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

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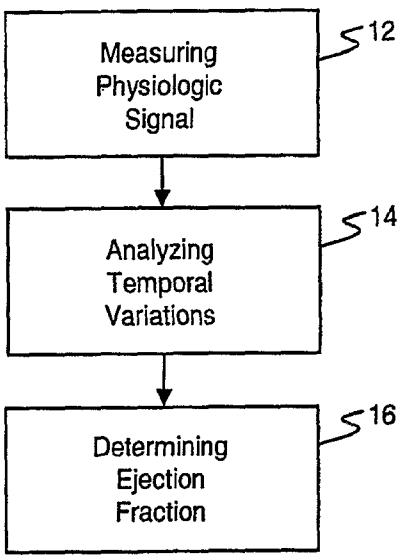
Declaration under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(88) Date of publication of the international search report:
6 November 2008

(54) Title: METHOD AND APPARATUS FOR DETERMINING EJECTION FRACTION



(57) Abstract: A method is provided for determining ejection fraction. The method includes: measuring a physiologic signal indicative of blood pressure; analyzing the physiologic signal at more than one time instance so as to extract information present in its temporal variations; and determining ejection fraction based in part on the extracted information

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A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/029 G06F17/00
ADD. A61B5/0215

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)
A61B G06F

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 practical, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/187481 A1 (HATIB FERAS [US] ET AL) 25 August 2005 (2005-08-25) paragraphs [0003], [0016], [0037], [0063], [0073], [0098], [0112] - [0114]	1-4,6, 8-10, 12-17, 19,20
Y	-----	18
X	US 5 086 776 A (FOWLER JR FRANKLIN S [US] ET AL) 11 February 1992 (1992-02-11) column 1, lines 5-10,50-58 column 6, lines 13-20 column 8, lines 65-67 column 9, lines 16-19 column 11, lines 30-33 column 12, line 25 - column 13, line 58	1,3,6,7, 11,21
Y	-----	18
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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

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

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"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
20 August 2008	25. 08. 2008

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gentil, Cédric

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Form PCT/ISA/210 (second sheet) (April 2005)

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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.
X	US 6 520 917 B1 (KUNIG SABINE VIVIAN [US] ET AL) 18 February 2003 (2003-02-18) column 3, lines 18,19 claims 1,4,11	1,3,5,12
A	US 5 450 850 A (IINUMA KAZUHIRO [JP]) 19 September 1995 (1995-09-19) the whole document	1-21
A	US 2003/109772 A1 (MILLS ALEXANDER K [US]) 12 June 2003 (2003-06-12) the whole document	1-21
X	SEGERS P ET AL: "Predicting systolic and diastolic aortic blood pressure and stroke volume in the intact sheep" JOURNAL OF BIOMECHANICS ELSEVIER UK, vol. 34, no. 1, January 2001 (2001-01), pages 41-50, XP002489273 ISSN: 0021-9290	22-30, 32-34, 38-41, 45-47, 58-87, 89-91, 95-98, 102,103, 115-140
Y	paragraphs [02.1] - [02.7]	31, 35-37, 42-44, 48-57, 88, 92-94, 99-101, 104-114
X	ELIE H. KARAM, ANTOINE B. ABCHE: "Left ventricular model using second order electromechanical coupling: effects of viscoelastic damping" PROCEEDINGS OF WORLD ACADEMY OF SCIENCE, ENGINEERING AND TECHNOLOGY, vol. 11, February 2006 (2006-02), pages 290-295, XP002489274 ISSN: 1307-6884 paragraph [00II]	22, 35-37, 47, 58-79, 92,94, 115-135, 138
Y		23-34, 38-46, 48-57, 80-91, 93, 95-114, 136,137, 139,140

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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.
X	EDWARD MARCUS, DAMIEN CRAIG, IRA CHEIFETZ: "Models of right ventricular shape and function" INTER JOURNAL, COMPLEX SYSTEMS, 2004, XP002489275 ISSN: 1081-0625 the whole document	22,47, 79,135, 138
Y		23-46, 48-78, 80-134, 136,137, 139,140
Y	MUKKAMALA R ET AL: "Continuous cardiac output monitoring by peripheral blood pressure waveform analysis" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING IEEE USA, vol. 53, no. 3, 1 March 2006 (2006-03-01), pages 459-467, XP002489276 ISSN: 0018-9294 column 2 page 459 - page 462	23-27, 42-44, 48-78, 80-84, 99-101, 104-134, 136,137
Y	THOMAS HELDT, EUN B. SHIM, ROGER D. KAMM, ROGER G. MARK: "Computational modeling of cardiovascular response to orthostatic stress" JOURNAL OF APPLIED PHYSIOLOGY, vol. 92, 2002, pages 1239-1254, XP002489277 ISSN: 8750-7587 page 1241, column 1	31,88

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INTERNATIONAL SEARCH REPORT

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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 allsearchable 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 reportcovers 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: 1-21

Method for determining ejection fraction using information present in temporal variations of a first physiologic signal indicative of blood pressure, said method comprising the step of measuring and analysing an additional physiological signal indicative of blood pressure.

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2. claims: 22-78,79-134,135-140

Apparatus and methods for determining ejection fraction using parameters estimated from a circulatory model allowing a physiological signal to be predicted.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/006454

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005187481 A1	25-08-2005	BR PI0416542 A	09-01-2007
		CA 2548592 A1	23-06-2005
		EP 1689294 A1	16-08-2006
		JP 2007512921 T	24-05-2007
		WO 2005055825 A1	23-06-2005
US 5086776 A	11-02-1992	AU 7463891 A	10-10-1991
		WO 9113589 A1	19-09-1991
US 6520917 B1	18-02-2003	NONE	
US 5450850 A	19-09-1995	JP 3392482 B2	31-03-2003
		JP 7124162 A	16-05-1995
US 2003109772 A1	12-06-2003	NONE	