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- (71) Applicant (for all designated States except US): **LUNA INNOVATIONS INCORPORATED** [US/US]; 1 Riverside Circle, Roanoke, VA 24016 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **FROGGATT, Mark, E.** [US/US]; 1751 Brush Mountain Creek Road, Blacksburg, VA 24060 (US). **GIFFORD, Dawn, K.** [US/US]; 2175 Craig Creek Road, Blacksburg, VA 24060 (US).
- (74) Agent: **LASTOVA, John, R.**; Nixon & Vanderhye P.C., 901 North Glebe Road, 11th Floor, Arlington, VA 22203-1808 (US).

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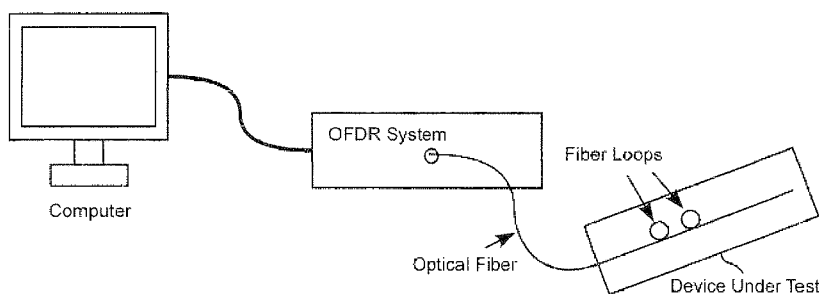


Fig. 11A

(57) Abstract: One or more mechanical parameters of a structure subjected to a force or condition are measured using distributed, optical fiber sensing technology. At least a curved portion an optical fiber having is attached to an object. A distributed, optically-based, strain sensing technique is used to determine strain information associated with multiple points along the curved portion of the fiber. The determined strain information is processed to generate one or more representations of one or more of the following: an expansion of the object, a thermal gradient associated with the object, or a stress- induced strain at multiple locations on the object corresponding to ones of the multiple points. An output is generated corresponding to the representation.

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A. CLASSIFICATION OF SUBJECT MATTER**G01B 11/16(2006.01)i, G01L 1/24(2006.01)i**

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)

G01B 11/16; E21B 47/06; G02F 1/295; G02B 6/34; G01I 3/00; G01N 21/00; G02B 6/00; E21B 17/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords:optical fiber, strain, multiple point

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DANIEL C. BETZ et al.`Advanced Layout of a Fiber Bragg Grating Strain Gauge Rosette` JOURNAL OF LIGHTWAVE TECHNOLOGY, VOL.24, NO.2, FEBRUARY 2006, pages 1019-1026, IEEE 0733-8724.	1,4,5,7,14
A	See page 1, column 1, line 24 - page 7, column 2, line 37	2,3,6,8-13,15-22
X	US 6586722 B1 (KENNY; ROBERT PATRICK et al.) 01 July 2003	1,14
A	See column 1, line 19 - column 11, line 12 and figures 1-15.	2-13,15-22
A	US 2007-0284112 A1 (SYLVAIN MAGNE et al.) 13 December 2007 See page 3, column 2, line 25 - page 9, column 1, line 30 and figures 2A, 2B, 3A, 3B.	1-22
A	US 2007-0201793 A1 (CHARLES ASKINS et al.) 30 August 2007 See page 2, column 2, line 38 - page 5, column 2, line 4 and figure 1.	1-22
A	US 7440087 B2 (FROGGATT MARK EARL et al.) 21 October 2008 See column 3, line 40 - column 8, line 30 and figures 4, 5, 6, 7.	1-22

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

* Special categories of cited documents:

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Authorized officer

KIM, Yong Ahn

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6586722 B1	01.07.2003	AT 252725 T	15.11.2003
		CA 2336193 A1	18.05.2000
		CA 2336193 C	06.11.2007
		DE 69912301 D1	27.11.2003
		DE 69912301 T2	29.07.2004
		DK1129327T3	01.03.2004
		EP 1129327 A1	05.09.2001
		EP 1129327 B1	22.10.2003
		ES 2209522 T3	16.06.2004
		GB 9824756 D0	06.01.1999
		JP 03-648454 B2	18.05.2005
		JP 2002-529728 A	10.09.2002
		JP 2002-529728 T	10.09.2002
		JP 2002-529728 T	10.09.2002
		N020006354A	23.02.2001
		N020006354D0	13.12.2000
		N0321905B1	17.07.2006
		PT1129327E	31.03.2004
		PT1129327T	31.03.2004
		WO 00-28294 A1	18.05.2000
US 2007-0284112 A1	13.12.2007	DE 602004005078 D1	12.04.2007
		DE 602004005078 T2	22.11.2007
		EP 1706714 A1	04.10.2006
		EP 1706714 B1	28.02.2007
		FR 2864202 A1	24.06.2005
		FR 2864202 B1	04.08.2006
		US 7703331 B2	27.04.2010
		WO 2005-064300 A1	14.07.2005
US 2007-0201793 A1	30.08.2007	None	
US 7440087 B2	21.10.2008	US 2005-219512 A1	06.10.2005