

(21) Application No: **0424072.7**  
(22) Date of Filing: **29.10.2004**  
(30) Priority Data:  
(31) **10352626** (32) **11.11.2003** (33) **DE**

(51) INT CL<sup>7</sup>:  
**A61B 5/0205 // A61B 5/00 8/02**  
(52) UK CL (Edition X ):  
**G1N NEAX N30PX N30P8 N30R**  
**G1G GPB**

(71) Applicant(s):  
**Dräger Safety AG & Co KGaA**  
**(Incorporated in the Federal Republic of Germany)**  
**Revalstrasse 1, D-23560 Lübeck,**  
**Federal Republic of Germany**

(56) Documents Cited:  
**GB 2243691 A** **WO 2004/075750 A1**  
**DE 010038247 A1** **JP 040253839 A**  
**US 20030032893 A1**

(72) Inventor(s):  
**Frank Sattler**  
**Jochim Koch**  
**Jorg-Uwe Meyer**  
**Michael Dowson**  
**Robin McWilliams**

(58) Field of Search:  
UK CL (Edition X ) **G1G, G1N**  
INT CL<sup>7</sup> **A61B, G01K**  
Other: **Online: WPI, EPODOC.**

(74) Agent and/or Address for Service:  
**Graham Watt & Co LLP, Patent & Trade Mark Attorneys**  
**St Botolph's House, 7-9 St Botolph's Road,**  
**SEVENOAKS, Kent, TN13 3AJ,**  
**United Kingdom**

(54) Abstract Title: **Ear wearable combined core body temperature and pulse rate sensor**

(57) A combined core body temperature and pulse rate sensing device has a sensor carrier 11 in which is located a heat flow sensor 1 for detecting two temperatures for the determination of core temperature  $T_c$ , an acoustic sensor 2 for measuring hear beat rate, measuring signal evaluation units 4, 5, 7 and a communication unit 9 for transmission of measured data to a remote device for display. The measured temperature and heart rate signals may be used to calculate a physiological strain index (PSI). The acoustic sensor 2 may also measure vocal signals. Transmission may be wired or wireless. The device may be worn behind the ear, on the chest or on the skull, or the device may be in the form of a wristwatch. The device may be used by athletes or fire fighters.

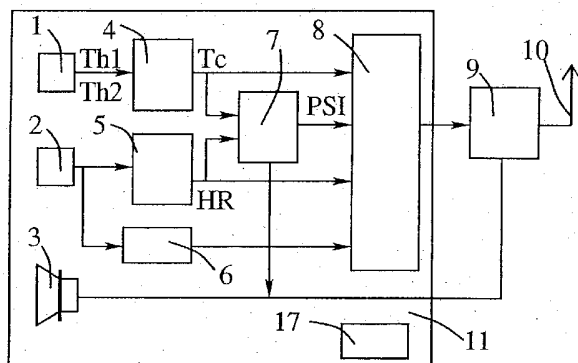


Fig. 1

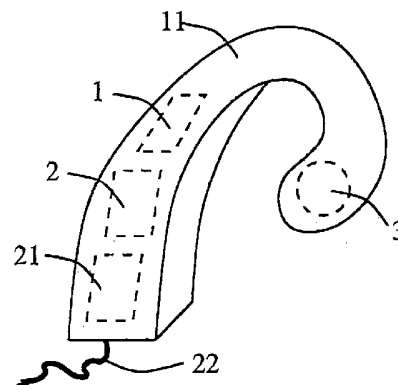


Fig. 3

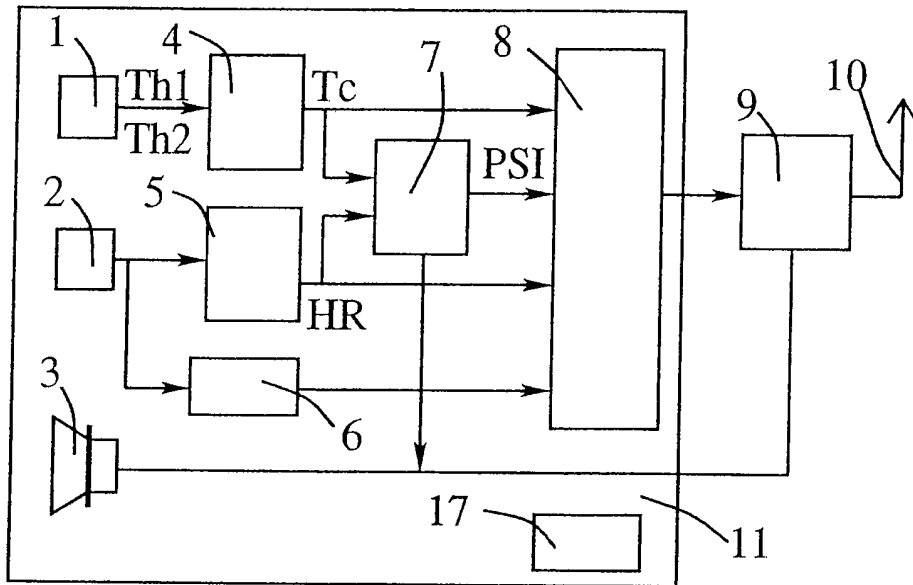


Fig. 1

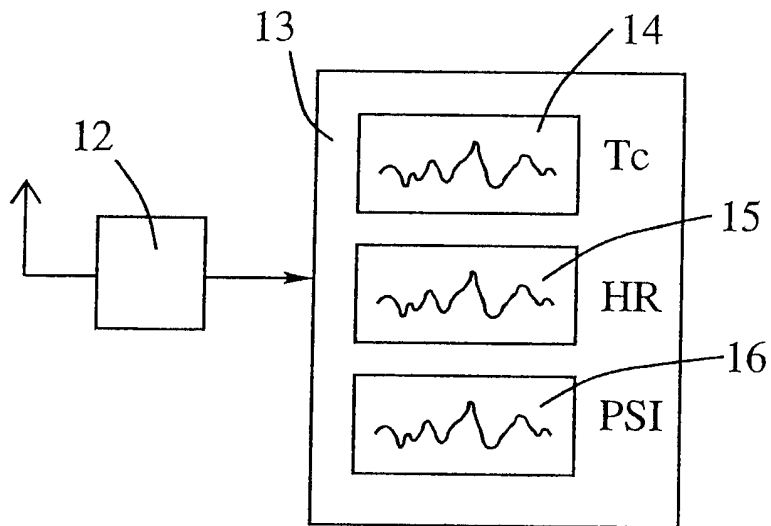


Fig. 2

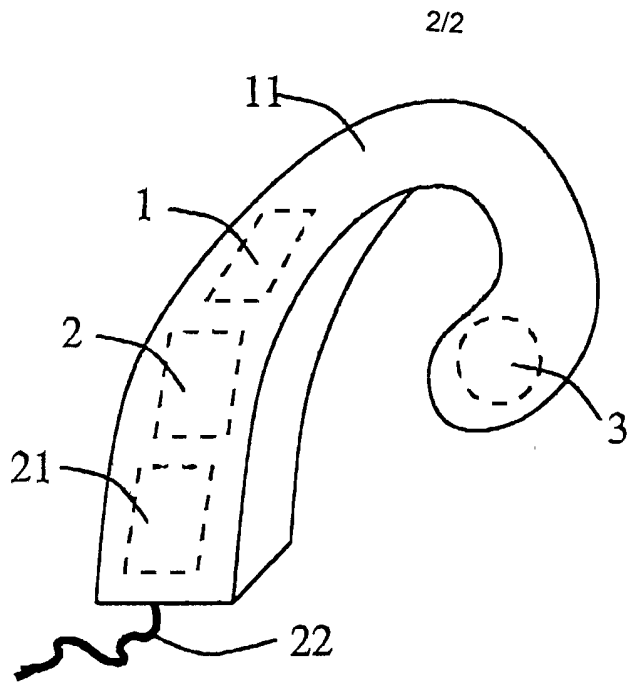


Fig. 3

Combination sensor for physiological measured variables

The invention relates to a combination sensor for physiological measured variables in a sensor carrier.

The determination and monitoring of physiological measured variables such as body temperature and heartbeat rate (HR) is of importance for sportsmen and in particular for firefighters experiencing severe physical strain.

Various methods are known for the measurement of the heartbeat rate, in particular there are optical, acoustic or electrical methods. Various measurement methods are also known for the determination of the body core temperature, for example a double-temperature sensor is known from DE 100 38 247 C2 for the determination of body core temperature ( $T_c$ ) from the computational linking of two temperatures measured on the patient. The calculation of the body core temperature ( $T_c$ ) from a measured near-skin temperature  $Th_1$  and from a near-room temperature  $Th_2$  is known from DE 101 397 05 A1.

In JP 0 425 3839 A in: Patent Abstracts of Japan, there is disclosed a sensor carrier that can be carried on the body, with a temperature sensor, a sensor for measuring the heartbeat rate and a communication interface. These known sensors are usually fitted at different points on the body and operate independently of one another.

From the linking of body core temperature ( $T_c$ ) and heartbeat rate (HR), it is possible to draw conclusions about the state of strain of the measured person by calculating an index for the physiological strain, such as for example PSI (physiological strain index), see "Stress Evaluation by the Physiological Strain Index (PSI)", Daniel S. Moran, Journal of Basic and Clinical Physiology and Pharmacology, Vol. 11, 4, 2000.

The present invention is as claimed in the claims.

The invention provides a compact combination sensor for the detection of the body core temperature ( $T_c$ ) and the heartbeat rate (HR) and for relaying the processed measurement data.

An essential advantage of the combination sensor according to the present invention consists in the compact arrangement of the sensors with the evaluation electronics in one single sensor carrier accommodating all the elements, said sensor carrier preferably being adapted to the shape of the human ear and being made from a plastic synthetic material such as silicone.

An exemplary embodiment of the invention will be explained below with the aid of the figures in which:

Figure 1 is a schematic diagram of an arrangement of the components of the combination sensor;

Figure 2 is a schematic diagram of a receiving unit for the reception and display of the signals received from the combination sensor and

Figure 3 is a schematic diagram of a one-piece design of the combination sensor, embedded in a plastic synthetic material, which is adapted to the external shape of the ear.

In figure 1, sensor carrier 11 first contains a heat-flow sensor 1, which is designed in particular in the form of a double-temperature sensor and delivers two values for the temperature ( $T_{h1}$ ,  $T_{h2}$ ), from which the body core temperature ( $T_c$ ) is determined in first measuring-signal evaluation unit 4 by means of a linkage known for example from DE 101 39 705 A1 and DE 198 18 170 C2.

Acoustic sensor 2 is used for the measurement of the heartbeat rate (HR) and delivers a time signal, which is processed in the frequency range from approx. 0.5 to 10 Hertz in a second measuring-signal evaluation unit 5 in order to determine the heartbeat rate (HR), whereby in second measuring-signal evaluation unit 5 the time signal is first pre-filtered in analogue or digital form and restricted to the frequency range from approx. 0.5 to 10 Hertz. The use of signal degeneration algorithms then follows. The Fourier transform and the correlation functions may be mentioned here as examples. Analyses with the aid of periodograms are also possible. In addition, acoustic sensor 2 also picks up voice signals, which are separated from the overall acoustic signal at the output of acoustic sensor 2 with the aid of filter 6 in the frequency range from approx. 100 to 3000 Hertz. Said filter can be designed as an analogue or digital bandpass filter with a bandpass frequency range from approx. 100 to 3000 Hertz.

In an optional third measuring-signal evaluation unit 7, an index for the physiological strain, in particular the PSI index, is ascertained from the linking of the values for  $T_c$  and HR and it is determined, by comparison with preset stored limiting values, whether an alarm is optionally triggered by means of loudspeaker 3.

The values  $T_c$ , HR and PSI and the voice signal from filter 6 arrive in communication interface 8, in which all the data are merged, compressed and digitalised, i.e. processed in such a way that they arrive via a data line or preferably by wireless at communication unit 9, so that the data transmission takes place by means of aerial 10 by radio to receiving unit 12, figure 2. Receiving unit 12 processes the received signals and separates the data  $T_c$ , HR and PSI, which are displayed in downstream display unit 13 with displays 14 for  $T_c$ , 15 for HR and 16 for PSI. Components 1 to 8 are located in sensor carrier 11 behind the ear of the person to be measured.

Communication unit 9 is carried separately, for example on the person's belt. Communication unit 9 and communication interface 8 can also be used for the voice, alarm and command reception of units 12 and 13. A voice or communication connection can also be produced for example between firefighters, who are each carrying a combination sensor. The power supply takes place either via a battery 17 integrated into sensor carrier 11, inductively or alternatively via the wire connection of communication unit 9 to communication interface 8 and thus to sensor carrier 11. Components 12 to 16 are located, in the case of the fire brigade for example, in a control centre or in an operational vehicle of the director of operations. Here, the displayed values are collected, evaluated and, case by case, transformed into operational commands or alarms.

In the case of a sportsman, the components may be located, for example, in a wristwatch, in order to display the real-time data of the physiological state.

In figure 3, the preferably one-piece design of the combination sensor is represented with sensor carrier 11 suitable for the space behind the human ear, with heat-flow sensor 1, acoustic sensor

2, loudspeaker 3, combined processing electronics 21 and the data line to communication unit 9, said data line being designed here as a wire connection 22.

Sensor carrier 11 in figure 3 is produced for example from a plastic synthetic material, so that an adaptation of the shape to the individual external shape and size of the ear can be made. Alternatively, the sensor carrier consists of several individual parts, which are connected together in a mobile fashion.

All the sensor elements of sensor carrier 11 rest solely on the skull and/or the external ear including the ear lobe. This measurement position has proved especially well-suited in order both to detect good measurement signals for the temperatures for the determination of the body core temperature as well as for the heartbeat rate. There are no small parts extending into the ear canal or capable of pressing into the sensitive ear with a sudden movement. Alternatively, a combination sensor according to the present invention can also be fitted at other points of the body suitable for the measurement of the body core temperature, such as for example on the skull or in the area of the chest.



CLAIMS

1. A combination sensor for physiological measured variables in a sensor carrier including a sensor carrier in which are located:
  - a) a heat-flow sensor for detecting two temperatures for the determination of the body core temperature;
  - b) an acoustic sensor for measuring the heartbeat rate (HR) and for detecting voice signals;
  - c) at least one measuring-signal evaluation unit; and
  - d) a communication interface for the transmission of processed data from the measuring-signal evaluation unit to a communication unit.
  
2. The combination sensor according to claim 1, in which an additional third measuring-signal evaluation unit is provided for calculating an index for physiological strain from the body core temperature and the heartbeat rate (HR) and for relaying to the communication unit.
  
3. The combination sensor according to claim 1 or 2, in which the sensor carrier is embedded in a plastic synthetic material, preferably in silicone, and is adapted to the shape of the human ear.
  
4. The combination sensor according to at least one of claims 1 to 3, in which the communication unit is arranged to send signals to a receiving unit, which is equipped with a downstream display unit for displaying heartbeat rate (HR), body core temperature and/or the index for the physiological strain.

5. The combination sensor according to at least one of claims 1 to 4, in which the sensor carrier has a loudspeaker, which is connected to the communication interface and/or to the measuring-signal evaluation unit and is activatable.

6. The combination sensor according to any one of the preceding claims, in which the data transmission between the communication interface and communication unit takes place by wireless.

7. A combination sensor substantially as hereinbefore described with reference to and/or as shown in the accompanying figures.



INVEST FOR IN PEOPLE

Application No: GB0424072.7

Examiner: Eleanor Hogan

Claims searched: 1-7

Date of search: 1 March 2005

### Patents Act 1977: Search Report under Section 17

#### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	DE 10038247 A1 (DRAEGER)
A	-	US 2003/0032893 A1 (KOCH)
A	-	JP 04253839 A (MITSUBISHI)
A,P	-	WO 2004/075750 A1 (REED)
A	-	GB 2243691 A (PAYNE)

#### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

#### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>X</sup> :

G1G; G1N

Worldwide search of patent documents classified in the following areas of the IPC<sup>07</sup>

A61B; G01K

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC.