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(54) Dive computer comprising dive checking means

(57) A dive computer (10, 12, 20) usually comprises means for detecting and measuring the dive depth and time, as well as other data relative to the underwater environment and to the instrumentation, the computer comprising means (10) for detecting, acquiring and processing (20) the diver's biometric parameters, that is to say, means which provide a measurement of the physical/chemical/biological parameters of the bloodstream, said parameters being detected by suitable sensors (12) applied to one or more parts of the diver's body and connected to the acquisition unit (10) by electrical connections established using a cable or wireless system or the like, a data processing unit (20) also being used, connected using a cable or other connections to the unit (10) and if necessary displaying the information, consisting of instruments of the type worn on the wrist or located at the end of the control hose or the like, there being the possibility of grouping together the three units for data acquisition and processing (10, 12 and 20) in a single block of instruments or dividing them into separate components which can be connected to each other using a cable or wireless system.

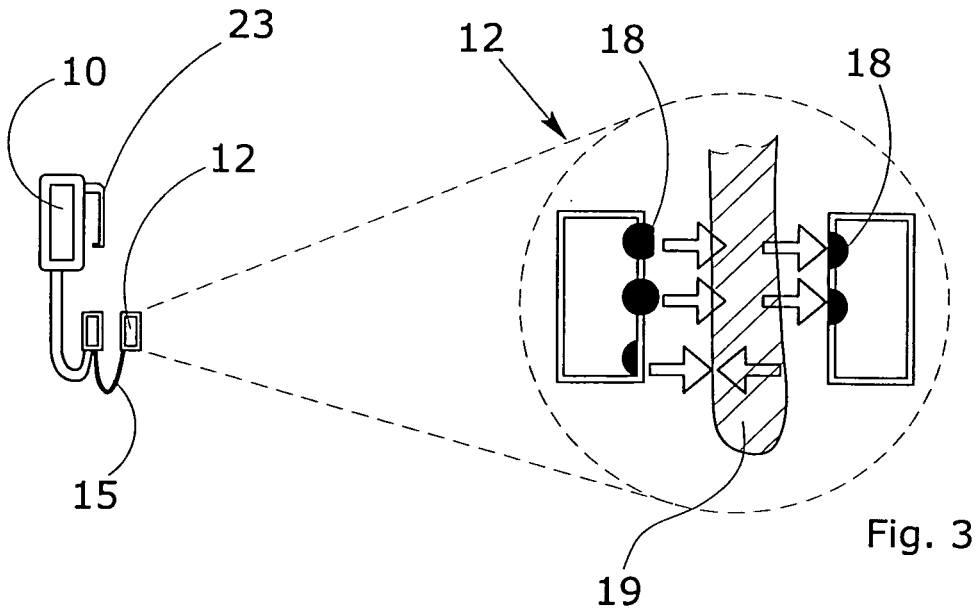

Fig. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to a dive computer comprising means for checking the diver's biometric parameters, that is to say, means which in addition to the normal information usually detectable, also provide a function not normally present, which is extremely useful if not essential: the processing and/or displaying of the measurement of the physical/chemical/biological parameters of the diver's bloodstream.

[0002] More particularly, the present invention relates to a dive computer able to read and process physical/chemical/biological parameters in the bloodstream such as:

- haemoglobin oxygen saturation;
- partial CO2 pressure;
- partial 02 pressure;
- heart rate.

[0003] The dive computer in accordance with the present invention can guarantee much greater safety for the diver during a dive because it can check and report on risks linked to:

- HYPOXEMIA and HYPOXIA, haemoglobin oxygen saturation.
- HYPEROXIA, quantity of oxygen dissolved.
- HYPERCAPNIA, quantity of CO2 dissolved.
- FATIGUE, analysed by interpolation of biometric data analysed by the dive computer.

[0004] The present invention is for use in the field of measuring instruments and in particular in the sector of instruments which may be worn on the wrist or may be portable, for sportsmen and women and in particular for diving.

BACKGROUND ART

[0005] It is known that in the sports sector there are many types of measuring devices used by athletes generally during exercise in order to monitor various parameters according to requirements.

[0006] In the diving sector there are various measuring and checking apparatuses and instruments, called dive computers, which can be worn on the wrist or located on the end of control hoses or in any other most suitable position.

[0007] As is known, a dive computer is an instrument used to measure various parameters during a dive, typically the dive time and depth, to allow calculation of the times for safe ascent to the surface without the well-known problem of the bends.

[0008] The bends are a pathology deriving from the formation of bubbles in the bloodstream or tissues and caused by failure to eliminate inert gases, such as nitrogen, following a dive.

[0009] It is also known that dive computers are designed to process decompression table data and can continuously estimate the partial pressure of the inert gases in the body, in particular nitrogen, based on continual reading of the diver's depth and the dive time.

[0010] Many dive computers also provide the diver with other information, for example the water temperature, the pressure of the gas in the cylinder or average air consumption, being real battery-powered computers enclosed in a watertight shell.

[0011] These instruments continuously monitor the dive profile, taking into account the time and pressure.

[0012] All dive computers measure the surrounding pressure to calculate the partial pressure of the gases in human tissues. The most advanced models also include further information such as the water temperature or the pressure inside the cylinder. Some dive computers even use an elastic strap on the diver's chest which, with special electrodes, detects the heart rate during the dive.

[0013] Prior art dive computers use the dive profile and with a mathematical algorithm estimate the partial pressure of the inert gases which must be expelled from the tissues. Based on these calculations, the computer estimates the possibility of direct ascent to the surface or, rather, ascent to the surface with one or more decompression stops.

[0014] Some algorithms used are the Buhlmann algorithm, the Multi-Tissue Model, the variable permeability model and, often, the Reduced Gradient Bubble Model (RGBM).

[0015] Some computers can calculate the decompression stops even for gases other than air, such as nitrox, pure oxygen, trimix, helium and other mixtures.

[0016] Most dive computers can plan a safe decompression even for dives at high altitude locations, which require slower ascent to the surface than at sea level, since the atmospheric pressure before the dive is measured. Moreover, if the diver must travel before or after a dive, and in particular in the case of an aeroplane journey, they should take the computer with them, so that it can continue to monitor the body's pressure profile.

[0017] The use of current dive computers has revealed several functional limits.

[0018] First, common dive computers are mainly designed to provide data about the problem dealt with in decompression tables, therefore based exclusively on the estimate of the partial pressure of inert gases in the body, in particular nitrogen, processing and supplying data only about the problem linked to the bends.

[0019] Therefore, operation of prior art dive computers depends on the reading of a few essential parameters, such as the dive time and water pressure.

[0020] Even models which analyse the heart rate using electrodes fixed to an elastic strap on the chest are extremely uncomfortable, as well as not being very practical and are rather inaccurate, given the presence of water

in the wetsuit, often salt water, that is to say seawater, notoriously more problematic than freshwater.

[0021] In short, conventional dive computers currently on the market concentrate their operation on the sole aim of avoiding the bends linked to the partial pressure of nitrogen in the blood.

[0022] This technological limit of conventional dive computers does not allow the detection of risks linked to the various physiological factors, such as hypoxia, that is to say, haemoglobin oxygen saturation, hyperoxia, that is to say, the quantity of oxygen dissolved, hypercapnia, that is to say, the quantity of CO2 dissolved, and does not even allow measurement of fatigue, thus each year there are several cases of divers who are taken ill, in some cases their condition being serious and often unfortunately lethal.

DESCRIPTION OF THE INVENTION

[0023] The present invention has for an aim to provide a dive computer comprising means for checking the diver's biometric parameters which is able to eliminate or at least reduce the above-mentioned disadvantages.

[0024] The invention also has for an aim to provide a dive computer comprising means for checking the diver's biometric parameters, and which consists as a whole of an apparatus designed for reading the diver's biophysical parameters and an apparatus able to process said data.

[0025] The apparatus for reading biophysical parameters and the data processing apparatus may be grouped together in a single device, or they may remain as separate components which may be connected to each other using a cable or a wireless system, that is to say by means of radio waves or the like.

[0026] This aim is achieved by a dive computer comprising means for checking the diver's biometric parameters whose features are described in the main claim.

[0027] The dependent claims of the solution disclosed outline advantageous embodiments of the invention.

[0028] The main advantages of this solution, in addition to all of the those deriving from the relatively simple design, relate first to the fact that, in practice, the data detected is transmitted to the unit, which using a dedicated software informs the diver of any problems deriving from dangerous quantities, and even warns of potentially dangerous trends or tendencies.

[0029] The dive computer can warn the diver visually or acoustically and if necessary will be able to activate special solenoid valves designed to modify the diver's buoyancy.

[0030] The device disclosed therefore substantially consists of an apparatus designed to read the diver's biophysical parameters and an apparatus able to process said data.

[0031] The computer uses technologies for reading data such as:

- oxygen saturation
- partial CO2 pressure
- partial 02 pressure
- heart rate.

[0032] Therefore the device comprises at least one biometric signal pick up element and at least one signal processor.

[0033] The various new data processed by the dive computer, again coinciding with reading of the depth (water pressure) and the dive time, is managed by a dedicated software which confirms precise information for the diver regarding oxygen saturation, informing the diver of any danger of hypoxia, the quantity of oxygen dissolved, with any danger of hyperoxia, the quantity of CO2 dissolved, with any danger of hypercapnia, the diver's fatigue level and supplies a very precise estimate of the danger of suffering the bends.

[0034] In short, this invention aims to make the diver's dive safer whether he or she is using an open-circuit scuba set (classic demand regulator), or a closed-circuit (use of rebreather), free diving or other.

DESCRIPTION OF THE DRAWINGS

[0035] Other features and advantages of the invention are apparent in the description which follows, of a preferred, non-restricting embodiment of the invention, with reference to the accompanying drawings, in which:

- Figure 1 is a schematic view of part of the dive computer in accordance with the invention comprising means for detecting biometric parameters, applied to a diver's mask;
- Figure 2 is a schematic view of a detail of the data acquisition and transmission part of the dive computer in accordance with the invention and of the respective connections to the group of sensors;
- Figure 3 is a schematic view of a dive computer in accordance with the invention and of a detail of the sensors which can be applied to an earlobe;
- Figure 4 is a schematic view of the layout of the inside of the dive computer in accordance with the invention;
- Figures 5 and 6 are schematic views of two possible embodiments of the part of the dive computer in accordance with the invention used for data processing and if necessary for displaying the data;
- Figure 7 is a schematic view of a dive computer in accordance with the invention applied to a diver's wrist, with a sensor applied on one finger.

DESCRIPTION OF ONE EMBODIMENT OF THE INVENTION

[0036] With reference to the accompanying drawings, the dive computer in accordance with the invention, labelled 10 and 20 as a whole, substantially consists of a data acquisition part 10, for example made using a wa-

tertight material casing and also able to resist underwater pressure, this acquisition part being connected, by a cable 11, or by means of a wireless or other most suitable system, to at least one sensor 12, designed to read biometric parameters, which can be applied to a part of the body sensitive to the data to be detected, and it also consists of a part 20 for processing the data received.

[0037] With reference first to Figures 1 and 3, it can be seen that the data acquisition part 10 of the computer may, for example, be applied on the elastic strap 13 of a diving mask 14 and secured there using a clip 23 on the elastic strap.

[0038] In the example illustrated the cable 11 connects the computer 10 to a group of luminous sensors and gas or chemical sensors, which are connected to the earlobe 19 for example using fixing clips 15.

[0039] The connecting cable 11 connects the battery container 16 and the reading circuit 17 with the actual sensors 18 designed to read the biometric parameters.

[0040] In the case illustrated in Figure 1, the group of sensors 12 is secured, by clips 15 to the earlobe 19, which is a particularly vascularised part of the body, but the sensors may be applied in the same way to other parts of the body, for example on one or more fingers, as illustrated in Figure 7.

[0041] Even other parts of the body, such as the fingertips, forehead, or other, depending on requirements, may be used for application of the sensors. For the oxygen saturation analysis the sensors normally used are two light sources at different frequencies 18 which, passing through the vascularised part of the skin, for example the earlobe 19, detect colour variations which indicate haemoglobin saturation. In contrast, a heating element and an optical and chemical pick up element is normally used to detect the partial CO2 pressure.

[0042] An electrode is generally used to detect the partial 02 pressure, whilst the heart rate is detected by the volumetric variation linked to the arterial pulse.

[0043] The rechargeable battery is located in the container 16 which is watertight. An adjacent watertight container holds the electronic circuit 17 designed to transmit the biometric data to the processor 20, located on the diver's wrist, or at the end of the compressed air hose 21.

[0044] The numeral 22 denotes cavities for the electronic circuits dedicated to the biometric sensors.

[0045] The system described therefore uses the acquisition unit 10 with the sensors 12, and the processing and if necessary display unit 20 of the dive computer to read and process the physical/chemical/biological parameters in the bloodstream, such as:

- haemoglobin oxygen saturation
- partial CO2 pressure
- partial 02 pressure
- heart rate.

[0046] The dive computer, consisting of the acquisition unit 10 with the sensors 12, and of the processing and if necessary display unit 20, is therefore able to guarantee much greater safety for the diver during a dive because it can check and report on risks linked to hypoxemia and hypoxia (haemoglobin oxygen saturation), hyperoxia (quantity of oxygen dissolved), hypercapnia (quantity of CO2 dissolved), fatigue (analysed by interpolation of the biometric data analysed by the dive computer).

[0047] Moreover, the sensors used for reading the above-mentioned data also provide very precise readings of the heart rate, obtained from the variation in volume linked to the arterial pulse, very useful for calculating the quantity of air actually breathed and the diver's level of fatigue.

[0048] All of this new data processed by the dive computer 10 and 20, again coinciding with reading of the depth (water pressure) and the dive time, is managed by a dedicated software which allows the display of precise information for the diver regarding oxygen saturation, informing the diver of any danger of hypoxemia and hypoxia, the quantity of oxygen dissolved, any danger of hyperoxia, the quantity of CO2 dissolved, any danger of hypercapnia, the diver's fatigue level and supplies a very precise estimate of the danger of suffering the bends.

[0049] In short, the system disclosed allows the diver's dive to be made safer whether he or she is using an open-circuit scuba set (classic demand regulator), or a closed-circuit (use of rebreather), free diving or other. Obviously, different sensors of any type may be used, such as those to be applied on the fingers, shown in Figure 7, or other kinds of sensors suitable for the purpose.

[0050] Moreover, as already indicated, the apparatus for reading biophysical parameters 10, 12 and the data processing apparatus 20 may be grouped together in a single device, or they may remain as separate components which may be connected to each other by a cable or through a wireless system, that is to say by means of radio waves or the like.

[0051] In addition, to keep costs low, versions of the computer may be made in which programs and detectors even with partial functions are installed, that is to say comprising systems for detecting only one or several of the physical/chemical/biological parameters of the bloodstream, that is to say, haemoglobin oxygen saturation and/or partial CO2 pressure, and/or partial 02 pressure and/or the heart rate.

[0052] The invention is described above with reference to a preferred embodiment. However, obviously the invention is susceptible of many variations without thereby departing from the inventive concept, consisting of technical equivalents.

Claims

1. A dive computer (10, 12, 20) usually comprising means for detecting and measuring the dive depth and time, as well as other data relative to the underwater environment and to the instrumentation, **char-**

acterised in that it comprises means (10) for detecting, acquiring and processing (20) the diver's biometric parameters, that is to say, means which provide a measurement of the physical/chemical/biological parameters of the bloodstream, said parameters being detected by suitable sensors (12) applied to one or more parts of the diver's body and connected to the acquisition unit (10) by electrical connections established using a cable or wireless system or the like, a data processing unit (20) also being used, connected using a cable or other connections to the unit (10) and if necessary displaying the information, consisting of instruments of the type worn on the wrist or located at the end of the control hose or the like, there being the possibility of grouping together the three units for data acquisition and processing (10, 12 and 20) in a single block of instruments or dividing them into separate components which can be connected to each other using a cable or wireless system.

2. A dive computer according to the foregoing claim, **characterised in that** the data acquisition unit (10) substantially consists of a casing made of watertight material which is also resistant to water pressure, connected, by a cable (11) or wireless system or the like to at least one sensor (12), designed to read biometric parameters, which can be applied to one or more parts of the body sensitive to the data to be detected.

3. A dive computer according to either of the foregoing claims, **characterised in that** the data acquisition part can be applied for example to the elastic strap (13) of a diving mask (14) or in another most suitable location.

4. A dive computer according to any of the foregoing claims, **characterised in that** the cable (11) connects the acquisition unit (10) to a group of luminous sensors and gas or chemical sensors, which are secured for example by clips (15) for fixing the container to the mask strap.

5. A dive computer according to any of the foregoing claims, **characterised in that** the connecting cable (11) connects the battery container (16) and the reading circuit (17) to the actual sensors designed to read the biometric parameters.

6. A dive computer according to any of the foregoing claims, **characterised in that** the group of sensors (12) is secured, by clips (15) or the like to the earlobe (19) or the like, or to particularly vascularised parts of the body.

7. A dive computer according to any of the foregoing claims, **characterised in that** the sensors may be secured to other parts of the body such as the fingertips, forehead, or other, depending on requirements.

8. A dive computer according to any of the foregoing claims, **characterised in that** for the oxygen saturation analysis it is normally possible to use as sensors light sources at different frequencies (18) or the like which, passing through the vascularised part of the skin for example of the earlobe (19), detect colour variations which indicate haemoglobin saturation, or other systems designed for the same purpose.

9. A dive computer according to any of the foregoing claims, **characterised in that** for detecting the partial CO2 pressure a heating element and an optical and chemical pick up device or other systems suitable for the purpose are usually used.

10. A dive computer according to any of the foregoing claims, **characterised in that** for detecting the partial 02 pressure an electrode or the like is usually used, whilst the heart rate is detected using the volumetric variation linked to the arterial pulse, or other systems suitable for the same purpose.

11. A dive computer according to any of the foregoing claims, **characterised in that** in the container (16) there is a watertight rechargeable battery, and in an adjacent watertight container there is the electronic circuit (17) designed to transmit biometric data to the processor (20), located on the diver's wrist, or at the end of the compressed air hose (21) or other systems designed for the same purpose.

12. A dive computer according to any of the foregoing claims, **characterised in that** it has cavities (22) for the electronic circuits dedicated to the biometric sensors.

13. A dive computer according to any of the foregoing claims, **characterised in that** the system therefore uses the acquisition unit 10 with the sensors 12, and the processing and if necessary display unit 20 for reading and processing the physical/chemical/biological parameters in the bloodstream, such as:

haemoglobin oxygen saturation;
partial CO2 pressure;
partial 02 pressure;
heart rate.

14. A dive computer according to any of the foregoing claims, **characterised in that** it can guarantee maximum safety for the diver during a dive because it can check and report on risks linked to hypoxia (haemoglobin oxygen saturation), hyperoxia (quantity of oxygen dissolved), hypercapnia (quantity of CO2

dissolved), fatigue (analysed by interpolation of the biometric data analysed by the dive computer).

15. A dive computer according to any of the foregoing claims, **characterised in that** the sensors used for reading the above-mentioned data also provide a precise reading of the heart rate, obtained from the variation in volume linked to the arterial pulse, useful for calculating the quantity of air actually breathed and the diver's level of fatigue.

16. A dive computer according to any of the foregoing claims, **characterised in that** the data processed by the dive computer, coinciding with the depth (water pressure) and dive time reading, is managed by a dedicated software which allows the display of precise information for the diver regarding the oxygen saturation, and informing the diver of any danger of hypoxia, the quantity of oxygen dissolved, any danger of hyperoxia, the quantity of CO2 dissolved, any danger of hypercapnia, the diver's level of fatigue and providing a very precise estimate of the danger of suffering the bends.

17. A dive computer according to any of the foregoing claims, **characterised in that** the apparatus for reading biophysical parameters (10, 12) and the data processing apparatus (20) may be grouped together in a single device, or may remain as separate components which can be connected to each other using a cable or a wireless system, that is to say, by means of radio waves or the like.

18. A dive computer according to any of the foregoing claims, **characterised in that**, to keep the costs low, versions of the computer may be made in which programs and detectors even with partial functions may be installed, that is to say comprising systems for detecting only one or several of the physical/chemical/biological parameters of the bloodstream, that is to say, haemoglobin oxygen saturation and/or partial CO2 pressure, and/or partial 02 pressure and/or the heart rate.

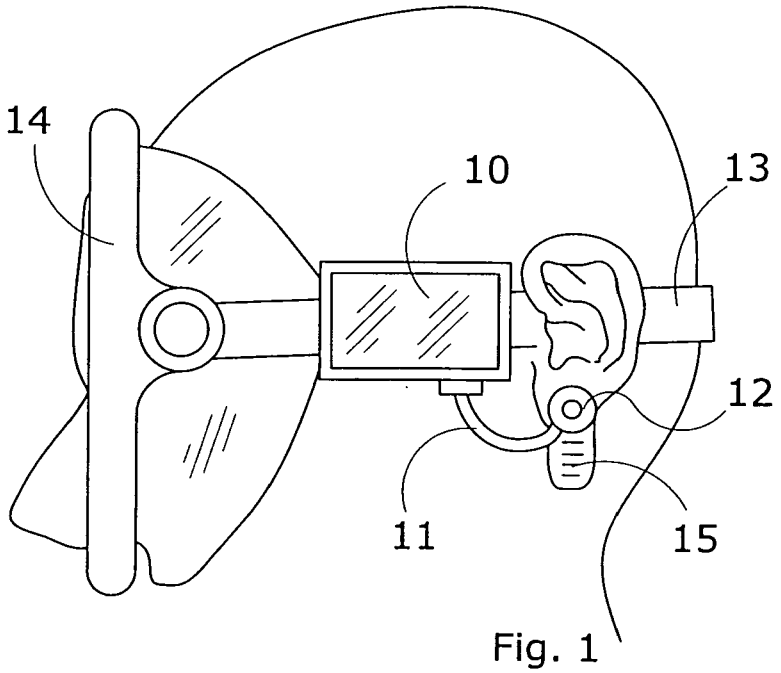

Fig. 1

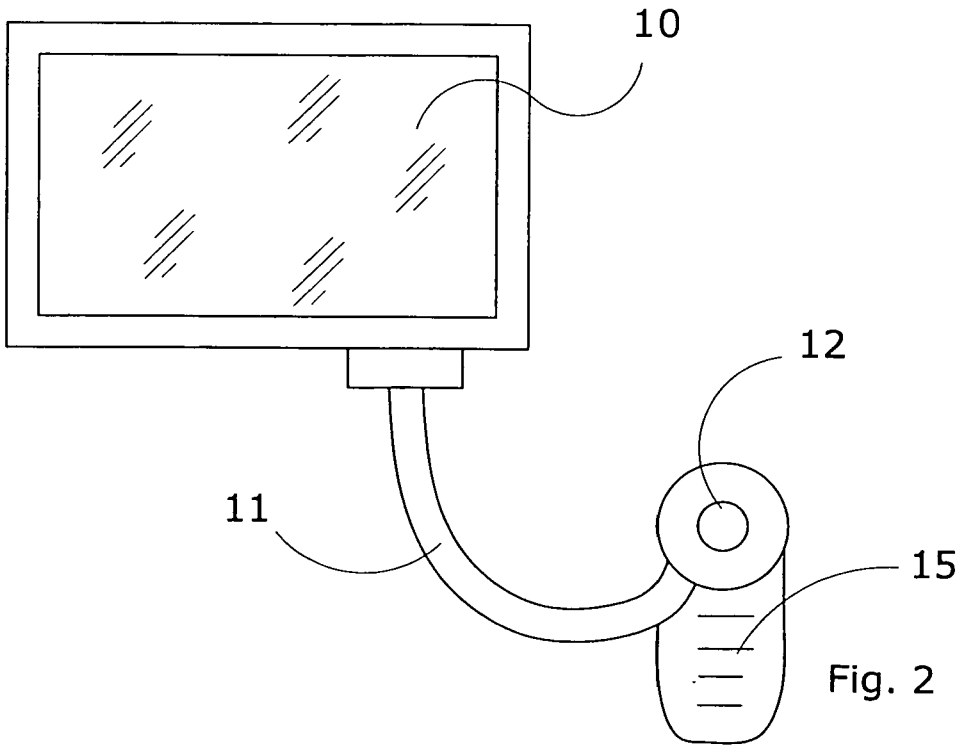

Fig. 2

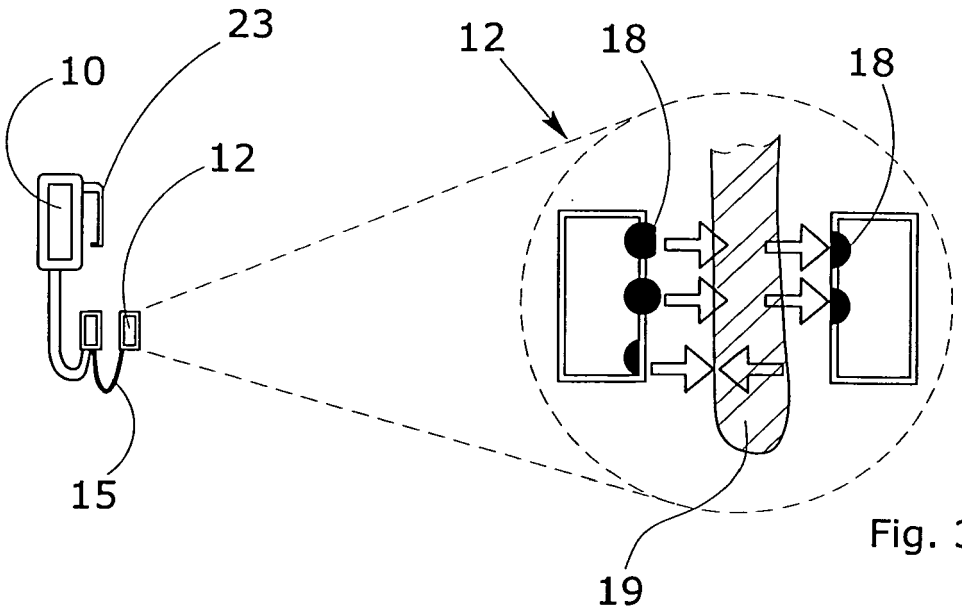
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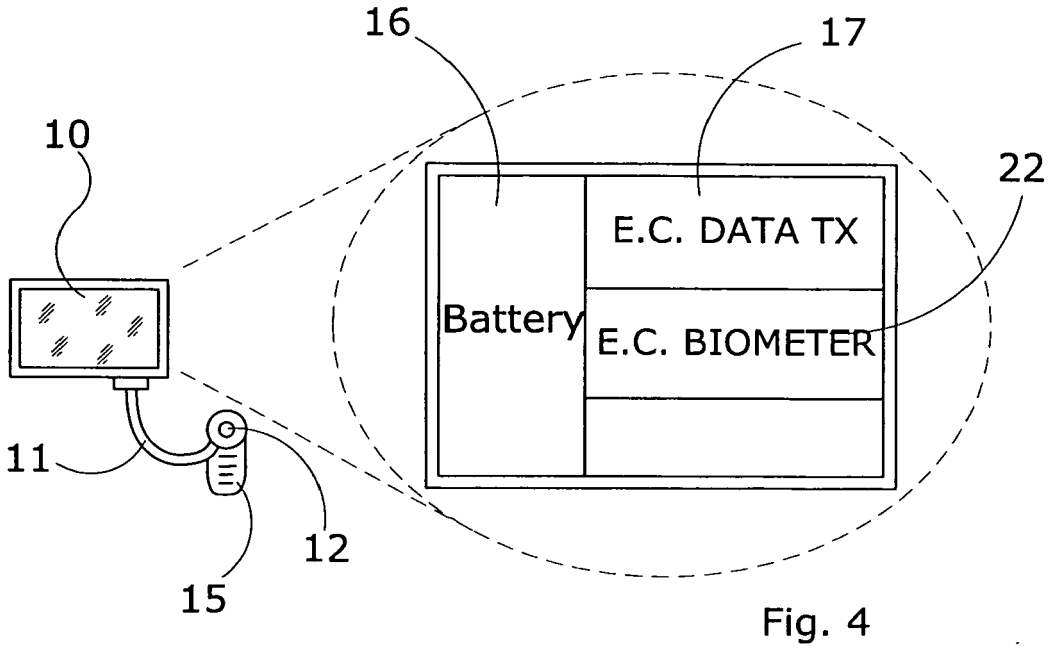
Fig. 3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17
10
22
E.C. DATA TX
Battery
E.C. BIOMETER
11
12
15

Fig. 4

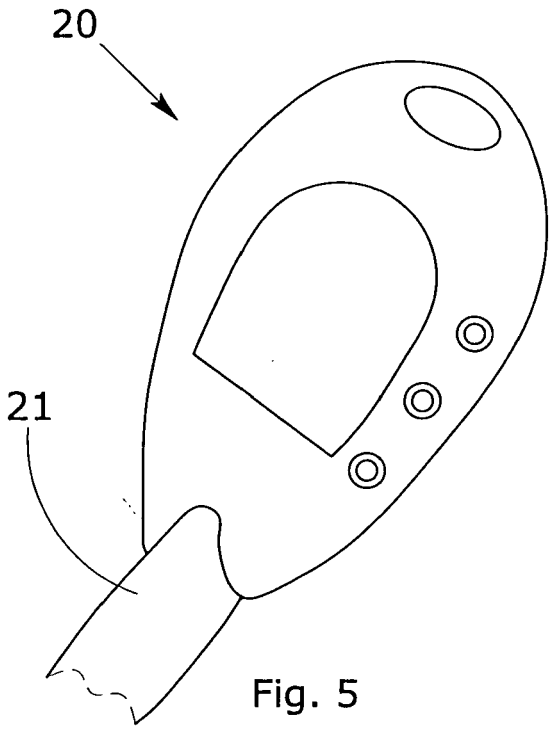

Fig. 5

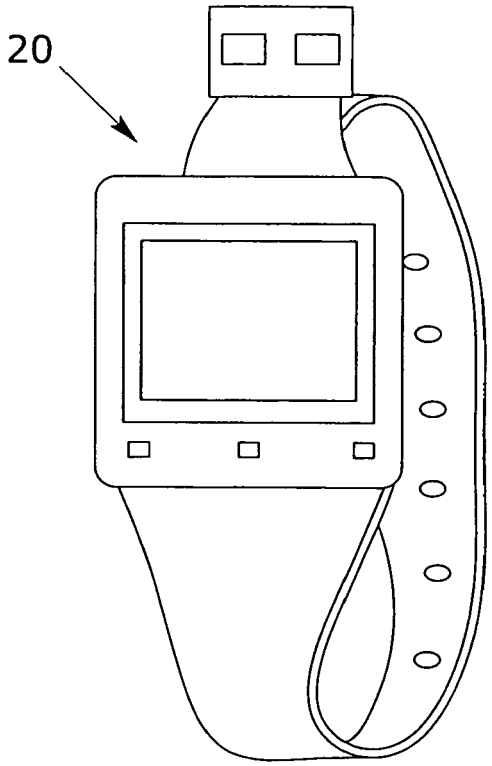

Fig. 6

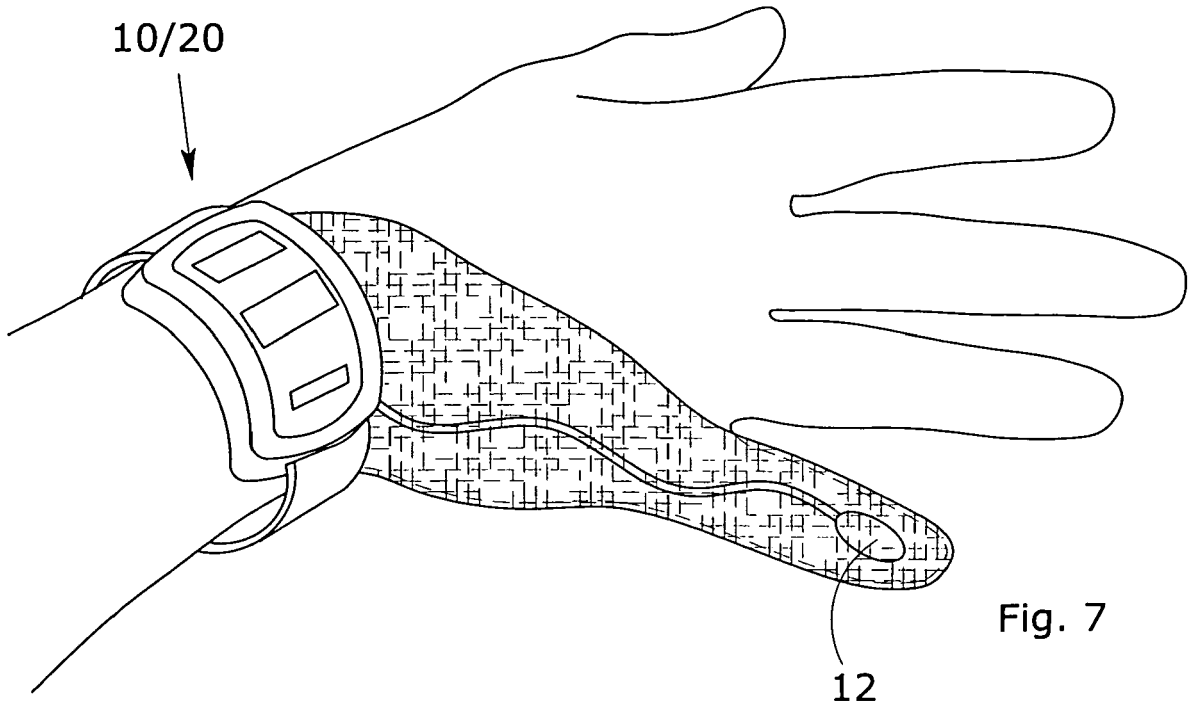

Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 42 5829

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	FR 2 878 751 A (DUFOUR VINCENT GERARD HENRI [FR]) 9 June 2006 (2006-06-09) * the whole document *	1-18	INV. B63C11/32
X	FR 2 895 970 A (BENISTY MICHEL [FR]; MILLA YVAN [FR]) 13 July 2007 (2007-07-13) * the whole document *	1-18	
A	GB 2 390 903 A (MARSH ANDREW JAMES [GB]) 21 January 2004 (2004-01-21) * the whole document *	1-18	

TECHNICAL FIELDS SEARCHED (IPC)

B63C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	20 May 2008	De Sena Hernandorena

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 42 5829

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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20-05-2008

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82