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(54) Title: SYSTEM AND METHOD FOR IDENTIFICATION, GROUPING AND SIZING OF EMBEDDED FLAWS IN ROTOR COMPONENTS USING ULTRASONIC INSPECTION

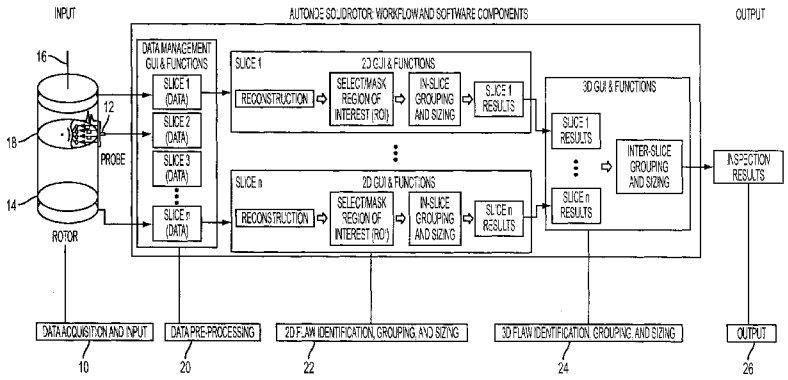


FIG. 1

(57) Abstract: A method and software system for flaw identification, grouping and sizing for fatigue life assessment for rotors used in turbines and generators. The method includes providing ultrasonic data of a plurality of rotor slices and providing volume reconstruction of the ultrasonic data. The method also includes providing in-slice identification, grouping and sizing of flaw indications in the rotor based on the volume reconstruction. Further, the method includes providing inter-slice identification, grouping and sizing of the flaw indications based on the in-slice flaw indications and providing flaw location and size information. The method can be used in both phased-array and A-scan inspections.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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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)
G01N G06T

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, INSPEC, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/109627 A1 (ZHANG JINGDAN [US] ET AL) 12 May 2011 (2011-05-12)	1,2, 7-12, 15-20
A	abstract; figures 2a, 2b,4-7 paragraphs [0002], [0024] - [0027], [0034], [0047], [0051], [0057]	5
X	US 3 981 184 A (MATAY ISTVAN M) 21 September 1976 (1976-09-21) abstract; figures 1,2 column 3, line 4 - column 5, line 29 column 5, line 53 - column 6, line 13	1,3-6,8, 12-14, 16,20

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[X] Further documents are listed in the continuation of Box C.

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 August 2014	02/09/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Filipas, Alin

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/010420

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011/113885 A1 (UEDA YOSHIO [JP] ET AL) 19 May 2011 (2011-05-19) abstract; figure 7 paragraphs [0004], [0045] - [0048], [0054] - [0057]	1,2,12, 20
Y	US 2008/245150 A1 (KATAYAMA MASAHIRO [JP] ET AL) 9 October 2008 (2008-10-09) paragraphs [0054], [0059], [0061], [0062], [0072], [0074], [0098], [0099]; figure 10	1,2,12, 20
X	US 5 275 052 A (LUTTRELL MICHAEL G [US] ET AL) 4 January 1994 (1994-01-04) abstract column 4, line 65 - column 5, line 9 column 6, lines 19-58 column 7, lines 14-20, 55-62	1-4, 12-14,20
X	JP 2006 275977 A (DAT JAPAN KK; NIKKO KENSA SERVICE KK; TECHNOVA KK; HITACHI SOFTWARE EN) 12 October 2006 (2006-10-12) abstract	1,3-6, 12-14,20
A	HUANG R ET AL: "Visualizing industrial CT volume data for nondestructive testing applications", VIS 2003. IEEE VISUALIZATION 2003. PROCEEDINGS. SEATTLE, WA, OCT. 19 - 24, 2003; [ANNUAL IEEE CONFERENCE ON VISUALIZATION], NEW YORK, NY : IEEE, US, 1 January 2003 (2003-01-01), pages 547-554, XP031173543, DOI: 10.1109/VISUAL.2003.1250418 ISBN: 978-0-7803-8120-9 paragraph [1.Introduction] paragraph [2.Driving.Application] paragraph [3.2.Region.Growing.Methods] paragraph [3.2.2.Criteria.Selection]	1,5,7, 12,15,20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/010420

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: 2(completely); 1, 12, 20(partially)

   A method for the ultrasonic inspection of a rotor, comprising the steps of providing ultrasonic data of a plurality of rotor slices, providing volume reconstruction of the ultrasonic data, providing in-slice identification, grouping and sizing of flaw indications in the rotor based on the volume reconstruction, providing inter-slice identification, grouping and sizing of flaw indications based on the in-slice flaw indications, and providing flaw location and size information, wherein a phased array probe is used for obtaining the ultrasonic data.

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2. claims: 3-6, 13, 14(completely); 1, 12, 20(partially)

   A method for the ultrasonic inspection of a rotor, comprising the steps of providing ultrasonic data of a plurality of rotor slices, providing volume reconstruction of the ultrasonic data, providing in-slice identification, grouping and sizing of flaw indications in the rotor based on the volume reconstruction, providing inter-slice identification, grouping and sizing of flaw indications based on the in-slice flaw indications, and providing flaw location and size information, wherein a predefined threshold is used for locating data points in the volume reconstruction.

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3. claims: 7-11, 15-19(completely); 1, 12, 20(partially)

   A method for the ultrasonic inspection of a rotor, comprising the steps of providing ultrasonic data of a plurality of rotor slices, providing volume reconstruction of the ultrasonic data, providing in-slice identification, grouping and sizing of flaw indications in the rotor based on the volume reconstruction, providing inter-slice identification, grouping and sizing of flaw indications based on the in-slice flaw indications, and providing flaw location and size information, wherein specific techniques (such as generating flaw clusters, defining a flaw area, grouping according to shape) are used for providing identification, grouping and sizing of flaw indications.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2014/010420

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011109627 A1	12-05-2011	NONE	
US 3981184 A	21-09-1976	NONE	
US 2011113885 A1	19-05-2011	AR 071647 A1	07-07-2010
		CA 2718297 A1	01-10-2009
		CN 102016566 A	13-04-2011
		EP 2259055 A1	08-12-2010
		JP 4491800 B2	30-06-2010
		JP 2009236668 A	15-10-2009
		US 2011113885 A1	19-05-2011
		WO 2009119539 A1	01-10-2009
US 2008245150 A1	09-10-2008	CN 1985165 A	20-06-2007
		CN 101477085 A	08-07-2009
		EP 1757928 A1	28-02-2007
		JP 4564286 B2	20-10-2010
		JP 2005351864 A	22-12-2005
		KR 20070027702 A	09-03-2007
		US 2008245150 A1	09-10-2008
		WO 2005121771 A1	22-12-2005
US 5275052 A	04-01-1994	NONE	
JP 2006275977 A	12-10-2006	NONE	