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(54) **NONINVASIVE BLOOD ANALYSIS BY OPTICAL PROBING OF THE VEINS UNDER THE TONGUE**

NICHTINVASIVE BLUTANALYSE DURCH OPTISCHE SONDIERUNG DER VENEN UNTER DER ZUNGE

ANALYSE SANGUINE NON-INVASIVE PAR SONDAGE OPTIQUE DES VEINES SUBLINGUALES

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a novel system and method for non-invasive analysis of blood including blood components and analytes.

[0002] More particularly, the present inventionrelates to a novel system and method for non-invasive analysis of blood including blood components and analytes, where the system is portable and pocket-sized and includes a probe having a tip designed to be placed in proximity to or in direct contact with tissue over a big vein on the underside of a patient's longue, where the tip includes an excitation port through which an input signal generated by a signal generator subsystem impinges on a surface of tissue over the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into a concentration of a blood component and/or a value of a blood parameter.

2. Description of the Related Art

[0003] Analysis of blood is needed for diagnostic and management of various diseases and conditions as well as for screening of healthy population. Current techniques and systems for blood analysis are invasive, require blood sampling, and cannot be performed in real time or continuously. At present, blood is usually analyzed in clinical laboratories after taking blood samples with invasive techniques.

[0004] Thus, there is a need in the art for a technique and system for noninvasive analysis of blood that would benefit a large population of patients and healthy people as well.

[0005] US 4,890,619 discloses a system for the measurement of the content of a gas in blood, comprising a mounting device and two holding members detachably fastened to the mounting device, each holding member comprising a measuring head.

SUMMARY OF THE INVENTION

[0006] In a first aspect the present invention provides a method as claimed in claim 1. In a second aspect the present invention provides an apparatus as claimed in claim 12.

[0007] The present invention provides a system for non-invasive analysis of blood, including a probe having a tip designed to be placed in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue, where the tip includes an excitation port through which an input signal generated by a signal generator subsystem impinges on a surface of the tissue over the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into concentration of a blood component and/or a value of a blood parameter.

[0008] The present invention also provides a portable and pocket-sized system for non-invasive analysis of blood, including a probe having a tip designed to be placed in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue, where the tip includes a n excitation port through which an input signal generated by a signal generator subsystem impinges on a surface tissue over the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into concentration of a blood component and/or a value of a blood parameter.

[0009] The present invention also provides a portable and pocket-sized system for non-invasive analysis of blood including an under the tongue apparatus comprising two side portions adapted to fit over teeth on each side of the lower jaw, a depressed portion between the two side portions including an excitation port through which an input signal generated by a signal generator subsystem impinges on a surface tissue over the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into a concentration of a blood component and/or a value of a blood parameter.

[0010] The present invention also provides a system, including an excitation signal generator, a probe including a tip designed to be placed in proximity to or in contact with tissue over a big vein on the underside of a patient's tongue and having an excitation signal port connected to the generator via a signal transmission conduit and a response port connected to a detector which is in turn connected to an analyzer or a detector analyzer, where the analyzer converts the response signal into a concentration of a blood component and/or a value of a blood parameter.

[0011] The present invention also provides a portable and pocket-sized system for noninvasive glucose and/or cholesterol measuring and monitoring including a probe having a tip designed to be placed in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue, where the tip includes an excitation port through which

an input signal generated by a signal generator subsystem impinges on a tissue surface over the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into concentrations of glucose and/or cholesterol in the blood.

[0012] The present invention also provides a portable and pocket-sized system for non-invasive hemoglobin, hematocrit, oxy-hemoglobin, deoxy-hemoglobin, carboxyhemoglobin, and/or glycosylated or glycated hemoglobin measuring and monitoring including a probe having a tip designed to be placed in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue, where the tip includes an excitation port through which an input signal generated by a signal generator subsystem impinges on a tissue surface of the vein and a response port through which a response signal is received by and forwarded to a detector and analyzer or a detector/analyzer, which converts the response signal into concentrations of hemoglobin, hematocrit, oxy-hemoglobin, deoxy-hemoglobin, carboxyhemoglobin, and/or glycosylated or glycated hemoglobin in the blood.

[0013] The present invention provides a method for measuring and/or monitoring blood components and/or parameters including the steps of placing a tip of a probe having an excitation port and a response port in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue. Once the tip is in proximity to or in contact with the tissue over the vein, an excitation signal is transmitted into the vein through the excitation port, where the excitation signal is generated by a signal generator connected to the excitation port of the probe via a signal transmission conduit. After the excitation signal or input signal is transmitted into the vein, the response port receives a response signal and detects the response signal in a detector.

[0014] The present invention provides a method for measuring and/or monitoring blood components and/or parameters including the steps of placing a tip of a probe having an excitation port and a response port in proximity to or in direct contact with tissue over a big vein on the underside of a patient's tongue. Once the tip is in proximity to or in contact with the tissue over the vein, an excitation signal is transmitted into the vein through the excitation port, where the excitation signal is generated by a signal generator connected to the excitation port of the probe via a signal transmission conduit. After the excitation signal or input signal is transmitted into the vein, the response port receives a response signal directly through a detector that generates a detector signal which is transmitted via a detector signal conduit to an analyzer or via a response signal conduit to a detector/analyzer. Once the signal has been detected, the analyzer converts the detected signal into a concentration of a blood component and/or a value of a blood parameter.

DESCRIPTION OF THE DRAWINGS

[0015] The invention can be better understood with reference to the following detailed description together with the appended illustrative drawings in which like elements are numbered the same:

[0016] Figures 1A-C depict three preferred embodiments of apparatuses of this invention;

[0017] Figures 1D-G depict three preferred embodiments of probes of this invention;

[0018] Figures 1H depict another embodiments of apparatus of this invention;

[0019] Figure 2 depicts another preferred embodiment of an apparatus of this invention, designed like an under tongue retainer;

[0020] Figure 3 depicts a reflectance spectra measured from sheep blood at different THb;

[0021] Figures 4 depicts a reflectance spectra measured from blood in vitro, the two veins (V1 and V2), and tongue tissue (T1, T2, and T3) on the underside of the tongue;

[0022] Figure 5 depicts a reflectance signal from sheep blood vs. THb at 805 nm;

[0023] Figures 6A-B depict a reflectance signal from circulating sheep blood vs. THb at 805, 1300, and 1450 nm and measurements performed through 0.15-mm glass slide;

[0024] Figures 7A-B depict a reflectance spectra measured from sheep blood at different Thb and measurements performed by using a probe with 3-mm distance between irradiation and detection fibers through 0.15-mm glass slide;

[0025] Figures 8A-B depict a reflectance signal from sheep blood vs. THb at 805 nm (a) and 1300 nm (b), where measurements were performed through 0.15-mm glass slide;

[0026] Figures 9A-B depict a total diffuse reflectance spectra (R_d) measured from sheep blood at different Thb, where measurements were performed by using an integrating sphere that collects all diffusively reflected light;

[0027] Figures 10A-B depict a total diffuse reflectance from sheep blood at 805 nm and 1300 nm (a) and the ratio $R_d(1300)/R_d(805)$ (b) vs. THb, where measurements were performed with the integrating sphere; and

[0028] Figures 11A-B depict a total diffuse reflectance v.s wavelength from sheep blood for THb 14.8 g/dL.

DETAILED DESCRIPTION OF THE INVENTION

[0029] The inventor has found that a novel system and method for non-invasive analysis of blood including blood components and analytes can be constructed and used. Portable, pocket-sized devices can be developed for home and clinical use based on this technique permitting wide application for the apparatuses of this invention.

[0030] The technique is based on optical analysis of blood circulating in a big vein under a patient's tongue. Light from an optical probe of an apparatus of this invention is directed into one of these veins by bringing a probe tip in close proximity to or in contact with the surface of tongue tissue above the vein, *i.e.*, the tip of the probe is brought into proximity to or in contact with epithelial tissue overlying the big veins beneath the surface of the underside of the tongue. Non-contact analysis may ultimately be the preferred method from a medical and practical point ofview because the tip does not make contact with the tissue, thereby reducing the possibility of infections. The emitted light interacts with blood flowing through the vein, producing a signal. The produced or output signal is received or received and measured by the probe, where the output signal will depend on optical properties of the blood. The optical properties of the blood are related to concentrations of blood components. Because the tissues between the probe tip and blood circulating in the vein is very thin, the output signals received by the apparatuses of this invention have minimal influences from the intervening tissue (*i.e.*, minimal background signals) caused by light scattering and absorption in the intervening tissue.

[0031] The term "in proximity to" means that the probe tip is sufficiently close to the surface tissue of the underside of the tongue of a patient to produce a response signal of sufficient intensity to be measured. Generally, the distance is between about 10 mm and about 1mm, with distances between about 5 mm and 1 mm being preferred. However, larger or smaller distances can be used as well provided an analyzable signal can be detected. The term "in contact with" means that the probe tip actually makes physical contact with the tissue of the underside of the patient's tongue.

[0032] The excitation light can be in the near infrared (wavelength range from about 760 to about 2,500 nm), the visible (wavelength range from about 400 to about 760 nm), or the near UV (from about 250 to about 400 nm) portions of the electromagnetic spectrum. These portions of the electromagnetic spectrum would have insignificant background signals due to relatively low scattering and absorption in the intervening tissue compared with light from other spectral ranges.

[0033] The method and system of this invention can utilize any optical detection technique or hybrid detection techniques including, but not limited to, reflectance techniques, confocal techniques, scanning confocal techniques, polarization techniques, interferometry techniques, optoacoustic techniques, low coherence reflectometry techniques, techniques based on speckle measurements, or similar techniques or mixtures or combinations thereof.

[0034] One preferred application of this invention is noninvasive measurement of hemoglobin concentration and/or hematocrit in blood. Other applications of the systems and methods of this invention include, without limitation, noninvasive measurements of glucose and/or cholesterol concentrations in blood and potentially can be used for measuring oxy-, deoxy-, carboxyhemoglobin, and/or glycosylated hemoglobin concentrations in blood. Other applications include, without limitation, measuring or monitoring analytes, drugs, exogenous substances, and/or blood parameters (such as pH).

[0035] This technique can be used for blood analysis of healthy population and patients with various diseases and disorders including critically ill patients.

[0036] Referring now to **Figures 1A-D,** a preferred embodiment of a system of this invention, generally **100,** is shown to include a probe **102** having a tip **104,** which is in proximity to or in contact with a surface tissue **106** over a vein **108** of an underside **109** of a patient's tongue 110. The system **100** also includes a light delivery subsystem **112** and detection/analysis subsystem **114.** The light delivery subsystem **112** terminates in the probe tip **104** at a light outlet or port **116,** while the detection/analysis subsystem **114** begins in the tip **104** at an output or response signal inlet or port **118.** The light delivery subsystem **112** includes a light source **120** and a light conduit **122** terminating at the light outlet **116.** Preferably, the light conduit **122** is an optical fiber or optical fiber bundle and the light source **120** is a laser or filtered broad spectrum light source (*e.g.*, lamp). The detection/analysis subsystem **114** includes a detector **124,** an analyzer unit **126** and a signal conduit **128** interconnecting the detector **124** and the analyzer **126.** The detector **124** can be located in the tip **104** as shown in **Figure 1A,** in the probe **102** as shown in **Figure 1B** or in the analyzer unit **126** as shown in **Figure 1C.** The output signal forwarded to the analyzer **126** can be optical and/or acoustic, if the detector **124** is located in the analyzer **126** or electrical, if the detector **124** is located in the probe **104.**

[0037] Referring now to **Figures 1D-G,** several probe tip and optical fiber arrangements are shown. Looking at **Figure 1D,** the light conduit **122** is a single optical fiber, while the signal conduit **128** includes six optical fibers surrounding the light conduit **122** for a cylindrical probe **102** and circular probe tip **104.** Looking at **Figure 1E,** the light conduit **122** includes four fibers and the signal conduit **128** includes four optical fibers surrounding the light conduit **122** arranged side by side for an oval shaped probe **102** and tip **104.** Looking at **Figure 1F,** the light conduit **122** includes four fibers and the signal conduit **128** includes four optical fibers surrounding the light conduit **122** arranged intermixed for a rectangular probe **102** and probe tip **104.** Looking at **Figure 1G,** the light conduit **122** includes one fiber and the signal conduit **128** includes three optical fibers surrounding the light conduit **122** for a triangular probe **102** and probe tip **104.**

[0038] Looking at **Figure 1H,** the system **100** works by placing the probe tip **104** in contact with the surface tissue **106** over the vein **108.** In this figure, the probe **102** also includes a finger grip **103** for better control of the probe tip placement. The light delivery system **112** is then activated, turned on, and excitation radiation travels from the light source **120** through the light conduit **122** and out the light outlet **116** in the probe tip **104.** The excitation radiation then propagates through the surface tissue **106,** a relatively thin tissue layer, and into the vein **108** where a response signal is produced. The response signal then enters the signal port **118** where it is either detected by the detector **124** in the

probe **102** or the probe tip **104** or travels down the signal conduit **128** to the detector **124** associated with the analyzer unit **126.** The detector **124** converts the signal into a detector response and the analyzer converts the response into a concentration of a blood component and/or a value of a blood parameter.

[0039] Referring now to **Figure 2,** a second embodiment of an apparatus of this invention, generally **200,** is shown to include a first teeth engaging side section **202a,** a second teeth engaging side section **202b,** a first and a second downwardly extending sections **204a&b** and a middle section **206** bridging the two downwardly extending sections **204a&b** adapted to contact the underside of a patient's tongue (not shown). The middle section **206** includes two emitters **208a&b** and two receivers **210a&b.** Extending from the two emitters **208a&b** and the two detectors **210a&b** are light conduits **212a&b,** shown here as two optical fibers **214a&b** terminating at the emitters **208a&b,** and signal conduits (light or sound) **216a&b,** also shown here as to optical fibers **218a&b** terminating at the receivers. The light conduits **212a&b** are connected to a light source **220,** while the signal conduits **216a&b** are connected to a detector/analyzer **222.**

THEORETICAL SECTION OF THE INVENTION

[0040] Most tissues are strongly scattering media in the visible and near-IR spectral range. Three major optical parameters are responsible for distribution of light in tissues: 1) the absorption coefficient (μ_a); 2) the scattering coefficient (μ_s); and 3) the effective attenuation (μ_{eff}) coefficient. The effective attenuation coefficient (μ_{eff}) is related to $_{\mu a}$, μ_s, and the anisotropy factor (g) thusly:

(1)

where $\mu_s(1\text{-}g)$ is the reduced scattering coefficient, μ_s'[1]. Light penetration depth in tissues is defined as $1/\mu_{eff}$. Absorption and reduced scattering coefficients of tissues are moderate in the visible spectral range and low in the near-IR spectral range (from 600 to 1600 nm), which results in deeper penetration of visible and especially near-IR radiation compared with that of other parts of the spectrum. Application of visible or near-IR radiation will allow insignificant attenuation of light in the thin tissues between the vein on the underside of the tongue and the probe.

[0041] Hemoglobin has a high absorption coefficient in the visible and near-IR spectral range that is dependent on hemoglobin oxygen saturation (the ratio of oxyhemoglobin to total hemoglobin (THb) [1]. The blood absorption coefficient, μ_a [blood], is related to oxyhemoglobin concentration (C[oxy]) and deoxyhemoglobin concentration (C[deoxy]) as follows:

$$\mu a\,[blood] = C[oxy] \times K[oxy] + C[deoxy] \times K[deoxy] \qquad (2)$$

where K[oxy] and K[deoxy] are know values of extinction coefficients of oxy- and deoxyhemoglobin at a given wavelength. Since K[oxy] = K[deoxy] = K at isosbestic wavelengths and THb = C[oxy] + C[deoxy], one can measure hemoglobin in the veins because:

$$\mu a\,[blood] = THb \times K \qquad (3)$$

[0042] The tissue between the vein on the underside of the tongue and the probe is optically thin in the visible and near IR spectral ranges because: $\mu_{eff} xL << 1$ due to relatively low μ_{eff} (~1-5 cm^{-1}) and small L (~0.01-0.02 cm). In contrast, blood in the vein is optically thick: $\mu_{eff,blood} \times L_{blood} >> 1$ because $\mu_{eff,blood}$ is high (~10 cm^{-1}) and L is about 2 to 3 mm. Attenuation is the tissue is insignificant and all signal will be from blood. The signal from the deeper tissues will not be significant due to strong light attenuation by blood in the vein.

EXPERIMENTAL DATA OF THIS INVENTION

[0043] **Figure 3** shows diffuse reflectance spectra obtained from sheep blood at different total hemoglobin concentration (THb) through the cylindrical wall (thickness 0.8 mm) of a 10-mL syringe. Blood with an initial THb of 8.2 g/dL, oxygenation of 56%, and volume of 5 mL was progressively diluted with saline with increments of 0.5 mL. The final concentration was 4.1 g/dL. The spectra were obtained with a portable (pocket size) spectrometer (range from 600 to 1180 nm) operated with a laptop computer. This range included the isobestic wavelength of 805 nm, where oxy- and deoxyhemoglobin have the same absorption coefficient. Therefore, variations of blood oxygenation do not influence the

accuracy of THb measurement at this wavelength. The sample was irradiated by a tungsten lamp (the lamp and its power supply are compact: pocket size; designed for this spectrometer) through a reflection probe combining one 0.4-mm illumination fiber and six 0.4-mm fibers around it for detection of the reflectance signal. The system was calibrated with a reflectance standard with 25% reflectivity. The standard is being widely used for calibration of optical spectroscopic instruments in a wide spectral range that includes ultraviolet (UV), visible, and near infra-red (near-IR) spectral ranges.

[0044] The diffuse reflectance signal is due to light scattering from red blood cells in blood. All spectra had: (1) a minimum at 760 nm due to the absorption peak (maximum of absorption) at this wavelength for deoxygenated hemoglobin and (2) low intensity at 600 nm due to strong absorption by hemoglobin. The spectra were dependent on THb. In this geometry of irradiation, the reflectance signal first increased and then decreased with dilution.

[0045] Since the tissues between the blood circulating in the tongue vein and the probe are very thin (01.-0.2 mm), they are optically thin in the visible and near-IR spectral ranges due to low tissue absorption. Therefore, the reflectance signal from blood circulating in the vein is not influenced by variation of optical properties of the tissue. **Figure 4** shows representative reflectance spectra measured: (1) in vitro from blood; (2) in vivo from the two big veins (V1 and V2) on underside of the tongue of a healthy volunteer; and (3) at three locations: right, left and middle part of the underside of the tongue (T1, T2, and T3, respectively). It is clearly seen that the spectra measured from the veins are similar to that of blood. As in pure blood, the spectra have minimum values at 760 nm and low intensity at 600 nm. The spectra measured from the tongue tissue are different from that of pure blood: high intensity at 600 nm and no minimum at 760 nm.

[0046] The reflectance signal at a given THb and oxygenation is dependent on wavelength and the reflectance probe configuration. We performed experiments with different probes in a wide spectral range with two spectrometers operating in the range from 520 to 1180 nm and from 900 to 1700 nm.

[0047] **Figure 5** shows the reflectance signal at 805 nm vs. THb for the spectra presented in **Figure 3.** The signal is linearly dependent on THb from 4.1 to 6.3 g/dL.

[0048] Another set of experiments was performed with circulating centrifuged sheep blood. Typically, THb of sheep blood (6-9 g/dL) is lower than that of human blood (11-16 g/dL). By using the centrifuge one can obtain blood with THb up to 14-16 g/dL (typical for human blood). To simulate the gap of 0.1-0.2 mm between the veins and the probe, we used a thin (0.15 mm) microscopic glass slide cover. **Figure 6A and 6B** show reflectance spectra obtained from blood (initial THb of 14.1 g/dL) with the two spectrometers, respectively. Both spectra were measured simultaneously by using a fiber-optic splitter attached to the detection fibers of the probe. One can see that the spectra are dependent on THb in both spectral ranges. Reflectance signals are presented as a function of THb for 805 and 1300 nm in **Figure 7A.** The dependence was linear up to approximately 8 and 9 g/dL for the wavelengths of 805 and 1300 nm, respectively. At 1450 nm, it was linear up to 10 g/dL as shown in **Figure 7B.**

[0049] Blood dilution lowers both the absorption coefficient (which is proportional to THb up to 1150 nm) and the scattering coefficient (which is proportional to hematocrit). In general, total diffuse reflection (all photons that are reflected from tissue due to scattering) decreases with the absorption coefficient and increases with scattering coefficient and should be constant for tissues if both these coefficients decrease proportionally. However, spatial distribution of the diffusively reflected light varies with blood dilution. Therefore, the reflection signal from blood is strongly dependent on the distance between the irradiation and detection fiber. To accurately measure THb and hematocrit, one needs to find a configuration of the probe with optimal distance between the irradiation and detection fibers. We performed a set of experiments with a probe that has a 3-mm distance between irradiation and detection fibers. Gradual increase of the reflectance signal was obtained in a wide spectral range from 600 to 1180 nm as shown in **Figure 7A&B** with blood dilution. **Figure 8A&B** demonstrated the increase of the reflectance signal with dilution at 805 and 1130 nm, respectively. The increase of the reflectance signal with THb is due to deeper penetration of light in blood (decrease of blood effective attenuation coefficients). More photons can reach the detection fiber (separated by 3 mm from the irradiation fiber) at lower effective attenuation coefficient.

[0050] The obtained results demonstrate that one can measure THb and hematocrit with this technique if optimum probe configuration and wavelengths are used. A probe with detection fibers aligned on one or two opposite sides from the irradiation fiber (and along the vein) may provide very accurate measurement because the value of the signals measured at different distances from the irradiation fiber can be used in the calculation of THb and hematocrit.

[0051] To find optimal wavelength we measured total diffuse reflectance R_d of blood with an integrating sphere and both spectrometers. The studies with integrating spheres are being used for measurement of optical properties of absorbing and scattering media. Sheep blood was centrifuged and gradually diluted as described above. The integrating sphere allowed to detect all photons reflected back due scattering by blood cells. **Figure 9A-B** shows spectra obtained from sheep venous blood (initial THb = 14.8 g/dL; oxygenation = 57%; Hct = 44.4%) at different THb concentrations. Decrease of THb resulted in different changes in different part of the spectra. One can see that the oxygenation gradually increased (the maximum at 760 nm is less pronounced at lower THb) due to penetration of oxygen in blood during dilutions. However, variations of the oxygenation in blood do not affect accuracy of measurements, if we use isosbestic wavelengths for analysis of the data and calibration of the system.

[0052] We plotted R_d vs. THb at two isobestic wavelengths: 805 and 1300 nm as shown in **Figure 10A.** We also

calculated the ratio R_d(1300nm)/R_d(805nm) and obtained a linear dependence in the whole range of THb (from 3.6 to 14.8 g/dL) with the correlation coefficient of R^2 = 0.998 as shown in **Figure 10B.** This demonstrates good correlation between the ratio R_d(1300nm)/R_d(805nm) and THb and indicates that this ratio can be used for accurate measurement of THb. The linear dependence was obtained at these wavelength because: (1) $R_d \sim \mu_s' / \mu_a$ at relatively high untypical of blood and (2) μ_a at 805 nm is linearly proportional to THb (negligible water absorption) and is constant at 1300 nm (negligible Hb absorption). This combination results in the linear dependence of R_d(1300nm)/R_d(805nm) vs. THb.

[0053] One can use these two wavelengths and this algorithm to accurately measure THb. We designed, built, and tested a compact inexpensive laser diode based-system operation at two wavelengths: 1300 nm and 790 nm (which is close to 805 nm). Although the use of integrating spheres (irradiation and detection window of about 1 cm) is possible for the noninvasive blood analysis, it is easier and more practical to use probes with smaller size.

We used a probe with one 0.4-mm fiber for illumination and six 0.4-mm fibers around it for detection. Same blood samples that we used in the studies with the integrating sphere were irradiated in a plastic cuvette (blood volume 0.3 mL; thickness - 4 mm) through a thin plastic film (thickness - 0.13 mm) simulating thin tissue between the vein and the surface of the underside of the tongue. **Figure 11A** shows the dependence of the reflectance signal at 790 and 1300 nm vs. THb that is similar to R_d vs. THb at the two isobestic wavelengths (805 and 1300 nm). Although the dependence of the ratio R (1300nm)/R(790nm) vs. THb is not linear as shown in Figure 11B, it can be used for calibration of the system. The dependence is not linear because of the following two reasons: the detection fibers collect light scattered almost backward (not in all directions as in the case of the integrating sphere) and 790 nm is not exactly at the isobestic point.

[0054] While this invention has been described fully and completely, it should be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. Although the invention has been disclosed with reference to its preferred embodiments, from reading this description those of skill in the art may appreciate changes and modifications that may be made within the scope of the claims.

Claims

1. A method for noninvasive analysis of at least one blood component comprising the steps of:

placing an apparatus (100) including a radiation outlet (116) and a response inlet (118) so that both the radiation outlet (116) and the response inlet (118) are in close proximity to or in contact with a surface of a tissue (106) over a big vein (108) associated with an underside of a patient's tongue (110) and where the radiation outlet (116) is connected to a light source (120) via a light source conduit (122) and the response inlet (118) is connected to a detector (124) via a response conduit (128);
irradiating blood in the big vein (108) with radiation having at least one frequency or wavelength generated by the light source (120) via the light source conduit (122) and the radiation outlet (116);
detecting a response from the blood irradiated in the irradiating step via a detector (124);
calculating a concentration of a blood component, a value of a blood parameter or a mixture or combination thereof from the response.

2. The method of claim 1, further comprising the step of:

displaying the response, the concentration and/or the value from the calculating step.

3. The method of claim 1 or claim 2, wherein the detecting step comprises the step of:

utilizing one or a combination of techniques selected from the group consisting of reflectance technique, confocal technique, scanning confocal technique, polarization techniques, interferometry, optoacoustics, low coherence interferometry and reflectometry, techniques based on speckle measurements, fluorescence technique, Raman scattering technique, and two or multi-photon techniques.

4. The method of any of the preceding claims, further comprising:

applying a static electric or magnetic field during the irradiating step and the detecting step.

5. The method of any of the preceding claims, further comprising using a hybrid technique for irradiation and detection.

6. The method of any of the preceding claims, wherein the response corresponds to a response selected from group consisting of: (a) a concentration of hemoglobin in the blood and the radiation is in a spectral wavelength selected

from the group consisting of 548 nm, 568 nm, 587 nm, and 805 nm (the isosbestic point) and spectral ranges from about 400 nm to about 640 nm and above about 1120 nm where absorption coefficients of oxy- and deoxygenated blood are close to each other, (b) a concentration of hematocrit; (c) concentrations of hemoglobin and/or glycosylated haemoglobin; (d) a concentration of glucose; (e) a concentration of cholesterol; (f) concentrations of oxy-hemoglobin, deoxyhemoglobin, and carboxy-hemoglobin, and (g) a concentration of an exogenous substance selected from the group consisting of a drug, a dye or other reporter in molecular state or a particle made of liquid, gas, or solid material including polymer, metal, semiconductor, dielectric, or a combination of liquid, gas, or solid materials, and a layered structure.

7. The method of claim 6, wherein the exogenous substance is selected from the group consisting of indocyanine green and Evans blue.

8. The method of claim 6, wherein the exogenous substance comprises particles with a size from about 0.1 nanometer to about 10 microns.

9. The method of any of the preceding claims, wherein the radiation is in a spectral range from about 200 nanometers to about 20 microns.

10. The method of any one of claims 1, 2, 3, 4, 5, 6, 7, or 8, wherein the radiation is selected from the group consisting of microwave radiation, radiofrequency radiation, ultrasound radiation and low-frequency electromagnetic radiation.

11. The method of any of the preceding claims, wherein the radiation comprises one, two, or many wavelengths (frequencies).

12. An apparatus for noninvasive blood analysis comprising:

a tongue apparatus (100, 200) including a tip having a radiation outlet (116, 208a, 208b) and a response inlet (118, 210a, 210b) disposed therein, wherein the tip is adapted to be placed in close proximity to or in contact with a surface of a tissue (106) over a big vein (108) associated with an underside of a patient's tongue (110) so that both the radiation outlet and the response inlet are in close proximity to or in contact with the surface of the tissue;
wherein the tongue apparatus (100, 200) is an under the tongue apparatus comprising two side portions (202a, 202b) adapted to fit over teeth on each side of a patient's lower jaw and a depressed portion (206) between the two side portions including the radiation outlet (116, 208a, 208b) and response inlet (118, 210a, 210b);
a light generation/delivery system (112) including a light source (120, 220) capable of generating at least one frequency of light, and a light conduit (122, 212a, 212b) interconnecting the light source (120, 220) with the radiation outlet (116, 208a, 208b), where the system is adapted to deliver radiation to blood in the big vein (108); and
a detector/analyzer system (114, 222) including a detector (124) adapted to detect a response from the irradiated blood via the response inlet (118, 210a, 210b) and an analyzer (126) adapted to convert the detected response into a concentration of a blood component and/or a value of a parameter of the blood.

13. The apparatus of claim 12, wherein the tongue apparatus (100, 200) comprises:

two transition sections (204a, 204b) extending downwardly from each of the side sections (202a, 202b), the depressed portion (206) being a middle section interposed between the two transitions (202a, 202b).

14. The apparatus (100) of claim 12, wherein the tongue apparatus (100) comprises:

a probe (102) including a tip (104) having the radiation outlet (116) and the response inlet (118).

15. The apparatus (200) of anyone of claims 12, 13, or 14, further comprising:

a plurality of light outlets (208a, 208b) and a plurality of response inlets (210a,210b).

16. The apparatus (100) of any one of claims 12, 13, 14 or 15, further comprising:

a display adapted to display the response (raw data) or converted response (refined data).

17. The apparatus (100) of any one of claims 12, 13, 14, 15, or 16, further comprising:

a static electric or magnetic field.

18. The apparatus (100) of any one of claims 12, 13, 14, 15, 16 or 17,further comprising:

a hybrid technique for irradiation and detection.

19. The apparatus (100) of any one of claims 12, 13, 14, 15, 16, 17 or 18, wherein the response corresponds to a response selected from group consisting of: (a) a concentration of hemoglobin in the blood and the radiation is in a spectral wavelength selected from the group consisting of 548 nm, 568 nm, 587 nm, and 805 nm (the isosbestic points) and spectral ranges from about 400 nm to about 640 nm and above about 1120 nm where absorption coefficients of oxy- and deoxygenated blood are close to each other, (b) a concentration of hematocrit; (c) concentrations of hemoglobin and/or glycosylated haemoglobin; (d) a concentration of glucose; (e) a concentration of cholesterol; (f) concentrations of oxyhemoglobin, deoxy-hemoglobin, and carboxy-hemoglobin, and (g) a concentration of an exogenous substance selected from the group consisting of a drug, a dye or other reporter in molecular state or a particle made of liquid, gas, or solid material including polymer, metal, semiconductor, dielectric, or a combination of liquid, gas, or solid materials, and a layered structure.

20. The apparatus (100) of claim 19, wherein the exogenous substance is selected from the group consisting of indocyanine green and Evans blue.

21. The apparatus (100) of claim 19, wherein the exogenous substance comprises particles with a size from about 0.1 nanometer to about 10 microns.

22. The apparatus (100) of any one of claims 12, 13, 14, 15, 16, 17, 18, 19, 20, or 21, wherein the radiation is in a spectral range from about 200 nanometers to about 20 microns.

23. The apparatus (100) of any one of claims 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 or 22, wherein the radiation is selected from the group consisting of microwave radiation, radiofrequency radiation, ultrasound radiation and low-frequency electromagnetic radiation.

24. The apparatus (100) of any one of claims 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 or 23, wherein the radiation comprises one, two, or many wavelengths (frequencies).

Patentansprüche

1. Verfahren für die nichtinvasive Analyse von mindestens einem Blutbestandteil, das folgende Schritte umfasst:

Platzierten einer Vorrichtung (100), die einen Strahlungsausgang (116) und einen Antworteingang (118) umfasst, so dass der Strahlungsausgang (116) und der Antworteingang (18) sich in unmittelbarer Nähe zu oder in Kontakt mit einer Oberfläche eines Gewebes (106) über einer großen Vene (108), die mit der Unterseite der Zunge (110) eines Patienten assoziiert ist, befinden und wobei der Strahlungsausgang (116) über eine Lichtquellenleitung (122) mit Lichtquelle (120) verbunden ist und der Antworteingang (118) über eine Antwortleitung (128) mit eine Detektor (124) verbunden ist;
Bestrahlen von Blut in der großen Vene (108) über die Lichtquellenleitung (122) und den Strahlungsausgang (116) mit von der Lichtquelle (120) erzeugter Strahlung, die mindestens eine Frequenz oder Wellenlänge aufweist;
Erfassen einer Antwort von dem in dem Bestrahlungsschritt bestrahlten Blut über einen Detektor (124);
Berechnen einer Konzentration eines Blutbestandteils, eines Werts eines Blutparameters oder einer Mischung oder Kombination derselben aus der Antwort.

2. Verfahren nach Anspruch 1, das weiter folgenden Schritt umfasst:

Anzeigen er Antwort, der Konzentration und/oder des Werts aus dem Berechnungsschritt.

3. Verfahren nach Anspruch 1 oder Anspruch 2, wobei der Erfassungsschritt folgenden Schritt umfasst:

Nutzen einer oder kombination von Techniken, die aus der aus Folgendem bestehenden Gruppe ausgewählt sind: Reflexionstechnik, Konfokaltechnik, konfokaler Rastertechnik, Polarisationstechniken, Interferometrie, Optoakustik, Niedrig-Kohärenz-Interferometrie und -Reflektometrie, auf Speckle-Messungen basierenden Techniken, Fluoreszenztechnik, Raman-Streuungstechnik und Zwei- oder Multiphoton-Techniken.

4. Verfahren nach einem der vorangehenden Ansprüche, das weiter Folgendes umfasst:

Anlegen eines statischen elektrischen oder magnetischen Felds währen des Bestrahlungsschritts und des Erfassungsschritts.

5. Verfahren nach eine der vorangehenden Ansprüche, das weiter Folgendes umfasst:

Verwenden einer Hybridtechnik für die Bestrahlung und Erfassung.

6. Verfahren nach einem der vorangehenden Ansprüche, wobei die Antwort einer Antwort entspricht, die aus der aus Folgendem bestehenden Gruppe ausgewählt ist: (a) einer Konzentration von Hämoglobin in dem Blut und die Strahlung befindet sich in einer spektralen Wellenlänge, ausgewählt aus der Gruppe, die besteht aus: 548 nm, 568 nm, 587 nm und 805 um (dem isobestischen Punkt) und Spektralbereichen von ungefähr 400 nm bis ungefähr 640 nm und über ungefähr 1120 nm, wo Absorptionskoeffizienten von oxy- und deoxygeniertem Blut nah beieinander liegen, (b) einer Konzentration von Hämatokrit; (c) Konzentrationen von Hämoglobin und/oder glykosyliertem Hämoglobin; (d) einer Konzentration von Glukose; (e) einer Konzentration von Cholesterol; (f) Konzentrationen von Oxy-Hämoglobin, Deoxy-Hämoglobin, und Carboxy-Hämoglobin, und (g) einer Konzentration einer exogenen Substanz, ausgewählt aus der Gruppe, die besteht aus: eine Medikament, einem Farbstoff oder anderem Reporter in molekularem Zustand oder einem Partikel aus Flüssigkeit, Gas oder Feststoff, einschließlich Polymer, Metall, Halbleiter, Dielektrikum oder einer Kombination von Flüssigkeit, Gas oder Feststoffen und einer geschichteten Struktur.

7. Verfahren nach Anspruch 6, wobei die exogene Substanz aus der aus Indocyaningrün und Evans-Blau bestehenden Gruppe ausgewählt ist.

8. Verfahren nach Anspruch 6, wobei die exogene Substanz Partikel mit einer Größe von ungefähr 0,1 Nanometer bis ungefähr 10 Mikron umfasst.

9. Verfahren nach einem der vorangehenden Ansprüche, wobei die Strahlung in einem Spektralbereich von ungefähr 200 Nanometer bis ungefähr 20 Mikron liegt.

10. Verfahren nach eine der Ansprüche 1, 2, 3, 4, 5, 6, 7 oder 8, wobei die Strahlung aus der aus Folgendem bestehenden Gruppe ausgewählt ist: Mikrowellenstrahlung, Funkfrequenzstrahlung, Ultraschallstrahlung und niederfrequenter elektromagnetischer Strahlung.

11. Verfahren, nach eine der vorangehenden Ansprüche, wobei die Strahlung eine, zwei oder viele Wellenlängen (Frequenzen) umfasst.

12. Vorrichtung für die nichtinvasive Blutanalyse, die Folgendes umfasst:

eine Zungenvorrichtung (100,200), umfassend eine Spitze mit einem Strahlungsausgang (116, 208a, 208b) und eine Antworteingang (118, 210a, 210b), die darin angeordnet sind, wobei die Spitze dazu angepasst ist, in unmittelbarer Nähe zu oder in Kontakt mit einer Oberfläche eines Gewebes (106) über einer großen vene (108) platziert zu werden, die mit einer Unterseite der Zunge (110) eines Patienten assoziiert ist, so dass sich der Strahlungsausgang und der Antworteingang in unmittelbarer Nähe zu oder in Kontakt mit der Oberfläche des Gewebes befinden;
wobei es sich bei der Zungenvorrichtung (100, 200) um eine Vorrichtung für unter die Zunge handelt, umfassend zwei Seitenabschnitte (202a, 202b), die dazu angepasst sind, über Zähne an beiden Seiten eines Unterkiefers eines Patienten zu passen, und einen tieferliegenden Abschnitt (206) zwischen den zwei Seitenabschnitten, der den Strahlungsausgang (116, 208a, 208b) und den Antworteingang (118, 210a, 210b) umfasst;
ein Lichterzeugungs-/Zufuhrsystem (112), umfassend eine Lichtquelle (120, 220), die fähig ist, mindestens eine Frequenz von Licht zu erzeugen und eine Lichtleitung (122, 212a, 212b), die die Lichtquelle (120, 220) mit dem Strahlungsausgang (116, 208a, 208b) verbindet, wobei das System dazu angepasst ist, Strahlung an Blut in der großen Vene (108) zuzuführen; und

ein Detektor-/Analysatorsystem (114, 222), fassend einen Detektor (124), der dazu angepasst ist, Antwort von dem bestrahlten Blut über den Antworteingang (118, 210a, 210b) zu erfassen, und einen Analysator (126), der dazu angepasst ist, die erfasste Antwort in eine Konzentration eines Blutbestandteils und/oder einen Wert eines Parameters des Bluts umzuwandeln.

13. Vorrichtung nach Anspruch 12, wobei die Zungenvorrichtung (100, 200) Folgendes umfasst:

zwei Übergangsabschnitte (204a, 204b), die sich von jedem der Seitenabschnitte (202a, 202b) nach unten erstrecken,
den tieferliegenden Abschnitt (206), bei dem es sich um einen mittleren Abschnitt handelt, der zwischen den zwei Übergängen (202a, 202b) angeordnet ist.

14. Vorrichtung (100) nach Anspruch 12, wobei die Zungenvorrichtung (100) Folgendes umfasst:

einen Messtaster (102), umfassend eine Spitze (104) mit dem Strahlungsausgang (116) und dem Antworteingang (118).

15. Vorrichtung (200) nach einem der Ansprüche 12, 13 oder 14, weiter umfassend:

mehrere Lichtausgänge (208a, 208b) und mehrere Antworteingänge (210a, 210b).

16. Vorrichtung (100) nach einem der Ansprüche 12, 13, 14 oder 15, weiter umfassend:

eine Anzeige, die dazu angepasst ist, die Antwort (Rohdaten) oder die umgewandelte Antwort (aufbereitete Daten) anzuzeigen.

17. Vorrichtung (100) nach eine der Ansprüche 12, 13, 14, 15 oder 16, weiter umfassend:

ein statisches elektrisches oder magnetisches Feld.

18. Vorrichtung (100) nach eine der Ansprüche 12, 13, 14, 15, 16 oder 17, weiter umfassend:

eine Hybridtechnik für die Bestrahlung und Erfassung.

19. Vorrichtung (100) nach eine der Ansprüche 12, 13, 14, 15, 16, 17 oder 18, wobei die Antwort einer Antwort entspricht, die aus der aus Folgendem bestehenden Gruppe ausgewählt ist: (a) einer Konzentration von Hämoglobin in dem Blut und die Strahlung befindet sich in einer spektralen Wellenlänge, ausgewählt aus der Gruppe, die besteht aus: 548 nm, 568 nm, 587 nm und 805 nm (den isobestischen Punkten) und Spektralbereichen von ungefähr 400 nm bis ungefähr 640 nm und über ungefähr 1120 nm, wo Absorptionskoeffizienten von oxy- und deoxygeniertem Blut nah beieinander liegen, (b) einer Konzentration von Hämatokrit; (c) Konzentrationen von Hämoglobin und/oder glykosyliertem Hämoglobin; (d) einer Konzentration von Glukose; (e) konzentration von Cholesterol; (f) Konzentrationen von Oxy-Hämoglobin, Deoxy-Hämoglobin, und Carboxy-Hämoglobin, und (g) einer Konzentration einer exogenen Substanz, ausgewählt aus der Gruppe, die besteht aus: einem Medikament, einem Farbstoff oder anderem Reporter in molekularem Zustand oder einem Partikel aus Flüssigkeit, Gas oder Feststoff, einschließlich Polymer, Metall, Halbleiter, Dielektrikum oder Kombination von Flüssigkeit, Gas oder Feststoffen und einer geschichteten Struktur.

20. Vorrichtung (100) nach Anspruch 19, wobei die exogene Substanz aus der aus Indocyaningrün und Evans-Blau bestehenden Gruppe ausgewählt ist.

21. Vorrichtung (100) nach Anspruch 19, wobei die exogene Substanz artikel mit einer Größe von ungefähr 0,1 Nanometer bis ungefähr 10 Mikron umfasst.

22. Vorrichtung (100) nach eine der Ansprüche 12, 13, 14, 15, 16, 17, 18, 19, 20 oder 21, wobei die Strahlung in einem Spektralbereich von ungefähr 200 Nanometer bis ungefähr 20 Mikron liegt.

23. Vorrichtung (100) nach einem der Ansprüche 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 oder 22, wobei die Strahlung aus der aus Folgendem bestehenden Gruppe ausgewählt ist: Mikrowellenstrahlung, Funkfrequenzstrahlung, Ultra-

schallstrahlung und niederfrequenter elektromagnetischer Strahlung.

24. Vorrichtung (100) nach einem der Ansprüche 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 oder 23, wobei die Strahlung, eine, zwei oder viele Wellenlängen (Frequenzen) umfasst.

Revendications

1. Procédé d'analyse non invasive d'au moins un constituant du comprenant les étapes suivantes :

le placement d'un appareil (100) comportant une sortie de rayonnement (116) et une entrée de réponse (118) de telle sorte que la sortie de rayonnement (116) et l'entrée de réponse (118) soient proches d'une surface d'un tissu (106) sur une veine principale (108) associée au dessous de la langue (110) d'un patient ou en contact avec cette surface et la sortie de rayonnement (116) étant connectée à une source de lumière (120) par l'intermédiaire d'un conduit de source de lumière (122) et l'entrée de réponse (118) étant connectée à un détecteur (124) par l'intermédiaire d'un conduit de réponse (128)
l'irradiation du sang se trouvant dans la veine principale (108) avec un rayonnement d'au moins une fréquence au longueur d'onde, généré par la source de lumière (120) par l'intermédiaire du conduit de source de lumière (122) et de la sortie de rayonnement (116) ;
la détection d'une réponse du sang irradié à l'étape d'irradiation par l'intermédiaire d'un détecteur (124) ;
le calcul d'une concentration d'un constituant du sang, d'une valeur d'un paramètre du sang ou d'un mélange ou d'une combinaison de celles-ci à partir de la réponse.

2. Procédé selon la revendication 1, comprenant en outre l'étape suivante :

l'affichage de la réponse, de la concentration et/ou de la valeur obtenue à l'étape de calcul.

3. Procédé selon la revendication 1 ou la revendication 2, dans lequel l'étape de détection comprend l'étape suivante :

l'utilisation d'une technique ou d'une combinaison de techniques sélectionnées dans le groupe consistant en technique de réflectance, technique confocale, technique confocale de balayage, techniques de polarisation, interférométrie, optoacoustique, réflectrométrie et interférométrie à faible cohérence, techniques basées sur des mesures de tavelures, technique de fluorescence, technique de diffusion de Raman, et techniques bi ou multiphotonique.

4. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre:

l'application d'un champ magnétique ou électrique statique durant l'étape d'irradiation et l'étape de détection.

5. Procédé selon l'une quelconque des revendications précédentes, comprenant en outre
l'utilisation d'une technique hybride d'irradiation et de détection.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel la réponse correspond à une réponse sélectionnée dans le groupe consistant en : (a) une concentration d'hémoglobine dans le sang et le rayonnement est dans une longueur d'onde spectrale sélectionnée dans le groupe consistant en 548 nm, 568 nm, 587 nm et 805 nm (le point isosbétique) et les gammes spectrales allant d'environ 400 nm à environ 640 nm et au-dessus d'environ 1120 nm où les coefficients d'absorption du sang oxygéné et désoxygéné sont proches l'un de l'autre, (b) une concentration d'hématocrite ; (c) des concentrations d'hémoglobine et/ou d'hémoglobine glycosylée; (d) une concentration de glucose ; (e) une concentration de cholestérol ; (f) des concentrations d'oxyhémoglobine, de déoxyhémoglobine, et de carboxyhémoglobine, et (g) une concentration d'une substance exogène sélectionnée dans le groupe consistant en un médicament, un colorant ou un autre rapporteur à l'état moléculaire ou une particule d'un matériau liquide, gazeux ou solide dont un polymère, un métal, un semi-conducteur, un diélectrique ou une combinaison de matériaux liquides, gazeux ou solides, et une structure en couches.

7. Procédé selon la revendication 6, dans lequel la substance exogène est sélectionnée dans le groupe consistant en vert d'indocyanine et bleu Evans.

8. Procédé selon la revendication 6, dans laquelle la substance exogène comprend des particules d'une grosseur

d'environ 0,1 nanomètre à environ 10 microns.

9. Procédé selon l'une quelconque des revendications précédentes, dans lequel le rayonnement est compris dans une gamme spectrale allant d'environ 200 nanomètres à environ 20 microns.

10. Procédé selon l'une quelconque des revendications 1, 2, 3, 4, 5, 6, 7 ou 8, dans lequel le rayonnement est sélectionné dans le groupe consistant en rayonnement hyperfréquence, rayonnement radiofréquence, rayonnement ultrasonore et rayonnement électromagnétique basse fréquence.

11. Procédé selon l'une quelconque des revendications précédentes, dans lequel le rayonnement comprend un, deux ou de nombreuses longueurs d'onde (fréquences).

12. Appareil d'analyse de sang non invasive comprenant :

un appareil lingual (100, 200) comportant une pointe à sortie de rayonnement (116, 208a, 208b) et une entrée de réponse (118, 210a, 210b) disposées à l'intérieur, la pointe étant adaptée pour être placée à proximité d'une surface d'un tissu (106) sur une veine principale (108) associée au dessous de la langue (110) d'un patient ou en contact avec cette surface de telle sorte que la sortie de rayonnement et l'entrée de réponse soient situées à proximité de la surface du tissu ou en contact avec celle-ci ;
l'appareil lingual (100, 200) étant appareil placé sous la langue comprenant deux parties latérales (202a, 202b) adaptées pour s'appliquer au-dessus des dents de chaque côté d'une mâchoire inférieure d'un patient et une partie affaissée (206) entre les deux parties latérales comportant la sortie de rayonnement (116, 208a, 208b) et l'entrée de réponse (118, 210a, 210b) ;
un système de génération/délivrance de lumière (112) comportant une source due lumière (120, 220) capable de générer au moins une fréquence de lumière, et un conduit de lumière (122, 212a, 212b) interconnectant la source de lumière (120, 220) avec la sortie de rayonnement (116, 208a, 208b), où le système est adapté pour délivrer un rayonnement au sang dans la veine principale (108) ; et
un système de détection/analyse (114, 222) comportant un détecteur (124) adapté pour détecter une réponse du sang irradié par l'intermédiaire de l'entrée de réponse (118, 210a, 210b) et d'un analyseur (126) adapté pour convertir la réponse détectée en une concentration d'un constituant du sang et/ou une valeur d'un paramètre du sang.

13. Appareil selon la revendication 12, dans lequel l'appareil lingual (100, 200) comprend :

deux sections de transition (204a, 204b) s'étendant vers le bas depuis chacune des sections latérales (202a, 202b),
la partie affaissée (206) étant une section médiane interposée entre les deux transitions (202a, 202b).

14. Appareil (100) selon la revendication 12, dans lequel l'appareil lingual (100) comprend :

une sonde (102) comportant une pointe (104) ayant la sortie de rayonnement (116) et l'entrée de réponse (118).

15. Appareil (200) selon l'une quelconque des revendications 12, 13 ou 14, comprenant en outre :

une pluralité de sorties de lumière (208a, 208b) et une pluralité d'entrées de réponse (210a, 210b).

16. Appareil (100) selon l'une quelconque des revendications 12, 13, 14 ou 15, comprenant en outre :

un afficheur adapté pour afficher la réponse (données brutes) ou la réponse convertie (données affinées).

17. Appareil (100) selon l'une quelconque des revendications 12, 13, 14, 15 ou 16, comprenant en outre :

un champ magnétique ou électrique statique.

18. Appareil (100) selon l'une quelconque des revendications 12, 13, 14,15,16 ou 17, comprenant en outre :

une technique hybride d'irradiation et de détection.

19. Appareil (100) selon l'une quelconque des revendications 12, 13, 14, 15, 16, 17 ou 18, dans lequel la réponse correspond à une réponse sélectionnée dans le groupe consistant en : (a) une concentration d'hémoglobine dans le sang et le rayonnement est à une longueur d'onde spectrale sélectionnée dans le groupe consistant en 548 nm, 568 nm, 587 nm et 805 nm (les points isosbétiques) et des gammes spectrales allant d'environ 400 nm à environ 640 nm et au-dessus d'environ 1120 nm où les coefficients d'absorption du sang oxygéné et désoxygéné sont proches l'un de l'autre, (b) une concentration d'hématocrite ; (c) des concentrations d'hémoglobine et/ou d'hémoglobine glycosylée ; (d) une concentration de glucose ; (e) une concentration de cholestérol ; (f) des concentrations d'oxyhémoglobine, de déoxyhémoglobine, et de carboxyhémoglobine, et (g) une concentration d'une substance exogène sélectionnée dans le groupe consistant en un médicament, un colorant ou un autre rapporteur à l'état moléculaire ou une particule d'un matériau liquide, gazeux ou solide dont un polymère, un métal, un semi-conducteur, un diélectrique ou une combinaison de matériaux liquides, gazeux ou solides, et une structure en couches.

20. Appareil (100) selon la revendication 19, dans lequel la substance exogène est sélectionnée dans le groupe consistant en vert d'indocyanine et bleu Evans.

21. Appareil (100) selon la revendication 19, dans laquelle la substance exogène comprend des particules d'une grosseur d'environ 0,1 nanomètre à environ 10 microns.

22. Appareil (100) selon l'une quelconque des revendications 12, 13, 14, 15, 16, 17, 18, 19, 20 ou 21, dans lequel le rayonnement est compris dans une gamme spectrale allant d'environ 200 nanomètres à environ 20 microns.

23. Appareil (100) selon l'une quelconque des revendications 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 ou 22, dans lequel le rayonnement est sélectionné dans le groupe consistant en rayonnement hyperfréquence, rayonnement radiofréquence, rayonnement ultrasonore et rayonnement électromagnétique basse fréquence.

24. Appareil (100) selon l'une quelconque des revendications 12, 13, 14, 15, 16, 17, 18, 19,20,21,22 ou 23, dans lequel le rayonnement comprend un, deux ou de nombreuses longueurs d'onde (fréquences).

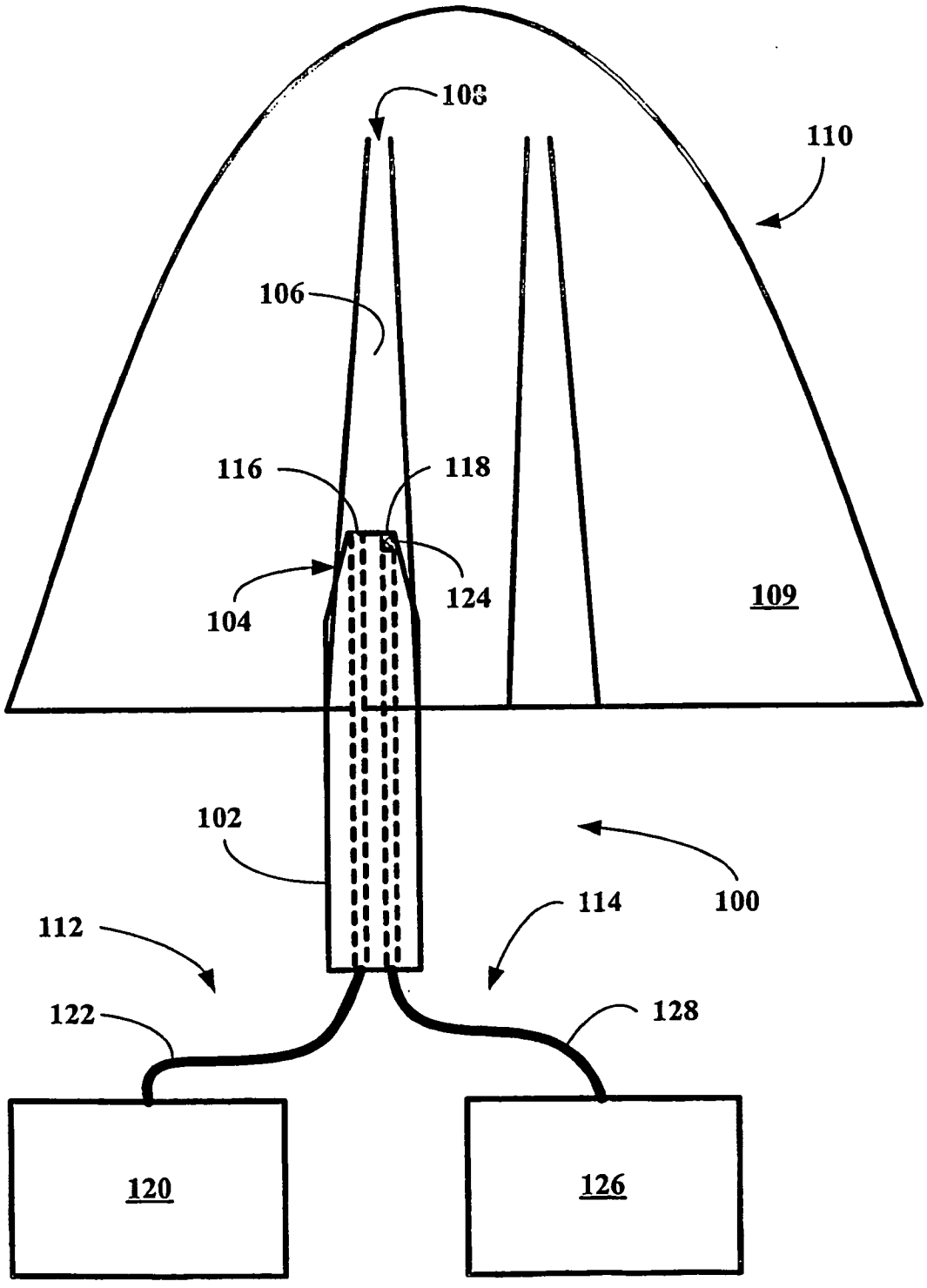

FIG. 1A

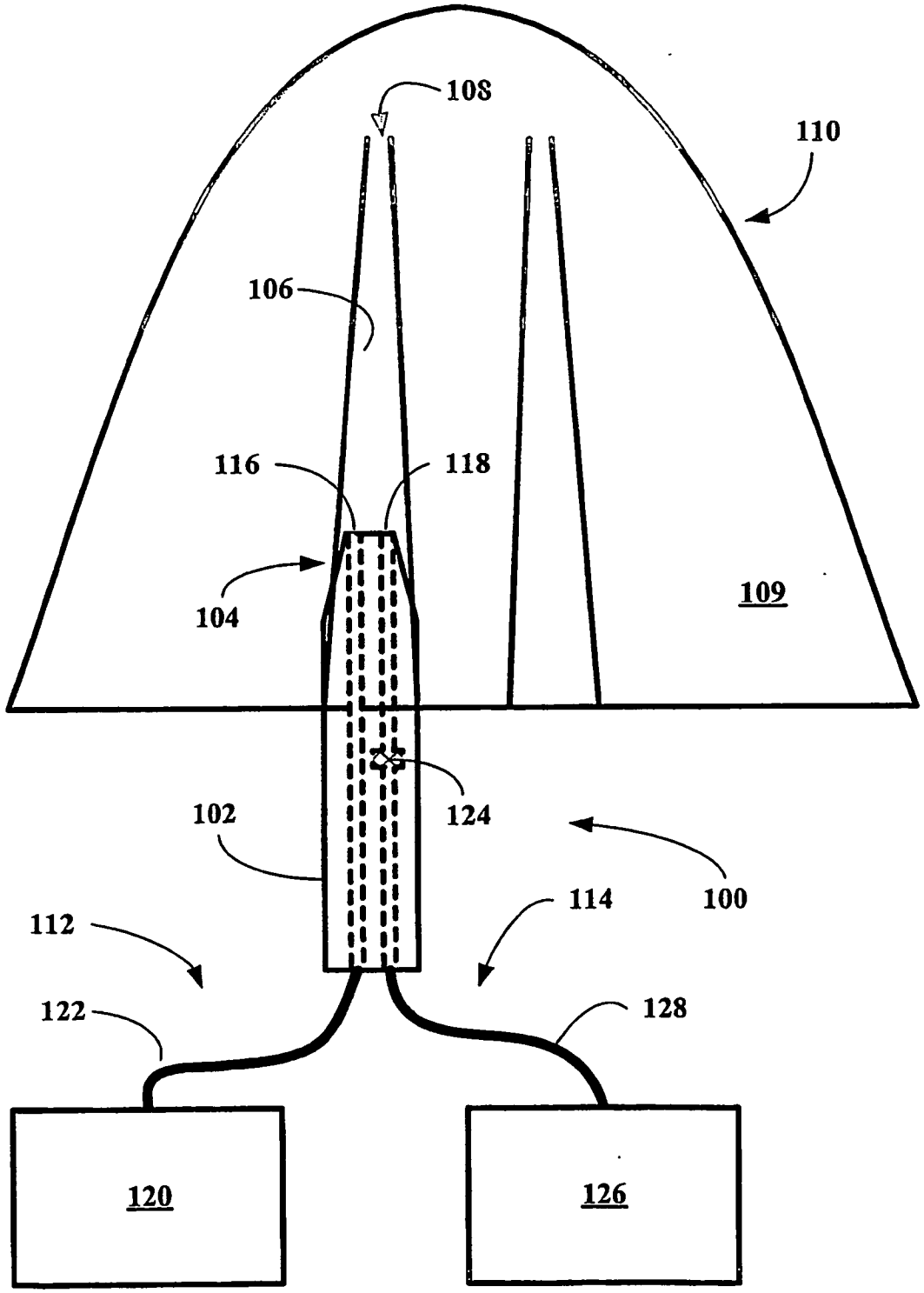

FIG. 1B

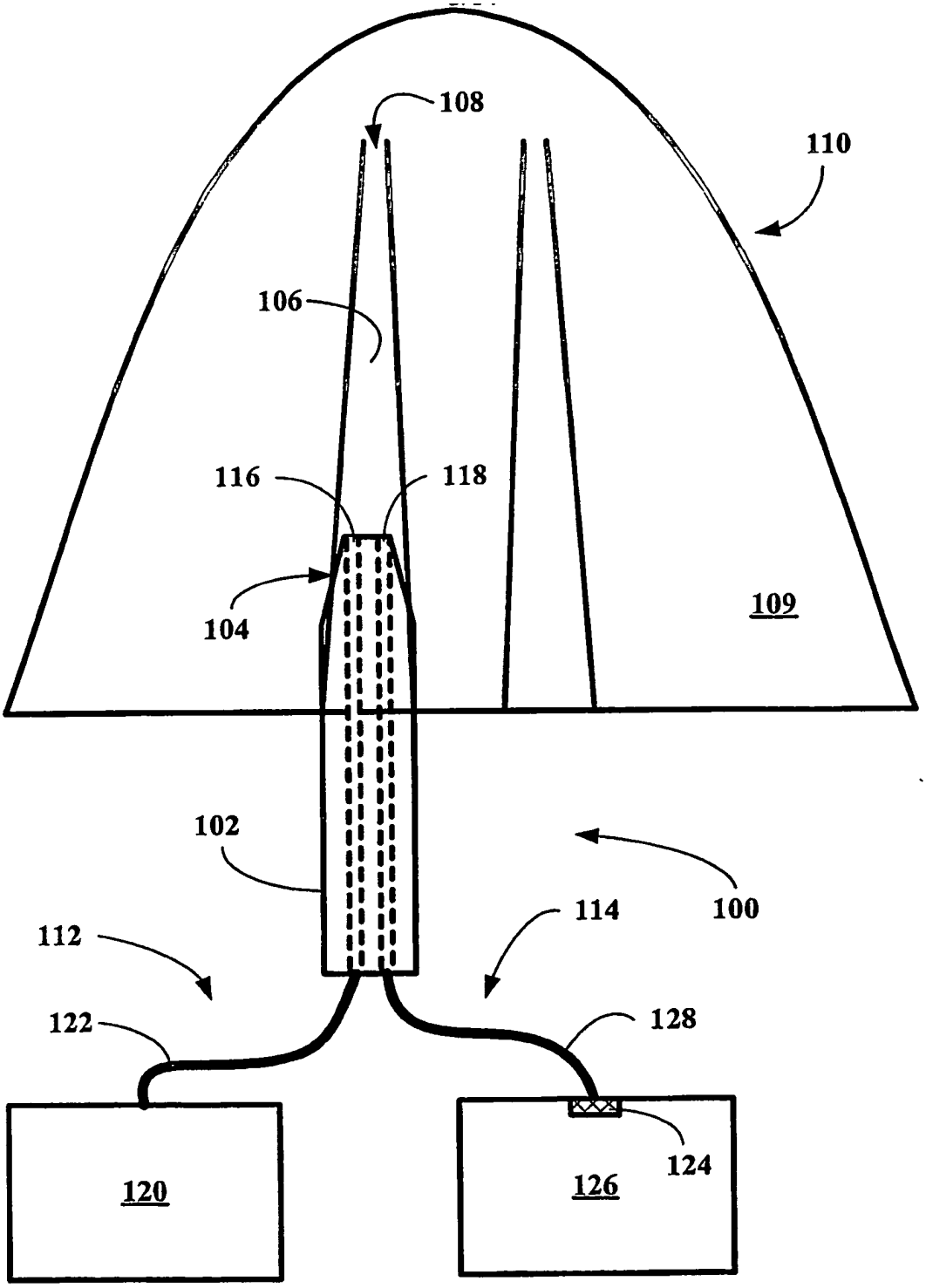

FIG. 1C

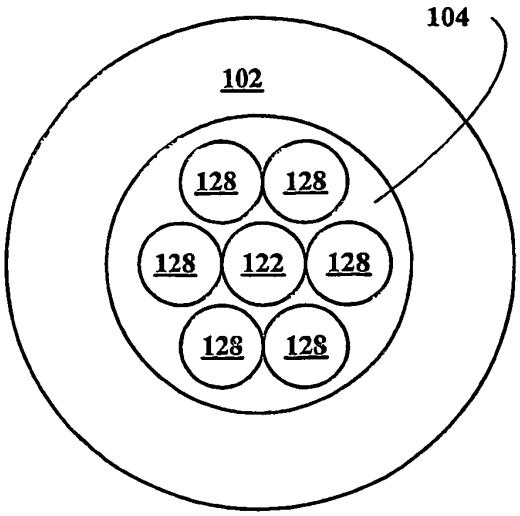

FIG. 1D

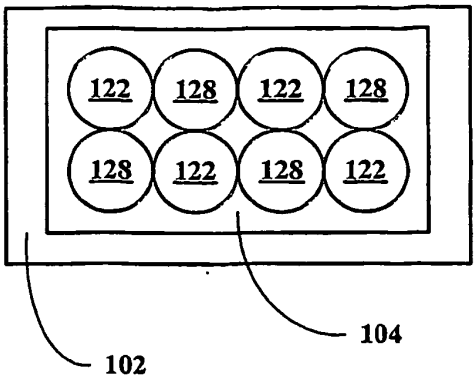

FIG. 1F

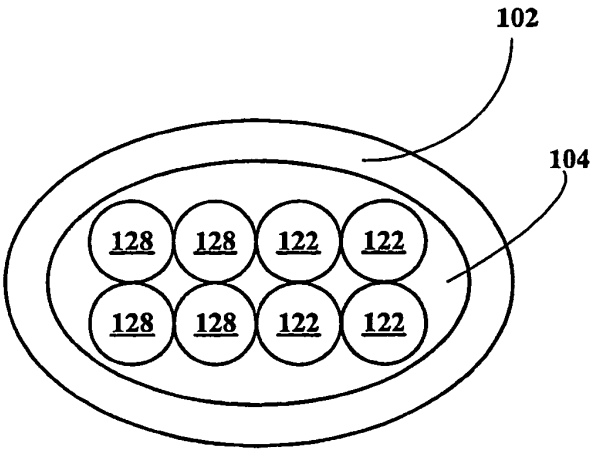

FIG. 1E

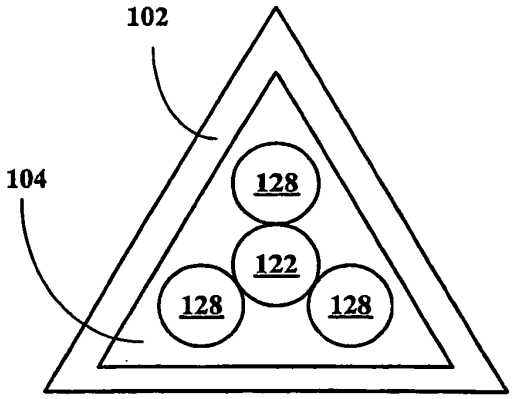

FIG. 1G

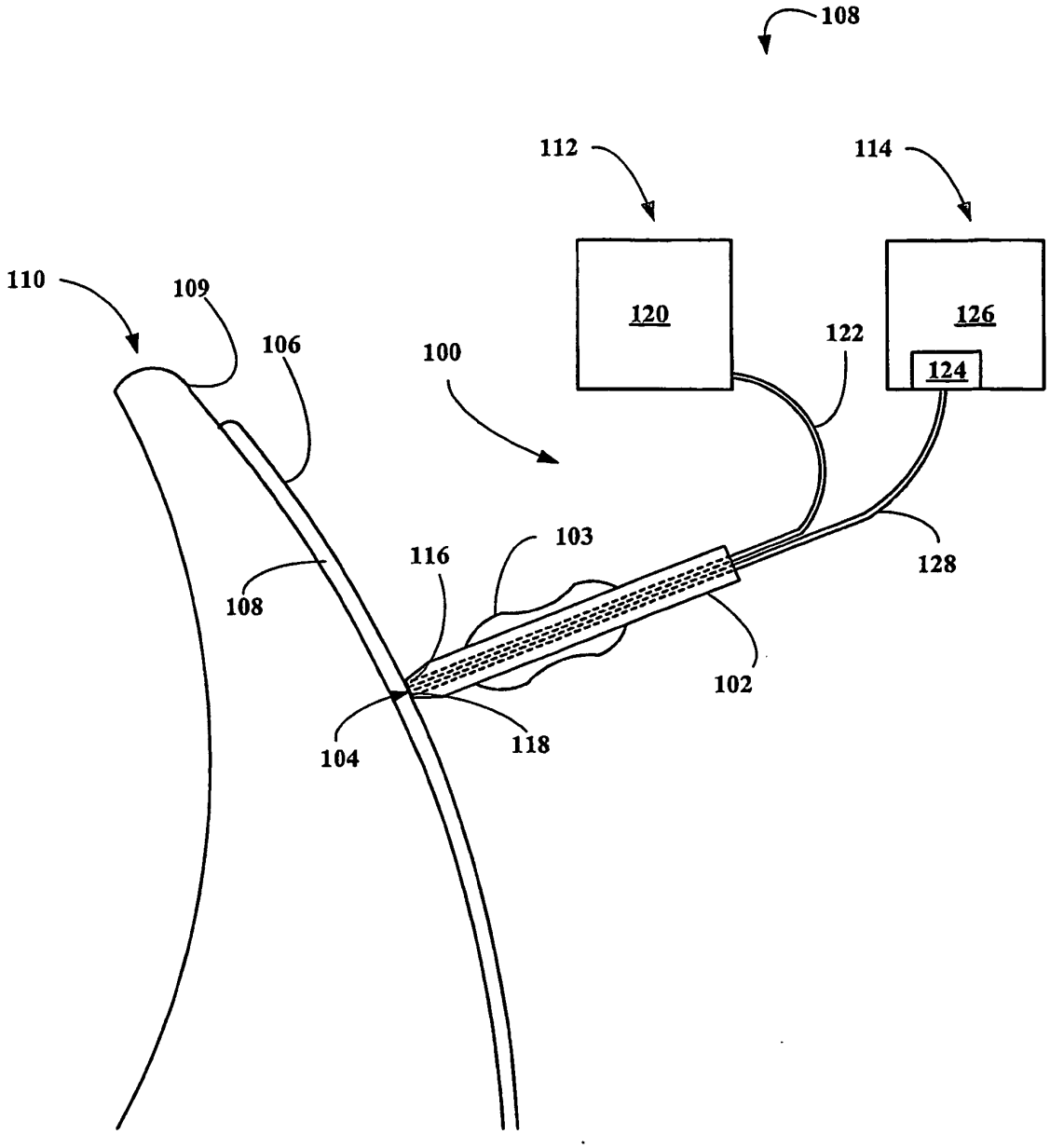
108
112
114
110
109
106
100
120
122
126
124
103
116
128
108
102
104
118

FIG. 1H

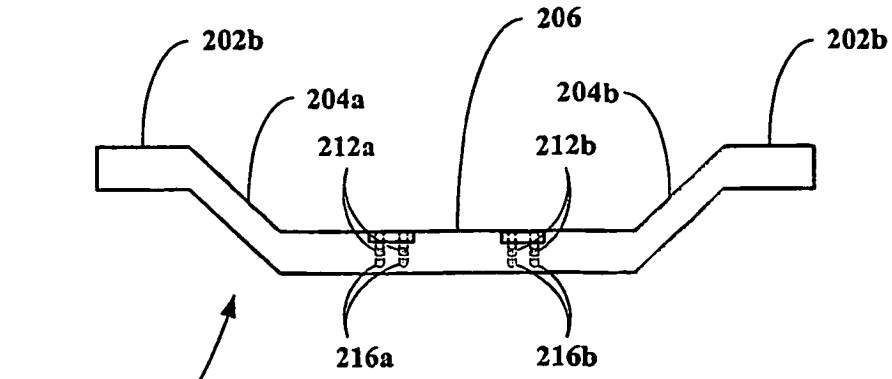
202b
206
202b
204a
204b
212a
212b
216a
216b

FIG. 2A

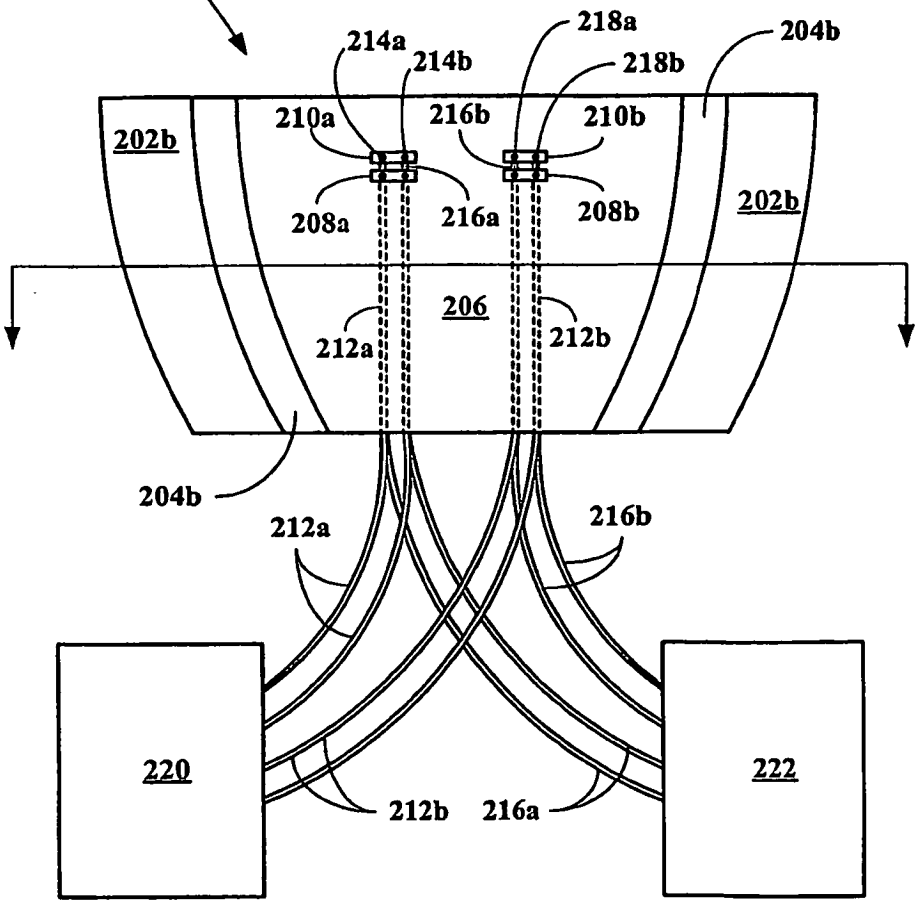
200
214a
214b
218a
218b
204b
210a
216b
210b
202b
208a
216a
208b
202b
206
212a
212b
204b
212a
216b
220
222
212b
216a

FIG. 2B

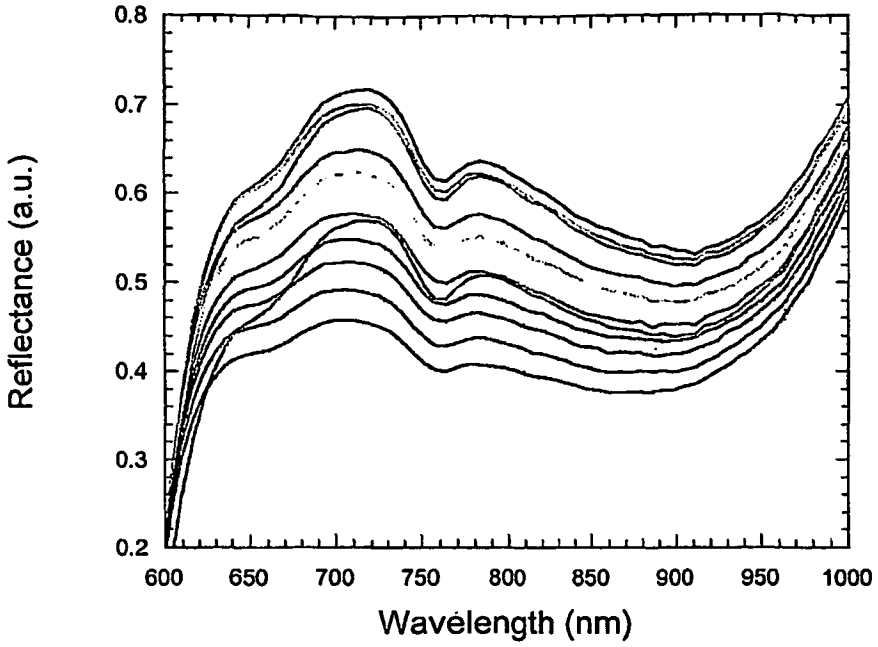
Reflectance (a.u.)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
600
650
700
750
800
850
900
950
1000
Wavelength (nm)

FIG. 3

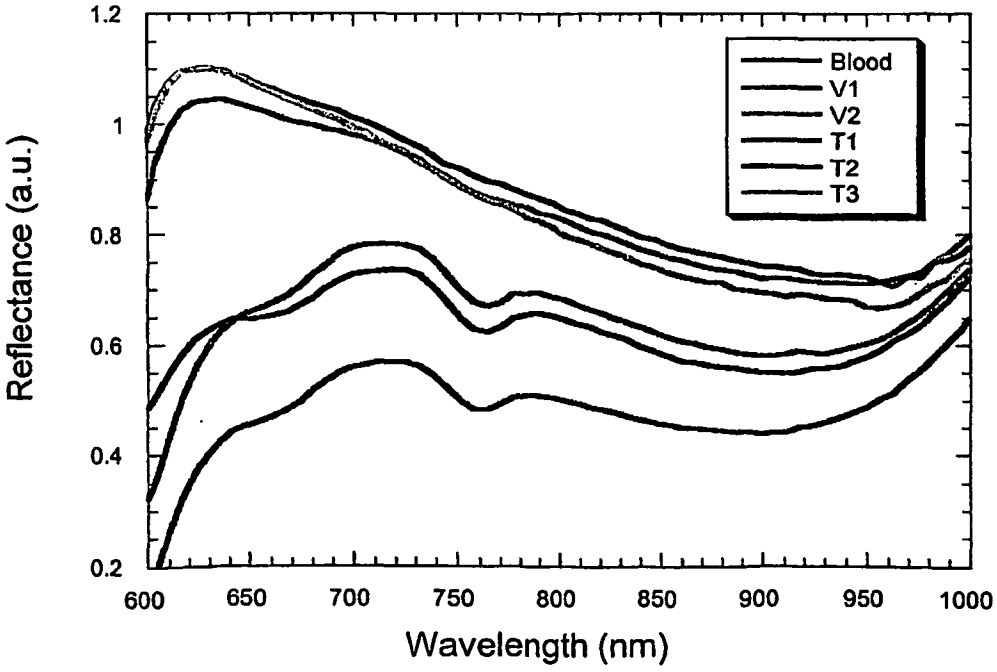
Reflectance (a.u.)
1.2
1
0.8
0.6
0.4
0.2
600
650
700
750
800
850
900
950
1000
Wavelength (nm)
Blood
V1
V2
T1
T2
T3

FIG. 4

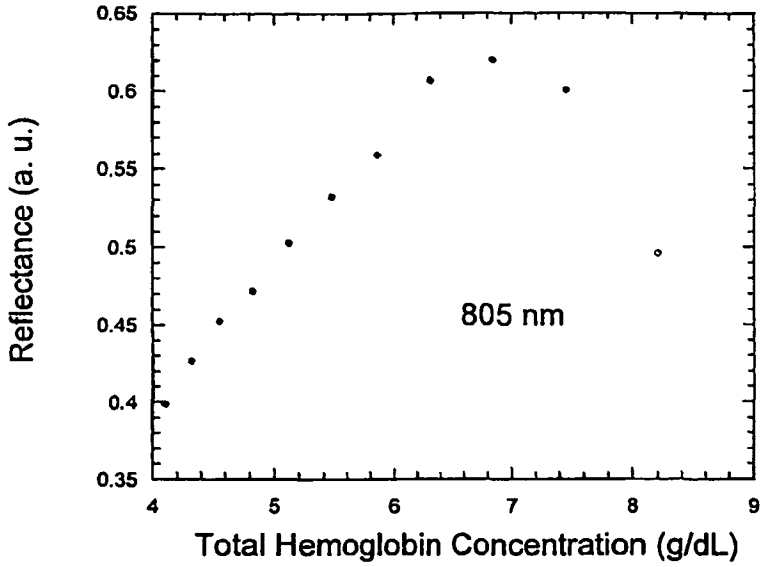
Reflectance (a. u.)
0.65
0.6
0.55
0.5
0.45
0.4
0.35
805 nm
4
5
6
7
8
9
Total Hemoglobin Concentration (g/dL)

FIG. 5

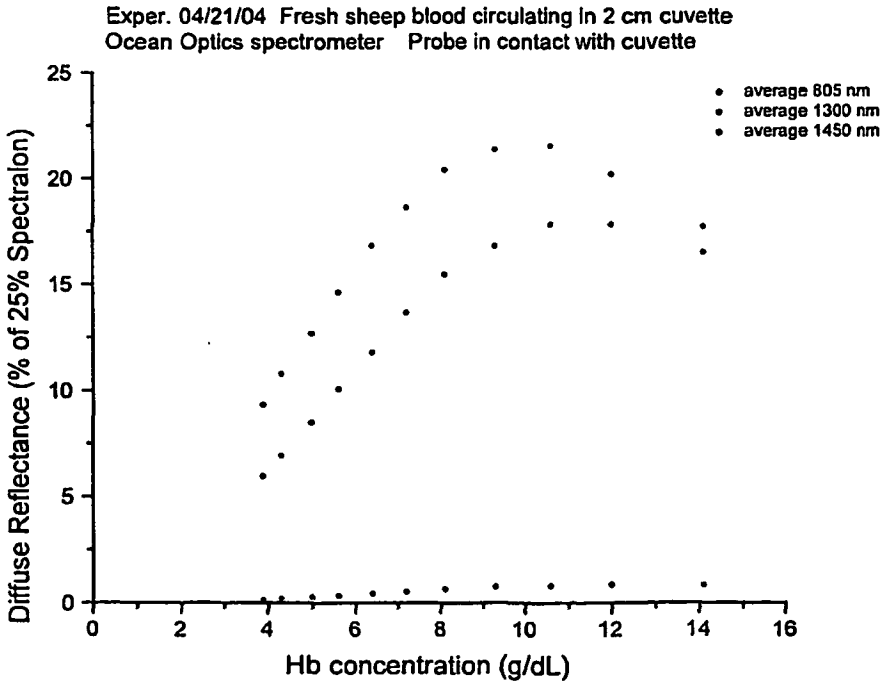
Exper. 04/21/04 Fresh sheep blood circulating in 2 cm cuvette
Ocean Optics spectrometer Probe in contact with cuvette
average 805 nm
average 1300 nm
average 1450 nm
Diffuse Reflectance (% of 25% Spectralon)
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
Hb concentration (g/dL)

FIG. 6A

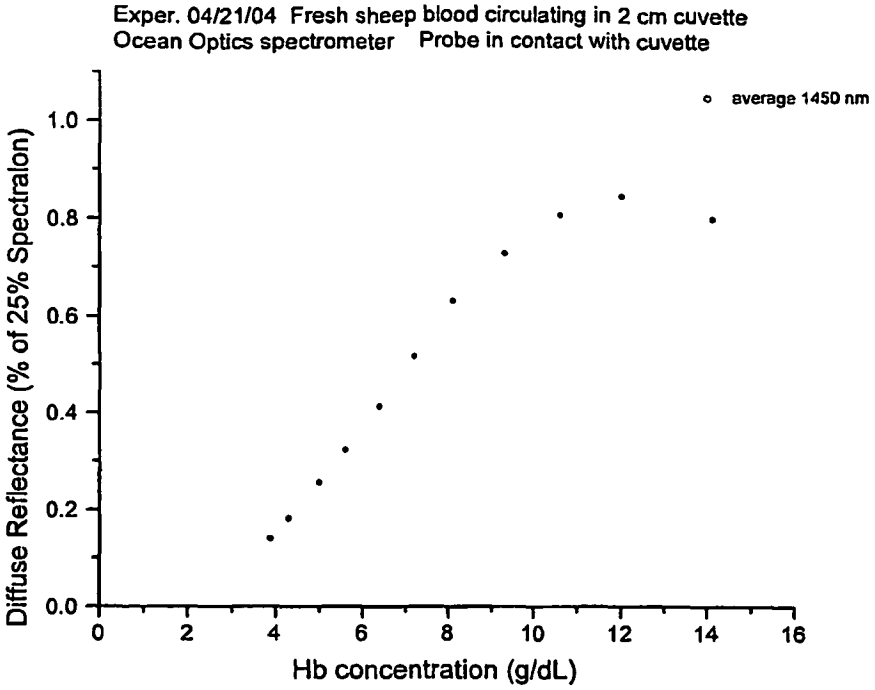
Exper. 04/21/04 Fresh sheep blood circulating in 2 cm cuvette
Ocean Optics spectrometer Probe in contact with cuvette
average 1450 nm
Diffuse Reflectance (% of 25% Spectralon)
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
Hb concentration (g/dL)

FIG. 6B

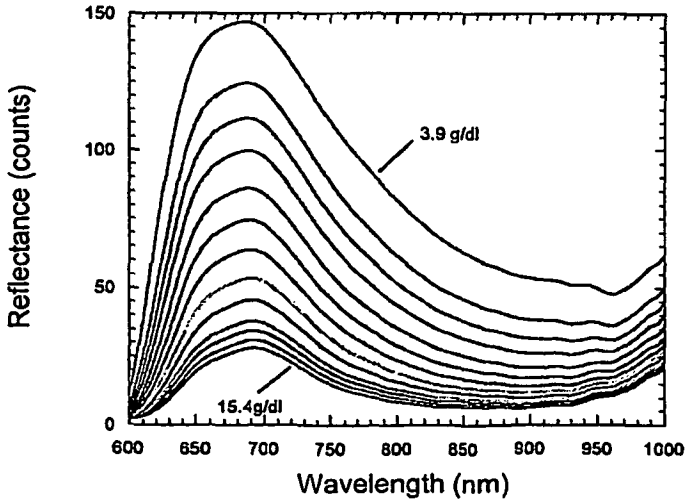
Reflectance (counts)
150
100
50
0
3.9 g/dl
15.4g/dl
600
650
700
750
800
850
900
950
1000
Wavelength (nm)

FIG. 7A

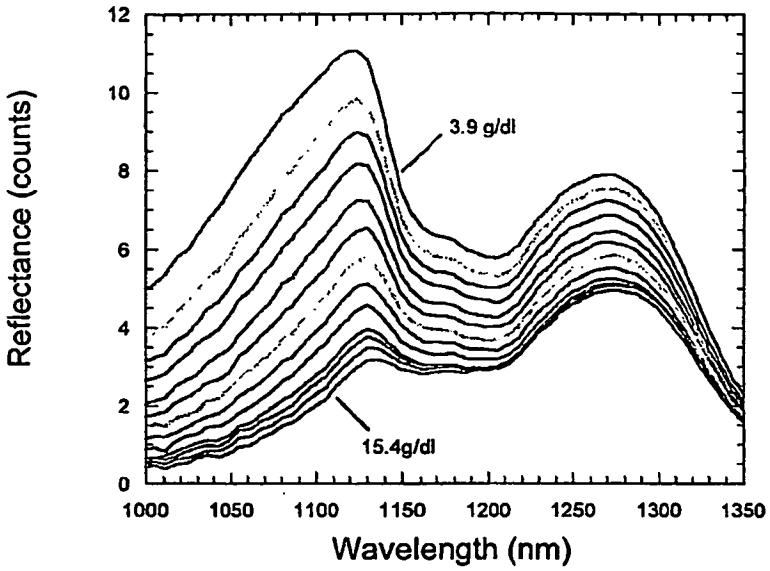
Reflectance (counts)
Wavelength (nm)
3.9 g/dl
15.4g/dl
0
2
4
6
8
10
12
1000
1050
1100
1150
1200
1250
1300
1350

FIG. 7B

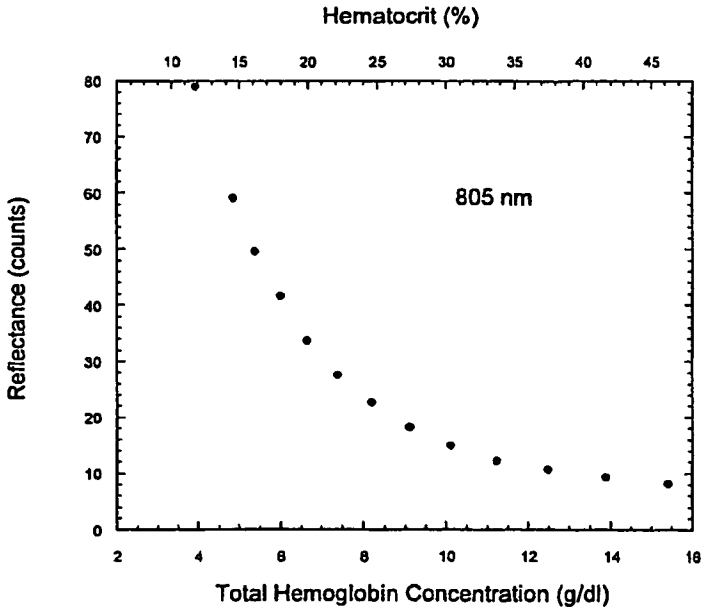
Hematocrit (%)
Reflectance (counts)
Total Hemoglobin Concentration (g/dl)
805 nm
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
2
4
6
8
10
12
14
16

FIG. 8A

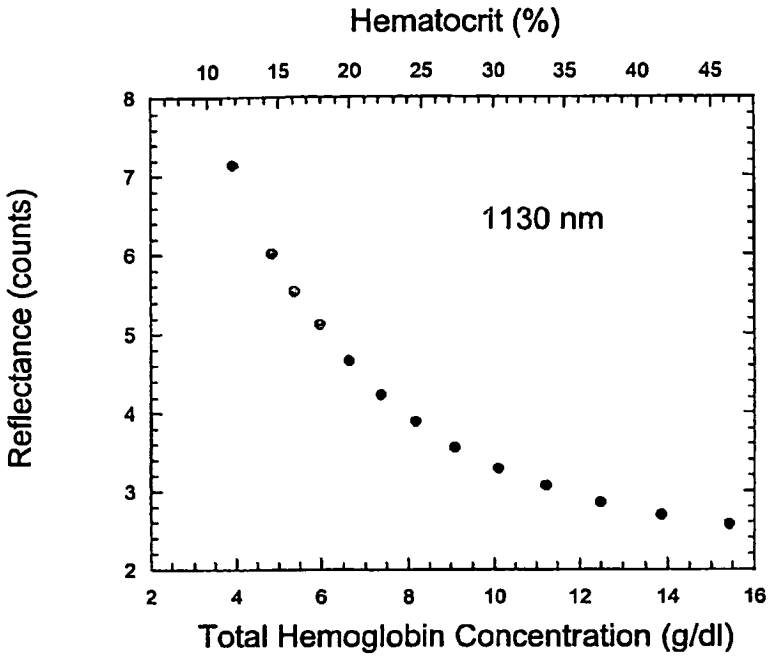
Hematocrit (%)
10 15 20 25 30 35 40 45
Reflectance (counts)
8 7 6 5 4 3 2
1130 nm
2 4 6 8 10 12 14 16
Total Hemoglobin Concentration (g/dl)

FIG. 8B

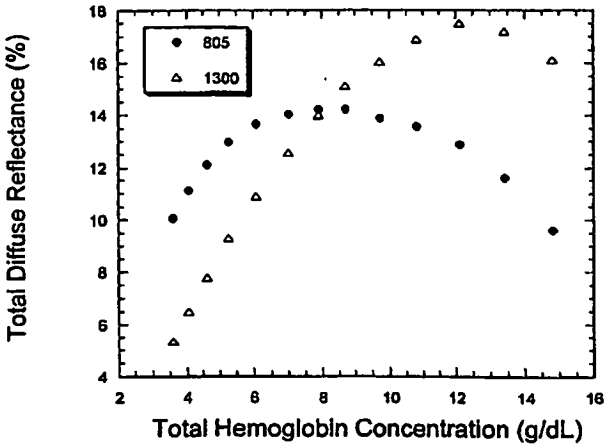
Total Diffuse Reflectance (%)
18 16 14 12 10 8 6 4
805
1300
2 4 6 8 10 12 14 16
Total Hemoglobin Concentration (g/dL)

FIG. 9A

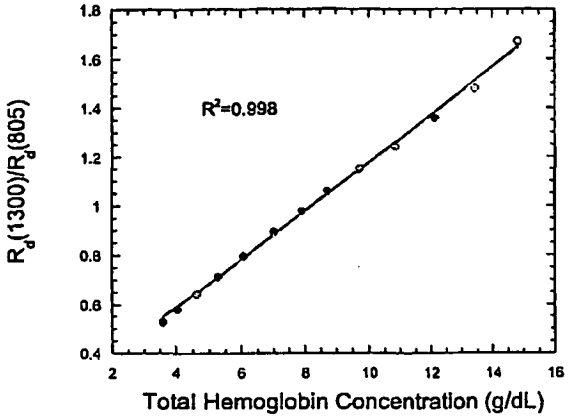

FIG. 9B

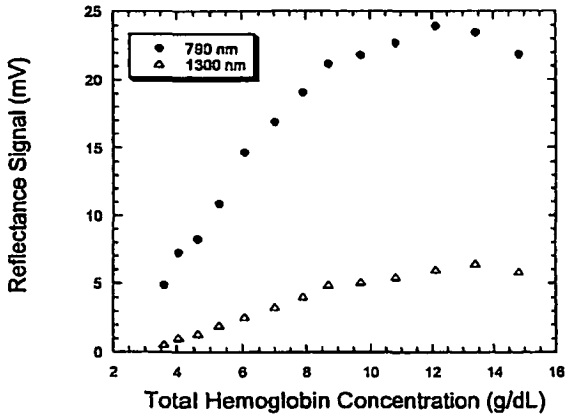

FIG. 10A

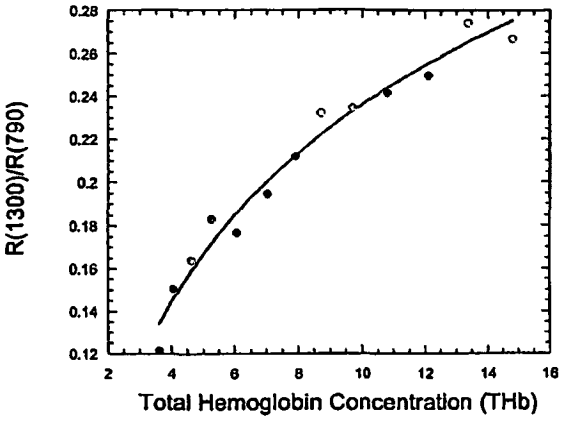

FIG. 10B

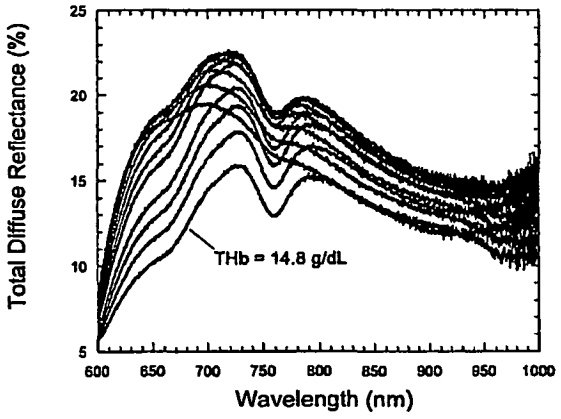

FIG. 11A

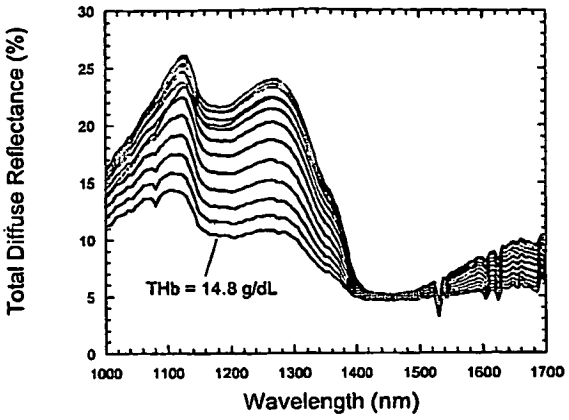
Total Diffuse Reflectance (%)
30
25
20
15
10
5
0
THb = 14.8 g/dL
1000
1100
1200
1300
1400
1500
1600
1700
Wavelength (nm)

FIG. 11B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 4890619 A **[0005]**

专利名称(译)	通过光学探测舌下静脉的无创血液分析		
公开(公告)号	EP1620002B1	公开(公告)日	2012-01-04
申请号	EP2004750643	申请日	2004-04-26
申请(专利权)人(译)	校董会，得克萨斯州大学系统		
当前申请(专利权)人(译)	校董会，得克萨斯州大学系统		
[标]发明人	ESENALIEV RINAT O PROUGH DONALD S		
发明人	ESENALIEV, RINAT, O. PROUGH, DONALD S.		
IPC分类号	A61B5/00 A61F		
CPC分类号	A61B5/0068 A61B5/0066 A61B5/14532 A61B5/14535 A61B5/14546 A61B5/1455 A61B5/682		
优先权	60/465134 2003-04-24 US		
其他公开文献	EP1620002A4 EP1620002A2		
外部链接	Espacenet		

摘要(译)

公开了一种用于分析血液成分或参数的方法，其中具有激发出口（116）和响应入口（118）的探针（102）被放置在患者舌头下侧的组织附近或与之接触舌中的大静脉（108）使得激励信号离开出口，产生响应，该响应进入入口以进行检测和分析。