(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 June 2014 (26.06.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/094036 A1

(51) International Patent Classification:
A61B 5/0478 (2006.01)

(21) International Application Number:
PCT/AU2013/001441

(22) International Filing Date:
10 December 2013 (10.12.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2012271910 21 December 2012 (21.12.2012) AU

(71) Applicant: **EDANSAFE PTY LTD** [AU/AU]; Building 101, 2436 Moggill Road, Pinjarra Hills, Queensland 4069 (AU).

(72) Inventor: **SLOB, Jelmer, Jampal**; c/o EdenSafe Pty Ltd, Building 103C, 2436 Moggill Road, Pinjarra Hills, Queensland 4069 (AU).

(74) Agent: **SHELSTON IP**; Shelston Ip, Level 21, 60 Margaret Street, Sydney, New South Wales 2000 (AU).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: HEADWEAR MOUNTED BRAIN MONITORING SYSTEM

(57) Abstract: A brain monitoring system is mounted in a cap (2) having a head covering portion (1), a peak (3) and a sweatband (4). The sweatband (4) is provided with an array (5) of flexibly mounted, conductive, compressible sensors which transmit signals from separate zones of the wearer's forehead to a docking station (8) located beneath the peak (3) of the cap.

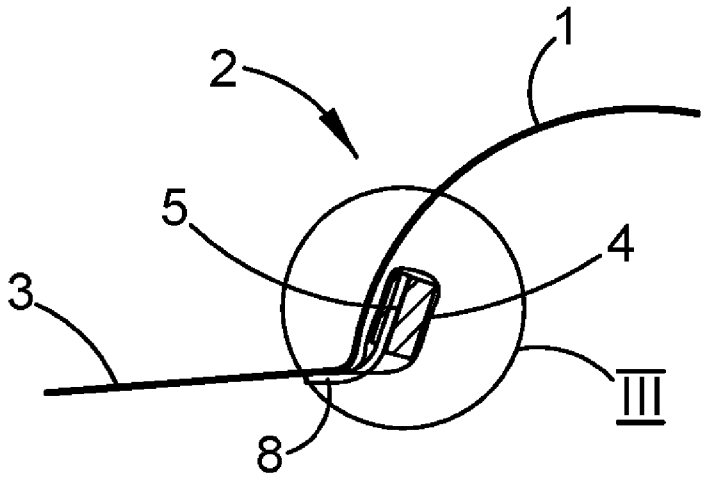

FIGURE 2

WO 2014/094036 A1

Headwear Mounted Brain Monitoring System

Field of the Invention

[0001] This invention relates to a headwear mounted brain monitoring system and has been devised particularly though not solely for monitoring fatigue patterns in the brainwaves of operators of heavy machinery.

Background of the Invention

[0002] In our earlier international patent application, PCT/AU2008/000919, we described and claimed a scalp potential measuring method and apparatus. The present invention has been made in order to provide a mechanism for conveniently implementing the scalp potential measuring method described in that specification by incorporating the sensors necessary to measure the brain waves of a user into an easy to wear cap or other headwear.

[0003] Although the headwear is described throughout the specification as a cap, and typically relates to a so-called baseball cap having a round headpiece and a forwardly extending peak, it will be appreciated that the invention can be incorporated into any other form of headwear having a sweatband in contact with the forehead of the wearer in use.

[0004] For example, in a mining situation where it is anticipated that the scalp potential measuring method could be utilized to detect the onset of fatigue in the operators of heavy machinery such as haul trucks, the driver of a haul truck may typically wear a baseball-type cap of the type referred to in this specification. In other applications, where the operator is required to wear a hardhat or some other form of protective headwear, the apparatus described and claimed in this application may also be incorporated into the sweatband of that headwear.

Summary of the Invention

[0005] Accordingly, the present invention provides a headwear mounted brain monitoring system including a cap or other headwear having a sweatband in contact with the forehead of the wearer in use, an array of discrete sensors located at spaced intervals within the sweatband, and an array of discrete bands of conductive embroidery each extending transversely across the sweatband in a vertical orientation in use such that electrical impulses from discrete regions on the forehead of a wearer are transmitted through adjacent

bands of conductive embroidery to the adjacent sensor without creating a cross connection from one sensor to another.

[0006] Preferably, the headband includes an elongate tube, horizontally orientated in use, and encompassing the sensor array, the bands of conductive embroidery being embroidered on the face of the elongate tube contacting the forehead of the wearer.

[0007] Preferably, a plurality of compressible pressure pads are located within the elongate tube, aligned with the sensors one to each, and wherein each pressure pad incorporates conductive thread arranged to transmit the electrical impulses from the adjacent bands of conductive embroidery to the adjacent sensor.

[0008] Preferably, the conductive thread encircles each pressure pad.

[0009] Alternatively, the conductive thread may be arranged to pass through each pressure pad.

[0010] Preferably, the compressible pressure pads comprise elastically deformable foam pads.

[0011] Preferably, the compressible pressure pads form part of a continuous array interconnected by thinner sections of elastically deformable foam.

[0012] Preferably, a further layer of elastically deformable foam is provided between the sensor array and the front face of the sweatband away from the forehead of the user.

[0013] In one form of the invention, the array of sensors in the sweatband is connected to a centrally disposed tail extending into a peak of the headwear in the form of a cap arranged such that a detachable processor is able to be plugged into the tail in the peak, and electrically connected to each sensor.

[0014] Preferably, the detachable processor is provided in the form of a signal processing card, which slots into a dock underneath the peak or brim of the cap.

[0015] In one form of the invention, the peak of the cap is provided in at least three sections flexibly connected to one another, there being at least one central section with side sections on either side, arranged such that the sections can flex relative to one another in

use allowing the sweatband to more closely conform to the shape of the forehead of the wearer.

[0016] Preferably, the detachable processor is located in a dock beneath the central section of the peak of the cap.

Brief Description of the Drawings

[0017] Notwithstanding any other forms that may fall within its scope, one preferred form of the invention will now be described by way of example only with reference to the accompanying drawings, in which:

[0018] Fig. 1 is a diagrammatic view of a sensor array with attached tail for use in a cap mounted brain monitoring system according to the invention;

[0019] Fig. 2 is a diagrammatic cross sectional view through a portion of the cap showing the sweatband within the encircled area;

[0020] Fig. 3 is an enlarged cross sectional view of the sweatband shown within circle III of Fig. 2;

[0021] Fig. 4 is a diagrammatic view of the inner surface of the sweatband of a cap mounted brain monitoring system according to the invention, showing the vertical bands of conductive embroidery;

[0022] Fig. 5 is an exploded horizontal cross section through the sensor array and adjacent compressible foam portions of the sweatband;

[0023] Fig. 6 is an assembled view of the sweatband components shown in Fig. 5;

[0024] Fig. 7 is a diagrammatic frontal view of a cap with a flexible peak adapted to incorporate the brain monitoring system according to the invention; and

[0025] Fig. 8 is a diagrammatic plan view of the cap shown in Fig. 7.

Preferred Embodiments of the Invention

[0026] In the preferred form of the invention, a cap mounted brain monitoring system will be described suitable to be incorporated into a cap of the so-called baseball cap style, but it will be appreciated that brain monitoring system can be mounted into any other headwear including but not limited to a hardhat, incorporating a sweatband in contact with the forehead of the wearer.

[0027] As can be seen in Fig. 2, the head covering portion 1 of a baseball-type cap 2 having a forwardly extending peak or brim 3 is provided with a sweatband 4 adapted to sit against and come into intimate contact with the forehead of a wearer in use.

[0028] The sweatband 4 incorporates a sensor array 5 which is shown in more detail in Fig. 1 and which typically incorporates a plurality of sensors 6 at spaced intervals within the sweatband. Each sensor is electrically connected through a tail 7 into a docking station shown diagrammatically at 8 located beneath the peak 3 of the baseball cap.

[0029] Each sensor 6 is arranged to read brainwave signals in the form of electrical impulses from discrete areas of the forehead of the wearer in the manner described in our earlier international patent application, PCT/AU2008/000919, the contents of which are incorporated herein by way of cross reference.

[0030] The difficulty in implementing the method of measuring brainwave activity and transmitting the impulses to a processor is overcome in the present invention by providing the sweatband in a specific configuration as will be described further below.

[0031] Turning now to Fig. 3, which is an enlarged cross section through the sweatband 4, it is noted firstly that the sweatband is provided in the form of an elongate tube 9. The elongate tube 9 surrounds the sensor array 5 on which are mounted foam pads 10 and 11 as will be described further below.

[0032] As can be seen in Figs. 5 and 6, a plurality of compressible pressure pads 10 are provided aligned with the sensors 6 one to each. The pressure pads 10 are typically formed in a continuous array interconnected by thinner sections 12 such that the array can be formed in a single piece from elastically deformable foam.

[0033] In order to provide some substance to the sweatband and to provide a good surface for the material of the cap 1 to sit against, the forward portion of the sweatband also incorporates a further layer of elastically deformable foam 11 provided between the sensor array 5 and the front face of the sweatband away from the forehead of the user as can be clearly seen in Fig. 3.

[0034] In order to conduct electrical impulses from the forehead of the wearer to each individual sensor 6 without cross connection or contamination from one area to the other, the inner surface 13 of the sweatband tube 9 is provided with an array of discrete bands 14 of conductive embroidery each extending transversely across the sweatband in a vertical orientation as can be seen in Fig. 4. In use, electrical impulses from discrete regions on the forehead of the wearer are transmitted through adjacent bands 14 of conductive embroidery to the adjacent sensor 6 without creating a cross connection from one sensor to another due to the fact that each band 14 of conductive embroidery is electrically separated from every other band.

[0035] To complete the electrical connection between the bands of conductive embroidery 14 and the sensor 6, each pressure pad 10 is electrically conductive. In one form this is provided by conductive thread 15 which either encircles each pressure pad or in the alternative, can be arranged to pass through each pressure pad between the inner surface 16 in contact with the bands of conductive embroidery 14 and the opposite surface 17 in contact with the adjacent sensor 6.

[0036] In this manner, electrical impulses from discrete regions on the forehead of a wearer are transmitted firstly through the discrete bands of conductive embroidery 14 in the inner face 13 of the tubular sweatband 9 to the conductive surface 16 of each pressure pad 10 and then through the conductive thread on each pressure pad 10 to the surface 17 in contact with the sensor 6.

[0037] It is a feature of the invention that due to the robust and flexible nature of each of the components, including the conductive embroidery bands 14 and the conductive threads 15, the entire cap is comfortable to wear and furthermore is readily able to be cleaned or washed as required. It is also a relatively inexpensive item to manufacture which enables frequent replacement of the cap without having to replace or refurbish expensive components.

[0038] This is facilitated by keeping the detachable processor in the form of a signal processing card (not shown) separate from the sensor array and typically located in a docking station 8 in the tail 7 of the sensor array, located beneath the central section of the peak 3.

[0039] This gives the advantages that the signal processing card (SP card) is charged in a separate unit. When the battery in the processor goes flat, the SP card is simply replaced, while the operator keeps using his own cap.

[0040] The individual cap belongs to each operator whereas the SP cards are interchangeable between caps so that they can used, or allocated, to any operator.

[0041] The cap itself, incorporating the sensor array, is washable and can be disposed once wear and tear begins to show on the fabric. Similarly, the electronics in the SP card are able to be recovered and recycled independently, as needed.

[0042] In order to facilitate good contact between the inner surface 13 of the sweatband 4 and the forehead of the user, the peak 3 of the cap can be provided in multiple sections flexibly connected to one another. This enables the peak or brim to flex which in turn enables the sweatband to more exactly conform to the forehead of the user.

[0043] This is shown diagrammatically in Figs. 7 and 8 where the peak or brim 3 has a central section 18 flexibly connected to side sections 19 on either side. This enables the outer edges 20 of the peak to flex upwardly and downwardly as shown by arrows 21 which in turn enables the sweatband 4 (Fig. 8) to move inwardly and outwardly at the ends as shown by arrows 22.

[0044] By allowing movement of the peak or brim in this manner, and consequent flexibility of the sweatband 4, the cap is more readily able to adapt to the exact forehead shape of the wearer which in turn enables intimate contact between the vertical embroidered bands 14 on the inner surface of the sweatband and the forehead of the user. This facilitates excellent conductivity between the discrete portions of the forehead of the user and the sensors 6.

Claims

1. A headwear mounted brain monitoring system including a headwear having a sweatband in contact with the forehead of the wearer in use, an array of discrete sensors located at spaced intervals within the sweatband, and an array of discrete bands of conductive embroidery each extending transversely across the sweatband in a vertical orientation in use such that electrical impulses from discrete regions on the forehead of a wearer are transmitted through adjacent bands of conductive embroidery to the adjacent sensor without creating a cross connection from one sensor to another.

2. A headwear mounted brain monitoring system as claimed in claim 1, wherein the headband includes an elongate tube, horizontally orientated in use, and encompassing the sensor array, the bands of conductive embroidery being embroidered on the face of the elongate tube contacting the forehead of the wearer.

3. A headwear mounted brain monitoring system as claimed in claim 2, wherein a plurality of conductive compressible pressure pads are located within the elongate tube, aligned with the sensors one to each.

4. A headwear mounted brain monitoring system as claimed in claim 3, wherein each pressure pad incorporates conductive thread arranged to transmit the electrical impulses from the adjacent bands of conductive embroidery to the adjacent sensor.

5. A headwear mounted brain monitoring system as claimed in claim 4, wherein the conductive thread encircles each pressure pad.

6. A headwear mounted brain monitoring system as claimed in any one of claims 3 to 5, wherein the compressible pressure pads comprise elastically deformable foam pads.

7. A headwear mounted brain monitoring system as claimed in claim 6, wherein the compressible pressure pads form part of a continuous array interconnected by thinner sections of elastically deformable foam.

8. A headwear mounted brain monitoring system as claimed in any one of the preceding claims, wherein the array of sensors in the sweatband is connected to a centrally disposed tail extending into a peak of the headwear in the form of a cap, and wherein a

detachable processor is able to be plugged into the tail in the peak, and electrically connected to each sensor.

9. A headwear mounted brain monitoring system as claimed in claim 8, wherein the peak of the cap is provided in at least three sections flexibly connected to one another, there being at least one central section with side sections on either side, arranged such that the sections can flex relative to one another in use allowing the sweatband to more closely conform to the shape of the forehead of the wearer.

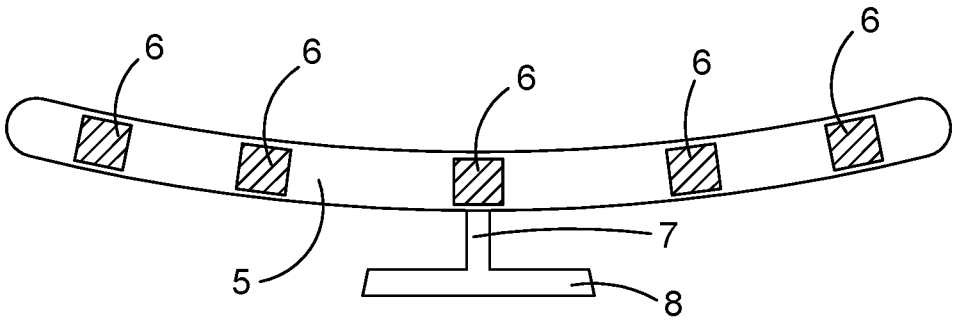

FIGURE 1

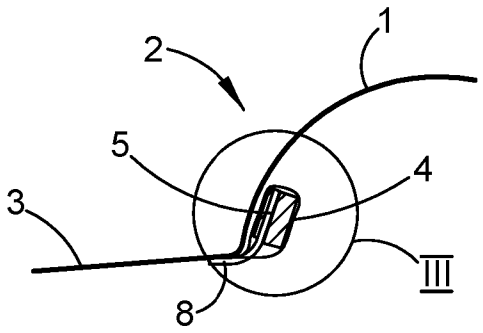

FIGURE 2

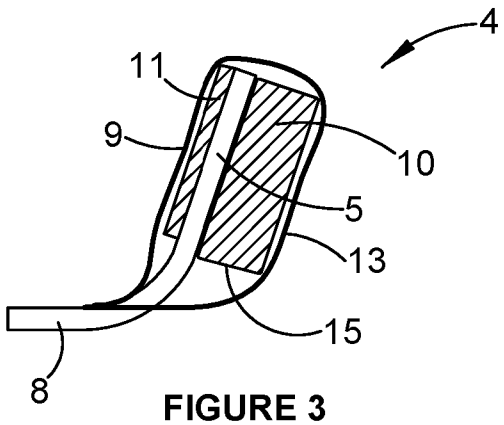

FIGURE 3

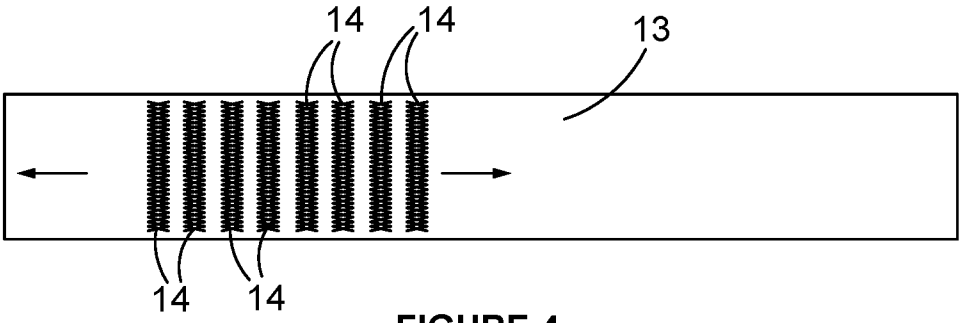

FIGURE 4

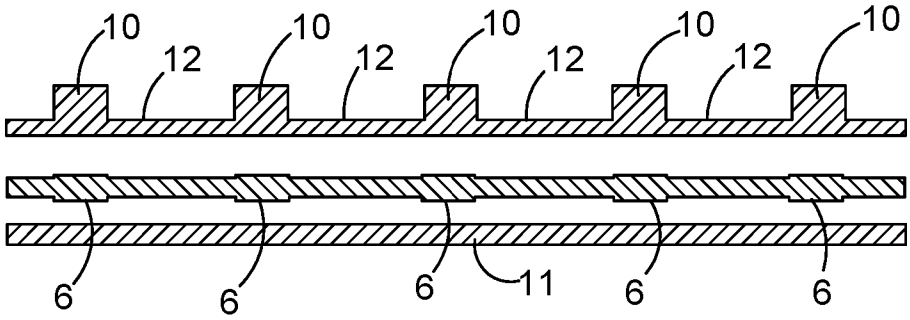

FIGURE 5

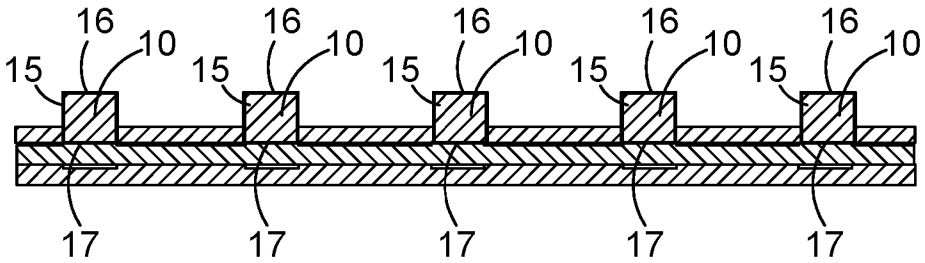

FIGURE 6

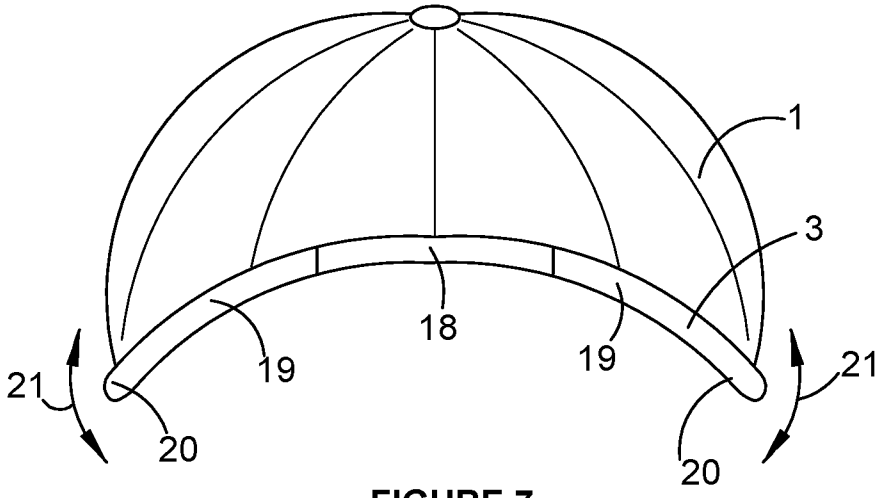

FIGURE 7

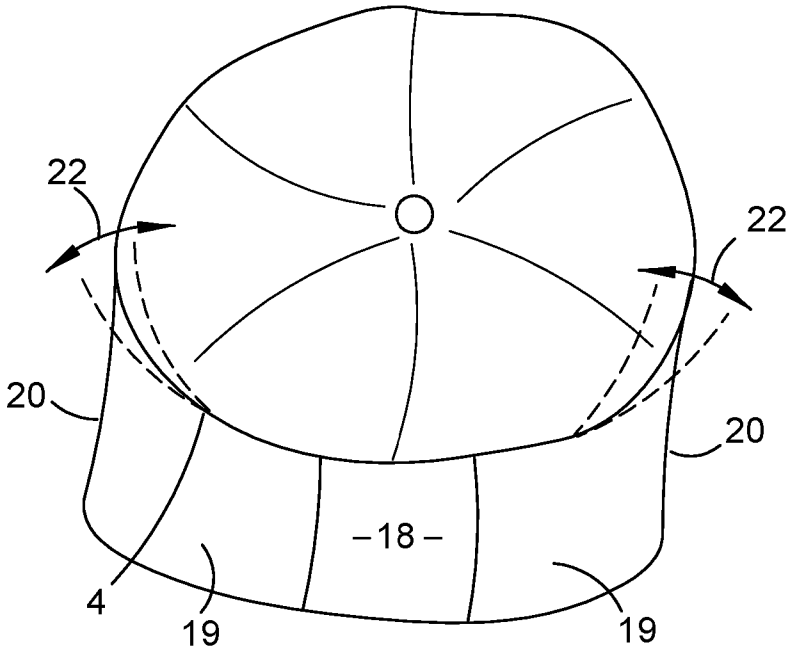

FIGURE 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2013/001441

A. CLASSIFICATION OF SUBJECT MATTER

A61B 5/0478 (2006.01)

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)

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)

EPODOC and WPI: IPC/CPC: A61B5/0476/LOW, A42B1, A42B3, A41D20; CPC: A61B2562/043, A61B2562/164, A61B5/6803, A61B5/6814/LOW, A61B5/6804/LOW, A61B5/0006, A61B5/02438; Keywords: brain, EEG, sensor, electrode, headwear, sweatband, headband, cap, forehead, fabric, textile; and like terms.

ESPACENET, GOOGLE PATENTS and GOOGLE: Keywords: headgear, headwear, brain, monitor, EEG, sensor, electrode, cap, forehead, headband, sweatband, dry, textile, fabric, Edansafe; and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[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

"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	Date of mailing of the international search report
11 February 2014	11 February 2014

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustralia.gov.au
Facsimile No.: +61 2 6283 7999

Authorised officer

Vivian Cheung
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0262832414

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2013/001441**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2407096 A1 (CECOTEPE ASBL) 18 January 2012 Fig. 1 and 2; paragraphs [0001-0002], [0010], [0015], [0017], [0023], [0028], [0031], [0033-0034]	1-9
X	US 2007/0249952 A1 (RUBIN et al.) 25 October 2007 Fig. 1-2B; paragraphs [0012], [0014], [0035-0036]	1-3, 6-9
A	WO 2009/013704 A2 (KONINKLIJKE PHILIPS ELECTRONICS N.V. et al.) 29 January 2009 Whole document	1-9
A	WO 2000/045701 A1 (ADVANCED BRAIN MONITORING, INC.) 10 August 2000 Whole document	1-9
A	WO 2011/055291 A1 (KONINKLIJKE PHILIPS ELECTRONICS N.V.) 12 May 2011 Whole document	1-9

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/001441**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
EP 2407096 A1	18 Jan 2012	EP 2407096 A1	18 Jan 2012
		EP 2593002 A1	22 May 2013
		US 2013172722 A1	04 Jul 2013
		WO 2012007384 A1	19 Jan 2012
US 2007/0249952 A1	25 Oct 2007	US 2006293608 A1	28 Dec 2006
		US 2007249952 A1	25 Oct 2007
		WO 2005084538 A1	15 Sep 2005
WO 2009/013704 A2	29 Jan 2009	EP 2173244 A2	14 Apr 2010
		JP 2010534502 A	11 Nov 2010
		US 2010324405 A1	23 Dec 2010
		WO 2009013704 A2	29 Jan 2009
WO 2000/045701 A1	10 Aug 2000	AU 3482000 A	25 Aug 2000
		AU 2002320527 A1	29 Jan 2003
		EP 1150605 A1	07 Nov 2001
		US 6161030 A	12 Dec 2000
		US 6381481 B1	30 Apr 2002
		US 2001044573 A1	22 Nov 2001
		US 6640122 B2	28 Oct 2003
		US 2002029005 A1	07 Mar 2002
		WO 0045701 A1	10 Aug 2000
		WO 03005897 A2	23 Jan 2003
WO 2011/055291 A1	12 May 2011	EP 2496135 A1	12 Sep 2012
		JP 2013509906 A	21 Mar 2013
		RU 2012122744 A	10 Dec 2013
		US 2012226127 A1	06 Sep 2012
		WO 2011055291 A1	12 May 2011

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.