



(11) **EP 1 792 564 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
24.11.2010 Bulletin 2010/47

(51) Int Cl.:
A61B 5/00 (2006.01)

(21) Application number: **05111626.7**

(22) Date of filing: **02.12.2005**

(54) **A probe and a method for use with a probe**

Sonde und Methode zur Benutzung der Sonde

Sonde et procédé d'utilisation de la sonde

(84) Designated Contracting States:
DE NL

(43) Date of publication of application:
06.06.2007 Bulletin 2007/23

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US-A- 6 064 898 **US-A1- 2002 042 558**
US-A1- 2005 203 357 **US-B1- 6 842 635**

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Description

[0001] The invention relates to a method for use with a probe, which produces a signal indicative of the light absorption of arterial blood at least at a first light wavelength and at a second light wavelength. The invention relates further to a probe comprising a light source sending optical signals through the tissue at least at a first light wavelength and at a second light wavelength, and a detector receiving optical signals after transmission through the tissue for producing signals indicative of the light absorption of arterial blood.

[0002] The invention relates for example to devices used for non-invasively determining the amount of at least one light absorbing substance in a subject. These devices are typically pulse oximeters used to measure the blood oxygenation of a patient. More specifically, the invention relates to the detection of "probe-off" in such a device. The invention relates generally to devices used for non-invasively determining the amount of at least one light absorbing substance in a subject. These devices are typically pulse oximeters used to measure the blood oxygenation of a patient. More specifically, the invention relates to the detection of "probe-off" in such a device.

[0003] Pulse oximetry is at present the standard of care for the continuous monitoring of arterial oxygen saturation (SpO₂). Pulse oximeters provide instantaneous in-vivo measurements of arterial oxygenation, and thereby provide early warning of arterial hypoxemia, for example.

[0004] A pulse oximeter comprises a computerized measuring unit and a probe attached to the patient, typically to his or her finger or ear lobe. The probe includes a light source for sending an optical signal through the tissue and a photo detector for receiving the signal after transmission through the tissue. On the basis of the transmitted and received signals, light absorption by the tissue can be determined. During each cardiac cycle, light absorption by the tissue varies cyclically. During the diastolic phase, absorption is caused by arterial and venous blood, tissue, bone, and pigments, whereas during the systolic phase, there is an increase in absorption, which is caused by the influx of arterial blood into the tissue. Pulse oximeters focus the measurement on this arterial blood portion by determining the difference between the peak absorption during the systolic phase and the constant absorption during the diastolic phase. Pulse oximetry is thus based on the assumption that the pulsatile component of the absorption is due to arterial blood only.

[0005] Light transmission through an ideal absorbing sample is determined by the known Lambert-Beer equation as follows:

$$I_{\text{out}} = I_{\text{in}} e^{-sDC} \quad (1)$$

where I_{in} is the light intensity entering the sample, I_{out} is the light intensity received from the sample, D is the path

length through the sample, ϵ is the extinction coefficient of the analyte in the sample at a specific wavelength, and C is the concentration of the analyte. When I_{in} , D , and ϵ are known and I_{out} is measured, the concentration C can be calculated.

[0006] In pulse oximetry, in order to distinguish between the two species of hemoglobin, oxyhemoglobin (HbO₂), and deoxyhemoglobin (RHb), absorption must be measured at two different wavelengths, i.e. the probe includes two different light emitting diodes (LEDs). The wavelength values widely used are 660 nm (red) and 940 nm (infrared), since the said two species of hemoglobin have substantially different absorption values at these wavelengths. Each LED is illuminated in turn at a frequency which is typically several hundred Hz.

[0007] The practical functionality of a pulse oximeter is affected by several factors. This is discussed briefly in the following.

[0008] First of these is that the finger must be reliably placed in the optical path from LED emitters to the photodetector. If the probe is off, depending of the probe type (clip or wrap) the detection of this condition, just based on the two optical signals, plus a signal proportional to the ambient light, i.e. independent of the LED intensities, is frequently unreliable.

[0009] Also conditions where the finger is partly in the optical path, or if coatings such as nail polish are interfering, operation of the oximeter may be erratic, without the system being able to detect this condition.

[0010] Furthermore, even with the probe correctly positioned, the optical signal may be degraded by both noise and motion artifacts. One source of noise is the ambient light received by the photodetector. Many solutions have been devised with the aim of minimizing or eliminating the effect of the movement of the patient on the signal, and the ability of a pulse oximeter to function correctly in the presence of patient motion depends on the design of the pulse oximeter. This condition is frequently confused with a probe-off condition, especially with wrap type sensors, where the CTR detection mechanism does not work.

[0011] Detecting probe-off in a pulse oximetry sensor is traditionally based on the increase in signal when a clip-on probe has no finger inserted (current transfer ratio CTR above threshold) or, in the case of a flexible or disposable probe, when the signal is noisy or uncorrelated.

[0012] Both methods work, but have limitations. The CTR method requires amplitude discriminated LED transmitters, and the correlation method is slower and frequently unreliable.

[0013] As examples of the solutions known in the prior art US Patent No. 6 714 803, US Patent No. 5 827 182, US Patent 6 714 803 and US 6 360 114 can be mentioned.

[0014] Furthermore US Patent No. 2005/0203357 and US Patent 6 842 635 disclose methods and probes using at least three different wavelengths but for the purpose of reducing noise rather than detecting a probe off situ-

ation.

[0015] An object of the invention is to provide a method and a probe eliminating the disadvantages of the prior art. This is achieved by the method and the probe according to the invention. The method of the invention is characterized in that in order to indicate if the probe is not properly attached to a tissue site the method comprises measuring with at a third wavelength, the third wavelength being chosen so that human tissue is less transparent than at the first and second wavelengths. The probe of the invention is characterized in that in order to indicate if the probe is not properly attached to a tissue site the probe further comprises a light emitter producing a signal at a third wavelength, the third wavelength being chosen so that human tissue is less transparent than at the first and second wavelengths.

[0016] The most important advantage of the invention is that the situation in which for example the probe is off is very reliably detected when compared to the prior art. The advantage of the invention is also in that the invention is very simple, and therefore the invention is inexpensive to take into use and to use.

[0017] In the following the invention will be described in detail by means of a preferred exemplary embodiment in the accompanying drawing, in which

Figure 1 shows schematically one embodiment of the invention.

[0018] Figure 1 shows schematically a pulse oximeter of the invention. Reference number 1 shows a patient. In the embodiment shown in figure 1 measurement is carried out from a finger of the patient, and therefore only one finger of the patient is shown.

[0019] Reference number 2 shows a light source and reference number 3 a photo detector. The light source 2 sends optical signals through the tissue at least at a first light wavelength and at a second light wavelength. The detector 3 receives optical signals after transmission through the tissue for producing signals indicative of the light absorption of arterial blood.

[0020] In the embodiment shown light source 2 comprises two different light emitting diodes (LED) 4, 5 having wavelengths of 660 nm (red) and 940 nm (infrared), since the two species of haemoglobin have two substantially different absorption values at these wavelengths as described earlier.

[0021] The device comprises further a drive unit 6 for light emitting diodes, an input amplifier 7 for the photo detector 3, and a control unit 8.

[0022] The matters described above are known to a person skilled in the art, and therefore said matters are not described in detail here.

[0023] The idea in the invention is that in order to indicate if the probe is not properly attached to a tissue site the invention comprises measuring with at a third wavelength, the third wavelength being chosen so that human tissue is less transparent than at the first and second

wavelengths. In other words in order to indicate if the probe is not properly attached to a tissue site the probe further comprises a light emitter 9 producing a signal at a third wavelength. The third wavelength is chosen so that it does not penetrate human tissue in the way as the first and the second wavelengths do.

[0024] Typically, the red and infrared signals penetrate human tissue in a similar fashion, somewhat dependent of the tissue type, skin color and oxygenation status.

[0025] As said above in this invention a third wavelength is added, typically green or blue, that essentially does not penetrate human tissue, or where the tissue absorption is significantly stronger than at the other two wavelengths.

[0026] The third wavelength is shorter than 600 nm or longer than 1000 nm. Preferably the third wavelength is essentially 500-550 nm or 1300 nm or more.

[0027] The third wavelength can also be a mixture of wavelengths, as in white light, as long as the fraction of the less transparent wavelengths is significant enough to allow identification of the higher absorption in human tissue.

[0028] By comparing the CTR of two or more wavelengths, for example the three wavelengths shown in figure 1, the system can characterize the type of obstacle, or the lack of obstacle, in the optical path. Thus a clip probe without a finger shows similar CTRs for all three wavelengths (colors), whereas a finger passes red and infrared, but blocks green.

[0029] A wrap type probe that is open, i.e. the LEDs do not face the detector, usually has equally low CTRs for all colors, except when it leans onto a blanket or other reflecting object. Again, comparing the three CTRs enables the new system to discriminate a normal reflecting surface from human tissue with much better reliability than just having two wavelengths.

[0030] In the embodiment shown only one wavelength not penetrating human tissue is used. This is however not the only possibility but it is quite possible to use also more than one poorly penetrating wavelengths if needed. It is also quite possible to use more than two tissue penetrating wavelengths, i.e. more than red and infrared described in figure 1, if there is some need for additional measurements.

[0031] The embodiment described above is not intended to restrict the invention, but the invention can be modified quite freely within the scope of the claims enclosed. The details of the invention need not be exactly similar shown for example in figure 1 but other solutions can also be used. It is for example quite possible to modify the device shown so that it gives an appropriate alarm if the results obtained show that the probe is not properly attached to a tissue site etc.

Claims

1. A method for use with a probe which produces sig-

nals indicative of the light absorption of arterial blood at least at a first light wavelength and at a second light wavelength, the method comprises measuring at a third wavelength, the third wavelength being chosen so that human tissue is less transparent than at the first and second wavelengths, **characterized in that** the measuring at the third wavelength providing an indication that the probe is not properly attached to a tissue site.

2. The method of claim 1, **characterized in that** current transfer ratio (CTR) of two or more wavelengths is compared.
3. The method of claim 1 or 2, **characterized in that** the third wavelength is shorter than 600 nm or longer than 1000 nm.
4. The method of claim 3, **characterized in that** the third wavelength is essentially 550-500 nm or 1300 nm or more.
5. The method of claim 1, **characterized in that** the method is for use with a pulse oximeter probe.
6. The method of claim 1, **characterized in that** more than one poorly penetrating wavelengths are used.
7. A probe comprising a light source (2) sending optical signals through the tissue at least at a first light wavelength and at a second light wavelength, and a detector (3) receiving optical signals after transmission through the tissue for producing signals indicative of the light absorption of arterial blood, the probe further comprises a light emitter (9) producing a signal at a third wavelength, the third wavelength being chosen so that human tissue is less transparent than at the first and second wavelengths, **characterized in that** the probe is adapted to indicate if the probe is not properly attached to a tissue site.
8. The probe of claim 7, **characterized in that** it comprises a unit for comparing current transfer ratio (CTR) of two or more wavelengths.
9. The probe of claim 7 or 8, **characterized in that** the third wavelength is shorter than 600 nm or longer than 1000 nm.
10. The probe of claim 9, **characterized in that** the third wavelength is essentially 500-550 nm or 1300 nm or more.
11. The probe of claim 7, **characterized in that** the probe is a pulse oximeter probe.
12. The probe of claim 7, **characterized in that** the probe further comprises at least more than one light

emitters producing a poorly penetrating wavelength.

Patentansprüche

1. Ein Verfahren zur Benutzung einer Sonde die Signale erzeugt, welche die Lichtabsorption von arteriellem Blut bei mindestens einer ersten Lichtwellenlänge und einer zweiten Lichtwellenlänge anzeigen, wobei das Verfahren eine Messung bei einer dritten Wellenlänge umfasst und die dritte Wellenlänge so gewählt ist, dass menschliches Gewebe weniger transparent ist als bei der ersten und zweiten Wellenlänge, **dadurch gekennzeichnet, dass** die Messung bei der dritten Wellenlänge anzeigt, dass die Sonde nicht richtig an einer Gewebestelle befestigt ist.
2. Das Verfahren aus Anspruch 1, **dadurch gekennzeichnet, dass** ein Strom-Übertragungsfaktor (CTR) von zwei oder mehreren Wellenlängen verglichen wird.
3. Das Verfahren aus Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die dritte Wellenlänge kürzer als 600 nm oder länger als 1000 nm ist.
4. Das Verfahren aus Anspruch 3, **dadurch gekennzeichnet, dass** die dritte Wellenlänge im Wesentlichen 550-500 nm oder 1300 nm oder mehr ist.
5. Das Verfahren aus Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren zur Verwendung einer Puls-Oximeter-sonde verwendet wird.
6. Das Verfahren aus Anspruch 1, **dadurch gekennzeichnet, dass** mehr als eine schlecht penetrierende Wellenlänge verwendet wird.
7. Eine Sonde umfassend eine Lichtquelle (2), welche optische Signale mit mindestens einer ersten Lichtwellenlänge und einer zweiten Lichtwellenlänge durch das Gewebe sendet, und einen Detektor (3), welcher optische Signale, welche durch das Gewebe gesendet wurden, empfängt um Signale zu erzeugen, die die Lichtabsorption von arteriellem Blut anzeigen, wobei die Sonde zusätzlich einen Lichtsender (9) umfasst, welcher ein Signal mit einer dritten Wellenlänge erzeugt und die dritte Wellenlänge so gewählt ist, dass menschliches Gewebe weniger transparent ist als bei der ersten und zweiten Wellenlänge, **dadurch gekennzeichnet, dass** die Sonde geeignet ist anzuzeigen, falls die Sonde nicht richtig an einer Gewebestelle befestigt ist.
8. Die Sonde aus Anspruch 7, **dadurch gekennzeichnet, dass** sie eine Einheit umfasst, welche einen Strom-Übertragungsfaktor (CTR) von zwei oder

mehreren Wellenlängen vergleicht.

9. Die Sonde aus Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** die dritte Wellenlänge kürzer als 600 nm oder länger als 1000 nm ist. 5
10. Die Sonde aus Anspruch 9, **dadurch gekennzeichnet, dass** die dritte Wellenlänge im Wesentlichen 500-550 nm oder 1300 nm oder mehr ist. 10
11. Die Sonde aus Anspruch 7, **dadurch gekennzeichnet, dass** die Sonde eine Puls-Oximetersonde ist. 15
12. Die Sonde aus Anspruch 7, **dadurch gekennzeichnet, dass** die Sonde weiter zumindest mehr als einen Lichtsender umfasst, welcher eine schlecht penetrierende Wellenlänge erzeugt. 20

Revendications

1. Procédé d'utilisation d'une sonde qui produit des signaux indicateurs de l'absorption de lumière du sang artériel au moins à une première longueur d'onde de lumière et à une deuxième longueur d'onde de lumière, le procédé comprend le mesurage à une troisième longueur d'onde, la troisième longueur d'onde étant choisie de sorte que le tissu humain est moins transparent qu'aux première et deuxième longueurs d'ondes, **caractérisé en ce que** le mesurage à la troisième longueur d'onde fournit une indication selon laquelle la sonde n'est pas correctement attachée au tissu. 25
2. Procédé selon la revendication 1, **caractérisé en ce que** le rapport de transfert de courant (CTR) de deux ou plusieurs longueurs d'ondes est comparé. 35
3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la troisième longueur d'onde est plus courte que 600 nm ou plus longue que 1 000 nm. 40
4. Procédé selon la revendication 3, **caractérisé en ce que** la troisième longueur d'onde est essentiellement de 500 à 550 nm ou de 1 300 nm ou plus. 45
5. Procédé selon la revendication 1, **caractérisé en ce que** le procédé est destiné à être utilisé avec une sonde d'oxymètre pulsatile. 50
6. Procédé selon la revendication 1, **caractérisé en ce que** plus d'une longueur d'onde à faible pénétration est utilisée. 55
7. Sonde comprenant une source de lumière (2) émettant des signaux optiques à travers le tissu au moins à une première longueur d'onde et à une deuxième longueur d'onde, et un détecteur (3) recevant les si-

gnaux optiques après une transmission à travers le tissu en vue de produire des signaux indicateurs de l'absorption de lumière du sang artériel, la sonde comprend en outre un émetteur de lumière (9) produisant un signal à une troisième longueur d'onde, la troisième longueur d'onde étant choisie de sorte que le tissu humain est moins transparent qu'aux première et deuxième longueurs d'ondes, **caractérisée en ce que** la sonde est conçue pour indiquer si la sonde n'est pas correctement attachée au tissu.

8. Sonde selon la revendication 7, **caractérisée en ce qu'elle** comprend une unité destinée à comparer le rapport de transfert de courant (CTR) de deux ou plusieurs longueurs d'ondes.
9. Sonde selon la revendication 7 ou 8, **caractérisée en ce que** la troisième longueur d'onde est plus courte que 600 nm ou plus longue que 1 000 nm.
10. Sonde selon la revendication 9, **caractérisée en ce que** la troisième longueur d'onde est essentiellement de 500 à 550 nm ou de 1 300 nm ou plus.
11. Sonde selon la revendication 7, **caractérisée en ce que** la sonde est une sonde d'oxymètre pulsatile.
12. Sonde selon la revendication 7, **caractérisée en ce que** la sonde comprend en outre au moins plus d'un émetteur de lumière produisant une longueur d'onde à faible pénétration.

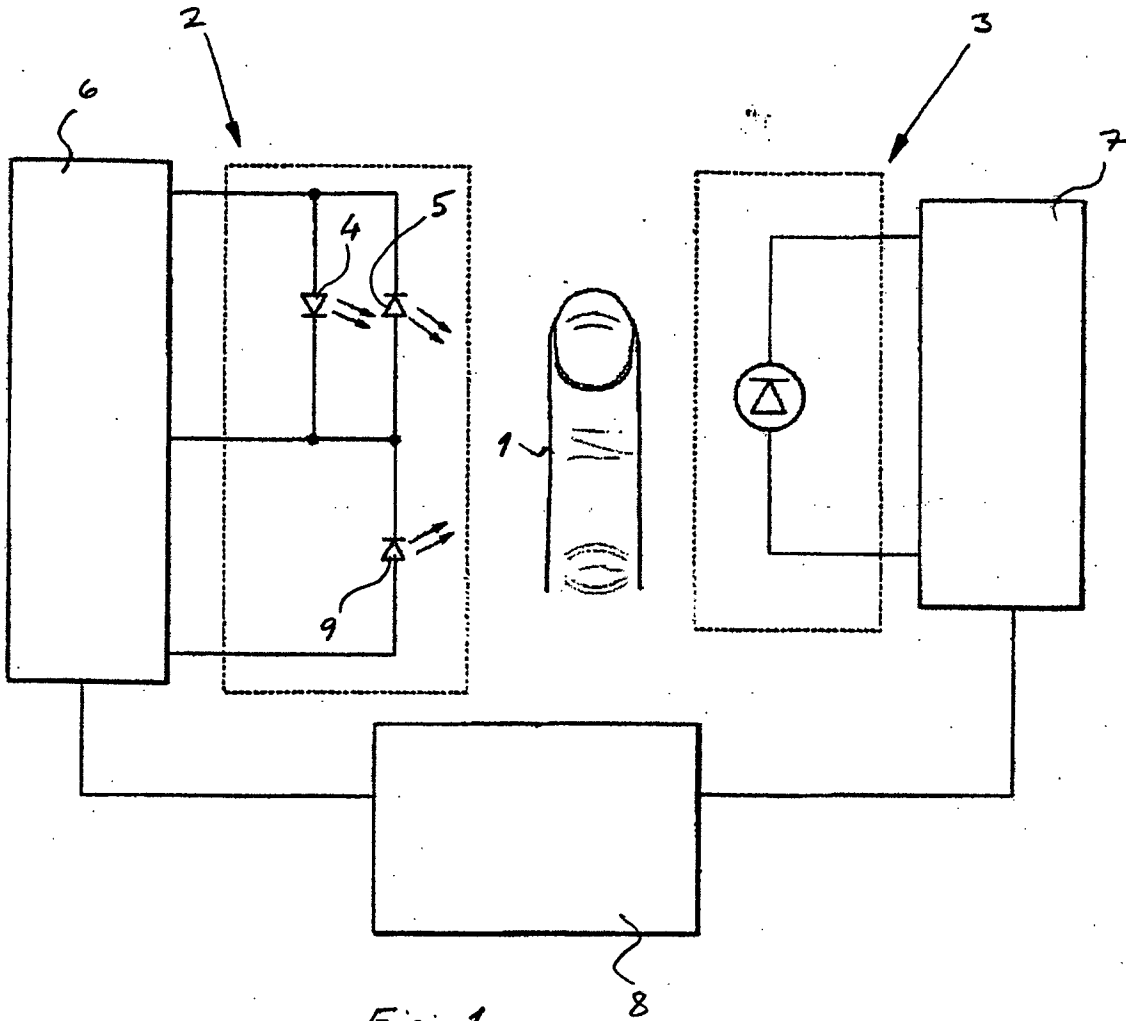


Fig 1

REFERENCES CITED IN THE DESCRIPTION

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- US 5827182 A [0013]
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专利名称(译)	用于探针的探针和方法		
公开(公告)号	EP1792564B1	公开(公告)日	2010-11-24
申请号	EP2005111626	申请日	2005-12-02
[标]申请(专利权)人(译)	通用电气公司		
申请(专利权)人(译)	通用电气公司		
当前申请(专利权)人(译)	通用电气公司		
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发明人	RANTALA, BÖRJE		
IPC分类号	A61B5/00		
CPC分类号	A61B5/14551		
其他公开文献	EP1792564A1		
外部链接	Espacenet		

摘要(译)

本发明涉及探针和与探针一起使用的方法，其产生指示至少在第一光波长和第二光波长下动脉血的光吸收的信号。为了指示探针是否未正确附着到组织部位，该方法包括用第三波长进行测量。选择第三波长使得人体组织比第一和第二波长更不透明。

$$I_{out} = I_{in} e^{-sDC} (1)$$