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(54) Title: SIGNAL PROCESSING METHODS FOR AN OPTICAL DETECTION SYSTEM

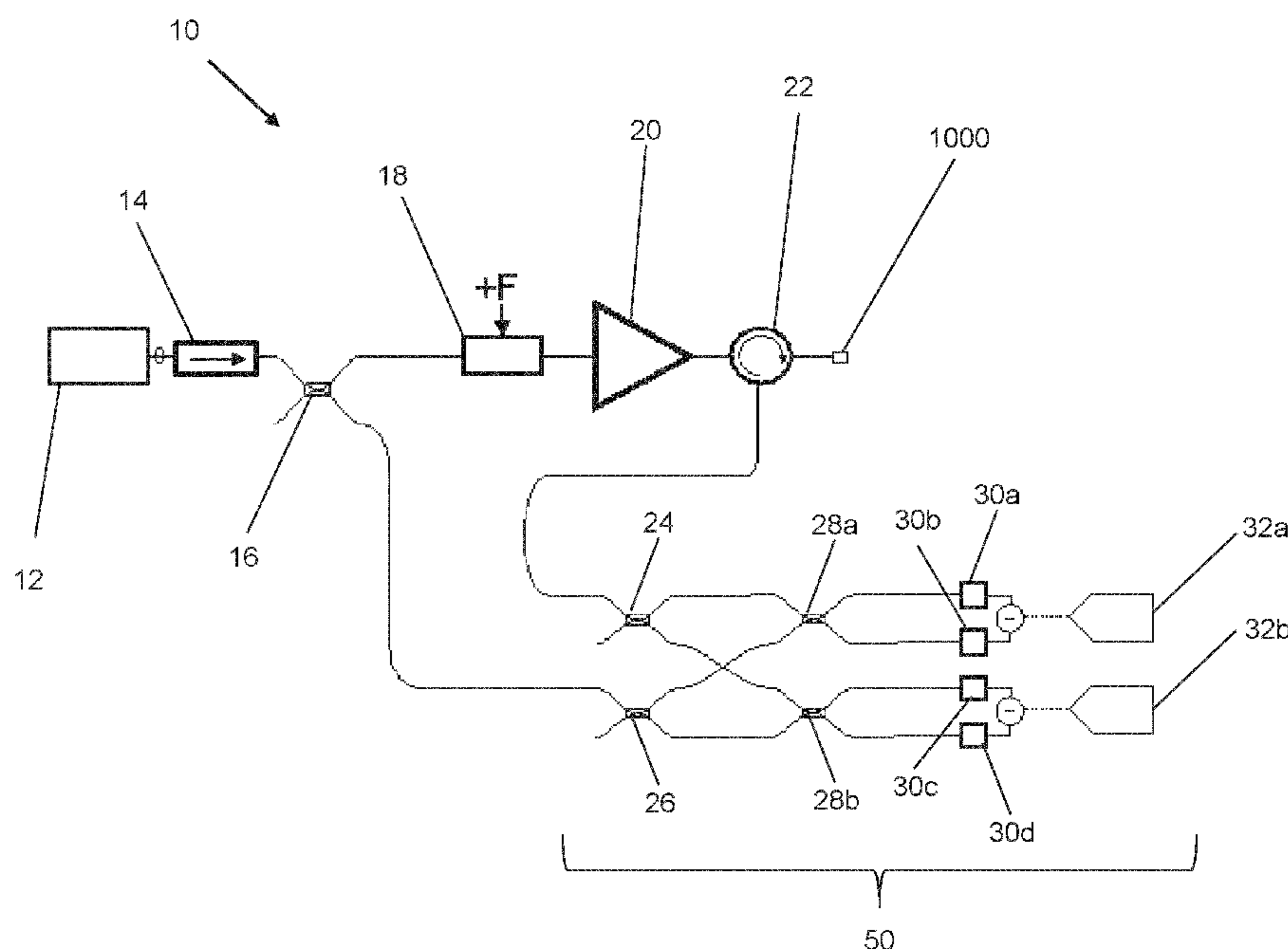


Fig. 1

(57) Abstract: The invention provides a signal processing method for a distributed acoustic sensing system (DAS), where a scattered signal that was scattered at a scattering location along an optical path is received and interfered with a local oscillator signal to generate a first carrier signal that is modulated by a phase difference between the local oscillator signal and the scattered signal. The first carrier signal is then digitally processed in order to generate a second carrier signal that is modulated by a spatial differential of the phase difference. The spatial differential of the phase difference is directly related to the strain (or acoustic environment) of the optical path at the scattering location, and so enables the strain at the scattering location to be estimated.

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INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. G01H9/00 G01D5/353
ADD. G01L1/24

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)
G01H G01D G01L H04B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/067118 A1 (HARTOG ARTHUR [GB] ET AL) 22 March 2012 (2012-03-22) figures 1-3,7,8 paragraphs [0027] - [0035], [0039], [0041] - [0043], [0063] - [0067], [0078] -----	1-23
A	US 2006/066839 A1 (PAYTON ROBERT M [US]) 30 March 2006 (2006-03-30) figures 1-3,6,7,12 paragraphs [0054], [0060], [0064], [0077] - [0080], [0082], [0093] - [0095], [0099] - [0101] paragraphs [0108] - [0112], [0114] - [0117], [1024], [0125], [0128] - [0130] paragraphs [0143], [0144], [0148] - [0150] ----- - / - -	1-23



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

6 April 2021

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16/04/2021

Name and mailing address of the ISA/

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	W0 2018/134137 A1 (FOCUS SENSORS LTD [GB]) 26 July 2018 (2018-07-26) figures 1-7,9-12 paragraphs [0002] - [0006], [0008], [0014], [0015], [0023], [0025], [0035], [0038] paragraphs [0044], [0045], [0059] - [0067], [0081] - [0102] -----	1-23
A	US 2018/259385 A1 (CEDILNIK GREGOR [DE]) 13 September 2018 (2018-09-13) figures 1-5 paragraphs [0047] - [0052], [0086] - [0090], [0094], [0095], [0098], [0102] -----	1-23
A	EP 2 053 364 A1 (OPTOPLAN AS [NO]) 29 April 2009 (2009-04-29) figures 1-7 paragraphs [0003], [0004], [0009], [0010], [0015] - [0018], [0036] - [0038] paragraphs [0053] - [0058], [0061] - [0067] -----	1-23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2020/078090

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:

see additional 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 an 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.:

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20(completely); 22, 23(partially)

A signal processing method for a distributed acoustic sensing system comprising: generating, based on an interference of the scattered signal and the local oscillator signal, a first complex carrier signal that is modulated by a phase difference between the local oscillator signal and the scattered signal; processing the first complex carrier signal to generate a second complex carrier signal that is modulated by a spatial differential of the phase difference, the spatial differential being taken along a length of the optical path.

2. claims: 21(completely); 22, 23(partially)

A signal processing method for a distributed acoustic sensing system comprising: for each of two or more of the scattered signals in the set of scattered signals, generating, based on an interference of that scattered signal and the local oscillator signal, a first complex carrier signal associated with that scattered signal, the first complex carrier signal being modulated by a phase difference between the local oscillator signal and that scattered signal; representing the first complex carrier associated with that scattered signal as a phasor; determining a reference phasor associated with that scattered signal, based on a time average of the phasor; rotating the phasor by an angle corresponding to a difference between a common reference phasor and the reference phasor associated with that scattered signal; wherein the common reference phasor is determined based on a sum of the reference phasors determined for the two or more scattered signals; summing the rotated phasors to generate a second complex carrier signal.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/078090

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