



(51) International Patent Classification:

A61B 5/024 (2006.01) A61B 5/11 (2006.01)
A61B 5/0408 (2006.01) A61B 5/00 (2006.01)

(21) International Application Number:

PCT/EP2015/057066

(22) International Filing Date:

31 March 2015 (31.03.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

MI2014U000136 8 April 2014 (08.04.2014) IT

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(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, 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, ST, 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).

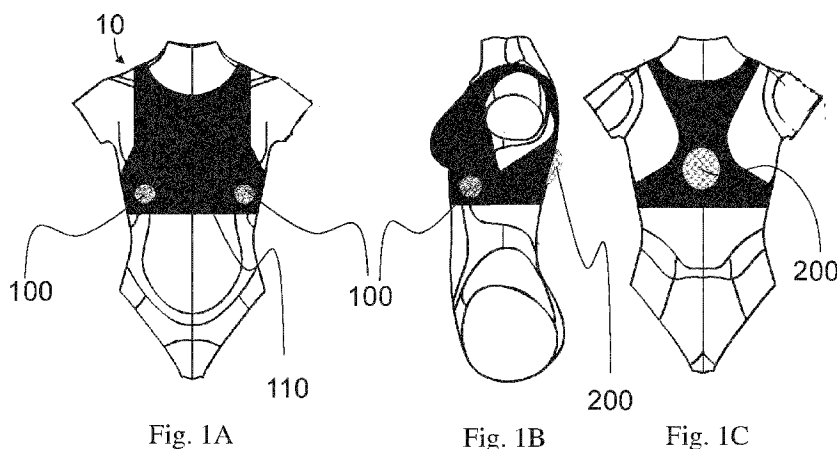
Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

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

(54) Title: WEARABLE SYSTEM FOR MONITORING A SWIMMER'S PERFORMANCE



(57) Abstract: The present invention relates to a wearable system for monitoring a swimmer's performance. In particular, it relates to a system composed of a garment comprising two or more heart rate and/or ECG signal sensors and a casing placed on the back portion of the garment comprising a movement detection inertial system comprising an accelerometer, a heart rate and/or ECG signal detection circuit, a microprocessor for analysing the data from said heart rate and/or ECG signal detection sensors, and a transmitter for sending said data to a receiver unit.

“WEARABLE SYSTEM FOR MONITORING A SWIMMER'S PERFORMANCE”**DESCRIPTION**

The present invention relates to a wearable system for monitoring a swimmer's performance. In particular, the present invention relates to a system composed of a sensor-fitted garment and a device coupled thereto, capable of providing data about the heart rate, movement and acceleration of the swimmer wearing it. The present invention is intended, therefore, to be used mainly by the user during swimming practice in order to improve his or her performance and increase fitness, or to measure the effects of a water-based rehabilitation therapy.

Swimming is a widely-practiced sport in our society, since it is an all-round sport that, compared to many other sports, moves the whole body and trains a wide range of muscles, which is why it is often recommended for children and people with particular back problems involving the muscles and bones.

At the same time, swimming does not require any costly equipment, but rather only a costume, a pair of goggles and a swimming cap.

The sport's popularity can also be attributed to the large number of sporting events that feature it, for example the Olympic Games, where swimming is one of the major sports and one of those most followed by the public.

These and other factors have helped to create a large number of amateur and semi-amateur swimmers who practice and follow the sport regularly.

In most cases, this category of swimmer is not followed by a trainer and does not make use of advanced instrumentation to analyse their sports training in order to improve their performance and optimize the time used for training.

Swimming is a cyclical sport, the aim of which is to move through water smoothly and quickly.

To achieve this, it is fundamental to have perfect coordination between the various parts of the body and excellent technique.

Technique and coordination are of similar, if not greater, strategic importance as athletic abilities. Indeed, when swimming, if one changes by even the slightest amount a movement or position of the body, for example the angle of rotation of the head or the stroke speed, it can result in a significant improvement or deterioration in performance.

Unfortunately, it is not always easy to identify how to improve performance precisely because it is difficult to understand how to change one's body movements to one's own advantage. Indeed, even with the help of a trainer, difficulties can arise due to the fact that most movements take place under the surface of the water and are therefore difficult to observe.

There are currently several products available on the market that can help and improve training for sports men and women. In particular, there are monitoring systems that can assess physical performance using the swimmer's heart rate associated with their speed and the amount of time that has elapsed.

These products have certain limitations, however, when they are used for swimming, since the electronic instrumentation may have problems caused by coming into contact with water, and may also be inadequate from the functional point of view when used for a technical sport such as swimming.

Furthermore, these products can be uncomfortable for the swimmer since they prevent the arms and legs from remaining free, or at least free of bracelets or ankle-bands, which can interfere with the swimming stroke and can even influence the swimmer's performance in terms of fluid-dynamics.

US PATENT 2011/0172549 describes a heart rate and Electrocardiogram (ECG) monitoring system for use in high-motion conditions, and even under water. The system features a strap on which both electrodes and the processor that analyses the signals from the electrodes are positioned. This processor is positioned on the chest of the swimmer, which however proves uncomfortable and bulky when swimming, and when practicing any other water sport. Furthermore, the use of a simple strap for positioning the electrodes and the processor, can be disadvantageous, since the swimmer's movement together with the presence of water, which acts as a lubricant, can cause the strap to slide along the swimmer's body, thereby compromising the detection of the ECG signal and the performance of the swimmer, who may now find an object hanging around his or her waist.

WO 2010/113134 describes a monitoring device for swimming wherein there is a sensor for detecting the position of the swimmer during physical activity. The device, which can also be fitted a heart rate detection system, presents certain problems in relation to the position of the sensor both in terms of stability and in terms of its bulk and the discomfort it may cause the swimmer. In particular, the position of the sensor in the centre of the swimmer's chest can be uncomfortable and impractical for swimming. Furthermore, the chest strap on which it is positioned can move easily when swimming, thereby changing the position of the sensor and invalidating the signal reading.

It would therefore be desirable to have a system for monitoring the physical performance of a swimmer, which can detect parameters of movement and physical performance of the athlete when under exertion in the water.

It would also be desirable to have a monitoring system that is easy to put on and stable during

sporting activity, in other words a system that does not change its position as a result of the swimmer's movements.

Lastly, it would be desirable to have a system that enables the parameters to be monitored constantly without compromising the swimmer's performance and without causing any kind of discomfort because of its position.

An aim of the present invention is therefore to provide a system for monitoring the physical performance of a swimmer that can also operate easily under water.

A further aim of the present invention is to provide a monitoring system that can be easily worn by the swimmer and at the same time is stable and not uncomfortable during physical exertion and movement.

Another aim of the present invention is to provide a monitoring system that can assess both the swimmer's technique and his or her physical performance, so as to obtain complete training data.

These and other aims and advantages of the invention, which will become more apparent from the following description, are achieved by means of a garment for practicing water sports, characterized in that it comprises two or more heart rate and/or ECG signal sensors, an inertial system for detecting movement comprising an accelerometer, a heart rate and/or ECG signal detection circuit, a microprocessor for analysing the data from said heart rate and/or ECG signal detection sensors, and a transmitter for sending said data to a receiver unit; said movement detection inertial system, said microprocessor, said circuit and said transmitter being contained in a casing placed on the back portion of said garment so that said casing is placed along the spinal column in a position corresponding to thoracic vertebrae T6-L3 when the garment is worn by the user. In this manner it is possible to monitor the physical performance of a swimmer practicing the sport in the water, in a stable, repetitive manner, without causing any discomfort to the swimmer and without risking movements or malfunctions of the sensors and of the movement detection inertial system.

Preferably the heart rate detection sensors are positioned on the thoracic-abdominal portion of the garment, so that said sensors are positioned in the upper thoracic-abdominal strip area in a position corresponding to ribs 9-12. This guarantees correct contact with the skin in the best position for detecting heart rate.

Preferably the movement detection inertial system comprises a gyroscope, so that it is possible to detect with great sensitivity the position of the swimmer in space.

Preferably the heart rate sensors are positioned along an elastic strap in the abdominal portion of the garment. This guarantees the correct position of the sensors and limited discomfort for

the swimmer even when breathing heavily during physical exertion.

Preferably the heart rate sensors are made of textile material. This guarantees an excellent contact with the skin so as to obtain a precise signal at all times.

Preferably the heart rate sensors have a convex profile turned towards the inside of the garment. In this way, contact with the swimmer's skin is maximized even in the event of a slight movement of the garment on the swimmer's body.

Preferably the casing containing the movement detection inertial system, the circuit, the microprocessor and the transmitter is made of an impermeable material. This will guarantee the optimal operation of the components even when operating in water, thereby making it possible to monitor the swimmer's performance while swimming.

Preferably the impermeable material the casing is made from is selected from the group made up of polyethylene, polypropylene and polystyrene. More preferably, the casing is made from high-density polyethylene. This will guarantee the optimal impermeability of the components while keeping the system as light as possible and also helping it to float.

Preferably the garment for practicing water sports according to the present invention comprises a data display unit comprising a receiver unit and a display. In this way it is possible to assess the swimmer's physical performance in real time and after the end of the training, so that both the technical components of the swimming stroke and the swimmer's physical performance can be improved based on the data obtained.

Preferably the garment for practicing water sports according to the present invention comprises a storage unit for recording the data analysed by said microprocessor, thereby making it possible to store data during the training session and transfer them subsequently to the receiver unit.

Further characteristics and advantages of the present invention will become more apparent from the following detailed description of a preferred embodiment thereof, illustrated by way of non-limiting example in the accompanying Figures, in which:

- Figure 1A shows a front view of an embodiment of the garment according to the present invention, for a female model;
- Figure 1B shows a side view of an embodiment of the garment according to the present invention, for a female model;
- Figure 1C shows a rear view of an embodiment of the garment according to the present invention, for a female model;
- Figure 2A shows a front view of an embodiment of the garment according to the present invention, for a male model;

- Figure 2B shows a side view of an embodiment of the garment according to the present invention, for a male model;
- Figure 2C shows a rear view of an embodiment of the garment according to the present invention, for a male model;
- Figure 3 shows a schematic view illustrating the position on the swimmer's back of the casing containing the accelerometer, microprocessor and transmitter;
- Figure 4 shows a schematic view illustrating the position on the swimmer's upper body of the heart rate sensors;
- Figure 5 shows a graph of the front-rear, lateral and vertical acceleration when doing crawl;
- Figure 6 shows a graph of the front-rear, lateral and vertical acceleration when doing the breaststroke;
- Figure 7 shows a graph of the front-rear, lateral and vertical acceleration when doing the backstroke.

With reference to the accompanying drawings, the garment for water sports consists of a costume, in other words a garment made from a material suitable for use in water when practicing sport as commonly recognized, which can be worn on the upper body of the swimmer, and in particular can be worn as a bib. This particular embodiment allows the garment to be comfortable and prevents it from moving and slipping along the swimmer's when swimming, which would alter the measurements and create discomfort, and the area of the electrodes in contact with the skin is made impermeable.

As illustrated in figures 1 and 2, the garment 10 can be used by both female and male athletes, thanks to the cut and shape of the fabric used. This enables swimmers to have a garment that fits perfectly and is therefore comfortable both for female users and male users.

The garment 10 according to the present invention comprises two or more heart rate and/or Electrocardiogram (ECG) signal sensors 100, positioned along an elastic strip 110 placed on the abdominal portion of the garment, as illustrated in figures 1A and 2A. In particular, the sensors 100 are placed such that they are in a position corresponding to ribs 9-12 once the garment has been put on by the swimmer, as illustrated in figure 4. This guarantees perfect reception of the electrical signal generated by the heartbeat. Furthermore, this position is also the ideal position from the ergonomic point of view, since it creates the least possible discomfort for the swimmer during periods of physical activity.

The elastic strip 110 serves the dual purpose of keeping the garment in the correct position, by adhering perfectly to the swimmer's upper body, and of guaranteeing the correct contact of the

heart rate sensors 100 with the swimmer's skin, thereby guaranteeing continuous, effective reception of the electrical signal needed to monitor heart rate, although the area in question is impermeable to prevent short circuits between the electrodes caused by the presence of water.

In a second embodiment of the present invention, not illustrated in the figures, the garment comprises a series of sensors positioned along the elastic strip in order to detect not only the heart rate but also to make it possible to obtain an electrocardiogram trace, so as to have additional, more detailed information about the swimmer's fitness.

In a preferred embodiment of the present invention, the heart rate and/or ECG signal sensors 100 are made of a textile material, in other words they are made of a fabric that can conduct electricity, which is applied to the elastic strip 110 in the inner portion of the garment so as to ensure a better contact with the swimmer's skin.

In order to further improve the contact with the swimmer's skin, in a preferred embodiment of the present invention, the sensors 100 are padded with soft, inert textile material so as to be slightly rounded and therefore to have a convex profile turned towards the inside of the garment 10. This guarantees a better contact of the electrodes on the skin, without creating discomfort for the swimmer.

The electrical signals detected by the sensors 100 are picked up by an electrical circuit and analysed by a microprocessor - according to the state of the art - which is connected to them by means of normal electrical connection systems.

The garment 10 according to the present invention comprises an inertial system consisting of at least one triaxial accelerometer or a series of uniaxial accelerometers capable of detecting and measuring the swimmer's acceleration and therefore capable of detecting movement along the three Cartesian axes X, Y and Z so as to have a precise indication of the movement of the swimmer's body in order to assess the technical component in relation to the various swimming strokes.

In a further embodiment of the present invention, not illustrated in the figures, the garment comprises a gyroscope capable of precisely detecting the swimmer's position in space, so as to be able to understand exactly the position of the swimmer's body during the various stages of the different swimming strokes, thereby making it possible to correct any errors of positioning or movement.

In particular, using the acceleration along the Front-rear axis, it is possible to evaluate the amount of propulsive thrust generated by the swimmer in the different swimming strokes. Acceleration along the lateral axis makes it possible to evaluate arm and feet movements in crawl and backstroke. Acceleration along the vertical axis makes it possible to evaluate

progress when doing the breaststroke.

The signals from the accelerometer are also collected and analysed by a microprocessor, in the same way as the signals coming from the heart rate sensors.

In a further embodiment of the present invention, not illustrated in the figures, the garment comprises a gyroscope capable of precisely detecting the swimmer's position in space, so as to be able to understand exactly the position of the swimmer's body during the various stages of the different swimming strokes, so as to be able to understand exactly the position of the swimmer's body during the various stages of the different swimming strokes.

According to the present invention, the inertial system and the microprocessor for processing the signals both from the inertial system itself and from the heart rate and/or ECG signal sensors, are contained in a casing 200 made of an impermeable material.

The casing 200 containing the inertial system and the microprocessor, is positioned on the back portion of the garment 10, as illustrated in figures 1B, 1C, 2B and 2C. In particular, it is placed along the spinal column of the swimmer so that it is in a position corresponding to thoracic vertebrae T7-T12 when the garment is put on by the swimmer, as illustrated in figure 3.

Preferably, the casing 200 is placed in a position corresponding to vertebrae T6-L3.

Even more preferably, the casing 200 is placed in a position corresponding to vertebrae T9-L1.

Figures 5, 6 and 7 show the graphs of the accelerations recorded by the accelerometer with reference to the three main swimming strokes. In particular, figure 5 shows the graph of accelerations for crawl, in which the individual strokes are indicated by the peaks of lateral acceleration and the propulsive forward thrust is indicated by the Front-rear accelerations, corresponding to each individual stroke. The figure also shows the moment of the turn by the swimmer after a length of the pool, so that it is possible to evaluate each individual length in detail, and any deterioration in the swimmer's performance over time.

Figure 6 shows the graph of accelerations for breaststroke, in which the phase of entering and exiting the water is indicated by the vertical accelerations.

Figure 7 shows the graph of accelerations for the backstroke, where the individual strokes are also indicated by the lateral accelerations.

The position of the casing 200 on the back portion of the garment 10 is particularly suitable both from the point of view of recording of the kinetic movement parameters by the inertial system, and from the point of view of comfort for the swimmer. The position on the back enables the accelerometer to record precisely the lateral, rear and vertical accelerations for the

purpose of assessing the swimmer's movement during the three swimming styles, so as to have precise indications of any technical errors to be corrected while swimming, as illustrated above. Furthermore, as far as the swimmer's comfort is concerned, this position creates the least possible discomfort for the swimmer, thereby allowing him or her to swim naturally, and therefore enabling a real, effective evaluation of the swimming stroke to be made.

The impermeable material of which the casing 200 is made must guarantee a high degree of impermeability to water, so as to allow the electrical components to operate correctly, but at the same time it must be a light, easily-worked material, so as to create the minimum possible discomfort for the swimmer during physical activity, and to allow easy installation of the components during the assembly phase. This impermeable material is selected from the group made up of polyethylene, polypropylene and polystyrene. Preferably, the casing 200 is made from high-density polyethylene (HDPE) so as to ensure adequate impermeability while at the same time keeping the weight of the whole garment down.

In order to evaluate the data obtained, the casing 200 contains a transmitter, connected to the microprocessor, capable of transmitting to a receiving unit the speed and heart rate data recorded. In particular, the data are transmitted to an external unit such as a PC, tablet or any other electronic device comprising a signal receiving unit and a display on which to evaluate the signals recorded.

These signal receiving and display instruments may be equipped with a data processing program that will enable the quality of the recorded data to be evaluated automatically, thereby providing precise indications relating to the swimmer's training and consequently to any technical changes to be made in order to optimize the swimming stroke and improve performance.

In a further embodiment of the present invention, the garment comprises a storage unit for recording the data analysed by the microprocessor. In this way the recorded data can be transferred to the display unit at any time, including not during the actual training session. This means that the recorded data can be analysed even after several training sessions and not after or during each individual training session.

In the case of other sports, this system offers the same information about heart rate and/or ECG signal and about the kinetic parameters relating to the movement or gesture made.

Similar information is obtained in the case of water-based motor rehabilitation.

CLAIMS

1. Garment (10) for practicing water sports, characterized in that it comprises two or more heart rate and/or ECG signal sensors (100), an inertial system for detecting movement comprising an accelerometer, a heart rate and/or ECG signal detection circuit, a microprocessor for analysing the data from said heart rate and/or ECG signal detection sensors, and a transmitter for sending said data to a receiver unit; said movement detection inertial system, said microprocessor, said circuit and said transmitter being contained in a casing (200) placed on the back portion of said garment so that said casing is placed along the spinal column in a position corresponding to thoracic vertebrae T6-L3 when the garment is worn by the user.
2. Garment (10) according to claim 1, characterized in that said movement detection inertial system comprises a gyroscope.
3. Garment (10) according to claim 1, characterized in that said heart rate sensors (100) are positioned on the thoracic-abdominal portion of said garment, so that said sensors are in a position corresponding to ribs 9-12.
4. Garment (10) according to claim 2, characterized in that said heart rate sensors (100) are positioned along an elastic strip (110) of said thoracic-abdominal portion of said garment.
5. Garment (10) according to claim 1, characterized in that said heart rate sensors (100) are made of textile material.
6. Garment (10) according to claim 1, characterized in that said heart rate sensors (100) have a convex profile turned towards the inside of the garment.
7. Garment (10) according to claim 1, characterized in that said casing (200) is made of an impermeable material.
8. Garment (10) according to claim 6, characterized in that said impermeable material is selected from the group made up of polyethylene, polypropylene and polystyrene.
9. Garment (10) according to claim 7, characterized in that said casing (200) is made from high-density polyethylene.
10. Garment (10) according to claim 1, characterized in that it comprises a data display unit comprising a receiving unit and a display.
11. Garment (10) according to claim 1, characterized in that it comprises a storage unit for recording the data analysed by said microprocessor.

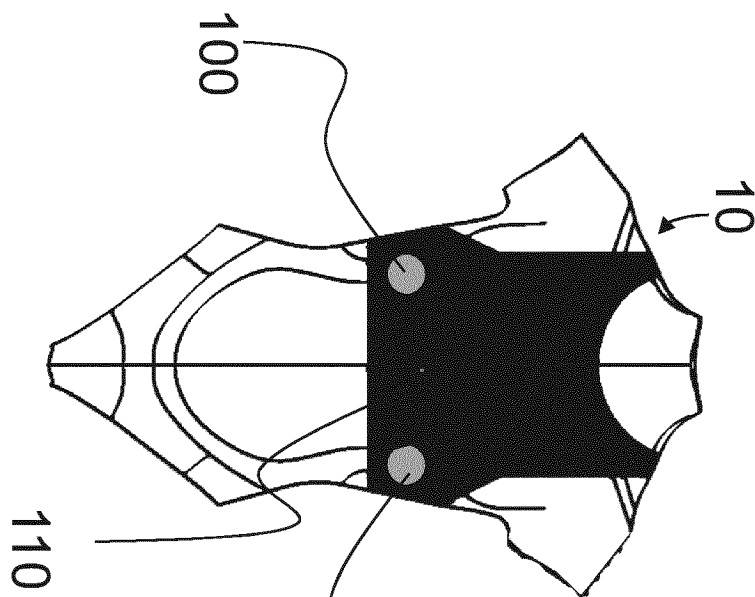


Fig. 1A

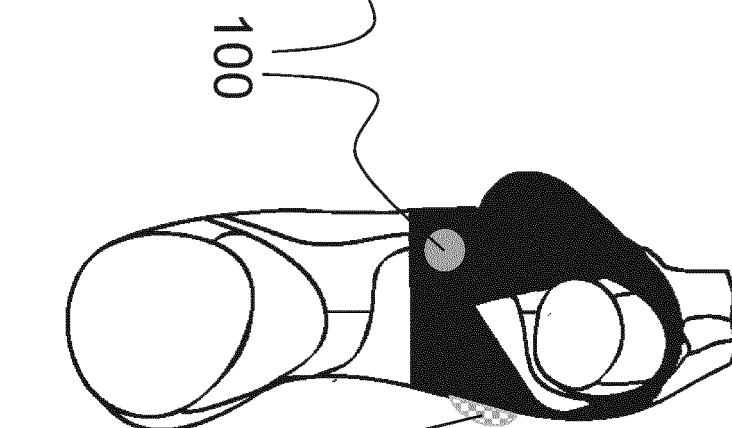


Fig. 1B

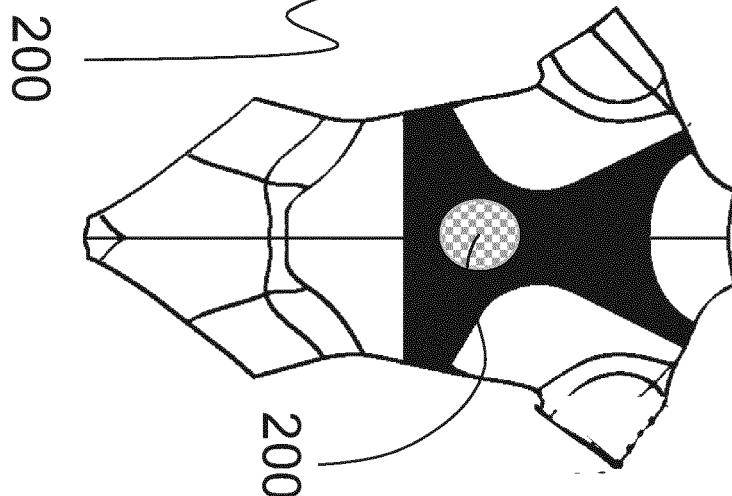


Fig. 1C

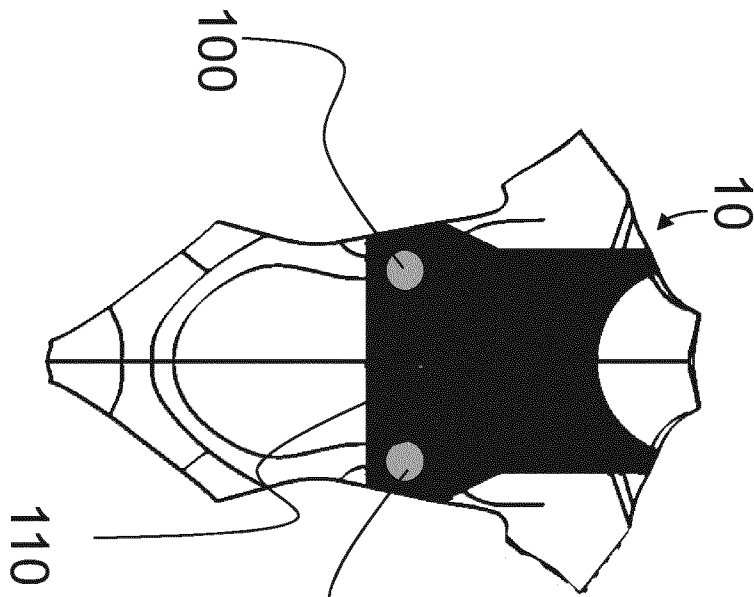


Fig. 2A

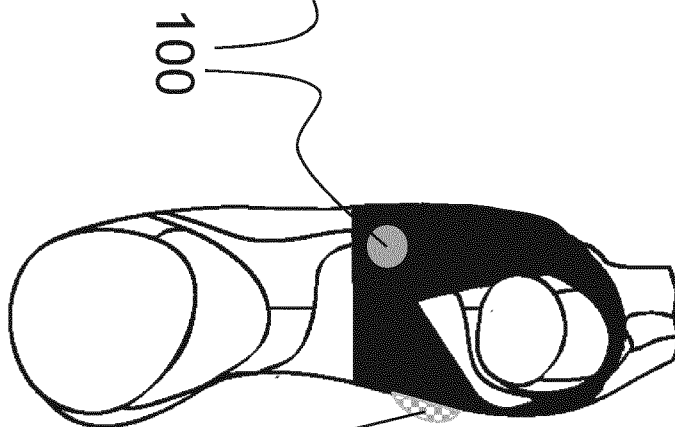


Fig. 2B

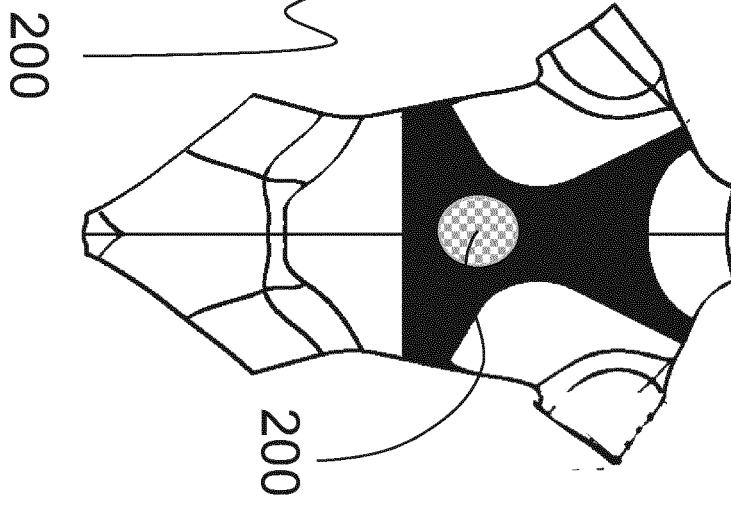


Fig. 2C

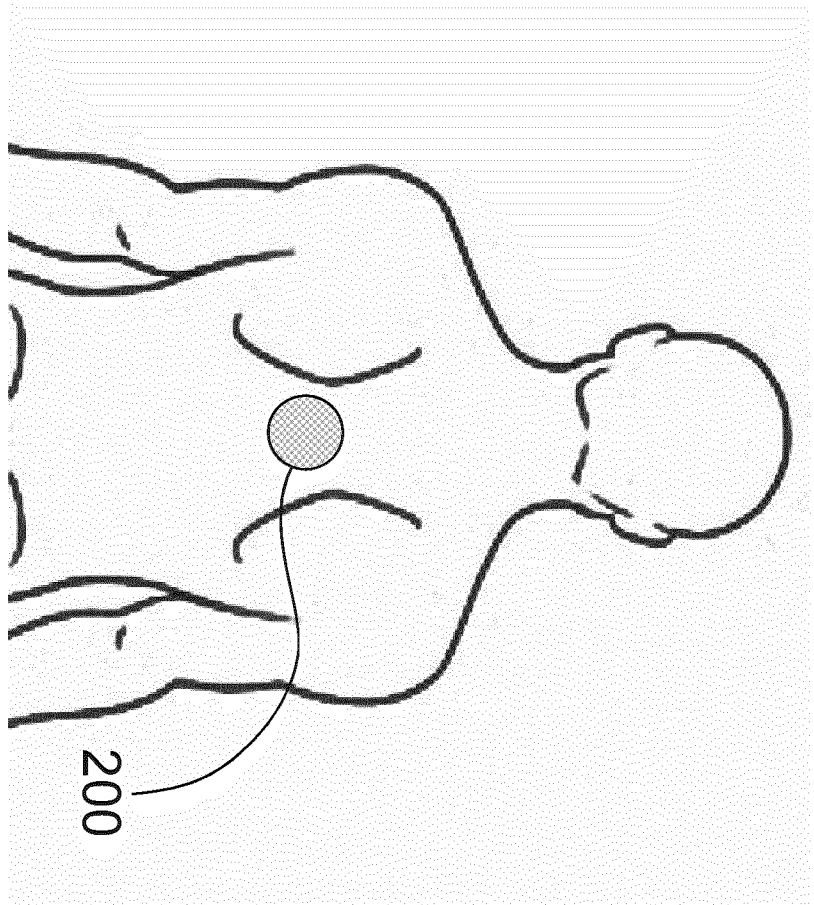


Fig. 3

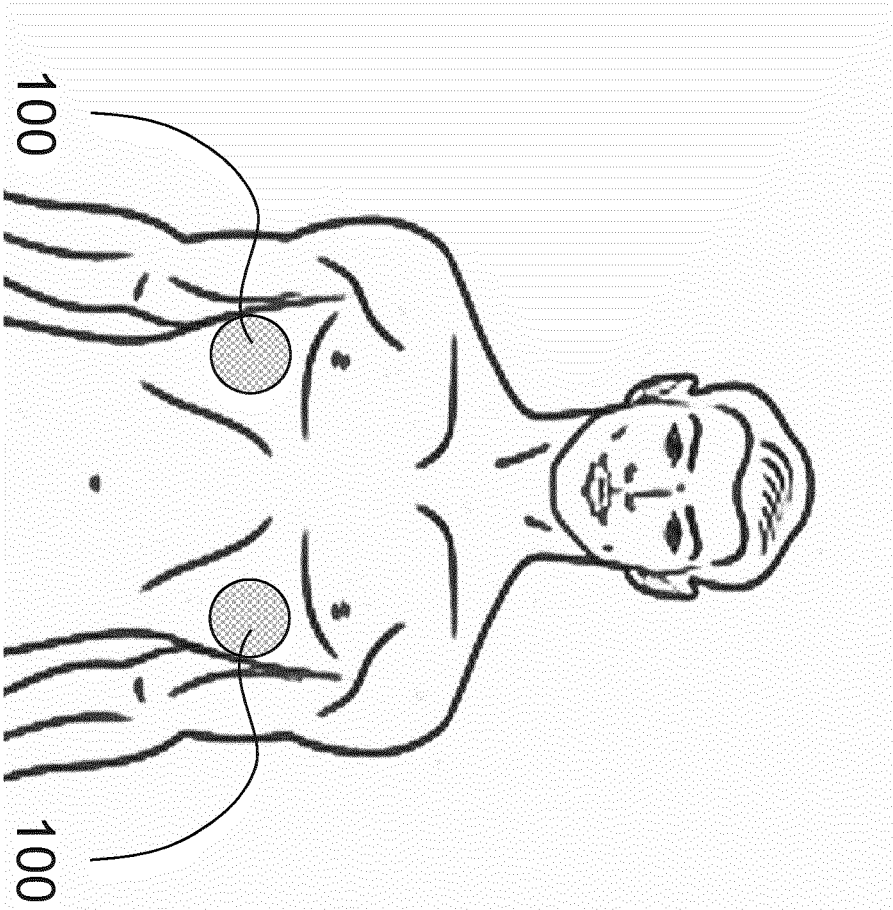


Fig. 4

Crawl

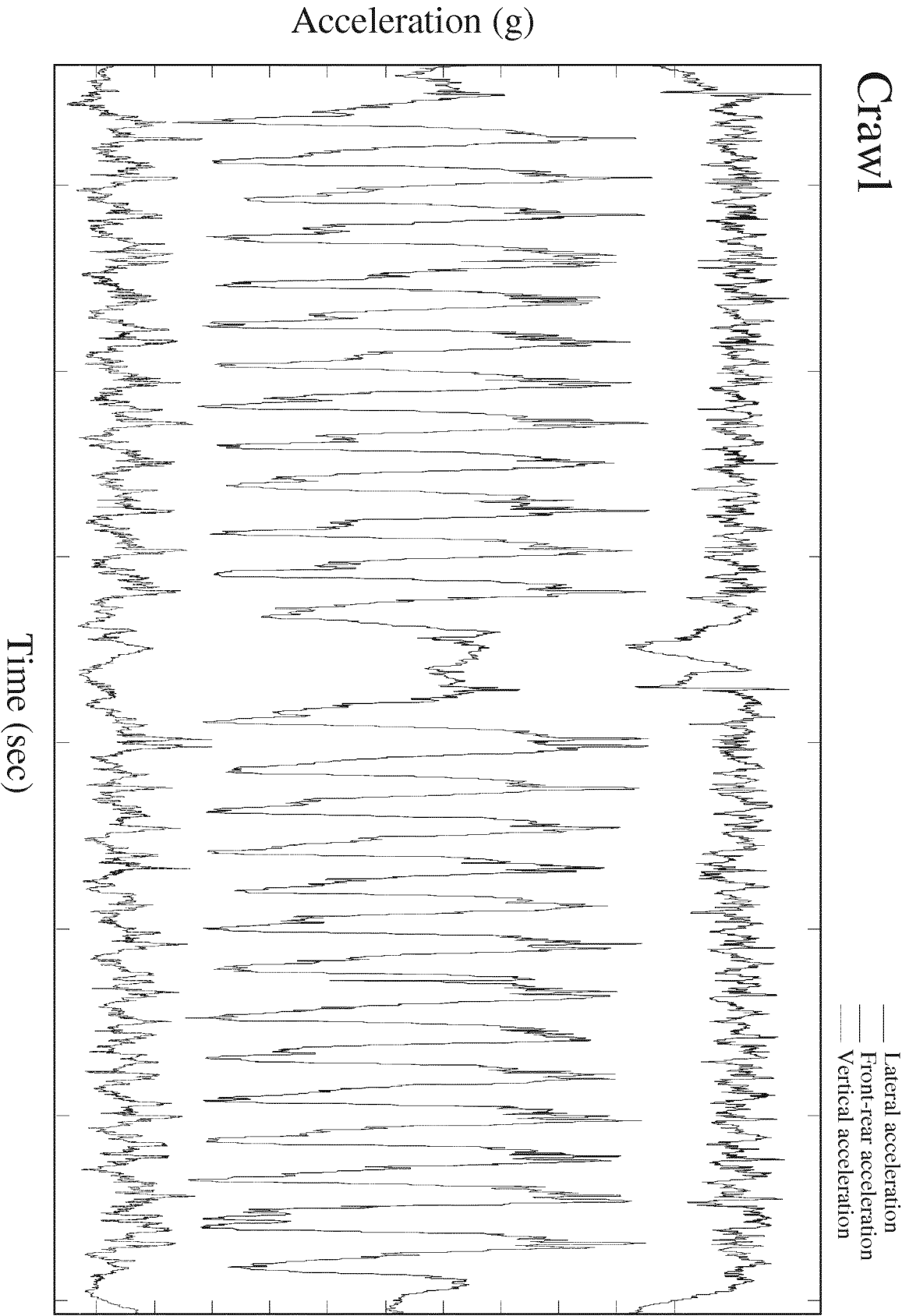


Fig. 5

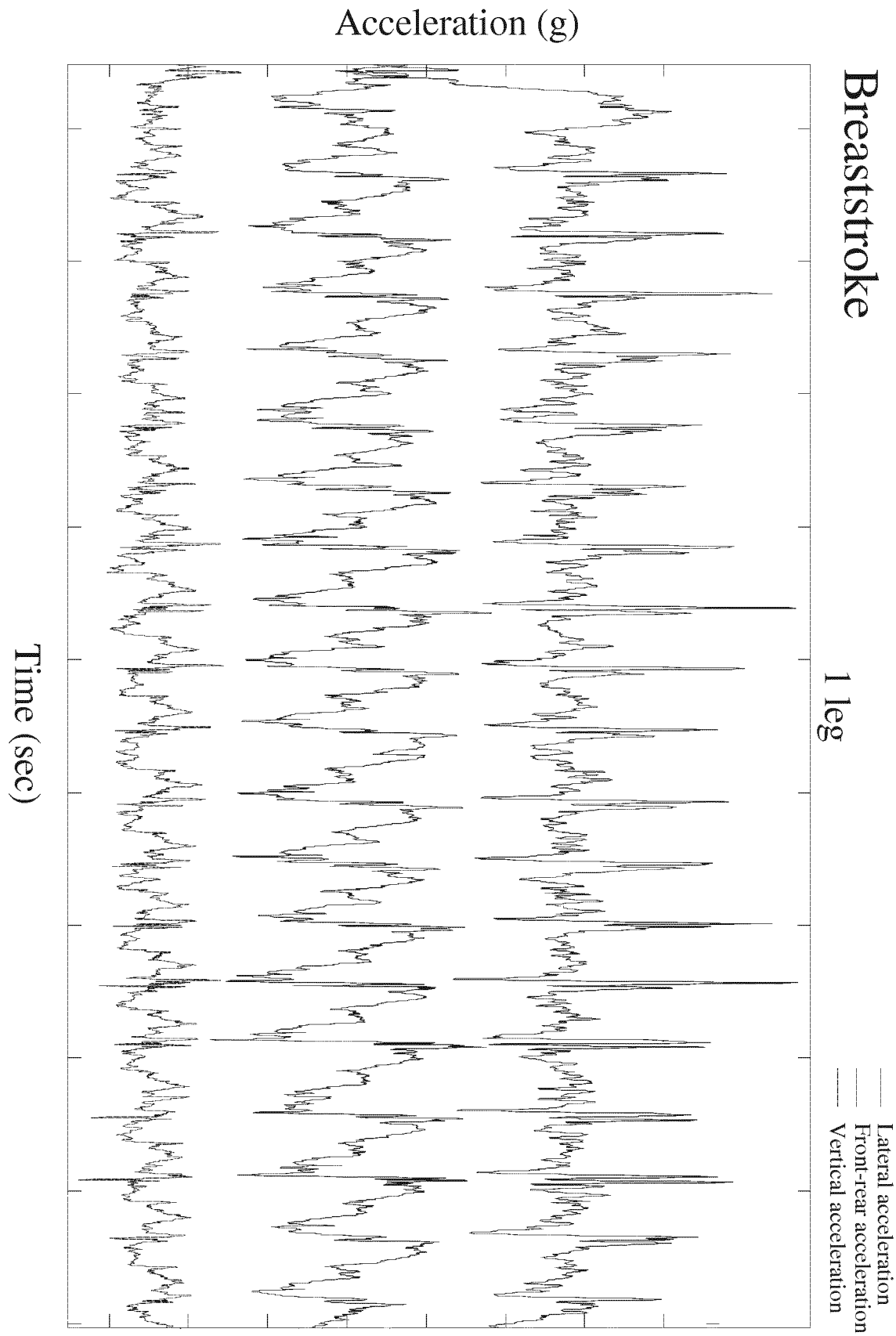


Fig. 6

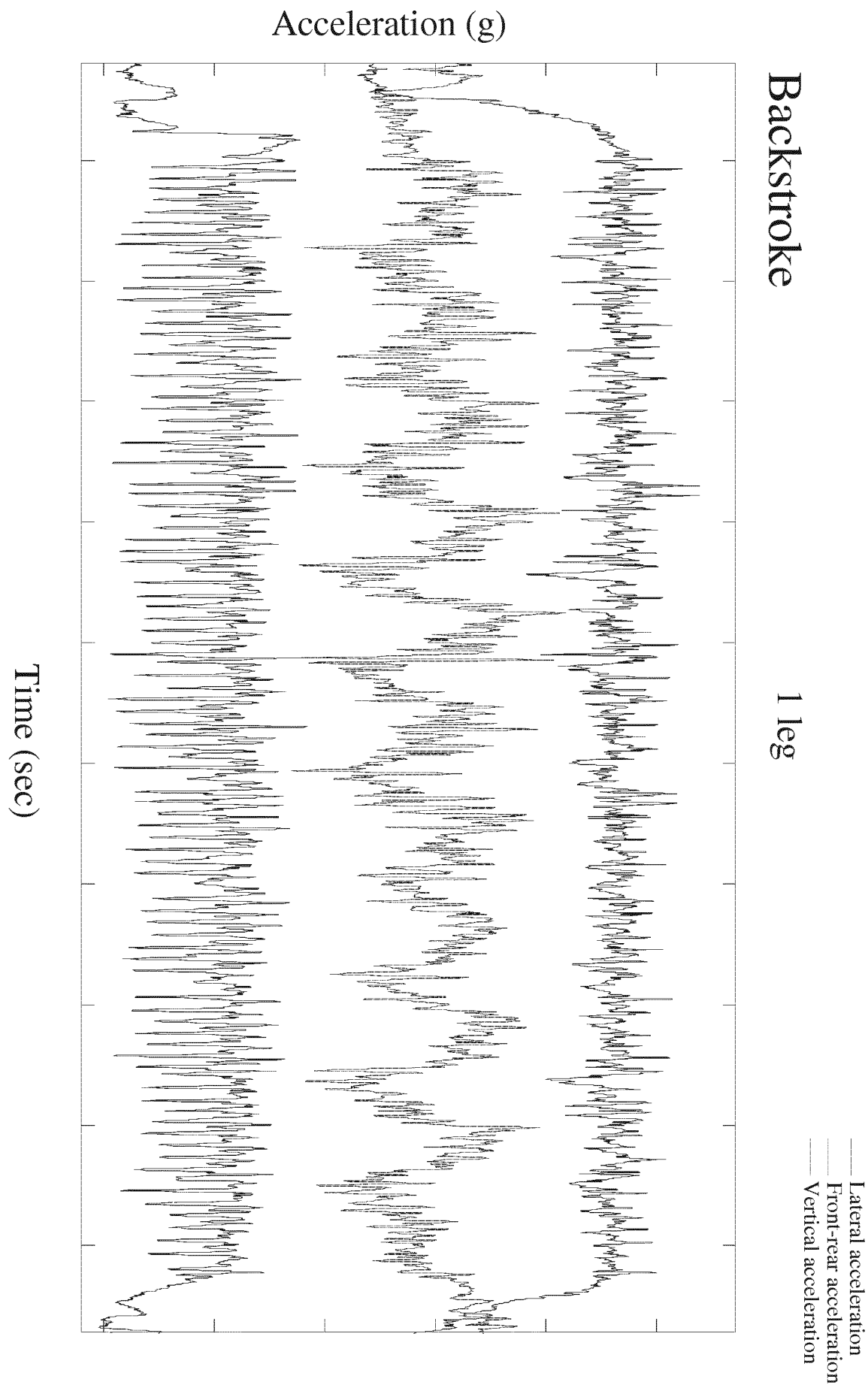


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/057066

A. CLASSIFICATION OF SUBJECT MATTER INV. A61B5/024 A61B5/0408 A61B5/11 A61B5/00 ADD.		
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 A63B		
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) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Ana S. Silva ET AL: "Wearable Monitoring Unit for Swimming Performance Analysis" In: "Networked Digital Technologies", 1 January 2013 (2013-01-01), Springer Berlin Heidelberg, Berlin, Heidelberg, XP055193538, ISSN: 1865-0929 ISBN: 978-3-64-214306-9 vol. 273, pages 80-93, DOI: 10.1007/978-3-642-29752-6_7, abstract	1-5,7-11
Y	pages 81-88 page 92 figures 1, 3, 4, 5a ----- -/--	6
☒ 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 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 9 June 2015		Date of mailing of the international search report 18/06/2015
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Sarcia, Regis

INTERNATIONAL SEARCH REPORT

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PCT/EP2015/057066

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	T. PEREIRA ET AL: "Wearable biopotential measurement using the TI ADS1198 analog front-end and textile electrodes", 2013 IEEE INTERNATIONAL SYMPOSIUM ON MEDICAL MEASUREMENTS AND APPLICATIONS (MEMEA), 1 May 2013 (2013-05-01), pages 325-330, XP055193511, DOI: 10.1109/MeMeA.2013.6549761 ISBN: 978-1-46-735196-6	6
A	III.D Electrodes; figure 5 -----	3,4

专利名称(译)	用于监控游泳运动员表现的可穿戴系统		
公开(公告)号	EP3128905A1	公开(公告)日	2017-02-15
申请号	EP2015716000	申请日	2015-03-31
[标]申请(专利权)人(译)	米兰理工大学		
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优先权	202014902251194 2014-04-08 IT		
外部链接	Espacenet		

摘要(译)

可穿戴系统技术领域本发明涉及一种用于监控游泳运动员表现的可穿戴系统。具体地，本发明涉及一种由包括两个或更多个心率和/或ECG信号传感器的服装和放置在服装的后部上的外壳组成的系统，该外壳包括运动检测惯性系统，该运动检测惯性系统包括加速度计，心率和/或者，ECG信号检测电路，用于分析来自所述心率和/或ECG信号检测传感器的数据的微处理器，以及用于将所述数据发送到接收器单元的发送器。