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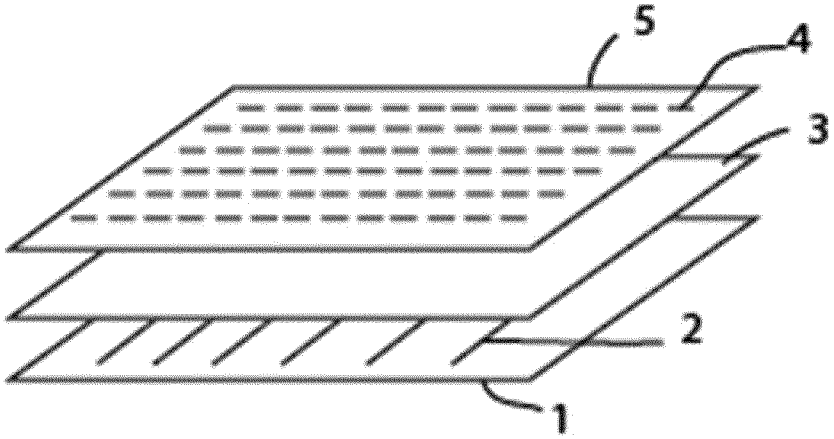
(54) PIEZORESISTIVE TEXTILE SENSOR AND SYSTEM FOR DETECTING THE HEART AND/OR RESPIRATORY RATE

(57) Textile piezoresistive sensor for detecting a heartbeat and respiratory rate that comprises a lower textile layer, onto which a conductor ink or paste is deposited, such that first conductor strips are defined, while said lower textile layer is attached to a second piezoresistive textile layer, onto which a second conductor strip is placed to which an upper textile layer is finally placed which can receive the ink and/or conductor pastes deposited, said textile piezoresistive sensor being present in a system for detecting a heartbeat and respiratory rate.

Figure 1



EP 3 047 794 A1

Description

[0001] The object of the invention herein is a textile, piezoresistive sensor especially designed for detecting the heartbeat and/or respiratory rate, whose main characteristic is its textile nature and that it is non-intrusive in the human body for measurement, (which simply means that it makes contact with the textile sensor of the surface with very little pressure, the usual pressures produced between the contact surfaces of objects on which the human body lies: a seat, a mattress, a chair, etc). The object of the present invention also includes a system applicable to a large textile area, in order to monitor the heartbeat and/or respiratory rate of a user either for medical reasons, for safety and for other applications.

STATE OF THE ART

[0002] At present, in order to detect the respiratory rate of a user, it is necessary to use different means or components placed directly on said user, which set the parameters for respiration and/or the heartbeat depending on the particular needs of each case.

[0003] In the case of piezoresistive materials such as sensor systems for measuring respiratory rate and heartbeat, this implies that the user must typically wear masks with piezoresistive elements, or be positioned in certain ways (awkward postures) which enable the electrical conductivity to be varied with deformation of the material. In addition, these materials are textile and/or flexible.

[0004] An example of use of piezoresistive systems for measuring heart rate may be the U.S. Patent US7689271B1, and unlike the object of the present invention, the object of said American patent is not based on a textile, deformable surface and which also requires a forced position in which at least the ends must be in contact with the sensor surface, but the sensor of the invention is based on the capture of signals, and because the sensor is much more sensitive, it requires a much simpler processing.

[0005] All known systems and devices would be incompatible, for example, with simultaneously operating machinery or vehicles, or with any other hazardous activity that required the user's full attention. This would be the case for an intrusive system for monitoring respiration and/or the heart rate of a driver, and to therefore know the condition thereof in order to avoid accidents due to fatigue or drowsiness.

DESCRIPTION OF THE INVENTION

[0006] The invention herein has been developed with the aim of providing a textile piezoresistive sensor that resolves the aforementioned drawbacks, further providing other additional advantages that will be apparent from the description detailed hereinafter.

[0007] An object of the invention herein is therefore a textile piezoresistive sensor for detecting heart rate and respiration, comprising a lower textile layer onto which a conductor ink or paste is deposited, such that a number of first conductor strips are defined, while said lower textile layer is attached to a second piezoresistive textile layer onto which a second conductor strip is placed to which an upper textile layer is finally placed which can receive the ink and/or conductor pastes deposited.

[0008] Thanks to its special design and functionality, the sensor presented herein can detect small changes in pressure caused by the movement of the rib cage in contact with the sensor even with low pressure between the body and the object.

[0009] Another major advantage of the sensor presented herein is that, given that it is a textile, it is flexible, deformable, light, washable and, therefore, can be integrated into covers for beds, chairs or the like, seats for vehicles or dangerous machinery, and in general, objects with three-dimensional shapes and that are even deformable during use.

[0010] Accordingly, given that it is a textile and being a non-intrusive sensor, the respiratory rate and/or heartbeat can be detected and/or measured while the user is lying on a mattress and/or sitting on a chair, having previously installed the sensor in the mattress cover or upholstery of the chair, for example. A driver of a vehicle or hazardous machinery can also be monitored such that situations of fatigue or drowsiness can be avoided. Due to minimal intrusiveness, the object of the present invention does not alter any normal operations performed by the users.

[0011] The sensor disclosed herein has high sensitivity in the low pressure area, which enables a small variation in the pressure applied on the fabric to be transformed into voltage increments that can be captured by suitable electronics. This is necessary for detecting pressure variations produced by the movement of the chest for the respiratory rate, in the order of $8g/cm^2$ and less than $1g/cm^2$ for the heart rate.

[0012] Preferably, the first and second conductor strip comprises at least one of the following elements: silver, silver chloride, copper, nickel, graphite, conductive polymers and carbon nanofibres. Furthermore, said first conductor strips and said second conductor strip may be applied by printing, either by screen printing or inkjet or by weaving, embroidering or stitching wires coated or impregnated with the above materials in specific designs.

[0013] In respect of the second piezoresistive textile layer, there may be a sensitivity which involves resistive changes exceeding 26 Ohms for a voltage of 12V, for changes in the pressure exerted of 1 g/cm^2.

[0014] Another object of the invention is also a heartbeat and/or respiration detection system, that incorporates at least one analogue-digital converter and a signal amplifier circuit that comprises at least one textile piezoresistive sensor according to the other object of the invention. If an array of sensors is arranged on a support and/or the seat of a chair, sofa or vehicle, for example, the user can move freely wherever they are located as

at least one of the sensors that is used can measure the heartbeat and/or respiratory rate under the conditions specified herein.

[0015] Said respiratory rate detection system can measure pressure variations lower than 35g/cm^2, more preferably lower than 28g/cm^2. It can also carry out at least 4 measurements per minute, more preferably at least 40 measurements per minute. The supply voltage of the system herein may be 12V.

[0016] Throughout the description and claims the word "comprise" and its variants do not intend to exclude other technical characteristics, addends, components or steps. For persons skilled in the art, other objects, advantages and characteristics of the invention will emerge partly from the description and partly from implementing the invention. The following examples and drawings are provided by way of illustration and are not intended to limit the invention disclosed herein. Furthermore, the invention herein covers all possible combinations of particular and preferred embodiments set forth herein.

BRIEF DESCRIPTION OF THE FIGURES

[0017] Described very briefly hereinafter are a series of drawings that help to better understand the invention and which are expressly related to an embodiment of said invention that is presented as a non-limiting example thereof.

FIG 1. Shows a schematic view of the textile piezoresistive sensor, according to the invention herein; and
FIG 2. Shows a schematic sectional view of the sensor in Figure 1.

PREFERRED EMBODIMENT OF THE INVENTION

[0018] A preferred embodiment of the invention is shown in the attached drawings. More specifically, a textile piezoresistive sensor for detecting a heart rate and respiration that comprises a lower textile layer (1) is shown, onto which a conductor ink or paste is deposited, such that a number of first conductor strips (2) are defined, while said lower textile layer (1) is attached to a second piezoresistive textile layer (3), onto which a second conductor strip (4) is placed to which an upper textile layer (5) is finally placed which can receive the ink and/or conductor pastes deposited.

[0019] The fact that three textile layers (1, 3, 5) are incorporated means a more reliable measurement of the heart rate can be taken rather than having a single layer, while maintaining optimal sensitivity in terms of conductance.

[0020] Said first conductor strip (2) and second conductor strip (4) comprises at least one of the following: silver, silver chloride, copper, nickel, graphite, conductive polymers and carbon nanofibres, wherein some or all of them may be present. In respect of said first conductor strips (2) and said second conductor strip (4), they may be applied by printing, either by screen printing or ink jet or by weaving, embroidering or stitching wires coated or impregnated with the above materials in specific designs.

[0021] Preferably, the fabric of the second piezoresistive textile layer (3) has a concentration of conductive particles of 34g/m^2, in particular made of copper as it has been observed in tests that it enables optimum transmission of electrical signals from the sensor to the other elements with the least amount of conductive materials. Nonetheless, it will be obvious that such an amount and/or material should be modified according to individual needs.

[0022] A heartbeat and/or respiration detection system that incorporates at least one analogue-digital converter (not shown) and a signal amplifier circuit (not shown) that comprises at least one piezoresistive textile sensor defined above is also an object of the invention herein. To measure heartbeat and/or respiratory rate for example, a plurality of said sensors may be provided in the seat of a vehicle, such that the user can move freely in the seat, as at least one of said sensors will obtain the correct reading.

[0023] It has been proven in the laboratory that in order to measure the heartbeat and/or respiratory rate it is necessary to measure pressure variations between the body and the sensor element lower than 35g/cm^2 although more preferably lower than 28g/cm2, as is the case of the sensor herein which advantageously can measure pressure variations of 1g/cm^2, having sensitivity to variation in resistance which involves resistive changes greater than 26 Ohms at a voltage of 12V. In respect of the measurement cycles, it has been established that the system should perform some 40 measurements per minute. In this manner, the number of breaths and heartbeats of the user can be optimally monitored.

[0024] When used in a conventional vehicle, for example, the system of the invention can be fed by a 12V current, although 6V or 24V voltages could also be used. The power supply (not shown) may be of any type known in the state of the art.

[0025] The conductor strips (2.4) are those that are connected to the analogue/digital converter or a signal booster in order to filter the noise from the electrical signal and boost the signal from the sensor assembly through the strips (2, 4). This noise filter is essential for operation in a vehicle or machinery, where there may be a lot of pollutant signals that would distort the results obtained by the system, making it impractical for use.

[0026] By using this system it is possible to control, among other things, the drowsiness or fatigue of a user, because it could also be used on a sofa, mattress or chair to monitor a patient.

[0027] When in use, the system herein would be installed for example in a vehicle seat, preferably provided with an array of sensors such as those defined in the invention herein. The user would sit and would be able to drive or operate the machinery normally, wearing his clothes without noticing any intrusive element. The flex-

ibility and elasticity of the sensors which fully adapts to all types of seats further contributes to the above. If the system detects that the parameters of the heartbeat or respiratory rate are modified according to a pattern of drowsiness, it may send a signal by any audio or visual means (not shown) to prevent the user from having an accident.

[0028] Although the option of the seat has been mentioned, incorporating the present invention into a safety belt across the chest to monitor the user of a vehicle could also be an option.

[0029] Therefore, the drawbacks of other systems based on the visual control of the user's eyes to determine the fatigue of the latter can be avoided, such as the wide range of features and different shapes of eyes, wearing glasses, inadequate brightness, and many others that make the use of these systems impractical.

Claims

1. Textile piezoresistive sensor for detecting a heart rate and respiration **characterised by** the fact that it comprises a lower textile layer (1), onto which a conductor ink or paste is deposited, such that a number of first conductor strips (2) are defined, while said lower textile layer (1) is attached to a second piezoresistive textile layer (3), onto which a second conductor strip (4) is placed to which an upper textile layer (5) is finally placed which can receive the ink and/or conductor pastes deposited.

2. Textile piezoresistive sensor according to claim 1, **characterised by** the fact that the first conductor strip (2) and the second conductor strip (4) comprise at least one of the elements: silver, silver chloride, copper, nickel, graphite, conductive polymers and carbon nanofibres.

3. Textile piezoresistive sensor according to claim 1, **characterised by** the fact that said first conductor strips (2) and said second conductor strip (4) are applied by printing.

4. Textile piezoresistive sensor according to claim 3, **characterised by** the fact that the printing is screen printing.

5. Textile piezoresistive sensor according to claim 3, **characterised by** the fact that the printing is inkjet.

6. Textile piezoresistive sensor according to claim 1, **characterised by** the fact that said first conductor strips (2) and said second conductor strip (4) are applied by weaving, embroidered or stitching of conductive wires.

7. Textile piezoresistive sensor according to claim 6, **characterised by** the fact that the conductor wires are coated or impregnated with at least one of the elements: silver, silver chloride, copper, nickel, graphite, conductive polymers and carbon nanofibres.

8. Textile piezoresistive sensor according to any of the preceding claims, **characterised by** the fact that the piezoresistive textile layer (3) has a sensitivity by way of variation in resistance which implies resistive changes exceeding 26 Ohms at 12V for changes in the pressure exerted of 1g/cm^2.

9. Textile piezoresistive sensor according to any of the preceding claims, **characterised by** the fact that the piezoresistive textile layer (3) has a conductive material concentration of 34 g/m^2.

10. Heartbeat and/or respiration detection system that incorporates at least one analogue-digital converter and a signal amplifier circuit **characterised by** the fact that it comprises at least one textile piezoresistive sensor according to any of the preceding claims.

11. Heartbeat and/or respiration detection system according to claim 10 **characterised by** the fact that it can measure pressure variations lower than 28 g/cm^2.

12. Heartbeat and/or respiration detection system according to claim 10 **characterised by** the fact that it can measure pressure variations lower than 1g/cm^2.

13. Heartbeat and/or respiration detection system according to claim 10 **characterised by** the fact that it can conduct at least 4 measurements per minute.

14. Heartbeat and/or respiration detection system according to claim 10 **characterised by** the fact that it can conduct at least 40 measurements per minute.

15. Heartbeat and/or respiration detection system according to any of the claims 10-14, **characterised by** the fact that the mains voltage supply is 12V.

Figure 1

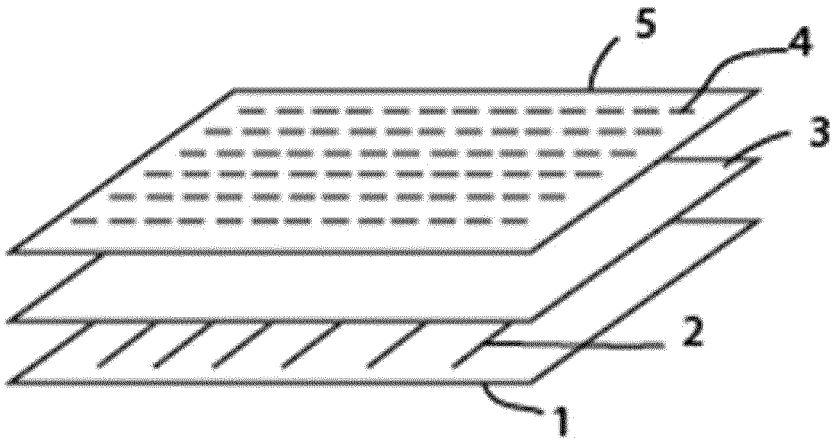
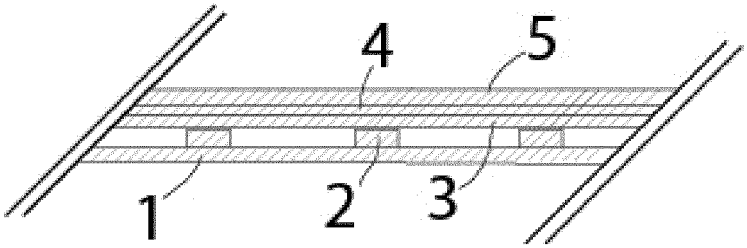


Figure 2



INFORME DE BÚSQUEDA INTERNACIONAL

Solicitud internacional Nº
PCT/ES2014/070705

A. CLASIFICACIÓN DEL OBJETO DE LA SOLICITUD

INV. A61B5/024 A61B5/08 G01L1/18 G01L1/20 B32B5/00

De acuerdo con la Clasificación Internacional de Patentes (CIP) o según la clasificación nacional y CIP.

B. SECTORES COMPRENDIDOS POR LA BÚSQUEDA

Documentación mínima buscada (sistema de clasificación seguido de los símbolos de clasificación)
A61B G01L B32B

Otra documentación consultada, además de la documentación mínima, en la medida en que tales documentos formen parte de los sectores comprendidos por la búsqueda

Bases de datos electrónicas consultadas durante la búsqueda internacional (nombre de la base de datos y, si es posible, términos de búsqueda utilizados) EPO-Internal, WPI Data

C. DOCUMENTOS CONSIDERADOS RELEVANTES

Categoría*	Documentos citados, con indicación, si procede, de las partes relevantes	Relevante para las reivindicaciones Nº
X	US 2006/255903 A1 (LUSSEY DAVID [GB] ET AL) 16 Noviembre 2006 (2006-11-16) parágrafos [0010] - [0036], [0054] - [0057]; figura 3	1-15
X	WO 2012/095608 A2 (CANNARD FRANCIS [FR]; DIOT BRUNO [FR]; VUILLERME NICOLAS [FR]; PAYAN Y) 19 Julio 2012 (2012-07-19) página 4, linea 27 - linea 30 página 8; figura 1	1,2,6,7
X,P	US 2014/155774 A1 (SARRAFZADEH MAJID [US] ET AL) 5 Junio 2014 (2014-06-05) parágrafo [0032] - parágrafo [0035]; figura 2	1

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☒ En la continuación del Recuadro C se relacionan otros documentos

☒ Los documentos de familias de patentes se indican en el Anexo

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"L" documento que puede plantear dudas sobre una reivindicación de prioridad o que se cita para determinar la fecha de publicación de otra cita o por una razón especial (como la indicada).

"O" documento que se refiere a una divulgación oral, a una utilización, a una exposición o a cualquier otro medio.

"P" documento publicado antes de la fecha de presentación internacional pero con posterioridad a la fecha de prioridad reivindicada.

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"&" documento que forma parte de la misma familia de patentes.

Fecha en que se ha concluido efectivamente la búsqueda internacional	Fecha de expedición del informe de búsqueda internacional
16 de Diciembre de 2014	05 de Enero de 2015

Nombre y dirección postal de la Administración encargada de la búsqueda internacional	Funcionario autorizado
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Koprinarov, Ivaylo
Nº de fax	Nº de teléfono

Formulario PCT/ISA/210 (segunda hoja) (Julio 2008)

INFORME DE BÚSQUEDA INTERNACIONAL

Solicitud internacional Nº

PCT/ES2014/070705

C (continuación). DOCUMENTOS CONSIDERADOS RELEVANTES

Categoría*	Documentos citados, con indicación, si procede, de las partes relevantes	Relevante para las reivindicaciones Nº
A	WO 99/38173 A1 (PERATECH LTD [GB]; LUSSEY DAVID [GB]; KING ANDREW BRIAN [GB]; LUSSEY C) 29 Julio 1999 (1999-07-29) página 14, linea 25 - linea 28	1-15

Formulario PCT/ISA/210 (continuación de la segunda hoja) (Julio 2008)

INFORME DE BÚSQUEDA INTERNACIONAL

Información relativa a miembros de familias de patentes

Solicitud internacional Nº
PCT/ES2014/070705

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Formulario PCT/ISA/210 (anexo_familia de patentes) (Julio 2008)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7689271 B1 **[0004]**

专利名称(译)	压阻式纺织品传感器和用于检测心脏和/或呼吸率的系统		
公开(公告)号	EP3047794A1	公开(公告)日	2016-07-27
申请号	EP2014780531	申请日	2014-09-16
[标]申请(专利权)人(译)	传感TEX		
申请(专利权)人(译)	传感TEX，S.L.		
当前申请(专利权)人(译)	传感TEX，S.L.		
[标]发明人	RIDAO GRANADO MIGUEL GOMEZ ANTA LUIS MIGUEL		
发明人	RIDAO GRANADO, MIGUEL GOMEZ ANTA, LUIS MIGUEL		
IPC分类号	A61B5/024 A61B5/08 G01L1/18 G01L1/20 B32B5/00 A61B5/00 A61B5/0205 B32B5/26 B60N2/90		
CPC分类号	A61B5/0205 A61B5/02444 A61B5/0816 A61B5/6804 G01L1/205 B32B5/26 B32B2307/20 B32B2307/202 B32B2307/4026 B32B2535/00 B60N2/90 A61B5/02 A61B5/024 A61B5/08 A61B5/6893 A61B2562/0247 A61B2562/166		
优先权	2013031341 2013-09-16 ES		
其他公开文献	EP3047794B1		
外部链接	Espacenet		

摘要(译)

用于检测心跳和呼吸速率的纺织压阻传感器，其包括下织物层，在其上沉积导体墨水或糊剂，使得限定第一导体条带，同时将所述下部织物层附接到第二压阻织物层上，第二导体条放置在其上，最终放置上部织物层，其可以接收沉积的墨水和/或导体浆料，所述纺织品压阻式传感器存在于用于检测心跳和呼吸速率的系统中。

Figure 1