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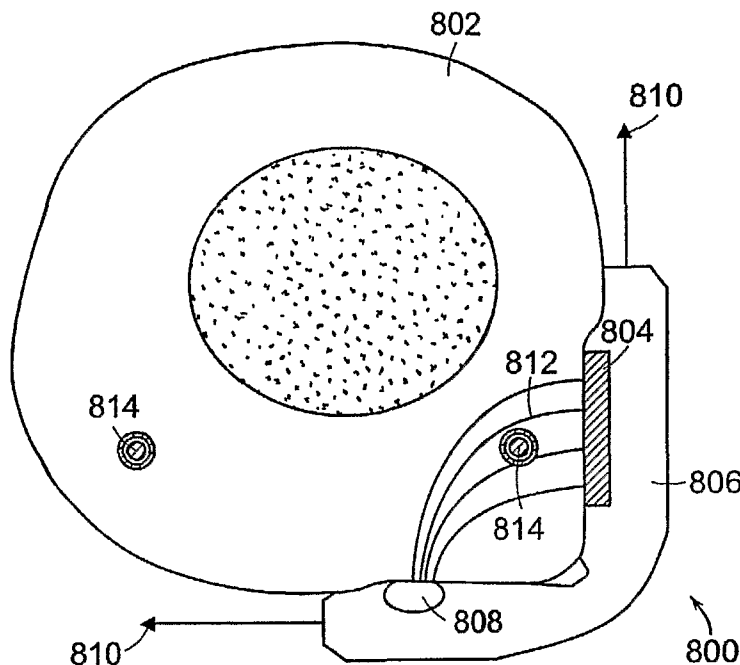
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(54) Title: WEARABLE BLOOD PRESSURE SENSOR AND METHOD OF CALIBRATION



(57) Abstract: Methods and apparatus for measuring arterial blood pressure at an extremity of a subject. Arterial blood pressure is derived from a circulatory measurement performed on an extremity of a subject and the circulatory measurement is normalized to account for the instantaneous vertical displacement of the extremity. The vertical displacement of the extremity relative to the heart of the subject is obtained using the angular orientation of the subject's extremity. An improved photoplethysmograph can discriminate light traversing the extremity from ambient light on the basis of differential response. The apparatus may have a conducting polymer actuator for applying pressure to the extremity of the subject. A pulsatile waveform from the photoplethysmographic signal may be obtained at a plurality of externally applied pressures to calibrate the photoplethysmograph.

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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/US2006/032601

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/022 A61B5/103 A61B5/0225

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 111 826 A (NASIFF ROGER E [US]) 12 May 1992 (1992-05-12)	1-3,5-28
Y	the whole document	4
A	WO 03/039326 A2 (MILLS ALEXANDER K [US]) 15 May 2003 (2003-05-15)	1-3,8, 16-18, 22,28
Y	page 13, line 24 - page 25, line 15; figures 2-21	4
A	WO 98/04182 A2 (ITAMAR MEDICAL C M 1997 LTD [IL]; GOOR DANIEL A [IL]; SCHNALL ROBERT P) 5 February 1998 (1998-02-05) the whole document	1,5,16, 17,19,28

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 document 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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2006/032601

Box 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 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 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.:

1-28

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- 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: 1-28

A method and a device having a plethysmographic sensor disposed on an extremity of a subject capable of sensing a plurality of plethysmographic signals at a plurality of heights and with an externally applied pressure, and a processor for deriving an arterial pressure.

2. claims: 29-34

A method for deriving arterial blood pressure from a circulatory measurement performed on an extremity of a subject, comprising: Calibrating the circulatory measurement as a function of vertical displacement of the extremity, acquiring an instantaneous vertical displacement of the extremity and normalizing the circulatory measurement.

3. claims: 35-48

A method and a device for measuring a height of a position on an extremity of a subject, comprising: Measuring acceleration due to gravity at a point on the extremity and inferring a height based at least upon the acceleration due to gravity and a temporal criterion.

4. claims: 49-52

A photoplethysmograph including a light source for illuminating a blood vessel of a subject, comprising: An array of photodetectors for detecting light from the light source traversing the blood vessel and a processor for discriminating light traversing the blood vessel from ambient light changes.

5. claims: 53-61

A device for modulating external pressure applied to an extremity of a subject, comprising: At least one conducting polymer actuator for modulating an external pressure, a pressure sensor for sensing the pressure applied and a processor for receiving signals from pressure sensor and controlling signal properties sent to the conducting polymer actuator.

6. claims: 62-70

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

A method for registering a photoplethysmograph for optimizing response, comprising: Illuminating with a light at a plurality of external pressures, modifying the drive characteristics of the light at each external pressure, detecting the light that has traversed the extremity, generating a plethysmographic signal and determining a maximum amplitude pulsatile waveform from the photoplethysmographic signal at each external pressure.

7. claims: 71-74

A wearable system for measuring blood pressure, comprising: A band for applying external pressure, a light source, a light detector for detecting light from the light source that has traversed the extremity, an accelerometer for measuring acceleration due to gravity and a processor for calculating the vertical displacement of the cuff and an arterial blood pressure.

8. claims: 75-77

A method for performing a circulatory measurement on a subject, comprising: Calibrating a plethysmographic signal of a plethysmographic sensor disposed on the subject so as to obtain a mapping of plethysmographic signal to arterial pressure and deriving a feature obtainable from a continuous arterial blood pressure on the basis of a measured plethysmographic signal.

9. claim: 78

A method for detecting differential volumetric pulsations of an artery, comprising: Applying a pressure by means of a protuberance and detecting volumetric pulsations with an optical sensor.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2006/032601

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