

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
 Stylesheet Version v1.2

EPAS ID: PAT6611162

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT
CONVEYING PARTY DATA	
Name	Execution Date
RUNE FISKE	09/30/2014
HENRIK ÖJELUND	09/30/2014
RASMUS KJÆR	09/11/2014
MIKE VAN DER POEL	09/11/2014
ARISH A. QAZI	09/11/2014
KARL-JOSEF HOLLENBECK	09/11/2014
RECEIVING PARTY DATA	
Name:	3SHAPE A/S
Street Address:	HOLMENS KANAL 7
City:	COPENHAGEN K
State/Country:	DENMARK
Postal Code:	DK-1060
PROPERTY NUMBERS Total: 1	
Property Type	Number
Application Number:	17206581
CORRESPONDENCE DATA	
Fax Number:	(703)836-2021
<i>Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.</i>	
Phone:	7038366620
Email:	mayra.castillo@bipc.com
Correspondent Name:	BUCHANAN INGERSOLL & ROONEY PC
Address Line 1:	P.O. BOX 1404
Address Line 4:	ALEXANDRIA, VIRGINIA 22314-1404
ATTORNEY DOCKET NUMBER:	0079124-000337-T1
NAME OF SUBMITTER:	MAYRA E. CASTILLO
SIGNATURE:	/MAYRA E. CASTILLO/
DATE SIGNED:	03/19/2021
This document serves as an Oath/Declaration (37 CFR 1.63).	

Total Attachments: 2

source=3. CON APP - CDA from parent--0079124-000337-T1#page1.tif

source=3. CON APP - CDA from parent--0079124-000337-T1#page2.tif

COMBINED DECLARATION AND ASSIGNMENT (JOINT)

As one of the below named inventors, I hereby declare that this Combined Declaration and Assignment is directed to:

- (1) ☐ U.S. application number or PCT application number _____, filed on _____, entitled _____; or
(2) ☒ the attached application entitled FOCUS SCANNING APPARATUS.

DECLARATION

As one of the below named inventors, I further declare that:

The above-identified application was made or authorized to be made by me.

I believe that I am an original joint inventor of a claimed invention in the application.

I have reviewed and understand the contents of the above-identified application, including the claims.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

ASSIGNMENT

THIS ASSIGNMENT, by the undersigned inventors (hereinafter referred to as "the Assignors"), respectively, witnesseth:

WHEREAS, the Assignors have invented certain new and useful improvements set forth in an application for Letters Patent of the United States, which is a nonprovisional application;

WHEREAS, 3SHAPE A/S, a corporation duly organized under and pursuant to the laws of DENMARK and having a principal place of business at Holmens Kanal 7, Copenhagen K, DK-1060 DENMARK (hereinafter referred to as "the Assignee"), is desirous of acquiring the entire right, title, and interest in and to said inventions, the right to file applications on said inventions and the entire right, title and interest in and to any applications, including provisional applications for Letters Patent of the United States or other countries claiming priority to said application, and in and to any Letters Patent or Patents, United States or foreign, to be obtained therefor and thereon.

NOW, THEREFORE, for good and sufficient consideration, the receipt of which is hereby acknowledged, the Assignors have sold, assigned, transferred, and set over, and by these presents do sell, assign, transfer, and set over, unto the Assignee, its successors, legal representatives, and assigns the entire right, title, and interest in and to the above-mentioned inventions, the right to file applications on said inventions and the entire right, title and interest in and to any applications for Letters Patent of the United States or other countries claiming priority to said applications, and any and all Letters Patent or Patents of the United States of America and all foreign countries that may be granted therefor and thereon, and in and to any and all applications claiming priority to said applications, divisions, continuations, and continuations-in-part of said applications, and reissues and extensions of said Letters Patent or Patents, and all rights under the International

Buchanan Ingersoll & Rooney PC
Attorneys at Law, Government Relations Professionals

Convention for the Protection of Industrial Property, the same to be held and enjoyed by the Assignee, for its own use and behoof and the use and behoof of its successors, legal representatives, and assigns, to the full end of the term or terms for which Letters Patent or Patents may be granted as fully and entirely as the same would have been held and enjoyed by the Assignors had this sale and assignment not been made;

AND for the same consideration, the Assignors hereby covenant and agree to and with the Assignee, its successors, legal representatives, and assigns, that, at the time of execution and delivery of these presents, the Assignors are the sole and lawful owners of the entire right, title, and interest in and to the inventions set forth in said applications and said applications, including provisional applications, above-mentioned, and that the same are unencumbered, and that the Assignors have good and full right and lawful authority to sell and convey the same in the manner herein set forth;

AND for the same consideration, the Assignors hereby covenant and agree to and with the Assignee, its successors, legal representatives, and assigns that the Assignors will, whenever counsel of the Assignee, or the counsel of its successors, legal representatives, and assigns, shall advise that any proceeding in connection with said inventions or said applications for Letters Patent or Patents, or any proceeding in connection with Letters Patent or Patents for said inventions in any country, including interference proceedings, is lawful and desirable, or that any application claiming priority to said application, division, continuation, or continuation-in-part of any applications for Letters Patent or Patents, or any reissue or extension of any Letters Patent or Patents to be obtained thereon, is lawful and desirable, sign all papers and documents, take all lawful oaths, and do all acts necessary or required to be done for the procurement, maintenance, enforcement, and defense of Letters Patent or Patents for said inventions, without charge to the Assignee, its successors, legal representatives, and assigns, but at the cost and expense of the Assignee, its successors, legal representatives, and assigns;

AND the Assignors hereby request the Commissioner of Patents to issue any and all said Letters Patent of the United States to the Assignee as the Assignee of said inventions, the Letters Patent to be issued for the sole use and behoof of the Assignee, its successors, legal representatives, and assigns.

30-Sept. 2014
Date

RUNE FISHER
Name

[Signature]
Signature

30/9-2014
Date

HENRIK ØJELUND
Name

[Signature]
Signature

30/9-2014
Date

RASMUS KJÆR
Name

[Signature]
Signature

30/9-2014
Date

MIKE van der POEL
Name

[Signature]
Signature

11-September-2014
Date

ARISH A. QAZI
Name

[Signature]
Signature

Sep 11, 2014
Date

KARL-JOSEF HOLLENBECK
Name

[Signature]
Signature

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**REQUEST FOR FILING CONTINUATION / DIVISIONAL
APPLICATION UNDER 37 C.F.R. § 1.53(b)**

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

Customer Number **21839**

Commissioner:

This is a request for filing a ☒ continuation ☐ divisional application under 37 C.F.R. § 1.53(b) of the following pending application, Application No. 16/774,843, filed January 28, 2020 entitled:

FOCUS SCANNING APPARATUS

by the following first named inventor:

Rune FISKER

- ☒ The entire disclosure of the prior application is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
- ☐ Enclosed is a copy of the prior Application No. _____ as originally filed on _____, including copies of the specification, claims, and drawings.
- ☐ Enclosed is a revised prior application. No new matter has been added to the revised application.

Applicant(s) claims foreign priority under 35 U.S.C. §§ 119 of the following application(s):

Country	Appl. No.	Filing Date MM-DD-YYYY
_____	_____	_____
_____	_____	_____
_____	_____	_____

- ☐ The certified copy / DAS Code of the priority application:
- ☐ was filed in prior Application No. _____, filed on _____.
 - ☐ was filed in the International Bureau and acknowledged by the Examiner in prior Application No. _____.
 - ☐ has not yet been filed.
- ☒ The filing fee has been calculated as follows:

					FEES
Basic Patent Application Filing Fee (1011)					\$320.00
Search Fee (1111)					\$700.00
Examination Fee (1311)					\$800.00
	No. of Claims		Extra Claims	Rate	
Total Claims	30	Minus 20=	10	x \$ 100.00 (1202)	\$1,000.00
Independent Claims	2	Minus 3=	0	x \$ 480.00 (1201)	
If multiple dependent claims are presented, add \$860.00 (1203)					
App. Size Fee (app + dwgs. exceeding 100 sheets) - \$420.00 / each add'l. 50 sheets (1081)					
Late Declaration Fee, add \$160.00 (1051)					
Track I - Prioritized Exam Fee, Processing Fee and Publication Fee					\$4,340.00
TOTAL APPLICATION FEE DUE					\$7,160.00

- ☐ Charge \$_____ to Deposit Account No. 02-4800 for the fee due.
- ☒ Charge \$7,160.00 to credit card. Filing fee being paid concurrent with electronic filing of application.
- ☒ The Commissioner is hereby authorized to charge any appropriate fees that may be required by this paper, or any other submissions in this application, and to credit any overpayment, to Deposit Account No. 02-4800.
- ☒ In accordance with 37 C.F.R. § 1.136(a)(3), the U.S. Patent and Trademark Office is hereby provided with a general authorization to treat any concurrent or future reply requiring a petition for an extension of time for its timely submission as containing a request therefor for the appropriate length of time.
- ☒ 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).

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: March 19, 2021

By: /WCRoland/
William C. Rowland
Registration No. 30,888

Customer Number 21839
703 836 6620

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

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor	1				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Rune		FSKER			
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service						
City	Virum		Country of Residence ⁱ	DK		
Mailing Address of Inventor:						
Address 1		Kapevej 87				
Address 2						
City	Virum		State/Province			
Postal Code	2830		Country ⁱ	DK		
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Henrik		OJELUND			
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service						
City	Lyngby		Country of Residence ⁱ	DK		
Mailing Address of Inventor:						
Address 1		Kulsvierparken 55				
Address 2						
City	Lyngby		State/Province			
Postal Code	2800		Country ⁱ	DK		
Inventor	3				Remove	
Legal Name						

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Prefix	Given Name	Middle Name	Family Name	Suffix
	Rasmus		KJÆR	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	København K		Country of Residence ⁱ	DK

Mailing Address of Inventor:

Address 1	Nørre Søgade 21, 1			
Address 2				
City	København K	State/Province		
Postal Code	1370	Country ⁱ	DK	
Inventor	4 Remove			
Legal Name				

Prefix	Given Name	Middle Name	Family Name	Suffix
	Mike		van der POEL	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	Rødovre		Country of Residence ⁱ	DK

Mailing Address of Inventor:

Address 1	Rævebakkevej 35B			
Address 2				
City	Rødovre	State/Province		
Postal Code	2610	Country ⁱ	DK	
Inventor	5 Remove			
Legal Name				

Prefix	Given Name	Middle Name	Family Name	Suffix
	Arish	A.	QAZI	
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service				
City	Toronto		Country of Residence ⁱ	CA

Mailing Address of Inventor:

Address 1	215-1369 Bloor Street West			
Address 2				
City	Toronto	State/Province		
Postal Code	M6P 4J4	Country ⁱ	CA	

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Inventor	6				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Karl-Josef		HOLLENBECK		
Residence Information (Select One) US Residency ☒ Non US Residency Active US Military Service					
City	Copenhagen Ø		Country of Residence ⁱ	DK	
Mailing Address of Inventor:					
Address 1	Rosenvængets Hovedvej 6B				
Address 2					
City	Copenhagen Ø	State/Province			
Postal Code	2100	Country ⁱ	DK		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add					

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
☐ An Address is being provided for the correspondence Information of this application.	
Customer Number	21839
Email Address	Add Email Remove Email

Application Information:

Title of the Invention	FOCUS SCANNING APPARATUS		
Attorney Docket Number	0079124-000337-T1	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	18	Suggested Figure for Publication (if any)	

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	21839		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16/774843	2020-01-28

Application Data Sheet 37 CFR 1.76		Attorney Docket Number		0079124-000337-T1	
		Application Number			
Title of Invention		FOCUS SCANNING APPARATUS			

Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16/774843	Continuation of	16433369	2019-06-06	10595010	2020-03-17
Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16433369	Continuation of	16217943	2018-12-12	10326982	2019-06-18
Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16217943	Continuation of	15974105	2018-05-08	10349041	2019-07-19
Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
15974105	Continuation of	14502230	2014-09-30	10097815	2018-10-09
Prior Application Status		Patented		Remove	
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14502230	Continuation of	13376427	2011-12-06	8878905	2014-11-04
Prior Application Status		Expired		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
13376427	a 371 of international	PCT/DK2010/050148	2010-06-17		
Prior Application Status		Expired		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
PCT/DK2010/050148	Claims benefit of provisional	61231118	2009-08-04		
Prior Application Status		Expired		Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
PCT/DK2010/050148	Claims benefit of provisional	61187744	2009-06-17		

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Add

Foreign Priority Information:

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	Remove

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant	1	Remove	
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
		Clear	
☒ Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	3SHAPE A/S		
Mailing Address Information For Applicant:			
Address 1	Holmens Kanal 7		
Address 2			
City	Copenhagen K	State/Province	
Country	DK	Postal Code	1060
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button. Add			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	0079124-000337-T1
		Application Number	
Title of Invention	FOCUS SCANNING APPARATUS		

Assignee 1			
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.			
			Remove
If the Assignee or Non-Applicant Assignee is an Organization check here.			☒
Organization Name	3SHAPE A/S		
Mailing Address Information For Assignee including Non-Applicant Assignee:			
Address 1	Holmens Kanal 7		
Address 2			
City	Copenhagen K	State/Province	
Country i	DK	Postal Code	1060
Phone Number		Fax Number	
Email Address			
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.			Add

Signature: [Remove](#)

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	WCRoland/		Date (YYYY-MM-DD)	2021-03-19
First Name	William	Last Name	Rowland	Registration Number
				30,888
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Title of Invention	FOCUS SCANNING APPARATUS		

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Focus scanning apparatus**Cross-Reference to Related Applications**

The present application is a continuation of U.S. Serial No. 16/774,843, filed on January 28, 2020, which is a continuation of U.S. Serial No. 16/433,369, filed on June 6, 2019, which is a continuation of U.S. Serial No. 16/217,943, filed on December 12, 2018, which is a continuation of U.S. Serial No. 15/974,105, filed on May 8, 2018, which is a continuation of U.S. Serial No. 14/502,230, filed on September 30, 2014, now U.S. Patent No. 10,097,815 B2, which in turn is a continuation of U.S. Serial No. 13/376,427, filed on December 6, 2011, now U.S. Patent No. 8,878,905 B2, which is a national stage application of PCT/DK2010/050148, filed on June 17, 2010, and which claims the benefit of US 61/187,744, filed on June 17, 2009, and US 61/231,118, filed on August 4, 2009, the contents of all of which are incorporated herein by reference in their entirety.

Field of the Invention

The present disclosure relates to an apparatus and a method for optical 3D scanning of surfaces. The principle of the apparatus and method according to the disclosure may be applied in various contexts. One specific embodiment of the invention is particularly suited for intraoral scanning, i.e. direct scanning of teeth and surrounding soft-tissue in the oral cavity. Other dental related embodiments of the invention are suited for scanning dental impressions, gypsum models, wax bites, dental prosthetics and abutments. Another embodiment of the invention is suited for scanning of the interior and exterior part of a human ear or ear channel impressions. The disclosure may find use within scanning of the 3D structure of skin in dermatological or cosmetic / cosmetological applications, scanning of jewelry or wax models of whole jewelry or part of jewelry, scanning of industrial parts and even time resolved 3D scanning, such as time resolved 3D scanning of moving industrial parts.

Background

The disclosure relates to three dimensional (3D) scanning of the surface geometry of objects. Scanning an object surface in 3 dimensions is a well known field of study and

the methods for scanning can be divided into contact and non-contact methods. An example of contact measurements methods are Coordinate Measurement Machines (CMM), which measures by letting a tactile probe trace the surface. The advantages include great precision, but the process is slow and a CMM is large and expensive. Non-contact measurement methods include x-ray and optical probes.

Confocal microscopy is an optical imaging technique used to increase micrograph contrast and/or to reconstruct three-dimensional images by using a spatial pinhole to eliminate out-of-focus light or flare in specimens that are thicker than the focal plane.

A confocal microscope uses point illumination and a pinhole in an optically conjugate plane in front of the detector to eliminate out-of-focus information. Only the light within the focal plane can be detected. As only one point is illuminated at a time in confocal microscopy, 2D imaging requires raster scanning and 3D imaging requires raster scanning in a range of focus planes.

In WO 00/08415 the principle of confocal microscopy is applied by illuminating the surface with a plurality of illuminated spots. By varying the focal plane in-focus spot-specific positions of the surface can be determined. However, determination of the surface structure is limited to the parts of the surface that are illuminated by a spot.

WO 2003/060587 relates to optically sectioning of a specimen in microscopy wherein the specimen is illuminated with an illumination pattern. Focus positions of the image plane are determined by characterizing an oscillatory component of the pattern. However, the focal plane can only be adjusted by moving the specimen and the optical system relative to each other, i.e. closer to or further away from each other. Thus, controlled variation of the focal plane requires a controlled spatial relation between the specimen and the optical system, which is fulfilled in a microscope. However, such a controlled spatial relation is not applicable to e.g. a hand held scanner.

US2007/0109559 A1 describes a focus scanner where distances are found from the focus lens positions at which maximum reflective intensity of light beams incident on the object being scanned is observed. In contrast to the disclosure disclosed here, this prior art exploits no pre-determined measure of the illumination pattern and exploits no contrast detection, and therefore, the signal-to-noise ratio is sub-optimal.

In WO 2008/125605, means for generating a time-variant pattern composed of alternating split images are described. This document describes a scanning method to obtain an optical section of a scan object by means of two different illumination profiles, e.g. two patterns of opposite phases. These two images are used to extract the optical section, and the method is limited to acquisition of images from only two different illumination profiles. Furthermore, the method relies on a predetermined calibration that determines the phase offset between the two illumination profiles.

Summary

Thus, an object of the disclosure is to provide a scanner which may be integrated in a manageable housing, such as a handheld housing. Further objects of the disclosure are: discriminate out-of-focus information and provide a fast scanning time.

This is achieved by a method and a scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object, said scanner comprising:

- at least one camera accommodating an array of sensor elements,
- means for generating a probe light incorporating a spatial pattern,
- means for transmitting the probe light towards the object thereby illuminating at least a part of the object with said pattern in one or more configurations,
- means for transmitting at least a part of the light returned from the object to the camera,
- means for varying the position of the focus plane of the pattern on the object while maintaining a fixed spatial relation of the scanner and the object,
- means for obtaining at least one image from said array of sensor elements,
- means for evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, where the weight function is determined based on information of the configuration of the spatial pattern;
- data processing means for:

- a) determining by analysis of the correlation measure the in-focus position(s) of:
 - each of a plurality of image pixels for a range of focus plane positions, or
 - each of a plurality of groups of image pixels for a range of focus plane positions, and
- b) transforming in-focus data into 3D real world coordinates.

The method and apparatus described in this disclosure is for providing a 3D surface registration of objects using light as a non-contact probing agent. The light is provided in the form of an illumination pattern to provide a light oscillation on the object. The variation / oscillation in the pattern may be spatial, e.g. a static checkerboard pattern, and/or it may be time varying, for example by moving a pattern across the object being scanned. The disclosure provides for a variation of the focus plane of the pattern over a range of focus plane positions while maintaining a fixed spatial relation of the scanner and the object. It does not mean that the scan must be provided with a fixed spatial relation of the scanner and the object, but merely that the focus plane can be varied (scanned) with a fixed spatial relation of the scanner and the object. This provides for a hand held scanner solution based on the present disclosure.

In some embodiments the signals from the array of sensor elements are light intensity.

One embodiment of the invention comprises a first optical system, such as an arrangement of lenses, for transmitting the probe light towards the object and a second optical system for imaging light returned from the object to the camera. In the preferred embodiment of the invention only one optical system images the pattern onto the object and images the object, or at least a part of the object, onto the camera, preferably along the same optical axis, however along opposite optical paths.

In the preferred embodiment of the invention an optical system provides an imaging of the pattern onto the object being probed and from the object being probed to the camera. Preferably, the focus plane is adjusted in such a way that the image of the pattern on the probed object is shifted along the optical axis, preferably in equal steps from one end of the scanning region to the other. The probe light incorporating the

pattern provides a pattern of light and darkness on the object. Specifically, when the pattern is varied in time for a fixed focus plane then the in-focus regions on the object will display an oscillating pattern of light and darkness. The out-of-focus regions will display smaller or no contrast in the light oscillations.

Generally we consider the case where the light incident on the object is reflected diffusively and/or specularly from the object's surface. But it is understood that the scanning apparatus and method are not limited to this situation. They are also applicable to e.g. the situation where the incident light penetrates the surface and is reflected and/or scattered and/or gives rise to fluorescence and/or phosphorescence in the object. Inner surfaces in a sufficiently translucent object may also be illuminated by the illumination pattern and be imaged onto the camera. In this case a volumetric scanning is possible. Some planktic organisms are examples of such objects.

When a time varying pattern is applied a single sub-scan can be obtained by collecting a number of 2D images at different positions of the focus plane and at different instances of the pattern. As the focus plane coincides with the scan surface at a single pixel position, the pattern will be projected onto the surface point in-focus and with high contrast, thereby giving rise to a large variation, or amplitude, of the pixel value over time. For each pixel it is thus possible to identify individual settings of the focusing plane for which each pixel will be in focus. By using knowledge of the optical system used, it is possible to transform the contrast information vs. position of the focus plane into 3D surface information, on an individual pixel basis.

Thus, in one embodiment of the disclosure the focus position is calculated by determining the light oscillation amplitude for each of a plurality of sensor elements for a range of focus planes.

For a static pattern a single sub-scan can be obtained by collecting a number of 2D images at different positions of the focus plane. As the focus plane coincides with the scan surface, the pattern will be projected onto the surface point in-focus and with high contrast. The high contrast gives rise to a large spatial variation of the static pattern on the surface of the object, thereby providing a large variation, or amplitude, of the pixel values over a group of adjacent pixels. For each group of pixels it is thus possible to identify individual settings of the focusing plane for which each group of pixels will be in

focus. By using knowledge of the optical system used, it is possible to transform the contrast information vs. position of the focus plane into 3D surface information, on an individual pixel group basis.

Thus, in one embodiment of the invention the focus position is calculated by determining the light oscillation amplitude for each of a plurality of groups of the sensor elements for a range of focus planes.

The 2D to 3D conversion of the image data can be performed in a number of ways known in the art. I.e. the 3D surface structure of the probed object can be determined by finding the plane corresponding to the maximum light oscillation amplitude for each sensor element, or for each group of sensor elements, in the camera's sensor array when recording the light amplitude for a range of different focus planes. Preferably, the focus plane is adjusted in equal steps from one end of the scanning region to the other. Preferably the focus plane can be moved in a range large enough to at least coincide with the surface of the object being scanned.

The present disclosure distinguishes itself from WO 2008/125605, because in the embodiments of the present invention that use a time-variant pattern, input images are not limited to two illumination profiles and can be obtained from any illumination profile of the pattern. This is because the orientation of the reference image does not rely entirely on a predetermined calibration, but rather on the specific time of the input image acquisition.

Thus WO 2008/125605 applies specifically exactly two patterns, which are realized physically by a chrome-on-glass mask as illuminated from either side, the reverse side being reflective. WO 2008/125605 thus has the advantage of using no moving parts, but the disadvantage of a comparatively poorer signal-to-noise ratio. In the present disclosure there is the possibility of using any number of pattern configurations, which makes computation of the light oscillation amplitude or the correlation measure more precise.

Definitions

Pattern: A light signal comprising an embedded spatial structure in the lateral plane. May also be termed "illumination pattern".

Time varying pattern: A pattern that varies in time, i.e. the embedded spatial structure varies in time. May also be termed "time varying illumination pattern". In the following also termed "fringes".

Static pattern: A pattern that does not vary in time, e.g. a static checkerboard pattern or a static line pattern.

Pattern configuration: The state of the pattern. Knowledge of the pattern configuration at a certain time amounts to knowing the spatial structure of the illumination at that time. For a periodic pattern the pattern configuration will include information of the pattern phase. If a surface element of the object being scanned is imaged onto the camera then knowledge of the pattern configuration amounts to knowledge of what part of the pattern is illuminating the surface element.

Focus plane: A surface where light rays emitted from the pattern converge to form an image on the object being scanned. The focus plane does not need to be flat. It may be a curved surface.

Optical system: An arrangement of optical components, e.g. lenses, that transmit, collimate and/or images light, e.g. transmitting probe light towards the object, imaging the pattern on and/or in the object, and imaging the object, or at least a part of the object, on the camera.

Optical axis: An axis defined by the propagation of a light beam. An optical axis is preferably a straight line. In the preferred embodiment of the invention the optical axis is defined by the configuration of a plurality of optical components, e.g. the configuration of lenses in the optical system. There may be more than one optical axis, if for example one optical system transmits probe light to the object and another optical system images the object on the camera. But preferably the optical axis is defined by the propagation of the light in the optical system transmitting the pattern onto the object and imaging the object onto the camera. The optical axis will often coincide with the longitudinal axis of the scanner.

Optical path: The path defined by the propagation of the light from the light source to the camera. Thus, a part of the optical path preferably coincides with the optical axis. Whereas the optical axis is preferably a straight line, the optical path may be a non-straight line, for example when the light is reflected, scattered, bent, divided and/or the like provided e.g. by means of beam splitters, mirrors, optical fibers and the like.

Telecentric system: An optical system that provides imaging in such a way that the chief rays are parallel to the optical axis of said optical system. In a telecentric system out-of-focus points have substantially same magnification as in-focus points. This may provide an advantage in the data processing. A perfectly telecentric optical system is difficult to achieve, however an optical system which is substantially telecentric or near telecentric may be provided by careful optical design. Thus, when referring to a telecentric optical system it is to be understood that it may be only near telecentric.

Scan length: A lateral dimension of the field of view. If the probe tip (i.e. scan head) comprises folding optics to direct the probe light in a direction different such as perpendicular to the optical axis then the scan length is the lateral dimension parallel to the optical axis.

Scan object: The object to be scanned and on which surface the scanner provides information. "The scan object" may just be termed "the object".

Camera: Imaging sensor comprising a plurality of sensors that respond to light input onto the imaging sensor. The sensors are preferably ordered in a 2D array in rows and columns.

Input signal: Light input signal or sensor input signal from the sensors in the camera. This can be integrated intensity of light incident on the sensor during the exposure time or integration of the sensor. In general, it translates to a pixel value within an image. May also be termed "sensor signal".

Reference signal: A signal derived from the pattern. A reference signal may also be denoted a weight function or weight vector or reference vector.

Correlation measure: A measure of the degree of correlation between a reference and input signal. Preferably the correlation measure is defined such that if the reference and input signal are linearly related to each other then the correlation measure obtains a larger magnitude than if they are not. In some cases the correlation measure is a light oscillation amplitude.

Image: An image can be viewed as a 2D array of values (when obtained with a digital camera) or in optics, an image indicates that there exists a relation between an imaged surface and an image surface where light rays emerging from one point on said imaged surface substantially converge on one point on said image surface.

Intensity: In optics, intensity is a measure of light power per unit area. In image recording with a camera comprising a plurality of individual sensing elements, intensity may be used to term the recorded light signal on the individual sensing elements. In this case intensity reflects a time integration of light power per unit area on the sensing element over the exposure time involved in the image recording.

Mathematical notation

A	A correlation measure between the weight function and the recorded light signal. This can be a light oscillation amplitude.
I	Light input signal or sensor input signal. This can be integrated intensity of light incident on the sensor during the exposure time or integration of the sensor. In general, it translates to a pixel value within an image.
f	Reference signal. May also be called weight value.
n	The number of measurements with a camera sensor and/or several camera sensors that are used to compute a correlation measure.
H	Image height in number of pixels
W	Image width in number of pixels

Symbols are also explained as needed in the text.

Detailed description of the preferred embodiments

The scanner preferably comprises at least one beam splitter located in the optical path. For example, an image of the object may be formed in the camera by means of a beam splitter. Exemplary uses of beam splitters are illustrated in the figures.

In a preferred embodiment of the invention light is transmitted in an optical system comprising a lens system. This lens system may transmit the pattern towards the object and images light reflected from the object to the camera.

In a telecentric optical system, out-of-focus points have the same magnification as in-focus points. Telecentric projection can therefore significantly ease the data mapping of acquired 2D images to 3D images. Thus, in a preferred embodiment of the invention the optical system is substantially telecentric in the space of the probed object. The optical system may also be telecentric in the space of the pattern and camera.

Varying focus

A pivotal point of the disclosure is the variation, i.e. scanning, of the focal plane without moving the scanner in relation to the object being scanned. Preferably the focal plane may be varied, such as continuously varied in a periodic fashion, while the pattern generation means, the camera, the optical system and the object being scanned is fixed in relation to each other. Further, the 3D surface acquisition time should be small enough to reduce the impact of relative movement between probe and teeth, e.g. reduce effect of shaking. In the preferred embodiment of the invention the focus plane is varied by means of at least one focus element. Preferably the focus plane is periodically varied with a predefined frequency. Said frequency may be at least 1 Hz, such as at least 2 Hz, 3, 4, 5, 6, 7, 8, 9 or at least 10 Hz, such as at least 20, 40, 60, 80 or at least 100 Hz.

Preferably the focus element is part of the optical system. I.e. the focus element may be a lens in a lens system. A preferred embodiment comprises means, such as a translation stage, for adjusting and controlling the position of the focus element. In that way the focus plane may be varied, for example by translating the focus element back and forth along the optical axis.

If a focus element is translated back and forth with a frequency of several Hz this may lead to instability of the scanner. A preferred embodiment of the invention thus comprises means for reducing and/or eliminating the vibration and/or shaking from the focus element adjustment system, thereby increasing the stability of the scanner. This may at least partly be provided by means for fixing and/or maintaining the centre of mass of the focus element adjustment system, such as a counter-weight to substantially counter-balance movement of the focus element; for example, by translating a counter-weight opposite to the movement of the focus element. Ease of operation may be achieved if the counter-weight and the focus element are connected and driven by the same translation means. This may however, only substantially reduce the vibration to the first order. If a counter-weight balanced device is rotated around the counter-weight balanced axis, there may be issues relating to the torque created by the counter-weights. A further embodiment of the invention thus comprises means for reducing and/or eliminating the first order, second order, third order and/or higher order vibration and/or shaking from the focus element adjustment system, thereby increasing the stability of the scanner.

In another embodiment of the invention more than one optical element is moved to shift the focal plane. In that embodiment it is desirable that these elements are moved together and that the elements are physically adjacent.

In the preferred embodiment of the invention the optical system is telecentric, or near telecentric, for all focus plane positions. Thus, even though one or more lenses in the optical system may be shifted back and forth to change the focus plane position, the telecentricity of the optical system is maintained.

The preferred embodiment of the invention comprises focus gearing. Focus gearing is the correlation between movement of the lens and movement of the focus plane position. E.g. a focus gearing of 2 means that a translation of the focus element of 1 mm corresponds to a translation of the focus plane position of 2 mm. Focus gearing can be provided by a suitable design of the optical system. The advantage of focus gearing is that a small movement of the focus element may correspond to a large variation of the focus plane position. In specific embodiments of the invention the focus gearing is between 0.1 and 100, such as between 0.1 and 1, such as between 1 and

10, such as between 2 and 8, such as between 3 and 6, such as least 10, such as at least 20.

In another embodiment of the invention the focus element is a liquid lens. A liquid lens can control the focus plane without use of any moving parts.

Camera

The camera may be a standard digital camera accommodating a standard CCD or CMOS chip with one A/D converter per line of sensor elements (pixels). However, to increase the frame rate the scanner according to the disclosure may comprise a high-speed camera accommodating multiple A/D converters per line of pixels, e.g. at least 2, 4, 8 or 16 A/D converters per line of pixels.

Pattern

Another central element of the disclosure is the probe light with an embedded pattern that is projected on to the object being scanned. The pattern may be static or time varying. The time varying pattern may provide a variation of light and darkness on and/or in the object. Specifically, when the pattern is varied in time for a fixed focus plane then the in-focus regions on the object will display an oscillating pattern of light and darkness. The out-of-focus regions will display smaller or no contrast in the light oscillations. The static pattern may provide a spatial variation of light and darkness on and/or in the object. Specifically, the in-focus regions will display an oscillating pattern of light and darkness in space. The out-of-focus regions will display smaller or no contrast in the spatial light oscillations.

Light may be provided from an external light source, however preferably the scanner comprises at least one light source and pattern generation means to produce the pattern. It is advantageous in terms of signal-to-noise ratio to design a light source such that the intensity in the non-masked parts of the pattern is as close to uniform in space as possible. In another embodiment the light source and the pattern generation means is integrated in a single component, such as a segmented LED. A segmented LED may provide a static pattern and/or it may provide a time varying pattern in itself by turning on and off the different segments in sequence. In one embodiment of the invention the time varying pattern is periodically varying in time. In another embodiment

of the invention the static pattern is periodically varying in space.

Light from the light source (external or internal) may be transmitted through the pattern generation means thereby generating the pattern. For example the pattern generation means comprises at least one translucent and/or transparent pattern element. For generating a time varying pattern a wheel, with an opaque mask can be used. E.g. the mask comprises a plurality of radial spokes, preferably arranged in a symmetrical order. The scanner may also comprise means for rotating and/or translating the pattern element. For generating a static pattern a glass plate with an opaque mask can be used. E.g. the mask comprises a line pattern or checkerboard pattern. In general said mask preferably possesses rotational and/or translational periodicity. The pattern element is located in the optical path. Thus, light from the light source may be transmitted through the pattern element, e.g. transmitted transversely through the pattern element. The time varying pattern can then be generated by rotating and/or translating the pattern element. A pattern element generating a static pattern does not need to be moved during a scan.

Correlation

One object of the disclosure is to provide short scan time and real time processing, e.g. to provide live feedback to a scanner operator to make a fast scan of an entire tooth arch. However, real time high resolution 3D scanning creates an enormous amount of data. Therefore data processing should be provided in the scanner housing, i.e. close to the optical components, to reduce data transfer rate to e.g. a cart, workstation or display. In order to speed up data processing time and in order to extract in-focus information with an optimal signal-to-noise ratio various correlation techniques may be embedded / implemented. This may for example be implemented in the camera electronics to discriminate out-of-focus information. The pattern is applied to provide illumination with an embedded spatial structure on the object being scanned.

Determining in-focus information relates to calculating a correlation measure of this spatially structured light signal (which we term input signal) with the variation of the pattern itself (which we term reference signal). In general the magnitude of the correlation measure is high if the input signal coincides with the reference signal. If the input signal displays little or no variation then the magnitude of the correlation measure is low. If the input signal displays a large spatial variation but this variation is different than the variation in the reference signal then the magnitude of the correlation measure

is also low. In a further embodiment of the invention the scanner and/or the scanner head may be wireless, thereby simplifying handling and operation of the scanner and increasing accessibility under difficult scanning situations, e.g. intra-oral or in the ear scanning. However, wireless operation may further increase the need for local data processing to avoid wireless transmission of raw 3D data.

The reference signal is provided by the pattern generating means and may be periodic. The variation in the input signal may be periodic and it may be confined to one or a few periods. The reference signal may be determined independently of the input signal. Specifically in the case of a periodic variation, the phase between the oscillating input and reference signal may be known independently of the input signal. In the case of a periodic variation the correlation is typically related to the amplitude of the variation. If the phase between the oscillating input and reference signals is not known it is necessary to determine both cosine and sinusoidal part of the input signal before the input signal's amplitude of variation can be determined. This is not necessary when the phase is known.

One way to define the correlation measure mathematically with a discrete set of measurements is as a dot product computed from a signal vector, $I = (I_1, \dots, I_n)$, with $n > 1$ elements representing sensor signals and a reference vector, $f = (f_1, \dots, f_n)$, of same length as said signal vector of reference weights. The correlation measure A is then given by

$$A = f \cdot I = \sum_{i=1}^n f_i I_i$$

The indices on the elements in the signal vector represent sensor signals that are recorded at different times and/or at different sensors. In the case of a continuous measurement the above expression is easily generalized to involve integration in place of the summation. In that case the integration parameter is time and/or one or more spatial coordinates.

A preferred embodiment is to remove the DC part of the correlation signal or correlation measure, i.e., when the reference vector elements sums to zero ($\sum_{i=1}^n f_i = 0$). The focus position can be found as an extremum of the correlation measure computed over all focus element positions. We note that in this case the correlation measure is proportional to the sample Pearson correlation coefficient between two variables. If the

DC part is not removed, there may exist a trend in DC signal over all focus element positions, and this trend can be dominating numerically. In this situation, the focus position may still be found by analysis of the correlation measure and/or one or more of its derivatives, preferably after trend removal.

Preferably, the global extremum should be found. However, artifacts such as dirt on the optical system can result in false global maxima. Therefore, it can be advisable to look for local extrema in some cases. If the object being scanned is sufficiently translucent it may be possible to identify interior surfaces or surface parts that are otherwise occluded. In such cases there may be several local extrema that corresponds to surfaces and it may be advantageous to process several or all extrema.

The correlation measure can typically be computed based on input signals that are available as digital images, i.e., images with a finite number of discrete pixels. Therefore conveniently, the calculations for obtaining correlation measures can be performed for image pixels or groups thereof. Correlation measures can then be visualized in as pseudo-images.

The correlation measure applied in this disclosure is inspired by the principle of a lock-in amplifier, in which the input signal is multiplied by the reference signal and integrated over a specified time. In this disclosure, a reference signal is provided by the pattern.

Temporal correlation

Temporal correlation involves a time-varying pattern. The light signal in the individual light sensing elements in the camera is recorded several times while the pattern configuration is varied. The correlation measure is thus at least computed with sensor signals recorded at different times.

A principle to estimate light oscillation amplitude in a periodically varying light signal is taught in WO 98/45745 where the amplitude is calculated by first estimating a cosine and a sinusoidal part of the light intensity oscillation. However, from a statistical point of view this is not optimal because two parameters are estimated to be able to calculate the amplitude.

In this embodiment of the invention independent knowledge of the pattern configuration at each light signal recording allows for calculating the correlation measure at each light sensing element.

In some embodiments of the invention the scanner comprises means for obtaining knowledge of the pattern configuration. To provide such knowledge the scanner preferably further comprises means for registering and/or monitoring the time varying pattern.

Each individual light sensing element, i.e. sensor element, in the camera sees a variation in the light signal corresponding to the variation of the light illuminating the object.

One embodiment of the invention obtains the time variation of the pattern by translating and/or rotating the pattern element. In this case the pattern configuration may be obtained by means of a position encoder on the pattern element combined with prior knowledge of the pattern geometry that gives rise to a pattern variation across individual sensing elements. Knowledge of the pattern configuration thus arises as a combination of knowledge of the pattern geometry that results in a variation across different sensing elements and pattern registration and/or monitoring during the 3D scan. In case of a rotating wheel as the pattern element the angular position of the wheel may then be obtained by an encoder, e.g. mounted on the rim.

One embodiment of the invention involves a pattern that possesses translational and/or rotational periodicity. In this embodiment there is a well-defined pattern oscillation period if the pattern is substantially translated and/or rotated at a constant speed.

One embodiment of the invention comprises means for sampling each of a plurality of the sensor elements a plurality of times during one pattern oscillation period, preferably sampled an integer number of times, such as sampling 2, 3, 4, 5, 6, 7 or 8 times during each pattern oscillation period, thereby determining the light variation during a period.

The temporal correlation measure between the light variation and the pattern can be obtained by recording several images on the camera during one oscillation period (or at least one oscillation period). The number of images recorded during one oscillation

period is denoted n . The registration of the pattern position for each individual image combined with the independently known pattern variation over all sensing element (i.e. obtaining knowledge of the pattern configuration) and the recorded images allows for an efficient extraction of the correlation measure in each individual sensing element in the camera. For a light sensing element with label j , the n recorded light signals of that element are denoted $I_{1j}, \dots, I_{nj}$. The correlation measure of that element, A_j , may be expressed as

$$A_j = \sum_{i=1}^n f_{i,j} I_{i,j}$$

Here the reference signal or weight function f is obtained from the knowledge of the pattern configuration. f has two indices i, j . The variation of f with the first index is derived from the knowledge of the pattern position during each image recording. The variation of f with the second index is derived from the knowledge of the pattern geometry which may be determined prior to the 3D scanning.

Preferably, but not necessarily, the reference signal f averages to zero over time, i.e. for all j we have

$$\sum_{i=1}^n f_{i,j} = 0$$

to suppress the DC part of the light variation or correlation measure. The focus position corresponding to the pattern being in focus on the object for a single sensor element in the camera will be given by an extremum value of the correlation measure of that sensor element when the focus position is varied over a range of values. The focus position may be varied in equal steps from one end of the scanning region to the other.

To obtain a sharp image of an object by means of a camera the object must be in focus and the optics of the camera and the object must be in a fixed spatial relationship during the exposure time of the image sensor of the camera. Applied to the present disclosure this should imply that the pattern and the focus should be varied in discrete steps to be able to fix the pattern and the focus for each image sampled in the camera, i.e. fixed during the exposure time of the sensor array. However, to increase the sensitivity of the image data the exposure time of the sensor array should be as high as the sensor frame rate permits. Thus, in the preferred embodiment of the invention images are recorded (sampled) in the camera while the pattern is continuously varying (e.g. by continuously rotating a pattern wheel) and the focus plane is continuously

moved. This implies that the individual images will be slightly blurred since they are the result of a time-integration of the image while the pattern is varying and the focus plane is moved. This is something that one could expect to lead to deterioration of the data quality, but in practice the advantage of concurrent variation of the pattern and the focus plane is bigger than the drawback.

In another embodiment of the invention images are recorded (sampled) in the camera while the pattern is fixed and the focus plane is continuously moved, i.e. no movement of the pattern. This could be the case when the light source is a segmented light source, such as a segment LED that flashes in an appropriate fashion. In this embodiment the knowledge of the pattern is obtained by a combination of prior knowledge of the geometry of the individual segments on the segmented LED give rise to a variation across light sensing elements and the applied current to different segments of the LED at each recording.

In yet another embodiment of the invention images are recorded (sampled) in the camera while the pattern is continuously varying and the focus plane is fixed.

In yet another embodiment of the invention images are recorded (sampled) in the camera while the pattern and the focus plane are fixed.

The temporal correlation principle may be applied in general within image analysis. Thus, a further embodiment of the invention relates to a method for calculating the amplitude of a light intensity oscillation in at least one (photoelectric) light sensitive element, said light intensity oscillation generated by a periodically varying illumination pattern and said amplitude calculated in at least one pattern oscillation period, said method comprising the steps of:

- providing the following a predetermined number of sampling times during a pattern oscillation period:
 - o sampling the light sensitive element thereby providing the signal of said light sensitive element, and
 - o providing an angular position and/or a phase of the periodically varying illumination pattern for said sampling, and
- calculating said amplitude(s) by integrating the products of a predetermined periodic function and the signal of the corresponding light sensitive element over

said predetermined number of sampling times, wherein said periodic function is a function of the angular position and/or the phase of the periodically varying illumination pattern.

This may also be expressed as

$$A = \sum_i f(p_i) I_i$$

where A is the calculated amplitude or correlation measure, i is the index for each sampling, f is the periodic function, p_i is the angular position / phase of the illumination pattern for sampling i and I_i is the signal of the light sensitive element for sampling i . Preferably the periodic function averages to zero over a pattern oscillation period, i.e.

$$\sum_i f(p_i) = 0.$$

To generalize the principle to a plurality of light sensitive elements, for example in a sensor array, the angular position / phase of the illumination pattern for a specific light sensitive element may consist of an angular position / phase associated with the illumination pattern plus a constant offset associated with the specific light sensitive element. Thereby the correlation measure or amplitude of the light oscillation in light sensitive element j may be expressed as

$$A_j = \sum_i f(\theta_j + p_i) I_{i,j},$$

where θ_j is the constant offset for light sensitive element j .

A periodically varying illumination pattern may be generated by a rotating wheel with an opaque mask comprising a plurality of radial spokes arranged in a symmetrical order. The angular position of the wheel will thereby correspond to the angular position of the pattern and this angular position may be obtained by an encoder mounted on the rim of the wheel. The pattern variation across different sensor elements for different position of the pattern may be determined prior to the 3D scanning in a calibration routine. A combination of knowledge of this pattern variation and the pattern position constitutes knowledge of the pattern configuration. A period of this pattern may for example be the time between two spokes and the amplitude of a single or a plurality of light sensitive elements of this period may be calculated by sampling e.g. four times in this period.

A periodically varying illumination pattern may be generated by a Ronchi ruling moving orthogonal to the lines and the position is measured by an encoder. This position corresponds to the angular position of the generated pattern. Alternatively, a checkerboard pattern could be used.

A periodically varying illumination pattern may be generated by a one-dimensional array of LEDs that can be controlled line wise.

A varying illumination pattern may be generated by a LCD or DLP based projector.

Optical correlation

The abovementioned correlation principle (temporal correlation) requires some sort of registering of the time varying pattern, e.g. knowledge of the pattern configuration at each light level recording in the camera. However, a correlation principle without this registering may be provided in another embodiment of the invention. This principle is termed "optical correlation".

In this embodiment of the invention an image of the pattern itself and an image of at least a part of the object being scanned with the pattern projected onto it is combined on the camera. I.e. the image on the camera is a superposition of the pattern itself and the object being probed with the pattern projected onto it. A different way of expressing this is that the image on the camera substantially is a multiplication of an image of the pattern projected onto the object with the pattern itself.

This may be provided in the following way. In a further embodiment of the invention the pattern generation means comprises a transparent pattern element with an opaque mask. The probe light is transmitted through the pattern element, preferably transmitted transversely through the pattern element. The light returned from the object being scanned is retransmitted the opposite way through said pattern element and imaged onto the camera. This is preferably done in a way where the image of the pattern illuminating the object and the image of the pattern itself are coinciding when both are imaged onto the camera. One particular example of a pattern is a rotating wheel with an opaque mask comprising a plurality of radial spokes arranged in a symmetrical order such that the pattern possesses rotational periodicity. In this embodiment there is a well-defined pattern oscillation period if the pattern is substantially rotated at a constant speed. We define the oscillation period as $2\pi/\omega$.

We note that in the described embodiment of the invention the illumination pattern is a pattern of light and darkness. A light sensing element in the camera with a signal proportional to the integrated light intensity during the camera integration time δt with label j , I_j is given by

$$I_j = K \int_t^{t+\delta t} T_j(t') S_j(t') dt'$$

Here K is the proportionality constant of the sensor signal, t is the start of the camera integration time, T_j is the time-varying transmission of the part of the rotating pattern element imaged onto the j 'th light sensing element, and S_j is the time-varying light intensity of light returned from the scanned object and imaged onto the j 'th light sensing element. In the described embodiment T_j is the step function substantially defined by $T_j(t) = 0$ for $\sin(\omega t + \phi_j) > 0$ and $T_j(t) = 1$ elsewhere. ϕ_j is a phase dependent on the position of the j 'th imaging sensor.

The signal on the light sensing element is a correlation measure of the pattern and the light returned from the object being scanned. The time-varying transmission takes the role of the reference signal and the time-varying light intensity of light returned from the scanned object takes the role of the input signal. The advantage of this embodiment of the invention is that a normal CCD or CMOS camera with intensity sensing elements may be used to record the correlation measure directly since this appears as an intensity on the sensing elements. Another way of expressing this is that the computation of the correlation measure takes place in the analog, optical domain instead of in an electronic domain such as an FPGA or a PC.

The focus position corresponding to the pattern being in focus on the object being scanned for a single sensor element in the camera will then be given by the maximum value of the correlation measure recorded with that sensor element when the focus position is varied over a range of values. The focus position may be varied in equal steps from one end of the scanning region to the other. One embodiment of the invention comprises means for recording and/or integrating and/or monitoring and/or storing each of a plurality of the sensor elements over a range of focus plane positions.

Preferably, the global maximum should be found. However, artifacts such as dirt on the optical system can result in false global maxima. Therefore, it can be advisable to look for local maxima in some cases.

Since the reference signal does not average to zero the correlation measure has a DC component. Since the DC part is not removed, there may exist a trend in DC signal over all focus element positions, and this trend can be dominating numerically. In this situation, the focus position may still be found by analysis of the correlation measure and/or one or more of its derivatives.

In a further embodiment of the invention the camera integration time is an integer number M of the pattern oscillation period, i.e. $t = 2M / \omega$. One advantage of this embodiment is that the magnitude of the correlation measure can be measured with a better signal-to-noise ratio in the presence of noise than if the camera integration time is not an integer number of the pattern oscillation period.

In another further embodiment of the invention the camera integration time is much longer than pattern oscillation period, i.e. $t \gg 2M / \omega$. Many times the pattern oscillation time would here mean e.g. camera integration time at least 10 times the oscillation time or more preferably such as at least 100 or 1000 times the oscillation time. One advantage of this embodiment is that there is no need for synchronization of camera integration time and pattern oscillation time since for very long camera integration times compared to the pattern oscillation time the recorded correlation measure is substantially independent of accurate synchronization.

Equivalent to the temporal correlation principle the optical correlation principle may be applied in general within image analysis. Thus, a further embodiment of the invention relates to a method for calculating the amplitude of a light intensity oscillation in at least one (photoelectric) light sensitive element, said light intensity oscillation generated by a superposition of a varying illumination pattern with itself, and said amplitude calculated by time integrating the signal from said at least one light sensitive element over a plurality of pattern oscillation periods.

Spatial correlation

The above mentioned correlation principles (temporal correlation and optical correlation) require the pattern to be varying in time. If the optical system and camera provides a lateral resolution which is at least two times what is needed for the scan of the object then it is possible to scan with a static pattern, i.e. a pattern which is not changing in time. This principle is termed "spatial correlation". The correlation measure is thus at least computed with sensor signals recorded at different sensor sites.

The lateral resolution of an optical system is to be understood as the ability of optical elements in the optical system, e.g. a lens system, to image spatial frequencies on the object being scanned up to a certain point. Modulation transfer curves of the optical system are typically used to describe imaging of spatial frequencies in an optical system. One could e.g. define the resolution of the optical system as the spatial frequency on the object being scanned where the modulation transfer curve has decreased to e.g. 50%. The resolution of the camera is a combined effect of the spacing of the individual camera sensor elements and the resolution of the optical system.

In the spatial correlation the correlation measure refers to a correlation between input signal and reference signal occurring in space rather than in time. Thus, in one embodiment of the invention the resolution of the measured 3D geometry is equal to the resolution of the camera. However, for the spatial correlation the resolution of the measured 3D geometry is lower than the resolution of the camera, such as at least 2 times lower, such as at least 3 times lower, such as at least 4 times lower, such as at least 5 times lower, such as at least 10 times lower. The sensor element array is preferably divided into groups of sensor elements, preferably rectangular groups, such as square groups of sensor elements, preferably adjacent sensor elements. The resolution of the scan, i.e. the measured 3D geometry, will then be determined by the size of these groups of sensor elements. The oscillation in the light signal is provided within these groups of sensor elements, and the amplitude of the light oscillation may then be obtained by analyzing the groups of sensor elements. The division of the sensor element array into groups is preferably provided in the data processing stage, i.e. the division is not a physical division thereby possibly requiring a specially adapted sensor array. Thus, the division into groups is "virtual" even though the single pixel in a group is an actual physical pixel.

In one embodiment of the invention the pattern possesses translational periodicity along at least one spatial coordinate. In a further embodiment of the invention the spatially periodic pattern is aligned with the rows and/or the columns of the array of sensor elements. For example in the case of a static line pattern the rows or columns of the pixels in the camera may be parallel with the lines of the pattern. Or in the case of a static checkerboard pattern the row and columns of the checkerboard may be aligned with the rows and columns, respectively, of the pixels in the camera. By aligning is meant that the image of the pattern onto the camera is aligned with the “pattern” of the sensor element in the sensor array of the camera. Thus, a certain physical location and orientation of the pattern generation means and the camera requires a certain configuration of the optical components of the scanner for the pattern to be aligned with sensor array of the camera.

In a further embodiment of the invention at least one spatial period of the pattern corresponds to a group of sensor elements. In a further embodiment of the invention all groups of sensor elements contain the same number of elements and have the same shape. E.g. when the period of a checkerboard pattern corresponds to a square group of e.g. 2x2, 3x3, 4x4, 5x5, 6x6, 7x7, 8x8, 9x9, 10x10 or more pixels on the camera.

In yet another embodiment one or more edges of the pattern is aligned with and/or coincide with one or more edges of the array of sensor elements. For example a checkerboard pattern may be aligned with the camera pixels in such a way that the edges of the image of the checkerboard pattern onto the camera coincide with the edges of the pixels.

In spatial correlation independent knowledge of the pattern configuration allows for calculating the correlation measure at each group of light sensing. For a spatially periodic illumination this correlation measure can be computed without having to estimate the cosine and sinusoidal part of the light intensity oscillation. The knowledge of the pattern configuration may be obtained prior to the 3D scanning.

In a further embodiment of the invention the correlation measure, A_j , within a group of sensor elements with label j is determined by means of the following formula:

$$A_j = \sum_{i=1}^n f_{i,j} I_{i,j}$$

Where n is the number of sensor elements in a group of sensors, $\mathbf{f}_j = (f_{1,j}, \dots, f_{n,j})$ is the reference signal vector obtained from knowledge of the pattern configuration, and $\mathbf{I}_j = (I_{1,j}, \dots, I_{n,j})$ is input signal vector. For the case of sensors grouped in square regions with N sensors as square length then $n = N^2$.

Preferably, but not necessarily, the elements of the reference signal vector averages to zero over space, i.e. for all j we have

$$\sum_{i=1}^n f_{i,j} = 0$$

to suppress the DC part of the correlation measure. The focus position corresponding to the pattern being in focus on the object for a single group of sensor elements in the camera will be given by an extremum value of the correlation measure of that sensor element group when the focus position is varied over a range of values. The focus position may be varied in equal steps from one end of the scanning region to the other.

In the case of a static checkerboard pattern with edges aligned with the camera pixels and with the pixel groups having an even number of pixels such as 2x2, 4x4, 6x6, 8x8, 10x10, a natural choice of the reference vector $\mathbf{f}$ would be for its elements to assume the value 1 for the pixels that image a bright square of the checkerboard and -1 for the pixels that image a dark square of the checkerboard.

Equivalent to the other correlation principles the spatial correlation principle may be applied in general within image analysis. In particular in a situation where the resolution of the camera is higher than what is necessary in the final image. Thus, a further embodiment of the invention relates to a method for calculating the amplitude(s) of a light intensity oscillation in at least one group of light sensitive elements, said light intensity oscillation generated by a spatially varying static illumination pattern, said method comprising the steps of:

- providing the signal from each light sensitive element in said group of light sensitive elements, and
- calculating said amplitude(s) by integrating the products of a predetermined function and the signal from the corresponding light sensitive element over said group of light sensitive elements, wherein said predetermined function is a function reflecting the illumination pattern.

To generalize the principle to a plurality of light sensitive elements, for example in a sensor array, the correlation measure or amplitude of the light oscillation in group j may be expressed as

$$A_j = \sum_{i=1}^n f(i, j) I_{i,j} ,$$

where n is the number of sensor elements in group j , $I_{i,j}$ is the signal from the i 'th sensor element in group j and $f(i, j)$ is a predetermined function reflecting the pattern.

Compared to temporal correlation, spatial correlation has the advantage that no moving pattern is required. This implies that knowledge of the pattern configuration may be obtained prior to the 3D scanning. Conversely, the advantage of temporal correlation is its higher resolution, as no pixel grouping is required.

All correlation principles, when embodied with an image sensor that allows very high frame rates, enable 3D scanning of objects in motion with little motion blur. It also becomes possible to trace moving objects over time ("4D scanning"), with useful applications for example in machine vision and dynamic deformation measurement. Very high frame rates in this context are at least 500, but preferably at least 2000 frames per second.

Transforming correlation measure extrema to 3D world coordinates

Relating identified focus position(s) for camera sensor or camera sensor groups to 3D world coordinates may be done by ray tracing through the optical system. Before such ray tracing can be performed the parameters of the optical system need to be known. One embodiment of the invention comprises a calibration step to obtain such knowledge. A further embodiment of the invention comprises a calibration step in which images of an object of known geometry are recorded for a plurality of focus positions. Such an object may be a planar checkerboard pattern. Then, the scanner can be calibrated by generating simulated ray traced images of the calibration object and then adjusting optical system parameters as to minimize the difference between the simulated and recorded images.

In a further embodiment of the invention the calibration step requires recording of images for a plurality of focus positions for several different calibration objects and/or several different orientations and/or positions of one calibration object.

With knowledge of the parameters of the optical system, one can employ backward ray tracing technique to estimate the 2D -> 3D mapping. This requires that the scanner's optical system be known, preferably through calibration. The following steps can be performed:

1. From each pixel of the image (at the image sensor), trace a certain number of rays, starting from the image sensor and through the optical system (backward ray tracing).
 2. From the rays that emit, calculate the focus point, the point where all these rays substantially intersect. This point represents the 3D coordinate of where a 2D pixel will be in focus, i.e., in yield the global maximum of light oscillation amplitude.
 3. Generate a look up table for all the pixels with their corresponding 3D coordinates.
- The above steps are repeated for a number of different focus lens positions covering the scanner's operation range.

Specular reflections

High spatial contrast of the in-focus pattern image on the object is often necessary to obtain a good signal to noise ratio of the correlation measure on the camera. This in turn may be necessary to obtain a good estimation of the focus position corresponding to an extremum in the correlation measure. This sufficient signal to noise ratio for successful scanning is often easily achieved in objects with a diffuse surface and negligible light penetration. For some objects, however, it is difficult to achieve high spatial contrast.

A difficult kind of object, for instance, is an object displaying multiple scattering of the incident light with a light diffusion length large compared to the smallest feature size of the spatial pattern imaged onto the object. A human tooth is an example of such an object. The human ear and ear canal are other examples. In case of intra oral scanning, the scanning should preferably be provided without spraying and/or drying the teeth to reduce the specular reflections and light penetration. Improved spatial contrast can be achieved by preferential imaging of the specular surface reflection from the object on the camera. Thus, one embodiment of the invention comprises means for preferential / selectively imaging of specular reflected light and/or diffusively

reflected light. This may be provided if the scanner further comprises means for polarizing the probe light, for example by means of at least one polarizing beam splitter. A polarizing beam splitter may for instance be provided for forming an image of the object in the camera. This may be utilized to extinguish specular reflections, because if the incident light is linearly polarized a specular reflection from the object has the property that it preserves its polarization state

The scanner according to the invention may further comprise means for changing the polarization state of the probe light and/or the light reflected from the object. This can be provided by means of a retardation plate, preferably located in the optical path. In one embodiment of the invention the retardation plate is a quarter wave retardation plate. A linearly polarized light wave is transformed into a circularly polarized light wave upon passage of a quarter wave plate with an orientation of 45 degrees of its fast axis to the linear polarization direction. This may be utilized to enhance specular reflections because a specular reflection from the object has the property that it flips the helicity of a circularly polarized light wave, whereas light that is reflected by one or more scattering events becomes depolarized.

The field of view (scanning length)

In one embodiment of the invention the probe light is transmitted towards the object in a direction substantially parallel with the optical axis. However, for the scan head to be entered into a small space such as the oral cavity of a patient it is necessary that the tip of the scan head is sufficiently small. At the same time the light out of the scan head need to leave the scan head in a direction different from the optical axis. Thus, a further embodiment of the invention comprises means for directing the probe light and/or imaging an object in a direction different from the optical axis. This may be provided by means of at least one folding element, preferably located along the optical axis, for directing the probe light and/or imaging an object in a direction different from the optical axis. The folding element could be a light reflecting element such as a mirror or a prism. In one embodiment of the invention a 45 degree mirror is used as folding optics to direct the light path onto the object. Thereby the probe light is guided in a direction perpendicular to the optical axis. In this embodiment the height of the scan tip is at least as large as the scan length and preferably of approximately equal size.

One embodiment of the invention comprises at least two light sources, such as light sources with different wavelengths and/or different polarization. Preferably also control means for controlling said at least two light sources. Preferably this embodiment comprises means for combining and/or merging light from said at least two light sources. Preferably also means for separating light from said at least two light sources. If waveguide light sources are used they may be merged by waveguides. However, one or more diffusers may also be provided to merge light sources.

Separation and/or merging may be provided by at least one optical device which is partially light transmitting and partially light reflecting, said optical device preferably located along the optical axis, an optical device such as a coated mirror or coated plate. One embodiment comprises at least two of said optical devices, said optical devices preferably displaced along the optical axis. Preferably at least one of said optical devices transmits light at certain wavelengths and/or polarizations and reflects light at other wavelengths and/or polarizations.

One exemplary embodiment of the invention comprises at least a first and a second light source, said light sources having different wavelength and/or polarization, and wherein

- a first optical device reflects light from said first light source in a direction different from the optical axis and transmits light from said second light source, and
- a second optical device reflects light from said second light source in a direction different from the optical axis. Preferably said first and second optical devices reflect the probe light in parallel directions, preferably in a direction perpendicular to the optical axis, thereby imaging different parts of the object surface. Said different parts of the object surface may be at least partially overlapping.

Thus, for example light from a first and a second light source emitting light of different wavelengths (and/or polarizations) is merged together using a suitably coated plate that transmits the light from the first light source and reflects the light from the second light source. At the scan tip along the optical axis a first optical device (e.g. a suitably coated plate, dichroic filter) reflects the light from the first light source onto the object and transmits the light from the second light source to a second optical device (e.g. a mirror) at the end of the scan tip, i.e. further down the optical axis. During scanning the focus position is moved such that the light from the first light source is used to project

an image of the pattern to a position below the first optical device while second light source is switched off. The 3D surface of the object in the region below the first optical device is recorded. Then the first light source is switched off and the second light source is switched on and the focus position is moved such that the light from the second light source is used to project an image of the pattern to a position below the second optical device. The 3D surface of the object in the region below the second optical device is recorded. The region covered with the light from the two light sources respectively may partially overlap.

In another embodiment of the invention the probe light is directed in a direction different from the optical axis by means of a curved fold mirror. This embodiment may comprise one or more optical elements, such as lenses, with surfaces that may be aspherical to provide corrected optical imaging.

A further embodiment of the invention comprises of at least one translation stage for translating mirror(s) along the optical axis. This allows for a scan tip with a smaller height than the scan length. A large scan length can be achieved by combining several scans with the mirror(s) in different positions along the optical axis.

In another embodiment of the invention the probe light is directed in a direction different from the optical axis by means of at least one grating that provides anamorphic magnification so that the image of the pattern on the object being scanned is stretched. The grating may be blazed. In this embodiment the light source needs to be monochromatic or semi-monochromatic.

The abovementioned embodiments suitable for increasing the scan length may comprise control means for providing a coordination of the light sources and the focus element.

Color scanning

One embodiment of the invention is only registering the surface topology (geometry) of the object being scanned. However, another embodiment of the invention is being adapted to obtain the color of the surface being scanned, i.e. capable of registering the color of the individual surface elements of the object being scanned together with the surface topology of the object being scanned. To obtain color information the light

source needs to be white or to comprise at least three monochromatic light sources with colors distributed across the visible part of the electromagnetic spectrum.

To provide color information the array of sensor elements may be a color image sensor. The image sensor may accommodate a Bayer color filter scheme. However, other color image sensor types may be provided, such as a Foveon type color image sensor, wherein the image sensor provides color registration in each sensor element.

One embodiment of the invention comprises means selecting one color of the probe light at a time, i.e. selectively switching between different colors of the probe light, thereby illuminating the object with different colors. If a white light source is used then some kind of color filtering must be provided. Preferably comprising a plurality of color filters, such as red, green and blue color filters, and means for inserting said color filters singly in front of the white light source, thereby selecting a color of the probe light.

In one embodiment of the invention color filters are integrated in the pattern generation means, i.e. the pattern generation means comprises color filters, such as translucent and/or transparent parts that are substantially monochromatically colored. For example a pattern element such as a rotating wheel with an opaque mask and where the translucent / transparent parts are color filters. For example one third of the wheel is red, one third is green and one third is blue.

Probe light of different colors may also be provided by at least three monochromatic light sources, such as lasers or LED's, said light sources having wavelengths distributed across the visible part of the wavelength spectrum. This will in general also require means for merging said light sources. For example suitable coated plates. In the case of waveguide light sources, the merging may be provided by a waveguide element.

To handle the different colors of the probe light the optical system is preferably substantially achromatic.

One embodiment of the invention comprises means for switching between at least two colors, preferably three colors, such as red, green and blue, of the probe light for a

focal plane position. I.e. for a single focal plane position it is possible to switch between different colors of the probe light. For example by switching on and off different monochromatic light sources (having one only light source turned on at a time) or by applying different color filters. Furthermore, the amplitude of the light signal of each of a plurality of the sensor elements may be determined for each color for each focal plane positions. I.e. for each focus position the color of the probe light may be switched. The embedded time varying pattern provides a single color oscillating light signal and the amplitude of the signal in each sensor element may be determined for that color. Switching to the next color the amplitude may be determined again. When the amplitude has been determined for all colors the focus position is changed and the process is repeated. The color of the surface being scanned may then be obtained by combining and/or weighing the color information from a plurality of the sensor elements. E.g. the color expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding to the maximum amplitude. This technique may also be applied when a static pattern is provided where the color of at least a part of the pattern is varying in time.

To decrease the amount of data to be processed the color resolution of the imaging may be chosen to be less than the spatial resolution. The color information is then provided by data interpolation. Thus, in one embodiment of the invention the amplitude of the light signal of each of a plurality of the sensor elements is determined for each color for selected full color focal plane positions, and the amplitude of the light signal of each of a plurality of the sensor elements is determined for one color for each focal plane position. Then the color of the surface being scanned may be obtained by interpolating the color information from full color focal plane positions. Thus, for example the amplitude is registered for all colors at an interval of N focus positions; while one color is selected for determination of the amplitude at all focus positions. N is a number which could be e.g. 3, 5, or 10. This results in a color resolution which is less than the resolution of the surface topology. This technique may also be applied when a static pattern is provided where the color of at least a part of the pattern is varying in time.

Another embodiment of the invention does not register full color information and employs only two light sources with different colors. An example of this is a dental

scanner that uses red and blue light to distinguish hard (tooth) tissue from soft (gum) tissue.

Impression scanning

One embodiment of the invention is adapted to impression scanning, such as scanning of dental impressions and/or ear canal impressions.

Small cavity scanner

Specific applications of the scanner according to the invention relates to scanning of cavities, in particular body cavities. Scanning in cavities may relate to scanning of objects in the cavity, such as scanning of teeth in a mouth. However, scanning of e.g. the ear relate to scanning of the inner surface of the cavity itself. In general scanning of a cavity, especially a small cavity, requires some kind of probe for the scanner. Thus, in one embodiment of the invention the point of emission of probe light and the point of accumulation of reflected light is located on a probe, said probe being adapted to be entered into a cavity, such as a body cavity.

In another embodiment of the invention the probe is adapted to scan at least a part of the surface of a cavity, such as an ear canal. The ability to scan at least a part of the external part of the ear and/or the ear canal and make a virtual or real model of the ear is essential in the design of modern custom-fitted hearing aid (e.g. ear shell or mold). Today, scanning of ears is performed in a two-step process where a silicone impression of the ear is taken first and the impression is subsequently scanned using an external scanner in a second step.

Thus, one embodiment of the invention comprises

- a housing accommodating the camera, pattern generation means, focus varying means and data processing means, and
- at least one probe accommodating a first optical system, preferably a substantially elongated probe.

Preferably, the point of emission of probe light and the point of accumulation of light returned from the scanned object is located on said probe. The optical system in the probe is for transmitting the probe light from the housing toward the object and also for transmitting and/or imaging light returned from the object back towards the housing

where the camera is located. Thus, the optical system in the probe may comprise a system of lenses. In one embodiment of the invention probe may comprise at least one optical fibre and/or a fibre bundle for transmitting / transporting / guiding the probe light and/or the returned light from the object surface. In this case the optical fibre(s) may act as an optical relay system that merely transports light (i.e. probe light and returned light) inside the probe. In one embodiment of the invention the probe is endoscopic. The probe may be rigid or flexible. Use of optical fibre(s) in the probe may e.g. provide a flexible probe with a small diameter.

In one embodiment of the invention the light is transmitted to the object and imaged by means of only the optical system in the probe, the first optical system. However, in a further embodiment of the invention the housing may further comprise a second optical system.

In a further embodiment of the invention the probe is detachable from the housing. Then preferably a first point of emission of probe light and a first point of accumulation of returned light is located on the probe, and a second point of emission of probe light and a second point of accumulation of returned light is located on the housing. This may require optical systems in both the housing and the probe. Thus, a scan may be obtained with the probe attached to the housing. However, a scan may also be obtained with the probe detached from the housing, i.e. the housing may be a standalone scanner in itself. For example the probe may be adapted to be inserted into and scanning the inside of a cavity, whereas the housing may be adapted to scanning of exterior surfaces. The attachment of the probe may include mechanical and/or electrical transfer between the housing and the probe. For instance attaching the probe may provide an electrical signal to the control electronics in the housing that signals the current configuration of the device.

In one embodiment of the invention the probe light is directed toward the object in a direction substantially parallel with the optical axis and/or the longitudinal axis of the probe. In a further embodiment the probe comprises a posterior reflective element, such as a mirror, for directing the probe light in a direction different from the optical axis, preferably in a direction perpendicular to the optical axis. Applying to the abovementioned example with a stand-alone scanner housing with the probe detached, the probe light may exit the housing in a direction parallel with the optical

axis of the optical system in the housing (i.e. the second optical system), whereas with the probe attached the probe light may be directed in a direction different than the optical axis of the optical system of the probe (i.e. the first optical system). Thereby the probe is better adapted to scanning a cavity.

In some embodiments of this invention, waste heat generated in the scanner is used to warm the probe such that no or less condensation occurs on the probe when the probe is inside the body cavity, e.g. the mouth. Waste heat can, e.g., be generated by the processing electronics, the light source, and/or the mechanism that moves the focus element.

In some embodiments of this invention, the scanner provides feedback to the user when the registration of subsequent scans to a larger model of the 3D surface fails. For example, the scanner could flash the light source.

Further, the probe may comprise means for rotating / spinning the reflective element, preferably around an axis substantially parallel with the optical axis and/or the longitudinal axis of the probe. Thereby the probe may be adapted to provide a scan 360° around the optical axis and/or the longitudinal axis of the probe, preferably without rotation of probe and/or scanner.

In a further embodiment of the invention a plurality of different probes matches the housing. Thereby different probes adapted to different environments, surfaces, cavities, etc. may be attached to the housing to account for different scanning situations. A specific example of this is when the scanner comprises a first probe being adapted to scan the interior part of a human ear and a second probe being adapted to scan the exterior part of said human ear. Instead of a second probe it may be the housing itself, i.e. with the probe detached, that is adapted to scan the exterior part of said human ear. I.e. the housing may be adapted to perform a 3D surface scan. In other words: the housing with the probe attached may be adapted to scan the interior part of a human ear and the housing with the probe detached may be adapted to scan the exterior part of said human ear. Preferably, means for merging and/or combining 3D data for the interior and exterior part of the ear provided, thereby providing a full 3D model of a human ear.

For handheld embodiments of this invention, a pistol-like design is ergonomic because the device rests comfortably inside the hand of the operator, with most of the mass resting on top of the hand and/or wrist. In such a design, it is advantageous to be able to orient the above-mentioned posterior reflective in multiple positions. For example, it could be possible to rotate a probe with the posterior reflective element, with or without the step of detaching it from the main body of the scanning device. Detachable probes may also be autoclavable, which is a definitely advantage for scanners applied in humans, e.g., as medical devices. For embodiments of this invention that realize a physically moving focus element by means of a motor, it is advantageous to place this motor inside a grip of the pistol-like shape.

Use of motion, gravity, and magnetic sensors

Handheld embodiments of the invention preferably include motion sensors such as accelerometers and/or gyros. . Preferably, these motion sensors are small like microelectromechanical systems (MEMS) motion sensors. The motion sensors should preferably measure all motion in 3D, i.e., both translations and rotations for the three principal coordinate axes. The benefits are:

- A) Motion sensors can detect vibrations and/or shaking. Scans such affected can be either discarded or corrected by use of image stabilization techniques.
- B) Motion sensors can help with stitching and/or registering partial scans to each other. This advantage is relevant when the field of view of the scanner is smaller than the object to be scanned. In this situation, the scanner is applied for small regions of the object (one at a time) that then are combined to obtain the full scan. In the ideal case, motion sensors can provide the required relative rigid-motion transformation between partial scans' local coordinates, because they measure the relative position of the scanning device in each partial scan. Motion sensors with limited accuracy can still provide a first guess for a software-based stitching/ registration of partial scans based on, e.g., the Iterative Closest Point class of algorithms, resulting in reduced computation time.
- C) Motion sensors can be used (also) as a remote control for the software that accompanies the invention. Such software, for example, can be used to

visualize the acquired scan. With the scanner device now acting as a remote control, the user can, for example, rotate and/or pan the view (by moving the remote control in the same way as the object on the computer screen should "move"). Especially in clinical application, such dual use of the handheld scanner is preferable out of hygienic considerations, because the operator avoids contamination from alternative, hand-operated input devices (touch screen, mouse, keyboard, etc).

Even if it is too inaccurate to sense translational motion, a 3-axis accelerometer can provide the direction of gravity relative to the scanning device. Also a magnetometer can provide directional information relative to the scanning device, in this case from the earth's magnetic field. Therefore, such devices can help with stitching/registration and act as a remote control element.

The present invention relates to different aspects including the scanner device described above and in the following, and corresponding methods, devices, uses and/or product means, each yielding one or more of the benefits and advantages described in connection with the first mentioned aspect, and each having one or more embodiments corresponding to the embodiments described in connection with the first mentioned aspect and/or disclosed in the appended claims.

In particular, disclosed herein is a method for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object, said method comprising the steps of:

- generating a probe light incorporating a spatial pattern,
- transmitting the probe light towards the object along the optical axis of an optical system, thereby illuminating at least a part of the object with said pattern,
- transmitting at least a part of the light returned from the object to the camera,
- varying the position of the focus plane of the pattern on the object while maintaining a fixed spatial relation of the scanner and the object,
- obtaining at least one image from said array of sensor elements,
- evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, where the weight

function is determined based on information of the configuration of the spatial pattern;

- determining by analysis of the correlation measure the in-focus position(s) of:
 - each of a plurality of image pixels in the camera for said range of focus plane positions, or
 - each of a plurality of groups of image pixels in the camera for said range of focus planes, and
- transforming in-focus data into 3D real world coordinates.

Disclosed is also a computer program product comprising program code means for causing a data processing system to perform the method, when said program code means are executed on the data processing system.

Disclosed is also a computer program product, comprising a computer-readable medium having stored there on the program code means.

Another aspect of the invention relates to a scanner for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object, said scanner comprising:

- at least one camera accommodating an array of sensor elements,
- means for generating a probe light,
- means for transmitting the probe light towards the object thereby illuminating at least a part of the object,
- means for transmitting light returned from the object to the camera,
- means for varying the position of the focus plane on the object,
- means for obtaining at least one image from said array of sensor elements,
- means for:
 - a) determining the in-focus position(s) of:
 - each of a plurality of the sensor elements for a range of focus plane positions, or
 - each of a plurality of groups of the sensor elements for a range of focus plane positions, and
 - b) transforming in-focus data into 3D real world coordinates;

wherein the scanner further comprises counter-weight means for counter-balancing the means for varying the position of the focus plane.

Disclosed is also a method for obtaining and/or measuring the 3D geometry of at least a part of the surface of an object, said method comprising the steps of:

- accommodating an array of sensor elements,
- generating a probe light,
- transmitting the probe light towards the object thereby illuminating at least a part of the object,
- transmitting light returned from the object to the camera,
- varying the position of the focus plane on the object,
- obtaining at least one image from said array of sensor elements,
- determining the in-focus position(s) of:
 - each of a plurality of the sensor elements for a range of focus plane positions, or
 - each of a plurality of groups of the sensor elements for a range of focus plane positions, and
- transforming in-focus data into 3D real world coordinates;

wherein the method further comprises counter-balancing the means for varying the position of the focus plane.

Another aspect of the invention relates to a handheld 3D scanner with a grip at an angle of more than 30 degrees from the scanner's main optical axis, for use in intraoral or in-ear scanning.

Brief description of the drawings

Fig. 1: A schematic presentation of a first example embodiment of the device according to the invention.

Fig. 2: A schematic presentation of a second example embodiment of the device according to the invention (optical correlation).

Figs. 3A through 3C: Schematic presentations of example embodiments of patterns according to the invention.

Fig. 4: A schematic presentation of a first example embodiment of a flat scan tip with large scan length, using a plurality of (dichroic) mirrors and light sources.

Fig. 5: A schematic presentation of a third example embodiment of a flat scan tip with a large scan length, using a curved mirror.

Fig. 6: A schematic presentation of a fourth example embodiment of a flat scan tip with large scan length, using a diffractive grating.

Fig. 7: A schematic presentation of an example embodiment of a mass-balanced focus lens scanner.

Fig. 8: A schematic presentation of an example embodiment of a device for simultaneous scanning of a surface shape and color.

Fig. 9: A schematic presentation of an example embodiment of a device for scanning the at least a part of the external part of the human ear and/or a part of the ear canal of a human ear.

Figs. 10A and 10B: Schematics showing how a scanner embodiment can be used to both scan the outer and inner ear, respectively.

Fig. 11: Schematic of a scanner probe embodiment used to scan a narrow body cavity, such as a human ear.

Figs. 12A through 12D: Examples of mirror configurations to be used with a scanner probe.

Fig. 13: A schematic representation of the reference signal values / weight values per pixel for a checkerboard pattern in an idealized optical system.

Figs. 14A through 14E: Illustration of the process of generating a fused reference signal, visualized as images.

Fig. 15: Top: Example image with projected pattern showing on a human tooth. Bottom: The correlation measure for the series of focus lens positions at the group of pixels framed in the top part of the figure.

Fig. 16: Example fused correlation measure image of an intraoral scene.

Fig. 17: Example of a handheld intraoral scanner with a pistol-like grip and a removable tip.

It will be understood that the ray traces and lenses depicted in the figures are for purpose of illustration only, and depict optical paths generally in the discussed systems. The ray traces and lens shapes should not be understood to limit the scope of the invention in any sense including the magnitude, direction, or focus of light rays or bundles passing through various optical components, notwithstanding any variations in

number, direction, shape, position or size thereof, except as expressly indicated in the following detailed description of the exemplary embodiments illustrated in the drawings.

Detailed description of the drawings

A functional hand held 3D surface scanner should preferably have the following properties:

- 1) Telecentricity in the space of the object being scanned,
- 2) possibility to shift the focal plane while maintaining telecentricity and magnification
- 3) simple focusing scheme that involves tuning of optical components only in the handle of the device and not in the probe tip, and
- 4) a total size consistent with a hand held scanning device.

The scanner embodiment illustrated in Fig. 1 is a hand-held scanner with all components inside the housing (head) **100**. The scanner head comprises a tip which can be entered into a cavity, a light source **110**, optics **120** to collect the light from the light source, pattern generation means **130**, a beam splitter **140**, an image sensor and electronics **180**, a lens system which transmits and images the light between the pattern, the object being scanned, and the image sensor (camera) **180**. The light from the light source **110** travels back and forth through the optical system **150**. During this passage the optical system images the pattern **130** onto the object being scanned **200** and further images the object being scanned onto the image sensor **181**. The lens system includes a focusing element **151** which can be adjusted to shift the focal imaging plane of the pattern on the probed object **200**. One way to embody the focusing element is to physically move a single lens element back and forth along the optical axis. The device may include polarization optics **160**. The device may include folding optics **170** which directs the light out of the device in a direction different to the optical axis of the lens system, e.g. in a direction perpendicular to the optical axis of the lens system. As a whole, the optical system provides an imaging of the pattern onto the object being probed and from the object being probed to the camera. One application of the device could be for determining the 3D structure of teeth in the oral cavity. Another application could be for determining the 3D shape of the ear canal and the external part of the ear.

The optical axis in Fig. 1 is the axis defined by a straight line through the light source **110**, optics **120** and the lenses in the optical system **150**. This also corresponds to the longitudinal axis of the scanner illustrated in Fig. 1. The optical path is the path of the light from the light source **110** to the object **220** and back to the camera **180**. The optical path may change direction, e.g. by means of beam splitter **140** and folding optics **170**.

The focus element is adjusted in such a way that the image of the pattern on the scanned object is shifted along the optical axis, preferably in equal steps from one end of the scanning region to the other. When the pattern is varied in time in a periodic fashion for a fixed focus position then the in-focus regions on the object will display an spatially varying pattern. The out-of-focus regions will display smaller or no contrast in the light variation. The 3D surface structure of the probed object is determined by finding the plane corresponding to an extremum in the correlation measure for each sensor in the camera's sensor array or each group of sensor in the camera's sensor array when recording the correlation measure for a range of different focus positions **300**. Preferably one would move the focus position in equal steps from one end of the scanning region to the other.

Pattern generation

An embodiment of the pattern generation means is shown in Fig. 3a: A transparent wheel with an opaque mask **133** in the form of spokes pointing radially from the wheel center. In this embodiment the pattern is time-varied by rotating the wheel with a motor **131** connected to the wheel with e.g. a drive shaft **132**. The position of the pattern in time may be registered during rotation. This can be achieved by e.g. using a position encoder on the rim of the pattern **134** or obtaining the shaft position directly from motor **131**.

Fig. 3b illustrates another embodiment of the pattern generation means: A segmented light source **135**, preferably a segmented LED. In this embodiment the LED surface is imaged onto the object under investigation. The individual LED segments **136** are turned on and off in a fashion to provide a known time-varying pattern on the object. The control electronics **137** of the time varying pattern is connected to the segmented light source via electrical wires **138**. The pattern is thus integrated into the light source and a separate light source is not necessary.

Fig. 3c illustrates a static pattern as applied in a spatial correlation embodiment of this invention. The checkerboard pattern shown is preferred because calculations for this regular pattern are easiest.

Temporal correlation

Fig. 1 is also an exemplary illustration of the temporal correlation wherein an image of the pattern on and/or in the object is formed on the camera. Each individual light sensing element in the camera sees a variation in the signal level corresponding to the variation of the illumination pattern on the object. The variation is periodic in the exemplary illustration. The light variation for each individual light sensing element will have a constant phase offset relative to the pattern position..

The correlation measure may be obtained by recording n images on the camera during at least one oscillation period. n is an integer number greater than one. The registration of the pattern position for each individual image combined with the phase offset values for each sensing element and the recorded images allows for an efficient extraction of the correlation measure in each individual sensing element in the camera using the following formula,

$$A_j = \sum_{i=1}^n f_{i,j} I_{i,j}$$

Here A_j is the estimated correlation measure of sensing element j , $I_{1,j}, \dots, I_{n,j}$ are the n recorded signals from sensing element j , $f_{1,j}, \dots, f_{n,j}$ are the n reference signal values obtained from the knowledge of the pattern configuration for each image recording. f has two indices i,j . The variation of f with the first index is derived from the knowledge of the pattern position during each image recording. The variation of f with the second index is derived from the knowledge of the pattern geometry which may be determined prior to the 3D scanning.

The focus position corresponding to the pattern being in focus on the object for a single sensor in the camera will be given by an extremum in the recorded correlation measure of that sensor when the focus position is varied over a range of values, preferably in equal steps from one end of the scanning region to the other.

Spatial correlation

In an example of the spatial correlation scheme, one image of the object with projected checkerboard pattern is recorded with as high resolution as allowed by the image sensor. The scheme in the spatial correlation is then to analyze groups of pixels in the recorded image and extract the correlation measure in the pattern. An extremum in the obtained correlation measures indicates the in-focus position. For simplicity, one can use a checkerboard pattern with a period corresponding to $n = N \times N$ pixels on the sensor and then analyze the correlation measure within one period of the pattern (in the general case the pattern need not be quadratic $N \times N$). In the best case, it will be possible to align the pattern so that the checkerboard edges coincide with the pixel edges but the scanning principle does not rely upon this. Fig. 16 shows this for the case $n = 4 \times 4 = 16$. For a sensor with $W \times H = 1024 \times 512$ pixels, this would correspond to obtaining 256×128 correlation measure points from one image. Extraction of the correlation measure A_j within an $N \times N$ group of pixels with label j is given by

$$A_j = \sum_{i=1}^n f_{i,j} I_{i,j}$$

where $f_j = (f_{1,j}, \dots, f_{n,j})$ is the reference signal vector obtained from knowledge of the pattern configuration, and $I_j = (I_{1,j}, \dots, I_{n,j})$ is input signal vector.

To suppress any DC part in the light we prefer that for all j that

$$0 = \sum_{i=1}^n f_{i,j}$$

For the situation depicted in Fig. 16 for instance, $f_{i,j} = -1$ for the pixels corresponding to the dark parts of the pattern, and $f_{i,j} = +1$ otherwise. If the pattern edge was not aligned with the edges of the pixels, or if the optical system was not perfect (and thus in all practical applications), then $f_{i,j}$ would assume values between -1 and +1 for some i . A detailed description of how to determine the reference function is given later.

Optical correlation

An example of the optical correlation shown in Fig. 2. In this embodiment an image is formed on the camera **180** which is a superposition of the pattern **130** with the probed object **200**. In this embodiment the pattern is of a transmissive nature where light is transmitted through the pattern and the image of the pattern is projected onto the object and back again. In particular this involves retransmission of the light through the

pattern in the opposite direction. An image of the pattern onto the camera is then formed with the aid of a beam splitter **140**. The result of this arrangement is an image being formed on the camera which is a superposition of the pattern itself and the object being probed. A different way of expressing this is that the image on the camera is substantially a multiplication of an image of the pattern projected onto the object with the pattern itself.

The variation is periodic in the exemplary illustration. The correlation measure between the light variation on the object and the pattern for a given focus distance may be obtained by time integrating the camera signal over a large number of oscillation periods so that exact synchronization of pattern oscillation time and camera integration time is not important. The focus position corresponding to the pattern being in focus on the object for a single sensor in the camera will be given by the maximum recorded signal value of that sensor when the focus position is varied over a range of values, preferably in equal steps from one end of the scanning region to the other.

Finding the predetermined reference function

In the following, the process for computing the reference signal f is described for a spatial correlation embodiment of this invention, and depicted in a stylized way in Figs. 14A - 14E.

The process starts by recording a series of images of the checkerboard pattern as projected, e.g., on a flat surface, preferably oriented orthogonally to the optical axis of the scanner. The images are taken at different positions of the focusing element, in effect covering the entire travel range of said focus element. Preferably, the images are taken at equidistant locations.

As the focus plane generally is not a geometrical plane, different regions of the flat surface will be in focus in different images. Examples of three such images are shown in Figs. 14A – 14C, where **1700** is an in-focus region. Note that in this stylized figure, transitions between regions in and out of focus, respectively, are exaggerated in order to demonstrate the principle more clearly. Also, in general there will be many more images than just the three used in this simple example.

In-focus regions within an image are found as those of maximum intensity variance (indicating maximum contrast) over the entire said series of images. The region to compute variance over need not be the same as the pixel group dimension used in spatial correlation, but should be large enough to contain the both dark and light regions of the pattern, and it must be the same for all images in the series.

Finally, a “fused image” (Fig. 14D) is generated by combining all the in-focus regions of the series (Figs. 14A – 14C). Note that in real applications, the fused image will generally not be a perfect checkerboard of black and white, but rather include intermediate gray values as caused by an imperfect optical system and a checkerboard that is not perfectly aligned with the camera sensors. An example of part of a real fused image is shown in Fig. 14E.

The pixel intensities within this image can be interpreted as a “weight image” with same dimensions as the original image of the pattern. In other words, the pixel values can be interpreted as the reference signal and the reference vector / set of weight values $\mathbf{f}_j = (f_{1,j}, \dots, f_{n,j})$ for the n pixels in the pixel group with index j can be found from the pixel values.

For convenience in the implementation of the calculations, especially when carried out on an FPGA, the fused image can be sub-divided into pixel groups. The DC part of the signal can then be removed by subtracting the within-group intensity mean from each pixel intensity value. Furthermore, one can then normalize by dividing by the within-group standard deviation. The thus processed weight values are an alternative description of the reference signal.

Because of the periodic nature of the “fused image” and thus the “weight image”, the latter can be compressed efficiently, thus minimizing memory requirements in the electronics that can implement the algorithm described here. For example, the PNG algorithm can be used for compression.

The “correlation image”

A “correlation” image is generated based on the “fused image” and the set of images recorded with the camera during a scan. For spatial correlation based on an $N \times N$ checkerboard pattern, recall that within-group correlation measure is

$$A_j = \sum_{i=1}^{N \times N} f_{i,j} I_{i,j},$$

where $f_j = (f_{1,j}, \dots, f_{n,j})$ are values from the fused image, and $I_j = (I_{1,j}, \dots, I_{n,j})$ are values from a recorded image on the camera. The pixel groupings used in any DC removal and possibly normalization that yielded the fused image are the same as in the above calculation. For each image recorded by the scanner during a sweep of the focusing element, there will thus be an array of $(H/N) \times (W/N)$ values of A . This array can be visualized as an image.

Fig. 15 (top section) shows one example correlation measure image, here of part of a human tooth and its edge. A pixel group of 6x6 pixels is marked by a square **1801**. For this example pixel group, the series of correlation measures A over all images within a sweep of the focusing element is shown in the chart in the bottom section of Fig. 15 (cross hairs). The x-axis on the chart is the position of the focusing element, while the y-axis shows the magnitude of A . Running a simple Gaussian filter over the raw series results in a smoothed series (solid line). In the figure the focus element is in the position that gives optimal focus for the example group of pixels. This fact is both subjectively visible in the picture, but also determined quantitatively as the maximum of the series of A . The vertical line **1802** in the bottom section of Fig. 15 indicates the location of the global extremum and thus the in-focus position. Note that in this example, the location of the maxima in the smoothed and the raw series, respectively, are visually indistinguishable. In principle, however, it is possible and also advantageous to find the maximum location from the smoothed series, as that can be between two lens positions and thus provide higher accuracy.

The array of values of A can be computed for every image recorded in a sweep of the focus element. Combining the global extrema (over all images) of A in all pixel groups in the same manner the fused image was combined, one can obtain a pseudo-image of dimension $(H/N) \times (W/N)$. This we call the "fused correlation image". An example of a fused correlation image of some teeth and gingiva is shown in Fig. 16. As can be seen, it is useful for visualization purposes.

Increasing field of view

For the scan head to be entered into a small space such as the oral cavity of a patient it is necessary that the tip of the scan head is sufficiently small. At the same time the light out of the scan head need to leave the scan head in a direction different from the optical axis, e.g. at a direction perpendicular to the optical axis. In one embodiment of the invention a 45 degree mirror is used as folding optics **170** direct the light path onto the object. In this embodiment the height of the scan tip need to be at least as large as the scan length.

Another embodiment of the invention is shown in Fig. 4. This embodiment of the invention allows for a scan tip with a smaller height (denoted b in the figure) than the scan length (denoted a in the figure). The light from two sources **110** and **111** emitting light of different colors/wavelengths is merged together using a suitably coated plate (e.g. a dichroic filter) **112** that transmit the light from **110** and reflects the light from **111**. At the scan tip a suitably coated plate (e.g. a dichroic filter) **171** reflects the light from one source onto the object and transmits the light from the other source to a mirror at the end of the scan tip **172**. During scanning the focus position is moved such that the light from **110** is used to project an image of the pattern to a position below **171** while **111** is switched off. The 3D surface of the object in the region below **171** is recorded. Then **110** is switched off and **111** is switched on and the focus position is moved such that the light from **111** is used to project an image of the pattern to a position below **172**. The 3D surface of the object in the region below **172** is recorded. The region covered with the light from **110** and **111** respectively may partially overlap.

Another embodiment of the invention that allows for a scan tip with a smaller height (denoted b in the figure) than the scan length (denoted a in the figure) is shown in Fig. 5. In this embodiment the fold optics **170** comprises a curved fold mirror **173** that may be supplemented with one or two lens elements **175** and **176** with surfaces that may be aspherical to provide corrected optical imaging.

Another embodiment of the invention that allows for a scan tip with a smaller height (denoted b in the figure) than the scan length (denoted a in the figure) is shown in Fig. 6. In this embodiment the fold optics **170** comprises a grating **177** that provides anamorphic magnification so that the image of the pattern on the object being scanned is stretched. The grating may be blazed. The light source **110** needs to be monochromatic or semi-monochromatic in this embodiment.

Achieving high spatial contrast of pattern projected onto difficult objects

High spatial contrast of the in-focus pattern image on the object is necessary to obtain a high correlation measure signal based on the camera pictures. This in turn is necessary to obtain a good estimation of the focus position corresponding to the position of an extremum of the correlation measure. This necessary condition for successful scanning is easily achieved in objects with a diffuse surface and negligible light penetration. For some objects, however, it is difficult to achieve high spatial contrast, or more generally variation.

A difficult kind of object, for instance, is an object displaying multiple scattering with a light diffusion length large compared to the smallest feature size of the spatial pattern imaged onto the object. A human tooth is an example of such an object. The human ear and ear canal are other examples. Improved spatial variation in such objects can be achieved by preferential imaging of the specular surface reflection from the object on the camera. An embodiment of the invention applies polarization engineering shown in Fig. 1. In this embodiment the beam splitter **140** is a polarizing beam splitter that transmits respectively reflects two orthogonal polarization states, e.g. S- and P-polarization states. The light transmitted through the lens system **150** is thus of a specific polarization state. Before leaving the device the polarization state is changed with a retardation plate **160**. A preferred type of retardation plate is a quarter wave retardation plate. A linearly polarized light wave is transformed into a circularly polarized light wave upon passage of a quarter wave plate with an orientation 45 degrees of its fast axis to the linear polarization direction. A specular reflection from the object has the property that it flips the helicity of a circularly polarized light wave. Upon passage of the quarter wave retardation plate by the specularly reflected light the polarization state becomes orthogonal to the state incident on the object. For instance an S-polarization state propagating in the downstream direction toward the object will be returned as a P-polarization state. This implies that the specularly reflected light wave will be directed towards the image sensor **181** in the beam splitter **140**. Light that enters into the object and is reflected by one or more scattering events becomes depolarized and one half of this light will be directed towards the image sensor **181** by the beam splitter **140**.

Another kind of difficult object is an object with a shiny or metallic-looking surface. This is particularly true for a polished object or an object with a very smooth surface. A piece of jewelry is an example of such an object. Even very smooth and shiny objects, however, do display an amount of diffuse reflection. Improved spatial contrast in such objects can be achieved by preferential imaging of the diffuse surface reflection from the object on the camera. In this embodiment the beam splitter **140** is a polarizing beam splitter that transmits respectively reflects two orthogonal polarization states, e.g. S- and P-polarization states. The light transmitted through the lens system **150** is thus of a specific polarization state. A diffuse reflection from the object has the property that it loses its polarization. This implies that half of the diffusely reflected light wave will be directed towards the image sensor **181** in the beam splitter **140**. Light that enters into the object and is reflected by specular polarization preserves its polarization state and thus none of it will be directed towards the image sensor **181** by the beam splitter **140**.

Reducing shaking caused by focus element

During scanning the focus position is changed over a range of values, preferably provided by a focusing element **151** in the optical system **150**. Fig. 7 illustrates an example of how to reduce shaking caused by the oscillating focus element. The focusing element is a lens element **152** that is mounted on a translation stage **153** and translated back and forth along the optical axis of said optical system with a mechanical mechanism **154** that includes a motor **155**. During scanning the center of mass of the handheld device is shifted due to the physical movement of the lens element and holder. This results in an undesirable shaking of the handheld device during scanning. The situation is aggravated if the scan is fast, e.g. a scan time of less than one second. In one implementation of the invention the shifting of the center of mass is eliminated by moving a counter-weight **156** in a direction opposite to the lens element in such a way that the center of mass of the handheld device remains fixed. In the preferred implementation the focus lens and the counter-weight are mechanically connected and their opposite movement is driven by the same motor.

Color measurement

An embodiment of a color 3D scanner is shown in Fig. 8. Three light sources **110**, **111**, and **113** emit red, green, and blue light. The light sources are may be LEDs or lasers. The light is merged together to overlap or essentially overlap. This may be achieved by means of two appropriately coated plates **112** and **114**. Plate **112** transmits the light

from **110** and reflects the light from **111**. Plate **114** transmits the light from **110** and **111** and reflects the light from **113**. The color measurement is performed as follows: For a given focus position the amplitude of the time-varying pattern projected onto the probed object is determined for each sensor element in the sensor **181** by one of the above mentioned methods for each of the light sources individually. In the preferred embodiment only one light source is switched on at the time, and the light sources are switched on after turn. In this embodiment the optical system **150** may be achromatic. After determining the amplitude for each light source the focus position is shifted to the next position and the process is repeated. The color expressed as e.g. an RGB color coordinate of each surface element can be reconstructed by appropriate weighting of the amplitude signal for each color corresponding the maximum amplitude.

One specific embodiment of the invention only registers the amplitude for all colors at an interval of P focus positions; while one color is selected for determination of the amplitude at all focus positions. P is a number which could be e.g. 3, 5, or 10. This results in a color resolution which is less than the resolution of the surface topology. Color of each surface element of the probed object is determined by interpolation between the focus positions where full color information is obtained. This is in analogy to the Bayer color scheme used in many color digital cameras. In this scheme the color resolution is also less than the spatial resolution and color information need to be interpolated.

A simpler embodiment of the 3D color scanner does not register full color information and employs only two light sources with different colors. An example of this is a dental scanner that uses red and blue light to distinguish hard (tooth) tissue from soft (gum) tissue.

Ear scanner embodiment

Figs. 9 - 12 schematically illustrate an embodiment of a time-varying structured light illumination-based scanner for direct scanning of human ears by scanning both the exterior (outer) and interior (inner) part of a human ear by use of a common scanner exterior handle and a detachable probe. This embodiment is advantageous in that it allows for non-intrusive scanning using a probe designed to be inserted into small cavities, such as a human ear. This is done in part by positioning the bulky and

essential parts of the scanner, such as the scanner camera, light source, electronics and focusing optics outside the closely confined part of the ear canal.

The ability to scan the outer and inner part of human ears and make a virtual or real model of the ear is essential in the design of modern custom-fitted hearing aid (e.g. ear shell or mold). Today, scanning of ears is performed in a two-step process where a silicone impression of the ear is taken first and the impression is subsequently scanned using an external scanner in a second step. The process of making the impression suffers from several drawbacks which will shortly be described in the following. One major drawback comes from frequent poor quality impressions taken by qualified clinic professionals due to the preparation and techniques required. Inaccuracies may arise because the impression material is known to expand during hardening and that deformation and creation of fractures in the impression are often created when the impression is removed from the ear. Another drawback is related to health risks involved with taking the impression due to irritation and allergic responses, damage to the tympanic membrane and infections. Finally, the impression process is an uncomfortable experience for many patients, especially for young children, who often require impressions taken at regular intervals (e.g. every four months) to accommodate the changing dimensions of the ear canal. In short, these drawbacks can be overcome if it is possible to scan the outer and inner ear in a non-intrusive way and obtain a registration between the inner and outer ear surfaces.

The following is not restricted to ear scanning but can be used to scan any small bodily cavity. Fig. 9 is a schematic of an embodiment of such a scanner. The scanner consists of two main parts – a scanner exterior **1001** and a scanner probe **1002**. The scanner exterior may be used without the probe to obtain a larger field-of-view needed e.g. to scan the exterior part of the ear **1102**, or the first part of the ear canal up to the first bend. The large field-of-view of the scanner exterior is important to obtain good registration between individual sub-scans and high global accuracy. By attaching a scanner probe **1002** to the scanner exterior **1001**, the combined scanner allows for scanning of small and bent cavity surfaces, such as the interior part of an ear **1203**. In this way and using the same system, the combined scanner exterior and probe are able to both scan larger external areas along with smaller internal areas.

In Fig. 9 the exterior part of the scanner embodiment **1001** consists of a diverging light source **1003** (laser, LED, Tungsten or another type) which is collimated using collimation optics **1004**. The collimated light is used to illuminate a transparent object **1005** (e.g. glass) with an opaque pattern, e.g. fringes on it. The pattern is subsequently imaged onto the object to be scanned using a suitable optical system. The pattern is observed using a similar optical system and a camera **1006**, where the latter is positioned outside the cavity. The 3D information is obtained from the 2D images by observing the light oscillation created by the movement of the pattern across the scan object as contained in the individual pixel amplitude.

To facilitate movement of the pattern, the fringe pattern **1005** is rotating in one embodiment. In another embodiment, the fringe pattern is positioned on a translating plate that moves in a plane perpendicular to the optical axis with a certain oscillation frequency. The light to and from the scan object is projected through a beam splitter arrangement **1007**, which consists of a prism cube in one embodiment and in another embodiment consists of an angled plate or membrane. The beam splitter serves to transmit the source light further down the system, while at the same time guide the reflected light from the scan object back to the camera, which is positioned on an axis perpendicular to the axis of the light source and beam splitter.

To move the focus plane the scanner exterior includes focusing optics, which in one embodiment consists of a single movable lens **1008**. The purpose of the focusing optics is to facilitate movement of the plane of focus for the whole imaging system in the required scanning range and along the optical axis. In one embodiment, the focusing optics of the scanner exterior **1101** includes an objective that can focus the light directly, without any use of additional optics, as shown in Fig. 10A. In another embodiment, the scanner exterior is supplied with a wide-angle objective designed with a large field-of-view, e.g. sufficiently large for scanning the exterior part of a human ear **1102**.

The optical part of the scanner probe consists of an endoscopic optical relay system **1009** followed by a probe objective **1010**, both of which are of sufficiently small diameter to fit into the canal of a human ear. These optical systems may consist of both a plurality of optical fibers and lenses and serve to transport and focus the light from the scanner exterior onto the scan object **1014** (e.g. the interior surface of an ear), as

well as to collimate and transport the reflected light from the scan object back to the scanner exterior. In one embodiment, the probe objective provides telecentric projection of the fringe pattern onto the scan object. Telecentric projection can significantly ease the data mapping of acquired 2D images to 3D images. In another embodiment, the chief rays (center ray of each ray bundle) from the probe objective are diverging (non-telecentric) to provide the camera with an angle-of-view larger than zero, as shown in Fig. 9.

The position of the focus plane is controlled by the focusing optics **1008** and can be moved in a range large enough to at least coincide with the scan surface **1014**. A single sub-scan is obtained by collecting a number of 2D images at different positions of the focus plane and at different positions of the fringe pattern, as previously described. As the focus plane coincides with the scan surface at a single pixel position, the fringe pattern will be projected onto the surface point in-focus and with high contrast, thereby giving rise to a large variation, or amplitude, of the pixel value over time. For each pixel it is thus possible to identify individual settings of the focusing optics for which each pixel will be in-focus. By using knowledge of the optical system, it is possible to transform the contrast information vs. position of the focus plane into 3D surface information, on an individual pixel basis.

In one embodiment, a mirror arrangement **1011**, consisting of a single reflective mirror, or prism, or an arrangement of mirrors, are located after the probe objective **1010**. This arrangement serves to reflect the rays to a viewing direction different from that of the of the probe axis. Different example mirror arrangements are found in Figs. 12A – 12D. In one particular embodiment, the angle between the mirror normal and the optical axis is approximately 45 degrees, thus providing a 90 degree view with respect to the probe axis - an arrangement ideal for looking round corners. A transparent window **1012** is positioned adjacent to the mirror and as part of the probe casing/shell, to allow the light to pass between the probe and the scan object, while keeping the optics clean from outside dirt particles.

To reduce the probe movement required by a scanner operator, the mirror arrangement may be rotated using a motor **1013**. In one embodiment, the mirror arrangement rotates with constant velocity. By full rotation of a single mirror, it is in this way possible to scan with 360 degree coverage around the probe axis without

physically moving the probe. In this case, the probe window **1012** is required to surround / go all around the probe to enable viewing in every angle. In another embodiment, the mirror rotates with a certain rotation oscillation frequency. In yet another embodiment, the mirror arrangement tilt with respect to the probe axis is varied with a certain oscillation frequency.

A particular embodiment uses a double mirror instead of a single mirror (Figs. 12B and 12D). In a special case, the normal of the two mirrors are angled approx. 90 degrees with respect to each other. The use of a double mirror helps registration of the individual sub-scans, since information of two opposite surfaces in this way is obtained at the same time. Another benefit of using a double mirror is that only 180 degrees of mirror rotation is required to scan a full 360 degrees. A scanner solution employing double mirrors may therefore provide 360 degrees coverage in less time than single mirror configurations.

“Pistol-like” grip

Fig. 17 shows an embodiment of the scanner with a pistol-like grip **2001**. This form is particularly ergonomic. The scanner in Fig. 17 is designed for intra-oral scanning of teeth. The tip **2002** can be removed from the main body of the scanner and can be autoclaved. Furthermore, the tip can have two positions relative to the main body of the scanner, namely looking down (as in Fig. 17) and looking up. Therefore, scanning the upper and the lower mouth of a patient is equally comfortable for the operator. Note that the scanner shown in Fig. 17 is an early prototype with several cables attached for testing purposes only.

Although some embodiments have been described and shown in detail, the invention is not restricted to them, but may also be embodied in other ways within the scope of the subject matter defined in the following claims. In particular, it is to be understood that other embodiments may be utilised and structural and functional modifications may be made without departing from the scope of the present invention.

In device claims enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims or described in different embodiments does not indicate that a combination of these measures cannot be used to advantage.

It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

The features of the method described above and in the following may be implemented in software and carried out on a data processing system or other processing means caused by the execution of computer-executable instructions. The instructions may be program code means loaded in a memory, such as a RAM, from a storage medium or from another computer via a computer network. Alternatively, the described features may be implemented by hardwired circuitry instead of software or in combination with software.

Claims

1. A scanner for determining the 3D geometry and color of at least a part of the surface of an object, said scanner comprising:

at least one camera accommodating an array of sensor elements,

a light source for generating a probe light,

an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object in a plurality of configurations and for transmitting at least a part of the light returned from the object to the at least one camera,

wherein the plurality of configurations is in the form of a time-varying illumination pattern, such that the 3D geometry is determined based on the time-varying illumination pattern, and

a hardware processor configured to:

selectively switch a color of the probe light, thereby illuminating the object with different colors at different times,

record different images by the at least one camera at the different times, thereby recording images of the object with the different colors, and

combine the different colors from the different images, thereby obtaining the color of the surface of the object.

Abstract

A scanner includes a camera, a light source for generating a probe light incorporating a spatial pattern, an optical system for transmitting the probe light towards the object and for transmitting at least a part of the light returned from the object to the camera, a focus element within the optical system for varying a position of a focus plane of the spatial pattern on the object, unit for obtaining at least one image from said array of sensor elements, unit for evaluating a correlation measure at each focus plane position between at least one image pixel and a weight function, a processor for determining the in-focus position(s) of each of a plurality of image pixels for a range of focus plane positions, or each of a plurality of groups of image pixels for a range of focus plane positions, and transforming in-focus data into 3D real world coordinates.

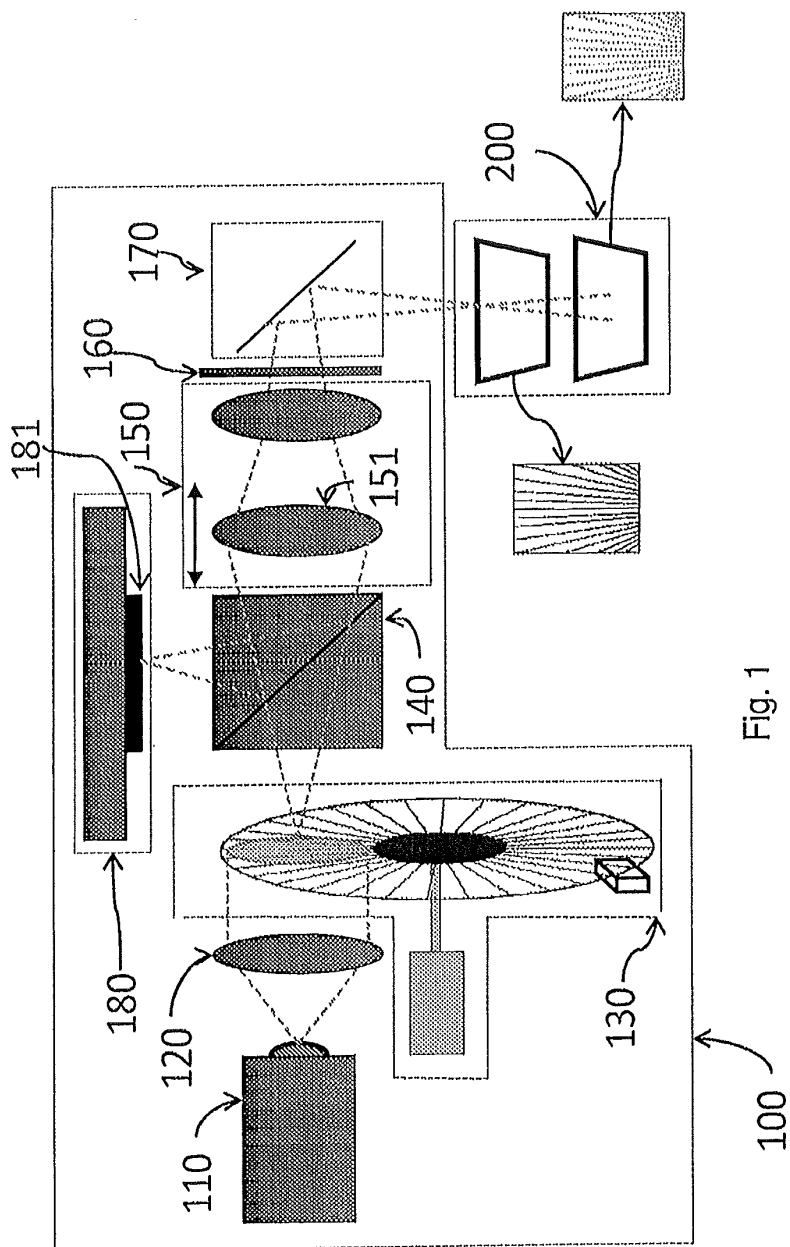


Fig. 1

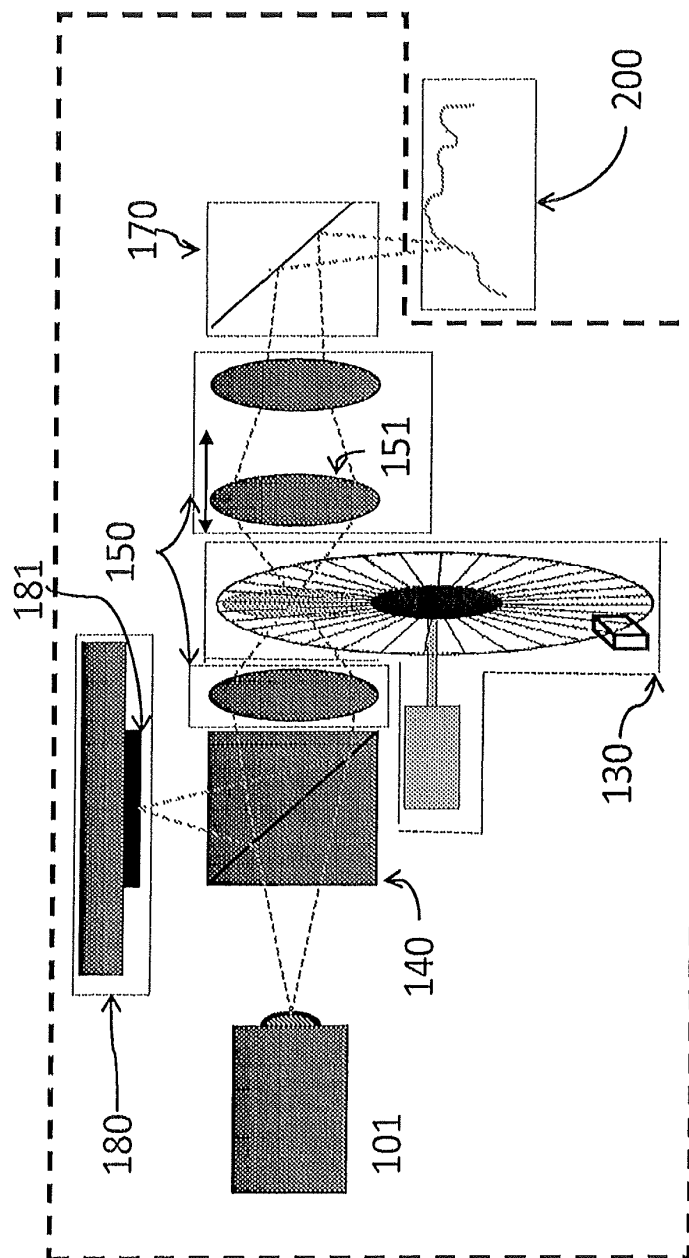


Fig. 2

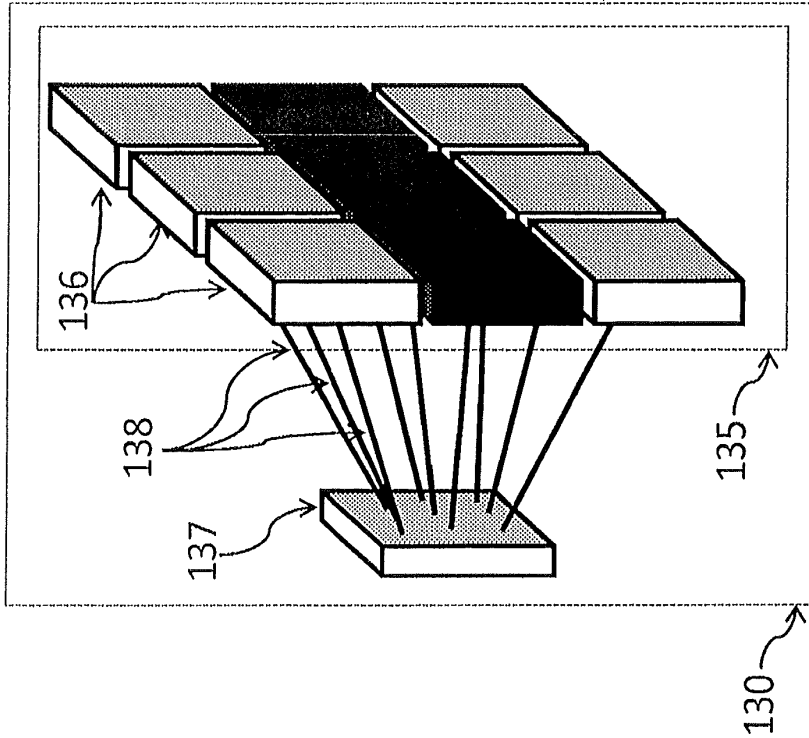


Fig. 3A

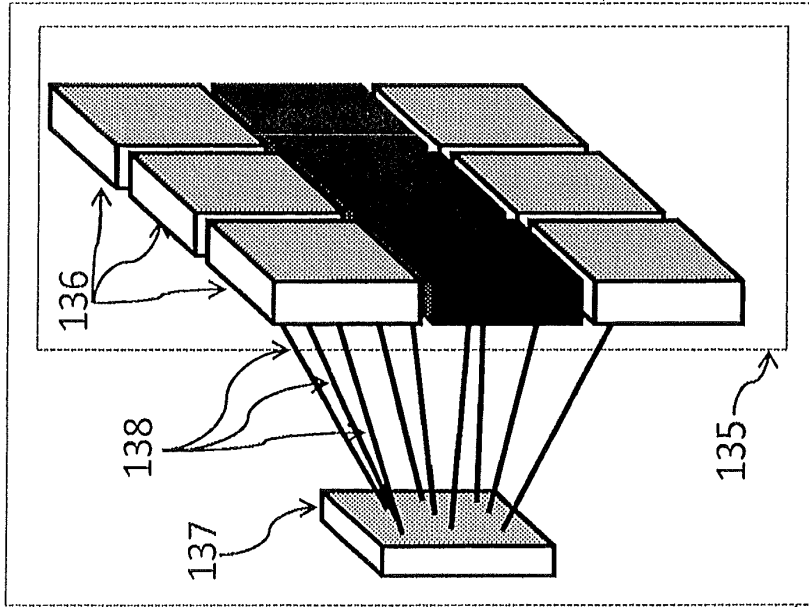


Fig. 3B

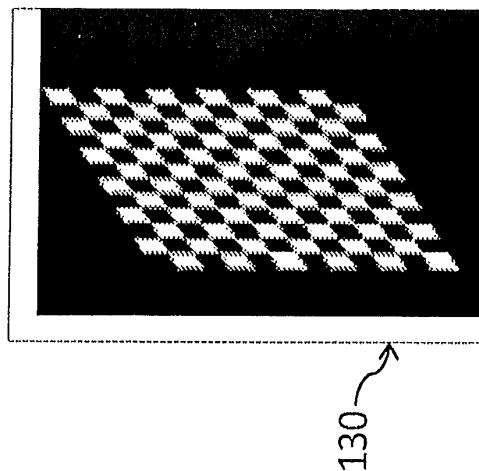


Fig. 3C

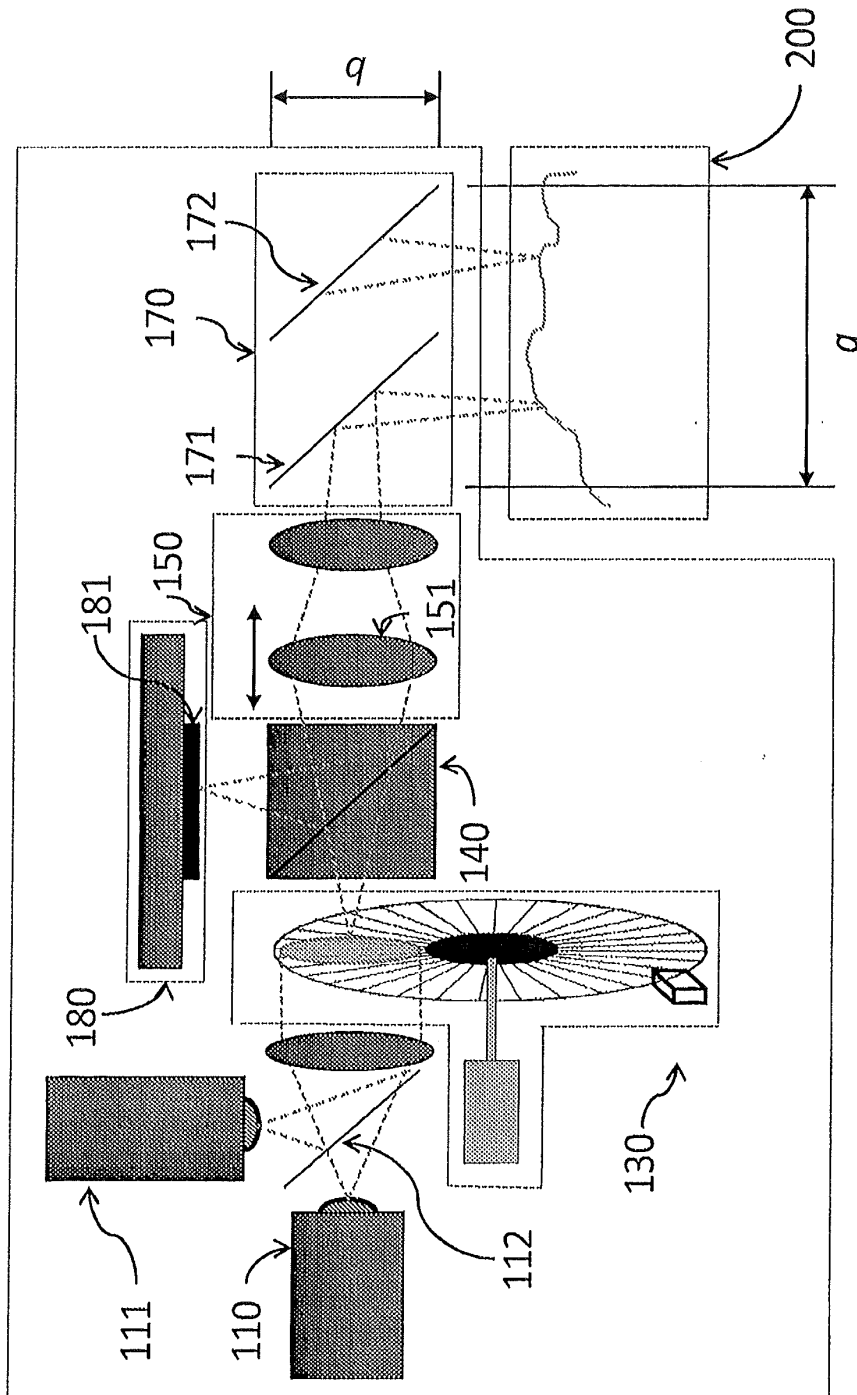


Fig. 4

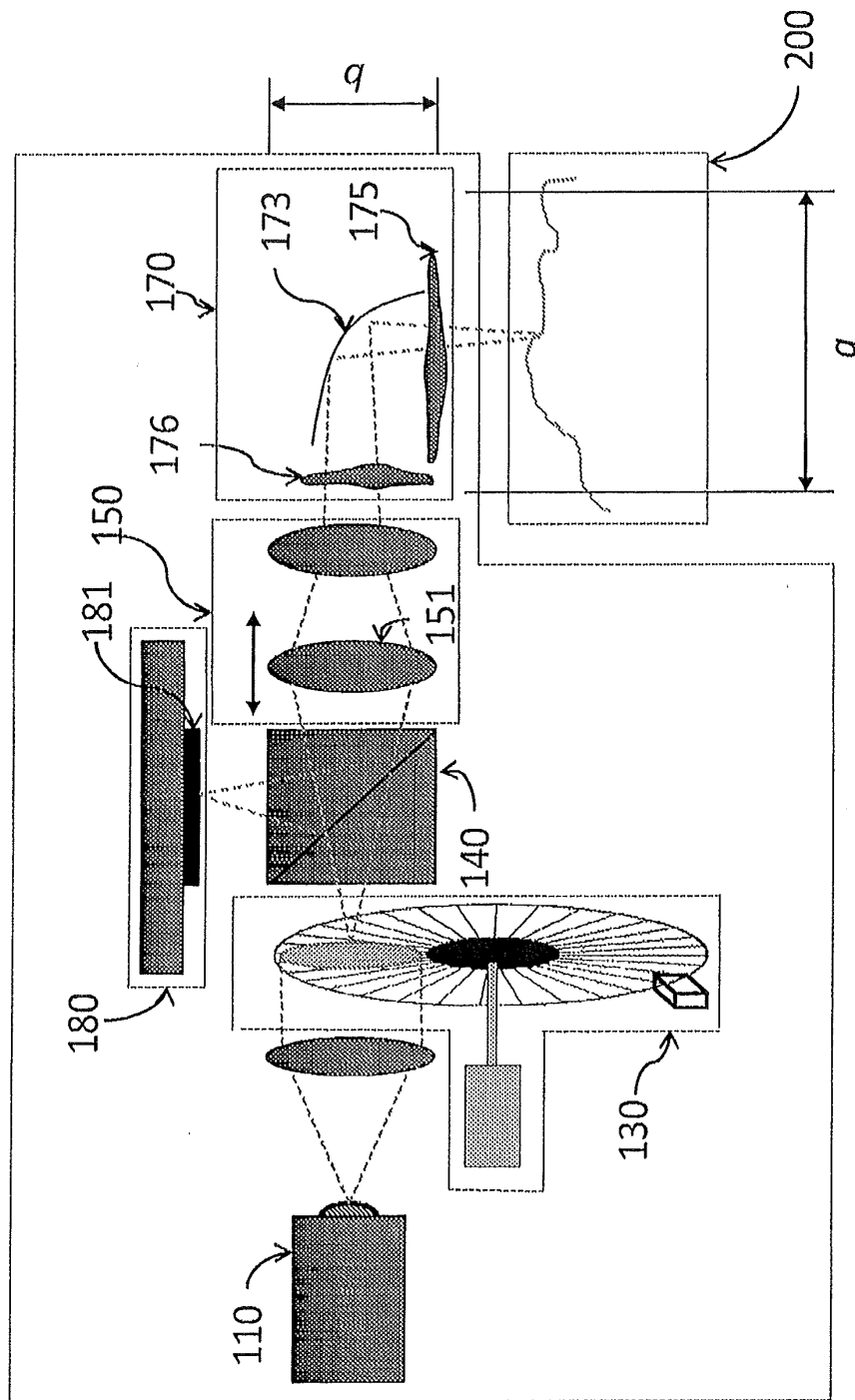


Fig. 5

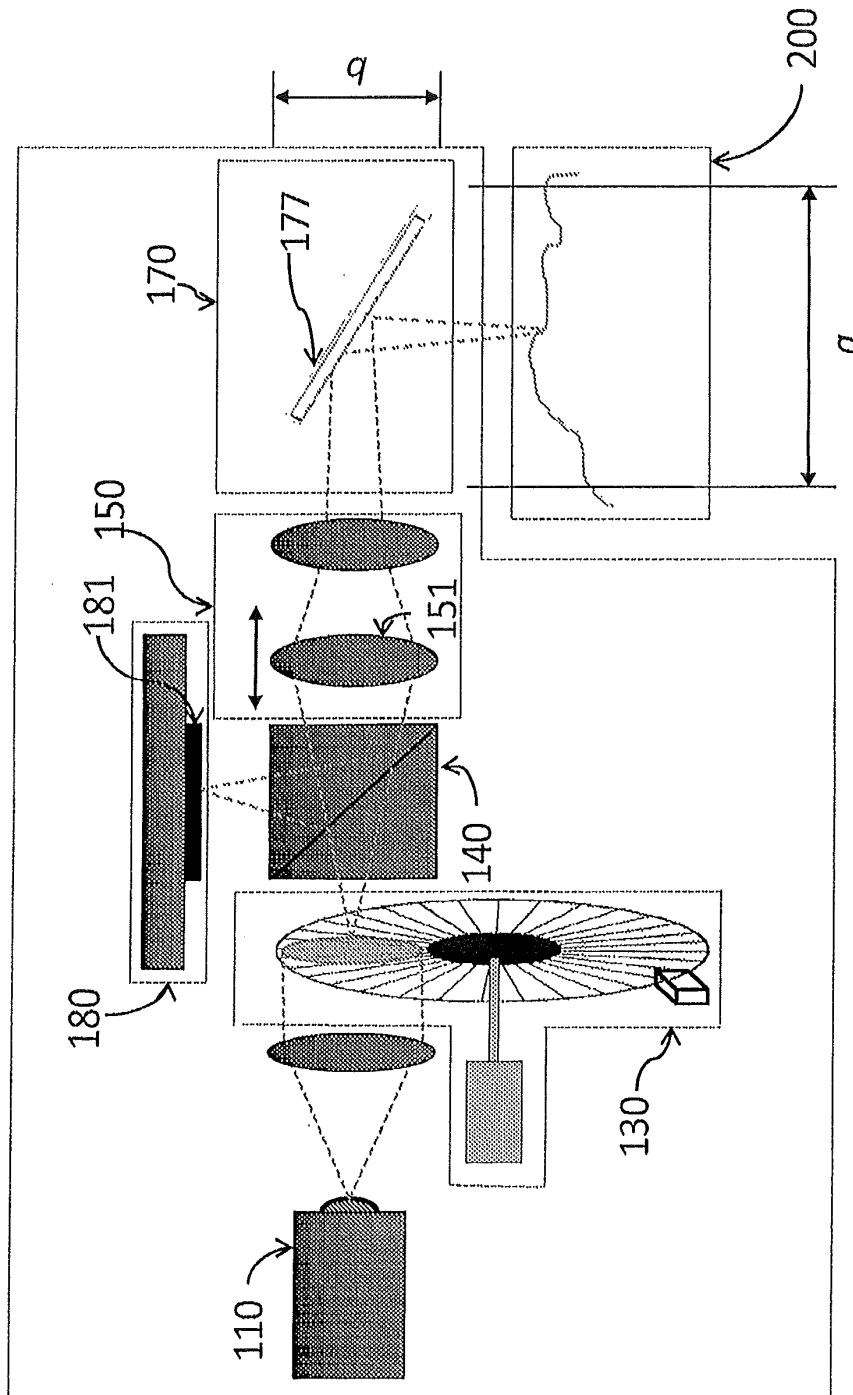


Fig. 6

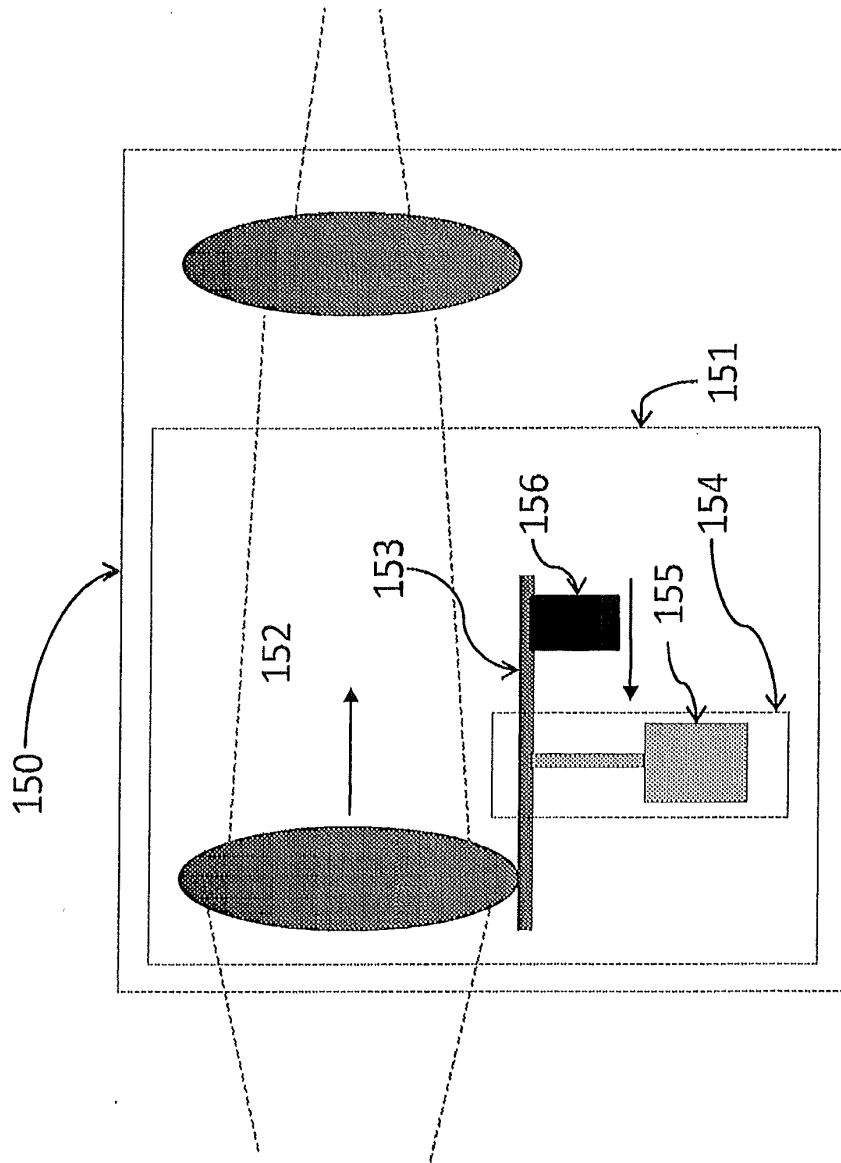


Fig. 7

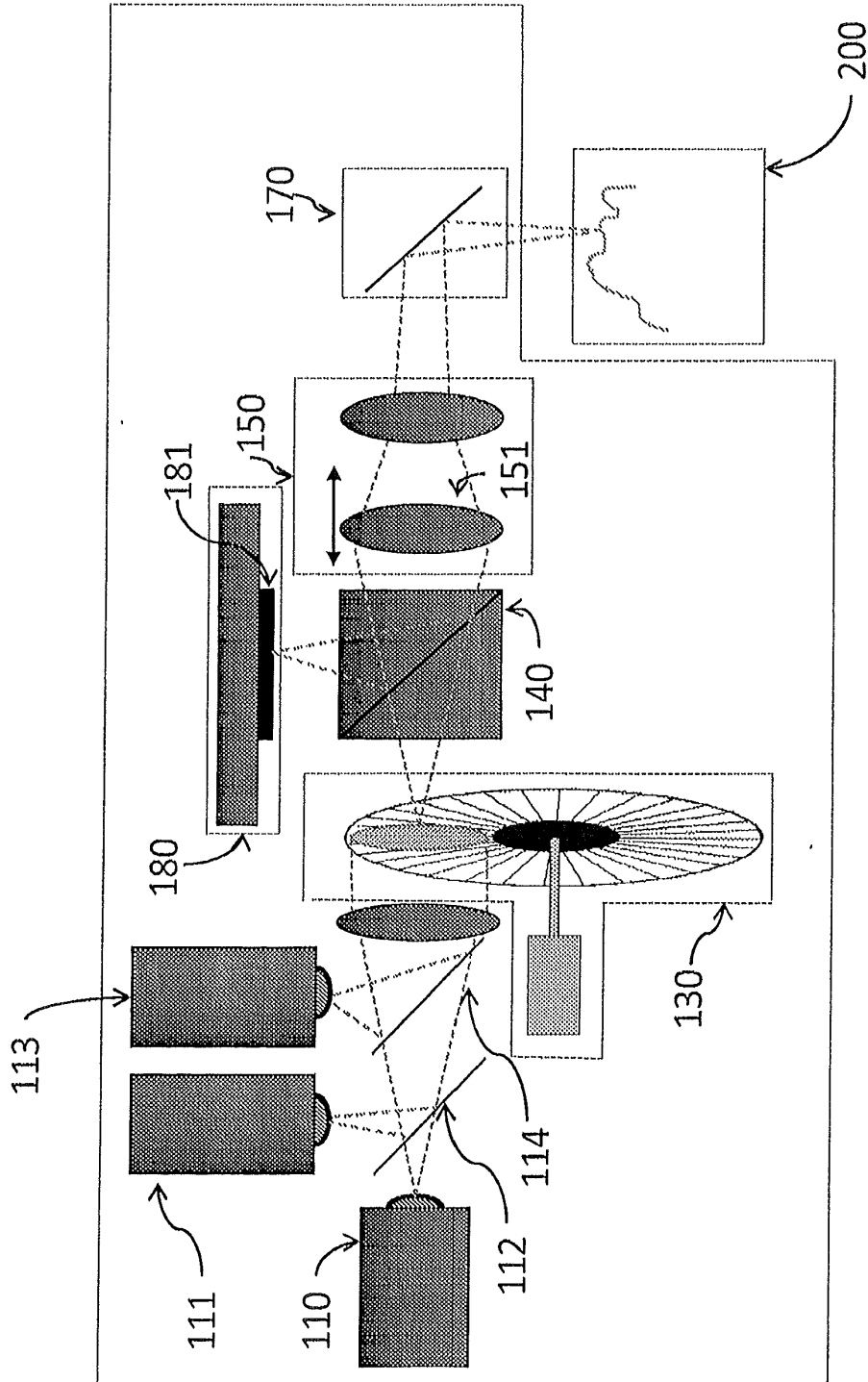


Fig. 8

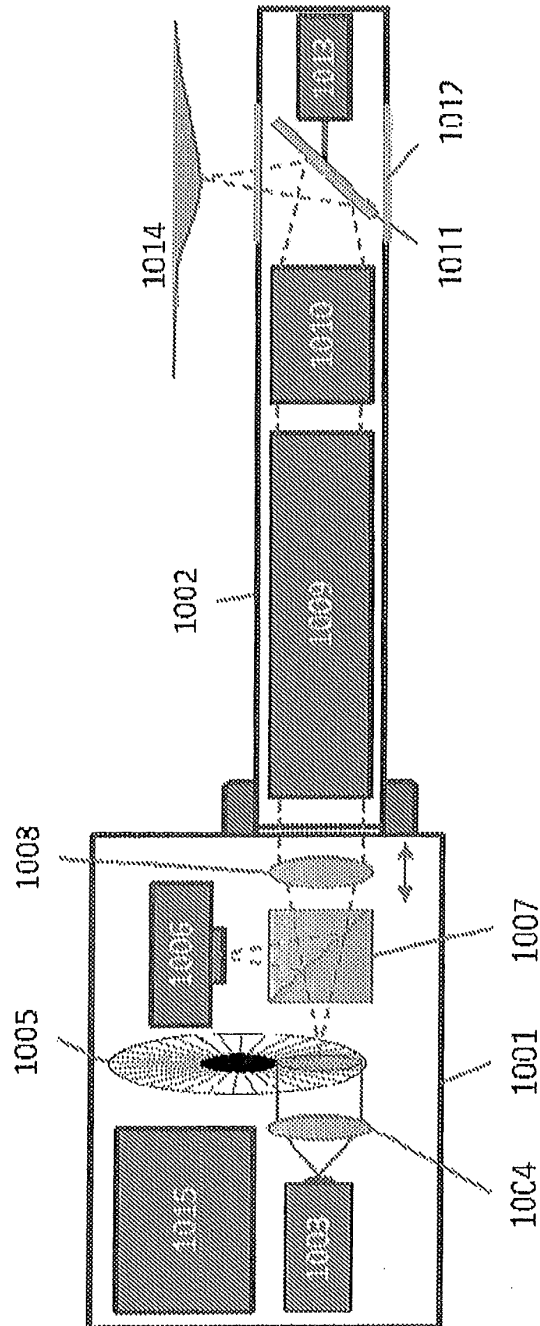


Fig. 9

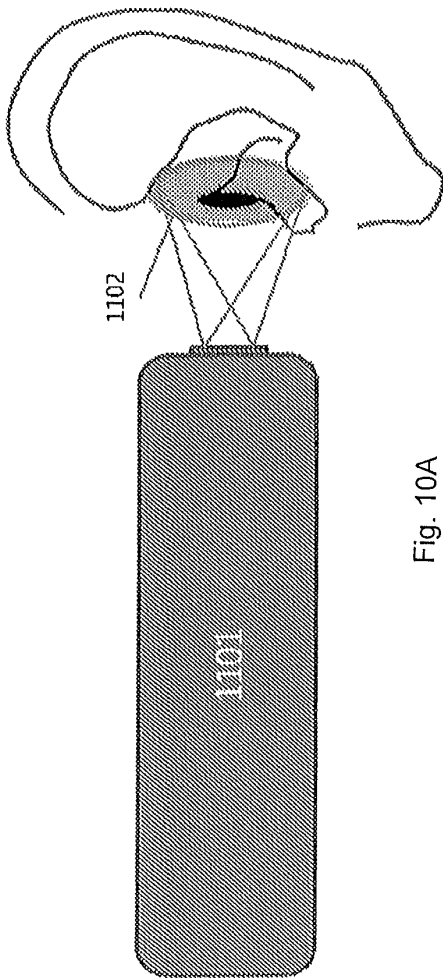


Fig. 10A

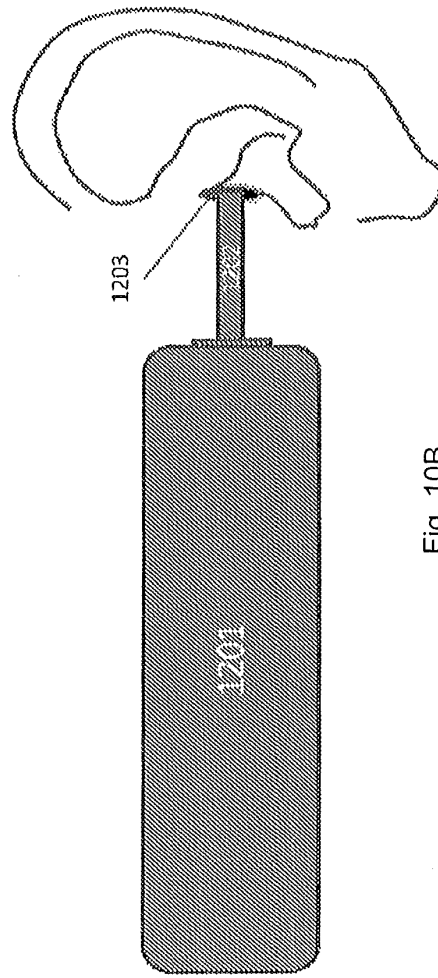


Fig. 10B

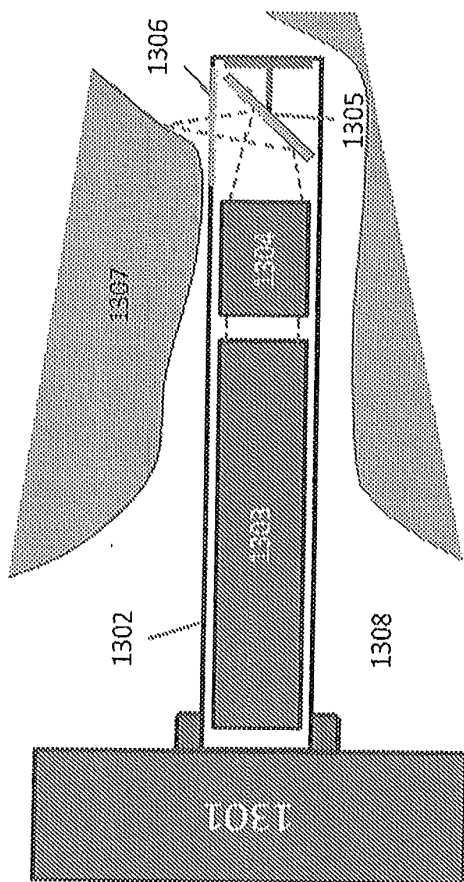


Fig. 11

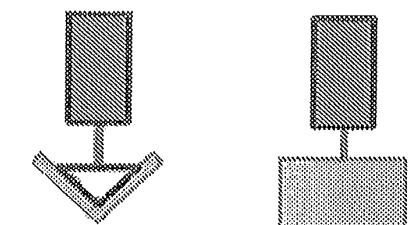


Fig. 12D

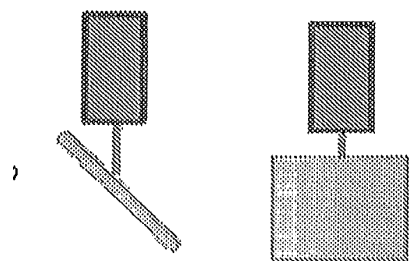


Fig. 12C



Fig. 12B



Fig. 12A

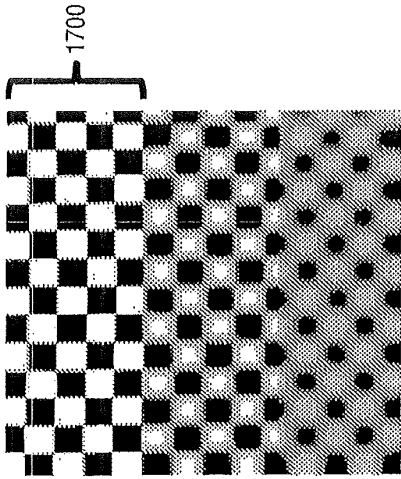


Fig. 14C

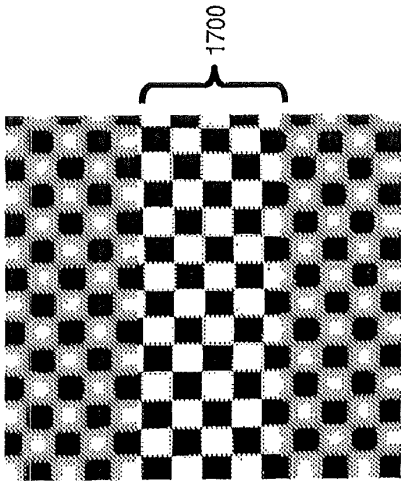


Fig. 14B

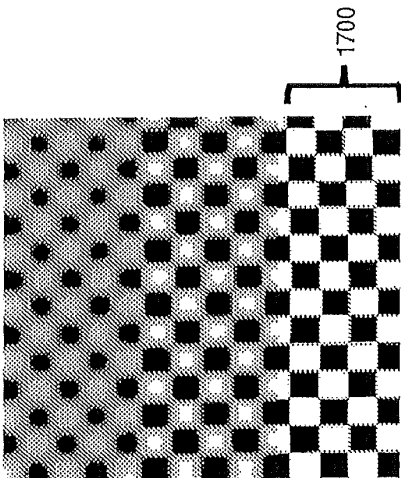


Fig. 14A

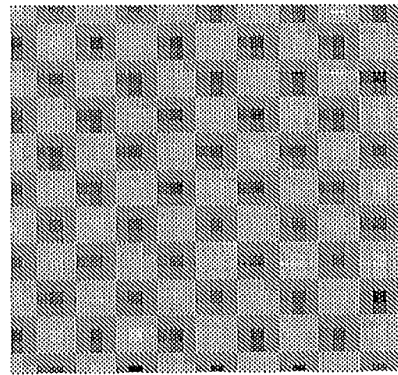


Fig. 14E

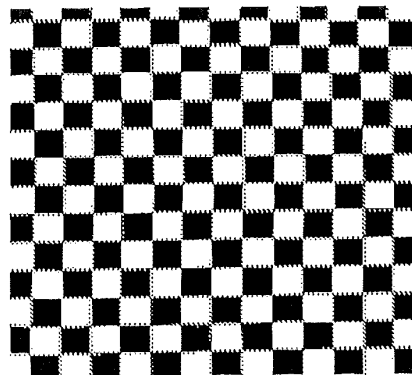


Fig. 14D

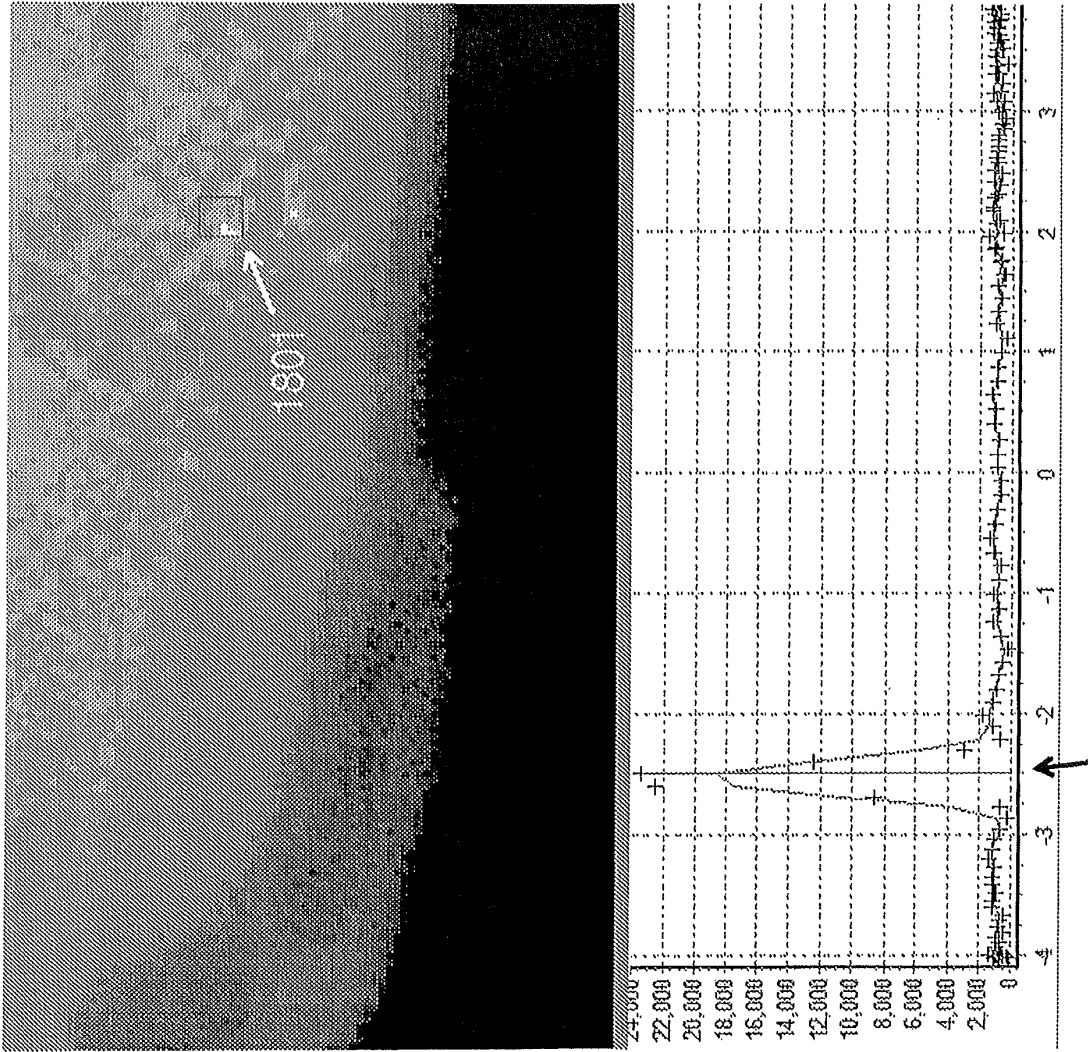


Fig. 15

1802



Fig. 16

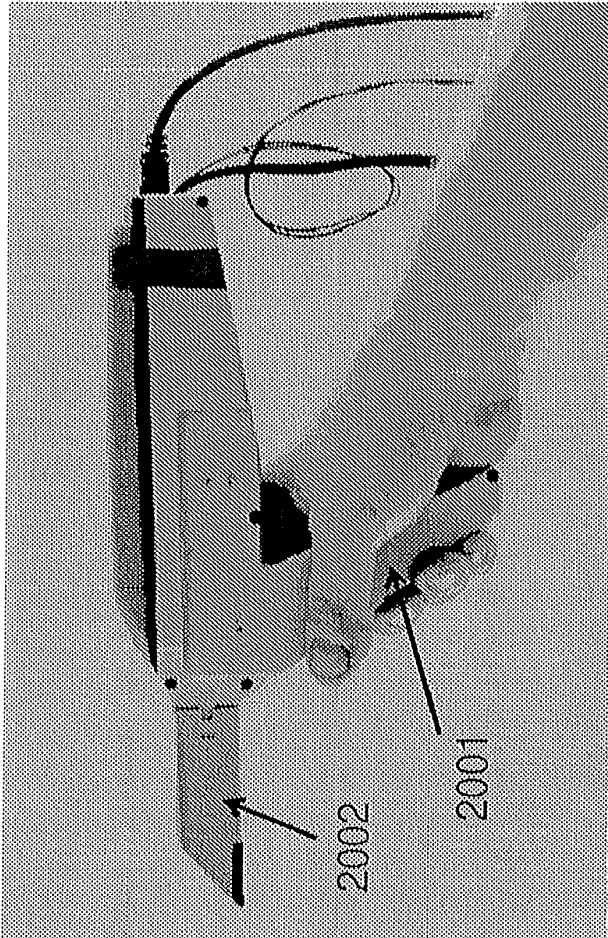


Fig. 17

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA/82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	March 19, 2021
First Named Inventor	Rune FISKER
Title	FOCUS SCANNING APPARATUS
Art Unit	
Examiner Name	
Attorney Docket Number	0079124-000337-T1

SIGNATURE of Applicant or Patent Practitioner

Signature	/WCRowland/	Date (Optional)	March 19, 2021
Name	William C. Rowland	Registration Number	30,888
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			
NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.			
☒ *Total of <u>1 (ONE)</u> forms are submitted.			

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number

Filing Date

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I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

3Shape A/S



Inventor or Joint Inventor (title not required below)



Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)



Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)



Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature

Date (Optional)

15 MAY 2012

Name

HETTE CARLSTEDT

Title

GENERAL COUNSEL

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of _____ forms are submitted.

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Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		FOCUS SCANNING APPARATUS		
First Named Inventor/Applicant Name:		Rune FISHER		
Filer:		William C. Rowland/Mayra Castillo		
Attorney Docket Number:		0079124-000337-T1		
Filed as Large Entity				
Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	320	320
UTILITY SEARCH FEE	1111	1	700	700
UTILITY EXAMINATION FEE	1311	1	800	800
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4200	4200
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	10	100	1000
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				7160

Electronic Acknowledgement Receipt	
EFS ID:	42190460
Application Number:	17206581
International Application Number:	
Confirmation Number:	6170
Title of Invention:	FOCUS SCANNING APPARATUS
First Named Inventor/Applicant Name:	Rune FISKER
Customer Number:	21839
Filer:	William C. Rowland/Mayra Castillo
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Attorney Docket Number:	0079124-000337-T1
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	TrackOne Request	TRACK_I--0079124-000337-T1.pdf	122707	no	1
			62e8fe3ff1f7732652179f6d011c438a8fb14b77		
Warnings:					
Information:					
2	Transmittal of New Application	CONTINUATION_TL--0079124-000337-T1.pdf	97765	no	2
			937229f8c849e2400752887a1bf923c7ddff338f		
Warnings:					
Information:					
3	Application Data Sheet	signedADS--0079124-000337-T1.pdf	1827424	no	11
			b345bf61d1e3891704ecc9a9e25dc0c40a3a62d4		
Warnings:					
Information:					
4		SPECIFICATION_TO_BE_FILED--0079124-000337.pdf	386998	yes	58
			f6fd25f0b1df64af874692c9d5592f57dfbf6374c		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	56	
	Claims		57	57	
	Abstract		58	58	
Warnings:					
Information:					
5	Drawings-other than black and white line drawings	DRAWINGS_TO_BE_FILED--0079124-000337.pdf	1125273	no	18
			6388c38cf30dbb4daabf1ba0fa6817f4fe4f02		

Warnings:					
Information:					
6	Power of Attorney	POA--0079124-000337-T1.pdf	394369	no	2
			87f810eeac56c1e2e5126008368df47f671e6e81		
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	41710	no	2
			462126c0e44f3b5601c9f7e7d100dcf1b603364b		
Warnings:					
Information:					
Total Files Size (in bytes):			3996246		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					

**CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION
UNDER 37 CFR 1.102(e)** (Page 1 of 1)

First Named Inventor:	Rune FISKER	Nonprovisional Application Number (if known):	Unassigned
Title of Invention:	FOCUS SCANNING APPARATUS		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently \$0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.
2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.
3. The applicable box is checked below:

I. ☒ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

- i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.
---OR---
(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.
- ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, or the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

- i. A request for continued examination has been filed with, or prior to, this form.
- ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
- iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
- iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
- v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /WCRoland/	Date March 19, 2021
Name William C. Rowland (Print/Typed)	Practitioner 30,888 Registration Number
Note: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.*	
☒ *Total of <u>1 (one)</u> forms are submitted.	

SCORE Placeholder Sheet for IFW Content

Application Number: 17206581

Document Date: 03/19/2021

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)	
	)	
Rune FISKER	)	Group Art Unit: Unassigned
	)	
Application No.: 17/206,581	)	Examiner: Unassigned
	)	
Filed: March 19, 2021	)	Confirmation No.: Unassigned
	)	
For: FOCUS SCANNING APPARATUS	)	
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PRELIMINARY AMENDMENT

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

Commissioner:

Prior to examination of the above-captioned patent application, kindly amend the
application as follows:

AMENDMENTS TO THE CLAIMS:

The following listing of claims will replace all prior versions and listings of claims in this application.

LISTING OF CLAIMS:

1. (Cancelled)
2. (New) An intraoral scanner for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, the intraoral scanner comprising:
 - at least one camera accommodating an array of sensor elements;
 - a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time-varying illumination pattern;
 - an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern, and for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;
 - a tip configured to be inserted into the oral cavity; and
 - a hardware processor configured to:
 - o selectively switch a color of the probe light, thereby illuminating the object with different colors at different times;
 - o record different images by the at least one camera at the different times, thereby recording images of the object with the different colors; and
 - o combine the different colors from the different images, thereby obtaining the color of the surface of the object,

wherein the intraoral scanner is wireless, and wherein the at least one camera is a high-speed camera.

3. (New) The intraoral scanner according to claim 2, wherein the pattern generator includes at least one translucent and/or transparent pattern element.

4. (New) The intraoral scanner according to claim 2, wherein the pattern generator is based on a projector such as a liquid crystal display (LCD) projector or a digital light processing (DLP) projector.

5. (New) The intraoral scanner according to claim 2, wherein the different colors are provided by at least three monochromatic light sources of the light source.

6. (New) The intraoral scanner according to claim 5, wherein the at least three monochromatic light sources are light-emitting diodes (LEDs) or a segmented LED.

7. (New) The intraoral scanner according to claim 5, wherein the hardware processor is configured to selectively switch the color of the probe light by switching on and off the at least three monochromatic light sources.

8. (New) The intraoral scanner according to claim 2, wherein the optical system is substantially achromatic.

9. (New) The intraoral scanner according to claim 2, wherein the probe light is directed towards the object in a direction substantially parallel with the longitudinal axis of the tip, and wherein the probe light is further reflected towards the object by a single reflective mirror located in the tip.

10. (New) The intraoral scanner according to claim 2, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

11. (New) The intraoral scanner according to claim 2, wherein the hardware processor is further configured to locally process raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

12. (New) The intraoral scanner according to claim 10, wherein the data for the 3D geometry is wirelessly transmitted to a workstation.

13. (New) The intraoral scanner according to claim 10, wherein the hardware processor processes the raw 3D data into data for the 3D geometry in real time.

14. (New) The intraoral scanner according to claim 2, wherein a temporal correlation measure is computed with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.

15. (New) The intraoral scanner according to claim 14, wherein the temporal correlation measure is computed for each individual sensing element.

16. (New) The intraoral scanner according to claim 14, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.

17. (New) The intraoral scanner according to claim 2, wherein the high-speed camera records images at a frame rate of at least 500 frames per second or at a frame rate of at least 2000 frames per second.

18. (New) The intraoral scanner according to claim 2, wherein the intraoral scanner comprises at least two light sources, each of the light sources configured to operate with the pattern generator.

19. (New) The intraoral scanner according to claim 18, wherein the at least two light sources are configured to operate with different wavelengths.

20. (New) The intraoral scanner according to claim 19, wherein the intraoral oral scanner is configured such that the different wavelengths can be manually selected, whereby the 3D geometry is dependent on which light source is being manually selected.

21. (New) The intraoral scanner according to claim 2, wherein the intraoral scanner further comprises polarization optics.

22. (New) A method for determining the 3D geometry and color of at least a part of the surface of an object in an oral cavity, said method comprising the steps of:

- using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern;
- transmitting the probe light, through a tip of intraoral scanner inserted into the oral cavity, towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern;
- transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images,

wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;

- selectively switching a color of the probe light, thereby illuminating the object with different colors at different times;
- recording different images by the at least one camera at the different times, thereby recording images of the object with the different colors;
- combining the different colors from the different images to obtain the color of the surface of the object; and
- wirelessly transmitting the data for the 3D geometry.

23. (New) The method according to claim 22, wherein the plurality of 2D images is recorded using a high-speed camera.

24. (New) The method according to claim 22, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted instead of the raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

25. (New) The method according to claim 22, wherein the method further comprises a step of locally processing, on the intraoral scanner, raw 3D data into data for the 3D geometry, such that the data for the 3D geometry is wirelessly transmitted at a reduced data rate in comparison with transmission of raw 3D data, and wherein the raw 3D data is based on the plurality of 2D images.

26. (New) The method according to claim 24, wherein the step of wirelessly transmitting the data for the 3D geometry is to a workstation.

27. (New) The method according to claim 24, wherein the step of locally processing is in real time.

28. (New) The method according to claim 22, where the method further comprises a step of computing a temporal correlation measure with sensor signals, in the at least one camera, recorded at different times while the plurality of configurations in the form of a time-varying illumination pattern are changed.

29. (New) The method according to claim 28, wherein the temporal correlation measure is computed for each individual sensing element.

30. (New) The method according to claim 28, wherein the temporal correlation measure is based on a reference signal that is based on knowledge or on calibration of the plurality of configurations of the time-varying illumination pattern.

31. (New) The method according to claim 22, wherein method further comprises a step of manually selecting a wavelength for which the intraoral scanner obtains the 3D geometry.

REMARKS

By way of the foregoing amendment, Claim 1 has been cancelled. Claims 2 - 31 have been added. No new matter is introduced by these changes.

It is requested that the application be examined on the basis of the amendments presented herein. Early and favorable consideration of this application is respectfully requested.

Should any questions arise in connection with this application, it is respectfully requested that the undersigned be contacted at the number indicated below.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date March 26, 2021

By: /WCRowland/
William C. Rowland
Registration No. 30,888

Customer No. 21839
703 836 6620

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	17206581
	Filing Date	2021-03-19
	First Named Inventor	Rune FISKER et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	0079124-000337

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111	TANG, et al., "Automatic Reconstruction of as-built Building Information Models from Laser-Scanned Point Clouds: A Review of Related Techniques, Automation in Construction 19", Automation in Construction, Volume 19, Number 7, November 1, 2010, pp. 829-843.	☐
112	TSUKIZAWA, et al., "3D Digitization of a Hand-held Object with a Wearable Vision Sensor", Published in International Workshop on Computer Vision in Human-Computer Interaction, CVHCI 2004: Computer Vision in Human-Computer Interaction, 2004, pp. 129-141.	☐
113	VEDULA, et al., "Shape and Motion Carving in 6D", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2000, 7 pages.	☐
114	WATANABE, et al., "Telecentric Optics for Constant-Magnification Imaging", Department of Computer Science, Columbia University, September 1995, 22 pages.	☐
115	WESTPHAL et al., "Correction of Geometric and Refractive Image Distortions in Optical Coherence Tomography Applying Fermat's Principle", Optics Express, Volume 10, No. 9, May 6, 2002, pp. 397-404.	☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	17206581
	Filing Date	2021-03-19
	First Named Inventor	Rune FISKER et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	0079124-000337

IDENTIFICATION OF EARLIER APPLICATION UNDER 37 C.F.R. § 1.98(d)

Documents cited on this form were previously made of record in prior application Serial No. 16/778,843 filed on January 28, 2020, upon which the Applicant relies for the benefits provided in 35 U.S.C. § 120.

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.

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CERTIFICATION STATEMENT

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

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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.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	17206581
	Filing Date	2021-03-19
	First Named Inventor	Rune FISKER et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	0079124-000337

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	/WCRowland/	Date (YYYY-MM-DD)	2021-03-26
Name/Print	William C. Rowland	Registration Number	30,888
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:	42292896
Application Number:	17206581
International Application Number:	
Confirmation Number:	6170
Title of Invention:	FOCUS SCANNING APPARATUS
First Named Inventor/Applicant Name:	Rune FISKER
Customer Number:	21839
Filer:	William C. Rowland/Mayra Castillo
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000337-T1
Receipt Date:	26-MAR-2021
Filing Date:	
Time Stamp:	13:13:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		PRELIMINARY_AMENDMENT--0079124-000337.pdf	100878	yes	8
			e456b92be137c3e14110d2effe0ae7d1c30d563c		

Multipart Description/PDF files in .zip description					
Document Description			Start	End	
Preliminary Amendment			1	1	
Claims			2	7	
Applicant Arguments/Remarks Made in an Amendment			8	8	
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS_1449--0079124-000337.pdf	232574	no	19
			ff31b36d173025829d4ce7d250cfc62d39b0c70c		
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
Total Files Size (in bytes):			333452		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO.	TOT CLAIMS	IND CLAIMS
17/206,581	03/19/2021	2852	2820	0079124-000337-T1	30	2

CONFIRMATION NO. 6170

FILING RECEIPT



0000000124431445

21839
BUCHANAN, INGERSOLL & ROONEY PC
1737 KING STREET
SUITE 500
ALEXANDRIA, VA 22314-2727

Date Mailed: 03/31/2021

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

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Inventor(s)

Rune FISKER, Virum, DENMARK;
Henrik ØJELUND, Lyngby, DENMARK;
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Mike van der POEL, Rødovre, DENMARK;
Arish A. QAZI, Toronto, CANADA;
Karl-Josef HOLLENBECK, Copenhagen Ø, DENMARK;

Applicant(s)

3SHAPE A/S, Copenhagen K, DENMARK

Assignment For Published Patent Application

3SHAPE A/S, Copenhagen K, DENMARK

Power of Attorney: The patent practitioners associated with Customer Number 21839

Domestic Priority data as claimed by applicant

This application is a CON of 16/774,843 01/28/2020
which is a CON of 16/433,369 06/06/2019 PAT 10595010
which is a CON of 16/217,943 12/12/2018 PAT 10326982
which is a CON of 15/974,105 05/08/2018 PAT 10349041
which is a CON of 14/502,230 09/30/2014 PAT 10097815
which is a CON of 13/376,427 12/06/2011 PAT 8878905
which is a 371 of PCT/DK2010/050148 06/17/2010
which claims benefit of 61/231,118 08/04/2009
and claims benefit of 61/187,744 06/17/2009

page 1 of 4

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

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

If Required, Foreign Filing License Granted: 03/29/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/206,581**

Projected Publication Date: 07/08/2021

Non-Publication Request: No

Early Publication Request: No

Title

FOCUS SCANNING APPARATUS

Preliminary Class

396

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

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Title 35, United States Code, Section 184

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 17/206,581				
APPLICATION AS FILED - PART I										
(Column 1)		(Column 2)		SMALL ENTITY		OTHER THAN SMALL ENTITY				
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)			
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	320			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	700			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	800			
TOTAL CLAIMS (37 CFR 1.16(i))	30	minus 20 = *	10			x 100 =	1000			
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2	minus 3 = *				x 480 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL		TOTAL	2820			
APPLICATION AS AMENDED - PART II										
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OTHER THAN SMALL ENTITY		
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=		x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=		x	=
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
TOTAL ADD'L FEE								TOTAL ADD'L FEE		
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	Total (37 CFR 1.16(i))	*	Minus	**	=	x	=		x	=
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x	=		x	=
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
TOTAL ADD'L FEE								TOTAL ADD'L FEE		
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3. ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.										

Doc code: IDS

Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-15)

Approved for use through 07/31/2016. OMB 0651-0031

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17206581	
	Filing Date		2021-03-19	
	First Named Inventor	Rune Fisker et al.		
	Art Unit			
	Examiner Name			
	Attorney Docket Number		0079124-000337	

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	8878905	B2	2014-11-04	Fisker et al.			
	2	10349042	B1	2019-07-09	Fisker et al.			
If you wish to add additional U.S. Patent citation information please click the Add button.								
U.S.PATENT APPLICATION PUBLICATIONS								
Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear		
	1	20050237581	A1	2005-10-27	Knighton et al.			
	2	20060212260	A1	2006-09-21	Kopelman et al.			
	3	20090279103	A1	2009-11-12	Thiel et al.	corresponds to DE 102007005726		
If you wish to add additional U.S. Published Application citation information please click the Add button.								
FOREIGN PATENT DOCUMENTS								
Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T ⁵

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	Art Unit			
	Examiner Name			
	Attorney Docket Number		0079124-000337	

	1	0837659	EP		1998-04-29	Siemens AG	w/English Abstract	☐
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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, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	Notification Concerning Transmittal of Copy of International Preliminary Report on Patentability (Forms PCT/1B/326 and PCT/1B/373) and the Written Opinion of the International Searching Authority (Form PCT/ISA237) issued on January 5, 2012, in the corresponding International Application No. PCT/DK2010/050148.	☐
	2	Exhibit 2- 3D Imagery Handbook (Moria Ogami, First Edition, Feb. 20, 2006, pages 45-46 (4 pages).	☐
	3	Exhibit 6- Latest Optical 3D Measurement (Toru Yoshizawa, First Edition, Nov. 20, 2006, pages 45-48 (16 pages).	☐
	4	"Amended Complaint, 3Shape A/S v. Align Technology, Inc., Case No. 1:18-886-LPS", August 30, 2019, 166 pages	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	
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**INFORMATION DISCLOSURE
STATEMENT BY APPLICANT**
(Not for submission under 37 CFR 1.99)

Application Number	17206581
Filing Date	2021-03-19
First Named Inventor	Rune Fisker et al.
Art Unit	
Examiner Name	
Attorney Docket Number	0079124-000337

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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).

☐ 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	/WCRowland/	Date (YYYY-MM-DD)	2021-04-02
Name/Print	William C. Rowland	Registration Number	30,888

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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.
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4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Acknowledgement Receipt	
EFS ID:	42353095
Application Number:	17206581
International Application Number:	
Confirmation Number:	6170
Title of Invention:	FOCUS SCANNING APPARATUS
First Named Inventor/Applicant Name:	Rune FISKER
Customer Number:	21839
Filer:	William C. Rowland/Stacey Pflieger
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000337-T1
Receipt Date:	02-APR-2021
Filing Date:	19-MAR-2021
Time Stamp:	11:47:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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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)	337ids.pdf	79175	no	4
			c4b4d1c5e2573ad3671207a0f129b4b581958006		

Warnings:

Information:	
This is not an USPTO supplied IDS fillable form	
Total Files Size (in bytes):	79175
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.	



UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISKER	0079124-000337-T1	6170
21839 7590 04/30/2021 BUCHANAN, INGERSOLL & ROONEY PC 1737 KING STREET SUITE 500 ALEXANDRIA, VA 22314-2727			EXAMINER	
			ART UNIT	PAPER NUMBER
			2484	
			NOTIFICATION DATE	DELIVERY MODE
			04/30/2021	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):

ADIPDOC1@BIPC.com

<i>Decision Granting Request for Prioritized Examination (Track I)</i>	Application No. 17/206,581	Applicant(s) FISKER et al.	
	Examiner CHERYL P GIBSON BAYLOR	Art Unit OPET	AIA (FITF) Status No
1. THE REQUEST FILED <u>19 March 2021</u> IS GRANTED . The above-identified application has met the requirements for prioritized examination A. ☒ for an original nonprovisional application (Track I). B. ☐ for an application undergoing continued examination (RCE). 2. The above-identified application will undergo prioritized examination. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs: A. filing a <u>petition for extension of time</u> to extend the time period for filing a reply; B. filing an <u>amendment to amend the application to contain more than four independent claims, more than thirty total claims</u>, or a multiple dependent claim; C. filing a <u>request for continued examination</u> ; D. filing a notice of appeal; E. filing a request for suspension of action; F. mailing of a notice of allowance; G. mailing of a final Office action; H. completion of examination as defined in 37 CFR 41.102; or I. abandonment of the application. Telephone inquiries with regard to this decision should be directed to CHERYL GIBSON BAYLOR at (571)272-3213. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.			
/CHERYL GIBSON BAYLOR/ Paralegal Specialist, OPET			



**UNITED STATES
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Alexandria, VA 22313 - 1450
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ELECTRONIC PAYMENT RECEIPT

APPLICATION #
17/206,581

RECEIPT DATE / TIME
05/17/2021 12:50:33 PM ET

ATTORNEY DOCKET #
0079124-000337-T1

Title of Invention

FOCUS SCANNING APPARATUS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 6170

FILED BY William Rowland

PATENT CENTER # 60195967

AUTHORIZED BY -

CUSTOMER # 21839

FILING DATE 03/19/2021

CORRESPONDENCE
ADDRESS -

FIRST NAMED
INVENTOR Rune FISKER

Payment Information

PAYMENT METHOD
DA / 024800

PAYMENT TRANSACTION ID
E20215GC51082424

PAYMENT AUTHORIZED BY
William Rowland

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
1814	STATUTORY DISCLAIMER, INCLUDING TERMINAL DISCLAIMER	170.00	1	170.00
TOTAL AMOUNT:				\$170.00

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

New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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



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APPROVAL LETTER

APPLICATION #
17/206,581

FILING DATE
03/19/2021

APPLICANT/PATENT UNDER REEXAMINATION
Rune FISKER

Title of Invention

FOCUS SCANNING APPARATUS

Electronic terminal disclaimer filed on 05/17/2021

 Approved

This patent is subject to a Terminal Disclaimer

Approved / Disapproved by: Electronic Terminal Disclaimer automatically approved



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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
17/206,581

RECEIPT DATE / TIME
05/17/2021 12:50:33 PM ET

ATTORNEY DOCKET #
0079124-000337-T1

Title of Invention

FOCUS SCANNING APPARATUS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 6170

FILED BY William Rowland

PATENT CENTER # 60195967

FILING DATE 03/19/2021

CUSTOMER # 21839

FIRST NAMED INVENTOR Rune FISKER

CORRESPONDENCE ADDRESS -

AUTHORIZED BY -

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
petition-request.pdf	3	Terminal Disclaimer-Filed (Electronic)	48 KB
grantLetter.pdf	1	Terminal Disclaimer-Electronic- Approved	18 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
petition-request.pdf	A28E1EE0713AD7AEBABB45BB40C5329D277FE13C602CD4E1 CF78136E7FCEF2B1DC9FC98035CC7350467D5FF44D718C4A

B801473E7CD40B1387570382D673B948

grantLetter.pdf

F951CBDE2020E3DA88A7C18D14510BA66441F9139968A4F89
E860CAEB73D5CE02BF69F551449DBC00148699030F974CA2B
5E908E784F0275CF40D520B77D0EC4

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

New Applications Under 35 U.S.C. 111

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New International Application Filed with the USPTO as a Receiving Office

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TERMINAL DISCLAIMER TO OBVIATE A PROVISIONAL DOUBLE PATENTING REJECTION OVER A PENDING "REFERENCE" APPLICATION

APPLICATION #
17206581

FILING DATE
03/19/2021

FIRST NAMED INVENTOR
Rune FISKER

ATTORNEY DOCKET #
0079124-000337-T1

Title of Invention

FOCUS SCANNING APPARATUS



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
3Shape A/S	100%
Total	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)

Application #	Filing Date
---------------	-------------

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.

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 prior patent number(s)

Patent #

10595010

as the term of said prior patent is presently shortened by any terminal disclaimer. 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 the prior patent 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 the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:

- 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 presently shortened by any terminal disclaimer.



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

Applicant claims the following entity status:

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.

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

Signature	Name	Registration #
/WCRowland/	William Rowland	30888

* 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.



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NOTICE OF ALLOWANCE AND FEE(S) DUE

21839 7590 05/28/2021
BUCHANAN, INGERSOLL & ROONEY PC
1737 KING STREET
SUITE 500
ALEXANDRIA, VA 22314-2727

EXAMINER

MESA, JOSE M

ART UNIT

PAPER NUMBER

2484

DATE MAILED: 05/28/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISHER	0079124-000337-T1	6170

TITLE OF INVENTION: FOCUS SCANNING APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	08/30/2021

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)

21839 7590 05/28/2021
BUCHANAN, INGERSOLL & ROONEY PC
1737 KING STREET
SUITE 500
ALEXANDRIA, VA 22314-2727

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

Certificate of Mailing or Transmission

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

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISKE	0079124-000337-T1	6170

TITLE OF INVENTION: FOCUS SCANNING APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	08/30/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
MESA, JOSE M	2484	348-046000

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
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISKER	0079124-000337-T1	6170
21839	7590	05/28/2021	EXAMINER	
BUCHANAN, INGERSOLL & ROONEY PC			MESA, JOSE M	
1737 KING STREET			ART UNIT	
SUITE 500			PAPER NUMBER	
ALEXANDRIA, VA 22314-2727			2484	

DATE MAILED: 05/28/2021

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

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

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

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

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

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

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

Privacy Act Statement

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

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

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

Notice of Allowability	Application No. 17/206,581	Applicant(s) FISKER et al.	
	Examiner JOSE M MESA	Art Unit 2484	AIA (FITF) Status No

-- 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 03/26/2021.
☐ 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 2-31. 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)	5. ☐ Examiner's Amendment/Comment
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>03/26/2021 04/02/2021</u> .	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/JOSE M MESA/ Examiner, Art Unit 2484	/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484
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DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Allowable Subject Matter

1. Claims 2-31 are allowed.

The following is an examiner's statement of reasons for allowance: **Independent claim 2** recites the uniquely distinct features for: "...a pattern generator configured to generate, using a light source, a probe light with a plurality of configurations in the form of a time-varying illumination pattern; an optical system for transmitting the probe light towards the object along an optical path thereby illuminating at least a part of the object with the time-varying illumination pattern, and for transmitting at least a part of the light returned from the object to the at least one camera to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;..." **And independent claim 22** recites the uniquely distinct features for: "...using a light source and a pattern generator to generate a probe light with a plurality of configurations in the form of a time-varying illumination pattern; transmitting the probe light, through a tip of an intraoral scanner inserted into the oral cavity, towards the object along an optical path, thereby illuminating at least a part of the object with the time-varying illumination pattern; transmitting at least a part of the light returned from the object to at least one camera accommodating an array of sensor elements to form a plurality of 2D images, wherein the 3D geometry is determined based on the plurality of 2D images and the time-varying illumination pattern;..." The

closest prior art in Babayoff et al. (US 2005/0283065) teaches a device 100 comprises a main illumination source 31 for illuminating the object of interest 26, typically a part of the intraoral cavity, and is optically coupled to main optics 41 to provide depth Z values for an array range of X-Y points (according to a known frame of reference) along the surface of the object 26. Detection optics 60 comprises an image sensor, typically a CCD, that is preferably monochromatic to maximise the resolution of the device, and which typically defines the X-Y frame of reference. Alternatively, the CCD may be adapted to receive color images. The detection optics 60 receives image data from the main optics 41 and the image processor 24 determines the depth Z values for each X-Y point illuminated on the object 26 based on this image data, Heinz et al. (US 2007/0041729) teaches an illustrative illumination arrangement 800 using a multimode optical fiber 802 to monitor a surface 804 with a detector 805 (e.g., detector 104 of FIG. 1, detector 302 of FIG. 3A, or detector A of FIG. 7, 7A). Optical radiation 806 that reflects from surface 804 will exhibit time-varying changes if surface 804 vibrates, if fiber 802 moves across surface 804, or if distance d changes (e.g., through tilt or movement of surface 804). The multimode interference pattern that illuminates detector 805 is time-varying in accordance with the movement of surface 804 (or end 814 or d), however, either singular or in combination, fails to anticipate or render the above underlined limitations obvious.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOSE M MESA whose telephone number is (571)270-1706. The examiner can normally be reached on Monday-Friday 8:30AM-6:00PM ET.

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, Thai Tran can be reached on 571-272-7382. 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.

5/17/2021

**/JOSE M MESA/
Examiner, Art Unit 2484**

**/THAI Q TRAN/
Supervisory Patent Examiner, Art Unit 2484**

<i>Notice of References Cited</i>	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISKER et al.	
	Examiner JOSE M MESA	Art Unit 2484	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-20050283065-A1	12-2005	Babayoff, Noam	G01J3/0224	600/407
*	B	US-20070041729-A1	02-2007	Heinz; Philip	H01L31/02024	398/25
	C					
	D					
	E					
	F					
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

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

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

U.S. Patent and Trademark Office
PTO-892 (Rev. 01-2001)

Notice of References Cited

Part of Paper No. 20210517

<i>Index of Claims</i> 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISHER et al.
	Examiner JOSE M MESA	Art Unit 2484

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47										
CLAIM		DATE								
Final	Original	05/17/2021								
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	2	=								
	3	=								
	4	=								
	5	=								
	6	=								
	7	=								
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	30	=								
	31	=								

Issue Classification 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISKER et al.
	Examiner JOSE M MESA	Art Unit 2484

CPC						
Symbol					Type	Version
H04N	/	13	/	296	F	2018-05-01
A61B	/	5	/	0068	I	2013-01-01
G01B	/	11	/	2513	I	2013-01-01
G01B	/	11	/	2518	I	2013-01-01
A61B	/	5	/	1077	I	2013-01-01
A61B	/	5	/	4547	A	2013-01-01
G01B	/	2210	/	58	A	2013-01-01
A61B	/	5	/	1075	A	2013-01-01
A61B	/	5	/	1076	A	2013-01-01

CPC Combination Sets					
Symbol			Type	Set	Ranking
/	/	/			

/JOSE M MESA/ Examiner, Art Unit 2484 (Assistant Examiner)	17 May 2021 (Date)	Total Claims Allowed: 30	
/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484 (Primary Examiner)	25 May 2021 (Date)	O.G. Print Claim(s) 2	O.G. Print Figure 8

U.S. Patent and Trademark Office

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Issue Classification 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISKER et al.
	Examiner JOSE M MESA	Art Unit 2484

INTERNATIONAL CLASSIFICATION			
CLAIMED			
H04N		13	296

NON-CLAIMED			

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

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

/JOSE M MESA/ Examiner, Art Unit 2484 (Assistant Examiner)	17 May 2021 (Date)	Total Claims Allowed: 30	
/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484 (Primary Examiner)	25 May 2021 (Date)	O.G. Print Claim(s) 2	O.G. Print Figure 8

Issue Classification 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISHER et al.
	Examiner JOSE M MESA	Art Unit 2484

☐ 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
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1	2	10	11	19	20	28	29								
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4	5	13	14	22	23										
5	6	14	15	23	24										
6	7	15	16	24	25										
7	8	16	17	25	26										
8	9	17	18	26	27										

/JOSE M MESA/ Examiner, Art Unit 2484 (Assistant Examiner)	17 May 2021 (Date)	Total Claims Allowed: 30	
/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484 (Primary Examiner)	25 May 2021 (Date)	O.G. Print Claim(s) 2	O.G. Print Figure 8

U.S. Patent and Trademark Office

Part of Paper No.: 20210517

<i>Search Notes</i> 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISKER et al.
	Examiner JOSE M MESA	Art Unit 2484

CPC - Searched*		
Symbol	Date	Examiner
H04N13/296, A61B5/0068, A61B5/1077, G01B11/2513	05/17/2021	JM
G01B11/2518, A61B5/1075, A61B5/1076, A61B5/4547	05/17/2021	JM
G01B2210/58	05/17/2021	JM

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G01B11/2518, A61B5/1075, A61B5/1076, A61B5/4547	05/17/2021	JM
G01B2210/58	05/17/2021	JM

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
East Search History, US-PGPUB, USPAT, USOCR, EPO, JPO, DERWENT, IBM_TDB.	05/17/2021	JM
Searched inventor's in PALM and PE2E for double patenting.	05/17/2021	JM

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	See East Search History for interference search.	05/17/2021	JM

/JOSE M MESA/ Examiner, Art Unit 2484	/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484
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<i>Search Notes</i> 	Application/Control No. 17/206,581	Applicant(s)/Patent Under Reexamination FISKER et al.
	Examiner JOSE M MESA	Art Unit 2484

/JOSE M MESA/ Examiner, Art Unit 2484	/THAI Q TRAN/ Supervisory Patent Examiner, Art Unit 2484
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EAST Search History**EAST Search History (Prior Art)**

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S237	14	((switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same probe same light same object) and (A61B5/1076).CPC.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S238	49	((switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same probe same light same object) and (A61B5/4547).CPC.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S239	43	((switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same probe same light same object) and (G01B2210/58).CPC.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S240	130	(selectiv\$4 same (switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same probe same light)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S241	64	((selectiv\$4 select\$4) same (switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same probe same light same (object tooth teeth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S242	3,679	((selectiv\$4 select\$4) same (switch\$4 chang\$4 modif\$4 alter\$4 adjust\$4) same color same light same (object tooth teeth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S243	167,832	("20030096210" "20040080754" "20050283065" "20060158665" "20070109559" "20070194214" "20070252074" "20090103103" "20090167948" "20090279103" "20100079581" "20100157086" "4291958" "4349880" "4516231" "4575805" "4629324" "4640620" "4896015" "5372502" "5381236" "5615003" "6697164").PN"	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S244	81	S242 and S243	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31

S245	139	(tim\$4 near2 var\$4 near2 illuminat\$4 near2 pattern)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S246	167,832	("20030096210" "20040080754" "20050283065" "20060158665" "20070109559" "20070194214" "20070252074" "20090103103" "20090167948" "20090279103" "20100079581" "20100157086" "4291958" "4349880" "4516231" "4575805" "4629324" "4640620" "4896015" "5372502" "5381236" "5615003" "6697164").PN"	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S247	6	S245 and S246	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S248	109	S245 and (scan\$4 scanner)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S249	21	S245 and (tooth teeth)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S250	852	(tim\$4 near50 var\$4 near50 illuminat\$4 near50 pattern)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S251	62	S250 and (tooth teeth)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S252	16	(segment\$4 near50 ((led) light near2 emitting near2 diode) near50 scanner)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S253	6	(segment\$4 near50 ((led) light near2 emitting near2 diode) near50 probe near50 light)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S254	10	(segmented same ((led) light near2 emitting near2 diode) same probe same light)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S255	14	(segment\$4 same5 ((led) light same emitting same diode) same5 probe same light) and (G01B11/2518).CPC.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S256	31	(segment\$4 same5 ((led) light same emitting same diode) same5 probe) and (G01B11/2518).CPC.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S257	19	(optical near2 system near2 substantially near2 achromatic)	USPAT	OR	OFF	2021/05/17 17:31
S258	40	(optical near2 system near2 substantially near2 achromatic)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S259	6	(optical near50 system near50 substantially near50 achromatic near50 color)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S260	1	(optical same system same substantially same achromatic same (tooth teeth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31

S261	10	(tim\$4 near50 var\$4 near50 illuminat\$4 near50 line near50 pattern)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S262	49	(tim\$4 near50 (var\$4 chang\$4) near50 illuminat\$4 near50 line near50 pattern)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S263	6	(tim\$4 same (var\$4 chang\$4) same illuminat\$4 same line same pattern same (tooth teeth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S264	195	(tim\$4 same5 (var\$4 chang\$4) same5 illuminat\$4 same5 (line adj5 pattern) same5 (tooth teeth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S265	5	(camera near2 two near2 cameras) near50 (tooth teeth)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S266	10	(tim\$4 near50 (var\$4 chang\$4 modif\$4 alter\$4) near50 (illuminat\$4 light\$4) near50 pattern near50 (teeth tooth))	US-PGPUB; USPAT; USOCR	OR	OFF	2021/05/17 17:31
S267	15	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth))	US-PGPUB; USPAT; USOCR	OR	OFF	2021/05/17 17:31
S268	53	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth) same dimensions)	US-PGPUB; USPAT; USOCR	OR	OFF	2021/05/17 17:31
S269	118	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth object) with dimensions)	US-PGPUB; USPAT; USOCR	OR	OFF	2021/05/17 17:31
S270	118	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth object) with dimensions)	US-PGPUB; USPAT; DERWENT	OR	OFF	2021/05/17 17:31
S271	20	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth) same dimensions)	US-PGPUB; USPAT; DERWENT	OR	OFF	2021/05/17 17:31
S272	13	(tim\$4 near50 (var\$4 chang\$4 modif\$4 alter\$4) near50 (illuminat\$4 light\$4) near50 pattern near50 (teeth tooth))	US-PGPUB; USPAT; DERWENT	OR	OFF	2021/05/17 17:31
S273	18	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth))	US-PGPUB; USPAT; DERWENT	OR	OFF	2021/05/17 17:31
S280	1	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth)	US-PGPUB; USPAT; DERWENT	OR	OFF	2021/05/17 17:31

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S285	1	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth object)) and ("20060158665" "4516231" "4640620" "4896015" "20050283065" "20060212260" "5377011" "7221332" "20050283065" "20070109559" "4291958" "4349880" "5615003" "20090231649" "20070171220" "6227850" "6645148" "7813591" "20090167948" "20060251408" "20070134615" "5722412" "6592371" "8903476" "20030096210" "20040080754" "20070252074" "20090279103" "20100157086" "5381236" "20070041729" "7213214"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:03

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S286	1	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth object)) and ("20060158665" "4516231" "4640620" "4896015" "20050283065" "20060212260" "5377011" "7221332" "20050283065" "20070109559" "4291958" "4349880" "5615003" "20090231649" "20070171220" "6227850" "6645148" "7813591" "20090167948" "20060251408" "20070134615" "5722412" "6592371" "8903476" "20030096210" "20040080754" "20070252074" "20090279103" "20100157086" "5381236" "20070041729" "7213214" "9329675" "20090103103" "20100079581" "5372502" "5428450" "6485413" "7551353" "6697164" "5737339" "20030164952" "20050237581" "20060020204" "20060092133" "20120179035" "5131844" "20070172112" "20100009308" "5181181" "20070194214" "4575805" "4629324" "20090322676" "5269325").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:03
S287	16	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same5 (illuminat\$4 light\$4) same2 pattern same2 (teeth tooth object)) and ("20060158665" "4516231" "4640620" "4896015" "20050283065" "20060212260" "5377011" "7221332" "20050283065" "20070109559" "4291958" "4349880" "5615003" "20090231649" "20070171220" "6227850" "6645148" "7813591" "20090167948" "20060251408"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:03

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S288	16	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same5 (illuminat\$4 light\$4) same2 pattern same2 (teeth tooth object)) and ("20060158665" "4516231" "4640620" "4896015" "20050283065" "20060212260" "5377011" "7221332" "20050283065" "20070109559" "4291958" "4349880" "5615003" "20090231649" "20070171220" "6227850" "6645148" "7813591" "20090167948" "20060251408" "20070134615" "5722412" "6592371" "8903476" "20030096210" "20040080754" "20070252074" "20090279103" "20100157086" "5381236" "20070041729" "7213214" "9329675" "20090103103" "20100079581" "5372502" "5428450" "6485413" "7551353" "6697164" "5737339" "20030164952" "20050237581" "20060020204" "20060092133" "20120179035" "5131844" "20070172112" "20100009308" "5181181" "20070194214" "4575805" "4629324" "20090322676" "5269325").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:04
S289	16	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same5 (illuminat\$4 light\$4) same2 pattern same2 (teeth tooth object)) and ("20060158665" "4516231" "4640620" "4896015" "20050283065" "20060212260"	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:04

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S290	198	(fisker-rune).in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:09
S291	49	(ojelund-henrik).in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:09
S292	11	(kjaer-rasmus).in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:09
S293	55	(van-der-poel-mike).in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:10
S294	17	(qazi-arish-a).in.	US-PGPUB; USPAT; USOCR; EPO; JPO;	OR	OFF	2021/05/17 18:10

			DERWENT; IBM_TDB			
S295	67	(hollenbeck-karl-josef).in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2021/05/17 18:10

5/17/2021 6:19:03 PM

C:\Users\jmesa1\Documents\EAST\Workspaces\case number_17206581_A-Scanner-Determine-3D-Geometry-AND-Color-Of-Surface-Of-Object-Array-Sensor-Elements.wsp

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S308	9	(tim\$4 near50 (var\$4 chang\$4 modif\$4 alter\$4) near50 (illuminat\$4 light\$4) near50 pattern near50 (teeth tooth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S309	14	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S310	4	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth object) with dimensions).clm.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S311	4	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth object) with dimensions).clm.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S312	20	(tim\$4 same (var\$4 chang\$4 modif\$4 alter\$4) same (illuminat\$4 light\$4) same pattern same (teeth tooth) same dimensions)	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S313	9	(tim\$4 near50 (var\$4 chang\$4 modif\$4 alter\$4) near50 (illuminat\$4 light\$4) near50 pattern near50 (teeth tooth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:31
S314	14	(tim\$4 with (var\$4 chang\$4 modif\$4 alter\$4) with (illuminat\$4 light\$4) with pattern with (teeth tooth))	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32
S315	188	(fisker-rune).in.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32
S316	9	(kjaer-rasmus).in.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32
S317	54	(van-der-poel-mike).in.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32
S318	16	(qazi-arish-a).in.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32
S319	64	(hollenbeck-karl-josef).in.	US-PGPUB; USPAT	OR	OFF	2021/05/17 17:32

5/17/2021 6:20:38 PM

C:\Users\jmesa1\Documents\EAST\Workspaces\case number_17206581_A-Scanner-Determine-3D-Geometry-AND-Color-Of-Surface-Of-Object-Array-Sensor-Elements.wsp

Bibliographic Data

Application No: 17/206,581

Foreign Priority claimed: ☐ Yes ☒ No

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

Verified and Acknowledged:

/JOSE M MESA/

Examiner's Signature

Initials

Title:

FOCUS SCANNING APPARATUS

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
03/19/2021	348	2484	0079124-000337-T1
RULE			

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Arish A. QAZI, Toronto, CANADA

Karl-Josef HOLLENBECK, Copenhagen Ø, DENMARK

CONTINUING DATA

This application is a CON of 16774843 01/28/2020

16774843 is a CON of 16433369 06/06/2019 PAT 10595010

16433369 is a CON of 16217943 12/12/2018 PAT 10326982

16217943 is a CON of 15974105 05/08/2018 PAT 10349041

15974105 is a CON of 14502230 09/30/2014 PAT 10097815

14502230 is a CON of 13376427 12/06/2011 PAT 8878905

13376427 is a 371 of PCT/DK2010/050148 06/17/2010

PCT/DK2010/050148 has PRO of 61231118 08/04/2009

PCT/DK2010/050148 has PRO of 61187744 06/17/2009

FOREIGN APPLICATIONS

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03/29/2021

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	17206581
	Filing Date	2021-03-19
	First Named Inventor	Rune FISKER et al.
	Art Unit	
	Examiner Name	
	Attorney Docket Number	0079124-000337

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	Filing Date	2021-03-19
	First Named Inventor	Rune FISKER et al.
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	Examiner Name	
	Attorney Docket Number	0079124-000337

		Authority (Form PCT/ISA237) issued on January 5, 2012, in the corresponding International Application No. PCT/DK2010/050.	
	39	Office Action issued on February 20, 2014, by the Chinese Patent Office in corresponding Chinese Patent Application No. 201080027248.7 and an English translation of the Office Action (30 pages).	☐
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	Attorney Docket Number	0079124-000337

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	Examiner Name	
	Attorney Docket Number	0079124-000337

IDENTIFICATION OF EARLIER APPLICATION UNDER 37 C.F.R. § 1.98(d)

Documents cited on this form were previously made of record in prior application Serial No. 16/778,843 filed on January 28, 2020, upon which the Applicant relies for the benefits provided in 35 U.S.C. § 120.

EXAMINER SIGNATURE

Examiner Signature	/JOSE M MESA/	Date Considered	05/17/2021
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CERTIFICATION STATEMENT

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

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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

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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.

☐

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

☒

A certification statement is not submitted herewith.

Doc code: IDS

PTO/SB/08a (03-15)

Doc description: Information Disclosure Statement (IDS) Filed

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	Filing Date		2021-03-19	
	First Named Inventor	Rune Fisker et al.		
	Art Unit			
	Examiner Name			
	Attorney Docket Number		0079124-000337	

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	8878905	B2	2014-11-04	Fisker et al.			
	2	10349042	B1	2019-07-09	Fisker et al.			
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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	20050237581	A1	2005-10-27	Knighton et al.			
	2	20060212260	A1	2006-09-21	Kopelman et al.			
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**INFORMATION DISCLOSURE
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(Not for submission under 37 CFR 1.99)

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First Named Inventor	Rune Fisker et al.
Art Unit	
Examiner Name	
Attorney Docket Number	0079124-000337

1	0837659	EP	1998-04-29	Siemens AG	w/English Abstract	☐
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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, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1	Notification Concerning Transmittal of Copy of International Preliminary Report on Patentability (Forms PCT/1B/326 and PCT/1B/373) and the Written Opinion of the International Searching Authority (Form PCT/ISA237) issued on January 5, 2012, in the corresponding International Application No. PCT/DK2010/050148.	☐
	2	Exhibit 2- 3D Imagery Handbook (Moria Ogami, First Edition, Feb. 20, 2006, pages 45-46 (4 pages).	☐
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	4	"Amended Complaint, 3Shape A/S v. Align Technology, Inc., Case No. 1:18-886-LPS", August 30, 2019, 166 pages	☐

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EXAMINER SIGNATURE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISKE	0079124-000337-T1	6170

TITLE OF INVENTION: FOCUS SCANNING APPARATUS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	08/30/2021

EXAMINER	ART UNIT	CLASS-SUBCLASS
MESA, JOSE M	2484	348-046000

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.

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(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

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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

3Shape A/S

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Kobenhavn K, DENMARK

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

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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

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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.

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Authorized Signature /WCRoland/

Date June 3, 2021

Typed or printed name William C. Rowland

Registration No. 30,888

Electronic Patent Application Fee Transmittal				
Application Number:		17206581		
Filing Date:		19-Mar-2021		
Title of Invention:		FOCUS SCANNING APPARATUS		
First Named Inventor/Applicant Name:		Rune FISKER		
Filer:		William C. Rowland/Stacey Pflieger		
Attorney Docket Number:		0079124-000337-T1		
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:				
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UTILITY APPL ISSUE FEE	1501	1	1200	1200

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
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Total in USD (\$)				1200

Electronic Acknowledgement Receipt	
EFS ID:	42887981
Application Number:	17206581
International Application Number:	
Confirmation Number:	6170
Title of Invention:	FOCUS SCANNING APPARATUS
First Named Inventor/Applicant Name:	Rune FISKER
Customer Number:	21839
Filer:	William C. Rowland/Stacey Pflieger
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000337-T1
Receipt Date:	03-JUN-2021
Filing Date:	19-MAR-2021
Time Stamp:	12:30:19
Application Type:	Utility under 35 USC 111(a)

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Authorized User	Stacey Pflieger
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)	337if.pdf	151072	no	1
			544598fe5f6ba3cb5f0a13667349cd03f744994e		

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30474	no	2
			a4717803df35ef8e9d7290f16999ea31559a4f59		

Warnings:

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Total Files Size (in bytes):	181546
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New Applications Under 35 U.S.C. 111

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

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

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

New International Application Filed with the USPTO as a Receiving Office

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



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	03/19/2021	Rune FISKER	0079124-000337-T1	6170
21839 7590 06/29/2021 BUCHANAN, INGERSOLL & ROONEY PC 1737 KING STREET SUITE 500 ALEXANDRIA, VA 22314-2727			EXAMINER MESA, JOSE M	
			ART UNIT 2484	PAPER NUMBER
			NOTIFICATION DATE 06/29/2021	DELIVERY MODE 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):

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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
17/206,581	03/19/2021	FSKER et al.	0079124-000337-T1

BUCHANAN, INGERSOLL & ROONEY PC 1737 KING STREET SUITE 500 ALEXANDRIA, VA 22314-2727		EXAMINER	
		JOSE M MESA	
		ART UNIT	PAPER
		2484	20210615

DATE MAILED: _____

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Commissioner for Patents

1449 5/28/2021 contains a typographical error in the list of references cited by the Applicant, for example, 2050237581 and 2060212260 are missing a zero, so it should be 20050237581 and 20060212260. Thanks.

/JOSE M MESA/
Examiner, Art Unit 2484

/THAI Q TRAN/
Supervisory Patent Examiner, Art Unit 2484

PTO-90C (Rev.04-03)

Notice of References Cited	Application/Control No. 17/206,581		Applicant(s)/Patent Under Reexamination FISKER et al.	
	Examiner JOSE M MESA		Art Unit 2484	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-20050237581-A1	10-2005	Knighton, Mark S.	H04N13/204	358/473
*	B	US-20060212260-A1	09-2006	Kopelman; Avi	A61C7/002	702/152
	C					
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	J					
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	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.

U.S. Patent and Trademark Office
PTO-892 (Rev. 01-2001)

Notice of References Cited

Part of Paper No. 20210615

Based on USPTO Form PTO/SB/08

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		17206581
	Filing Date		2021-03-19
	First Named Inventor	Rune FISKER et al.	
	Art Unit		
	Examiner Name		
	Attorney Docket Number		0079124-000337

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	68	8564657	B2	2013-10-22	Michalke, et al.	
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	70	8867820	B2	2014-10-21	Peeper, et al.	
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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
Change(s) applied to document, /K.S.S./ 6/28/2021	1	~~2050297501~~	A1	2005-10-27	Knighton et al. 20050237581	
	2	20060092133	A1	2006-05-04	Touma et al.	
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	6	20070172112	A1	2007-07-26	Paley et al.	



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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/206,581	07/27/2021	11076146	0079124-000337-T1	6170

21839 7590 07/07/2021
BUCHANAN, INGERSOLL & ROONEY PC
1737 KING STREET
SUITE 500
ALEXANDRIA, VA 22314-2727

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

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

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

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

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

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

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

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3SHAPE A/S, Copenhagen K, DENMARK
Henrik ØJELUND, Lyngby, DENMARK;
Rasmus KJÆR, København K, DENMARK;
Mike van der POEL, Rødovre, DENMARK;
Arish A. QAZI, Toronto, CANADA;
Karl-Josef HOLLENBECK, Copenhagen Ø, DENMARK;

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IR103 (Rev. 10/09)



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/206,581	03/19/2021	Rune FISKER	0079124-000337-T1

CONFIRMATION NO. 6170

21839
BUCHANAN, INGERSOLL & ROONEY PC
1737 KING STREET
SUITE 500
ALEXANDRIA, VA 22314-2727

PUBLICATION NOTICE



OC000000126832704

Title: FOCUS SCANNING APPARATUS

Publication No. US-2021-0211638-A1

Publication Date: 07/08/2021

NOTICE OF PUBLICATION OF APPLICATION

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

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

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

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

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

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

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court For The Western District of Texas, Waco Division on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 6:21-cv-1110	DATE FILED 10/26/2021	U.S. DISTRICT COURT For The Western District of Texas, Waco Division
PLAINTIFF 3SHAPE A/S		DEFENDANT CARESTREAM DENTAL, LLC
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 RE48,221	9/22/2020	3SHAPE A/S
2 10,695,151	6/30/2020	3SHAPE A/S
3 11,076,146	7/27/2021	3SHAPE A/S
4		
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT		
CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court _____ for the Western District of Texas Waco Division _____ on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO.	DATE FILED 5/2/2022	U.S. DISTRICT COURT for the Western District of Texas Waco Division
PLAINTIFF 3Shape A/S		DEFENDANT Medit Corp.
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 11,076,146	7/27/2021	3Shape A/S
2 9,629,551	4/25/2017	3Shape A/S
3 10,064,553	9/4/2018	3Shape A/S
4 10,695,151	6/30/2020	3Shape A/S
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
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3		
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5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT		
CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy