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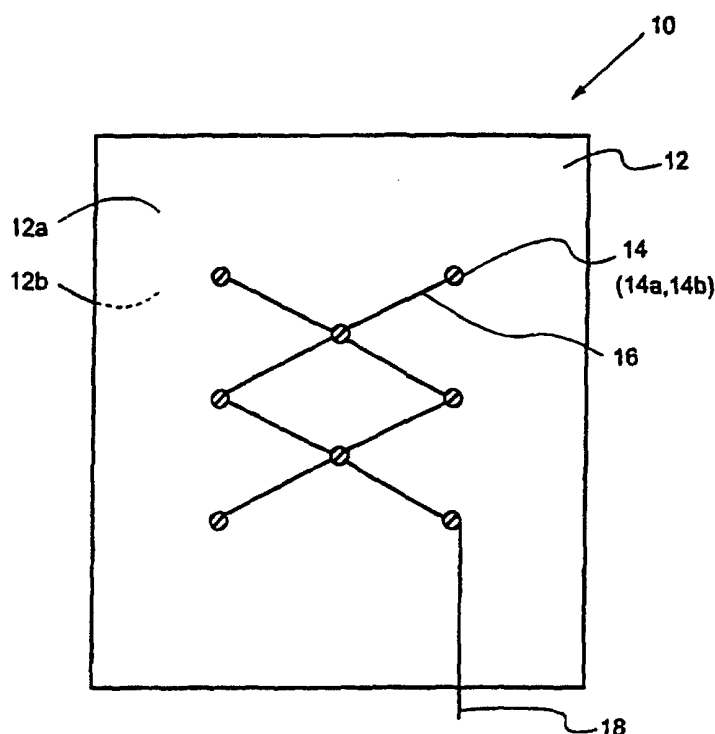
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- (51) International Patent Classification⁷: **G01B 5/30**, 7/16, G01L 1/22, 7/00 (72) Inventors: **CHANG, Fu-Kuo**; 739 San Rafael Place, Stanford, CA 94305 (US). **LIN, Mark**; 450 El Escarpada Way, Stanford, CA 94305 (US).
- (21) International Application Number: PCT/US00/41839 (74) Agent: **ALBOSZTA, Marek**; 45 Cabot Avenue, Suite 110, Santa Clara, CA 95051-6670 (US).
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[Continued on next page]

(54) Title: DIAGNOSTIC LAYER AND METHODS FOR DETECTING STRUCTURAL INTEGRITY OF COMPOSITE AND METALLIC MATERIALS



(57) Abstract: A diagnostic layer (10) having a network of actuators and sensors (14) may be incorporated into or on the surface of composite, metallic, and laminated materials (12) for monitoring the structural health of the material. The diagnostic layer (10) is adapted for detecting and measuring changes in the condition of the material, e.g., the site and extent of damage in the material. In a preferred embodiment, piezoelectric devices are embedded in the diagnostic layer in a network, and serve as actuators and sensors. Signals emitted from the sensors in response to physical deformation, either by an impact or as a result of stress waves generated (10) by actuators, are diagnostic of the current condition of the diagnostic layer. The diagnostic layer is also adapted to monitor the curing process of a composite material and accurately determine when curing is complete. Methods for monitoring changes in conditions of a material are also disclosed.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/41839

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G01B 5/30, 7/16, G01L 1/22, 7/00
US CL : 73/760, 763, 767, 772, 855, 862.41, 862.046

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)

U.S. : 73/760, 763, 767, 772, 855, 862.41, 862.046

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)

EAST

search terms: layer, actuator, sensor, composite, metallic, diagnostic, damage, curing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,978,731 A (REEDER et al) 07 September 1976 (07.09.1976), see claim 1 and figures 1-4	1-4
A	US 4,359,720 A (CHAI et al) 16 November 1982 (16.11.1982), see the entire patent.	1-23
A	US 4,843,891 A (BRUNNER, III et al) 04 July 1989 (04.07.1989), see the entire patent.	1-23
X	US 4,921,415 A (THOMAS, II et al) 01 May 1990 (01.05.1990), see claim 1.	24
Y	US 5,195,046 A (GERARDI et al) 16 March 1993 (16.03.1993), see the claims.	5-23 and 25
Y	US 4,779,452 A (COHEN-TENOUDJI et al) 25 October 1988 (25.10.1988), see the claims.	24-25

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"E" earlier document published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search

27 APRIL 2001

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INTERNATIONAL SEARCH REPORT

International application No.
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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international 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 II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Form PCT/ISA/206 - Chapter I - Invitation To Pay Additional Fee's, mailed 24 March 24, 2001. Applicant elected to pay additional fee's.

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 fee, this Authority did not invite payment of any additional fee.
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.
☐ No protest accompanied the payment of additional search fees.