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(54) Title: SYSTEMS AND METHODS FOR OPTICAL AND ACOUSTIC COUPLING MATERIALS, SYSTEMS, AND METHODS OF USE

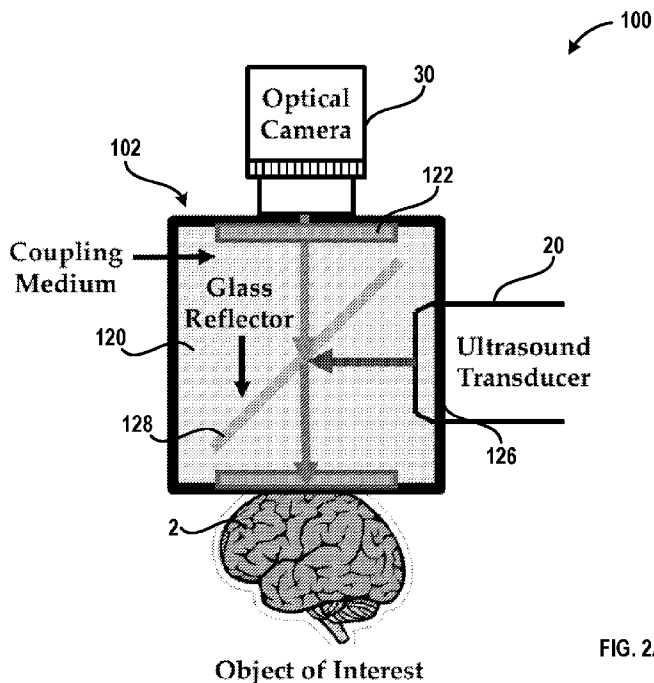


FIG. 2A

(57) Abstract: A system includes an adapter for a photoacoustic imaging system that includes a coupling media made from gellan gum, which exhibits improved acoustic and optical properties for facilitation of photoacoustic (PA) and pulse-echo (PE) imaging. The system is particularly aimed at improving imaging within a short-wave infrared (SWIR) frequency band. The coupling media can include deuterium oxide mixed with gellan gum for further improvement of PA and PE imaging. Validation studies are presented herein for comparison of gellan gum-based coupling media with currently-available coupling media.



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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/76492

## A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. A61B 8/00, A61B 5/00, G01S 15/02 (2024.01)

ADD.

CPC - INV. A61B 8/4281, A61B 8/4209, A61B 5/0095

ADD. A61B 2562/146

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y -- A	US 2015/0226845 A1 (THE ARIZONA BOARD OF REGENTS ON BEHALF OF THE UNIVERSITY OF ARIZONA); 13 August 2015 (13.08.2015); entire document, especially Abstract, Fig. 2a-b, para. [0124]-[0126].	1-3, 5-8, 10-11 ----- 4, 9
Y -- A	Ciofini, Daniele & Mencaglia, Andrea & Siano, Salvatore. (2018). A photoacoustic pulse-echo probe for monitoring surface stone mechanical properties: Validation tests in consolidation of Carrara marble. Construction and Building Materials. 187. 610-619.	1-3, 5-8, 10-11 ----- 4, 9
Y -- A	US 2012/0157837 A1 (NAGATA et al.); 21 June 2012 (21.06.2012); entire document.	1-3, 5 ----- 9
A	US 2020/0340954 A1 (SMITH et al.); 29 October 2020 (29.10.2020); entire document.	1-11
A	US 2019/0170695 A1 (THE BOARD OF REGENTS OF THE UNIVERSITY OF OKLAHOMA); 6 June 2019 (06.06.2019); entire document.	1-11
A	US 2017/0156600 A1 (HELMHOLTZ ZENTRUM MUENCHEN DEUTSCHES FORSCHUNGSZENTRUM etc.); 8 June 2017 (08.06.2017); entire document.	1-11

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/76492

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:  
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-11 directed to an adaptor for use with an ultrasonic probe.

Group II: Claims 12-20 directed to a coupling medium for use with an ultrasonic probe, and associated methods of fabrication.

-\*-Continued in extra sheet--\*

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-11

### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

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

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

**SPECIAL TECHNICAL FEATURES**

The invention of Group I includes the special technical features of a photoacoustic adapter for real-time optical monitoring using ultrasound, including: a coupling medium chamber defining: a first optical window along a proximal portion of the coupling medium chamber; a second optical window along a distal portion of the coupling medium chamber and configured to contact a surface of an object of interest, the second optical window being defined opposite from the first optical window, the first optical window and the second optical window being coaligned along a first axis; an ultrasound transducer port configured to engage an ultrasonic probe; [a coupling medium] disposed within the coupling medium chamber, a prism element disposed within the coupling medium chamber and configured to direct acoustic emissions from the ultrasonic probe towards the object of interest in alignment with the first axis; wherein a response of the object of interest to the acoustic emissions is observable by an optical sensor aligned with the first optical window, not required in Group II.

The invention of Group II includes the special technical features of [the coupling medium] comprising gellan gum, not required in Group I.

**COMMON TECHNICAL FEATURES**

The inventions of Groups I-II share the technical features of a coupling medium for use with an ultrasonic probe, the coupling medium comprising a gelling agent. The common technical features are known in prior art as shown in US 2016/019902.6 A1 to Theracision (hereinafter 'Theracision'). Therefore, Groups I-II lack unity since the shared technical features do not represent a contribution over Theracision which teaches a coupling medium for use with an ultrasonic probe (coupling liquid for ultrasound devices, Abstract), the coupling medium comprising a gelling agent (coupling liquid comprising at least one hydrophilic polymer, Abstract; "hydrophilic polymer" as understood herein means a polymer which has a sufficient affinity to water as to dissolve therein or to form a gel with it, para. [0015]).

As the common features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

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