を出射するように構成されている。

[0005] また、カメラ１３は、アクティブタイプのシステムとして、ＬＥＤランプ１２から出射される近赤外線に対して感度を有する固体撮像素子から構成され、近赤外線による画像撮像を行なう。

[0006] モニタ１５は、自動車の車室内に設けられた専用のモニタ又はカーナビゲーションシステム等のモニタを使用して、その画面上に上述した撮像画面が表示され、あるいは所謂ヘッドアップディスプレイとして、フロントガラスの内面に設けられたスクリーンに上述した撮像画面が投影されるようになっている。

[0007] また、赤外受光素子１６は、パッシブタイプのシステムとして、歩行者や動物等が発する赤外線を検出する。

先行技術文献

特許文献

[0008] 特許文献1：特開２００２－２７４２５８号公報

発明の概要

発明が解決しようとする課題

[0009] しかしながら、特許文献１に開示された従来技術では、暗闇等を明るくするための光源と、カメラ１３で撮像を行うため近赤外光を発振する光源（ＬＥＤランプ１２）を、それぞれ設置する必要があり、システム（装置）の小型化、軽量化が難しいという課題を有している。

[0010] また、近年、検知システムの性能向上、用途拡大させるためには、特に距離情報を正確に取得することが求められている。

[0011] 前記課題を鑑み、システム（装置）の小型化、軽量化と高い測距精度を備える測距システム及び信号発生装置を提供する。

課題を解決するための手段

[0012] 上記課題を解決するために、本開示の一態様に係る測距システムは、光照射を指示する発光信号と反射光の露光を指示する露光信号とを発生する信号発生部と、前記発光信号を受信して、測距を目的としない照明と、反射光による測距のための前記光照射とを行う第１の照明測距兼用光源部と、前記露光信号を受信して前記露光を行い、前記反射光の露光量を取得する撮像部と、前記露光量を用いて、距離情報を演算して出力する演算部とを備え、前記第１の照明測距兼用光源部に前記照明を行わせる照明モードと、前記第１の照明測距兼用光源部に前記光照射をさせて前記撮像部を動作させることにより第１の測距を行う第１の測距モードとを、動作モードとして有する。

[0013] この構成によれば、１つの光源（照明測距兼用光源部）を、照明だけでなく測距にも兼用するので、照明システムと測距システムとを独立にそれぞれを設置する場合と比べて、測距システムの小型化、軽量化を容易にすることができる。しかも、照明測距兼用光源部は照明にも用いる光源なので測距に十分な光量の反射光を得られることから、測距精度を高めることができる。

[0014] また、本開示の一態様に係る測距システムでは、前記第１の測距モードにおいて前記第１の照明測距兼用光源部から照射される光の振幅は、前記照明モードにおいて前記第１の照明測距兼用光源部から照射される光の振幅より

も大きくなるようにしてもよい。

[0015] この構成によれば、測距精度をもっと高めることができる。

[0016] また、本開示の一態様に係る測距システムでは、前記第１の測距モードにおいて前記第１の照明測距兼用光源部から照射される光の点灯時間幅は、前記照明モードにおいて前記第１の照明測距兼用光源部から照射される光の点灯時間幅よりも短くなるようにしてもよい。

[0017] この構成によれば、測距精度をもっと高めることができる。

[0018] また、本開示の一態様に係る測距システムは、さらに、前記第１の照明測距兼用光源部を消灯した状態で、前記撮像部を動作させ前記演算部にバックグラウンド光量を計測させるモードを備え、前記演算部は、前記第１の測距モードの露光量から前記バックグラウンド光量を減じる補正を行ってもよい。

[0019] この構成によれば、測距精度をさらにもっと高めることができる。

[0020] また、本開示の一態様に係る測距システムにおいて、前記第１の照明測距兼用光源部は、単色のＬＥＤ、又は複数色のＬＥＤを搭載してもよい。

[0021] また、本開示の一態様に係る測距システムにおいて、前記第１の測距モードおよび前記照明モードの切り替えを少なくとも１２０回／秒としてもよい。

[0022] また、本開示の一態様に係る測距システムは、さらに第２の照明測距兼用光源部を備え、前記演算部は、さらに、前記第１および第２の照明測距兼用光源部の位相差情報を用いて測距を行ってもよい。

[0023] また、本開示の一態様に係る測距システムにおいて、前記第１および第２の照明測距兼用光源部は、車両に備えられた左右のハイビーム光源と左右のロービーム光源のうち、（ａ）左および右のハイビーム光源、並びに（ｂ）左および右のロービーム光源のいずれかであってもよい。

[0024] また、本開示の一態様に係る測距システムにおいて、前記演算部は、前記撮像部からの画像信号を用いて現在のフレームと前のフレームを比較することにより第２の測距を行ってもよい。

[0025] また、本開示の一態様に係る測距システムにおいて、前記演算部は、前記第１および第２の測距による距離情報の一方を、前記第１および第２の測距の距離情報の他方により補正を行ってもよい。

[0026] また、本開示の一態様に係る測距システムにおいて、前記第１、第２の測距を、昼夜、天候、被写体までの距離、又は、前記被写体もしくは前記測距システムの動き速度により使い分けてもよい。

[0027] また、本開示の一態様に係る測距システムにおいて、前記撮像部は固体撮像素子を備え、前記固体撮像素子はＣＣＤ型の固体撮像素子であってもよい。

[0028] また、本開示の一態様に係る測距システムは、前記撮像部は複数の画素を有する固体撮像素子を備え、前記複数の画素のそれぞれは、光電変換する受光部と、前記受光部から読み出された信号電荷を蓄積する蓄積部とを備え、前記固体撮像素子は、前記複数の画素において前記受光部の信号電荷を前記蓄積部に一括して読み出すＭＯＳ型の固体撮像素子であってもよい。

[0029] また、本開示の一態様に係る測距システムにおいて、前記撮像部は複数の画素を有する固体撮像素子を備え、前記複数の画素のそれぞれは、受光面と垂直な軸を中心軸とし異なる屈折率の材料を同心状に繰り返し配置した構造を有するマイクロレンズを備えていてもよい。

[0030] また、本開示の一態様に係る測距システムは、前記撮像部は複数の画素を有する固体撮像素子を備え、前記複数の画素のそれぞれは、赤外線透過フィルタ、赤色光および赤外線を透過する第１のフィルタ、緑色光および赤外線を透過する第２のフィルタ、および、青色光および赤外線を透過する第３のフィルタの何れかを備えてもよい。

[0031] また、本開示の一態様に係る測距システムは、前記赤外線透過フィルタ、および、前記第１から第３フィルタの少なくとも１つは、無機材料を積層したフィルタであってもよい。

[0032] また、本開示の一態様に係る測距システムは、重機、又は、重機と作業現場の構造物に搭載してもよい。

[0033] また、本開示の一態様に係る測距システムは、輸送機器に搭載してもよい。

[0034] また、本開示の一態様に係る測距システムは、住宅設備機器に搭載してもよい。

[0035] また、本開示の一態様に係る信号発生装置は、発光パルス信号を制御する信号発生装置であって、前記信号発生装置は、複種類の前記発光パルス信号を制御し、前記複種類の発光パルス信号は、測距を行うための光照射を指示する第１発光パルス信号と、測距を目的としない照明の点灯を指示する第２発光パルス信号とを含み、前記第２発光パルス信号がＯＦＦとなるときに、前記第１発光パルス信号はＯＮとなる。

[0036] この構成によれば、測距精度を高めることができる。

[0037] また、本開示の一態様に係る信号発生装置において、前記第１発光パルス信号がＯＮとなる期間は、前記第２発光パルス信号がＯＮとなる期間よりも短くてもよい。

[0038] この構成によれば、測距精度をもっと高めることができる。

[0039] また、本開示の一態様に係る信号発生装置において、前記第２発光パルス信号は、前記第１発光パルス信号がＯＮとなる期間を複数回繰り返した後に、ＯＮとなってもよい。

[0040] また、本開示の一態様に係る信号発生装置において、前記第１発光パルス信号がＯＮとなる回数と前記第２発光パルス信号がＯＮとなる回数との合計は、少なくとも１２０回／秒としてもよい。

[0041] また、本開示の一態様に係る信号発生装置において、前記第１発光パルス信号の振幅は、前記第２発光パルス信号の振幅よりも大きくてもよい。

[0042] また、本開示の一態様に係る信号発生装置において、前記第１発光パルス信号は、Ｔｉｍｅ　Ｏｆ　Ｆｌｉｇｈｔにより測距を行うために用いられてもよい。

[0043] また、本開示の一態様に係る信号発生装置は、前記第１発光パルス信号により発生した照射光の、被写体による反射光の露光を指示する露光信号を制

御してもよい。

発明の効果

[0044] 本開示に係る測距システム及び信号発生装置によれば、システム（装置）の小型化、軽量化と高い測距精度を実現することが出来る。

図面の簡単な説明

[0045] [図1]図１は、実施の形態１に係る測距システムの概略構成を示す機能ブロック図である。

[図2]図２は、実施の形態１に係る測距システムの搭載例を示す概略搭載図である。

[図3]図３は、実施の形態１に係る測距システムの搭載例を示す概略搭載図である。

[図4]図４は、実施の形態１に係る固体撮像素子の画素の構造を示す断面図である。

[図5]図５は、実施の形態１に係るＣＣＤ型の固体撮像素子の機能構成図である。

[図6]図６は、実施の形態１に係るＭＯＳ型の固体撮像素子の単位セルの構成を示す回路図である。

[図7]図７は、実施の形態１に係る単位セルが２次元状に配置されてなるＭＯＳイメージセンサの概略構成図である。

[図8]図８は、実施の形態１に係る発光信号及び露光信号による動作例を示す第１のタイミングチャートである。

[図9A]図９Ａは、実施の形態１に係る発光信号及び露光信号による動作例を示す第２のタイミングチャートである。

[図9B]図９Ｂは、実施の形態１に係る発光信号によるＴＯＦモード又は照明モードで一定回数連続して動作させる動作例を示す図である。

[図10]図１０は、実施の形態１に係る発光信号及び露光信号による動作例を示す第３のタイミングチャートである。

[図11]図１１は、実施の形態２に係る測距システムの概略構成を示す機能ブ

ロック図である。

[図12]図１２は、実施の形態２に係る測距システムを自動車に搭載した例を示す概略搭載図である。

[図13A]図１３Ａは、実施の形態２に係る測距システムの第１および第２の照明測距兼用光源の詳細を示した図である。

[図13B]図１３Ｂは、実施の形態２に係る測距システムのＴＯＦモード（第１の測距モード）と照明モードにおけるハイビーム光源、ロービーム光源の組み合わせ例を示す図である。

[図14A]図１４Ａは、実施の形態３に係る、単独の照明測距兼用光源を備える測距システムの概略構成を示す機能ブロック図である。

[図14B]図１４Ｂは、実施の形態３に係る、第１および第２の照明測距兼用光源を備える測距システムの概略構成を示す機能ブロック図である。

[図15A]図１５Ａは、実施の形態３に係る固体撮像素子のマイクロレンズの第１の配列例を示す図である。

[図15B]図１５Ｂは、実施の形態３に係る固体撮像素子のマイクロレンズの第２の配列例を示す図である。

[図15C]図１５Ｃは、実施の形態３に係る固体撮像素子のマイクロレンズの第３の配列例を示す図である。

[図15D]図１５Ｄは、実施の形態３に係る固体撮像素子と、レンズおよび被写体との間の光路を示す説明図である。

[図16]図１６は、実施の形態に係る固体撮像素子のマイクロレンズの配置および構造を単位セル群毎に示す平面構造図である。

[図17]図１７は、実施の形態４に係る測距システムを住宅設備機器に搭載した例を示す図である。

[図18A]図１８Ａは、実施の形態に係る測距システムの搭載されるイメージセンサの画素について、特にＩＲ透過フィルタ（フォトニック型）の詳細を説明した断面構造図である。

[図18B]図１８Ｂは、実施の形態に係る測距システムの搭載されるイメージセ

ンサの画素について、特にＩＲ透過フィルタ（有機材料型）の詳細を説明した断面構造図である。

[図19]図１９は、実施の形態に係る固体撮像素子の平面構造図である。

[図20]図２０は、実施の形態に係る固体撮像素子の断面構造図である。

[図21]図２１は、従来技術の検知システムの概略構成を示す機能ブロック図である。

発明を実施するための形態

[0046] 以下、本開示の実施の形態に係る測距システムについて、図面を参照しながら説明する。なお、以下の実施の形態は、いずれも本開示の一具体例を示すものであり、数値、形状、材料、構成要素、構成要素の配置位置及び接続形態などは、一例であり、本開示を限定するものではない。

[0047] （実施の形態１）

実施の形態１に係る測距システム（センシングシステム）は、光照射を指示する複種類の発光信号（発光パルス信号）と反射光の露光を指示する露光信号とを発生（制御）する信号発生部（信号発生装置）と、発光信号を受信して、測距（センシング）を目的としない照明と、反射光による測距（センシング）のための光照射とを行う第１の照明測距兼用光源部と、露光信号を受信して露光を行い、反射光の露光量を取得する撮像部と、露光量を用いて、距離情報を演算して出力する演算部とを備え、撮像部および演算部を動作させることなく第１の照明測距兼用光源部に照明を行わせる照明モードと、第１の照明測距兼用光源部に光照射をさせて撮像部を動作させることにより第１の測距を行う第１の測距モード（センシングモード）とを、動作モードとして有することを特徴とする。

[0048] 図１は、実施の形態１に係る測距システムの概略構成を示す機能ブロック図である。

[0049] 同図に示すように、測距システム（検知システム）１は、撮像部１０と、照明測距兼用光源２０（第１の照明測距兼用光源部）と、信号発生部３０と、演算部４０とを備える。

[0050] 照明測距兼用光源２０は、駆動回路、コンデンサ及び発光素子を有し、コンデンサに保持した電荷を発光素子へ供給することで光を発する。発光素子としてはレーザダイオードや発光ダイオード（ＬＥＤ）等のその他の発光素子を用いてもよい。

[0051] また、照明測距兼用光源２０は、測距を目的としないで暗闇等を明るくするための照明用光源と、距離などの物理量を検知するための測距用光源とが兼用となっている。例えば、後述する図１２のように、輸送機器（例えば、自動車）に用いる場合は、ヘッドライト又はフォグランプ等と兼用する。

[0052] また、照明測距兼用光源２０として用いるＬＥＤは、単色ＬＥＤ（例として白色ＬＥＤ）を用いることが出来る。

[0053] また、照明測距兼用光源２０として用いるＬＥＤとして複数色のＬＥＤ（例えば、赤色ＬＥＤ、青色ＬＥＤ．黄色ＬＥＤ等）を組み合わせてもよく、この場合は、測距に長波長側（例えば、赤色ＬＥＤ）の光源を用いると、霧等の拡散粒子による減衰が軽減され、白色を用いた場合に比べてより遠くを測距すること出来る。

[0054] また、複数色のＬＥＤとして、例えば、赤色ＬＥＤ、青色ＬＥＤ，黄色ＬＥＤ等と共に白色ＬＥＤを組み合わせることもでき、この場合は、例えば、夕方等において強い日差しを受けている場合はより波長の短い白色を用い、雨が降っている場合などは散乱による減衰を低減できる波長の長い光源（例えば、赤色ＬＥＤ等）を使い、夜間は道路状況に応じて対向車線側ではなく歩道側の光源をより強力にして到達距離を上げるというように使い分けることより、どのような天候、環境状況でも高い精度で測距することが出来る。

[0055] また、赤色ＬＥＤ、青色ＬＥＤ、黄色ＬＥＤ等による複数種類の色のＬＥＤを組み合わせることにより、照明光源から発振される光の波長領域の中から、近赤外光を選択的に用いた測距を行うことも出来る。

[0056] また、信号発生部３０は、光照射を指示する発光信号（第１発光パルス信号、第２発光パルス信号）５１と、被写体からの反射光の露光を指示する露光信号５２とを発生する。照明測距兼用光源２０は、信号発生部３０で発生

する発光信号（第１発光パルス信号）５１を受信するタイミングに従って被写体に対する測距のための光照射と、信号発生部３０で発生する発光信号（第２発光パルス信号）５１を受信するタイミングに従って測距を目的としないで暗闇を明るくするための光照射とを行う。

[0057] 撮像部１０は、カメラレンズ、固体撮像素子（イメージセンサ）、及びＡ／Ｄコンバータ等のＲＡＷデータ５３を作成し出力する回路を有する。なお、本実施の形態は、Ａ／Ｄコンバータ等のＲＡＷデータ５３を作成し出力する回路は固体撮像素子に搭載されている場合も含む。

[0058] また、撮像部１０は、対象物体（被写体）を含む領域に対して、信号発生部３０で発生する露光信号５２が示すタイミングに従って複数回の露光を行い、複数回の露光量の総和に対応したＲＡＷデータ５３（ＴＯＦ（Ｔｉｍｅ Ｏｆ Ｆｌｉｇｈｔ）情報）を出力する。

[0059] また、演算部４０は、撮像部１０から受けたＲＡＷデータ５３に基づいて演算し、被写体までの距離情報（検知情報）を出力する。

[0060] なお、本実施の形態では、信号発生部３０、撮像部１０及び演算部４０は、その一部又はすべてが、半導体基板にワンチップで搭載される場合も含む。

[0061] 図２、図３は、図１の測距システムの搭載例を示す概略搭載図である。図２は、重機であるショベルカーに搭載した場合であり、特に、照明測距兼用光源２０と撮像部１０の詳細を示した概略図である。

[0062] 図２では、ショベルカー９０には、照明測距兼用光源２０と撮像部１０が搭載され、撮像部１０はショベルカー９０の上部旋回体の上部に搭載されている。また、ショベルカー９０の上部旋回体における車両前部にはアームが備えられ、アームの先端部分に、バルク材を掬い込むバケット９６が設けられている。また、上部旋回体は３６０度旋回可能となっている。

[0063] また、図３では、ショベルカー９０には撮像部１０が搭載されており、工事現場の構造物１８に照明測距兼用光源２０が設置されている。

[0064] 本実施の形態に係る測距システム１を重機、又は、重機と作業現場の構造

物に搭載すれば、例えば、地面等を掘り下げる場合の障害物までの距離を正確に測定することが出来、つまり、一定の距離又は障害物（例えば図２、図３のＹ箇所）までの距離まで自動的に掘り下げ、想定する距離から外れた（又は、想定する距離に近づいた）場合は自動的に動作停止など、小型かつ軽量な測距システム１でありながら自動運転を行うことも出来るようになる。

[0065] なお、図２、図３では重機の搭載した例を示したが、これに限定されず、例えば、その他の重機（ブルドーザー等）、輸送機器（自動車、自転車、オートバイ、鉄道車両、飛行機、宇宙機等）、輸送機器とインフラ設備、住宅設備機器など、あらゆる機器に搭載することが可能である。

[0066] また、図４は、本実施の形態に係る固体撮像素子の画素の構造を示す断面図である。

[0067] 図中の固体撮像素子は、半導体基板３０１、受光部（ＰＤ）３０３、金属配線、ゲート電極又は転送電極３０５、マイクロレンズ３０７等を含む。被写体からの反射光は、マイクロレンズ３０７により集光されて受光部（ＰＤ）３０３に到達する。

[0068] なお、本実施の形態に係る固体撮像素子は、赤外線（以下、ＩＲと呼ぶ）に対してのみ感度を有するイメージセンサを使用出来ると共に、赤色領域、緑色領域及び青色領域（以下、ＲＧＢと呼ぶ）、並びに、ＩＲ（以下、ＲＧＢ＋ＩＲと呼ぶ）に対して感度を有するイメージセンサを用いることが可能である。なお、ＲＧＢ＋ＩＲを用いた場合の詳細は後述する。

[0069] 次に、本実施の形態に係る測距システム１の撮像部１０に、ＣＣＤ型の固体撮像素子を用いた場合について説明する。

[0070] 図５は、ＣＣＤ型の固体撮像素子の機能構成図である。同図に示すように、ＣＣＤ型固体撮像素子は、受光部（フォトダイオード、ＰＤ）１０１と、複数の垂直転送部１０２と、水平転送部１０３と、信号電荷検出部１０４とを備える。

[0071] フォトダイオード１０１は、受光した光を電荷に変換する。垂直転送部１０２は、複数のゲートから構成され、フォトダイオード１０１から読み出し

た電荷を順次垂直方向に転送する。水平転送部１０３は、複数のゲートから構成されている複数のゲートがパケットとして垂直転送部１０２から受けた電荷を順次水平方向に転送する。信号電荷検出部１０４は、水平転送部から受けた電荷を順次検出して電圧信号に変換してＲＡＷデータ（ＴＯＦ情報）５３を出力する。

[0072] また、複数のフォトダイオード（ＰＤ）１０１を一括してリセットする動作、いわゆるグローバルリセットにより各ＰＤにおいて検出する光の時間差を無くすることが出来るので、被測定物への光の遅延を計測することを利用する高精度な測距を実現することが出来る。

[0073] なお、図５はＣＣＤイメージセンサ（ＣＣＤ型固体撮像素子）であるが、本実施の形態ではＭＯＳイメージセンサを用いることも出来る。このＭＯＳイメージセンサは複数の画素を有する固体撮像素子を備え、複数の画素のそれぞれは、光電変換する受光部と、受光部から読み出された信号電荷を蓄積する蓄積部とを備える。ＭＯＳイメージセンサは、複数の画素において受光部の信号電荷を蓄積部に一括して読み出すことを特徴とする。

[0074] 図６は、本実施の形態に係る測距システム１の撮像部１０に用いるＭＯＳ型の固体撮像素子の一例であり、ＭＯＳイメージセンサにおける単位セル２０１の構成を示す回路図である。ここに、ｎは１から４までの整数とする。

[0075] 図６より、個々の単位セル２０１は、受光部であるＰＤと、シャッタ信号ＴＸＳｎをＨとすることでＰＤに蓄積した信号電荷をリセット（排出）するためのシャッタトランジスタＭ５と、蓄積部であるフローティングディフュージョン（ｆｌｏａｔｉｎｇ　ｄｉｆｕｓｉｏｎ：ＦＤ）と、転送信号ＴＸｎをＨとすることでＰＤに蓄積した信号電荷をＦＤに読み出すための読み出しトランジスタＭ１と、リセット信号ＲＳｎをＨとすることでＦＤに読み出された信号電荷をリセットするためのリセットトランジスタＭ２と、ゲートがＦＤに接続されたソースフォロワトランジスタＭ３と、選択信号ＳＥＬｎをＨとすることでソースフォロワトランジスタＭ３を垂直信号線へ接続するライン選択トランジスタＭ４とから構成される。リセットトランジスタＭ２

とソースフォロワトランジスタＭ３とシャッタトランジスタＭ５とのドレインは、画素電極ＶＤＤに接続されている。

[0076] 図７は、図６の単位セル２０１が２次元状に配置されてなるＭＯＳイメージセンサの概略構成図である。

[0077] 図７のＭＯＳイメージセンサは、単位セル２０１を４行４列の２次元状に配列した撮像領域２０２と、列ごとのトランジスタ閾値電圧のばらつきにより発生する固定パターンノイズ（ｆｉｘｅｄ　ｐａｔｔｅｒｎ　ｎｏｉｓｅ：ＦＰＮ）を除去するためのＦＰＮ除去部２０３と、ＦＰＮ除去部２０３の出力信号を順次選択するための水平選択部２０４と、水平選択部２０４の出力信号を増幅するための差動アンプ２０５とから構成されている。なお、撮像領域２０２は説明の便宜上４行４列の小サイズとしている。

[0078] 撮像領域２０２の行は、不図示の垂直走査部により順次選択される。各列の垂直信号線２０６に電流源２０９が接続されている。ＦＰＮ除去部２０３の各列は、サンプルホールド信号ＳＨＳを受ける信号レベル用のサンプルトランジスタＭ１１と、サンプルホールド信号ＳＨＮを受けるリセットレベル用のサンプルトランジスタＭ１２と、信号レベル用の容量ＣＩＩと、リセットレベル用の容量Ｃ１２とから構成される。水平選択部２０４の各列は、信号レベル用の容量ＣＩＩと第１の水平信号線２０７との間に介在した第１の列選択トランジスタＭ２１と、リセットレベル用の容量Ｃ１２と第２の水平信号線２０８との間に介在した第２の列選択トランジスタＭ２２とから構成される。水平選択部２０４の各列は、不図示の水平走査部からの信号Ｈ１～Ｈ４により順次選択される。差動アンプ２０５は、第１の水平信号線２０７と第２の水平信号線２０８との間の電位差を増幅する。

[0079] 図６、図７に示した固体撮像素子は、ＰＤの信号電荷を全画素において一括して読み出し蓄積する蓄積部（図６のＦＤ）を備えることを特徴とし、撮像領域２内の複数のフォトダイオードＰＤを一括してリセットすることが出来、つまり、ＭＯＳ型であってもグローバルシャッタ＆グローバルリセット機能を実現する。

[0080] 但し、本実施の形態に係る固体撮像素子は、図５、図６、図７で示したＣＣＤ型、ＭＯＳ型イメージセンサに限定されるものではなく、測距システム１として他の要求を考慮して、その他の固体撮像素子（イメージセンサ）を用いても後述する効果（測距精度向上、等）を得ることが可能である。

[0081] 次に、本実施の形態に係る測距システムの動作方法について、図８、図９Ａ、図１０のタイミングチャートを用いて詳細を説明する。図８、図９Ａ、図１０は、発光信号及び露光信号による動作例を示す第１～第３のタイミングチャートである。本実施の形態では、第１～第３のタイミングチャートのいずれかの動作を用いることが出来る。

[0082] まず、第１の駆動方法として、図８を用いて測距時（ＴＯＦモード）の駆動操作を説明すると、発光信号５１は測距を行うための光照射を指示する第１発光パルス信号と、測距を目的としない照明の点灯を指示する第２発光パルス信号とを含み、第２発光パルス信号がＯＦＦのときに、第１発光パルス信号はＯＮとなり、第１発光パルス信号は、ＴＯＦにより測距を行うために用いられる。また、投射した光が対象物まで往復するのにかかる時間から距離を計測するＴＯＦを基本原理とし、発光信号（第１発光パルス信号）５１により発生した照射光の、被写体である測定対象物による反射光の露光を指示する露光信号５２が、第一の露光信号と第二の露光信号との異なるタイミングの２パターンで制御されることで露光したそれぞれの光量の比に基づいて測定対象物までの距離を算出する。例えば、第一の露光信号によって、測定対象物からの反射光の全てを含むように露光を行い、第二の露光信号によって、測定対象物からの反射光が発光タイミングに対して遅延する程、露光量が増加するような露光を行う。また背景光等のオフセット成分を検出するため、発光信号５１を停止させて第一の露光信号、第二の露光信号と同じ条件の露光を行う。

[0083] そして、第一の露光信号による露光量の総和Ｓ０、第二の露光信号による露光量の総和Ｓ１、背景光の露光量の総和ＢＧ、照射する直接光の発光信号５１の時間幅Ｔ０、光速度ｃの各値から被写体までの距離Ｌを算出する（式

１参照）。

[0084] [数1]

$$L = \frac{c \cdot T_0}{2} \times \left(\frac{S1 - BG}{S0 - BG} \right) \qquad (式１)$$

[0085] また、１画面における発光信号５１、第一の露光信号、第二の露光信号のタイミングでは、発光信号（第１発光パルス信号）５１と第一の露光信号とを複数回繰り返し出力し、その後発光信号（第１発光パルス信号）５１と第二の露光信号とを同じ回数だけ繰り返し出力し、その後発光信号（第１発光パルス信号）５１を停止させて第一の露光信号や第二の露光信号と同じ条件の露光信号５２を同じ回数だけ繰り返し出力する。この一連のタイミングを１セットとし、これを複数セット繰り返し出力した後、蓄積された露光量を出力して被写体までの距離を（式１）により算出するようにしてもよい。

[0086] 続いて、図８を用いて照明時（照明モード）の駆動操作を説明すると、光の振幅が照明モードに比べてＴＯＦモード（センシングモード）の方が高い強度となるように動作を行う。つまり、第１発光パルス信号の振幅は第２発光パルス信号の振幅よりも大きく、これにより、ＴＯＦモードにおいて照明測距兼用光源２０から照射される光の振幅は、照明モードにおいて照明測距兼用光源２０から照射される光の振幅よりも大きい。

[0087] これにより、本実施の形態に係る測距システム１は、暗闇等を明るくするための光源と、反射光により測距を行うため光源を兼用することにより、測距システム１の小型化、軽量化を実現することが出来、さらに、距離情報を正確に取得することが出来る。

[0088] 次に、第２の駆動方法を、図９Ａを用いて、図８で説明した内容との相違点を中心に詳細を説明する。

[0089] まず、照明モードでの駆動は、図８の駆動方法と同じである。一方、ＴＯＦモード（センシングモード）では、図８を説明した駆動と同様に行うが、この一連の動作時間が照明モードより短時間に行う。つまり、点灯時間幅が

照明モードに比べてＴＯＦモードの方が短い（狭い）ようにする。言い換えれば、第１発光パルス信号がＯＮとなる期間は第２発光パルス信号がＯＮとなる期間よりも短く、これにより、ＴＯＦモードにおいて照明測距兼用光源２０から照射される光の点灯時間幅は、照明モードにおいて照明測距兼用光源２０から照射される光の点灯時間幅よりも短い。

[0090] この動作により、図８と同様に、測距システム１の小型化、軽量化を実現することが出来、さらに、距離情報を正確に取得することが出来る。

[0091] 次に、第３の駆動方法として、図１０を用いて、図８で説明した内容との相違点を中心に詳細を説明する。

[0092] 図１０では、ＴＯＦモード（センシングモード）に、第１の測距モードとバックグラウンド光量測定モード（第２の測距モード）を備えている。この例では、測距システム１は、照明測距兼用光源２０を消灯した状態で、撮像部１０を動作させ演算部４０にバックグラウンド光量を計測させるモードを備え、演算部４０は、第１の測距モードの露光量からバックグラウンド光量を減じる補正を行う。

[0093] 第１の測距モードでは基本的な動作は図８、図９Ａで説明したものと同じである。バックグラウンド光量を測定するモードでは露光信号５２のタイミングパターンとして第三の露光信号を追加している。具体的には、照明測距兼用光源２０を消灯した状態でバックグラウンド光量を測定するモード（つまり、測距計算時に背景光量をＴＯＦモードの受信データから引く）となる駆動である。

[0094] この動作により、測距システム１の小型化、軽量化を実現することが出来、距離情報を更に正確に取得することが出来る。

[0095] 引き続き、測距システムの動作方法について説明すると、図８、図９Ａ、図１０の駆動方法において、照明点灯＋ＴＯＦ点灯の回数は一定回数よりも多くとなるように、第１発光パルス信号がＯＮとなる回数と第２発光パルス信号がＯＮとなる回数との合計は６０回以上／秒、より好ましくは、１２０回以上／秒とする高速パルス駆動を行う。例えば、照明点灯＋ＴＯＦ点灯の

回数を６０回以上／秒、より好ましくは、１２０回以上／秒とする。つまり、第１の測距モードおよび照明モードの切り替えを少なくとも１２０回／秒とする。

[0096] これにより、ＬＥＤ光源からの光が被写体、歩行者等に対して、目のちらつきを感じることを防ぎ、アイセーブを実現することが出来る。言い換えれば、ＬＥＤは実際には１２０回／秒以上の速さでパルス駆動により動的に点灯するけれども、人の目には残像効果により連続発光しているように見えるため、ちらつきや違和感から人の目を保護する。

[0097] つまり、本実施の形態では、測距システム１の小型化、軽量化、さらに、正確な距離情報の取得と共に、被写体、歩行者等に対してアイセーブを実現することが出来る。

[0098] なお、本実施の形態の測距システムは、図８、図９Ａ、図１０の駆動方法を組み合わせて駆動を行うことも可能である。

[0099] また、図８、図９Ａ、図１０の駆動方法では、ＴＯＦモードと照明モードを交互に駆動する例を説明したが、それに限定されるものではなく、第２発光パルス信号は、第１発光パルス信号がＯＮとなる期間を複数回繰り返した後に、ＯＮとなっても良い。図９Ｂは、発光信号によるＴＯＦモード又は照明モードで一定回数連続して動作させる動作例を示す図である。図９Ｂに示すように、例えば、ＴＯＦモード又は照明モードで一定回数連続して動作を行うことも出来る。

[0100] （実施の形態２）

以下、図面を参照しながら、実施の形態２に係る測距システム１の構成及び動作について、これまでの実施の形態で説明した内容との相違点を中心に詳細を説明する。

[0101] 実施の形態２における測距システムは、さらに、第２の前記照明測距兼用光源部を備え、演算部４０は、第１および第２の照明測距兼用光源部の位相差情報を用いて測距を行うように構成されている。図１１は実施の形態２に係る別の測距システムの概略構成を示す機能ブロック図である。また、図１

２は実施の形態２を一例として、測距システム１を輸送機器である自動車に搭載した場合であり、特に、照明測距兼用光源２０と撮像部１０の詳細を示した概略斜視図である。第１および第２の照明測距兼用光源部は、照明測距兼用光源部２０ａおよび２０ｂである。

[0102] 図１１、図１２では、自動車用のヘッドライトのように、一定の距離で離れた複数の照明測距兼用光源２０ａ、２０ｂとして、照明用光源と距離などの物理量を検知するための測距用光源とが兼用となっている。

[0103] これにより、異なる位置から照射された光の複数の反射光を撮像部１０が受け取り、撮像部１０から複数のＲＡＷデータ５３ａ、５３ｂを演算部４０に出力する。演算部４０では、左右ヘッドライトを用いたＴＯＦによる距離演算と、さらに、複数のＲＡＷデータ５３ａ、５３ｂ、つまり位相差のある反射光を用いた第２の距離情報を補正情報としてＴＯＦデータの補正を行う。これにより、本実施の形態の測距システムは、更に精度の高い検知を行うことが出来る。

[0104] さらに、照明測距兼用光源２０ａ、２０ｂに対して、測距時においてそれぞれ異なる波長の光源を用いることにより、照明測距兼用光源２０ａ、２０ｂから得られる画像データ、および距離データを得、物体の形状を立体的に捉えることが出来る。

[0105] すなわち、本実施の形態では、特に複数の照明測距光源として自動車のヘッドライトシステムに適用することがより好ましく、この方法では照射光ａと反射光ａの経路と照射光ｂと反射光ｂの経路の差によって被写体とイメージセンサとの相対位置を計算することが出来、既存の照明機器の構成を大きく変えることなく、より高い精度の距離検知を行うことが可能となる。

[0106] なお、図１２では、一定の距離で離れた複数の照明用光源としてヘッドライトを用いたが、その他の光源（例えば、フォグランプ１００ａ、１００ｂ）を用いることも可能である。

[0107] また、図１２では、撮像部１０をフロントガラス内上部（バックミラー付近）に設置したが、それに限定されるものではなく、例えば、フロントグリ

ル内、フロンバンパー内、等に設置することも可能である。

[0108] さらに、本実施の形態の詳細な説明を続けると、図１３Ａは実施の形態２を自動車用途として用いた自動車用の測距システム１であり、特に、第１および第２の照明測距兼用光源の詳細を示した図である。第１および第２の照明測距兼用光源部は、車両に備えられた左右のハイビーム光源と左右のロービーム光源のうち、（ａ）左および右のハイビーム光源、および（ｂ）左および右のロービーム光源のいずれかである。

[0109] つまり、自動車のヘッドライトに本実施の形態の測距システム１を用い、ハイビーム光源１１ａ、１１ｂおよびロービーム光源１２ａ、１２ｂを第１および第２の照明測距兼用光源として用いる。つまり、第１の照明測距兼用光源は、ハイビーム光源１１ａおよびロービーム光源１２ａの少なくとも一方を含み、第２の照明測距兼用光源は、ハイビーム光源１１ｂおよびロービーム光源１２ｂの少なくとも一方を含む。これにより、夜間時に暗闇を充分に照らしながら、精度良く距離測定を行うことが出来る。

[0110] 図１３Ｂは、ＴＯＦモード（第１の測距モード）と照明モードにおける第１および第２の照明測距兼用光源部としてのハイビーム光源１１ａ、１１ｂ、ロービーム光源１２ａ、１２ｂの組み合わせ例を示す図である。

[0111] 図１３Ｂ中の組Ａは、ＴＯＦモード（第１の測距モード）、照明モードの両方においてもロービーム光源１２ａ、１２ｂを用いることを示す。つまり、図８～図１０における動作および位相差情報を用いた測距を組Ａで行う。

[0112] 同様に、組Ｂは、ＴＯＦモード（第１の測距モード）、照明モードの両方においてもハイビーム光源１１ａ、１１ｂを用いることを示す。組Ｃは、ＴＯＦモード（第１の測距モード）ではロービーム光源１２ａ、１２ｂを用いて、照明モードではハイビーム光源１１ａ、１１ｂを用いることを示す。組Ｄは、ＴＯＦモード（第１の測距モード）ではハイビーム光源１１ａ、１１ｂを用いて、照明モードではロービーム光源１２ａ、１２ｂを用いることを示す。

[0113] なお、組Ｄの場合、ハイビームに別途赤外光を用い、ロービーム光源１２

ａ、１２ｂと同期を取ればロービームによる暗闇を照らす照明と、赤外光ハイビームによる被写体、歩行者等に対して、まぶしさを与えることなく測距が可能となる。ここでいう同期とは、第１および第２の照明測距兼用光源部の一方の消灯と他方の点灯とを同期させることをいう。

[0114] なお、本実施の形態は、上述した図８、図９Ａ、図１０で説明したＴＯＦモード、照明モード、バックグラウンド光量測定モードの各動作を用いることも可能であり、より高い精度となる測距を行うことが出来る。

[0115] なお、図１２、図１３Ａでは自動車の搭載した例を示したが、これに限定されず、例えば、その他の輸送機器（自転車、オートバイ、鉄道車両、飛行機、宇宙機等）、輸送機器とインフラ設備、重機（ショベルカー、ブルドーザー等）、住宅設備機器など、あらゆる機器に搭載することが可能である。

[0116] （実施の形態３）

実施の形態３では、撮像部からの画像信号を用いて現在のフレームと前のフレームを比較することにより第２の測距を行う画像測距モードを有する測距システムについて説明する。

[0117] 以下、図面を参照しながら、実施の形態３に係る測距システム１の構成及び動作について、上述した実施の形態との相違点を中心に説明する。

[0118] 図１４Ａ、図１４Ｂは、実施の形態３に係る測距システム１の概略構成を示す機能ブロック図である。そのうち、図１４Ａは、実施の形態１における図１で示したような単独の照明測距兼用光源２０を備えた場合であり、図１４Ｂは実施の形態２における図１１で示したように第１および第２の照明測距兼用光源を備えた場合である。

[0119] 図１４Ａ、図１４Ｂより、測距システム１は、撮像部１０と、照明測距兼用光源２０と、信号発生部３０と、演算部４０とを備える。

[0120] 照明測距兼用光源２０（２０ａ、２０ｂ）は、駆動回路、コンデンサ及び発光素子を有し、コンデンサに保持した電荷を発光ダイオードへ供給することで光を発する。発光素子としてはレーザダイオードや発光ダイオード（ＬＥＤ）等のその他の発光素子を用いてもよい。

[0121] また、信号発生部３０は、光照射を指示する発光信号５１（５１ａ、５１ｂ）と、被写体からの反射光の露光を指示する露光信号５２（５２ａ、５２ｂ）とを発生する。照明測距兼用光源２０（２０ａ、２０ｂ）は、信号発生部３０で発生する発光信号５１を受信するタイミングに従って被写体に対して測距のための光照射を行う。

[0122] 更に、信号発生部３０で発生する発光信号５１（５１ａ、５１ｂ）を受信するタイミングに従って、測距を目的としないで暗闇を明るくするための光照射を行う。

[0123] 撮像部１０は、カメラレンズ、固体撮像素子（イメージセンサ）、及びＡ／Ｄコンバータ等のＲＡＷデータ５３（５３ａ、５３ｂ）を作成し出力する回路を有する。また、撮像部１０は、対象物体（被写体）を含む領域に対して、信号発生部３０で発生する露光信号５２（５２ａ、５２ｂ）が示すタイミングに従って複数回の露光を行い、複数回の露光量の総和に対応したＲＡＷデータ５３（５３ａ、５３ｂ）（ＴＯＦ情報）を得る。

[0124] さらに、撮像部１０は、撮像を行い、その画像情報を演算部４０に出力する。

[0125] 演算部４０は、撮像部１０から受けたＲＡＷデータ５３（５３ａ、５３ｂ）、及び、画像情報を用いて演算し、被写体までの距離情報（検知情報）を出力する。

[0126] まず、ＴＯＦモードで測距を行うのは上述した実施の形態と同じである。

[0127] さらに、本実施の形態では画像撮像を行い、その画像データから距離を測定する。その方法の一例として、撮像部１０で連続画像を撮影し、現在のフレーム（画像）と前のフレーム（画像）を比較し、演算により距離を算出する（画像測距モード）。

[0128] このように、ＴＯＦデータと画像情報の両方を距離情報として用いて、以下のような使い方により、測距精度を向上させることが出来る。

[0129] 第１の使い方は、昼夜により測定モード（距離情報）を使い分ける方法である。例えば、昼間など通常は照明光源を点灯させないような場合、本実施

の形態では照明測距兼用光源２０（２０ａ、２０ｂ）は消灯して画像測距モードで測距を行う。また、夜間などで通常照明光源を点灯させる場合は、本実施の形態では照明測距兼用光源２０（２０ａ、２０ｂ）は点灯（パルス点灯駆動）させて、ＴＯＦモードで測距を行う。これにより、昼間は照明測距兼用光源２０を点灯させずに、昼夜を問わずに正確な測距することが出来る。

[0130] 第２の使い方は、ＴＯＦモードの距離情報に、画像測距モードの距離情報でデータ補完を行う方法である。この方法では、より一層測距精度を向上させることが出来る。

[0131] 第３の使い方は、扱われる天候や環境条件などにより測定モード（距離情報）を使い分ける方法である。例えば、夕方等の強い日差しを受けている場合、雨が降っている場合など（つまり、画像認識が難しい場合は）はＴＯＦモードを用い、それ以外の環境では、画像測距モードを用いる。これによって、どのような天候、状況でも高い精度で測距することが出来る。

[0132] 第４の使い方は、被写体までの距離により測定モード（距離情報）を使い分ける方法である。すなわち、例えば１０ｍまでの近距離ではＴＯＦモードと画像測距モードを用い、例えば１０ｍ以上の遠距離では主としてＴＯＦモードを用いる。これにより、どのような被写体までの距離の場合でも高い精度で測距することが出来る。

[0133] 第５の使い方は、本システムが搭載された輸送機器（例えば、自動車）、又は被写体の動き速度によって測定モード（距離情報）を使い分ける方法である。例えば輸送機器の速度が、例えば３０ｋｍ／ｈまでの低速度ではＴＯＦモードと画像測距モードを用い、例えば３０～１００ｋｍ／ｈまでの中速度ではＴＯＦモードと画像測距モードをフレームごとに使い分け、例えば１００ｋｍ／ｈ以上の高速度ではＴＯＦモードをそれぞれ用いる。これにより、どのような被写体までの距離の場合でも高い精度で測距することが出来る。

[0134] なお、本実施の形態は、上述した図８、図９Ａ、図１０で説明したＴＯＦ

モード、照明モード、バックグラウンド光量測定モードの各動作を用いることも可能であり、より高い精度となる測距を行うことが出来る。

[0135] また、本実施の形態に係る測距システム１を、上述した図２、図３のように、重機、又は、重機と作業現場の構造物に搭載すれば、障害物に到達するまでは自動的に掘り下げ、更に、掘り下げることが出来ない障害物（物体が硬い、爆発の危険がある、等）と画像撮像から認識した場合は自動的に動作停止など、小型かつ軽量な測距システム１でありながら自動運転を行うことも出来るようになる。

[0136] また、本実施の形態の測距システム１は、例えば、輸送機器（自転車、オートバイ、鉄道車両、飛行機、宇宙機等）、輸送機器とインフラ設備、重機（ショベルカー、ブルドーザー等）、住宅設備機器など、あらゆる機器に搭載することが可能である。

[0137] （実施の形態３の変形例）

以下、図面を参照しながら、本変形例に係る測距システム１の構成及び動作について、これまでの実施の形態で説明した内容との相違点を中心に詳細を説明する。

[0138] まず、図１５Ａ～図１５Ｃは、単位セル（マイクロレンズ）の第１～第３の配列例を示す図である。図１５Ｄは、固体撮像素子と、レンズおよび被写体との間の光路を示す説明図である。領域Ａ、Ｂはそれぞれレンズ中の領域である。

[0139] 図１５Ａ～図１５Ｃでは、第１の単位セル４０１は図１５Ｄの領域Ａからの光を受光する単位セルに対応し、第２の単位セル４０２は図１５Ｄの領域Ｂからの光を受光する単位セルに対応している。

[0140] 図１５Ａでは、複数の第１の単位セル４０１と複数の第２の単位セル４０２とが千鳥格子で配置されており、列方向（垂直方向）および行方向（水平方向）に交互に配置されている。図１５Ｂでは、第１の単位セル４０１の列と第２の単位セル４０２の列とが行方向に交互に配置されている。図１５Ｃでは、第１の単位セル４０１の行と第２の単位セル４０２の行とが列方向に

交互に配置されている。なお、単位セルの配列としては３種類を図示したが、第１の単位セル４０１および第２の単位セル４０２を数セル単位のブロック毎に配置するなどしても良い。このように配置することで局所的には２種類の光を同時に受光する。

[0141] 図１６は、マイクロレンズの配置および構造を単位セル群毎に示す平面構造図である。

[0142] 上述した図４で示したように、一般的にマイクロレンズ３０７は曲面構造を備え、マイクロレンズ及びマイクロレンズが接触する物質（気体、固体等）の屈折率間差により光を曲げて集光させる。

[0143] 一方、図１６に示したマイクロレンズは、上方から見たとき、マイクロレンズへの入射光の波長と同程度かそれよりも短い線幅で分離され、マイクロレンズの受光面に対して垂直な方向の軸を中心軸とする同心構造の複数の光透過膜を有し、複数の光透過膜の組み合わせによって制御された実効屈折率分布を有している。つまり、上記の中心軸から異なる屈折率の材料（光透過膜）を繰り返し配置した構造によりレンズとしての実効屈折率分布を有する。

[0144] また、このようなマイクロレンズを実現するために、マイクロレンズは、例えば無機材料で形成されたマイクロレンズ、いわゆるデジタルマイクロレンズとされる。図１６のような上面パターンを持つマイクロレンズを各単位セルの上方に実装すれば、各単位セルで局所的に入射角度変化に対する異なる集光特性を持つことが出来る。つまり、上記の中心軸を単位セルの中心から偏心させることによって、光量（受光感度）が最大となる入射角度を設定することができる。

[0145] したがって、光量が最大となる入射角度が異なる第１の単位セルおよび第２の単位セルが隣り合って設けられるため、２方向の入射光を同時に受光でき、いわゆるステレオカメラを用いることなく、単眼のイメージセンサにより立体画像を実現できる。

[0146] 本構成により、ステレオカメラ（複眼カメラ）を用いなくても、立体画像

を描画することが出来、その立体画像データからを用いた画像測距モードは、より一層高精度で測距を行うことが出来る。

[0147] なお、上述したデジタルマイクロレンズは、図４、図１８Ａ、図１８Ｂで説明したマイクロレンズ３０７に用いることも可能である。

[0148] （実施の形態４）

以下、図面を参照しながら、実施の形態３に係る測距システム１の構成及び動作について説明する。

[0149] 図１７は、実施の形態１又は実施の形態２で説明した測距システム１を住宅設備機器（住空間）に搭載した例を示す図である。同図では、特に、照明測距兼用光源２０と撮像部１０を示す。

[0150] 本実施の形態に係る測距システム１を住宅設備機器に搭載すれば、例えば、空間内の寸法情報、家具など配置情報をデータとして自動的に得ることが出来、データを用いて、通信販売で家具等を購入する場合に、サイズ的に設置が可能であるか、などのシミュレーションを自動的に行うことが可能となる。

[0151] （実施の形態の変形例１）

以下、図面を参照しながら、本変形例に係る測距システム１の構成及び動作について、これまでの実施の形態で説明した内容との相違点を中心に詳細を説明する。

[0152] 図１８Ａ、図１８Ｂは、本実施の形態１～３に係る測距システム１の搭載されるイメージセンサの画素について、特にＩＲ透過フィルタの詳細を説明した構造断面図である。

[0153] 図１８Ａでは、ＩＲ透過フィルタは、例えば、互いに屈折率が異なる層を周期的に積層させた、いわゆるフォトニックカラーフィルタ３３１とする。ＩＲ透過フィルタは、例えば、積層構造のうちの少なくとも一つの層の厚さを色光ごとに異ならせることで、単位セル２１が検出対象とする色光に応じて、選択的に透過させる波長に差が設けられている。

[0154] また、ＩＲ透過フィルタは、無機材料、例えば、ＳｉＯ２やＴｉＯ２を積

層させて構成されている。ＩＲ透過フィルタは、例えば、スパッタリング、真空蒸着等の真空成膜法により製造する。無機材料を使用することで、単位セル２１ごとに波長特性に差を持たせたＩＲ透過フィルタを形成することができる。

[0155] ここで、図４で上述したように、イメージセンサは、ＩＲ光を受光し信号電荷を発生させるのは、受光部（例えば、フォトダイオード）の構造の最適化（例えば、不純物プロファイルの最適化）により、ＩＲ透過フィルタが無くても受光、信号電荷発生は可能である。しかしながら、ＩＲ透過フィルタをイメージセンサに搭載することにより、受光する光の波長を選択することが出来る。

[0156] さらに、図１８ＢのようにＩＲ透過フィルタを一般的な有機材料でＩＲ透過フィルタ３３０を形成し本開示の効果を得ることは可能であるが、上述したような無機材料で形成することにより、選択する光の波長幅を狭くすることが出来る。

[0157] 以上により、より高精度な測距を行うことが出来る。

[0158] （実施の形態の変形例２）

また、図１９は、本実施の形態に係る固体撮像素子の平面構造図であり、各画素にはＲ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲの各フィルタが設置されている。

[0159] この画素は、また、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲの各々の画素にはフィルタ透過により、背景光が赤外成分を含む場合はその一部の赤外光が受光される。つまり、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲの各々の画素にＲ成分と前記一部の赤外成分、Ｇ成分と前記一部の赤外成分、Ｂ成分と前記一部の赤外成分が受光される。また、ＩＲ透過フィルタにより、ＩＲ画素には一部の赤外成分のみが受光されて光電変換が行われ、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲ各々の画素で、可視露光時間中に蓄積される。

[0160] このとき、実施の形態２及び実施の形態３の測距システム１において、ＩＲ透過フィルタを透過した光を用いＴＯＦモードで測距を行い、Ｒ＋ＩＲ、

Ｇ＋ＩＲ、Ｂ＋ＩＲ透過フィルタを透過した光を用いて、画像撮像を行い、その画像データからを用いた距離を測定する。その方法の一例として、撮像部１０で連続画像を撮影し、現在のフレーム（画像）と前のフレーム（画像）を比較演算により距離を算出すれば、より高精度な測距を行うことが出来る。

[0161] なお、本変形例では、図２０に示すように、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲの各フィルタを、上述した図１８Ａのように無機材料を積層することで形成することも可能である。

[0162] また、本変形例では、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲの各フィルタを、上述した図１８Ｂのように有機材料で形成することも可能である。

[0163] また、本変形例では、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲの各フィルタを、無機材料によるフィルタと有機材料によるフィルタとに適宜分けて形成することも可能である。

[0164] また、本変形例では、Ｒ＋ＩＲ、Ｇ＋ＩＲ、Ｂ＋ＩＲ、ＩＲの各フィルタを、無機材料によるフィルタと有機材料によるフィルタを組み合せて（例えば、半導体基板に対して垂直方向に重なるように）形成することも可能である。

産業上の利用可能性

[0165] 本開示に係る測距システムは、周辺環境に依存することなく、測定対象物の高精度な３次元測定が実現できるため、例えば、人物、建物などの３次元測定に有用である。

符号の説明

[0166]
１ 測距システム
２ 撮像領域
１０ 撮像部
１１ａ、１１ｂ ハイビーム光源
１２ａ、１２ｂ ロービーム光源
１８ 構造物

２０、２０ａ、２０ｂ　照明測距兼用光源
２１　単位セル
３０　信号発生部
４０　演算部
５１　発光信号
５２　露光信号
５３、５３ａ、５３ｂ　ＲＡＷデータ
９０　ショベルカー
９６　バケット
１００ａ、１００ｂ　フォグランプ
１０１　フォトダイオード
１０２　垂直転送部
１０３　水平転送部
１０４　信号電荷検出部
２０１　単位セル
２０２　撮像領域
２０３　除去部
２０４　水平選択部
２０５　差動アンプ
２０６　垂直信号線
２０７、２０８　水平信号線
２０９　電流源
３０１　半導体基板
３０５　金属配線、ゲート電極又は転送電極
３０７　マイクロレンズ
３３０　透過フィルタ
３３１　フォトニックカラーフィルタ
４０１　第１の単位セル

４０２　第２の単位セル

Ｃ１１、Ｃ１２　容量

Ｍ１　読み出しトランジスタ

Ｍ２　リセットトランジスタ

Ｍ３　ソースフォロワトランジスタ

Ｍ４　ライン選択トランジスタ

Ｍ５　シャッタトランジスタ

ＰＤ　フォトダイオード

Ｍ１２　リセットレベル用サンプルトランジスタ

Ｍ２１、Ｍ２２　列選択トランジスタ

ＭＩＩ　信号レベル用サンプルトランジスタ

ＲＳｎ　リセット信号

ＳＨＮ　サンプルホールド信号

ＳＨＳ　サンプルホールド信号

ＴＸｎ　転送信号

ＶＤＤ　画素電極

ＳＥＬｎ　選択信号

ＴＸＳｎ　シャッタ信号

請求の範囲

[請求項1] 光照射を指示する発光信号と反射光の露光を指示する露光信号とを発生する信号発生部と、

前記発光信号を受信して、測距を目的としない照明と、反射光による測距のための前記光照射とを行う第１の照明測距兼用光源部と、

前記露光信号を受信して前記露光を行い、前記反射光の露光量を取得する撮像部と、

前記露光量を用いて、距離情報を演算して出力する演算部とを備え、

前記第１の照明測距兼用光源部に前記照明を行わせる照明モードと、前記第１の照明測距兼用光源部に前記光照射をさせて前記撮像部を動作させることにより第１の測距を行う第１の測距モードとを、動作モードとして有する

測距システム。

[請求項2] 前記第１の測距モードにおいて前記第１の照明測距兼用光源部から照射される光の振幅は、前記照明モードにおいて前記第１の照明測距兼用光源部から照射される光の振幅よりも大きい

請求項１に記載の測距システム。

[請求項3] 前記第１の測距モードにおいて前記第１の照明測距兼用光源部から照射される光の点灯時間幅は、前記照明モードにおいて前記第１の照明測距兼用光源部から照射される光の点灯時間幅よりも短い

請求項１又は２に記載の測距システム。

[請求項4] さらに、前記第１の照明測距兼用光源部を消灯した状態で、前記撮像部を動作させ前記演算部にバックグラウンド光量を計測させるモードを備え、

前記演算部は、前記第１の測距モードの露光量から前記バックグラウンド光量を減じる補正を行う

請求項１～３のいずれかに記載の測距システム。

[請求項5] 前記第１の照明測距兼用光源部は、単色のＬＥＤ、又は複数色のＬＥＤを搭載する

請求項１～４のいずれかに記載の測距システム。

[請求項6] 前記第１の測距モードおよび前記照明モードの切り替えを少なくとも１２０回／秒とする

請求項５に記載の測距システム。

[請求項7] 前記測距システムは、さらに第２の照明測距兼用光源部を備え、

前記演算部は、さらに、前記第１および第２の照明測距兼用光源部の位相差情報を用いて測距を行う

請求項１～６のいずれかに記載の測距システム。

[請求項8] 前記第１および第２の照明測距兼用光源部は、車両に備えられた左右のハイビーム光源と左右のロービーム光源のうち、（ａ）左および右のハイビーム光源、並びに（ｂ）左および右のロービーム光源のいずれかである

請求項７に記載の測距システム。

[請求項9] 前記演算部は、

前記撮像部からの画像信号を用いて現在のフレームと前のフレームを比較することにより第２の測距を行う

請求項１～８のいずれかに記載の測距システム。

[請求項10] 前記演算部は、前記第１および第２の測距による距離情報の一方を、前記第１および第２の測距の距離情報の他方により補正を行う

請求項９に記載の測距システム。

[請求項11] 前記第１、第２の測距は、昼夜、天候、被写体までの距離、又は、前記被写体もしくは前記測距システムの動き速度により使い分ける

請求項９又は１０に記載の測距システム。

[請求項12] 前記撮像部は固体撮像素子を備え、

前記固体撮像素子はＣＣＤ型の固体撮像素子である

請求項１～１１のいずれかに記載の測距システム。

[請求項13] 前記撮像部は複数の画素を有する固体撮像素子を備え、

前記複数の画素のそれぞれは、

光電変換する受光部と、

前記受光部から読み出された信号電荷を蓄積する蓄積部とを備え、

前記固体撮像素子は、前記複数の画素において前記受光部の信号電荷を前記蓄積部に一括して読み出すＭＯＳ型の固体撮像素子である

請求項１～１１のいずれかに記載の測距システム。

[請求項14] 前記撮像部は複数の画素を有する固体撮像素子を備え、

前記複数の画素のそれぞれは、受光面と垂直な軸を中心軸とし異なる屈折率の材料を同心状に繰り返し配置した構造を有するマイクロレンズを備える

請求項１～１３のいずれかに記載の測距システム。

[請求項15] 前記撮像部は複数の画素を有する固体撮像素子を備え、

前記複数の画素のそれぞれは、赤外線透過フィルタ、赤色光および赤外線を透過する第１のフィルタ、緑色光および赤外線を透過する第２のフィルタ、および、青色光および赤外線を透過する第３のフィルタの何れかを備える

請求項１～１４のいずれかに記載の測距システム。

[請求項16] 前記赤外線透過フィルタ、および、前記第１から第３フィルタの少なくとも１つは、無機材料を積層したフィルタである

請求項１５に記載の測距システム。

[請求項17] 前記測距システムを重機、又は、重機と作業現場の構造物に搭載した

請求項１～１６のいずれかに記載の測距システム。

[請求項18] 前記測距システムを輸送機器に搭載した

請求項１～１６のいずれかに記載の測距システム。

[請求項19] 前記測距システムを住宅設備機器に搭載した

請求項１～１６のいずれかに記載の測距システム。

[請求項20] 発光パルス信号を制御する信号発生装置であって、

前記信号発生装置は、複種類の前記発光パルス信号を制御し、

前記複種類の発光パルス信号は、測距を行うための光照射を指示する第１発光パルス信号と、測距を目的としない照明の点灯を指示する第２発光パルス信号とを含み、

前記第２発光パルス信号がＯＦＦとなるときに、前記第１発光パルス信号はＯＮとなる

信号発生装置。

[請求項21] 前記第１発光パルス信号がＯＮとなる期間は、前記第２発光パルス信号がＯＮとなる期間よりも短い

請求項２０に記載の信号発生装置。

[請求項22] 前記第２発光パルス信号は、前記第１発光パルス信号がＯＮとなる期間を複数回繰り返した後に、ＯＮとなる

請求項２０又は２１に記載の信号発生装置。

[請求項23] 前記第１発光パルス信号がＯＮとなる回数と前記第２発光パルス信号がＯＮとなる回数との合計は、少なくとも１２０回／秒とする

請求項２０～２２のいずれかに記載の信号発生装置。

[請求項24] 前記第１発光パルス信号の振幅は、前記第２発光パルス信号の振幅よりも大きい

請求項２０～２３のいずれかに記載の信号発生装置。

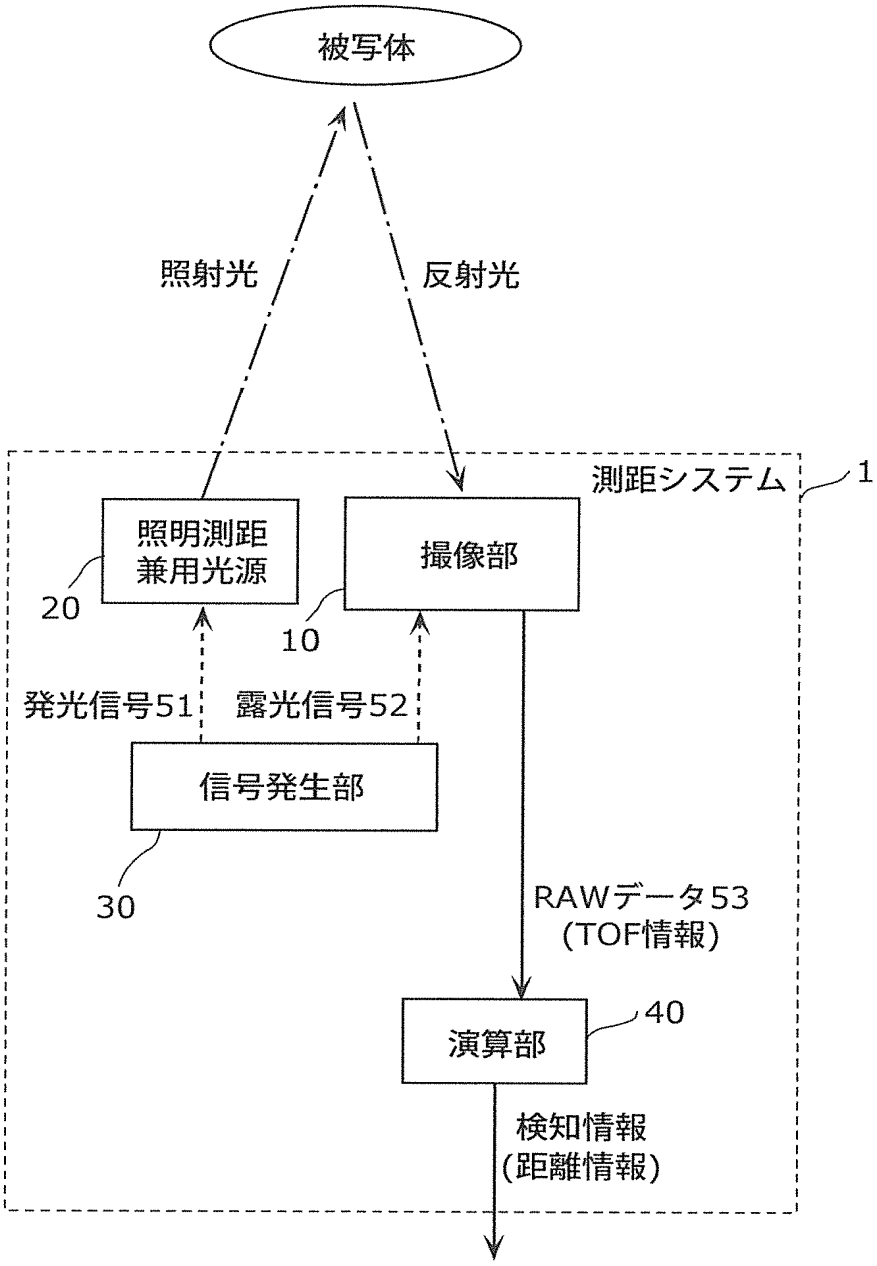
[請求項25] 前記第１発光パルス信号は、Ｔｉｍｅ　Ｏｆ　Ｆｌｉｇｈｔにより測距を行うために用いられる

請求項２０～２４のいずれかに記載の信号発生装置。

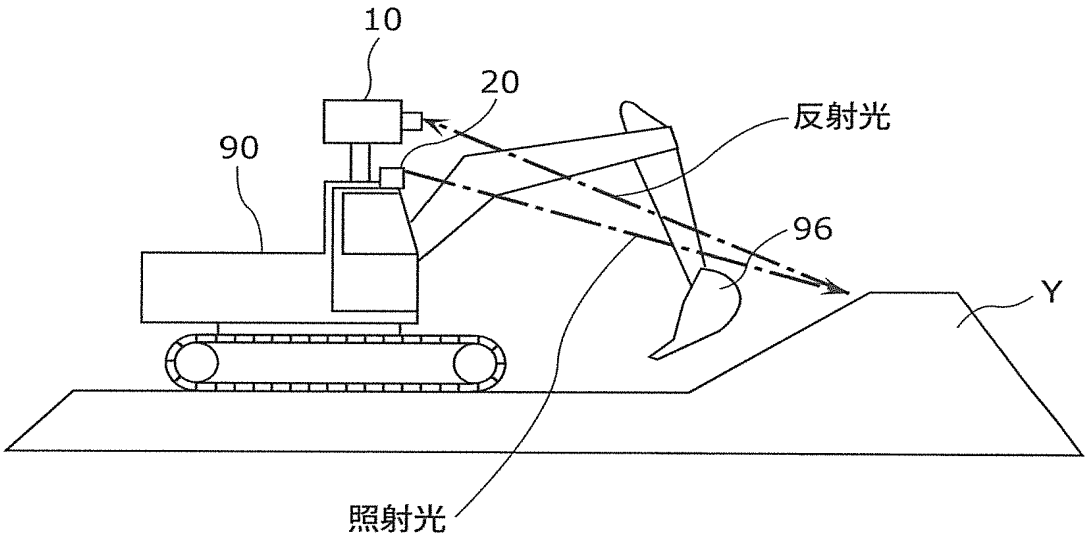
[請求項26] 前記信号発生装置は、前記第１発光パルス信号により発生した照射光の、被写体による反射光の露光を指示する露光信号を制御する

請求項２０～２５のいずれかに記載の信号発生装置。

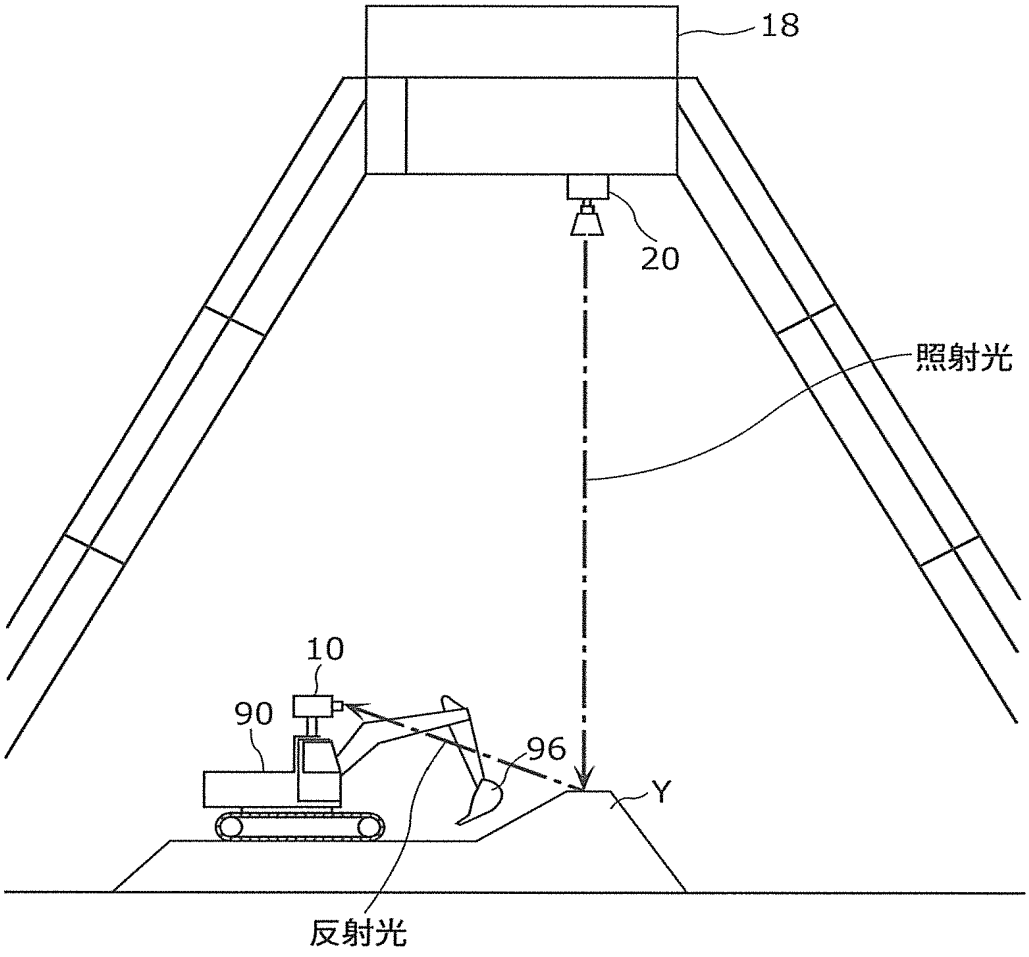
[図1]


被写体
照射光
反射光
測距システム
1
照明測距
兼用光源
20
撮像部
10
発光信号51
露光信号52
信号発生部
30
RAWデータ53
(TOF情報)
演算部
40
検知情報
(距離情報)

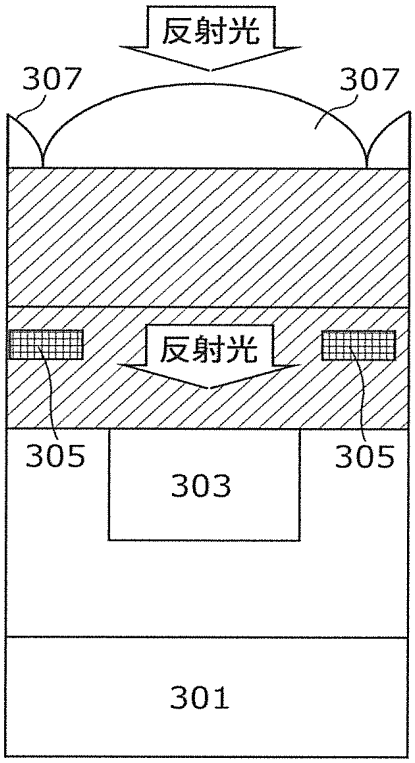
[図2]



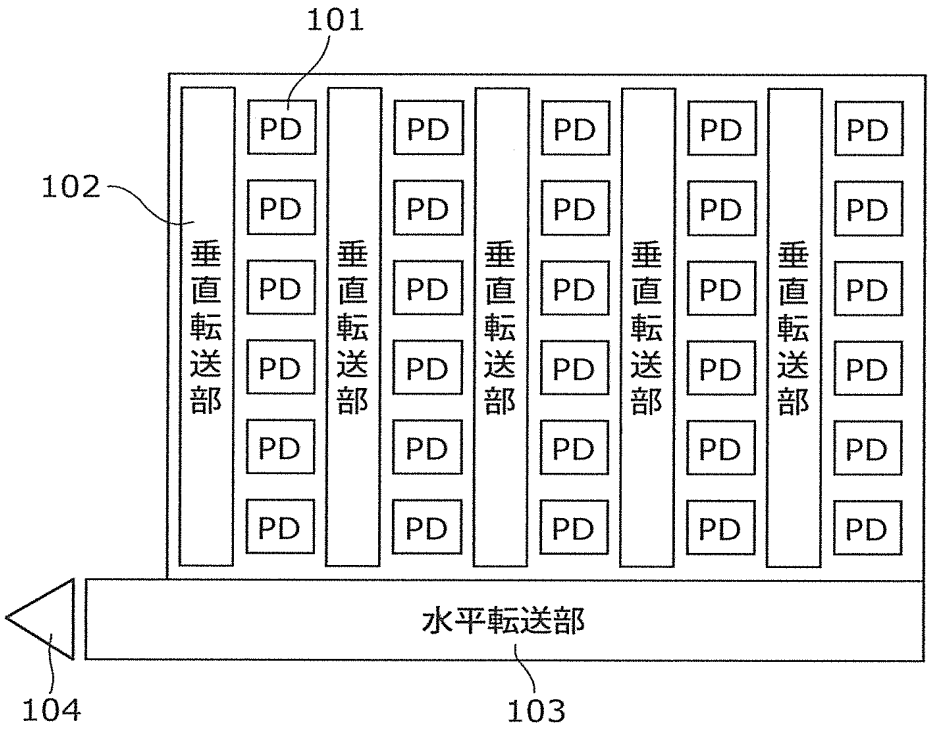
[図3]



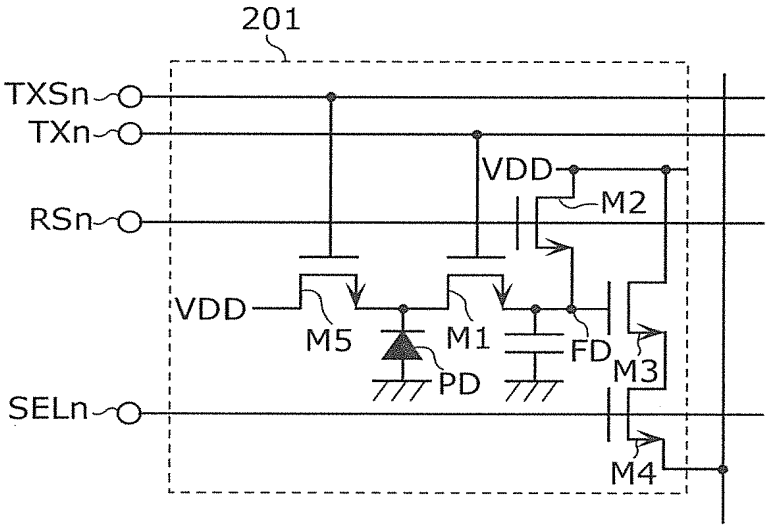
[図4]



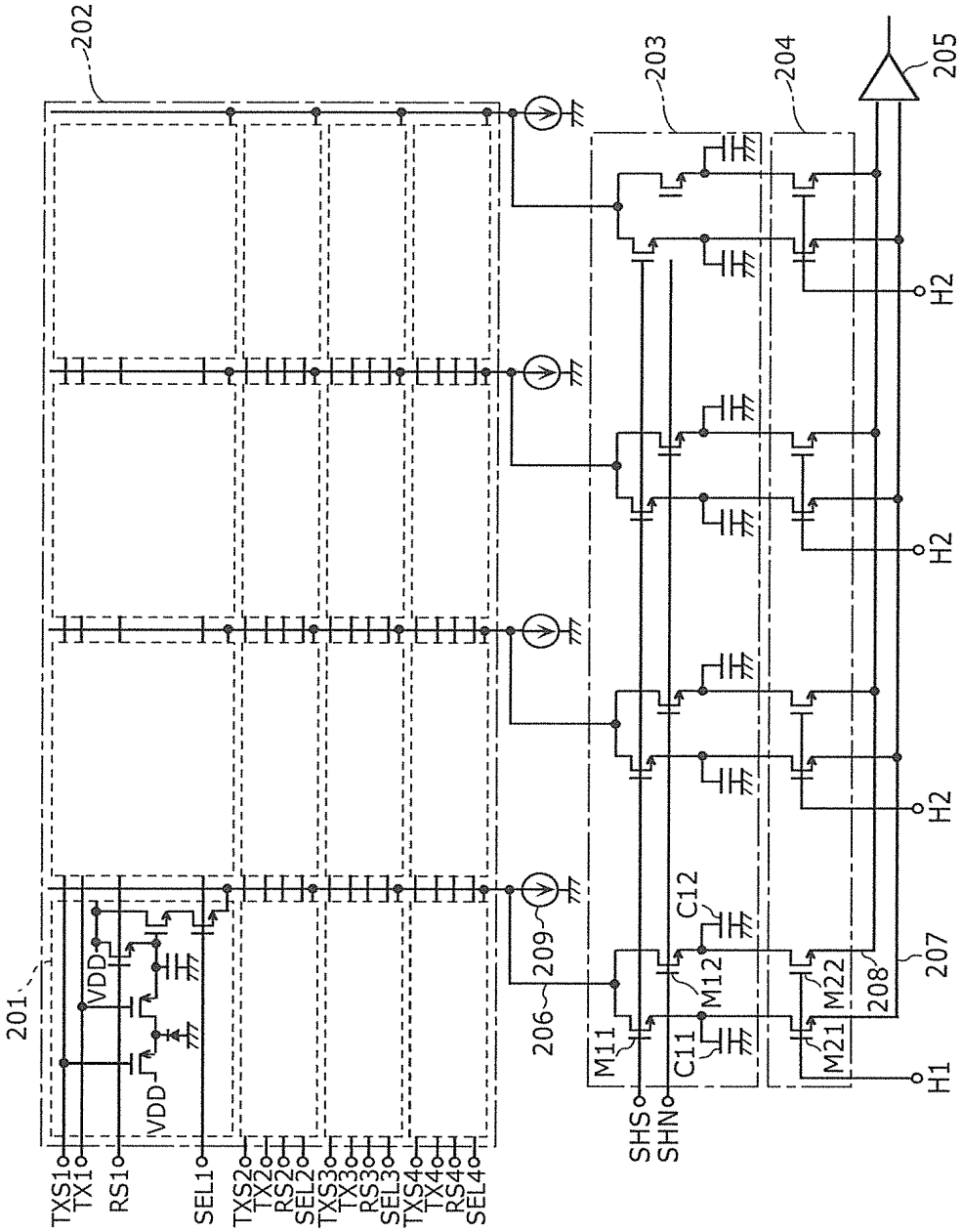
[図5]


101
102
PD
垂直転送部
水平転送部
104
103

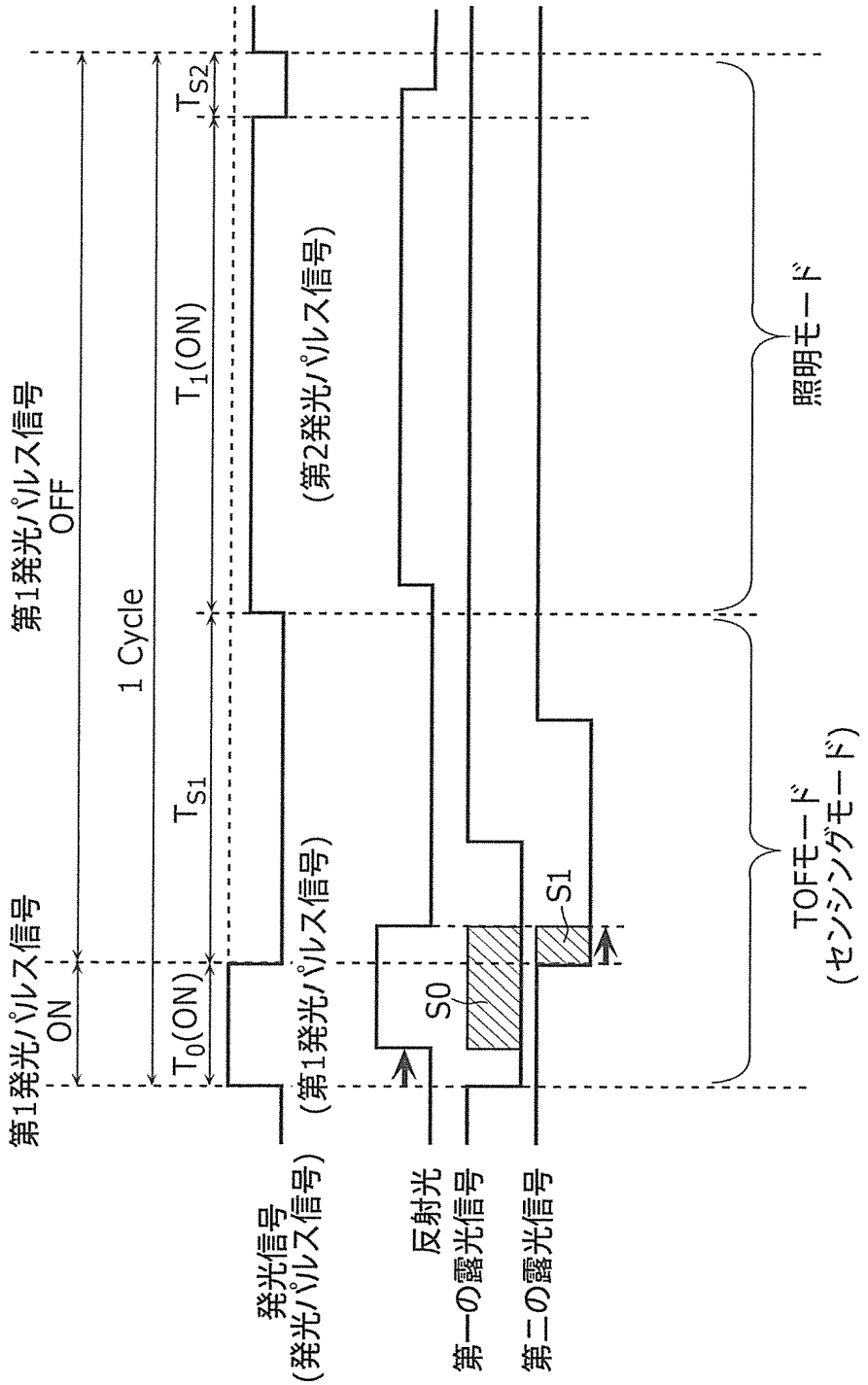
[図6]


201
TXSn
TXn
RSn
SELn
VDD
M2
M5
M1
FD
M3
M4
PD

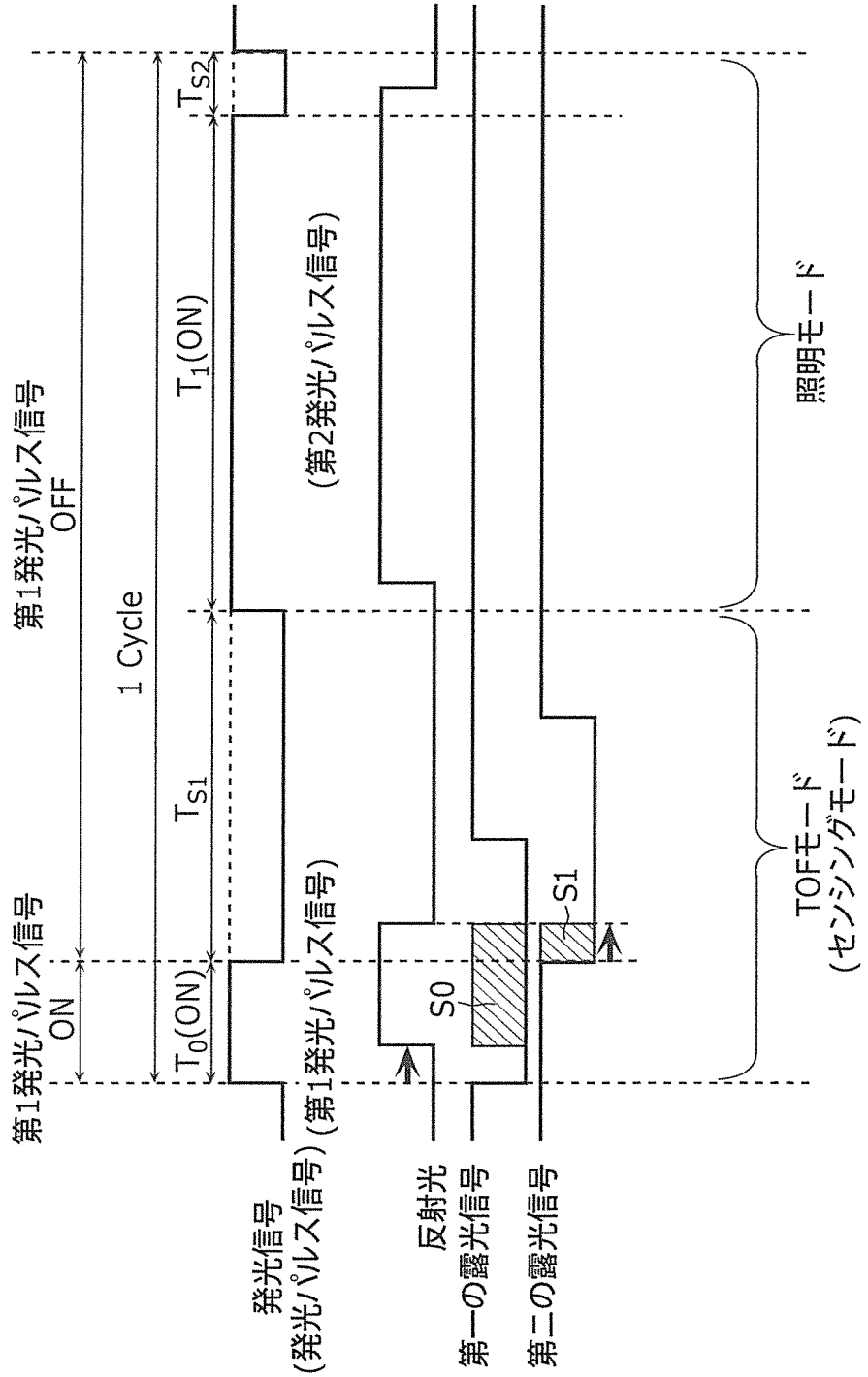
[図7]


202
203
204
205
H2
H2
H2
H1
201
VDD
VDD
209
206
C12
M12
M11
C11
M22
M21
208
207
SHS
SHN
TXS1
TX1
RS1
SEL1
TXS2
TX2
RS2
SEL2
TXS3
TX3
RS3
SEL3
TXS4
TX4
RS4
SEL4

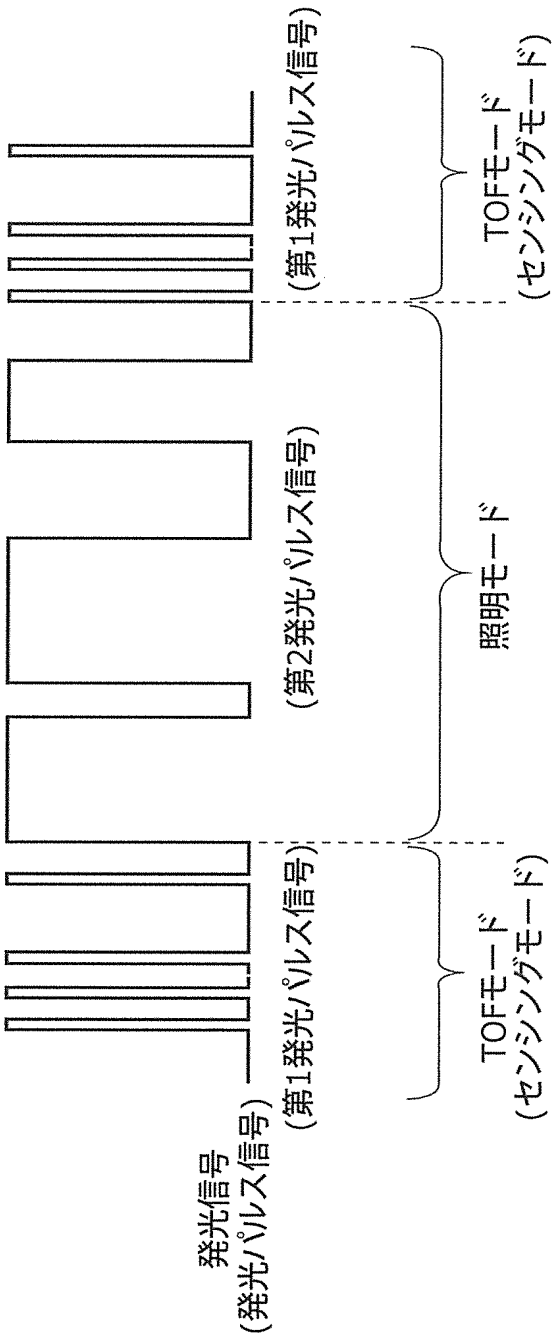
[図8]


第1発光パルス信号
ON
第1発光パルス信号
OFF
1 Cycle
T_0(ON)
T_{S1}
T_1(ON)
T_{S2}
(第1発光パルス信号)
(第2発光パルス信号)
発光信号
(発光パルス信号)
反射光
S0
S1
第一の露光信号
第二の露光信号
TOFモード
(センシングモード)
照明モード

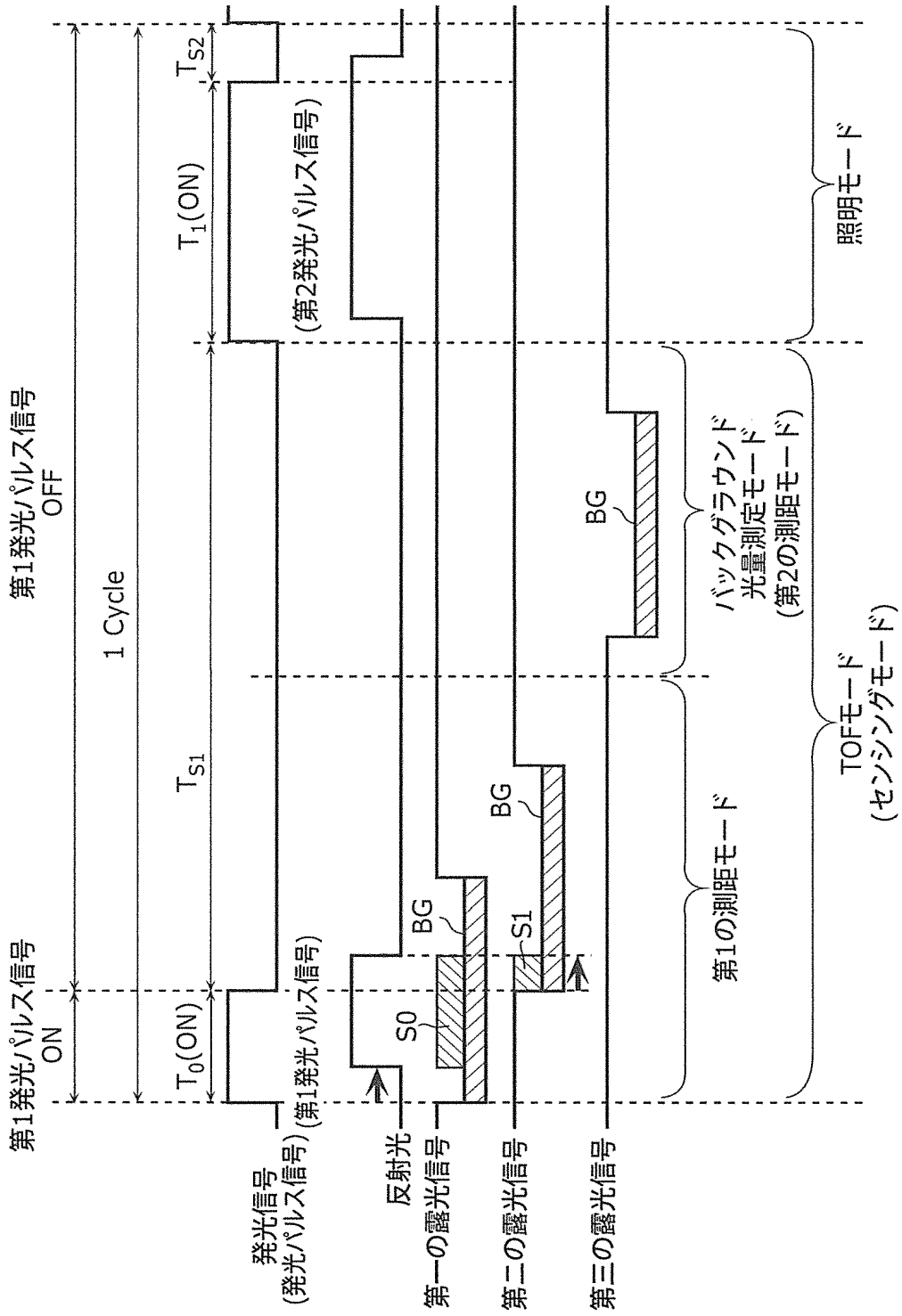
[図9A]


第1発光パルス信号
ON
第1発光パルス信号
OFF
1 Cycle
T_0(ON)
T_{S1}
T_1(ON)
T_{S2}
発光信号
(発光パルス信号)
(第1発光パルス信号)
(第2発光パルス信号)
反射光
S0
S1
第一の露光信号
第二の露光信号
TOFモード
(センシングモード)
照明モード

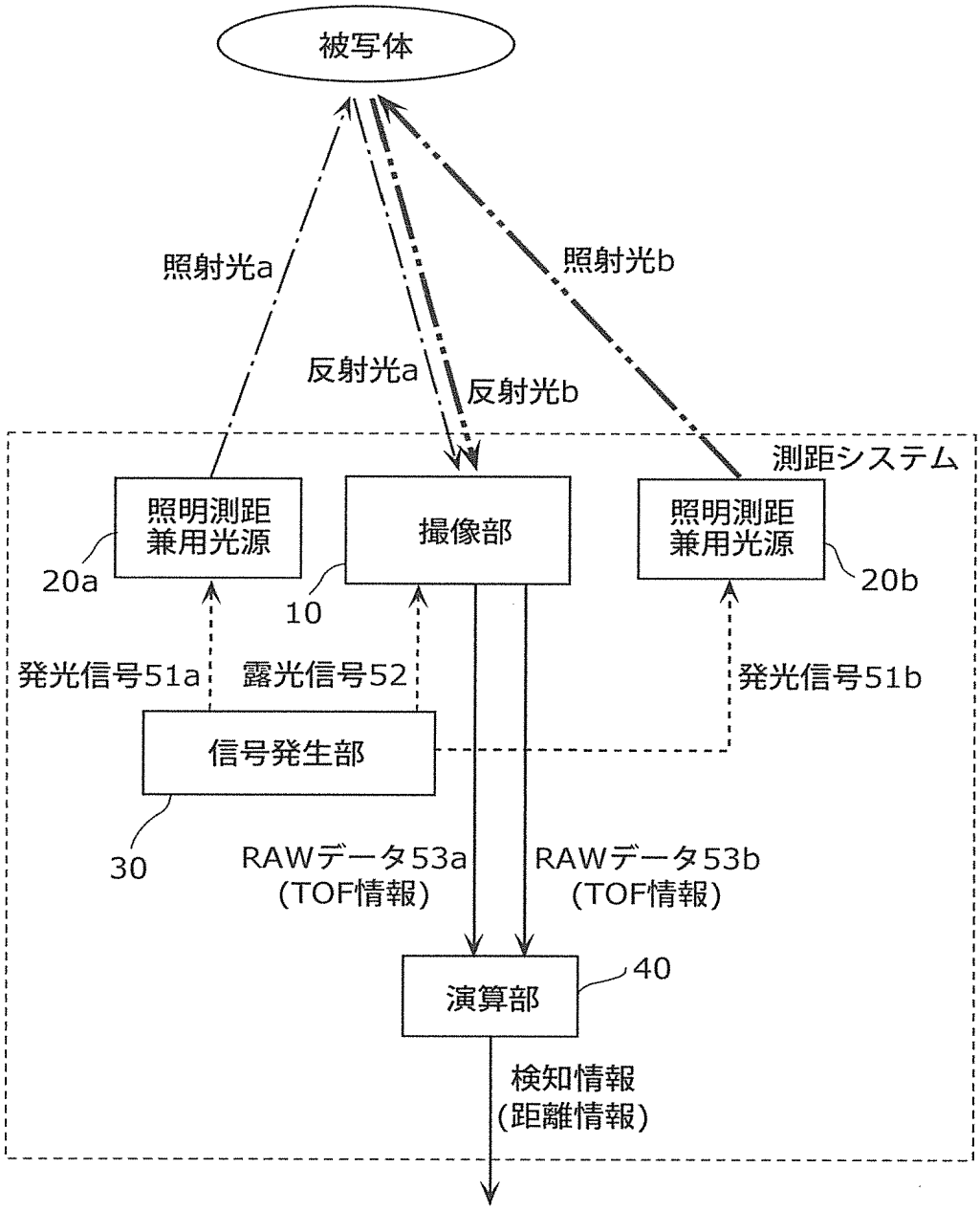
[図9B]


発光信号
(発光パルス信号)
(第1発光パルス信号)
(第2発光パルス信号)
(第1発光パルス信号)
TOFモード
(センシングモード)
照明モード
TOFモード
(センシングモード)

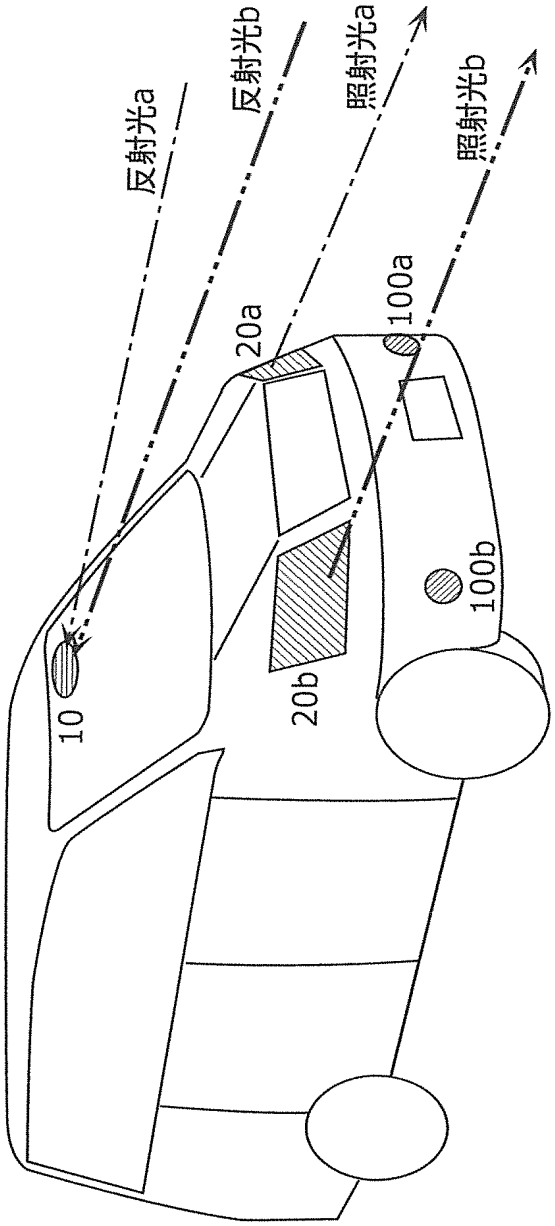
[図10]


第1発光パルス信号
ON
第1発光パルス信号
OFF
1 Cycle
T_0(ON)
T_{S1}
T_1(ON)
T_{S2}
発光信号
(発光パルス信号)
(第1発光パルス信号)
(第2発光パルス信号)
反射光
S0
BG
第一の露光信号
S1
BG
第二の露光信号
BG
第三の露光信号
第1の測距モード
バックグラウンド
光量測定モード
(第2の測距モード)
TOFモード
(センシングモード)
照明モード

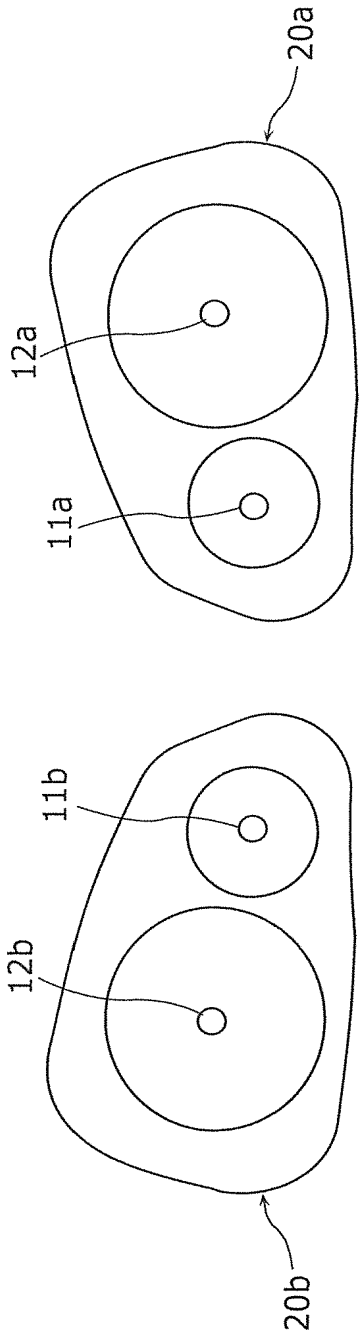
[図11]


被写体
照射光a
照射光b
反射光a
反射光b
測距システム
照明測距
兼用光源
20a
撮像部
10
照明測距
兼用光源
20b
発光信号51a
露光信号52
発光信号51b
信号発生部
30
RAWデータ53a
(TOF情報)
RAWデータ53b
(TOF情報)
演算部
40
検知情報
(距離情報)

[図12]



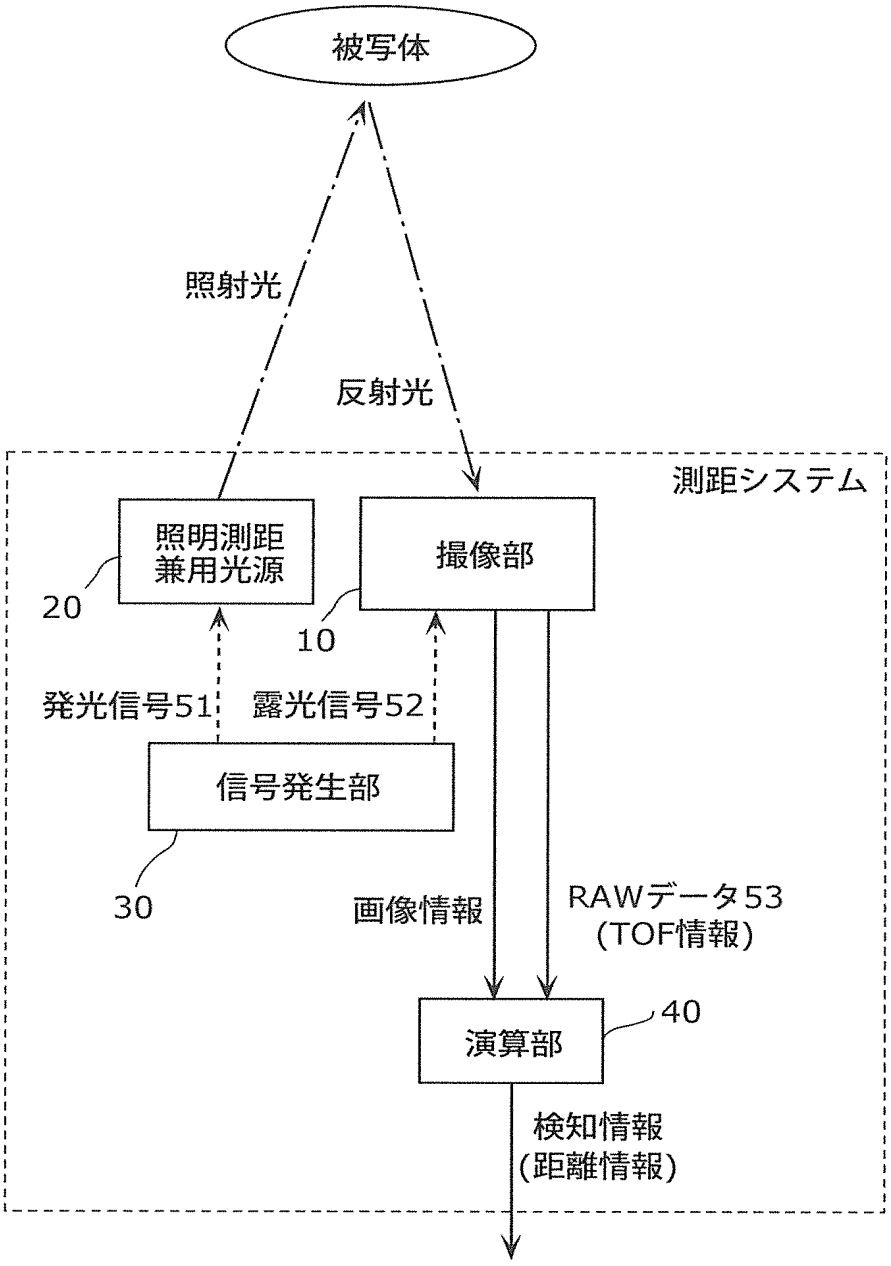
[図13A]



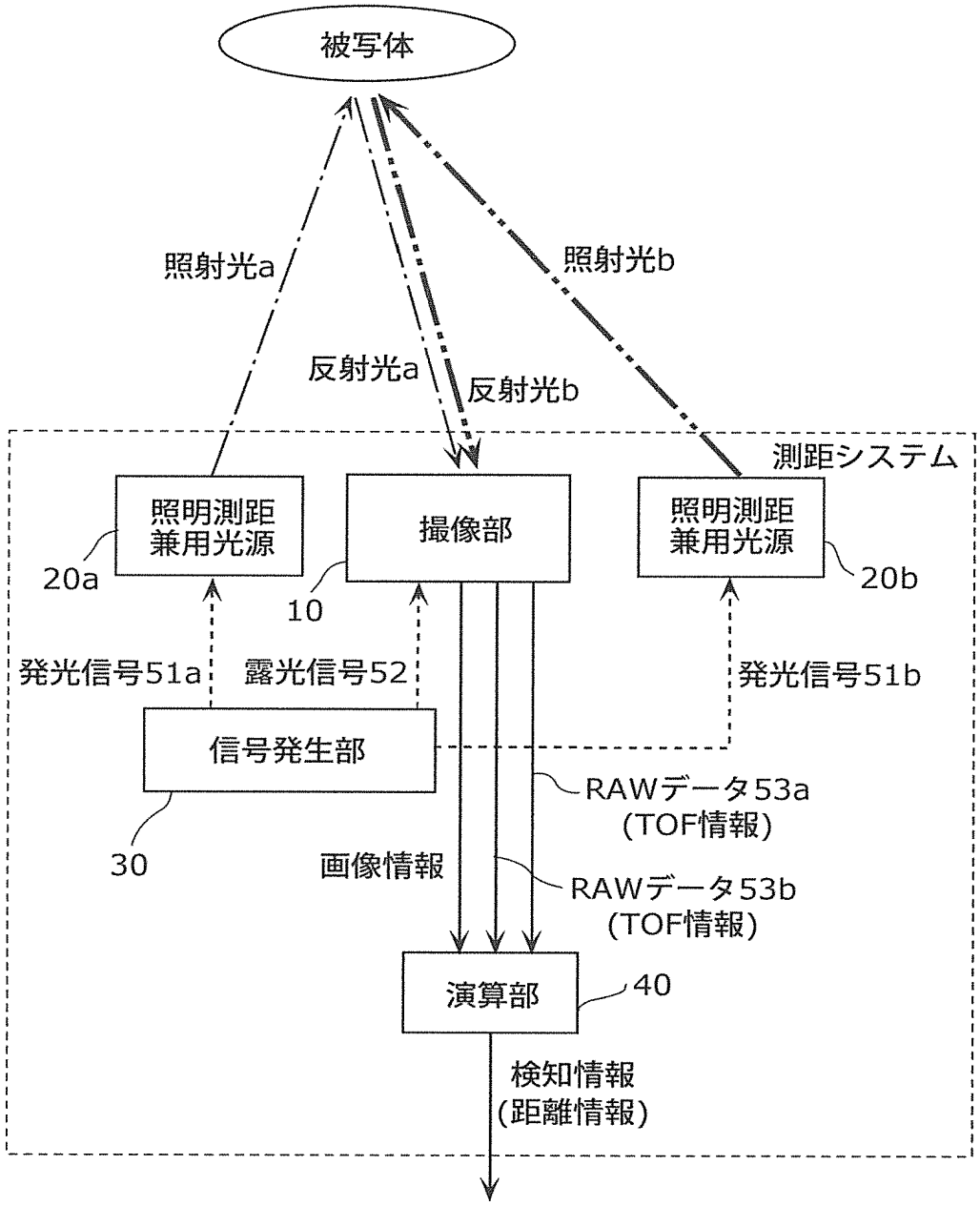
[図13B]

	第1の測距モード	照明モード
組A	ロービーム	ロービーム
組B	ハイビーム	ハイビーム
組C	ロービーム	ハイビーム
組D	ハイビーム(赤外光)	ロービーム

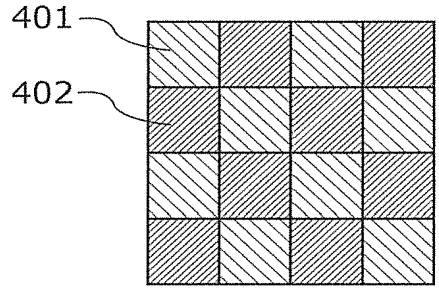
[図14A]


被写体
照射光
反射光
測距システム
照明測距
兼用光源
20
撮像部
10
発光信号51
露光信号52
信号発生部
30
画像情報
RAWデータ53
(TOF情報)
演算部
40
検知情報
(距離情報)

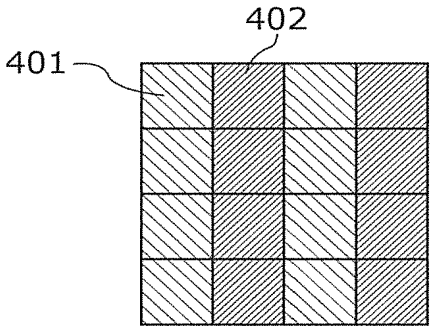
[図14B]


被写体
照射光a
照射光b
反射光a
反射光b
測距システム
照明測距
兼用光源
撮像部
照明測距
兼用光源
20a
10
20b
発光信号51a
露光信号52
発光信号51b
信号発生部
RAWデータ53a
(TOF情報)
30
画像情報
RAWデータ53b
(TOF情報)
演算部
40
検知情報
(距離情報)

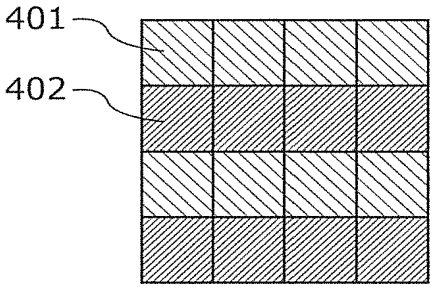
[図15A]



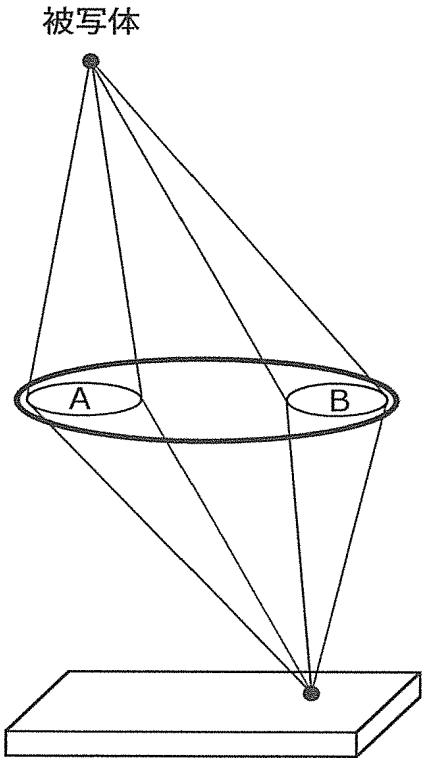
[図15B]



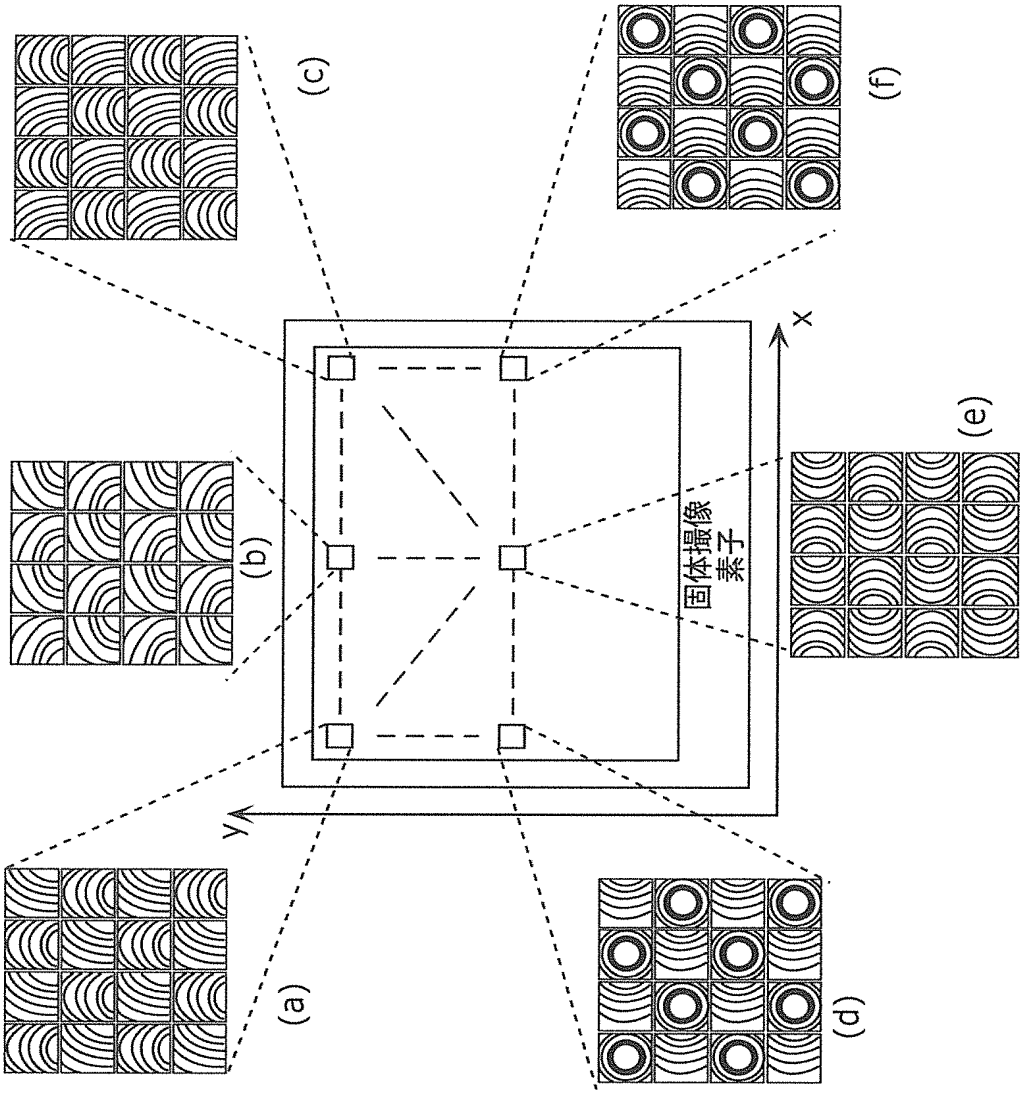
[図15C]



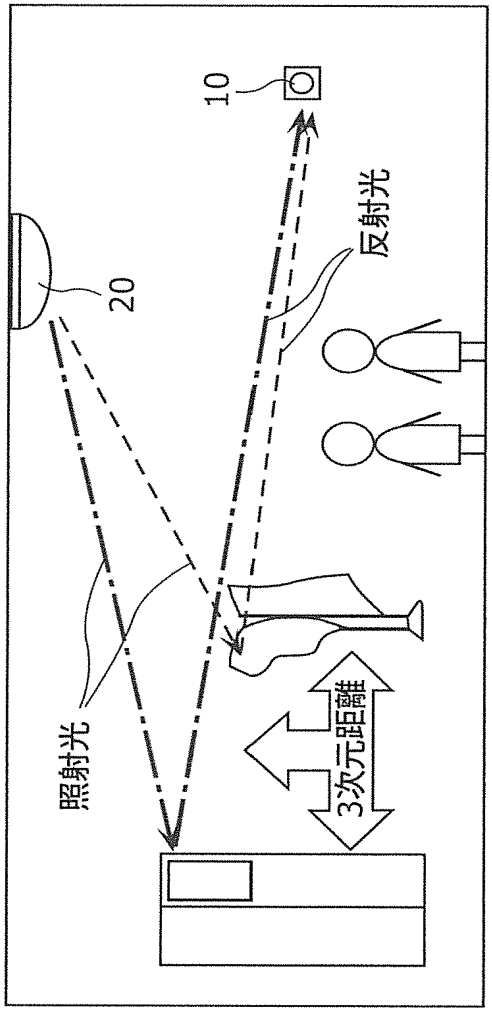
[図15D]



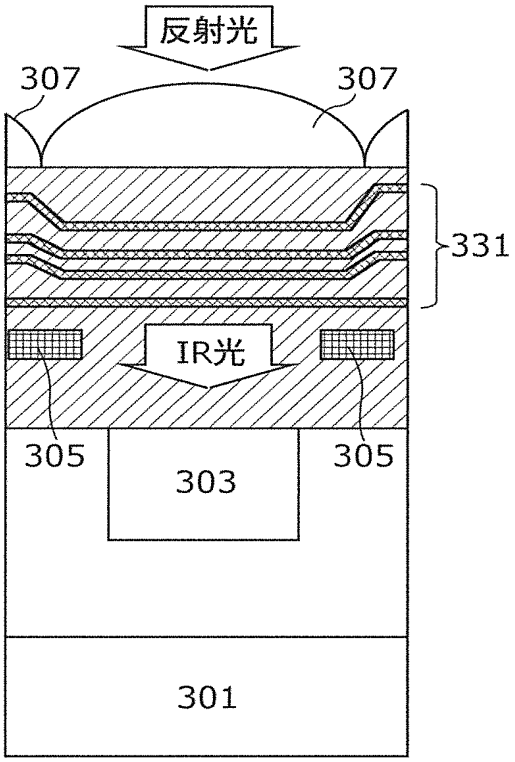
[図16]



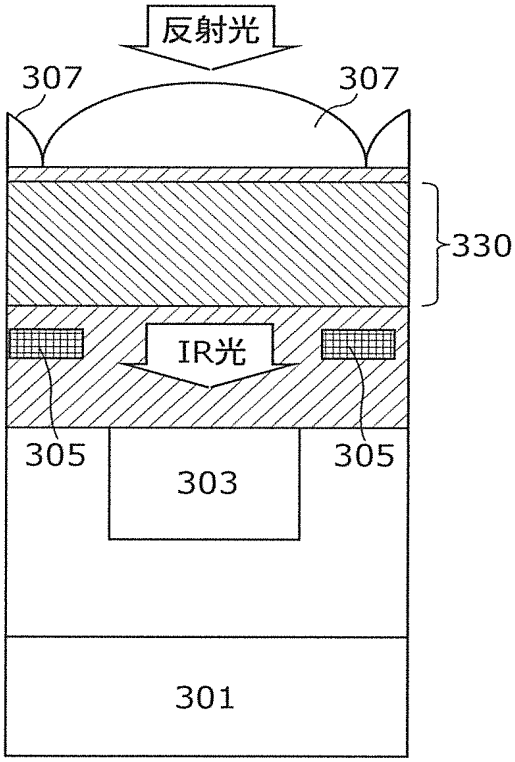
[図17]



[図18A]


反射光
307
307
331
IR光
305
305
303
301

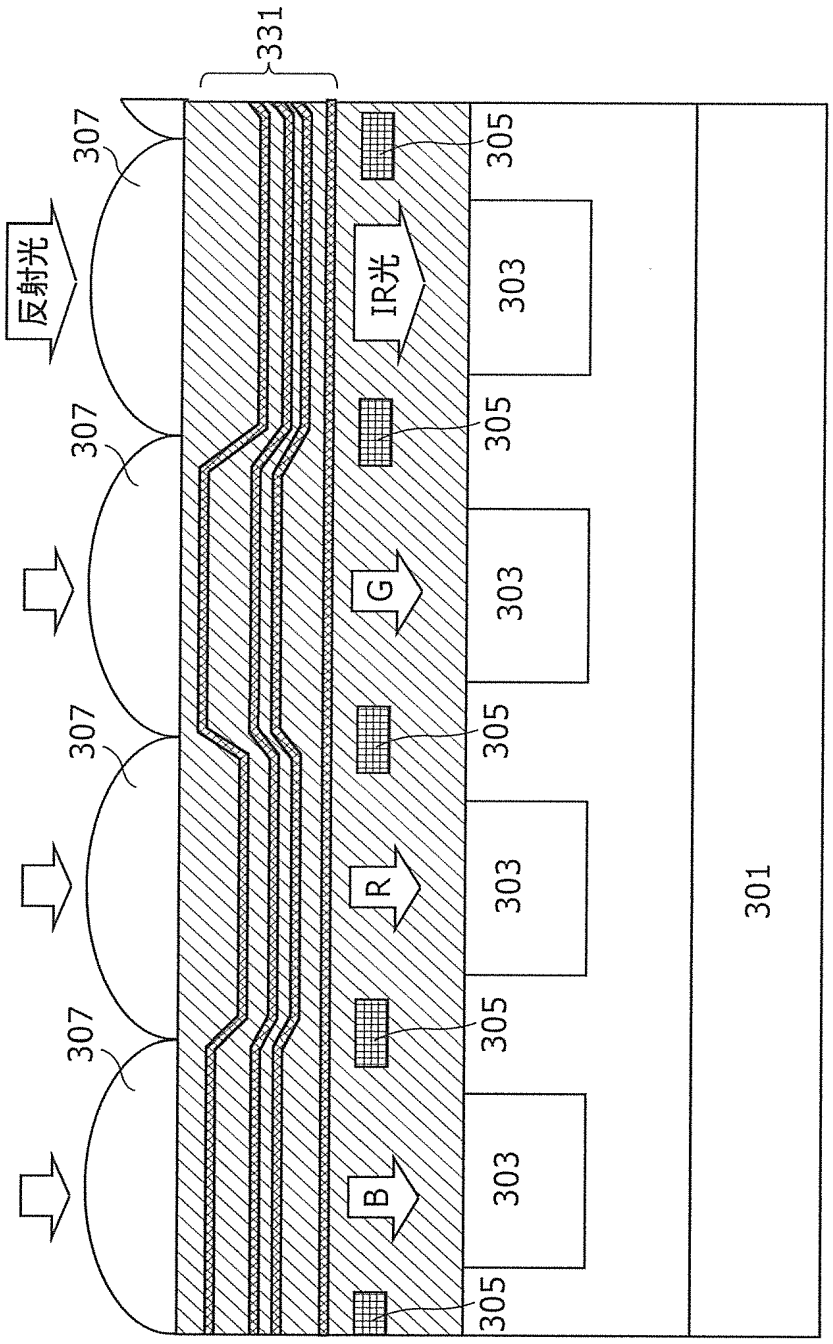
[図18B]


反射光
307
307
330
IR光
305
305
303
301

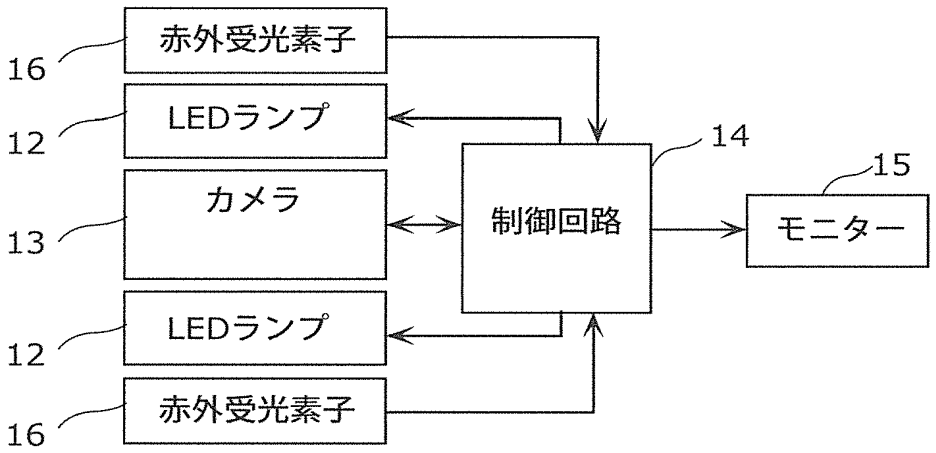
[図19]

R+IR	G+IR	R+IR	G+IR
IR	B+IR	IR	B+IR
R+IR	G+IR	R+IR	G+IR
IR	B+IR	IR	B+IR

[図20]


331
307
307
307
307
反射光
IR光
G
R
B
305
305
305
305
305
303
303
303
303
301

[図21]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/004146

A. CLASSIFICATION OF SUBJECT MATTER
G01C3/06(2006.01)i, *B60R21/00*(2006.01)i, *G01S7/484*(2006.01)i, *G01S17/10*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60R21/00-21/13, 21/34-21/38, G01B11/00-11/30, G01C3/00-3/32, G01S7/48-7/51, 17/00-17/95

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010-535334 A (Koninklijke Philips Electronics N.V.), 18 November 2010 (18.11.2010), entire text; all drawings & US 2010/0271617 A1 & EP 2176678 A0 & WO 2009/016551 A2 & KR 10-2010-0054138 A & CN 101772711 A	1-26
Y	JP 2002-191554 A (Asahi Optical Co., Ltd.), 09 July 2002 (09.07.2002), paragraphs [0015] to [0034]; all drawings & US 2002/0082474 A1	1-26
Y	JP 2000-83260 A (Asahi Optical Co., Ltd.), 21 March 2000 (21.03.2000), paragraphs [0014] to [0058]; all drawings (Family: none)	1-26

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 October, 2014 (31.10.14)	11 November, 2014 (11.11.14)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

HESAI EX1002, P.407

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/004146

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2013-120133 A (Fujitsu Ltd.), 17 June 2013 (17.06.2013), paragraphs [0002] to [0007]; fig. 1 to 2B (Family: none)	9-19 1-8,20-26
Y A	JP 2006-318059 A (Olympus Corp.), 24 November 2006 (24.11.2006), paragraphs [0046] to [0055] & US 2008/0089557 A1 & EP 1901225 A1 & WO 2006/121088 A1	9-19 1-8,20-26
Y A	JP 2004-279284 A (Mitsubishi Heavy Industries, Ltd.), 07 October 2004 (07.10.2004), paragraph [0035] (Family: none)	11-19 1-10,20-26
Y A	WO 2012/122572 A2 (SIONYX, INC.), 13 September 2012 (13.09.2012), page 12, line 16 to page 14, line 31 & US 2013/0062522 A1 & EP 2684221 A2 & CN 103636006 A & JP 2014-514733 A & KR 10-2014-0014230 A	13-19 1-12,20-26
Y A	JP 10-239029 A (Olympus Optical Co., Ltd.), 11 September 1998 (11.09.1998), paragraph [0029]; fig. 5, 6 (Family: none)	14-19 1-13,20-26
Y A	JP 2012-209913 A (Toshiba Corp.), 25 October 2012 (25.10.2012), paragraphs [0045] to [0047] & US 2012/0236190 A1 & CN 102683363 A & KR 10-2012-0106560 A & TW 201300926 A	15-19 1-14,20-26

国際調査報告

国際出願番号　ＰＣＴ／ＪＰ２０１４／００４１４６

Ａ．　発明の属する分野の分類（国際特許分類（ＩＰＣ））

Int.Cl.　G01C3/06(2006.01)i, B60R21/00(2006.01)i, G01S7/484(2006.01)i, G01S17/10(2006.01)i

Ｂ．　調査を行った分野

調査を行った最小限資料（国際特許分類（ＩＰＣ））

Int.Cl.　B60R21/00-21/13, 21/34-21/38, G01B11/00-11/30, G01C3/00-3/32, G01S7/48-7/51, 17/00-17/95

最小限資料以外の資料で調査を行った分野に含まれるもの

日本国実用新案公報	１９２２－１９９６年
日本国公開実用新案公報	１９７１－２０１４年
日本国実用新案登録公報	１９９６－２０１４年
日本国登録実用新案公報	１９９４－２０１４年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

Ｃ．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求項の番号
Y	JP 2010-535334 A (コーニンクレッカ　フィリップス　エレクトロニクス　エヌ　ヴィ) 2010.11.18, 全文, 全図 & US 2010/0271617 A1 & EP 2176678 A0 & WO 2009/016551 A2 & KR 10-2010-0054138 A & CN 101772711 A	１－２６
Y	JP 2002-191554 A (旭光学工業株式会社) 2002.07.09, 段落【００１５】－【００３４】, 全図 & US 2002/0082474 A1	１－２６

☑　Ｃ欄の続きにも文献が列挙されている。　　☐　パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー
「Ａ」特に関連のある文献ではなく、一般的技術水準を示すもの
「Ｅ」国際出願日前の出願または特許であるが、国際出願日以後に公表されたもの
「Ｌ」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「Ｏ」口頭による開示、使用、展示等に言及する文献
「Ｐ」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「Ｔ」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「Ｘ」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Ｙ」特に関連のある文献であって、当該文献と他の１以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「＆」同一パテントファミリー文献

国際調査を完了した日 ３１．１０．２０１４	国際調査報告の発送日 １１．１１．２０１４
国際調査機関の名称及びあて先 日本国特許庁（ＩＳＡ／ＪＰ） 郵便番号１００－８９１５ 東京都千代田区霞が関三丁目４番３号	特許庁審査官（権限のある職員）　２Ｓ　９７０５ 神谷　健一 電話番号　０３－３５８１－１１０１　内線　３２５８

様式ＰＣＴ／ＩＳＡ／２１０（第２ページ）（２００９年７月）

Ｃ（続き）．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求項の番号
Ｙ	JP 2000-83260 A（旭光学工業株式会社）2000.03.21，段落【００１４】－【００５８】，全図（ファミリーなし）	１－２６
Ｙ Ａ	JP 2013-120133 A（富士通株式会社）2013.06.17，段落【０００２】－【０００７】，図１－２Ｂ（ファミリーなし）	９－１９ 1-8，20-26
Ｙ Ａ	JP 2006-318059 A（オリンパス株式会社）2006.11.24，段落【００４６】－【００５５】 & US 2008/0089557 A1 & EP 1901225 A1 & WO 2006/121088 A1	９－１９ 1-8，20-26
Ｙ Ａ	JP 2004-279284 A（三菱重工業株式会社）2004.10.07，段落【００３５】（ファミリーなし）	１１－１９ 1-10，20-26
Ｙ Ａ	WO 2012/122572 A2（SIONYX，INC.）2012.09.13，１２頁１６行－１４頁３１行 & US 2013/0062522 A1 & EP 2684221 A2 & CN 103636006 A & JP 2014-514733 A & KR 10-2014-0014230 A	１３－１９ 1-12，20-26
Ｙ Ａ	JP 10-239029 A（オリンパス光学工業株式会社）1998.09.11，段落【００２９】，図５，６（ファミリーなし）	１４－１９ 1-13，20-26
Ｙ Ａ	JP 2012-209913 A（株式会社東芝）2012.10.25，段落【００４５】－【００４７】 & US 2012/0236190 A1 & CN 102683363 A & KR 10-2012-0106560 A & TW 201300926 A	１５－１９ 1-14，20-26

Espacenet

Bibliographic data: WO2015025497 (A1) — 2015-02-26

DISTANCE MEASUREMENT SYSTEM AND SIGNAL GENERATION DEVICE

Inventor(s): ITO JUNJI; YAMADA TOHRU; FUJII TOSHIYA ± (ITO, JUNJI, ; YAMADA, TOHRU, ; FUJII, TOSHIYA)

Applicant(s): PANASONIC IP MAN CO LTD [JP] ± (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD)

Classification: - international: ***B60R21/00; G01C3/06; G01S17/10; G01S7/484***
- cooperative: **G01S17/003 (EP, US); G01S17/10 (EP, US); G01S17/86 (EP, US); G01S17/87 (EP, US); G01S17/894 (EP, US); G01S7/4814 (EP, US)**

Application number: WO2014JP04146 20140808 Global Dossier

Priority number(s): JP20130173529 20130823

Also published as: CN105452807 (A) JP6459069 (B2) JPWO2015025497 (A1) US10151835 (B2) US2016161611 (A1) more

Abstract of WO2015025497 (A1)

A distance measurement system (1) is provided with: a signal generation unit (30) for generating a light emission signal instructing that light be irradiated and an exposure signal instructing that exposure to reflected light be carried out; a first light source unit for illumination and distance measurement (20) that carries out, upon receiving the light emission signal, illumination not intended for distance measurement and carries out light irradiation for distance measurement using reflected light; an imaging unit (10) for receiving the exposure signal, carrying out exposure, and acquiring a reflected light exposure amount; and a calculation unit (40) for using the exposure amount to calculate and output distance information. The distance measurement system (1) has, as operation modes, an illumination mode for making the first light source unit for illumination and distance measurement carry out illumination and a first distance measurement mode for carrying out first distance measurement by making the first light source unit for illumination and distance measurement irradiate light and making the imaging unit operate.

Patent Translate
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DESCRIPTION WO2015025497A1

10 Distance measurement system and signal generator The present disclosure relates to a ranging system and a signal generator.

12 FIG. 21 is a conventional detection system disclosed in Patent Document 1 among various detection systems proposed so far.

14 This detection system is used for automobiles, and includes an LED lamp 12 as an infrared light source provided in the front part of the automobile, a camera 13 as an imaging means, and a control circuit 14 as a control means provided inside the automobile. And a monitor 15 as a display means.

18 Further, the LED lamp 12 is a light source different from the headlight light source for illuminating the darkness, is provided near the end of the bumper of the automobile, and is configured to emit near-infrared light having a wavelength of 880 nm, for example.

21 Further, as an active type system, the camera 13 is composed of a solid-state image sensor having sensitivity to near infrared rays emitted from the LED lamp 12, and performs image imaging by near infrared rays.

24 The monitor 15 uses a dedicated monitor provided in the passenger compartment of an automobile or a monitor such as a car navigation system, and the above-mentioned imaging screen is displayed on the screen, or as a so-called head-up display, the inner surface of the windshield. The above-mentioned imaging screen is projected on the screen provided in the above.

29 Further, the infrared light receiving element 16 detects infrared rays emitted by a pedestrian, an animal, or the like as a passive type system.

31 However, in the prior art disclosed in Patent Document 1, it is necessary to install a light source for brightening darkness and the like and a light source (LED lamp 12) for oscillating near-infrared light for taking an image with the camera 13. Therefore, there is a problem that it is difficult to reduce the size and weight of the system (device).

35 Further, in recent years, in order to improve the performance of the detection system and expand its applications, it is particularly required to accurately acquire distance information.

37 In view of the above problems, a distance measuring system and a signal generating device

having a miniaturization, weight reduction and high distance measuring accuracy of the system (device) are provided.

40 In order to solve the above problems, the distance measuring system according to one aspect of the present disclosure uses a signal generating unit that generates a light emitting signal instructing light irradiation and an exposure signal instructing exposure of reflected light, and the light emitting signal. A first illumination distance measuring light source unit that receives and performs illumination that is not intended for distance measurement and the light irradiation for distance measurement by reflected light, and the exposure signal is received and the exposure is performed. An imaging unit that acquires the exposure amount of the reflected light and a calculation unit that calculates and outputs distance information using the exposure amount are provided, and the first illumination distance measuring light source unit is provided with the illumination. The operation mode includes an illumination mode and a first distance measurement mode in which the first distance measurement is performed by irradiating the first illumination distance measurement combined light source unit with the light and operating the image pickup unit.

53 According to this configuration, one light source (light source unit for both illumination and distance measurement) is used not only for lighting but also for distance measurement. Therefore, compared with the case where the lighting system and the distance measurement system are installed independently. It is possible to easily reduce the size and weight of the distance measuring system. Moreover, since the light source unit for both illumination and distance measurement is a light source that is also used for illumination, it is possible to obtain reflected light in a sufficient amount for distance measurement, so that the distance measurement accuracy can be improved.

61 Further, in the distance measuring system according to one aspect of the present disclosure, the amplitude of the light emitted from the first illumination distance measuring combined light source unit in the first distance measuring mode is the amplitude of the light emitted from the first illumination in the lighting mode. The amplitude may be larger than the amplitude of the light emitted from the light source unit for distance measurement.

66 According to this configuration, the distance measurement accuracy can be further improved.

67 Further, in the distance measuring system according to one aspect of the present disclosure, the lighting time width of the light emitted from the first illumination distance measuring combined light source unit in the first distance measuring mode is the first in the lighting mode. The lighting time width of the light emitted from the light source unit for both illumination and distance measurement may be shorter.

72 According to this configuration, the distance measurement accuracy can be further improved.

73 Further, the distance measuring system according to one aspect of the present disclosure further includes a mode in which the imaging unit is operated and the calculation unit measures the amount of background light while the first illumination distance measuring light source unit is turned off. In addition, the calculation unit may make a correction for subtracting the background light amount from the exposure amount in the first ranging mode.

78 According to this configuration, the distance measurement accuracy can be further improved.

79 Further, in the distance measuring system according to one aspect of the present disclosure,

the first illumination distance measuring combined light source unit may be equipped with a single color LED or a plurality of color LEDs.

82 Further, in the distance measuring system according to one aspect of the present disclosure, the switching between the first distance measuring mode and the lighting mode may be at least 120 times / sec.

85 Further, the distance measuring system according to one aspect of the present disclosure further includes a second lighting distance measuring light source unit, and the calculation unit further includes a phase difference between the first and second lighting distance measuring light source units. Distance measurement may be performed using the information.

89 Further, in the distance measuring system according to one aspect of the present disclosure, the first and second illumination distance measuring combined light sources are (a) left of the left and right high beam light sources and the left and right low beam light sources provided in the vehicle. And right high beam light sources, and (b) left and right low beam light sources.

93 Further, in the distance measuring system according to one aspect of the present disclosure, the calculation unit may perform the second distance measurement by comparing the current frame and the previous frame using the image signal from the imaging unit. Good.

96 Further, in the distance measuring system according to one aspect of the present disclosure, the calculation unit uses one of the distance information obtained by the first and second distance measuring as the distance information of the first and second distance measuring. You may make a correction.

100 Further, in the distance measuring system according to one aspect of the present disclosure, the first and second distance measuring may be used properly depending on the day and night, the weather, the distance to the subject, or the movement speed of the subject or the distance measuring system. Good.

104 Further, in the distance measuring system according to one aspect of the present disclosure, the image pickup unit may include a solid-state image sensor, and the solid-state image sensor may be a CCD-type solid-state image sensor.

107 Further, in the distance measuring system according to one aspect of the present disclosure, the image pickup unit includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels is read from the light receiving unit for photoelectric conversion and the light receiving unit. The solid-state image sensor may be a MOS-type solid-state image sensor that includes a storage unit that stores the signal charges that have been generated, and collectively reads the signal charges of the light-receiving unit into the storage unit in the plurality of pixels. ..

114 Further, in the distance measuring system according to one aspect of the present disclosure, the image pickup unit includes a solid-state image pickup element having a plurality of pixels, and each of the plurality of pixels has a different refractive index with an axis perpendicular to the light receiving surface as a central axis. A microlens having a structure in which the materials of the above are repeatedly arranged concentrically may be provided.

119 Further, in the ranging system according to one aspect of the present disclosure, the image pickup unit includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels transmits an infrared transmission filter, red light, and infrared rays. The

filter, a second filter that transmits green light and infrared rays, and a third filter that transmits blue light and infrared rays may be provided.

124 Further, in the distance measuring system according to one aspect of the present disclosure, at least one of the infrared transmission filter and the first to third filters may be a filter in which an inorganic material is laminated.

127 Further, the distance measuring system according to one aspect of the present disclosure may be mounted on a heavy machine or a structure of the heavy machine and a work site.

129 Further, the distance measuring system according to one aspect of the present disclosure may be mounted on a transportation device.

131 Further, the distance measuring system according to one aspect of the present disclosure may be mounted on the housing equipment.

133 Further, the signal generator according to one aspect of the present disclosure is a signal generator that controls a light emission pulse signal, and the signal generator controls a plurality of types of the light emission pulse signals and the plurality of types of light emission pulses. The signal includes a first emission pulse signal instructing light irradiation for performing distance measurement and a second emission pulse signal instructing lighting of lighting not intended for distance measurement, and the second emission pulse signal is OFF. When becomes, the first emission pulse signal is turned ON.

140 According to this configuration, the distance measurement accuracy can be improved.

141 Further, in the signal generator according to one aspect of the present disclosure, the period during which the first emission pulse signal is ON may be shorter than the period during which the second emission pulse signal is ON.

144 According to this configuration, the distance measurement accuracy can be further improved.

145 Further, in the signal generator according to one aspect of the present disclosure, the second emission pulse signal may be turned ON after repeating the period during which the first emission pulse signal is ON a plurality of times.

148 Further, in the signal generator according to one aspect of the present disclosure, the total of the number of times the first emission pulse signal is turned ON and the number of times the second emission pulse signal is turned ON may be at least 120 times / second. ..

151 Further, in the signal generator according to one aspect of the present disclosure, the amplitude of the first emission pulse signal may be larger than the amplitude of the second emission pulse signal.

154 Further, in the signal generator according to one aspect of the present disclosure, the first emission pulse signal may be used for distance measurement by Time Of Flight.

156 Further, the signal generator according to one aspect of the present disclosure may control an exposure signal for instructing exposure of the reflected light by the subject of the irradiation light generated by the first emission pulse signal.

159 According to the distance measuring system and the signal generator according to the present disclosure, it is possible to realize miniaturization, weight reduction and high distance measuring accuracy of the system (device).

162 FIG. 1 is a functional block diagram showing a schematic configuration of a distance measuring system according to the first embodiment. FIG. 2 is a schematic mounting

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diagram showing a mounting example of the distance measuring system according to the first embodiment. FIG. 3 is a schematic mounting diagram showing a mounting example of the distance measuring system according to the first embodiment. FIG. 4 is a cross-sectional view showing the structure of the pixels of the solid-state image sensor according to the first embodiment. FIG. 5 is a functional configuration diagram of the CCD type solid-state image sensor according to the first embodiment. FIG. 6 is a circuit diagram showing a configuration of a unit cell of the MOS type solid-state image sensor according to the first embodiment. FIG. 7 is a schematic configuration diagram of a MOS image sensor in which unit cells according to the first embodiment are arranged two-dimensionally. FIG. 8 is a first timing chart showing an operation example using the light emission signal and the exposure signal according to the first embodiment. FIG. 9A is a second timing chart showing an operation example using the light emission signal and the exposure signal according to the first embodiment. FIG. 9B is a diagram showing an operation example in which the light emitting signal according to the first embodiment is continuously operated a certain number of times in the TOF mode or the illumination mode. FIG. 10 is a third timing chart showing an operation example using the light emission signal and the exposure signal according to the first embodiment. FIG. 11 is a functional block diagram showing a schematic configuration of the distance measuring system according to the second embodiment. FIG. 12 is a schematic mounting diagram showing an example in which the distance measuring system according to the second embodiment is mounted on an automobile. FIG. 13A is a diagram showing details of the first and second illumination ranging light sources of the ranging system according to the second embodiment. FIG. 13B is a diagram showing an example of a combination of a high beam light source and a low beam light source in the TOF mode (first distance measurement mode) and the illumination mode of the distance measurement system according to the second embodiment. FIG. 14A is a functional block diagram showing a schematic configuration of a distance measuring system including a single illumination distance measuring combined light source according to the third embodiment. FIG. 14B is a functional block diagram showing a schematic configuration of a distance measuring system including the first and second illumination distance measuring combined light sources according to the third embodiment. FIG. 15A is a diagram showing a first arrangement example of microlenses of the solid-state image sensor according to the third embodiment. FIG. 15B is a diagram showing a second arrangement example of the microlenses of the solid-state image sensor according to the third embodiment. FIG. 15C is a diagram showing a third arrangement example of the microlens of the solid-state image sensor according to the third embodiment. FIG. 15D is an explanatory diagram showing an optical path between the solid-state image sensor according to the third embodiment and the lens and the subject.

200 FIG. 16 is a planar structure diagram showing the arrangement and structure of the microlenses of the solid-state image sensor according to the embodiment for each unit cell group. FIG. 17 is a diagram showing an example in which the distance measuring system according to the fourth embodiment is mounted on a housing equipment. FIG. 18A is a cross-sectional structure diagram illustrating the details of the IR transmission filter (photonic type) with respect to the pixels of the image sensor mounted on the distance measuring

system according to the embodiment. FIG. 18B is a cross-sectional structure diagram illustrating the details of the IR transmission filter (organic material type) with respect to the pixels of the image sensor mounted on the ranging system according to the embodiment. FIG. 19 is a plan view of the solid-state image sensor according to the embodiment. FIG. 20 is a cross-sectional structural view of the solid-state image sensor according to the embodiment. FIG. 21 is a functional block diagram showing a schematic configuration of a detection system of the prior art.

213 Hereinafter, the distance measuring system according to the embodiment of the present disclosure will be described with reference to the drawings. It should be noted that the following embodiments all show specific examples of the present disclosure, and numerical values, shapes, materials, components, arrangement positions of components, connection forms, etc. are examples. It is not limited.

218 (Embodiment 1) The ranging system (sensing system) according to the first embodiment generates a plurality of types of light emission signals (light emission pulse signals) instructing light irradiation and an exposure signal instructing exposure of reflected light (Embodiment 1). A first signal generator (signal generator) to control), illumination that receives a light emission signal and is not intended for distance measurement (sensing), and light irradiation for distance measurement (sensing) by reflected light. It is equipped with a light source unit that also serves as an illumination distance measuring device, an imaging unit that receives an exposure signal for exposure and acquires an exposure amount of reflected light, and a calculation unit that calculates and outputs distance information using the exposure amount. An illumination mode in which the first illumination distance measuring light source unit is illuminated without operating the imaging unit and the calculation unit, and a light irradiation mode in which the first illumination distance measuring light source unit is irradiated to operate the imaging unit. It is characterized in that it has a first ranging mode (sensing mode) in which the first ranging is performed as an operation mode.

233 FIG. 1 is a functional block diagram showing a schematic configuration of a distance measuring system according to the first embodiment.

235 As shown in the figure, the distance measurement system (detection system) 1 includes an imaging unit 10, an illumination distance measurement combined light source 20 (first illumination distance measurement combined light source unit), a signal generation unit 30, and a calculation unit 40. And.

239 The illumination distance measuring light source 20 has a drive circuit, a capacitor, and a light emitting element, and emits light by supplying the electric charge held in the capacitor to the light emitting element. As the light emitting element, other light emitting elements such as a laser diode and a light emitting diode (LED) may be used.

243 Further, the illumination distance measuring light source 20 is used as both an illumination light source for brightening darkness and the like without the purpose of distance measurement and a distance measuring light source for detecting a physical quantity such as a distance. For example, as shown in FIG. 12 described later, when it is used for a transportation device (for example, an automobile), it is also used as a headlight or a tog

lamp.

249 Further, as the LED used as the light source 20 for both illumination and distance measurement, a monochromatic LED (for example, a white LED) can be used.

251 Further, as the LED used as the light source 20 for both illumination and distance measurement, a plurality of color LEDs (for example, a red LED and a blue LED. (Yellow LED, etc.) may be combined. In this case, if a light source on the long wavelength side (for example, red LED) is used for distance measurement, the attenuation due to diffused particles such as fog is reduced, and compared to the case where white is used. You can measure the distance farther.

257 Further, as the LED of a plurality of colors, for example, a white LED can be combined with a red LED, a blue LED, a yellow LED, etc. In this case, for example, a white LED having a shorter wavelength when receiving strong sunlight in the evening or the like. When it is raining, use a light source with a long wavelength that can reduce the attenuation due to scattering (for example, red LED), and at night, depending on the road conditions, the light source on the side of the side instead of the oncoming lane is stronger. By properly using the LED to increase the reach, it is possible to measure the distance with high accuracy in any weather and environmental conditions.

265 In addition, by combining LEDs of multiple types of colors such as red LED, blue LED, and yellow LED, distance measurement using near-infrared light selectively from the wavelength range of light oscillated from the illumination light source can be performed. You can also do it.

269 Further, the signal generation unit 30 generates a light emission signal (first light emission pulse signal, second light emission pulse signal) 51 instructing light irradiation and an exposure signal 52 instructing exposure of reflected light from the subject. The illumination distance measuring light source 20 irradiates the subject with light for distance measurement according to the timing of receiving the light emitting signal (first light emitting pulse signal) 51 generated by the signal generating unit 30, and the light emitting signal generated by the signal generating unit 30. According to the timing of receiving the (second light emission pulse signal) 51, light irradiation for brightening the darkness is performed without the purpose of distance measurement.

278 The image pickup unit 10 has a circuit that creates and outputs RAW data 53 such as a camera lens, a solid-state image sensor (image sensor), and an A / D converter. The present embodiment also includes a case where a circuit for creating and outputting RAW data 53 such as an A / D converter is mounted on a solid-state image sensor.

282 Further, the image pickup unit 10 exposes the region including the target object (subject) a plurality of times according to the timing indicated by the exposure signal 52 generated by the signal generation unit 30, and corresponds to the sum of the exposure amounts of the plurality of times. RAW data 53 (TOF (Time Of Light) information) is output.

286 Further, the calculation unit 40 calculates based on the RAW data 53 received from the imaging unit 10, and outputs distance information (detection information) to the subject.

288 In the present embodiment, a part or all of the signal generation unit 30, the image pickup unit 10, and the calculation unit 40 may be mounted on the semiconductor substrate on a

single chip.

291 2 and 3 are schematic mounting diagrams showing a mounting example of the distance measuring system of FIG. FIG. 2 is a schematic view showing the details of the light source 20 for both illumination and distance measurement and the image pickup unit 10 when mounted on a shovel car which is a heavy machine.

295 In FIG. 2, the excavator car 90 is equipped with a light source 20 for both illumination and distance measurement and an image pickup unit 10, and the image pickup section 10 is mounted on the upper part of the upper swing body of the excavator car 90. Further, an arm is provided at the front portion of the vehicle in the upper swing body of the excavator car 90, and a bucket 96 for scooping the bulk material is provided at the tip end portion of the arm. In addition, the upper swivel body can swivel 360 degrees.

301 Further, in FIG. 3, the excavator car 90 is equipped with the image pickup unit 10, and the light source 20 for both illumination and distance measurement is installed in the structure 18 at the construction site.

304 If the distance measuring system 1 according to the present embodiment is mounted on a heavy machine or a heavy machine and a structure at a work site, for example, the distance to an obstacle when digging the ground or the like can be accurately measured, that is, , Automatically digs down to a certain distance or a distance to an obstacle (for example, Y point in Fig. 2 and Fig. 3), and automatically stops operation when it deviates from the expected distance (or approaches the expected distance). It will be possible to perform automatic operation even though it is a compact and lightweight distance measuring system 1.

312 Although heavy machinery is mounted in FIGS. 2 and 3, the example is not limited to this, and for example, other heavy machinery (bulldozer, etc.) and transportation equipment (automobile, bicycle, motorcycle, railroad vehicle, airplane, spacecraft) are shown. Etc.), transportation equipment and infrastructure equipment, housing equipment, etc., can be installed in all types of equipment.

317 Further, FIG. 4 is a cross-sectional view showing the structure of the pixels of the solid-state image sensor according to the present embodiment.

319 The solid-state image sensor in the figure includes a semiconductor substrate 301, a light receiving unit (PD) 303, metal wiring, a gate electrode or a transfer electrode 305, a microlens 307, and the like. The reflected light from the subject is collected by the microlens 307 and reaches the light receiving unit (PD) 303.

323 As the solid-state image sensor according to the present embodiment, an image sensor having sensitivity only to infrared rays (hereinafter referred to as IR) can be used, and a red region, a green region and a blue region (hereinafter referred to as RGB) can be used. , And an image sensor having sensitivity to IR (hereinafter referred to as RGB + IR) can be used. The details when RGB + IR are used will be described later.

328 Next, a case where a CCD type solid-state image sensor is used for the image pickup unit 10 of the distance measurement system 1 according to the present embodiment will be described.

331 FIG. 5 is a functional configuration diagram of a CCD type solid-state image sensor. As shown

in the figure, the CCD type solid-state imaging device includes a light receiving unit (photodiode, PD) 101, a plurality of vertical transfer units 102, a horizontal transfer unit 103, and a signal charge detection unit 104.

335 The photodiode 101 converts the received light into an electric charge. The vertical transfer unit 102 is composed of a plurality of gates, and sequentially transfers the electric charge read from the photodiode 101 in the vertical direction. The horizontal transfer unit 103 sequentially transfers the electric charges received from the vertical transfer unit 102 as packets by the plurality of gates composed of the plurality of gates in the horizontal direction. The signal charge detection unit 104 sequentially detects the charges received from the horizontal transfer unit, converts them into voltage signals, and outputs RAW data (TOF information) 53.

343 Further, since the time difference of the light detected in each PD can be eliminated by the operation of resetting the plurality of photodiodes (PD) 101 at once, so-called global reset, the delay of the light to the object to be measured can be measured. It is possible to realize high-precision distance measurement using.

347 Although FIG. 5 shows a CCD image sensor (CCD type solid-state image sensor), a MOS image sensor can also be used in the present embodiment. This MOS image sensor includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels includes a light receiving unit for photoelectric conversion and a storage unit for accumulating signal charges read from the light receiving unit. The MOS image sensor is characterized in that the signal charges of the light receiving unit are collectively read out to the storage unit in a plurality of pixels.

354 FIG. 6 is an example of a MOS type solid-state image sensor used in the image pickup unit 10 of the distance measurement system 1 according to the present embodiment, and is a circuit diagram showing the configuration of the unit cell 201 in the MOS image sensor. Here, n is an integer from 1 to 4.

358 From FIG. 6, each unit cell 201 is a PD which is a light receiving unit, a shutter transistor M5 for resetting (discharging) the signal charge accumulated in the PD by setting the shutter signal TXSn to H, and an storage unit. Floating diffusion (FD), a read transistor M1 for reading the signal charge accumulated in the PD to the FD by setting the transfer signal TXn to H, and reading to the FD by setting the reset signal RSn to H. A reset transistor M2 for resetting the signal charge, a source follower transistor M3 whose gate is connected to the FD, and a line selection transistor M4 which connects the source follower transistor M3 to the vertical signal line by setting the selection signal SELn to H. It is composed of and. The drains of the reset transistor M2, the source follower transistor M3, and the shutter transistor M5 are connected to the pixel electrode VDD.

368 FIG. 7 is a schematic configuration diagram of a MOS image sensor in which the unit cells 201 of FIG. 6 are arranged two-dimensionally.

370 The MOS image sensor of FIG. 7 has an imaging region 202 in which unit cells 201 are arranged in a two-dimensional manner in 4 rows and 4 columns, and fixed pattern noise (fixed pattern noise: FPN) generated by variations in the transistor threshold voltage for each column. It is composed of an FPN removing unit 203 for removing, a horizontal selection

unit 204 for sequentially selecting the output signal of the FPN removing unit 203, and a differential amplifier 205 for amplifying the output signal of the horizontal selection unit 204. There is. The imaging region 202 has a small size of 4 rows and 4 columns for convenience of explanation.

378 The rows of the imaging region 202 are sequentially selected by a vertical scanning unit (not shown). A current source 209 is connected to the vertical signal line 206 of each row. Each row of the FPN removing unit 203 includes a sample transistor M11 for a signal level that receives the sample hold signal SHS, a sample transistor M12 for a reset level that receives the sample hold signal SHN, a capacitance Cll for the signal level, and a reset level. It is composed of the capacity C12 of. Each row of the horizontal selection unit 204 includes a first row selection transistor M21 interposed between the capacitance Cll for the signal level and the first horizontal signal line 207, the capacitance C12 for the reset level, and the second horizontal signal. It is composed of a second column selection transistor M22 interposed between the line 208. Each row of the horizontal selection unit 204 is sequentially selected by signals H1 to H4 from a horizontal scanning unit (not shown). The differential amplifier 205 amplifies the potential difference between the first horizontal signal line 207 and the second horizontal signal line 208.

391 The solid-state image sensor shown in FIGS. 6 and 7 is characterized by including a storage unit (FD in FIG. 6) for collectively reading and accumulating PD signal charges in all pixels, and a plurality of photos in the imaging region 2. The diode PD can be reset at once, that is, the global shutter & global reset function is realized even if it is a MOS type.

395 However, the solid-state image sensor according to the present embodiment is not limited to the CCD type and MOS type image sensors shown in FIGS. 5, 6 and 7, and other requirements are taken into consideration as the distance measuring system 1. Therefore, it is possible to obtain the effects (improvement of distance measurement accuracy, etc.) described later by using another solid-state image sensor (image sensor).

400 Next, the operation method of the distance measuring system according to the present embodiment will be described in detail with reference to the timing charts of FIGS. 8, 9A and 10. 8, 9A, and 10 are first to third timing charts showing operation examples based on the light emission signal and the exposure signal. In the present embodiment, any operation of the first to third timing charts can be used.

405 First, as the first driving method, the driving operation at the time of distance measurement (TOF mode) will be described with reference to FIG. 8. The light emitting signal 51 includes a first light emitting pulse signal for instructing light irradiation for distance measurement. The first emission pulse signal is turned ON when the second emission pulse signal is OFF, and the first emission pulse signal is generated by the TOF, including the second emission pulse signal for instructing the lighting of lighting not for the purpose of distance measurement. It is used to measure the distance. Further, based on the basic principle of TOF, which measures the distance from the time required for the projected light to reciprocate to the object, the irradiation light generated by the light emission signal (first light emission pulse signal) 51 depends on the measurement target which is the subject. The exposure signal 52 that instructs the exposure of the reflected light is controlled by two patterns of different.

timings of the first exposure signal and the second exposure signal, so that the object to be measured is up to the object to be measured based on the ratio of the amount of each exposed light. Calculate the distance of. For example, the first exposure signal is used for exposure so as to include all the reflected light from the measurement target object, and the second exposure signal delays the reflected light from the measurement target object with respect to the emission timing. Perform exposure so that the amount of exposure increases. Further, in order to detect an offset component such as background light, the light emitting signal 51 is stopped to perform exposure under the same conditions as the first exposure signal and the second exposure signal.

425 Then, the total exposure amount S0 by the first exposure signal, the total exposure amount S1 by the second exposure signal, the total exposure amount BG of the background light, the time width T0 of the emission signal 51 of the direct light to be irradiated, and the light velocity. The distance L from each value of c to the subject is calculated (see Equation 1).

429 Further, at the timing of the light emission signal 51, the first exposure signal, and the second exposure signal on one screen, the light emission signal (first light emission pulse signal) 51 and the first exposure signal are repeatedly output a plurality of times, and then light is emitted. The signal (first emission pulse signal) 51 and the second exposure signal are repeatedly output the same number of times, and then the emission signal (first emission pulse signal) 51 is stopped to stop the first exposure signal and the second exposure signal. The exposure signal 52 under the same conditions as above is repeatedly output the same number of times.

437 This series of timings may be set as one set, and after repeating the output of a plurality of sets, the accumulated exposure amount may be output and the distance to the subject may be calculated by (Equation 1).

440 Subsequently, the drive operation during illumination (illumination mode) will be described with reference to FIG. 8. The operation is performed so that the amplitude of light is higher in the TOF mode (sensing mode) than in the illumination mode. That is, the amplitude of the first emission pulse signal is larger than the amplitude of the second emission pulse signal, so that the amplitude of the light emitted from the illumination distance measurement light source 20 in the TOF mode is the illumination distance measurement light source in the illumination mode. It is larger than the amplitude of the light emitted from 20.

447 As a result, the distance measurement system 1 according to the present embodiment uses both a light source for brightening darkness and the like and a light source for performing distance measurement with reflected light, thereby reducing the size and weight of the distance measurement system 1. Can be realized, and further, distance information can be accurately acquired.

452 Next, the second driving method will be described in detail with reference to FIG. 9A, focusing on the differences from the contents described with reference to FIG.

454 First, the driving in the illumination mode is the same as the driving method shown in FIG. On the other hand, in the TOF mode (sensing mode), the same as the drive described in FIG. 8 is performed, but the series of operation times is shorter than that in the illumination mode. That is, the lighting time width is made shorter (narrower) in the TOF mode than in the

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lighting mode. In other words, the period during which the first emission pulse signal is ON is shorter than the period during which the second emission pulse signal is ON, so that the lighting time width of the light emitted from the illumination distance measuring light source 20 in the TOF mode is set. , It is shorter than the lighting time width of the light emitted from the light source 20 for both illumination and distance measurement in the illumination mode.

463 By this operation, it is possible to realize the miniaturization and weight reduction of the distance measuring system 1 as in FIG. 8, and further, it is possible to accurately acquire the distance information.

466 Next, as a third driving method, the details will be described with reference to FIG. 10, focusing on the differences from the contents described with reference to FIG.

468 In FIG. 10, the TOF mode (sensing mode) includes a first ranging mode and a background light intensity measuring mode (second ranging mode). In this example, the distance measuring system 1 includes a mode in which the imaging unit 10 is operated and the calculation unit 40 measures the background light amount with the illumination distance measuring light source 20 turned off, and the calculation unit 40 is the first. Correction is performed to reduce the amount of background light from the amount of exposure in the distance measurement mode.

475 In the first distance measuring mode, the basic operation is the same as that described with reference to FIGS. 8 and 9A. In the mode for measuring the amount of background light, a third exposure signal is added as a timing pattern for the exposure signal 52. Specifically, the drive is a mode in which the background light amount is measured with the illumination distance measurement combined light source 20 turned off (that is, the background light amount is subtracted from the received data in the TOF mode at the time of distance measurement calculation).

482 By this operation, the distance measuring system 1 can be made smaller and lighter, and the distance information can be acquired more accurately.

484 Continuing to explain the operation method of the distance measuring system, in the driving methods of FIGS. 8, 9A and 10, the first emission pulse signal is turned on so that the number of times of lighting + TOF lighting is more than a certain number of times. The total of the number of times the pulse is turned on and the number of times the second light emission pulse signal is turned on is 60 times or more, more preferably 120 times or more / second. For example, the number of times of lighting + TOF lighting is 60 times or more / second, more preferably 120 times or more / second. That is, the switching between the first ranging mode and the lighting mode is set to at least 120 times / sec.

492 As a result, it is possible to prevent the light from the LED light source from feeling flickering of the eyes to the subject, pedestrians, etc., and to realize eye saving. In other words, the LED actually lights up dynamically by pulse drive at a speed of 120 times / second or more, but it seems to the human eye that it continuously emits light due to the afterimage effect, so people may feel flickering or discomfort. Protect your eyes.

497 That is, in the present embodiment, it is possible to reduce the size and weight of the distance measuring system 1 and to acquire accurate distance information and to realize eye saving for a subject, a pedestrian, and the like.

500 The distance measuring system of the present embodiment can also be driven by combining the driving methods of FIGS. 8, 9A, and 10.

502 Further, in the driving methods of FIGS. 8, 9A and 10, an example of alternately driving the TOF mode and the illumination mode has been described, but the present invention is not limited to this, and the second emission pulse signal is the first emission pulse. After repeating the period in which the signal is turned on a plurality of times, the signal may be turned on. FIG. 9B is a diagram showing an operation example of continuously operating the TOF mode or the illumination mode by the light emitting signal a fixed number of times. As shown in FIG. 9B, for example, the operation can be continuously performed a fixed number of times in the TOF mode or the lighting mode.

510 (Embodiment 2) Hereinafter, with reference to the drawings, the configuration and operation of the distance measuring system 1 according to the second embodiment will be described in detail, focusing on the differences from the contents described in the previous embodiments. To do.

514 The distance measuring system according to the second embodiment further includes the second lighting distance measuring combined light source unit, and the calculation unit 40 measures using the phase difference information of the first and second lighting distance measuring combined light source units. It is configured to perform distance. FIG. 11 is a functional block diagram showing a schematic configuration of another ranging system according to the second embodiment. Further, FIG. 12 is a case where the distance measuring system 1 is mounted on an automobile which is a transportation device, taking the second embodiment as an example, and in particular, a schematic perspective view showing details of an illumination distance measuring light source 20 and an imaging unit 10. Is. The first and second illumination distance measurement combined light source units are the illumination distance measurement combined light source units 20a and 20b.

525 In FIGS. 11 and 12, a plurality of lighting light sources 20a and 20b separated by a certain distance, such as a headlight for an automobile, are used for distance measurement for detecting a physical quantity such as a distance from the lighting light source. It is also used as a light source.

529 As a result, the imaging unit 10 receives a plurality of reflected lights of the light emitted from different positions, and outputs the plurality of RAW data 53a and 53b from the imaging unit 10 to the calculation unit 40. The calculation unit 40 corrects the TOF data by calculating the distance by the TOF using the left and right headlights and further using a plurality of RAW data 53a and 53b, that is, the second distance information using the reflected light having a phase difference as the correction information. I do. As a result, the distance measuring system of the present embodiment can perform detection with higher accuracy.

537 Further, by using light sources having different wavelengths at the time of distance measurement with respect to the illumination distance measurement light sources 20a and 20b, image data and distance data obtained from the illumination distance measurement light sources 20a and 20b can be obtained, and the object can be obtained. The shape can be captured three-dimensionally.

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542 That is, in the present embodiment, it is more preferable to apply it to a headlight system of an automobile as a plurality of illumination ranging light sources, and in this method, the path of the irradiation light a and the reflected light a, the irradiation light b, and the reflected light b. The relative position between the subject and the image sensor can be calculated from the difference in the route, and it is possible to perform distance detection with higher accuracy without significantly changing the configuration of the existing lighting equipment.

549 In FIG. 12, headlights are used as a plurality of light sources for illumination separated by a certain distance, but other light sources (for example, fog lamps 100a and 100b) can also be used.

552 Further, in FIG. 12, the imaging unit 10 is installed in the upper part of the windshield (near the rearview mirror), but the present invention is not limited to this, and for example, it can be installed in the front grill, the front bumper, or the like. is there.

555 Further, to continue the detailed description of the present embodiment, FIG. 13A is a distance measuring system 1 for an automobile using the second embodiment for an automobile application, and in particular, a first and second illumination distance measuring light source. It is a figure which showed the detail of. Of the left and right high beam light sources and the left and right low beam light sources provided in the vehicle, the first and second illumination distance measuring light sources are (a) left and right high beam light sources, and (b) left and right low beams. One of the light sources.

562 That is, the distance measuring system 1 of the present embodiment is used for the headlight of the automobile, and the high beam light sources 11a and 11b and the low beam light sources 12a and 12b are used as the first and second illumination distance measuring light sources. That is, the first illumination ranging light source includes at least one of the high beam light source 11a and the low beam light source 12a, and the second illumination ranging light source includes at least one of the high beam light source 11b and the low beam light source 12b. As a result, it is possible to measure the distance with high accuracy while sufficiently illuminating the darkness at night.

570 FIG. 13B is a diagram showing an example of a combination of high beam light sources 11a and 11b and low beam light sources 12a and 12b as the first and second illumination distance measurement combined light sources in the TOF mode (first distance measurement mode) and the illumination mode. is there.

574 Group A in FIG. 13B shows that the low beam light sources 12a and 12b are used in both the TOF mode (first ranging mode) and the illumination mode. That is, the operation in FIGS. 8 to 10 and the distance measurement using the phase difference information are performed in the set A.

578 Similarly, Group B shows that the high beam light sources 11a and 11b are used in both the TOF mode (first ranging mode) and the illumination mode. Group C shows that the low beam light sources 12a and 12b are used in the TOF mode (first ranging mode) and the high beam light sources 11a and 11b are used in the illumination mode. Group D indicates that the high beam light sources 11a and 11b are used in the TOF mode (first ranging mode) and the low beam light sources 12a and 12b are used in the illumination mode.

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584 In the case of Group D, infrared light is separately used for the high beam, and if it is synchronized with the low beam light sources 12a and 12b, the illumination that illuminates the darkness by the low beam and the glare of the subject, pedestrian, etc. by the infrared high beam. Distance measurement is possible without giving. The term "synchronization" as used herein means synchronizing the extinguishing of one of the first and second illumination distance measuring light sources and the lighting of the other.

590 In this embodiment, it is also possible to use the TOF mode, the illumination mode, and the background light amount measurement mode described in FIGS. 8, 9A, and 10 described above, and the distance measurement with higher accuracy can be achieved. Can be done.

593 Although FIGS. 12 and 13A show examples of mounting on an automobile, the present invention is not limited to this, and for example, other transportation equipment (bicycle, motorcycle, railroad vehicle, airplane, spacecraft, etc.), transportation equipment and infrastructure equipment. , Heavy machinery (excavator car, bulldozer, etc.), housing equipment, etc., can be installed in any equipment.

598 (Embodiment 3) In the third embodiment, a distance measuring system having an image ranging mode in which a second ranging is performed by comparing a current frame with a previous frame using an image signal from an imaging unit. explain.

601 Hereinafter, the configuration and operation of the distance measuring system 1 according to the third embodiment will be described with reference to the drawings, focusing on the differences from the above-described embodiment.

604 14A and 14B are functional block diagrams showing a schematic configuration of the distance measuring system 1 according to the third embodiment. Of these, FIG. 14A is a case where the single light source for both illumination and distance measurement as shown in FIG. 1 in the first embodiment is provided, and FIG. 14B is the first as shown in FIG. 11 in the second embodiment. And a case where a second light source for both illumination and distance measurement is provided.

610 From FIGS. 14A and 14B, the distance measuring system 1 includes an imaging unit 10, an illumination distance measuring light source 20, a signal generating unit 30, and a calculation unit 40.

613 The illumination distance measuring light source 20 (20a, 20b) has a drive circuit, a capacitor, and a light emitting element, and emits light by supplying the electric charge held in the capacitor to the light emitting diode. As the light emitting element, other light emitting elements such as a laser diode and a light emitting diode (LED) may be used.

617 Further, the signal generation unit 30 generates a light emitting signal 51 (51a, 51b) instructing light irradiation and an exposure signal 52 (52a, 52b) instructing exposure of reflected light from the subject. The illumination distance measuring light source 20 (20a, 20b) irradiates the subject with light for distance measurement according to the timing of receiving the light emission signal 51 generated by the signal generation unit 30.

622 Further, according to the timing of receiving the light emission signals 51 (51a, 51b) generated by the signal generation unit 30, light irradiation for brightening the darkness is performed without the purpose of distance measurement.

625 The image pickup unit 10 has a circuit that creates and outputs RAW data 53 (53a, 53b) such

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as a camera lens, a solid-state image sensor (image sensor), and an A / D converter. Further, the imaging unit 10 exposes the region including the target object (subject) a plurality of times according to the timing indicated by the exposure signals 52 (52a, 52b) generated by the signal generating unit 30, and the exposure amount is a plurality of times. RAW data 53 (53a, 53b) (TOF information) corresponding to the sum of the above are obtained.

631 Further, the image pickup unit 10 takes an image and outputs the image information to the calculation unit 40.

633 The calculation unit 40 calculates using the RAW data 53 (53a, 53b) received from the imaging unit 10 and the image information, and outputs the distance information (detection information) to the subject.

636 First, performing distance measurement in the TOF mode is the same as in the above-described embodiment.

638 Further, in the present embodiment, an image is captured and the distance is measured from the image data. As an example of the method, a continuous image is taken by the imaging unit 10, the current frame (image) and the previous frame (image) are compared, and the distance is calculated by calculation (image distance measurement mode).

642 In this way, both TOF data and image information can be used as distance information, and the distance measurement accuracy can be improved by the following usage.

644 The first usage is to use the measurement mode (distance information) properly depending on the day and night. For example, when the illumination light source is not normally turned on, such as in the daytime, in the present embodiment, the illumination distance measuring light sources 20 (20a, 20b) are turned off and the distance measurement is performed in the image distance measuring mode. Further, when the normal illumination light source is turned on at night or the like, in the present embodiment, the illumination distance measuring light sources 20 (20a, 20b) are turned on (pulse lighting drive), and the distance measurement is performed in the TOF mode. As a result, accurate distance measurement can be performed day and night without turning on the light source 20 for both illumination and distance measurement in the daytime.

654 The second usage is a method of complementing the distance information in the TOF mode with the distance information in the image distance measurement mode. With this method, the distance measurement accuracy can be further improved.

657 The third usage is a method of properly using the measurement mode (distance information) depending on the weather and environmental conditions to be handled. For example, the TOF mode is used when it is exposed to strong sunlight such as in the evening or when it is raining (that is, when image recognition is difficult), and the image distance measurement mode is used in other environments. This makes it possible to measure the distance with high accuracy in any weather and situation.

663 The fourth usage is a method of properly using the measurement mode (distance information) according to the distance to the subject. That is, for example, the TOF mode and the image ranging mode are used for a short distance up to 10 m, and the TOF mode is mainly used for a long distance of 10 m or more, for example. As a result, it is possible to measure the distance with high accuracy regardless of the distance to any subject.

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668 The fifth usage is a method of properly using the measurement mode (distance information) depending on the transportation device (for example, an automobile) equipped with this system or the movement speed of the subject. For example, when the speed of the transportation equipment is low, for example, up to 30 km / h, the TOF mode and the image ranging mode are used. For example, at the medium speed of 30 to 100 km / h, the TOF mode and the image ranging mode are used properly for each frame. For example, the TOF mode is used at high speeds of 100 km / h or more. As a result, it is possible to measure the distance with high accuracy regardless of the distance to any subject.

676 In this embodiment, it is also possible to use the TOF mode, the illumination mode, and the background light amount measurement mode described in FIGS. 8, 9A, and 10 described above, and the distance measurement with higher accuracy can be achieved. Can be done.

679 Further, if the distance measuring system 1 according to the present embodiment is mounted on a heavy machine or a heavy machine and a structure at a work site as shown in FIGS. 2 and 3 described above, it is automatically mounted until it reaches an obstacle. It is a compact and lightweight ranging system 1 that automatically stops operation when it recognizes an obstacle that cannot be dug down (the object is hard, there is a danger of explosion, etc.) from the image imaging. However, it will also be possible to perform automatic operation.

686 Further, the distance measuring system 1 of the present embodiment includes, for example, transportation equipment (bicycle, motorcycle, railroad vehicle, airplane, spacecraft, etc.), transportation equipment and infrastructure equipment, heavy equipment (excavator car, bulldozer, etc.), housing equipment equipment. It can be installed in any device.

690 (Modified Example of Embodiment 3) Hereinafter, with reference to the drawings, the configuration and operation of the ranging system 1 according to this modified example will be detailed, focusing on the differences from the contents described in the previous embodiments. Will be explained.

694 First, FIGS. 15A to 15C are diagrams showing first to third arrangement examples of unit cells (microlenses). FIG. 15D is an explanatory diagram showing an optical path between the solid-state image sensor and the lens and the subject. Regions A and B are regions in the lens, respectively.

698 In FIGS. 15A to 15C, the first unit cell 401 corresponds to the unit cell that receives the light from the region A of FIG. 15D, and the second unit cell 402 is the unit that receives the light from the region B of FIG. 15D. Corresponds to the cell.

701 In FIG. 15A, a plurality of first unit cells 401 and a plurality of second unit cells 402 are arranged in a houndstooth, and are arranged alternately in the column direction (vertical direction) and the row direction (horizontal direction). ing. In FIG. 15B, the columns of the first unit cell 401 and the columns of the second unit cell 402 are alternately arranged in the row direction. In FIG. 15C, the rows of the first unit cell 401 and the rows of the second unit cell 402 are alternately arranged in the column direction. Although three types of unit cell arrays are shown in the figure, the first unit cell 401 and the second unit cell 402 may be arranged in blocks of several cell units. By arranging in this way, two kinds of light are locally received at the same time.

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710 FIG. 16 is a planar structure diagram showing the arrangement and structure of the microlenses for each unit cell group.

712 As shown in FIG. 4 described above, the microlens 307 generally has a curved structure, and the light is bent and focused by the difference in refractive index between the microlens and the substance (gas, solid, etc.) with which the microlens comes into contact. ..

715 On the other hand, the microlens shown in FIG. 16 is separated by a line width equal to or shorter than the wavelength of the incident light on the microlens when viewed from above, and is in a direction perpendicular to the light receiving surface of the microlens. It has a plurality of light transmitting films having a concentric structure centered on the axis of, and has an effective refractive index distribution controlled by a combination of the plurality of light transmitting films. That is, it has an effective refractive index distribution as a lens due to a structure in which materials (light transmitting films) having different refractive indexes are repeatedly arranged from the central axis.

723 Further, in order to realize such a microlens, the microlens is, for example, a microlens made of an inorganic material, a so-called digital microlens. If a microlens having an upper surface pattern as shown in FIG. 16 is mounted above each unit cell, each unit cell can locally have different focusing characteristics with respect to a change in incident angle. That is, by eccentricizing the central axis from the center of the unit cell, it is possible to set the incident angle at which the amount of light (light receiving sensitivity) is maximized.

729 Therefore, since the first unit cell and the second unit cell having different incident angles that maximize the amount of light are provided next to each other, the incident light in two directions can be received at the same time, and the monocular can be used without using a so-called stereo camera. A stereoscopic image can be realized by an image sensor.

733 With this configuration, it is possible to draw a stereoscopic image without using a stereo camera (compound eye camera), and the image distance measurement mode using the stereoscopic image data enables distance measurement with even higher accuracy. You can.

736 The digital microlens described above can also be used for the microlens 307 described with reference to FIGS. 4, 18A and 18B.

738 (Embodiment 4) Hereinafter, the configuration and operation of the distance measuring system 1 according to the third embodiment will be described with reference to the drawings.

741 FIG. 17 is a diagram showing an example in which the distance measuring system 1 described in the first embodiment or the second embodiment is mounted on a housing equipment (living space). In the figure, in particular, the illumination distance measuring light source 20 and the imaging unit 10 are shown.

745 If the distance measuring system 1 according to the present embodiment is mounted on the housing equipment, for example, dimensional information in the space, arrangement information such as furniture can be automatically obtained as data, and the data can be used for mail-order sales. When purchasing furniture, etc., it is possible to automatically perform a simulation such as whether it can be installed in terms of size.

750 (Modified Example 1 of the Embodiment) Hereinafter, with reference to the drawings, the configuration and operation of the ranging system 1 according to the modified example will

be detailed, focusing on the differences from the contents described in the previous embodiments. Will be explained.

754 18A and 18B are structural cross-sectional views for explaining the details of the IR transmission filter with respect to the pixels of the image sensor mounted on the distance measuring system 1 according to the first to third embodiments.

757 In FIG. 18A, the IR transmission filter is, for example, a so-called photonic color filter 331 in which layers having different refractive indexes are periodically laminated. In the IR transmission filter, for example, by making the thickness of at least one layer of the laminated structure different for each colored light, the wavelength to be selectively transmitted by the unit cell 21 differs depending on the colored light to be detected. It is provided.

763 Further, the IR transmission filter is configured by laminating inorganic materials such as SiO2 and TiO2. The IR transmission filter is manufactured by a vacuum film forming method such as sputtering or vacuum deposition. By using an inorganic material, it is possible to form an IR transmission filter having a difference in wavelength characteristics for each unit cell 21.

768 Here, as described above in FIG. 4, the image sensor receives IR light and generates a signal charge by optimizing the structure of the light receiving unit (for example, a photodiode) (for example, optimizing the impurity profile). Therefore, it is possible to receive light and generate signal charges without an IR transmission filter. However, by mounting the IR transmission filter on the image sensor, the wavelength of the received light can be selected.

773 Further, as shown in FIG. 18B, it is possible to obtain the effect of the present disclosure by forming the IR transmission filter 330 with a general organic material for the IR transmission filter, but the IR transmission filter can be selected by forming the IR transmission filter with an inorganic material as described above. The wavelength width of the light to be emitted can be narrowed.

778 As a result, more accurate distance measurement can be performed.

779 (Modified Example 2 of the Embodiment 2) Further, FIG. 19 is a plan structure diagram of the solid-state image sensor according to the present embodiment, and R + IR, G + IR, B + IR, and IR filters are installed in each pixel. ..

782 In addition, when the background light contains an infrared component, a part of the infrared light is received by the R + IR, G + IR, and B + IR pixels by the filter transmission. That is, each pixel of R + IR, G + IR, and B + IR receives the R component and the partial infrared component, the G component and the partial infrared component, and the B component and the partial infrared component. Further, the IR transmission filter receives only a part of the infrared components in the IR pixels, performs photoelectric conversion, and accumulates in each of the R + IR, G + IR, B + IR, and IR pixels during the visible exposure time.

789 At this time, in the distance measuring system 1 of the second embodiment and the third embodiment, the distance is measured in the TOF mode using the light transmitted through the IR transmission filter, and the light transmitted through the R + IR, G + IR, and B + IR transmission filters is used. , Image imaging is performed, and the distance is measured using the image data. As an example of the method, if a continuous image is taken by the imaging

unit 10 and the distance is calculated by comparing the current frame (image) and the previous frame (image), more accurate distance measurement can be performed. ..

796 In this modification, as shown in FIG. 20, each filter of R + IR, G + IR, B + IR, and IR can be formed by laminating inorganic materials as shown in FIG. 18A described above.

798 Further, in this modification, each of the R + IR, G + IR, B + IR, and IR filters can be formed of an organic material as shown in FIG. 18B described above.

800 Further, in this modification, each of the R + IR, G + IR, B + IR, and IR filters can be appropriately divided into a filter made of an inorganic material and a filter made of an organic material.

803 Further, in this modification, the R + IR, G + IR, B + IR, and IR filters may be formed by combining a filter made of an inorganic material and a filter made of an organic material (for example, so as to overlap in the direction perpendicular to the semiconductor substrate). It is possible.

807 The ranging system according to the present disclosure is useful for, for example, three-dimensional measurement of a person, a building, etc., because it can realize highly accurate three-dimensional measurement of a measurement object without depending on the surrounding environment.

811 1 Distance measurement system 2 Imaging area 10 Imaging unit 11a, 11b High beam light source 12a, 12b Low beam light source 18 Structure 20, 20a, 20b Lighting distance measurement combined light source 21 Unit cell 30 Signal generator 40 Calculation unit 51 Light emitting signal 52 Exposure signal 53 , 53a, 53b RAW data 90 excavator car 96 bucket 100a, 100b fog lamp 101 photodiode 102 vertical transfer unit 103 horizontal transfer unit 104 signal charge detection unit 201 unit cell 202 imaging area 203 removal unit 204 horizontal selection unit 205 differential amplifier 206 vertical Signal line 207, 208 Horizontal signal line 209 Current source 301 Semiconductor substrate 305 Metal wiring, gate electrode or transfer electrode 307 Microlens 330 Transmission filter 331 Photonic color filter 401 First unit cell 402 Second unit cell C11, C12 Capacity M1 Read Transistor M2 Reset Transistor M3 Source Follower Transistor M4 Line Selection Transistor M5 Shutter Transistor PD Photodiode M12 Reset Level Sample Transistor M21, M22 Column Selection Transistor Mll Signal Level Sample Transistor RSn Reset Signal SHN Sample Hold Signal SHS Sample Hold Signal T Transfer signal VDD pixel electrode SELn selection signal TXSn shutter signal

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CLAIMS WO2015025497A1

1.

A signal generator that generates a light emission signal that instructs light irradiation and an exposure signal that instructs exposure of reflected light, lighting that receives the light emission signal and is not intended for distance measurement, and distance measurement by reflected light. Using the first illumination ranging light source unit that performs the light irradiation, the imaging unit that receives the exposure signal and performs the exposure, and acquires the exposure amount of the reflected light, and the exposure amount. It is provided with a calculation unit that calculates and outputs distance information, and has a lighting mode in which the first lighting distance measuring light source unit is provided with the illumination and the first lighting distance measuring light source unit is provided with the light irradiation. A distance measurement system having a first distance measurement mode in which the first distance measurement is performed by operating the imaging unit as an operation mode.

2.

The amplitude of the light emitted from the first illumination distance measuring light source unit in the first ranging mode is larger than the amplitude of the light emitted from the first illumination ranging light source unit in the lighting mode. Large The distance measuring system according to claim 1.

3.

The lighting time width of the light emitted from the first illumination distance measurement combined light source unit in the first distance measurement mode is the lighting of the light emitted from the first illumination distance measurement combined light source unit in the illumination mode. The distance measuring system according to claim 1 or 2, which is shorter than the time width.

4.

Further, a mode is provided in which the image pickup unit is operated and the calculation unit measures the amount of background light while the first illumination distance measurement light source unit is turned off, and the calculation unit has the first distance measurement mode. The distance measuring system according to any one of claims 1 to 3, wherein the background light amount is reduced from the exposure amount of the above.

5.

The distance measurement system according to any one of claims 1 to 4, wherein the first illumination distance measurement combined light source unit is equipped with a single color LED or a plurality of color LEDs.

6.

The distance measuring system according to claim 5, wherein the switching between the first distance measuring mode and the lighting mode is at least 120 times / second.

7.

The distance measuring system further includes a second lighting distance measuring light source unit, and the calculation unit further performs distance measurement using the phase difference information of the first and second lighting distance measuring light source units. The distance measuring system according to any one of claims 1 to 6.

8.

Of the left and right high beam light sources and the left and right low beam light sources provided in the vehicle, the first and second illumination distance measuring light sources are (a) left and right high beam light sources, and (b) left and right. The distance measuring system according to claim 7, which is one of the low beam light sources.

9.

The distance measuring system according to any one of claims 1 to 8, wherein the calculation unit performs a second distance measurement by comparing a current frame with a previous frame using an image signal from the imaging unit.

10.

The distance measurement system according to claim 9, wherein the calculation unit corrects one of the distance information obtained by the first and second distance measurement with the other of the distance information of the first and second distance measurement.

11.

The distance measurement system according to claim 9 or 10, wherein the first and second distance measurement are used properly according to day and night, weather, distance to a subject, or the movement speed of the subject or the distance measurement system.

12.

The distance measuring system according to any one of claims 1 to 11, wherein the image pickup unit includes a solid-state image sensor, and the solid-state image sensor is a CCD type solid-state image sensor.

13.

The image pickup unit includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels includes a light receiving unit for photoelectric conversion and a storage unit for accumulating signal charges read from the light receiving unit. The distance measuring system according to any one of claims 1 to 11, wherein the solid-state image sensor is a MOS-type solid-state image sensor that collectively reads out the signal charges of the light receiving unit to the storage unit in the plurality of pixels.

14.

The image pickup unit includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels is a microlens having a structure in which materials having different refractive indexes are repeatedly arranged concentrically with an axis perpendicular to the light receiving surface as a central axis. The distance measuring system according to any one of claims 1 to 13.

15.

The image pickup unit includes a solid-state image sensor having a plurality of pixels, and each of the plurality of pixels has an infrared transmission filter, a first filter that transmits red light and infrared rays, and a second filter that transmits green light

and infrared rays. The distance measuring system according to any one of claims 1 to 14, further comprising any of a third filter that transmits blue light and infrared rays.

16.

The distance measuring system according to claim 15, wherein the infrared transmission filter and at least one of the first to third filters are filters in which inorganic materials are laminated.

17.

The distance measuring system according to any one of claims 1 to 16, wherein the distance measuring system is mounted on a heavy machine or a structure of a heavy machine and a work site.

18.

The distance measuring system according to any one of claims 1 to 16, wherein the distance measuring system is mounted on a transportation device.

19.

The distance measuring system according to any one of claims 1 to 16, wherein the distance measuring system is mounted on a housing equipment.

20.

A signal generator that controls a light emission pulse signal, the signal generator controls a plurality of types of the light emission pulse signals, and the multiple types of light emission pulse signals instruct light irradiation for performing distance measurement. The first emission pulse signal includes the first emission pulse signal and the second emission pulse signal for instructing the lighting for the purpose of distance measurement, and when the second emission pulse signal is OFF, the first emission pulse signal is turned ON. Naru signal generator.

21.

The signal generator according to claim 20, wherein the period during which the first emission pulse signal is ON is shorter than the period during which the second emission pulse signal is ON.

22.

The signal generator according to claim 20 or 21, wherein the second light emitting pulse signal is turned on after the period in which the first light emitting pulse signal is turned on is repeated a plurality of times.

23.

The signal generator according to any one of claims 20 to 22, wherein the total of the number of times the first light emission pulse signal is turned on and the number of times the second light emission pulse signal is turned on is at least 120 times / second.

24.

The signal generator according to any one of claims 20 to 23, wherein the amplitude of the first emission pulse signal is larger than the amplitude of the second emission pulse signal.

25.

The signal generator according to any one of claims 20 to 24, wherein the first emission pulse signal is used for performing distance measurement by Time Of Flight.

26.

The signal generator according to any one of claims 20 to 25, wherein the signal generator controls an exposure signal for instructing exposure of reflected light by a subject of the irradiation light generated by the first emission pulse signal.

Electronic Acknowledgement Receipt

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Application Number:	15979266
International Application Number:	
Confirmation Number:	9761
Title of Invention:	SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW
First Named Inventor/Applicant Name:	Angus PACALA
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1		IDS-P006US3.pdf	184336 a275226ca8899885388b87190e9210bbb9d3d3e1	yes	4

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

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KILPATRICK TOWNSEND & STOCKTON LLP

By: /La Renda Meyer-Johnson/

PATENT
Attorney Docket No.: 103033- P006US3-1086284
Client Ref. No.: P006US3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Confirmation No.: 9761
Angus Pacala	Examiner: Not yet assigned
Application No.: 15/979,266	Technology Center/Art Unit: 2875
Filed: May 14, 2018	
For: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND STATIONARY WINDOW	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 remaining cited references are provided.

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Respectfully submitted,

/ William L. Shaffer /

William L. Shaffer
Registration No. 37,234

KILPATRICK TOWNSEND & STOCKTON LLP

Attachment

PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
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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.	20180191967	A1	Jul 5, 2018	Kester	

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]
	2	1193539	EP		Apr 3, 2002	Agfa Corporation		
	3	1918427	CN		Feb 21, 2007	Schott AG		
	4	101413905	CN		Apr 22, 2009	Shenzhen University		
	5	2110699	EP		Oct 21, 2009	Diehl Defence GmbH & Co. KG		
	6	102640037	CN		Aug 15, 2012	Eastman Kodak Co.		
	7	102015217908	DE		Mar 23, 2017	Robert Bosch GmbH		
	8	1193539	EP		Apr 3, 2002	Agfa Corporation		

1

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]
	9.	15/979,253 , "Non-Final Office Action", October 23, 2020, 12 pages	
	10	15/979,253 , "Notice of Allowance", November 13, 2020, 7 pages	
	11.	CN202010078057.9 , "Office Action", November 9, 2020, 9 pages	
	12	EP18802192.7 , "Extended European Search Report", November 12, 2020, 11 pages	

PTO/SB/08a (01-10)
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	Attorney Docket Number	103033- P006US3-1086284

	13	PCT/US2018/032601 , "International Preliminary Report on Patentability", November 28, 2019, 13 pages	

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[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.
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KILPATRICK TOWNSEND & STOCKTON LLP

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Respectfully submitted,

/ William L. Shaffer /

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KILPATRICK TOWNSEND & STOCKTON LLP

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DE102015217908

LIDAR SENSOR

Abstract

Lidar sensor, in particular for motor vehicles, having a light source (12), a movable deflection mirror (18) for producing a scanning beam (32), which scans a monitoring space (36), by deflecting a light beam (14) emitted by the light source (12), and having an optical receiver (42) for detecting light which has been reflected at an object (38) which has been hit by the scanning beam (32) in the monitoring space (36) , characterized in that the light source (12) and the deflection mirror (18) are set up to use the deflected light beam (26) to scan an array (20) of micro-optical elements (22), each of which, when hit by the light beam, widens this light beam to form a divergent beam (28), and in that a light-focusing element (30) is arranged at a distance from the array (20) of micro-optical elements and converts the divergent beam (28) into a beam which forms the scanning beam (32) and the beam diameter of which is greater than that of the deflected beam (26).

(19) Deutsches Patent- und Markenamt

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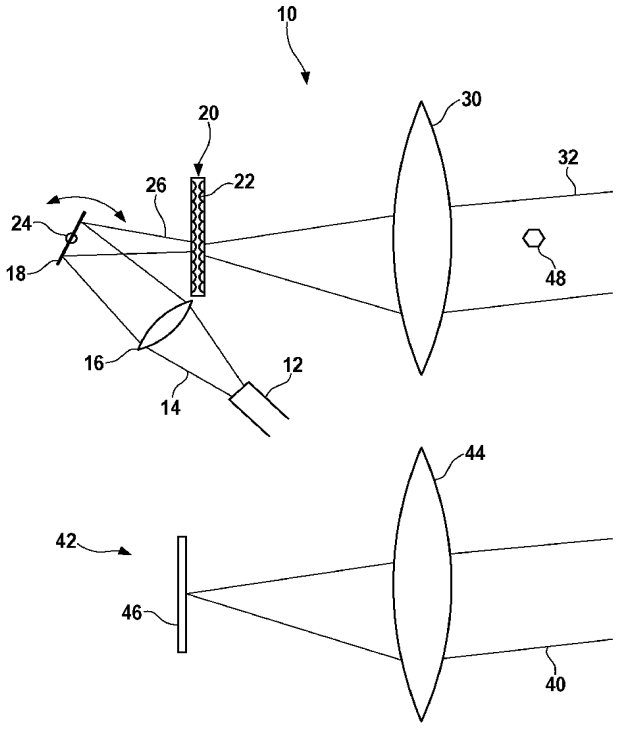
(71) Anmelder:
Robert Bosch GmbH, 70469 Stuttgart, DE

(72) Erfinder:
Schwarz, Hans-Jochen, 70567 Stuttgart, DE; Stoppel, Klaus, 74395 Mundelsheim, DE; Buettner, Axel, 70197 Stuttgart, DE; Schnitzer, Reiner, 72762 Reutlingen, DE

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Lidarsensor**

(57) Zusammenfassung: Lidarsensor, insbesondere für Kraftfahrzeuge, mit einer Lichtquelle (12), einem beweglichen Ablenkspiegel (18) zum Erzeugen eines einen Überwachungsraum (36) überstreichenden Taststrahls (32) durch Ablenken eines von der Lichtquelle (12) emittierten Lichtstrahls (14), und mit einem optischen Empfänger (42) zum Detektieren von Licht, das an einem von dem Taststrahl (32) getroffenen Objekt (38) im Überwachungsraum (36) reflektiert wurde, dadurch gekennzeichnet, dass die Lichtquelle (12) und der Ablenkspiegel (18) dazu eingerichtet sind, mit dem abgelenkten Lichtstrahl (26) ein Feld (20) mikro-optischer Elemente (22) abzutasten, deren jedes, wenn es von dem Lichtstrahl getroffen wird, diesen Lichtstrahl zu einem divergenten Strahl (28) aufweitet, und dass in Abstand zu dem Feld (20) mikro-optischer Elemente ein Licht bündelndes Element (30) angeordnet ist, das den divergenten Strahl (28) in einen den Taststrahl (32) bildenden Strahl umformt, dessen Strahldurchmesser größer ist als der des abgelenkten Strahls (26).



Beschreibung

[0001] Die Erfindung betrifft einen Lidarsensor, insbesondere für Kraftfahrzeuge, mit einer Lichtquelle, einem beweglichen Ablenkspiegel zum Erzeugen eines einen Überwachungsraum überstreichenden Taststrahls durch Ablenken eines von der Lichtquelle emittierten Lichtstrahls, und mit einem optischen Empfänger zum detektieren von Licht, das an einem von dem Taststrahl getroffenen Objekt im Überwachungsraum reflektiert wurde.

Stand der Technik

[0002] Lidarsensoren werden unter anderem in Fahrerassistenzsystemen für Kraftfahrzeuge zur Erfassung des Verkehrsumfelds eingesetzt, beispielsweise zur Ortung von vorausfahrenden Fahrzeugen oder anderen Hindernissen.

[0003] Bei herkömmlichen Lidarsensoren der oben genannten Art wird der von der Lichtquelle, beispielsweise einem Halbleiterlaser, erzeugte Lichtstrahl durch eine Optik geringfügig aufgeweitet, so dass er einen Strahldurchmesser von beispielsweise 1–2 mm hat. Dieser Strahl wird dann am Ablenkspiegel abgelegt und bildet unmittelbar den Taststrahl zur Ortung von Objekten. Der Ablenkspiegel wird oszillierend in einer Dimension oder in zwei Dimensionen bewegt, so dass der Taststrahl einen bestimmten Winkelbereich oder – im Fall einer zweidimensionalen Bewegung des Ablenkspiegels – einen bestimmten Raumwinkelbereich überstreicht, der den Überwachungsraum bildet.

[0004] Aufgrund des kleinen Strahldurchmessers kann ein kleinbauender Ablenkspiegel verwendet werden, der ein entsprechend kleines Trägheitsmoment hat, so dass die Mechanik des Spiegels auch bei hohen Oszillationsfrequenzen nicht überbeansprucht wird und somit eine Abtastung des Überwachungsraumes mit hoher Framerate möglich ist.

[0005] Nachteilig ist jedoch, dass bei Staub, Regen oder Schnee verhältnismäßig hohe Absorptions- und Streuverluste auftreten, weil der Strahldurchmesser im Verhältnis zu den streuenden Partikeln (z. B. Schneeflocken) relativ klein ist. Unter ungünstigen Bedingungen wird dadurch die Reichweite und Empfindlichkeit des Lidarsensors begrenzt. Durch das Erfordernis der Augensicherheit wird außerdem die maximal zulässige Intensität des Laserstrahls begrenzt. Auch daraus ergeben sich Beschränkungen hinsichtlich Reichweite und Empfindlichkeit.

[0006] Als Alternative sind sogenannte Makroscanner bekannt, bei denen der Laserstrahl durch die Optik wesentlich stärker aufgeweitet wird. Aufgrund der Erhaltung des Strahlparameterprodukts kann dann im Fernfeld ein sehr kleiner Öffnungswinkel des Taststrahls erreicht werden. Zum Ablenken des Strahls würde allerdings ein sehr groß dimensionierter Ablenkspiegel benötigt. Aus diesem Grund wird zumeist der Lidarsensor als Ganzes im Azimut verschwenkt. Aufgrund der Abmessungen und Massenträgheit des Sensors sind dann jedoch nur relativ kleine Öffnungswinkel des Überwachungsraumes und/oder kleine Abtastfrequenzen und damit niedrige Frameraten möglich. Wenn eine Winkelauflösung auch in Elevation erforderlich ist, wird zumeist mit Mehrstrahlsystemen gearbeitet, bei denen mehrere Taststrahlen unter unterschiedlichen Elevationswinkeln abgestrahlt werden.

Offenbarung der Erfindung

[0007] Aufgabe der Erfindung ist es, einen Lidarsensor zu schaffen, der bei der gebotenen Augensicherheit und geringer Empfindlichkeit gegenüber Streupartikeln eine hohe Abtastfrequenz und/oder große Öffnungswinkel des Überwachungsraumes ermöglicht.

[0008] Diese Aufgabe wird erfindungsgemäß dadurch gelöst, dass die Lichtquelle und der Ablenkspiegel dazu eingerichtet sind, mit dem abgelenkten Lichtstrahl ein Feld mikro-optischer Elemente abzutasten, deren jedes, wenn es von dem Lichtstrahl getroffen wird, diesen Lichtstrahl zu einem divergenten Strahl aufweitet, und dass in Abstand zu dem Feld mikro-optischer Elemente ein Licht bündelndes Element angeordnet ist, das den divergenten Strahl in einen den Taststrahl bildenden Strahl umformt, dessen Strahldurchmesser größer ist als der des abgelenkten Strahls.

[0009] Die mikro-optischen Elemente und das Licht bündelnde Element bewirken zusammen eine Strahlaufweitung ähnlich wie bei einem Makroscanner, so dass die Augensicherheit auch bei erhöhter Gesamtleistung des Laserstrahls gewährleistet werden kann, da der Strahldurchmesser größer ist als der Pupillendurchmesser des menschlichen Auges. Auch die Empfindlichkeit gegenüber Streupartikeln ist ähnlich gering wie bei Makroscannern. Da jedoch der auf den Ablenkspiegel auftreffende Strahl einen wesentlich kleineren Durchmesser hat, kann ein kleinbauender Ablenkspiegel verwendet werden, mit dem entsprechend hohe Abtastfrequenzen möglich sind. Der am Ablenkspiegel abgelenkte Strahl tastet nicht unmittelbar den Überwachungsraum ab, sondern nur das Feld mikro-optischer Elemente. Die Richtung, in die dann der Taststrahl abgestrahlt wird, ist von der Lage des jeweils getroffenen mikro-optischen Elements relativ zur optischen Achse des Licht bündelnden Elements abhängig. Der Öffnungswinkel des Überwachungsraumes kann deshalb deutlich größer sein als der Winkel, um den der Lichtstrahl am Ablenkspiegel maximal abgelenkt wird. Auf diese Weise wird ei-

ne Abtastung eines Überwachungsraumes mit weitem Öffnungswinkel mit hoher Framerate ermöglicht.

[0010] Vorteilhafte Ausgestaltungen und Weiterbildungen der Erfindung sind in den Unteransprüchen angegeben.

[0011] Die mikro-optischen Elemente können wahlweise Licht brechende Elemente (z. B. Zerstreuungslinsen) oder reflektierende Elemente (z. B. Wölbspiegel oder Hohlspiegel) sein. Auch beugende Elemente (z.B. DOEs, Diffractive Optische Elemente) können verwendet werden.

[0012] Das Licht bündelnde Element kann eine optische Linse sein, in deren Fokalebene das Feld mikro-optischer Elemente liegt, so dass die divergenten Strahlen durch die Linse in nahezu parallele Strahlen umgeformt werden. Alternativ wäre anstelle einer Linse auch ein Hohlspiegel denkbar.

[0013] Das Licht bündelnde Element kann zugleich das Objektiv des optischen Empfängers bilden, so dass der eintreffende, am Objekt reflektierte Strahl mit dem emittierten Strahl koaxial ist und somit bei der Auswertung des detektierten Signals keine Parallaxenfehler berücksichtigt zu werden brauchen. Beispielsweise kann im Strahlengang zwischen der Lichtquelle und dem Licht bündelnden Element, also zwischen der Lichtquelle und dem Ablenkspiegel, zwischen dem Ablenkspiegel und dem Feld mikro-optischer Elemente oder zwischen dem Feld mikro-optischer Elemente und dem Licht bündelnden Element, ein Strahlteiler vorgesehen sein, der das empfangene Licht auf ein Detektorfeld umlenkt. In einer Ausführungsform kann auch das Feld mikro-optischer Elemente zugleich die Funktion eines Strahlteilers haben.

[0014] Zum Ausgleich von Abbildungsfehlern kann es vorteilhaft sein, wenn das Feld mikro-optischer Elemente oder ein Spiegel, der das Licht auf dieses Feld umlenkt, gewölbt ausgebildet ist.

[0015] Im folgenden werden Ausführungsbeispiele der Erfindung anhand der Zeichnungen näher erläutert.

[0016] Es zeigen:

[0017] **Fig.** 1 eine Skizze eines erfindungsgemäßen Lidarsensors;

[0018] **Fig.** 2 eine Illustration eines Anwendungsbeispiels, bei dem der Lidarsensor zur Objektortung in einem Kraftfahrzeug eingesetzt wird; und

[0019] **Fig.** 3 bis **Fig.** 8 eine Skizzen von Lidarsensoren gemäß weiteren Ausführungsformen der Erfindung.

[0020] Der in **Fig.** 1 gezeigte Lidarsensor **10** weist als Lichtquelle **12** einen Halbleiterlaser auf, der einen Lichtstrahl **14** im sichtbaren Bereich des Spektrums oder wahlweise auch im Infrarotbereich emittiert. Eine Abbildungslinse **16** fokussiert das Licht über einen Ablenkspiegel **18** auf ein Feld **20** mikro-optischer Elemente **22**. Im gezeigten Beispiel ist das Feld **20** eine transparente Platte, beispielsweise eine Glasplatte, die ein feines Raster von Zerstreuungslinsen als mikrooptische Elemente **22** aufweist.

[0021] Der Ablenkspiegel **18** ist um eine senkrecht zur Zeichenebene in **Fig.** 1 verlaufende Achse **24** schwenkbar und wird oszillierend bewegt, wie in **Fig.** 1 durch einen Doppelpfeil angedeutet wird. Der Lichtstrahl **14** wird am Ablenkspiegel **18** so abgelenkt, das er einen abgelenkten Strahl **26** bildet, der das Feld **20** abtastet. Diejenige der Zerstreuungslinsen, die von dem abgelenkten Strahl **26** getroffen wird, erzeugt einen divergenten Strahl **28**, der auf ein Licht bündelndes Element in Form einer Linse **30** trifft.

[0022] Der Abstand zwischen dem Feld **20** und der Linse **30** entspricht etwa der Brennweite der Linse **30**, so dass der divergente Strahl **28** durch die Linse in ein annähernd paralleles Strahlenbündel umgeformt wird, das als Taststrahl **32** vom Lidarsensor **10** ausgestrahlt wird. Die Abstrahlrichtung des Taststrahls **32** ist dabei von dem Ort des mikro-optischen Elements **22** abhängig, das gerade von dem abgelenkten Strahl **26** getroffen wird. Auf diese Weise bewirkt der Ablenkspiegel **18** mittelbar auch eine Ablenkung des Taststrahls **32**.

[0023] **Fig.** 2 zeigt ein Kraftfahrzeug **34**, bei dem der Lidarsensor **10** in der Frontpartie eingebaut und in Fahrtrichtung nach vorn gerichtet ist. Der Taststrahl **32** wird mit Hilfe des Ablenkspiegels oszillierend abgelenkt und überstreicht einen Winkelbereich $\pm\alpha$, der im gezeigten Beispiel $\pm 12°$ beträgt und einen von dem Lidarsensor **10** abgetasteten Überwachungsraum **36** definiert. Im gezeigten Beispiel befindet sich im Überwachungsraum **36** ein Objekt **38**, nämlich ein vorausfahrendes Fahrzeug, das von dem Taststrahl **32** getroffen wird und einen Teil der Strahlung reflektiert, so dass ein reflektierter Strahl **40** zum Lidarsensor **10** zurückläuft und dort empfangen wird.

[0024] In dem in **Fig.** 1 gezeigten Beispiel wird ein Empfänger **42** des Lidarsensors durch eine Linse **44** und einen opto-elektronischen Bildsensor **46** gebildet. Der reflektierte Strahl **40** wird durch die Linse **44**, die neben der Linse **30** angeordnet ist, auf den Bildsensor **46** fokussiert. Der Bildsensor wird beispielsweise durch eine Zeile oder ein Feld von CCD-Elementen gebildet.

[0025] Bei der in **Fig.** 1 gezeigten Anordnung bestimmt der Abstand zwischen dem Ablenkspiegel **18** und dem Feld **20** den Winkel, um den der Ablenkspie-

gel gedreht werden muss, um das Feld **20** vollständig abzutasten. Je größer dieser Abstand ist, desto kleiner ist der Winkelbereich, in dem der Ablenkspiegel **18** verschwenkt werden muss. Der Winkelbereich, der von dem Abtaststrahl **32** überstrichen wird und somit den Überwachungsraum **36** definiert, ist dagegen von der Brennweite der Linse **30** und damit vom Abstand zwischen dem Feld **20** und der Linse **30** abhängig und kann deshalb deutlich mehr als das Zweifache des Winkelbereichs betragen, in dem der Ablenkspiegel **18** verschwenkt wird.

[0026] Im Fall eines eindimensionalen Lidarsensors wird der Taststrahl **32** nur in einer Dimension verschwenkt, beispielsweise im Azimut, wie in **Fig.** 2. In dem Fall besteht das Feld **20** nur einer einzigen Zeile von dicht nebeneinander angeordneten mikro-optischen Elementen **22**.

[0027] Im Fall eines zweidimensionalen Lidarsensors, bei dem der Taststrahl **32** auch in Elevation verschwenkt wird, ist das Feld **20** hingegen ein zweidimensionales Feld, das auch in der Richtung senkrecht zur Zeichenebene in **Fig.** 1 ausgedehnt ist, und der Ablenkspiegel **18** ist nicht nur um die Achse **24** schwenkbar, sondern auch um eine Achse, die rechtwinklig zur Achse **24** in Längsrichtung des Spiegels verläuft.

[0028] In einem praktischen Beispiel hat der von der Lichtquelle **12** erzeugte Lichtstrahl **14** eine Beugungsmesszahl M^2 von etwa 3,3, einen Öffnungswinkel von etwa 1,7° und an der dünnsten Stelle einen Durchmesser von etwa 0,14 mm. Die Abbildungslinse **16** hat einen Durchmesser von 3 mm und eine Brennweite von 29 mm, der Abstand zur Lichtquelle beträgt 76 mm. Der Ablenkspiegel **18** ist etwa 11 mm von der Abbildungslinse **16** und etwa 40 mm vom Feld **20** der mikro-optischen Elemente entfernt. Das Feld **20** hat in der Hauptabtastrichtung (vertikal in **Fig.** 1) eine Länge von 22 mm und bildet zehn Mikrolinsen pro Millimeter. Die Linse **30** hat einen Durchmesser von 50 mm und eine Brennweite von 50 mm. Der Taststrahl **32** kann dann in dem genannten Winkelbereich von +/–12° verschwenkt werden und hat einen Durchmesser, der am Ort der Linse etwa 19 mm beträgt und über eine Entfernung von 180 m auf etwa 57 cm zunimmt. Der Durchmesser des Taststrahls **32** ist somit selbst unmittelbar am Lidarsensor mehr als doppelt so groß wie die Eintrittspupille eines menschlichen Auges (ca. 7 mm), so dass die nötige Augensicherheit auch bei hoher Gesamtleistung der Laserstrahlung und entsprechend großer Reichweite und Empfindlichkeit des Lidarsensors gewahrt werden kann. Außerdem ist der Strahldurchmesser größer als der typische Durchmesser von Streupartikeln wie Schneeflocken **48**, Regentropfen, Staubkörnchen und dergleichen, so dass nur entsprechend geringe Streu- und Absorptionsverluste auftreten.

[0029] **Fig.** 3 zeigt als weiteres Ausführungsbeispiel einen Lidarsensor **10a**, mit einem Feld **20a** mikro-optischer Elemente **22a**, das durch eine reflektierende Platte gebildet wird. Die einzelnen mikro-optischen Elemente **22a** werden in diesem Fall durch kleine Wölbspiegel (oder wahlweise auch Hohlspiegel mit sehr kurzer Brennweite) gebildet.

[0030] Die Linse **30** bildet in diesem Ausführungsbeispiel zugleich das Objektiv eines Empfängers **42a**, der außerdem einen Strahlteiler **50** aufweist, beispielsweise einen halbdurchlässigen Spiegel, der den divergenten Strahl von den mikrooptischen Elementen **22a** zur Linse **30** durchlässt, jedoch einen Teil des empfangenen Lichts auf einen Bildsensor **46a** ablenkt. Diese Ausbildung des Empfängers **42a** ist selbstverständlich auch bei Ausführungsformen mit Licht brechenden Elementen als mikro-optischen Elementen möglich, wie umgekehrt auch in Kombination mit den reflektierenden mikro-optischen Elementen **22a** ein separat von der Linse **30** angeordneter Empfänger möglich ist.

[0031] **Fig.** 4 zeigt einen Lidarsensor **10b**, der sich von dem Lidarsensor **10a** dadurch unterscheidet, dass ein anders aufgebauter Empfänger **42b** vorgesehen ist. Dieser Empfänger weist einen Strahlteiler **50b** in der Form eines halbdurchlässigen Spiegels auf, der zwischen der Lichtquelle **12** und der Abbildungslinse **16** angeordnet ist und das empfangene Licht auf einen Bildsensor **46b** umlenkt, der durch ein einzelnes lichtempfindliches Element gebildet wird. Bei dieser Ausführungsform wird somit das empfangene Licht von der Linse **30** auf das Feld **20a** fokussiert, dort auf den Ablenkspiegel **18** reflektiert und schließlich durch die Abbildungslinse **16** und über den Strahlteiler **50b** auf den Bildsensor **46b** fokussiert. Die Richtung, aus der das empfangene Licht eintrifft, ergibt sich in diesem Fall aus der zu jedem Zeitpunkt bekannten Winkelstellung des Ablenkspiegels **18**, wobei angenommen wird, dass die Signallaufzeit des Lichts so kurz ist, dass der Drehwinkel, um den der Ablenkspiegel **18** innerhalb dieser Zeit verdreht wird, vernachlässigbar klein ist.

[0032] **Fig.** 5 zeigt einen Lidarsensor **10c**, der sich von dem Lidarsensor nach **Fig.** 4 dadurch unterscheidet, dass als Feld mikro-optischer Elemente ein gewölbtes Feld **20c** vorgesehen ist. Die Wölbung dieses Feldes erlaubt es, Abbildungsfehler zu minimieren. Als mikro-optische Elemente sind in diesem Beispiel Licht beugende Elemente **22c** vorgesehen. Wahlweise könnten jedoch auch Licht brechende oder reflektierende Elemente vorgesehen sein.

[0033] Zwischen dem Ablenkspiegel **18** und dem Feld **20c** ist in diesem Beispiel ein weiterer Spiegel **52** vorgesehen, der das Licht so umlenkt, dass es längs der optischen Achse der Linse **30** auf das Feld **20c** fällt.

[0034] **Fig.** 6 zeigt als modifiziertes Ausführungsbeispiel einen Lidarsensor **10d**, der den gleichen grundsätzlichen Aufbau wie der Lidarsensor **10c** in **Fig.** 5 aufweist, mit dem Unterschied, dass das gewölbte Feld **20c** gemäß **Fig.** 5 durch das nicht gewölbte Feld **20** mikro-optischer Elemente gemäß **Fig.** 1 ersetzt ist. Dafür ist hier zum Ausgleich von Abbildungsfehlern anstelle des ebenen Spiegels **52** ein gewölbter Spiegel **52d** vorgesehen.

[0035] **Fig.** 7 zeigt einen Lidarsensor **10e**, bei dem die Lichtquelle **12** einen scharf gebündelten parallelen Laserstrahl erzeugt, der über den Ablenkspiegel **18** und einen halbdurchlässigen Spiegel eines Strahlteilers **50e** auf das Feld **20** mikrooptischer Elemente gelenkt wird. Das empfangene und von der Linse **30** gebündelte Licht (hier durch gestrichelte Linien dargestellt) fällt durch das (lichtdurchlässige) Feld **20** hindurch auf den Strahlteiler **50e** und wird durch diesen auf einen Empfänger **42e** ausgekoppelt, der durch einen flächigen (oder zeilenförmigen) Bildsensor **46e** und eine Abbildungslinse **16e** gebildet wird. Die zusätzliche Abbildungslinse **16e** ermöglicht die Verwendung eines sehr kleinen Bildsensors **46e**. Außerdem kann bei dieser Anordnung die Empfangsapertur besser ausgenutzt werden. Der Bildsensor **46** empfängt das gesamte Licht eines Strahlenbündels, das an der Linse **30** den vollen Querschnitt dieser Linse ausfüllt. Auf diese Weise wird eine höhere Signalstärke im Empfangspfad erreicht.

[0036] **Fig.** 8 zeigt schließlich einen Lidarsensor **10f**, der sich von dem Lidarsensor **10e** dadurch unterscheidet, dass ein Feld **20f** reflektierender mikro-optischer Elemente vorgesehen ist, das jedoch halbdurchlässig ist und somit zugleich als Strahlteiler fungiert.

Patentansprüche

1. Lidarsensor, insbesondere für Kraftfahrzeuge, mit einer Lichtquelle (**12**), einem beweglichen Ablenkspiegel (**18**) zum Erzeugen eines einen Überwachungsraum (**36**) überstreichenden Taststrahls (**32**) durch Ablenken eines von der Lichtquelle (**12**) emittierten Lichtstrahls (**14**), und mit einem optischen Empfänger (**42**; **42a**; **42b**; **42e**) zum Detektieren von Licht, das an einem von dem Taststrahl (**32**) getroffenen Objekt (**38**) im Überwachungsraum (**36**) reflektiert wurde, **dadurch gekennzeichnet,** dass die Lichtquelle (**12**) und der Ablenkspiegel (**18**) dazu eingerichtet sind, mit dem abgelenkten Lichtstrahl (**26**) ein Feld (**20**; **20a**, **20c**; **20f**) mikro-optischer Elemente (**22**; **22a**; **22c**) abzutasten, deren jedes, wenn es von dem Lichtstrahl getroffen wird, diesen Lichtstrahl zu einem divergenten Strahl (**28**) aufweitet, und dass in Abstand zu dem Feld (**20**; **20a**, **20c**; **20f**) mikro-optischer Elemente ein Licht bündelndes Element (**30**) angeordnet ist, das den divergenten Strahl (**28**) in einen den Taststrahl (**32**) bildenden Strahl umformt, dessen Strahldurchmesser größer ist als der des abgelenkten Strahls (**26**).

2. Lidarsensor nach Anspruch 1, bei dem mikro-optischen Elemente (**22**) Mikrolinsen sind.

3. Lidarsensor nach Anspruch 1, bei dem die mikro-optischen Elemente (**22a**) reflektierende Elemente sind.

4. Lidarsensor nach Anspruch 1, bei dem die mikro-optischen Elemente (**22c**) Licht beugende Elemente sind.

5. Lidarsensor nach einem der vorstehenden Ansprüche, mit einer Abbildungslinse (**16**), die den von der Lichtquelle (**12**) emittierten Lichtstrahl (**14**) über den Ablenkspiegel (**18**) auf das Feld (**20**; **20a**) der mikro-optischen Elemente fokussiert.

6. Lidarsensor nach einem der vorstehenden Ansprüche, bei dem der emittierte Lichtstrahl (**14**) und der abgelenkte Lichtstrahl (**26**) einen Durchmesser von maximal 5 mm haben und das Licht bündelnde Element (**30**) einen Durchmesser von mindestens 15 mm hat.

7. Lidarsensor nach einem der vorstehenden Ansprüche, bei dem das Licht bündelnde Element (**30**) zugleich ein Objektiv des Empfängers (**42a**; **42b**; **42e**) bildet.

8. Lidarsensor nach Anspruch 7, mit einem Strahlteiler (**50**; **50b**; **50e**) im Strahlengang zwischen der Lichtquelle (**12**) und dem Licht bündelnden Element (**30**), zum Ablenken des empfangenen Lichts auf einen Bildsensor (**46a**; **46b**; **46e**) des Empfängers.

9. Lidarsensor nach Anspruch 8, bei dem der Strahlteiler (**50**) zwischen dem Feld (**20a**) mikro-optischer Elemente und dem Licht bündelnden Element (**30**) angeordnet ist.

10. Lidarsensor nach Anspruch 8, bei dem der Strahlteiler (**50b**) zwischen der Lichtquelle (**12**) und dem Ablenkspiegel (**18**) angeordnet ist.

11. Lidarsensor nach Anspruch 8, bei dem der Strahlteiler (**50e**) zwischen dem Ablenkspiegel (**18**) und dem Feld (**20**) mikro-optischer Elemente angeordnet ist.

12. Lidarsensor nach einem der vorstehenden Ansprüche, bei dem der Empfänger (**42b**; **42e**) eine Linse (**16**; **16e**) zum Fokussieren des empfangenen, von dem Licht bündelnden Element (**30**) vorfokussierten Lichts auf einen Bildsensor (**46b**; **46e**) aufweist.

13. Lidarsensor nach Anspruch 12, bei dem die Linse (**16e**) des Empfängers (**46e**) und das Licht bün-

delnde Element (**30**) eine gemeinsame optische Achse haben und ein Strahlteiler (**50e**) so auf der gemeinsamen optischen Achse angeordnet ist, dass er das vom Ablenkspiegel (**18**) kommende Licht zu dem Licht bündelnden Element (**30**) umlenkt und das empfangene Licht in den Empfänger (**42**) auskoppelt.

14. Lidarsensor nach Anspruch 13, bei dem der Strahlteiler durch das Feld (**20f**) mikro-optischer Elemente gebildet wird.

15. Lidarsensor nach einem der vorstehenden Ansprüche, bei dem das Feld (**20c**) mikro-optischer Elemente gewölbt ist.

16. Lidarsensor nach einem der vorstehenden Ansprüche, bei dem auf der optischen Achse des Licht bündelnden Elements (**30**) ein Spiegel (**52**; **52d**) angeordnet ist, der den vom Ablenkspiegel (**18**) abgelenkten Strahl auf das Feld (**20**; **20c**) mikro-optischer Elemente umlenkt.

17. Lidarsensor nach Anspruch 16, bei dem der Spiegel (**52d**) gewölbt ist.

Es folgen 5 Seiten Zeichnungen

HESAI EX1002, P.450

Anhängende Zeichnungen

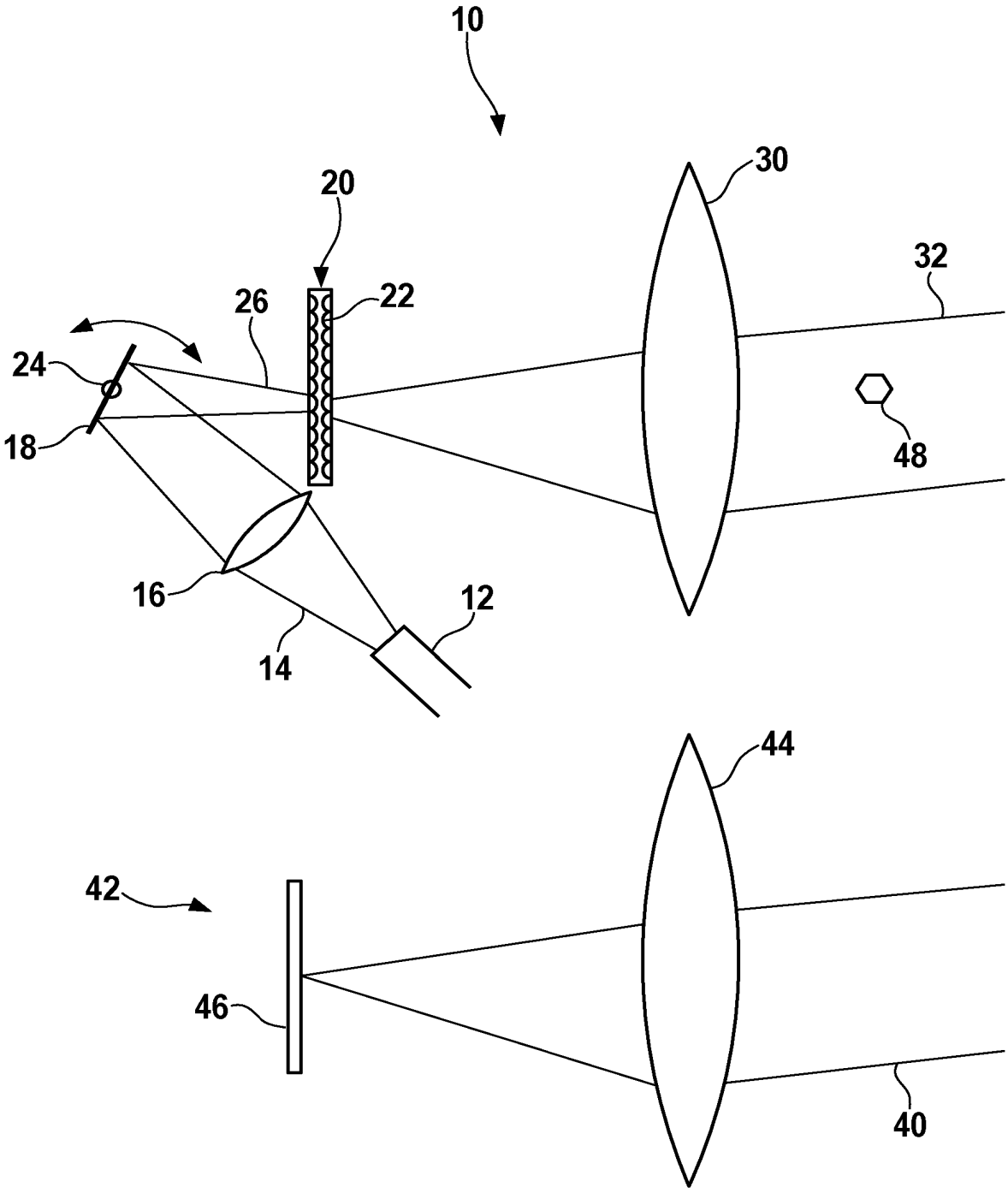


Fig. 1

HESAI EX1002, P.451

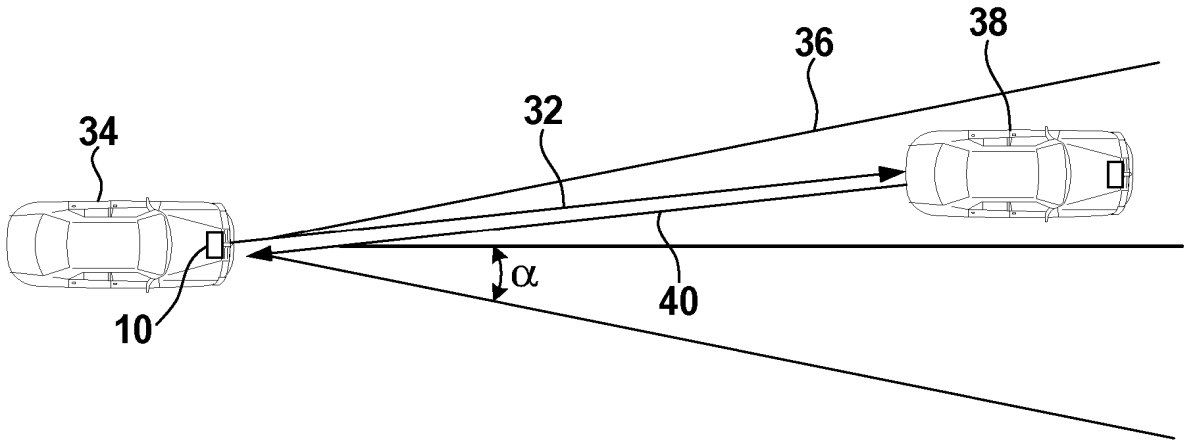


Fig. 2

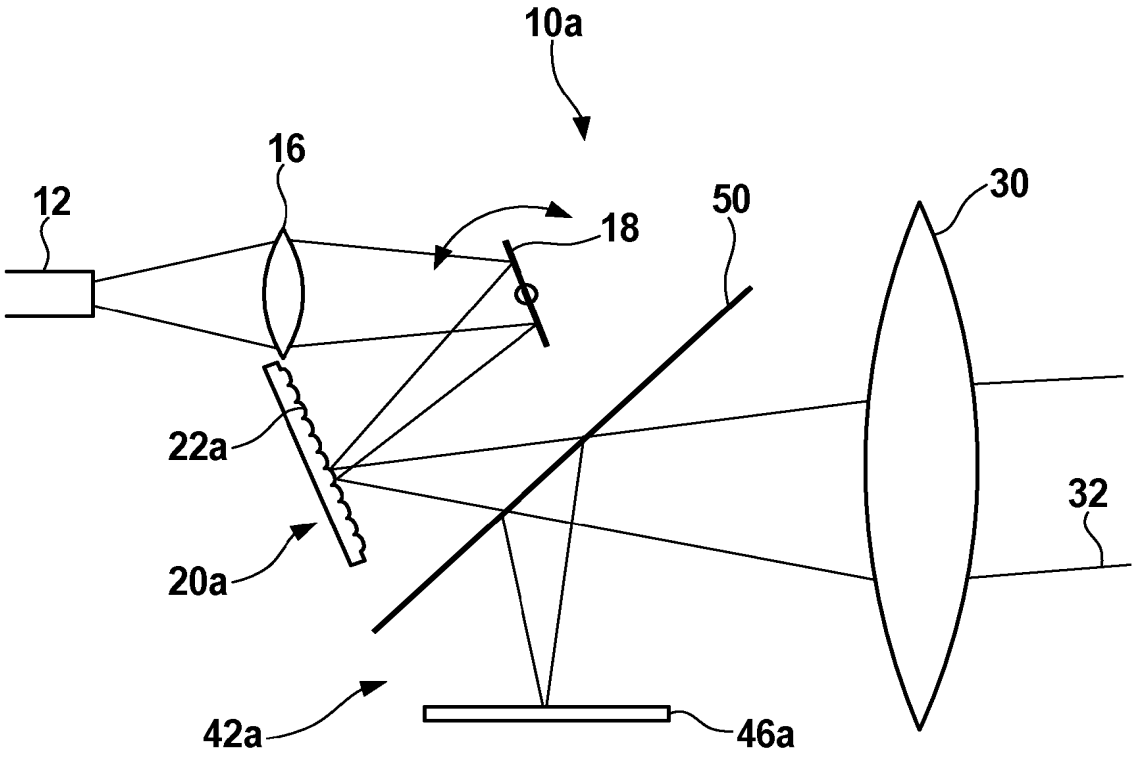


Fig. 3

HESAI EX1002, P.452

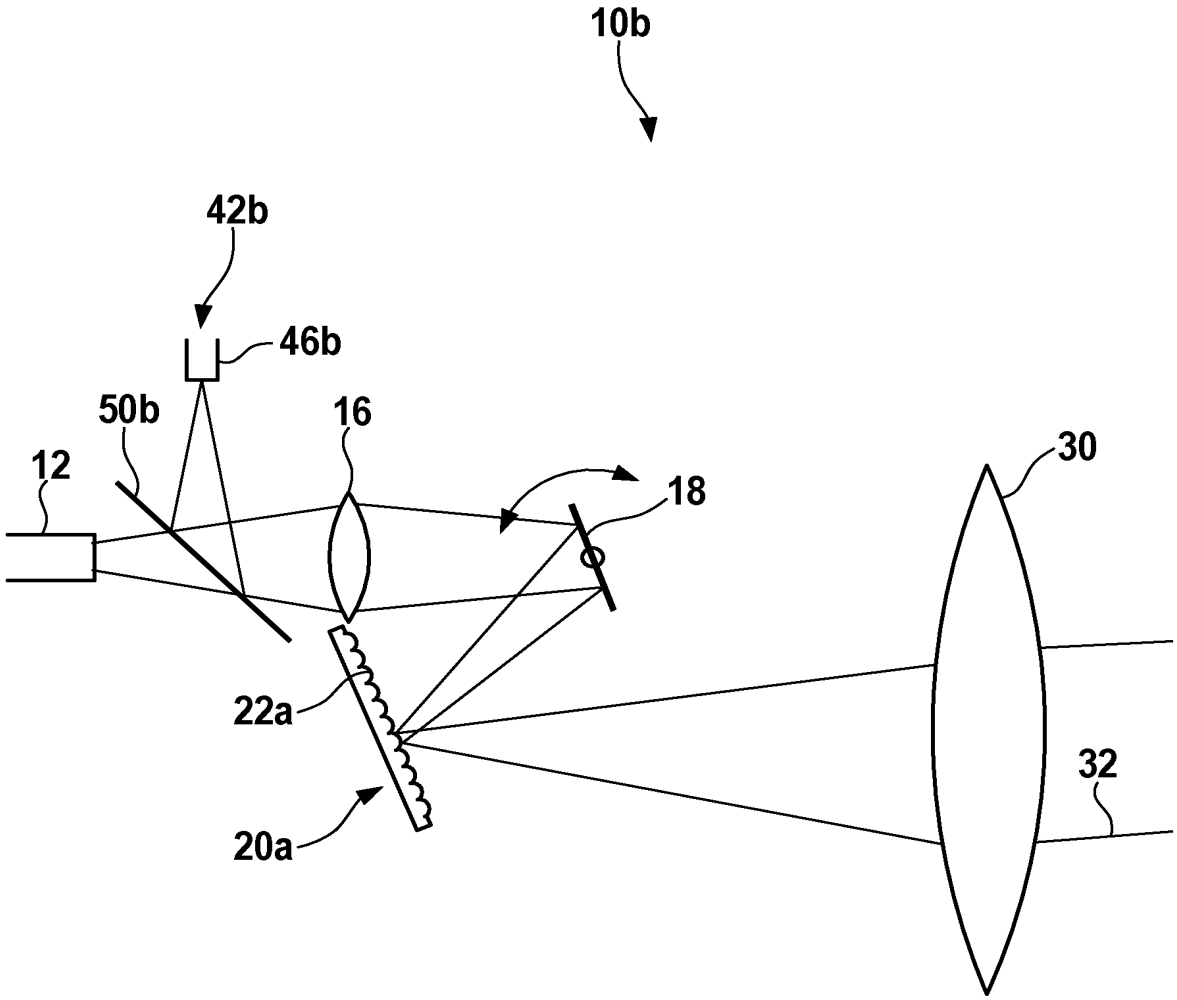


Fig. 4

HESAI EX1002, P.453

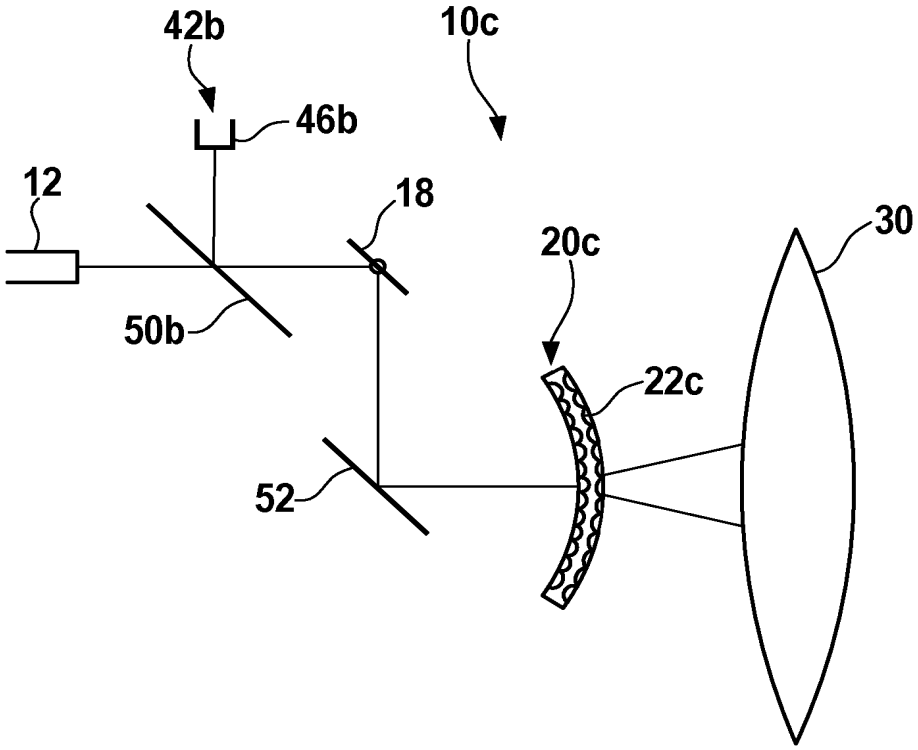


Fig. 5

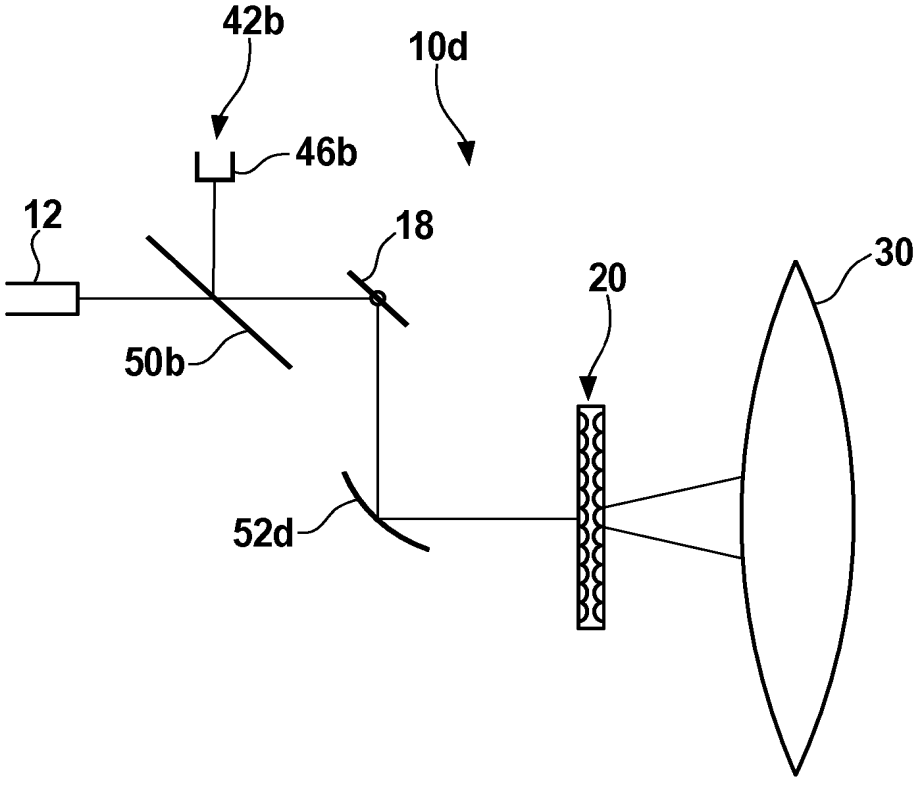


Fig. 6

HESAI EX1002, P.454

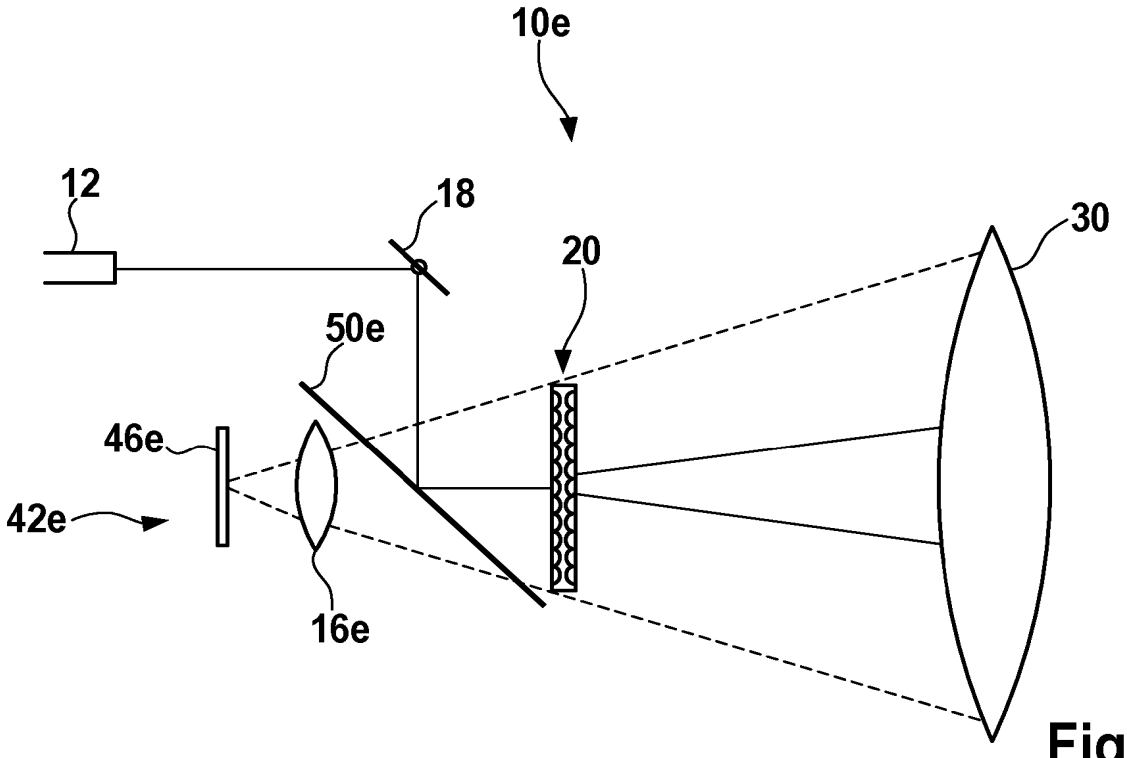


Fig. 7

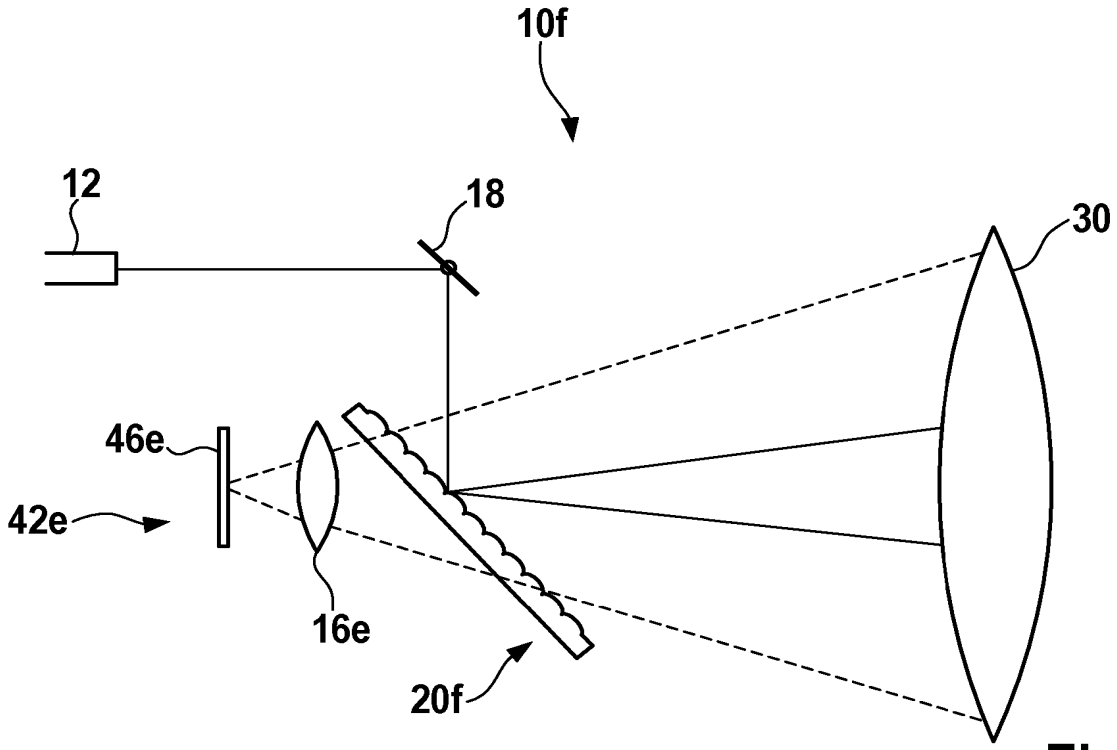


Fig. 8

HESAI EX1002, P.455

EP2110699A3

Method and device for lighting an object scene

Abstract

The device has a turning unit (24) for turning radiation (10) directed by a radiation source (18) in an object scene (8) using multiple micro optical grids. A lens (26) i.e. zoom lens, modifies beam divergence of the radiation directed in the object scene. The lens has a divergence angle (alpha), which is larger than a divergence angle between two adjacent deflection maximums. The lens expands a collimated radiation (22) of the radiation source such that radiation amplitude lies in a radiation center between the two adjacent deflection maximums. An independent claim is also included for a method for lighting an object scene.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

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(51) Int Cl.:
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G01S 7/481 *(2006.01)*

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(71) Anmelder: **Diehl BGT Defence GmbH & Co. KG**
88662 Überlingen (DE)

(72) Erfinder:
- **Rungenhagen, Matthias**
  88662 Überlingen (DE)
- **Löbau, Jörg Dr.**
  88633 Heiligenberg (DE)

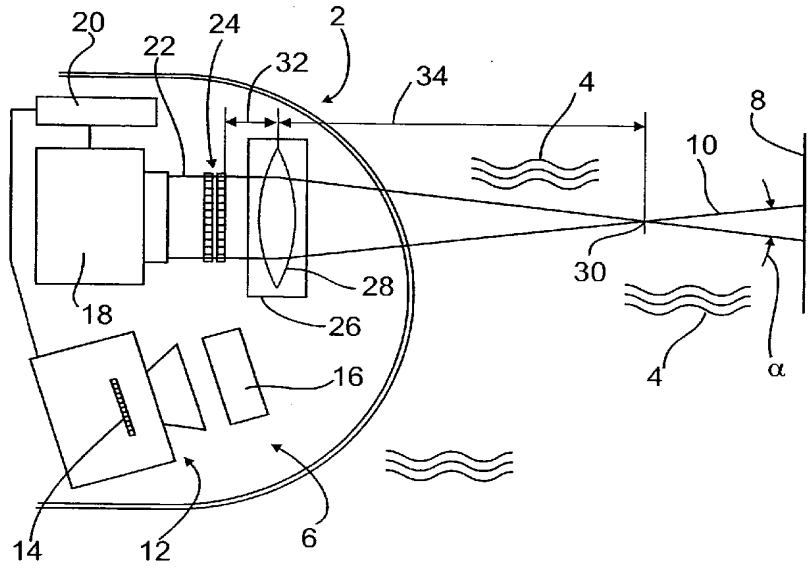
(74) Vertreter: **Diehl Patentabteilung**
c/o Diehl Stiftung & Co. KG
Stephanstrasse 49
90478 Nürnberg (DE)

(54) Vorrichtung und Verfahren zum Beleuchten einer Objektszene

(57) Die Erfindung geht aus von einer Vorrichtung zum Beleuchten einer Objektszene (8) mit einer Strahlungsquelle (18) und einer Schwenkeinheit (24) zum Schwenken eines von der Strahlungsquelle (18) in die Objektszene (8) gerichteten Strahls (10).

Um die Objektszene (8) relativ stabil gegenüber Beschleunigungen und Erschütterungen mit einer hohen Abbildungsgüte und hohem Kontrast durch geringe Streustrahlung abbilden zu können, wird vorgeschlagen, dass die Vorrichtung eine Anzahl von mikrooptischen Rastern (36, 38, 40) der Schwenkeinheit (24) zum Schwenken des Strahls (10) und eine Optik (26) zur Veränderung der Strahldivergenz des in die Objektszene (8) gerichteten Strahls (10) umfasst.

FIG 1



EP 2 110 699 A3

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EUROPÄISCHER RECHERCHENBERICHT

Nummer der Anmeldung
EP 09 00 4517

EINSCHLÄGIGE DOKUMENTE

Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (IPC)
X	WO 2008/018955 A2 (ARETE ASSOCIATES [US]; KANE DAVID M [US]; MURRAY JAMES T [US]; DAIKER) 14. Februar 2008 (2008-02-14) * Zusammenfassung; Anspruch 1; Abbildungen 6,5,1 * * Seite 14 - Seite 15, Zeile 15 * * Seite 17, Zeile 25 - Seite 20, Zeile 4 *	1-7	INV. G02B26/10 G02B27/30 G01S7/481
X	DE 44 28 704 A1 (TRW INC [US]) 23. Februar 1995 (1995-02-23) * Zusammenfassung * * Spalte 3, Zeile 30 - Spalte 4, Zeile 36; Abbildungen 1,2 *	1-7	
X	WATSON E A: "ANALYSIS OF BEAM STEERING WITH DECONTERED MICROLENS ARRAYS", OPTICAL ENGINEERING, SOC. OF PHOTO-OPTICAL INSTRUMENTATION ENGINEERS, BELLINGHAM, Bd. 32, Nr. 11, 1. November 1993 (1993-11-01), Seiten 2665-2670, XP000413673, ISSN: 0091-3286, DOI: 10.1117/12.148100 * Zusammenfassung * * Kapitel 1 und 2 *	1,7-9	
X	HANS DIETER THOLL: "<title>Novel laser beam steering techniques</title>", PROCEEDINGS OF SPIE, Bd. 6397, 28. September 2006 (2006-09-28), Seite 639708, XP055057256, ISSN: 0277-786X, DOI: 10.1117/12.689900 * Zusammenfassung * * Kapitel 1 und 4 *	1,7-9	
A	US 6 751 009 B2 (KHOSHNEVISAN MOHSEN [US] ET AL) 15. Juni 2004 (2004-06-15) * Zusammenfassung *	1-7	

-/--

RECHERCHIERTE SACHGEBIETE (IPC)

G01S
G02B

~~Der vorliegende Recherchenbericht wurde für alle Patentans~~prüche erstellt

Recherchenort	Abschlußdatum der Recherche	Prüfer
München	20. März 2013	Grübl, Alexander

KATEGORIE DER GENANNTEN DOKUMENTE

X : von besonderer Bedeutung allein betrachtet
Y : von besonderer Bedeutung in Verbindung mit einer anderen Veröffentlichung derselben Kategorie
A : technologischer Hintergrund
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D : in der Anmeldung angeführtes Dokument
L : aus anderen Gründen angeführtes Dokument

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2

EPO FORM 1503 03.82 (P04C03)

HESAI EX1002, P.458

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EUROPÄISCHER RECHERCHENBERICHT

Nummer der Anmeldung
EP 09 00 4517

EINSCHLÄGIGE DOKUMENTE

Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (IPC)
A	DE 196 35 792 A1 (ZEISS CARL FA [DE]) 3. April 1997 (1997-04-03) * Zusammenfassung * -----	1-7	
			RECHERCHIERTE SACHGEBIETE (IPC)

~~Der vorliegende Recherchenbericht wurde für alle Patentans~~prüche erstellt

Recherchenort	Abschlußdatum der Recherche	Prüfer
München	20. März 2013	Grübl, Alexander

KATEGORIE DER GENANNTEN DOKUMENTE

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☐ Keine der Anspruchsgebühren wurde innerhalb der vorgeschriebenen Frist entrichtet. Der vorliegende europäische Recherchenbericht wurde für die Patentansprüche erstellt, für die keine Zahlung fällig war.

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Siehe Ergänzungsblatt B

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☐ Da für alle recherchierbaren Ansprüche die Recherche ohne einen Arbeitsaufwand durchgeführt werden konnte, der eine zusätzliche Recherchengebühr gerechtfertigt hätte, hat die Recherchenabteilung nicht zur Zahlung einer solchen Gebühr aufgefordert.

☐ Nur ein Teil der weiteren Recherchengebühren wurde innerhalb der gesetzten Frist entrichtet. Der vorliegende europäische Recherchenbericht wurde für die Teile der Anmeldung erstellt, die sich auf Erfindungen beziehen, für die Recherchengebühren entrichtet worden sind, nämlich Patentansprüche:

☒ Keine der weiteren Recherchengebühren wurde innerhalb der gesetzten Frist entrichtet. Der vorliegende europäische Recherchenbericht wurde für die Teile der Anmeldung erstellt, die sich auf die zuerst in den Patentansprüchen erwähnte Erfindung beziehen, nämlich Patentansprüche:

1-9

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Nummer der Anmeldung
EP 09 00 4517

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1. Ansprüche: 1-9

   Lenken eines Strahls in Richtung der Beugungsmaxima eines mikrooptischen Rasters und eine geeignete Aufweitung des Strahls

   ---

2. Anspruch: 10

   Kombination einer Kamera mit einem abtastenden Sensor

   ---

3. Anspruch: 11

   Abtasten eines Bereichs mit verschiedenen Divergenzwinkeln

   ---

4. Anspruch: 12

   Abtasten einer Unterwasserumgebung

HESAI EX1002, P.461

ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT ÜBER DIE EUROPÄISCHE PATENTANMELDUNG NR. EP 09 00 4517

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten europäischen Recherchenbericht angeführten Patentdokumente angegeben.
Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am
Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

20-03-2013

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
WO 2008018955 A2	14-02-2008	KEINE	
DE 4428704 A1	23-02-1995	DE 4428704 A1	23-02-1995
		IL 110449 A	10-06-1997
		JP 2637046 B2	06-08-1997
		JP H0777660 A	20-03-1995
		US 5392157 A	21-02-1995
US 6751009 B2	15-06-2004	KEINE	
DE 19635792 A1	03-04-1997	DE 19635792 A1	03-04-1997
		JP 4005651 B2	07-11-2007
		JP H09133862 A	20-05-1997
		US 5850310 A	15-12-1998

EPO FORM P0461

Für nähere Einzelheiten zu diesem Anhang : siehe Amtsblatt des Europäischen Patentamts, Nr.12/82

HESAI EX1002, P.462

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Optical projection system with curved speckle reduction element surface

Abstract

In a coherent light projection system including an image forming system (12), a relay system (18), a speckle reduction element (40), and a projection subsystem (20), the relay system can have a first f-number, and the projection subsystem can have a second f-number less than the first f-number. The relay system can have a first working distance (Wa), and the projection subsystem can have a second working distance (Wb) less than the first working distance. The image forming system can project an initial image having a first size, and an intermediate image can have a second size greater than or equal to the first size. The speckle reduction element can have a curved surface through which the intermediate image is transferred. The speckle reduction element can include a lenslet arrangement (44) formed on a surface thereof.; The speckle reduction element can be moved in a direction parallel to an optical axis of the speckle reduction element.

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(71)申请人 伊斯曼柯达公司
地址 美国纽约州

(72)发明人 B·D·西尔弗斯泰因 J·R·比特里
G·E·诺萨德 R·梅茨格
A·F·库尔茨

(74)专利代理机构 中国专利代理(香港)有限公司 72001
代理人 徐小会 王忠忠

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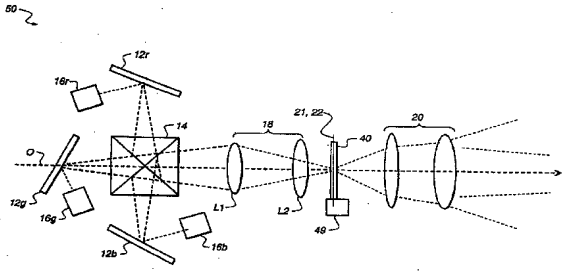
权利要求书 2 页 说明书 16 页 附图 8 页

(54)发明名称

具有弯曲的散斑减少元件表面的光学投影系统

(57)摘要

在包括图像形成系统(12)、中继系统(18)、散斑减少元件(40)和投影子系统(20)的相干光投影系统中，中继系统可以具有第一f数，并且投影子系统可以具有比第一f数小的第二f数。中继系统可以具有第一焦点距离(Wa)，并且投影子系统可以具有小于第一焦点距离的第二焦点距离(Wb)。图像形成系统可以投影具有第一尺寸的初始图像，并且中间图像可以具有大于或等于第一尺寸的第二尺寸。散斑减少元件可以具有弯曲表面，中间图像经过该弯曲表面。散斑减少元件可以包括形成在其表面上的小透镜布置(44)。散斑减少元件可以在平行于散斑减少元件的光轴的方向上移动。



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1. 一种相干光投影系统，包括：

相干光源系统，所述相干光源系统至少被构造成发射相干光；

图像形成系统，所述图像形成系统至少被构造成以与图像数据相一致的方式与所述相干光相互作用；

中继系统，所述中继系统至少被构造成根据由所述图像形成系统输出的相干光形成在中间图像平面处的中间图像，所述中间图像是空中的实际图像；

位于或基本位于所述中间图像平面处的散斑减少元件，所述散斑减少元件具有弯曲表面，所述弯曲表面构造成使所述中间图像经过所述弯曲表面；

运动生成系统，所述运动生成系统至少被构造成使所述散斑减少元件移动；以及

投影子系统，所述投影子系统至少被构造成在所述中间图像经过所述散斑减少元件时对所述中间图像进行投影。

2. 根据权利要求 1 所述的系统，其中，所述投影子系统被进一步构造成对胶片变形效应进行校正，并且其中所述弯曲表面至少被构造成对所述投影子系统对胶片变形效应进行的校正进行补偿。

3. 根据权利要求 1 所述的系统，其中，所述弯曲表面是这样的表面：所述中间图像通过该表面被所述散斑减少元件接收。

4. 根据权利要求 1 所述的系统，其中，所述弯曲表面是这样的表面：所述中间图像通过该表面离开所述散斑减少元件。

5. 根据权利要求 1 所述的系统，其中，所述散斑减少元件的所述弯曲表面是经蚀刻或抛光的表面。

6. 根据权利要求 5 所述的系统，其中，所述弯曲表面包括任意或基本任意分布的表面结构。

7. 根据权利要求 1 所述的系统，其中，所述图像形成系统包括光调制器和二向色组合器，所述二向色组合器将来自所述相干光源系统的多个颜色通道对准到公共轴线上。

8. 根据权利要求 1 所述的系统，其中，所述运动生成系统至少被构造成导致所述散斑减少元件在平行于所述散斑减少元件的光轴的方向上的运动。

9. 根据权利要求 8 所述的系统，其中，平行于所述光轴的运动在所述投影子系统的焦深内。

10. 根据权利要求 8 所述的系统，其中，平行于所述光轴的运动在所述中继系统的焦深内。

11. 根据权利要求 8 所述的系统，其中，所述运动生成系统至少被进一步构造成导致所述散斑减少元件在垂直于所述散斑减少元件的光轴的方向上的运动。

12. 根据权利要求 1 所述的系统，其中，所述散斑减少元件包括形成在所述散斑减少元件的表面上的小透镜布置，所述小透镜布置包括各自具有孔的小透镜，其中所有或基本上所有小透镜孔中的每一个都大于或等于所述中间图像平面处的中间图像的像素的尺寸。

13. 根据权利要求 12 所述的系统，其中，所述小透镜布置包括小透镜的任意或基本任意分布。

14. 根据权利要求 12 所述的系统，其中，所述小透镜布置包括呈或基本呈六角形、线性、或对角线图案的小透镜。

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15. 根据权利要求 12 所述的系统，其中，所述小透镜布置完全或几乎完全包括邻接的小透镜。

16. 根据权利要求 12 所述的系统，其中，所述小透镜布置完全或几乎完全包括非邻接的或稀疏分布的小透镜。

17. 根据权利要求 12 所述的系统，其中，所述运动生成系统至少被构造成使所述散斑减少元件在平面内移动大于或等于小透镜的重复周期的距离。

18. 根据权利要求 12 所述的系统，其中，所述小透镜布置至少被构造成在所述中间图像经过所述散斑减少元件时将所述中间图像的第四阶或更低阶能量传递到所述投影子系统的受光孔中。

19. 根据权利要求 1 所述的系统，其中，所述图像形成系统被进一步构造成投影具有第一尺寸的初始图像，并且其中所述中间图像具有大于或等于所述第一尺寸的第二尺寸。

20. 根据权利要求 19 所述的系统，其中，所述第二尺寸与 16mm、35mm 或 70mm 的胶片格式相一致。

21. 根据权利要求 19 所述的系统，其中，所述投影子系统被进一步构造成对胶片变形效应进行校正。

22. 一种投影光的方法，包括：

由相干光源系统产生相干光；

利用图像形成系统至少通过以与图像数据相一致的方式与所述相干光相互作用来形成图像；

至少根据从所述图像形成系统输出的相干光形成在中间图像平面处的中间图像，所述中间图像是利用中继系统形成的空中实际图像；

使所述中间图像经过位于或基本位于所述中间图像平面处的散斑减少元件的弯曲表面；

在所述中间图像经过所述散斑减少元件时利用运动生成系统移动所述散斑减少元件；以及

在所述中间图像经过所述散斑减少元件时利用投影子系统对所述中间图像进行投影。

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具有弯曲的散斑减少元件表面的光学投影系统

技术领域

[0001] 本发明通常涉及一种数字图像投影，并且更具体地涉及一种提供散斑（speckle）补偿的相干光投影系统。

背景技术

[0002] 用于将图像投影到显示表面上的传统投影透镜被设计为具有相对较快的光学元件。对于影院投影尤其如此，其中传统的胶片投影透镜可以达到～ f/1.8 那么快，并且在新兴的数字影院技术中，透镜通常为～ f/2.5。这些低 f/# 值以及相应的大角度的光在很大程度上是由于所使用的大集光率光源（例如，各种类型的非常亮的弧光灯和类似的光源），同时又期望尽可能多地利用这种光。

[0003] 在数字影院投影中，通过像素化的空间光调制器，例如 LCD 和 LCOS 调制器、数字微镜器件（DMD）、尤其是由德克萨斯州达拉斯市的德州仪器公司提供的 DLP（数字光处理器）来提供图像内容。以像素寻址的方式来调制（modulate）这些电子光调制装置的各个像素，以将图像数据赋予经过的光束。为了实现影院投影，使用具有～ 400-600mm^2 的有效面积的大型（large version）装置，以在与用于影院投影的大集光率氙气灯光源使用时这些装置能够兼容并且光学高效。然而，我们已经确定：这些大集光率光源以各种不利的方式影响投影仪的设计，包括光学部件的尺寸和成本、对这些部件的热载荷和应力，以及由光学元件提供的光学成像性能和图像质量。例如，传输大角度光入射的空间光调制器装置及其相关的偏振光学元件将不利地影响投影图像的质量，具有峰值对比度和对比度一致性缺陷。

[0004] 更详细地，数字投影系统的照明和投影子系统通常比其在传统的基于胶片的系统中的等效装置更复杂。特别地，在数字系统中，相比于传统投影光学元件，投影透镜系统通常担负不同的附加要求。作为一个示例，用于数字系统的投影透镜一般需要提供长的后焦距或焦点距离，即，最后的透镜表面与空间光调制器之间的距离。在大多数情况下，需要焦点距离超过透镜焦距的 2 倍，以容纳用来将来自不同颜色路径的经调制的光组合到公共光轴上的多个光学部件，并且根据所使用的空间光调制器的类型来提供光的偏振、滤光以及其他调节和引导。结合在一起，如光学设计领域技术人员所熟知的，长的后焦距与速度要求（低 F#）组合起来促使了使用大的元件的复杂透镜设计。结果，用于大会场或数字影院投影系统的投影透镜非常昂贵，特别是当与诸如在基于胶片的投影仪中使用的传统投影透镜相比时。

[0005] 作为减小该问题的程度的一种尝试，如在共同转让给 Cobb 的题为“使用空间光调制器的投影装置（Projection Apparatus Using Spatial Light Modulator）”的美国专利 No.6,808,269 中描述的系统使用成像中继（relay）透镜。通过中继透镜对每个调制器进行成像，以在组合棱镜的出射面附近创建实际的空中放大的中间图像。调制器平面处的大的数值孔径（NA）减小，例如减小一半，从而使 F# 相应地增大一倍。通过棱镜组合三色图像，然后通过公共投影透镜将该三色图像成像到屏幕上。尽管具有三个成像中继器的整个系统的复杂性增加了，但投影透镜的简化大大弥补了复杂性和成本的增大，其中投影透镜以较大的 F# 工作，没有焦点距离要求。

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[0006] 作为另一种方法，相比于传统光源，具有有利的小集光率的可见激光的使用提出了提供简化的系统光学元件的机会，例如通过使投影透镜能够具有与用于基于胶片的投影的透镜相似等级的适度复杂性。近年来，可见激光光源在成本、复杂性和性能方面得到了改进，从而对于在包括用于影院的投影中使用变得更可行。激光可以为图像投影提供大量优点，包括扩展的色域，但其较小的集光率对于基于 LCD、DLP 和其他类型的光调制器以及更小、更慢和更便宜的透镜元件的数字系统是特别有利的，其中可以使用在 f/8 范围内或更慢的值，同时仍为影院应用以及其他投影应用提供具有足够可见光通量的光。应当注意，激光还使得其他调制器类型（例如光栅机电 (GEMS) 调制器）能够用于投影，该光栅机电调制器是利用衍射来生成图像数据的线性阵列器件，且其需要小集光率。

[0007] 激光为投影系统提供很多潜在的实质优点，包括大大扩展的色域、可能的长寿命源、以及简化的光学设计。然而，激光也引入了散斑，该散斑由于来自显示屏的散射表面的局部反射的相干干涉而出现。散斑是使图像质量严重变差的高对比度颗粒噪声源。在成像技术中已知可以以多种方式来减少散斑，例如，通过叠加多个不相关的散斑图案，或者通过使用频率或偏振的变化。在 Joseph W.Goodman 的“光学中的散斑现象 :理论和 应用 (Speckle Phenomena in Optics :Theory and Applications)”中公开了这些方法中的很多种。作为有关于投影的散斑减少方法的一个示例，利用通常沿着围绕光轴的小圆或椭圆的振荡运动来快速地移动显示屏。散斑随着显示屏移动而变化，这是因为通过屏幕运动而改变了激光与散射特征的局部相互作用。当该振荡运动足够快时，通过时空平均化减小了散斑的可见性，并且散斑能够变得使观察者察觉不到。散斑减少的另一策略是将光漫射器布置在位于投影仪内的中间图像平面处并且在投影透镜之前。然后，漫射器的振荡具有减小观察者对散斑的察觉能力的效果。

[0008] 多种光漫射器已经被用于激光投影的散斑减少，包括基于磨砂玻璃、体积、全息摄像以及小透镜的装置。作为一个示例，在 Trisnadi 的题为“用于减少激光散斑的方法、装置和漫射器 (Method, Apparatus, and Diffuser for Reducing Laser Speckle)”的美国专利 No.6,747,781 中公开的装置中，使用图案化为哈达玛矩阵的漫射器，与衍射线性阵列调制器 (GLV) 一起为经调制的光的扫描线的中间图像提供时间相位变化。这种漫射器由漫射相位单元的阵列构成，每个这种漫射相位单元均被再次划分为 N 个单元部分，这些单元部分的图案通过哈达玛矩阵计算来确定。示例性的单元可以是 24μm 的正方形，并且可以包括是 3μm 的正方形的 N = 64 个单元部分。这些单元部分或者是基底表面的区域，或者是高度为 π 的隆起的平顶山状区域。如果单元图案化和漫射器运动提供的时间相位变化是适当的，则在传输的激光束中的相位变化被去相关，从而能够实现散斑减少。然后，需要特别设计的投影和扫描光学元件以将每条调节过的光线投影到显示屏上。一般地，用于这种线扫描装置的投影透镜具有 2.5 的 f/#。虽然 Trisnadi 提供了投影的散斑的有效减少，但散斑减少仅是激光投影系统设计的一个方面。通过位于内部中间图像平面处的运动漫射器（即，然后被成像到屏幕上）提供的散斑减少引入了各种进一步的问题，这些问题包括图像质量（分辨率或 MTF) 降低，由漫射（散射或衍射）导致的光损失，以及需要更快的成像光学元件来收集漫射光。

[0009] 尽管存在诸如这些的多种散斑减少技术，但在本领域还存在对改进技术的持续需求，其减小对投影图像的散斑察觉能力，同时还能改进激光投影系统的设计和系统性能。

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发明内容

[0010] 在本领域通过根据本发明的各种实施例的用于相干光投影的系统和 方法解决了上述问题并实现了技术方案。在本发明的实施例中，相干光源系统发射相干光。图像形成系统以与图像数据一致的方式与相干光相互作用。中继系统根据从图像形成系统输出的相干光形成在中间图像平面处的中间图像。中间图像为空中的实际图像。散斑减少元件位于或基本位于中间图像平面。运动生成系统使散斑减少元件移动，并且投影子系统在中间图像经过或穿过散斑减少元件时投影中间图像。

[0011] 在本发明的一些实施例中，中继系统具有第一 f 数，并且投影子系统具有比第一 f 数少的第二 f 数。在这些实施例的一些实施例中，第二 f 数为第一 f 数的至少一半。例如，第一 f 数可以是 f/6 或更大，并且第二 f 数可以是 f/3 或更小。

[0012] 在本发明的一些实施例中，中继系统具有第一焦点距离，并且投影子系统具有比第一焦点距离小的第二焦点距离。在这些实施例的一些实施例中，第二焦点距离为第一焦点距离的至少一半。例如，第一焦点距离可以是 100mm 或更大，并且第二焦点距离可以是 50mm 或更小。

[0013] 在本发明的一些实施例中，图像形成系统投影具有第一尺寸的初始图像，并且中间图像在中间图像平面处具有大于或等于第一尺寸的第二尺寸。在这些实施例的一些实施例中，第二尺寸与 16mm、35mm、或 70mm 的胶片格式一致。此外，在这些实施例的一些实施例中，投影子系统对胶片变形效应进行校正。

[0014] 在本发明的一些实施例中，散斑减少元件具有弯曲表面，中间图像可以经过该弯曲表面。在这些实施例的一些实施例中，投影子系统对胶片变形效应进行校正，并且弯曲表面对投影子系统对胶片变形效应进行的校正进行补偿。该弯曲表面可以是这样的表面 ：中间图像通过该表面被散斑减少元件接收，或者中间图像通过该表面离开散斑减少元件。散斑减少元件的弯曲表面可以是经蚀刻或抛光的表面，并且可以包括任意或基本任意分布的表面结构，例如小透镜。

[0015] 在本发明的一些实施例中，散斑减少元件包括形成在散斑减少元件的表面上的小透镜布置，该小透镜布置包括小透镜，其中每一个小透镜均具有孔。所有或几乎所有小透镜孔中的每一个均大于或等于中间图像平面处的中间图像的像素的尺寸。小透镜布置可以具有小透镜的任意或基本任意的分布。透镜可以呈或基本呈六边形、线性、或对角线图案。并且，小透镜可以是邻接的或非邻接的。如果它们不邻接，则小透镜之间的间隔可以足够大或基本足够大，以允许来自该间隔的漫射进入投影透镜的受光孔 中。小透镜之间的间隔可以大于或等于中间图像平面处的中间图像的像素的尺寸。在一些实施例中，运动生成系统使散斑减少元件在平面内移动大于或等于小透镜的重复周期的距离。在一些实施例中，投影子系统内的透镜的受光孔捕捉由小透镜之间的间隔或者邻接的小透镜之间的凹谷所导致的漫射。在一些实施例中，投影子系统内的透镜的受光孔捕捉散斑减少的图像的第四阶或更低的能量。在一些实施例中，小透镜布置将散斑减少的图像的第四阶或更低的能量传递到投影子系统的受光孔中。

[0016] 在本发明的一些实施例中，运动生成系统导致散斑减少元件在平行于散斑减少元件的光轴的方向上的运动。在这些实施例的一些实施例中，运动在投影子系统的焦深内。此

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外，在这些实施例的一些实施例中，运动在中继系统的焦深内。运动还可以包括在垂直于散斑减少元件的光轴的方向上的运动。

[0017] 本发明的各种实施例特别适用于诸如 DLP 装置的空间光调制器，所述调制器调制来自激光器或具有相干性的高亮度光源的光。本发明的各种实施例提供了一种光学系统，其允许使用传统类型的投影透镜元件，并利用了可用激光获得的高亮度。

[0018] 根据下面对优选实施例的详细描述和所附权利要求的回顾并参考附图，可以更清楚地理解和了解本发明的这些和其他方面、目的、特征和优点。

附图说明

[0019] 通过以下结合附图考虑的对示例性实施例的更详细的描述将更容易理解本发明，其中：

[0020] 图 1 是示出了在本发明的实施例中使用的一些普通部件的图；

[0021] 图 2 是示出了用于具有减少的散斑的数字图像投影的本发明实施例的设备的图；

[0022] 图 3 是示出了具有近似的 f# 与受光孔 (acceptance aperture) 的关系的本发明实施例的设备的图；

[0023] 图 4 是示出了具有弯曲表面的散斑减少元件的本发明实施例的设备的图；

[0024] 图 5a 和图 5b 分别示出了包括中间图像和漫射图像的内部系统图像；

[0025] 图 5c 示出了如在传统基于胶片的投影系统中出现的胶片变形 (film buckle) 和胶片成像；

[0026] 图 6a 是使用稀疏分布的微透镜的散斑减少元件的实施例的图；以及

[0027] 图 6b 示出了根据本发明的实施例将散斑减少元件用于增大通过投影透镜成像的角分集。

具体实施方式

[0028] 对于以下详细说明，应当理解，没有具体示出或描述的元件可以是本领域技术人员已知的各种形式。文中示出和描述的附图被提供用来根据本发明的实施例示出操作原理和部件沿其相应的光学路径的关系，并且可能没有示出实际大小或尺寸。一些放大可能是必要的，以强调基本结构关系或操作原理。在一些情况下，没有示出通常位于投影设备的光学路径中的部件，以便更清楚地描述投影光学元件的操作。

[0029] 本发明包含文中描述的实施例的组合。对特定实施例等的参照是指在本发明的至少一个实施例中存在的特征。“实施例”或“特定实施例”等的单独参照未必一定指的是相同的一个或多个实施例；然而，这种实施例不是互斥的，除非进行了这样的说明或者对本领域技术人员是显而易见的。在涉及“方法”或“多个方法”等时所使用的单数和 / 或复数不是限制性的。

[0030] 如在本公开内容中使用的术语“f 数”或 f/# 具有其传统的含义，即：焦距与受光孔直径之比。此外，除非文中明确指出或如上下文所要求，否则词语“或”以非排他的含义用于本公开内容中。

[0031] 图 1 示出了在本发明的各个实施例中使用的几个普通相干光投影系统部件中的简化示意图。后面的视图和后续的描述引入了添加到图 1 所示的普通部件的附加部件。在

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这方面，图 1 示出了具有发射高度相干的光的相干光源系统的相干光投影系统 10。在图 1 的情况下，相干光系统包括相干光源 16r、16g 和 16b，分别用于红色通道、绿色通道和蓝色通道中的每一个。然而，可以使用其他颜色通道。同样在图 1 的情况下，相干光 源 16r、16g 和 16b 为激光光源，例如直接发射式二极管激光阵列、光纤激光器、或 IP 泵浦的谐振变换激光器。然而，可以使用具有足够亮度和光束质量的任何相关或局部相干的光源。例如，可以使用可见光波长超辐射发光二极管 (SLED)。

[0032] 从相干光源 16r、16g、16b 发射的光被图像形成系统接收，在图 1 的情况下，该图像形成系统包括空间光调制器 12r、12g、12b（例如，DLP（数字微镜）器件）和组合元件（例如，二向色组合器 14)。每个光调制器 12r、12g、12b 分别位于投影系统的对象平面 5r、5g、5b 处；在这种情况下，投影系统为投影子系统 20 的成像透镜 20a。此外，每个空间光调制器 12r、12g、12b 与显示表面 30 处的显示图像平面 7 是图像共轭的，其中屏幕可以设置在显示表面 30 处。该布置可用于 LCD 或其他类型的光调制器。

[0033] 在相干光投影系统 10 的操作期间，光调制器 12r、12g、12b 以与图像数据（例如，表示电影中的图像帧的图像数据）一致的方式与从光源 16r、16g、16b 发射的相干光相互作用。在这方面，通过诸如控制系统的数据处理系统（未示出）将控制信号提供给光调制器 12r、12g、12b，该数据处理系统使用本领域已知的技术和设备以与图像数据一致的方式控制光调制器 12r、12g、12b。特别地，光调制器 12 包括根据图像数据信号来调制入射光的可寻址调制器像素（未示出）的二维阵列。可以通过多种方式来提供光调制，包括：通过使微镜 (DLP) 倾斜而重新定向、偏振旋转 (LCOS 或 LCD)、光散射、吸收、或衍射。

[0034] 来自光调制器 12r、12g、12b 的调制光在二向色组合器 14 处被组合到相同的光学路径、轴线 O 上。被组合器 14 组合的光最终到达投影子系统 20，在这种情况下，该投影子系统 20 包括用于将图像内容的图像投影到显示表面 30 上的示例性透镜对 20a、20b。

[0035] 通过考虑图 1 的简化示意图能够更好地理解光学系统设计者所面临的一些问题。在系统 10 中，由于来自多个光调制器 12r、12g、12b 的光在被投影子系统 20 投影到显示表面 30 之前经由组合器 14 被组合，因此 需要长的焦点距离。此外，使投影子系统 20 在对象空间内以大 f#（例如，f/6 或更高）工作是有利的，从而以更容易且更低廉的方式实现了长焦点距离。此外，通过不捕捉大角度的光，投影子系统 20 将不会获取很多可能从附近的表面结构散射的许多不期望的杂散光。例如，诸如 MEMS 器件的部件（例如，DLP 调制器）、透镜元件边缘和缺陷、以及其他结构能够在成像系统内散射光。该散射光或闪耀光能够穿过透镜到达屏幕，并可以减小宽区域图像对比度 (ANSI 对比度）以及局部或图像细节对比度两者，从而影响明显的屏幕黑度和可分辨的细节。另一方面，为了减少来自相干源投影子系统 20 的散斑可见性，优选将会聚光传输到具有大角度宽度（大数值孔径（“NA”））的显示表面 30。然而，假设来自投影子系统 20 的恒定放大率，意味着光在调制器侧上的角度宽度也很大，例如，具有低 f#（例如，f/3 或更低）。因此，减小潜在散斑可见性的期望与降低透镜的复杂性和成本以及使内部散射光的收集最小化的需要相冲突。

[0036] 图 2 的示意性框图示出了根据本发明的实施例的相干光投影系统 50，其改变了图 1 的基本设计，以减少散斑可见性。特别地，穿过组合器 14 的光被引导通过中继系统，在这种情况下，为中继透镜 18。包括至少一个中继透镜元件 L1 的中继透镜 18 被定位成使每个光调制器 12r、12g 和 12b 成为与形成在中间图像平面 21 处的中间图像 22 图像共轭的对

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象。中间图像 22 是由中继系统（即，中继透镜 L1）和中间图像平面 21 处的其他上游光学元件形成的空中实际图像。如果屏幕或其他显示结构被布置在相应的图像平面处（在这种情况下，为中间图像平面 21），则空中实际图像为能够看到的位于空间内的图像。在这种情况下，图 5a 中示出的空中中间图像 22 包括是调制器像素的像素图像的中间图像像素 23 的阵列，。特别地，中间图像像素 23 包括来自红色调制器、绿色调制器和蓝色调制器（12r、12g、12b）的相应像素图像的重叠且对准的图像。优选地，相应的被成像的调制器像素在中间图像平面 21 处的整个中间图像 22 范围内被共同对准到 1/4 像素误差或更好的像素误差内。中间图像平面 21 位于或基本位于散斑减少系统内，在这种情况下，该散斑减少系统包括散斑减 少元件 40 和用于移动散斑减少元件 40 的运动生成系统，在这种情况下，该运动生成系统为致动器 49。中间图像 22 在经过或穿过散斑减少元件 40 时通过投影子系统 20 被投影。中继透镜 18 具有大约 150mm 的相对较长的焦点距离 Wa（参见图 3），并且是大约 f/6 的相对较慢的透镜。在一些实施例中，中继透镜 18 在面对光调制器 12 的一侧是远心的。

[0037] 图 3 示出了中继透镜 18 具有比投影子系统 20 的 f#（即，图 3 中的第二 f#24）大（例如为其大约两倍大）的 f#（即，图 3 中的第一 f#19）的实施例。换句话说，中继透镜 18 的出射角大约是投影子系统 20 的接收角 (acceptance angle) 的一半。在本发明的一些实施例中，中继透镜 18 具有 f/6 或更大的 f 数，并且投影子系统 20 具有 f/3 或更小的 f 数。如前面提到的，中继透镜 18 可以具有长的焦点距离 Wa，该焦点距离是容纳组合自不同成像通道的光束所需的。可替代地，投影子系统 20 具有第二焦点距离 Wb，第二焦点距离 Wb 可以比第一焦点距离 Wa 小得多。虽然投影子系统 20 需要容纳散斑减少系统的光学元件（例如，散斑减少元件 40），并且或许还需要容纳场镜，但与容纳组合器 14 相比，所需的空间小得多。在一些实施例中，第一焦点距离为 150mm 或更大，并且第二焦点距离为 50mm 或更小。由于投影子系统 20 在光学方面更快，但其可以具有较短的焦点距离，因此与对于当前数字影院投影透镜常见的即快且需要长焦点距离的透镜相比，其更容易设计和制造。

[0038] 同样地，中继透镜 18 的设计是有利的，因为其以小的放大率（1x-2x）工作。虽然中继透镜 18 仍提供长焦点距离 Wa，但该透镜比传统数字影院投影透镜在光学上慢，因此中继透镜 18 在制造和设计方面也更便宜。此外，由于光学组合器 14 此时处于光学路径的相对较慢的部分中，因此其中的光学涂层设计和制造的难度要低得多，这是因为其仅需要在较小角度范围内进行组合。在 MEM 空间光调制器——其基于输入光与输出光之间的角度差来区别输入光和输出光——的情况下，提高了对比率。这些 f 数与焦点距离的关系优化了有效成像性能，以通过增大下面论述的角分集来提供低成本的光学设计简单化、更简单的光学涂层、以及具有高对比率 的高图像质量参数和散斑减少。

[0039] 返回到图 3，中继透镜 18 引导其光锥，以在散斑减少系统附近的中间图像平面 21 处形成中间图像 22，在这种情况下，该散斑减少系统包括通过致动器 49 移动的散斑减少元件 40。散斑减少元件 40 以通过在时间上改变反射与显示表面 30 的相干干涉来减少投影图像中的散斑可见性的方式（例如，通过相位改变和 / 或角度改变）来改变中间图像 22 或来自于中间图像 22 的光传播。

[0040] 运动生成系统（例如，图 4 中所示的致动器 49）可以是散斑减少系统的一部分。运动生成系统在中间图像经过散斑减少元件 40 时为散斑减少元件 40 提供振动、旋转或者其他重复或随机的运动，以减少散斑。

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[0041] 在一个实施例中，散斑减少元件 40 是光漫射器，例如，体积或表面浮凸漫射器（例如，全息摄像漫射器）。在这些情况下，运动生成系统包括本领域已知的使漫射器在平面内来回移动，或者在漫射器的平面内旋转地运动的致动器 49，使得漫射器保持在中间图像平面 21 处或其附近。换句话说，“平面运动”指的是例如在垂直于散斑减少元件 40 的光轴（在图 2 的示例中为轴线 O）的方向上的运动。

[0042] 已知当漫射器被用作散斑减少元件 40 时，其改变与形成漫射图像像素 23’的每个中间图像像素 23 相关联的图像光的任意相位，如图 5b 所示。由该配置中的运动生成系统导致的实际散斑减少取决于几个因素，这些因素包括：漫射器特征（或结构）的属性（尺寸、形状和分布）、漫射器运动特性（速率和范围）、显示表面 30 上的投影透镜分辨元素（图像像素）的数量、以及屏幕（显示表面 30）上的散射特征的特性。由于通过散斑减少元件（漫射器）40 的运动改变了与中间图像像素相关联的图像光的相位结构，因此到达显示表面 30 的入射相位和位置也稍微改变，从而改变了与显示表面微结构的相互作用以及反射光中的散斑干涉。观看者的有效眼睛分辨率（由观看者离屏幕的距离以及观看者的个人视力（例如，20-20）来确定）也影响散斑可见性。散斑可见性随着漫射器特征和显示表面 30 上的图像像素的数量增加而减小，但其最终限制在非零的值。

[0043] 应当注意，虽然光漫射器可用于散斑减少元件 40，但其也以多种方式影响通过系统 50 的光传播。作为一个示例，漫射器在中间图像平面 21 处或其附近的布置实质上限定了系统 50 内的新对象，即图 5b 中示出了漫射图像 22’，这是因为光的角度范围（或 NA）增大了。角度范围的改变可以被建模成光漫射轮廓和入射光分布（中继透镜 F#(19)）的卷积。当然，投影透镜需要容纳的有效集光率同样增大。作为第二效果，由于漫射器特征和漫射器运动引入了模糊和对比度损失，所以中间图像平面 21 处的中间图像像素 23 的有效尺寸增大，从而产生了漫射图像像素 23’。当通过投影子系统 50 将具有其漫射图像像素 23’的该新图像对象（漫射图像 22’）成像到显示表面 30 上时，投影图像质量，在分辨率（或 MTF）方面降低了。

[0044] 再次参照图 2，中继透镜 18 包括至少一个中继透镜元件 L1，并且其可以包括可选的场镜 L2，场镜 L2 沿光轴 Q 设置在散斑减少元件 40 附近，在其与散斑减少元件 40 之间没有中间透镜。在图 2 的情况下，场镜 L2 位于散斑减少元件 40 与中继透镜元件 L1 之间，并且以使来自产生的漫射图像 22’的漫射图像光进入投影子系统 20 的受光孔的方式促进了中间图像 22 向散斑减少元件 40 中的引导。在其他实施例中，场镜 L2 可以位于散斑减少元件 40 的下游，而仍然位于投影子系统 20 之前。来自散斑减少元件 40 的输出是相位改变了的图像，该图像被投影子系统 20 投影到显示表面 30（图 2 中未示出）上。

[0045] 虽然中间图像平面 21 处的中间图像 22 的图像尺寸可以等于、小于、或大于光调制器 12 的面积，但在很多情况下，理想的是图像面积等于或大于调制器 12 的面积，这是因为可以减小由投影透镜 50 收集的 NA。在这方面，图像形成系统（例如，光调制器 12r、12b、12g 和组合器 14）可以将组合的初始图像朝中继系统（例如，中继透镜 18）投影，其中该初始图像具有对应于光调制器的尺寸的第一尺寸。然后，该中继系统（例如，中继透镜 18）可以形成具有大于或等于第一尺寸的第二尺寸的中间图像 22。

[0046] 在本发明的一些实施例中，第二尺寸，即，中间图像平面 21 处的中间图像 22 的尺寸可以被中继系统（例如，中继透镜 18）放大，以与诸如 16mm、35mm、或 70mm 胶片格式的

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电影胶片尺寸相一致。对于 16mm、35mm 和 70mm 的胶片格式，这些电影胶片尺寸分别具有 13.73mm、25.81mm 和 52.80mm 的对角线。使中间图像 22 处在这些电影胶片尺寸允许了将传统的胶片投影透镜（例如，设计并用于传统的 16mm、35mm、或 70mm 胶片投影仪的透镜）使用在投影子系统 20 中，从而降低了成本并简化了设计。

[0047] 特别地，基于胶片的投影透镜，例如德国的 Schneider Kreuznach 销售的透镜，以从 24 至 100mm 的约 30 个不同焦距的范围提供，以适应电影产业中存在的各种屏幕距离和对角线。这些各种类型的透镜使得影院操作人员能够选择对于他们的特定会场的最佳解决方案。诸如可变定焦镜头的一些透镜也设计成处理 1 ： 137 至 1 ： 1.85 的不同胶片格式比，而其他透镜使用失真光学元件来传输 1 ： 2.39 格式的宽格式立体声宽银幕电影内容。这种宽阔的可用性和格式的灵活性提供了优于传统的数字影院透镜的显著优点，传统的数字影院透镜更昂贵且更具限制性。Schneider 仅为数字影院提供了十二个固定镜头。或许，更显著地，这些普通胶片投影透镜的 f 值通常在 f/1.7 至 f/2.8 之间的范围内。与普通漫射器的更常见的随机相位移动 (phase walk) 相比，这种较低的 f 数范围特别适于通过使用时间上均匀化的角分集来减小来自相干光源的散斑。然而，这些透镜仅具有在 30-57mm 范围内的后向 (back) 焦点距离，该焦点距离可能太小而不能适应诸如由三种颜色组合的光束的数字投影仪特性。在使用传统的胶片投影透镜时，还增大了改变格式尺寸的可用性和方便程度。普通失真透镜还能够用来切换到像用于特别宽的视景的范围一样的格式。

[0048] 将传统胶片投影透镜用于数字影院应用中的一个考虑是，较高质量的传统胶片投影透镜中的很多被设计为补偿胶片曲率或“变形”，如图 5C 所示。当胶片 60 的图像区域被照亮时，胶片感光乳剂根据图像内容吸收光。生成的热使胶片（其为弹性聚合物片材料）向平面外变形或弯曲一定 距离“d”。这种效应由图像区域通过孔板 62 相对于为声轨、穿孔和组帧栏 (framing bar) 提供的周围未照亮区域的不均匀照射和不均匀加热复合而成。被照亮区域膨胀，而固定区域不膨胀，迫使成像区域在光轴方向上移动，从而引入 d ～ 150-400μm 一样多的胶片表面曲率，朝照明源变形。因此，相对于投影透镜 20，胶片 60 此时为成像到屏幕 30 上的弯曲对象。

[0049] 最便宜的胶片投影透镜通常被设计成用于平的图像平面，因此导致被成像区域的外部边缘上的散焦（假设放映员将焦点设置在图像中心）。如果这些透镜的性能特性是适当的，则理想的是将这些透镜与数字空间光调制器 12 一起使用，其中，在投影期间图像平面保持平坦。另一方面，提供最佳投影图像质量的较贵的胶片投影透镜 20 也设计成对在 a ～ 1 英寸宽的区域上具有 d ～ 100-200μm 胶片变形深度的凹陷的弯曲对象（胶片 60）进行最佳的成像，以补偿胶片变形效果，例如，由于照明系统加热而导致的胶片平面偏差。

[0050] 关于用于数字投影的本发明，可以以若干种方式来适应如胶片类型投影透镜所预期的那样的成像平面（平坦）光调制器 12 和与弯曲对象平面共同对准的中间图像平面 21 的不太可能的组合。参照图 2，与投影子系统 20 相比，中继透镜 18 相对较慢。在中继透镜 L1 的情况下，由于透镜 L1 的焦深较大，因此对于 100-200μm 的小图像平面凹陷的校正不那么重要。在图 5a 中示出了焦深 (DOF)，并且其被定义为 ：

[0051]

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$$DOF = \pm \frac{\emptyset}{2 * \tan\left(\arcsin\left(\frac{1}{2 * f\#}\right)\right)}$$

[0052] 其中，Φ =模糊圈直径。为了可分辨，呈现到中间图像平面 21 的中间图像像素 23 的尺寸可以几乎等于（如果不大于的话）模糊圈直径。例如，如果空间光调制器 12 包括以 1.2 倍的放大率成像到中间图像平面 21 的 10μm 像素的阵列，那么生成的 12μm 的中间图像像素尺寸上可与模糊圈直径（Φ）相当，或是其 2-3 倍大。

[0053] 焦深是在 z 方向上的模糊点的尺寸增长被认为是可允许的的一定限定量的距离。衍射、像差、或散焦、或其组合，以变化的量，可以导致点模糊。例如，Rayleigh 的四分之一波标准是在成像系统中使用的通用度量。使用上述公式，并假定 f/6 中继透镜 18，则在中间图像平面 21 处的焦深可以是大约 120μm，其处于标准胶片投影透镜曲率的数量级。因此，在这种情况下，中继透镜 18 在焦深内粗略地适应图像平面曲率，而无需明显的校正。名义上，中继透镜 18 沿光轴 O 轴向地定位，使得由中继透镜 18 提供的最佳质量图像位置（最佳 MTF）与投影透镜 20 的最佳对象共轭平面位置基本重叠。中继透镜 18 还可以被设计成将调制器 12 的具有适当的曲率的弯曲图像呈现给胶片类型的投影透镜 20。

[0054] 另一方面，由于这些投影透镜的焦深（DOF）相对较小，因此被设计成最佳地成像弯曲对象的投影透镜 20 与平面的中间图像之间的失配不能简单地留待不校正。例如，使用 12μm 的中间图像像素尺寸和 f/1.7 的投影子系统 20，焦深仅为大约 36μm。该小焦深证明了使胶片类型投影透镜 20 的最佳成像弯曲平面与中间图像 22 和散斑减少元件 40 的表面相匹配的需要。

[0055] 在图 4 中示出的一个实施例中，散斑减少元件 40 具有弯曲表面 43，通过该弯曲表面 43 来接收中间图像 22。在其他实施例中（未示出），散斑减少元件 40 具有弯曲表面，漫射图像 22’或中间图像 22 通过该弯曲表面离开，从而被投影透镜 20 成像。在任一种情况下，曲率都可以是外凸的或内凹的。无论如何，弯曲表面具有与对这些商业可用胶片类型的投影透镜校正的胶片变形曲率匹配或基本匹配的曲率。表面结构可以以任意图案或有序的图案被设置在弯曲表面 43 上。在一个实施例中，在普通曲率的顶部上形成小透镜。在替代性的实施例中，通过蚀刻、抛光或成型，表面结构可以具有相位深度。在使用蚀刻或抛光工艺来制造散斑减少元件 40 的弯曲表面 43 的情况下，装置制造可以相对简单。通过比较发现，难以制造平版印刷的弯曲散斑减少元件 40 的表面特征，因为该工艺主要利用平的晶片工作。能够在平坦的基质上通过平板印刷来图案化散斑减少元 件 40 的表面特征，然后通过复制和成型工艺产生柔性或弯曲的散斑减少元件 40。例如，柔性底版然后可被用来将散斑减少表面特征铸造到球表面平面基底或具有包含光功率的第二表面的平的表面上。因此，可以产生对弯曲图像平面的进行光学校正的便宜的复制散斑减少元件 40。

[0056] 代替在散斑减少元件 40 上生成弯曲表面的替代方法是添加校正透镜系统（图 2 中的 L2 可以被配置为这种校正透镜），以校正商业可用胶片投影透镜的这种预先存在的图像曲率。这种与散斑减少元件 40 分开的校正透镜系统仅需要是在中继透镜元件 L1 与传统投影子系统 20 之间布置有非常小的光功率的简单校正透镜。在这方面，校正透镜系统（例如，L2）可以位于散斑减小元件 40 的上游或下游，并且可以位于在光轴 O 中在散斑减少元件 40 附近且在其与散斑减少元件 40 之间没有中间透镜。此外，校正透镜系统可以包括仅一侧

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弯曲或两侧都弯曲的透镜，并且这种曲率可以是外凸的或内凹的，这取决于设计的选择。或者，与所有透镜系统一样，可以使用多于一个透镜。因此，本领域技术人员将清楚，本发明不限于校正透镜系统的任何特定实现方式，只要其对前面讨论的标准影院胶片型投影透镜的胶片变形校正进行补偿即可。此外，根据选择的特定商业可用透镜，该校正透镜系统对于投影系统 20 可以是标准的或可选的。

[0057] 回到关于散斑减少元件 40 的一般论述，与胶片变形校正无关且不受所使用的中继透镜和投影透镜的类型约束，根据本发明的一些实施例，这种元件 40 位于或基本位于中间图像平面 21 处。此外，与胶片变形校正无关且不受所使用的中继透镜和投影透镜的类型约束，例如通过包括漫射器，该散斑减少元件 40 可以是漫射的，或者例如通过包括设置于其上的小透镜布置 44，该散斑减少元件 40 可以是折射的，这将在后面论述。

[0058] 在散斑减少元件 40 是漫射的实施例中，这种元件 40 提供中间图像 22 的相移和漫射。如上所述，由于致动器 49，该相移以时间为基础发生，使得由投影子系统 20 输出的光的有效空间相干性被眼睛平均化，以有效减少观看者察觉的散斑。散斑减少元件 40 可以是衍射元件，该衍射元件可以由诸如玻璃、熔融硅石、塑料或环氧树脂的多种不同材料制成。对于 基于高亮度等级偏振的光学系统，重要的是材料不吸收光、从而出现热致应力双折射。类似地，诸如蚀刻、抛光、成型、平板印刷术和全息摄像的各种方法可被用来制造散斑减少元件 40。此外，对于偏振敏感系统，期望的是不引入应力双折射的方法。这些漫射器可以创建有任意的或周期性的图案，以最小化散斑。

[0059] 如前所述，关于图 5a 和图 5b，使用漫射器可以导致图像模糊和分辨率损失。此外，由传统漫射器引入的增大的角度扩展虽然有利于减小散斑效应，但也增大了有效系统拉格朗日，从而所需的锥角（或数值孔径 (NA)）以搜集所有漫射光。投影透镜 20 的 f# 的这种减少可增大透镜制造的成本和难度。例如，普通磨砂玻璃漫射器本质上以朗伯方式工作，其中，大量的光 55 溢出到投影子系统 20 的集合 f 数 24 之外，如图 3 所示。甚至现代的全息摄像漫射器也能够显著增大角度范围，从而使溢出光 55、光效损耗、投影透镜孔径、以及图像模糊增大。

[0060] 由于折射和衍射效应的组合而产生光漫射或散射，所述折射和衍射效果可以是体积相关或表面相关的。来自散斑减少元件 40 的表面的衍射导致包含较低级（角度）和较高级（角度）内容的角度扩展。公知的是，对于来自圆形孔的衍射，大约 99％的来自衍射光的能量落在由孔形成的艾里斑图案的第四阶暗环内。理想的是将漫射结构设计成使得由衍射导致的角度扩展的大部分位于投影子系统 20 的受光孔 (F#24) 内。例如，在散斑减少元件 40 主要是衍射的一些实施例中，散斑减少元件 40 将来自第四阶以及更低阶的能量引导至投影子系统 20 的受光孔中。在需要较低 f 数投影透镜时，存在能量收集的减小返回。

[0061] 虽然漫射性散斑减少元件 40 在减少察觉到的散斑方面是有效的，但从中间图像 22 来创建漫射图像 22’ 的表面处理和结构类型通常产生能量损耗，这是由于可以溢出投影系统 20 的衍射导致的。该漫射图像 22’ 本质上变为相对于投影子系统 20 的对象，其具有新的波前和图像质量参数。虽然来自中继透镜 18 的像差被给予漫射图像 22’ 的漫射图像像素 23’ 的像素结构、尺寸和形状，但投影子系统 20 不能被最优化为校正它们，这是 因为原始相位（波前）内容被漫射性散斑减少元件 40 丢失。

[0062] 对利用漫射性散斑减少元件 40 来减少散斑的替代性减少散斑的方法是使用折射

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性散斑减少元件 40，该折射性散斑减少元件 40 在角度上移动中间图像 22，同时保持原始相位内容的至少一部分。如前所述，折射性散斑减少元件 40 可以布置在中间图像平面 21 处，在该中间图像平面 21 处通过中继系统（中继透镜 18）和其他上游光学元件来形成中间图像 22。与通过漫射性散斑减少元件 40 生成的漫射图像 22'不同，位于或基本位于中间图像平面 21 处的折射性散斑减少元件 40 传递中间图像 22，同时基本上保持由中继透镜 18 投影的波前数据。

[0063] 在一些实施例中，该折射性散斑减少元件 40 是结构化的窗口元件 45，其包括如相对于漫射性散斑减少元件 40 所描述的在时间上移动的小透镜布置（图 3、图 6a 和图 6b 中的 44）。与创建随机相位移动的漫射性散斑减少元件 40 不同，这种结构化的窗口元件生成在时间上变化的角分集，该角分集改变入射光与显示表面 30 的微结构的相互作用，并且因此改变反射的光干涉，从而减少散斑。

[0064] 如图 6a 所示，结构化的窗口元件 45 可以由小透镜 41 构成，每个小透 41 镜均具有形成在基质 46 上的孔 A。因此，如图 6b 所示，每个小透镜 41 用作子孔（sub-aperture）场镜，当结构化的窗口元件 50 被致动器 49 移动时，所述子孔场镜使被投影透镜 20 收集的图像光绕投影透镜的受光孔偏转。该小透镜 41 对通过中继透镜 18 形成的至少一个中间图像像素 23 进行采样，然后结合通过运动生成系统（例如，致动器 49）导致的这种结构化的窗口元件 45 的移动以时间变化的方式将与给定中间图像像素 23 相关的光的角度范围（圆锥或立体角 25）重新导向至投影子系统 20 的具有相对较大的受光孔径（捕捉的立体角 26）的不同部分（偏转的立体角 25'）。因此，当中间图像 22 经过散斑减少元件的小透镜 41 的布置时，运动生成系统将中间图像 22 的图像光引导到投影子系统 20 的受光孔中。然后，投影子系统 20 在中间图像经过移动的散斑减少元件时将中间图像的被引导的图像光投影到显示屏上，该显示屏反映出散斑减少的图像。由 于对于给定的场点（给定的中间图像像素 23），小透镜 41 主要提供用于光束引导而不是用于漫射的机制，因此在显示表面 30 上的基本相同位置处形成相应的屏上图像，无论图像光向上或向下或向侧面或最小程度地偏转或是完全不偏转，这些取决于在给定时间点与该给定像素最近的小透镜的位置。因此，通过每个移动的小透镜 41 和投影子系统 20 的组合，发生以最小图像质量损失被传递到图像投影表面 30（图 1 中所示）的角度引导。任何图像质量损耗均是由于，至少一部分由于每个小透镜 41 传输的光功率的微小变化导致的。剩余的漫射效果还可能增大来自中间图像像素 23 的收集到的立体角、或者降低图像质量。

[0065] 如前所述，折射性散斑减少元件 40 可以是具有小透镜 41 的结构化的窗口元件 45，其中小透镜中的每一个均具有孔 A，如图 6a 所示。相比于诸如蚀刻玻璃的普通漫射器表面的表面结构，该孔的尺寸相对较大。尽管小透镜孔 A 可以是圆形、方形、或其它形状，但理解提供像素尺寸的适当采样以减小散斑并传递大部分的光到显示表面 30 的特性是有利的。圆形孔的衍射公式显示了小透镜直径（孔径 A）与第四阶暗环的角度扩展之间的关系由下式给定：

[0066] $A = 4.24 * \lambda / \alpha$

[0067] 其中，A = 小透镜直径或孔径

[0068] α = 角度扩展（弧度）

[0069] λ = 关注的波长

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[0070] 例如，如果透镜 20a 是 f/2.8 透镜，则其具有大约 0.18 弧度的受光角 α。对于 0.000550mm 光的波长，最小的小透镜尺寸（直径 A）为大约 13μm。该尺寸与空间光调制器像素 (5-15μm) 或其图像（即，中间图像像素）处于相同的数量级。在比大约 13μm 小很多的尺寸下，相当大量的光被衍射或散射，并且被损失掉。因此，一种解决方案是使得每一个小透镜均对中间图像平面 21 处的中间图像 22 的一个或多个中间图像像素 23 进行采样。换句话说，所有或几乎所有小透镜孔径 A 中的每一个均大于或等 于中间图像平面 21 处的中间图像像素 23 的尺寸。在一些实施例中，使得小透镜孔径 A 比中间图像平面 21 处的中间图像的 N^2 个中间图像像素的尺寸大是有利的。在一些实施例中，N 为～ 2-4。由于小透镜孔径 A 对于中间图像像素 23 的尺寸来说相对较大，因此像素 23 实质上将小透镜 41 有效地看做是窗口。

[0071] 理解小透镜结构之间的间隙 42（如果存在的话）的参数也是有用的。在这方面，可以使用狭缝孔 (slit aperture) 衍射模型，其中小透镜 41 直接邻接，以提供简化的分析。在这方面，狭缝孔以与圆形孔相似的方式工作。在第一暗环内出现 83.8％的能量，在该示例中为大约 4μm，如下给出：

[0072] $Ag = 1.22*\lambda / \alpha$

[0073] 以下示出了在特定光带内的能量百分比：

[0074]

阶	圆形孔	狭缝孔
0 阶	83.8%	90.3%
1 阶	7.2%	4.7%
2 阶	2.8%	1.7%
3 阶	1.5%	0.8%
4 阶	1.0%	0.5%

[0075] 在需要较低 f# 投影透镜 20 时或者在将漫射结构制造得较小时，特别是在来自 0 阶光束的一些衍射损失的情况下，存在能量收集的减小返回。对于可见光，理想的是甚至使间隙结构处在 Ag ～ 5-20μm 的放大像素尺寸的数量级上。同样，结构的尺寸捕捉全部 0 阶至全部 4 阶的设计将有效地简化光学元件并捕捉增加的能量。换句话说，在一些实施例中，小透镜布置 44 至少被构造成在经过通过散斑减少元件时将中间图像的第四阶或更低阶的能量传递到投影子系统的受光孔中。换而言之，在一些实施例中，投影子系统 20 中的透镜的受光孔在中间图像转移通过散斑减少元件时捕捉中间图像的第四阶或更低阶的能量。

[0076] 从另一个视角来观察图 6b，由中继透镜 18 提供的到中间图像平面 22 的入射 F#(19) 在图像光经过散斑减少元件 40（为结构化的窗口元件 45）时基本上被保存。也就是说，除了任何残余的漫射外，拉格朗日和波前（或相位）信息基本上也都被保存，无论光是穿过窗口状的小透镜间隙 42 或是被小透镜 41 偏转到投影透镜 (24) 的较大受光 F# 中。因此，给定中间图像像素 23 的放大图像然后被图像质量损失最小地提供在显示表面 30 处，无

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论图像光是经过通过投影子系统 20 的偏转路径或是未偏转路径。

[0077] 包括结构化的窗口元件 45 作为折射性散斑减少元件 40 的实施例可以具有位于元件 40 的上游侧（例如，面对中继透镜 18）或位于元件 40 的下游侧（例如，面对投影子系统 20，如图 3 所示）的小透镜布置 44。此外，在折射性散斑减少元件 40 具有弯曲表面以补偿投影子系统 20 中的胶片变形校正的实施例中，如果适用的话，小透镜布置 44 可以位于所述弯曲表面上或者位于所述弯曲表面的相反侧上的平表面上。小透镜布置 44 主要使结构化的窗口元件 45 的相应表面是折射性的。在一些实施例中，小透镜布置 44 完全或几乎完全包括邻接的小透镜，例如如图 3 所示。在其他实施例中，例如如图 6a 和 6b 所示，小透镜布置 44 完全或几乎完全包括稀疏分布（例如，不邻接）的小透镜 41，其中在小透镜 41 之间具有间隙 42。间隙 42 包括小透镜 42 之间的空间，其中基质 42 的前表面和后表面名义上彼此平行。在任一种情况下，小透镜布置 44 都导致一定的漫射。例如，当小透镜 41 邻接时，邻接的小透镜 41 之间的凹谷由于残余衍射和边缘效应而导致一定的漫射。另一方面，当小透镜 41 不邻接时，小透镜 41 之间的空间或间隙 42 可导致一定的漫射（通过衍射或散射）。不论这种漫射的原因是什么，在本发明的一些实施例中，投影子系统 20 中的透镜的受光孔（由捕捉的立体角 26 表示）都捕捉由小透镜之间的间距或邻接的小透镜 41 之间的凹谷导致的这种漫射。在使用非邻接的小透镜 41 的实施例中，理想的是使得或基本上使得小透镜 41 之间的间隙 42 足够大，以允许来自小透镜间隙 42 的漫射光进入投影透镜 20 的受光孔中。在一个实施例中，小透镜间隙 42 大于或等于中间图像平面处的中间图像 的像素的尺寸。基本上，如前所述，这意味着小透镜间隙 42 应当足够大 (Ag)，以致其不引起显著的衍射效应。

[0078] 关于这一点更进一步地，在一些实施例中，可以使用组合元件作为散斑减少元件 40，该组合元件导致更加等量的漫射和折射，或者衍射和折射，以产生时间上变化的角分集和一定程度的随机相位移动。例如，小透镜间隙 42 可以不是平的，而是具有某种轻度表面结构，具有带大的空间尺寸（几微米）和最小凹陷的任意斑点化的轮廓，以引入轻度的漫射。在一些实施例中，可以使用小透镜或棱镜阵列，其中小透镜或棱镜结构的表面被进一步结构化，除了由于折射导致的角度移动外，还具有可变或固定相移深度内容。因此，当移动散斑减少元件 40 时，存在进入投影透镜中的图像的角度移动以及还有相干光的相位移动。

[0079] 在包括具有小透镜布置 44 的结构化的窗口元件 45 作为折射性散斑减少元件 40 的实施例中，各个小透镜 41 的布置可以是或者基本是六边形的，对角线形的，任意的，或者在两个尺寸中的任一个是线性的以创建图案。在一些实施例中，使得运动生成系统在平面内移动散斑减少元件 40 大于或等于小透镜重复周期（一个小透镜和一个间隙（如果存在），例如，图 6a 中的竖直小透镜周期 38 或水平小透镜周期 39）的距离，从而允许来自小透镜 41 的角分集的全部范围。该运动允许在眼睛的时间响应上的平均化。与前面关于漫射性散斑减少元件 40 的论述相同，结构化的窗口元件 45 可以以任何多种方式在平面内移动（对于图 5a 所示的 X-Y 平面），例如通过线性转换器或通过利用马达来旋转。因此，本领域普通技术人员将理解，致动器 49 可以采取多种形式中的任一种，例如包括压电转换器。

[0080] 在一些实施例中，不论散斑减少元件 40 是衍射性的或是折射性的，具有散斑减少元件 40 的平面外运动（沿 Z 轴，见图 5a）是有益的，只要这种运动位于较快的投影子系统 20 的焦深内并且对于屏幕处的容许散焦具有一定的宽裕即可。由于中继透镜 18 具有大得

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多的焦深，该焦深名义上与投影透镜焦深重合，所以根据这种约束设计的系统 50 将几乎没有图像质量损失。上下文中的“平面外运动”指的是平行于或基本平行于散斑 减少元件 40 的光轴（在图 2 的示例中为轴线 O）方向的运动。这种通常留在投影子系统 20 和中继透镜 18 的焦深内的平面外运动通过引入附加的角分集或相移进一步减小了散斑，而基本上不影响像素分辨率。在平面外运动提供给散斑减少元件 40 的实施例中，平面内运动也被提供。

[0081] 为了减少来自散斑减少元件 40 的光的损失（无论是衍射性的或是折射性的），有益的是将散斑减少元件 40 设计成使得来自中继透镜 18 的图像光的组合角（在 f#19 内）加上散斑减少元件 40 形成的角分集和漫射（见图 6b，对于折射性散斑减少元件 40 的情况）等于或基本等于投影子系统 20 的可捕捉立体角 26 或受光 f- 数 24（在图 3 中示为项 24）。例如，如果对于具有大约 f/2.5 的投影透镜 f#，位于折射性散斑减少元件 40 之外的 f# 基本大于大约 f/5，则散斑减少将由于缺少角分集而被减少。替代地，如果位于折射性散斑减少元件 40 之外的 f# 小于投影子系统 20 的 f#，则一些光将不被投影子系统 20 收集，并且光学处理能力将降低。

[0082] 值得注意的是，当照明来自激光时，相干光投影系统 10 的内部部件可以具有低的集光率，一般在大约 f/6 的范围内。从光学设计的视角来看，这种低集光率是有利的，其允许在每个颜色通道内使用较小、较慢且更便宜的透镜元件和光调制器。

[0083] 数字微镜或 DLP 器件在其调制的光，从其镜元件的反射的光基本是远心的，基板上平行于光轴出现时最有效地工作。诸如激光的低集光率光源对于提供远心系统中的照明是有利的，并且非常适于提供 DLP 照明源。

[0084] 此处描述的本发明的实施例有助于通过校正中间图像内的散斑来对散斑进行补偿。中间图像可以以仿效传统胶片格式的尺寸或格式形成，从而使得能够使用现成的投影透镜用于随后投影到显示表面上。因此，本发明的各种实施例允许使用激光和相关的高度相干源，其对于亮度和光谱特性是有利的，具有数字光调制器，没有过多的散斑。

[0085] 已经参照本发明的某些实施例详细描述了本发明。然而，应当理解，能够实现处于本发明的范围内的变型和修改。例如，透镜元件可以由任何合适类型的透镜玻璃或其他光学材料制造。可以提供各种类型的透镜安装 布置。可以使用多种类型的激光源，例如包括激光器阵列。可以使用众多不同类型的光调制器中的任一种，包括数字微镜、液晶显示 (LCD) 装置、机电光栅装置，如光栅机电系统 (GEMS) 装置和光栅光阀 (GLV) 装置，或者其他类型的像素化阵列装置。尽管已经描述了使用三原色 (RGB) 的实施例，但也可以使用本发明的这样的实施例 ：其中使用多于或少于三个光源或调制器。另外，术语“系统”和“子系统”在本文中经常用来承认尽管文中示出的某些实施例具有透镜或其他部件的特定布置，但本领域普通技术人员将理解，这些特定布置可以被一种或多种其他布置替代，以实现与文中所描述的相同的功能。例如，中继系统在本文通常被描述为包括中继透镜 18。这种透镜 18 可以被仍形成在中间图像平面 21 处的中间图像 22 的多个透镜替代。同样的推理也适用于本文描述的投影子系统 20 和其他系统。另外，术语“系统”和“子系统”还在本说明书中用来承认也可以存在本文未示出或描述的附加的传统部件。例如，中继系统 18 可以包括中继透镜 L1，但其可能还包括透镜安装硬件、某些光学涂层等。

[0086] 部件列表

[0087] 5 对象平面

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[0088] 7 显示图像平面

[0089] 10 相干光投影系统

[0090] 12r、12g、12b 光调制器

[0091] 14 组合器

[0092] 16r、16g、16b 光源

[0093] 18 中继透镜

[0094] 19 中继透镜 f#

[0095] 20 投影子系统

[0096] 20a 投影子系统的透镜

[0097] 20b 投影子系统的透镜

[0098] 21 中间图像平面

[0099] 22 中间图像

[0100] 22’ 漫射图像

[0101] 23 中间图像像素

[0102] 23’ 漫射图像像素

[0103] 24 投影子系统入口 f#

[0104] 25 立体角

[0105] 25’ 偏转的立体角

[0106] 26 捕捉的立体角

[0107] 30 显示表面（或屏幕）

[0108] 38 竖直小透镜周期

[0109] 39 水平小透镜周期

[0110] 40 散斑减少元件

[0111] 41 小透镜

[0112] 42 小透镜间隙

[0113] 43 弯曲的漫射器表面

[0114] 44 小透镜布置

[0115] 45 结构化的窗口元件

[0116] 46 基质

[0117] 49 致动器

[0118] 50 相干光投影系统

[0119] 55 溢出光

[0120] 60 胶片

[0121] 62 孔板

[0122] L1 中继透镜元件

[0123] L2 场镜（或校正透镜）

[0124] O 光轴

[0125] Wa、Wb 焦点距离

[0126] d 胶片变形

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[0127] Φ 模糊圈直径

[0128] A 小透镜孔

[0129] Ag 小透镜间隙孔尺寸

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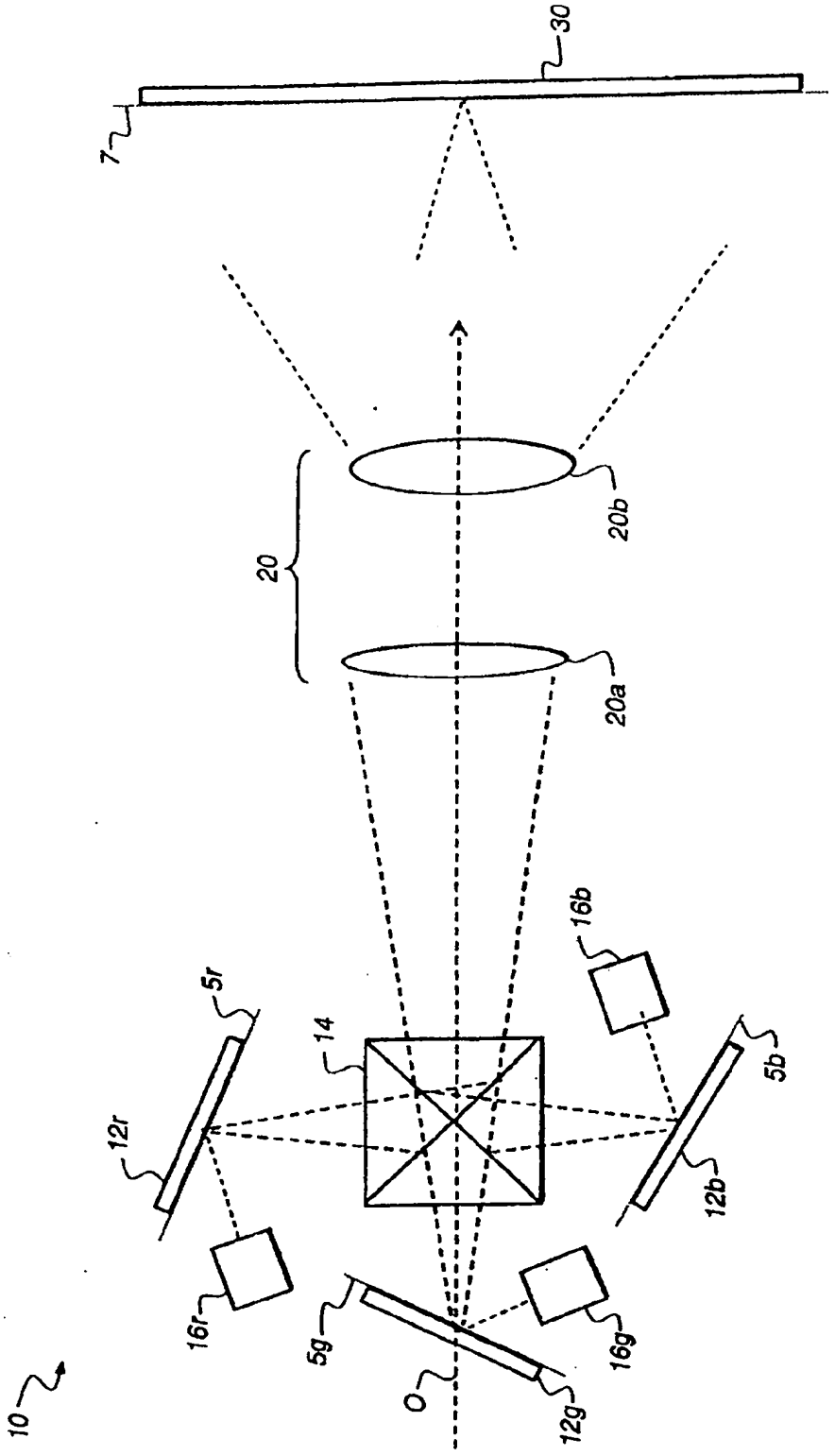


图 1

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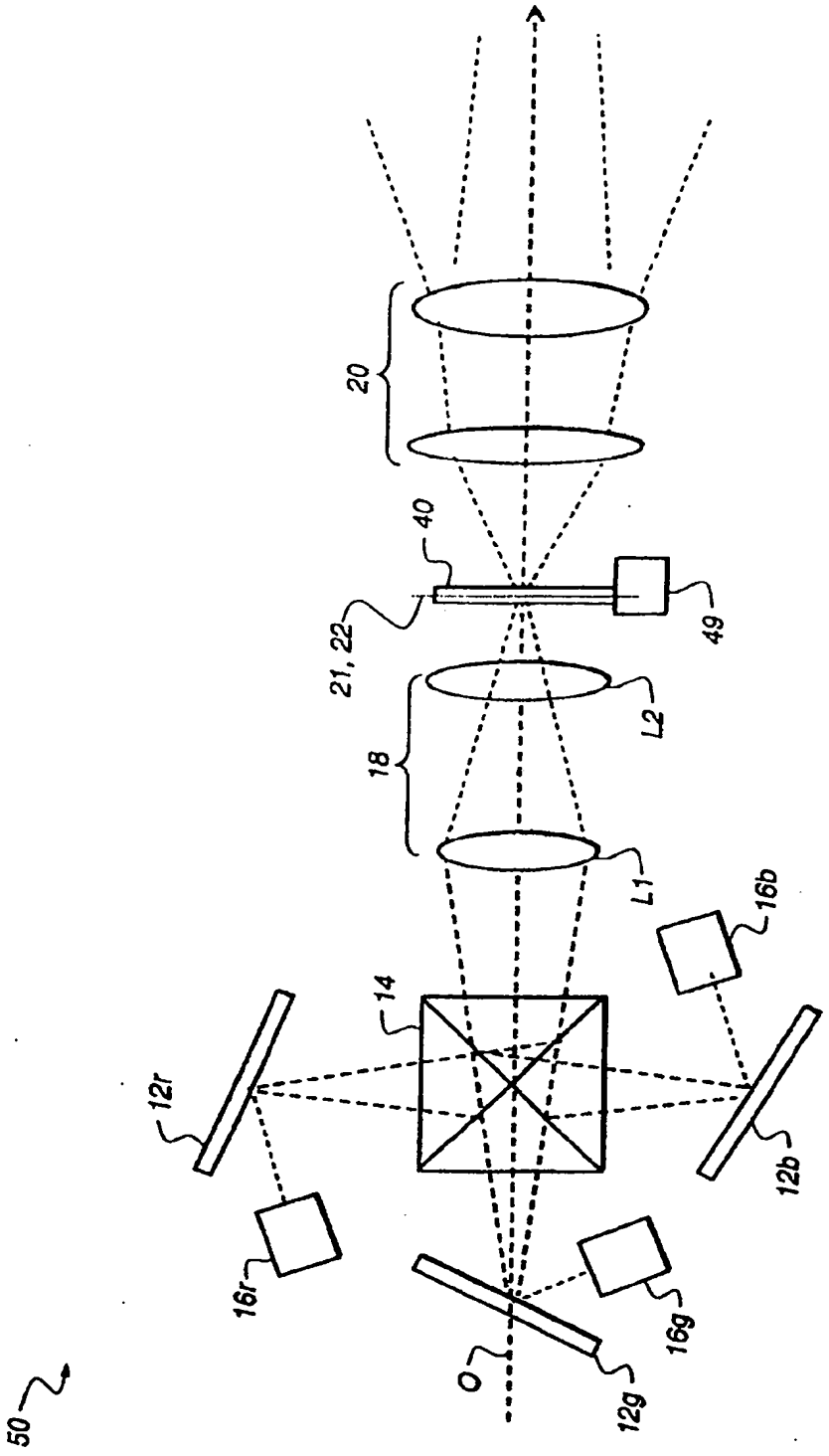


图 2

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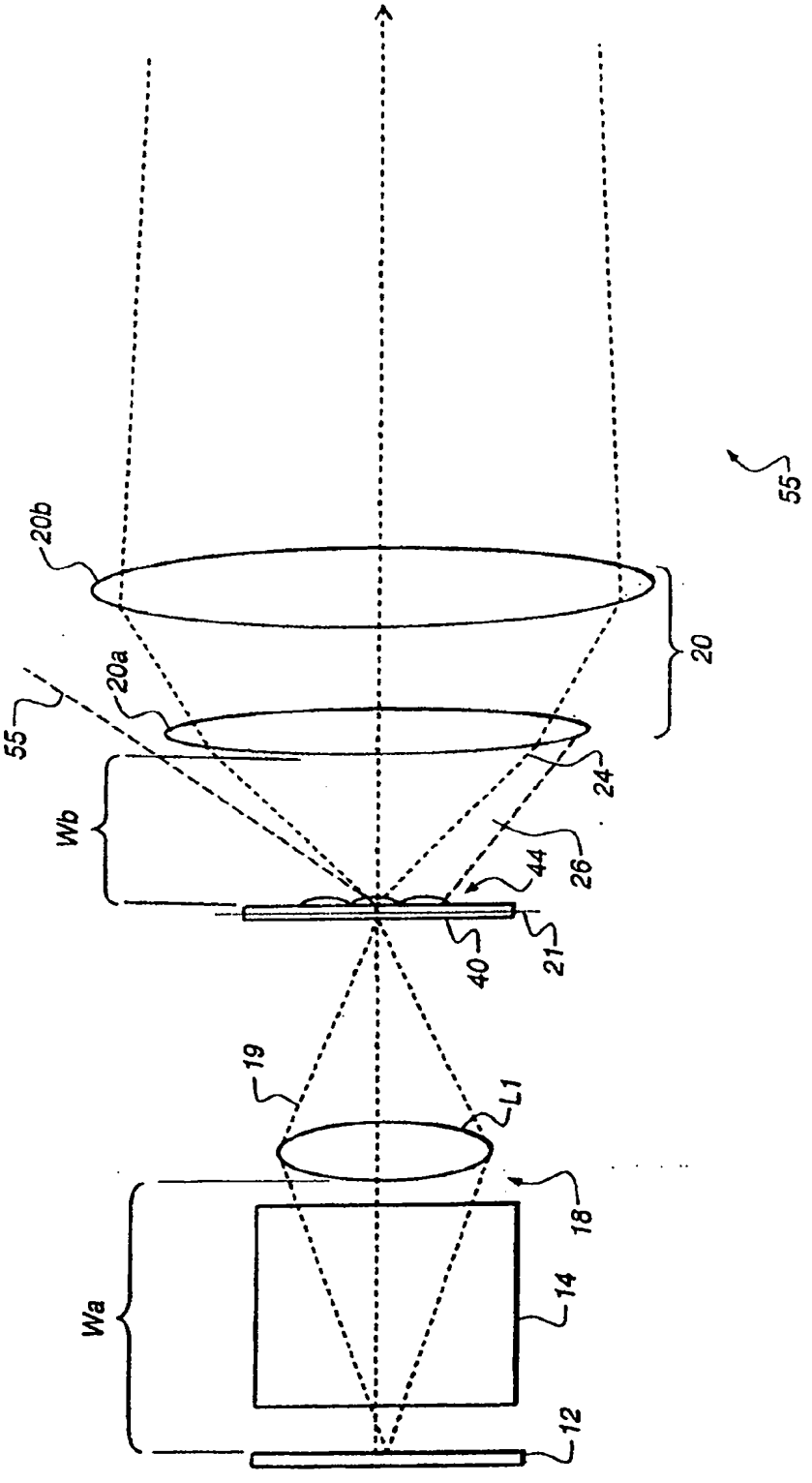


图 3

HESAI EX1002, P.485

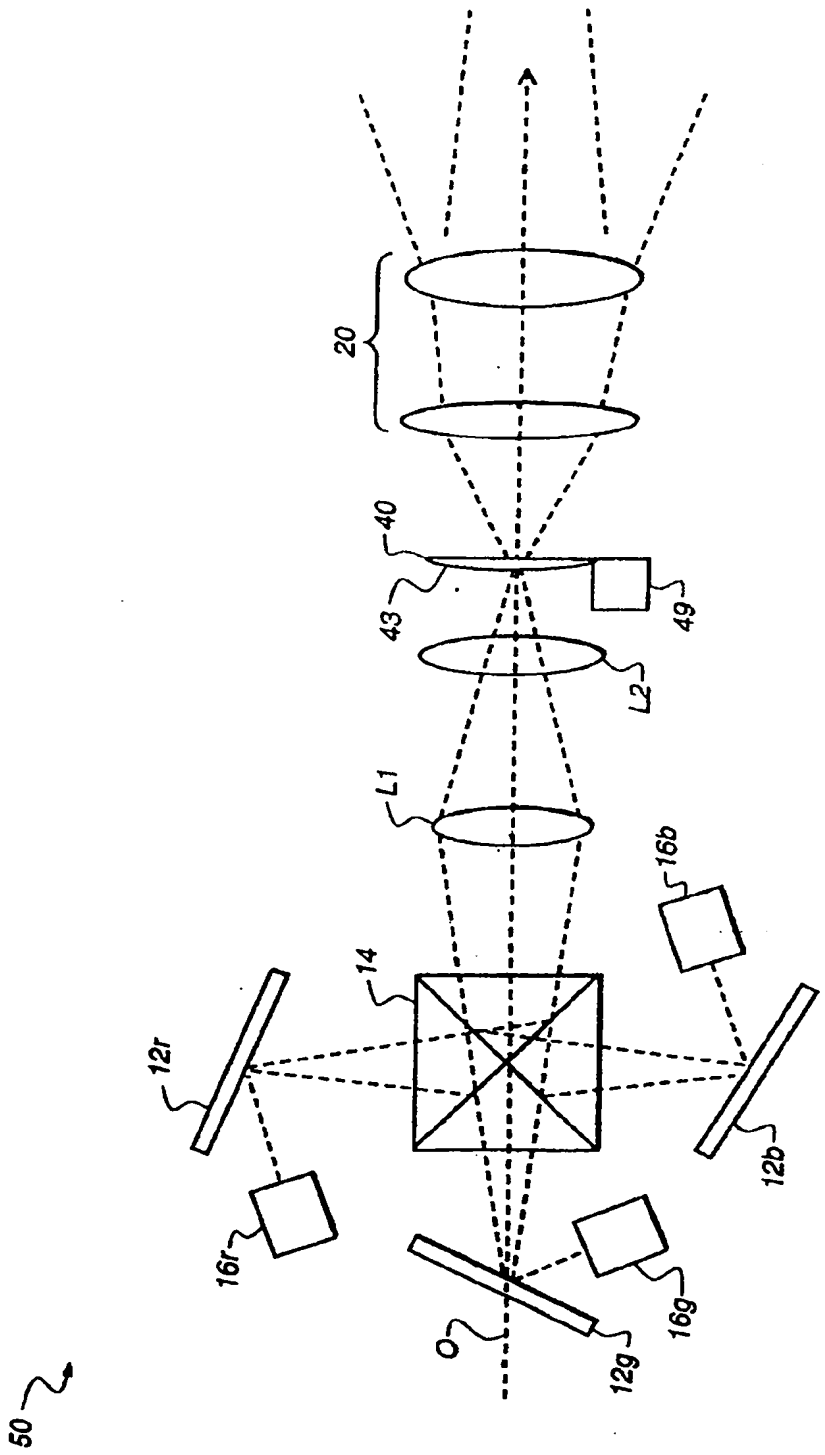


图 4

HESAI EX1002, P.486

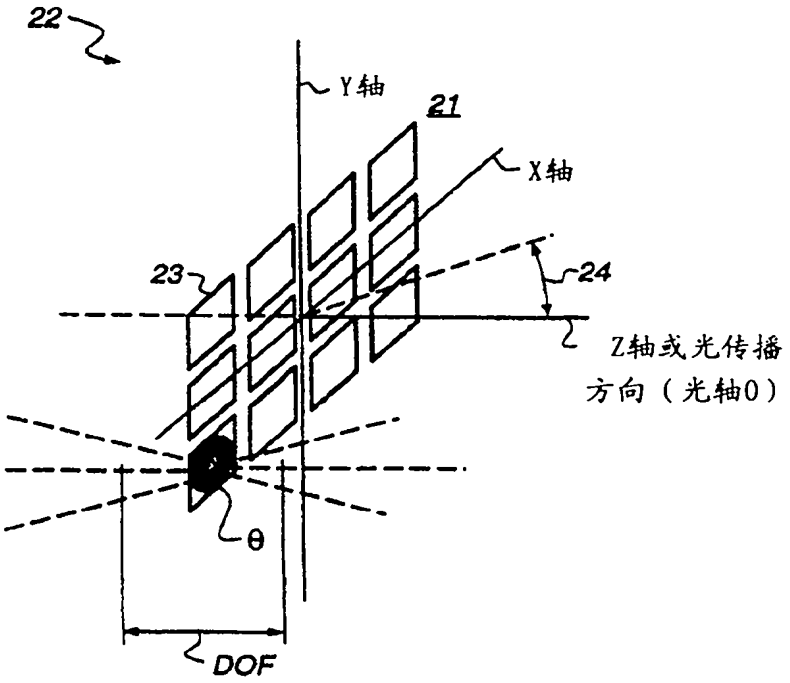


图 5a

HESAI EX1002, P.487

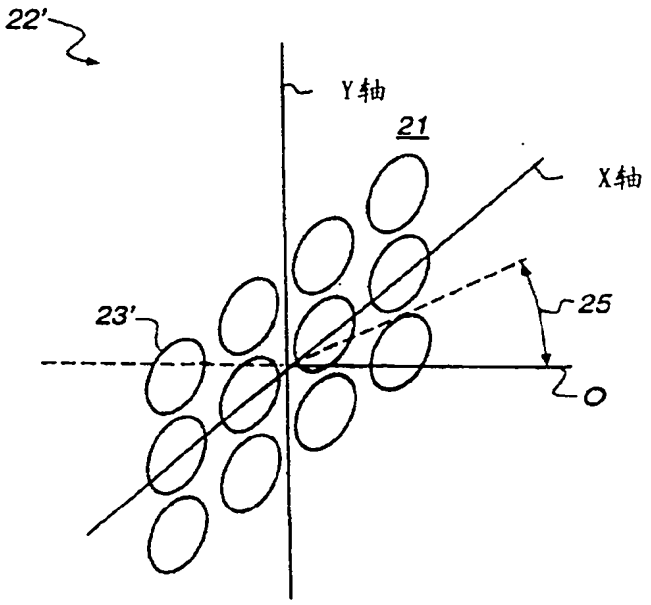


图 5b

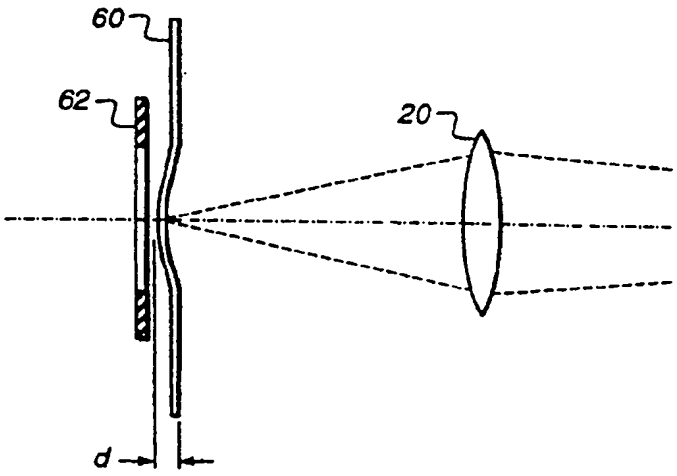


图 5c（现有技术）

HESAI EX1002, P.488

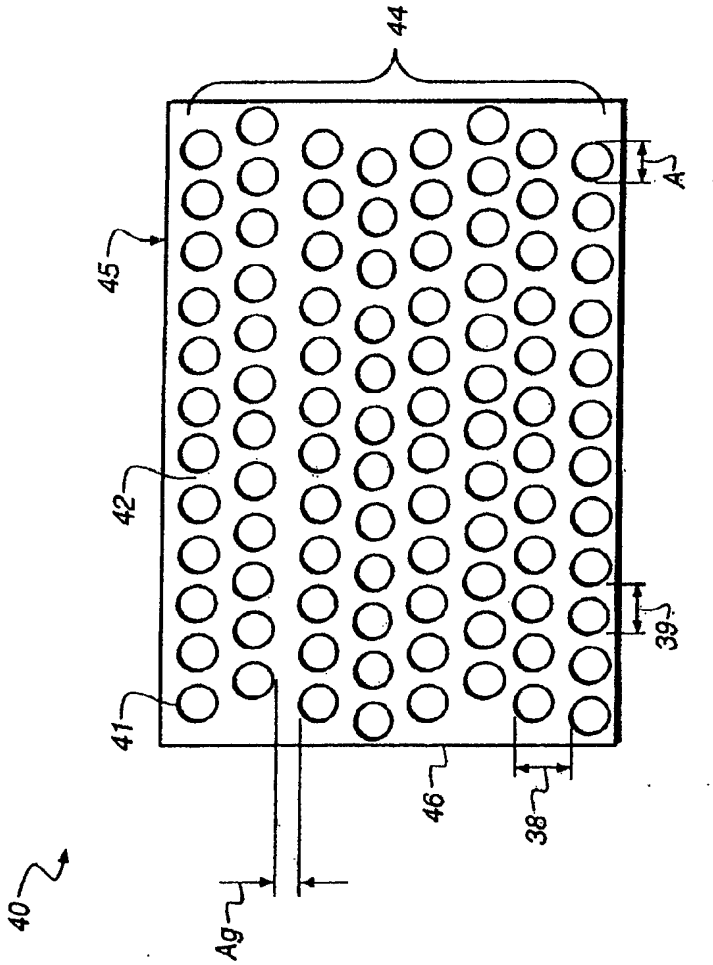


图 6a

HESAI EX1002, P.489

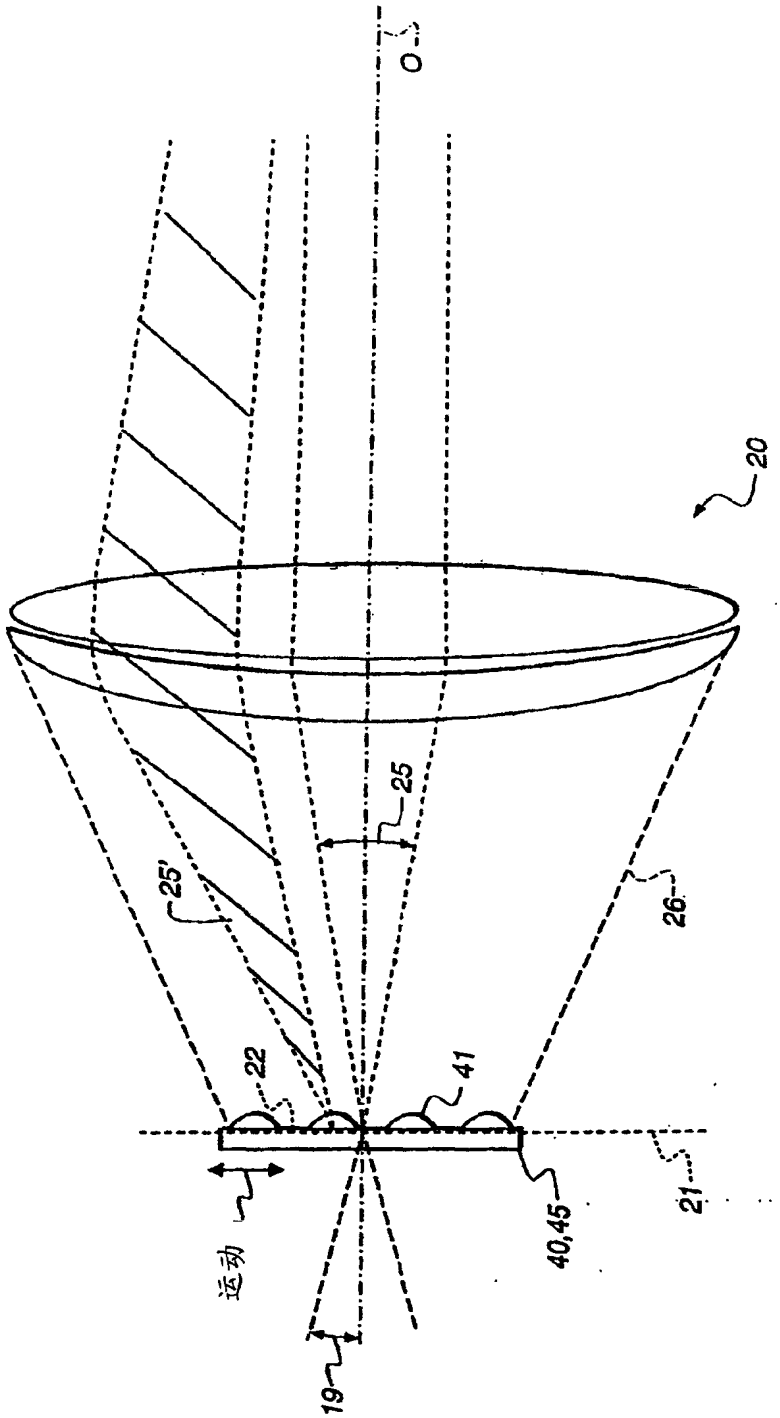


图 6b

HESAI EX1002, P.490