



(51) International Patent Classification:

E21B 47/107 (2012.01) *E21B 47/135* (2012.01)
E21B 41/00 (2006.01)

(21) International Application Number:

PCT/EP2019/082809

(22) International Filing Date:

27 November 2019 (27.11.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

PCT/EP2018/082985

29 November 2018 (29.11.2018) EP

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: EVENT DETECTION USING DAS FEATURES WITH MACHINE LEARNING

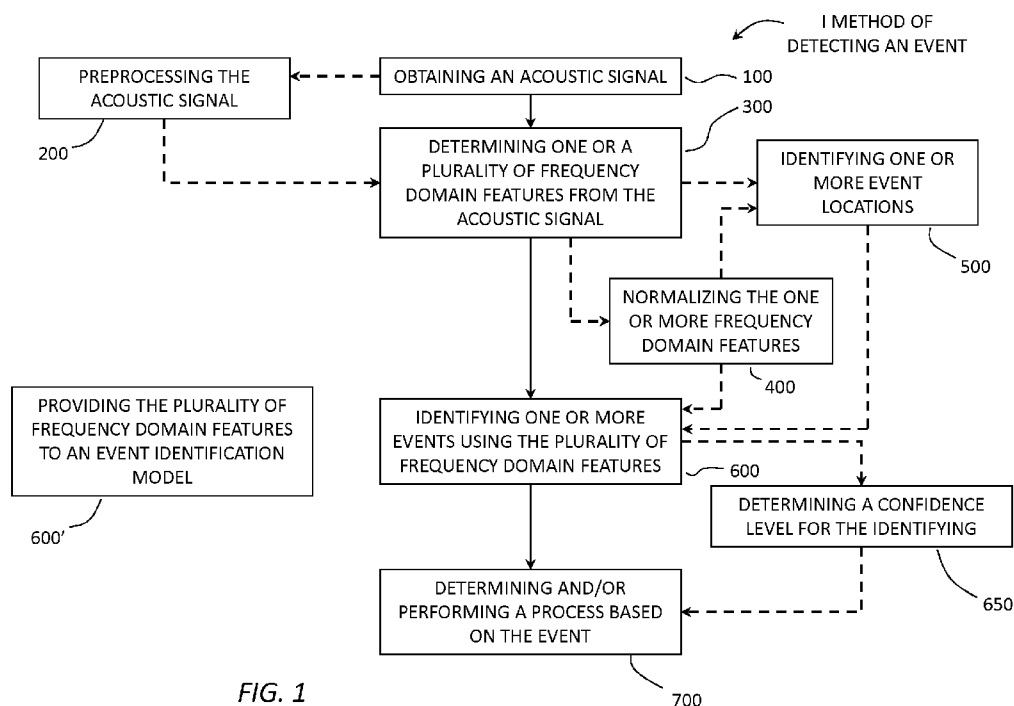


FIG. 1

(57) Abstract: A method of identifying events includes obtaining an acoustic signal from a sensor, determining one or more frequency domain features from the acoustic signal, providing the one or more frequency domain features as inputs to a plurality of event detection models, and determining the presence of one or more events using the plurality of event detection models. The one or more frequency domain features are obtained across a frequency range of the acoustic signal, and at least two of the plurality of event detection models are different.

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:

09 July 2020 (09.07.2020)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/082809

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B47/107 E21B41/00 E21B47/135
ADD.

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)
E21B

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.
X	WO 2017/174746 A1 (BP EXPLORATION OPERATING [GB]) 12 October 2017 (2017-10-12) paragraphs [0026], [0059], [0060], [0062], [0063], [0068], [0071], [0080], [0097] paragraphs [0103], [0104], [0117], [0131], [0132]; figures 1-10 ----- -/--	1-5, 7-11, 13-17, 19-22, 24,26-29



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

20 May 2020

Date of mailing of the international search report

29/05/2020

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2019/082809

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2019/072899 A2 (BP EXPLORATION OPERATING COMPANY LTD [GB]) 18 April 2019 (2019-04-18) Paragraphs 1-9, 16 starting on page 9; paragraphs [0055], [0056], [0070], [0082], [0127]; figures 1, 9, 10 -----	1,3,4, 6-10, 13-16, 18-21, 24, 26-28,30
X	WO 2016/115030 A1 (HALLIBURTON ENERGY SERVICES INC [US]; LU YINGHUI [US] ET AL.) 21 July 2016 (2016-07-21) paragraphs [0022] - [0024], [0031], [0032], [0035] - [0039], [0042], [0043], [0048]; figures 1, 4A, 5B, 8, 11 -----	1-5, 7-17, 19-29, 31-35, 37-44
X	EP 3 006 908 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 13 April 2016 (2016-04-13) paragraphs [0006], [0007], [0063], [0064], [0124] - [0134], [0234]; figures 1-10 -----	1,4, 6-10,13, 14,16, 18-21,24
X	US 2017/119255 A1 (MAHAJAN AMAN [US] ET AL) 4 May 2017 (2017-05-04) paragraphs [0012], [0051] - [0058], [0060] - [0063], [0074]; figure 2 -----	1,4, 7-10, 12-14, 16, 19-21, 23,24
X	Tatiana Silkina: "Application of Distributed Acoustic Sensing to Flow Regime Classification", 30 June 2014 (2014-06-30), XP055604509, Retrieved from the Internet: URL:https://core.ac.uk/download/pdf/52098723.pdf [retrieved on 2019-07-11] Chapters 2.5-2.7,2.7.4, 3, 5 and 6 ----- -/--	31,32, 37,38,44

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/082809

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Christopher L Stokely ET AL: "SPE-179151-MS Acoustics-Based Flow Monitoring During Hydraulic Fracturing", 9 February 2016 (2016-02-09), XP055338190, Retrieved from the Internet: URL:https://www.onepetro.org/download/conference-paper/SPE-179151-MS?id=conference-paper/SPE-179151-MS [retrieved on 2017-01-24] Headings "Abstract", "Experimental Setup", "Deriving Anaalytic Models Using Symbolic Regression", "Conclusions" -----	31-44

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2019/082809

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: 1-30

Method and system to identify events

2. claims: 31-44

Method of developing an event identification model

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/082809

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2017174746 A1	12-10-2017	AU 2017246520 A1	18-10-2018
		AU 2017246521 A1	25-10-2018
		CA 3020007 A1	12-10-2017
		CA 3020223 A1	12-10-2017
		EP 3440313 A1	13-02-2019
		EP 3440314 A2	13-02-2019
		WO 2017174746 A1	12-10-2017
		WO 2017174750 A2	12-10-2017
WO 2019072899 A2	18-04-2019	AU 2018350092 A1	14-05-2020
		WO 2019072899 A2	18-04-2019
WO 2016115030 A1	21-07-2016	BR 112017013331 A2	10-04-2018
		EP 3215712 A1	13-09-2017
		US 2018010443 A1	11-01-2018
		WO 2016115030 A1	21-07-2016
EP 3006908 A1	13-04-2016	CN 105452822 A	30-03-2016
		EP 3006908 A1	13-04-2016
		KR 20140143069 A	15-12-2014
		US 2016150338 A1	26-05-2016
		WO 2014196836 A1	11-12-2014
US 2017119255 A1	04-05-2017	AU 2015259002 A1	10-11-2016
		CA 2947476 A1	19-11-2015
		CN 106456017 A	22-02-2017
		EP 3142546 A1	22-03-2017
		JP 6678118 B2	08-04-2020
		JP 2017521106 A	03-08-2017
		KR 20170007286 A	18-01-2017
		US 2017119255 A1	04-05-2017
		WO 2015175904 A1	19-11-2015