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(54) MEDICAL SENSOR AND TECHNIQUE FOR USING THE SAME

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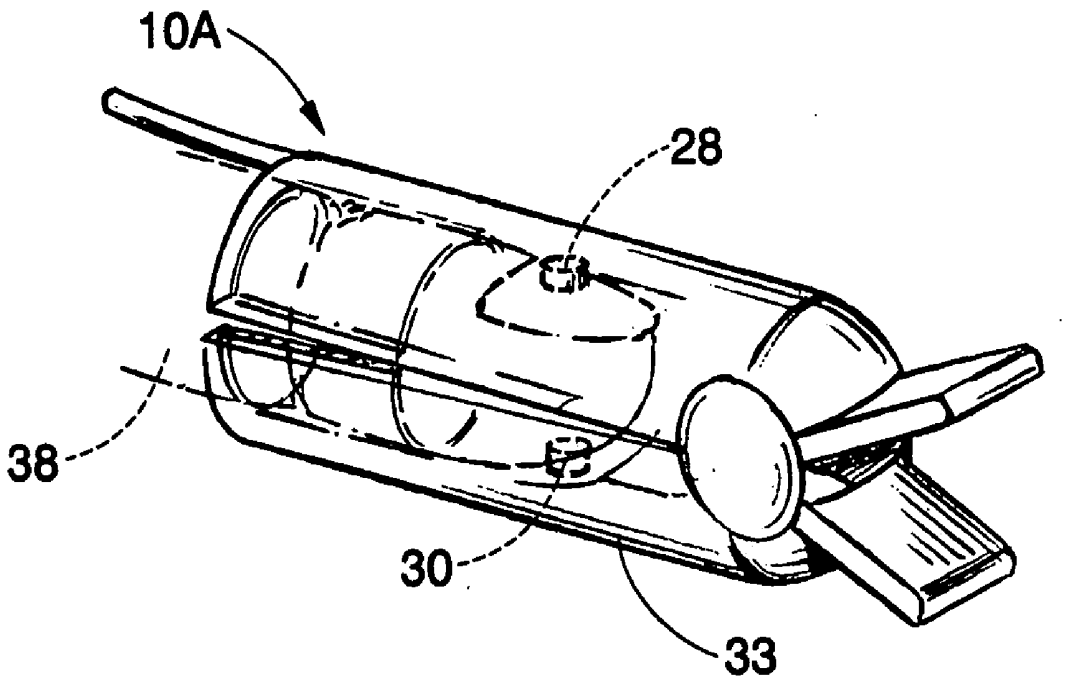
(57) **ABSTRACT**

A sensor may be adapted to account for factors that cause irregularities in sensor measurements. A sensor may selectively absorb light from outside sources. A sensor may selectively absorb light near a region of tissue having relatively large subcutaneous anatomic structures, such as large blood vessels, and selectively reflect light near a region of tissue that is relatively free of large blood vessels or other structures. The sensor is adapted to reduce the effect of large subcutaneous anatomic structures and outside light on measurements for pulse oximetry or other spectrophotometric techniques.



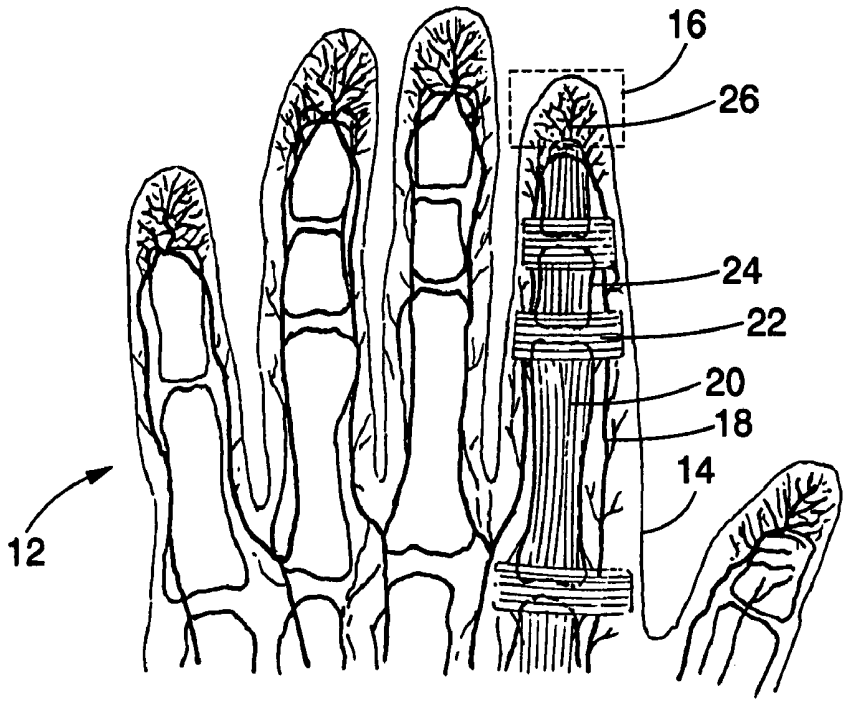


FIG. 1

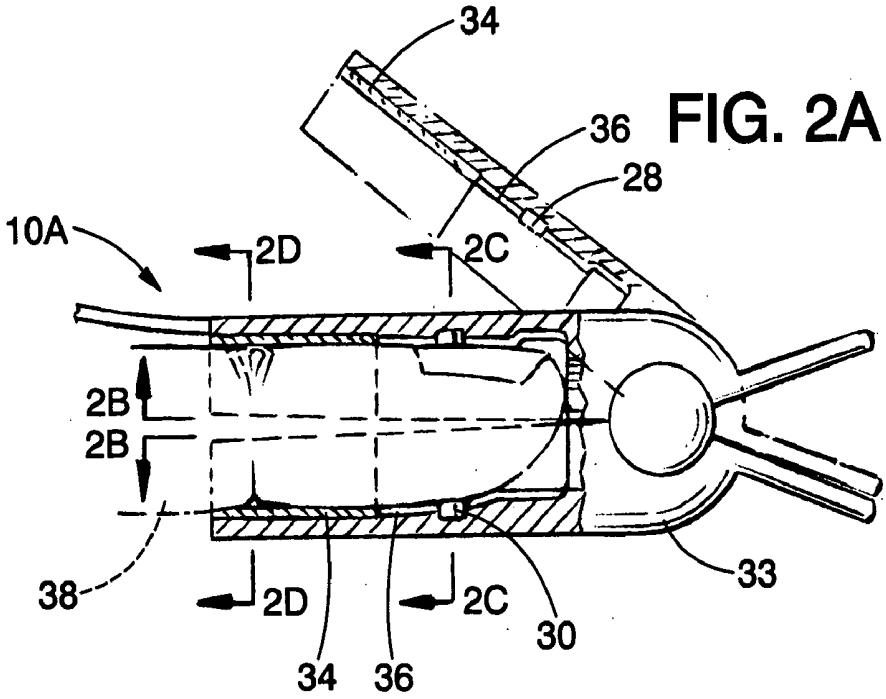


FIG. 2A

FIG. 2B

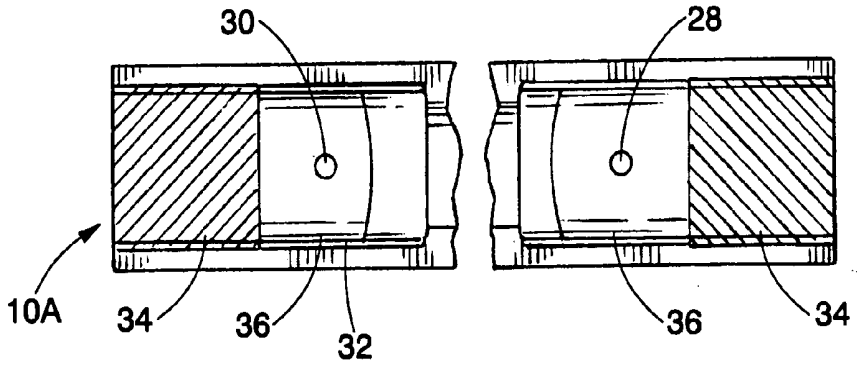
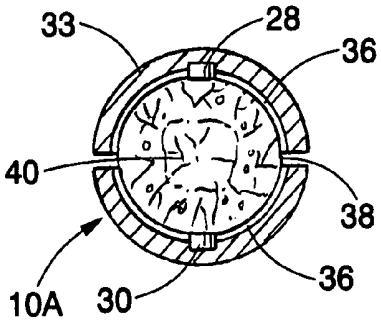


FIG. 2C



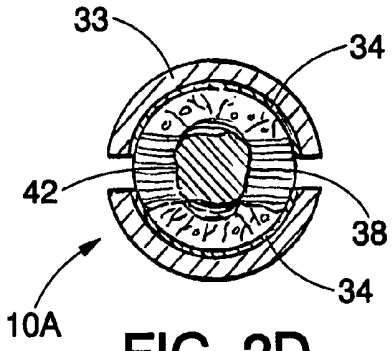


FIG. 2D

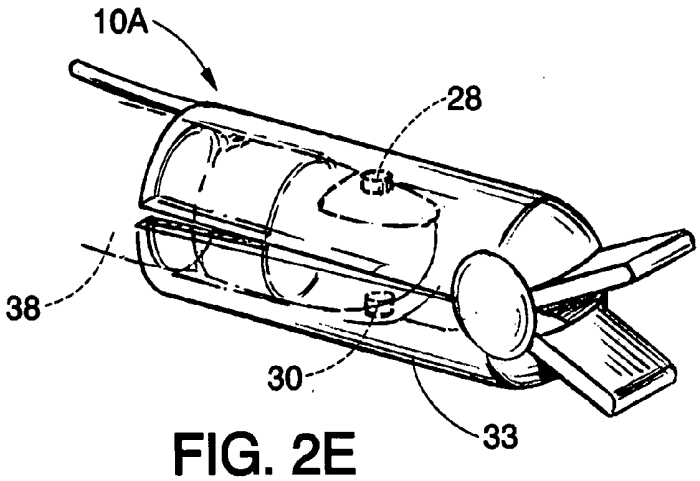


FIG. 2E

FIG. 3A

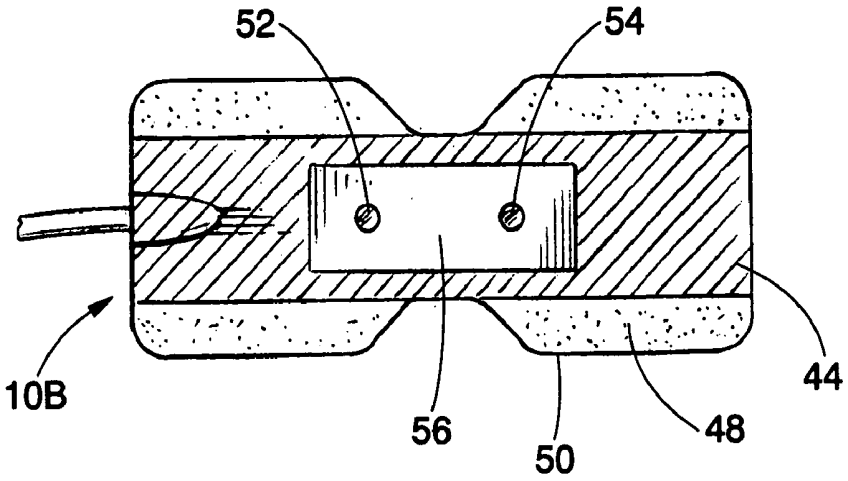


FIG. 3B

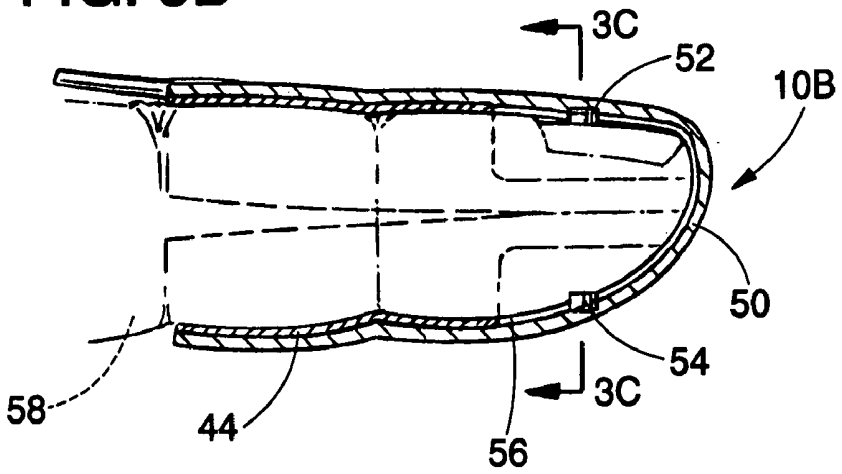


FIG. 3C

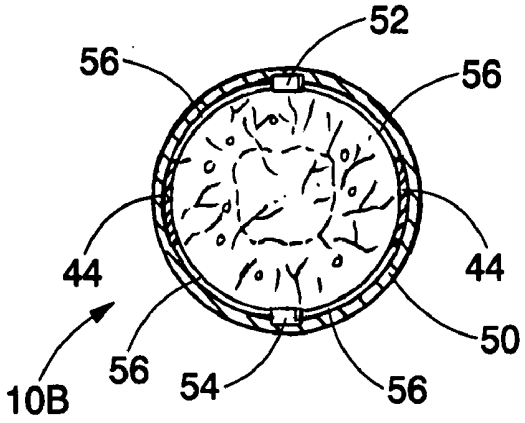


FIG. 4A

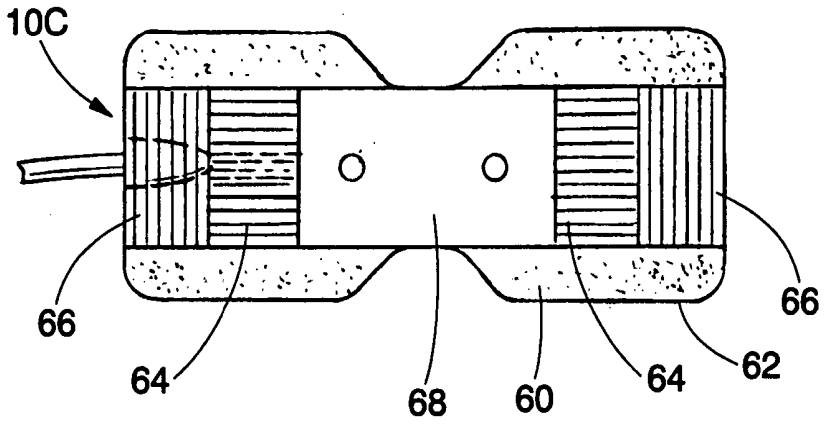


FIG. 4B

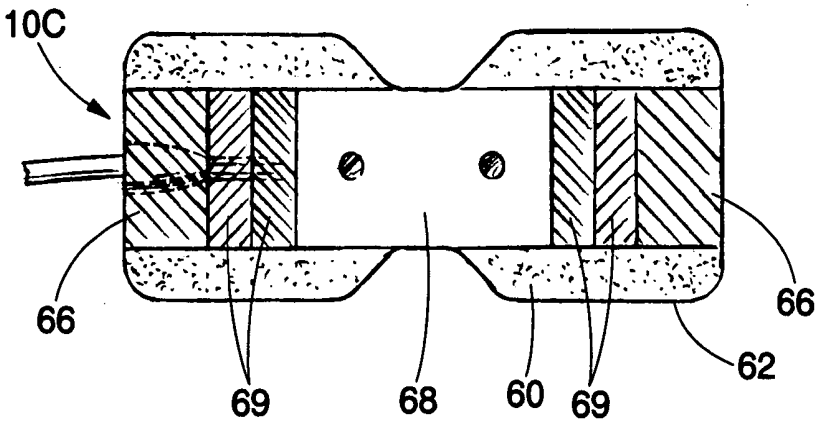
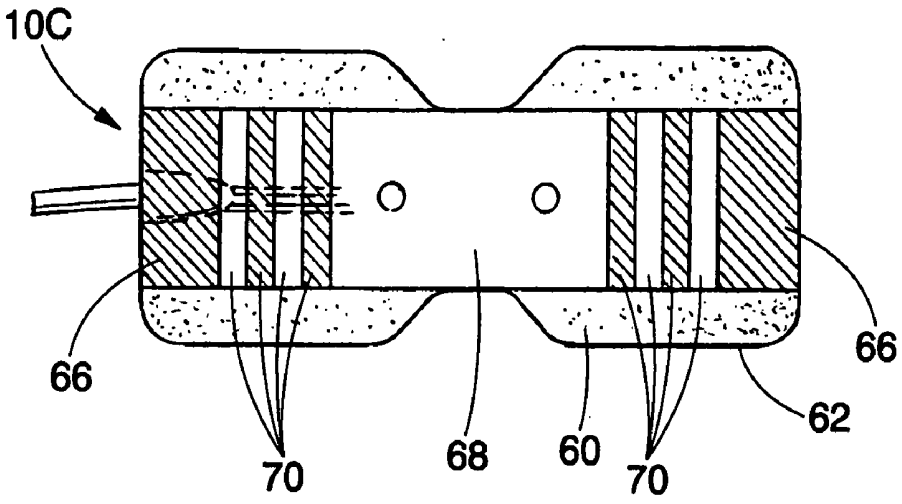


FIG. 4C



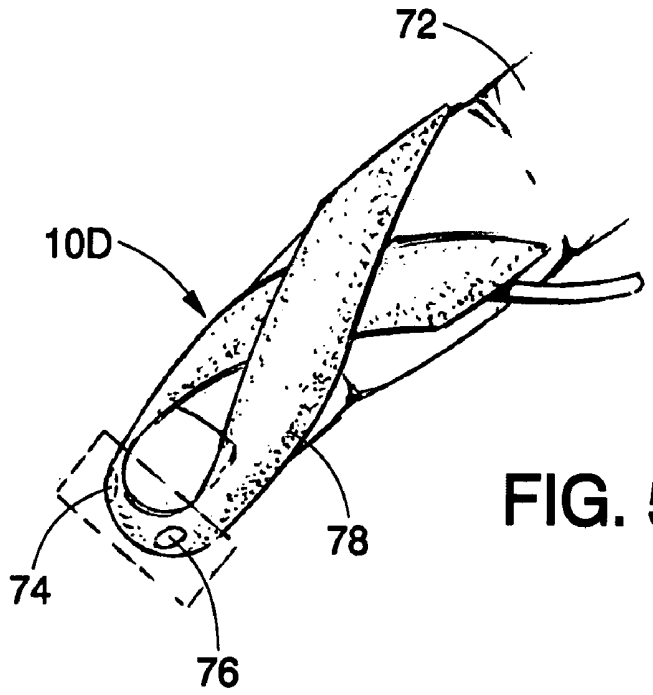
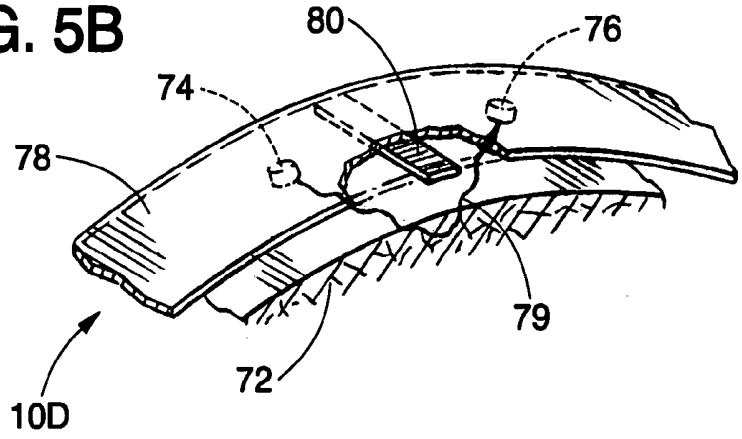


FIG. 5A

FIG. 5B



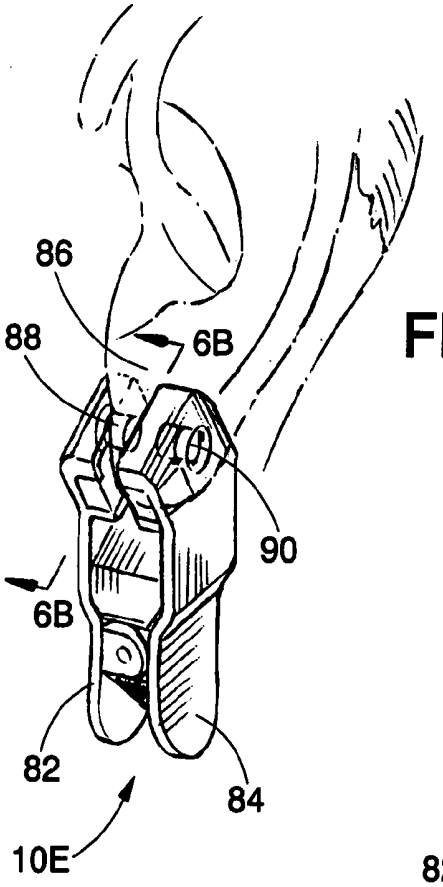


FIG. 6A

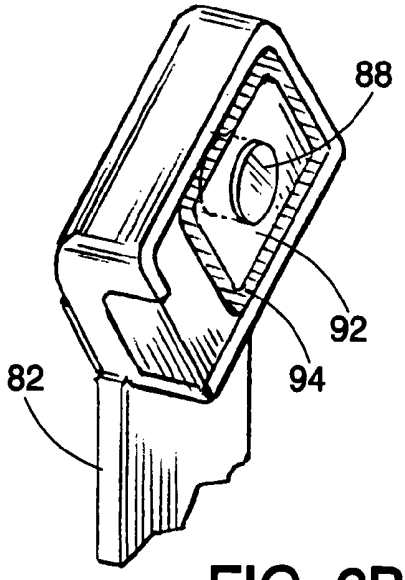


FIG. 6B

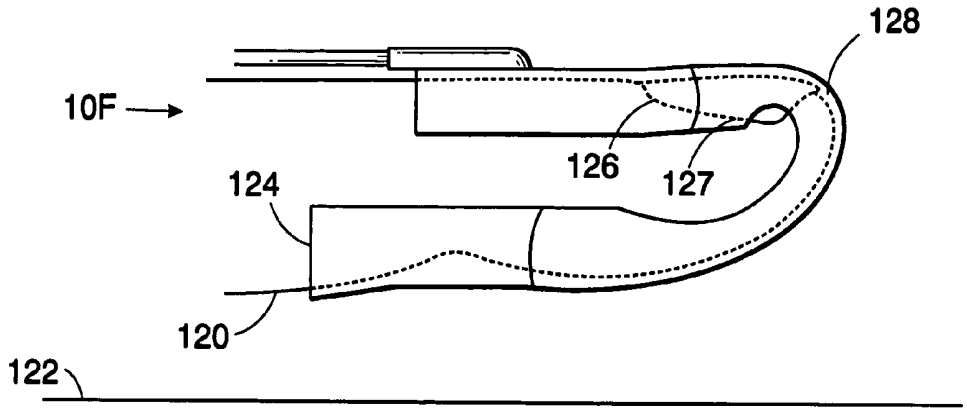


FIG. 7A

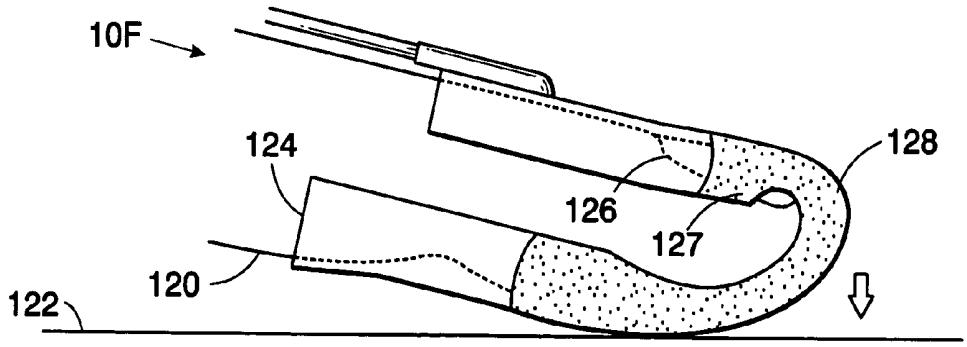


FIG. 7B

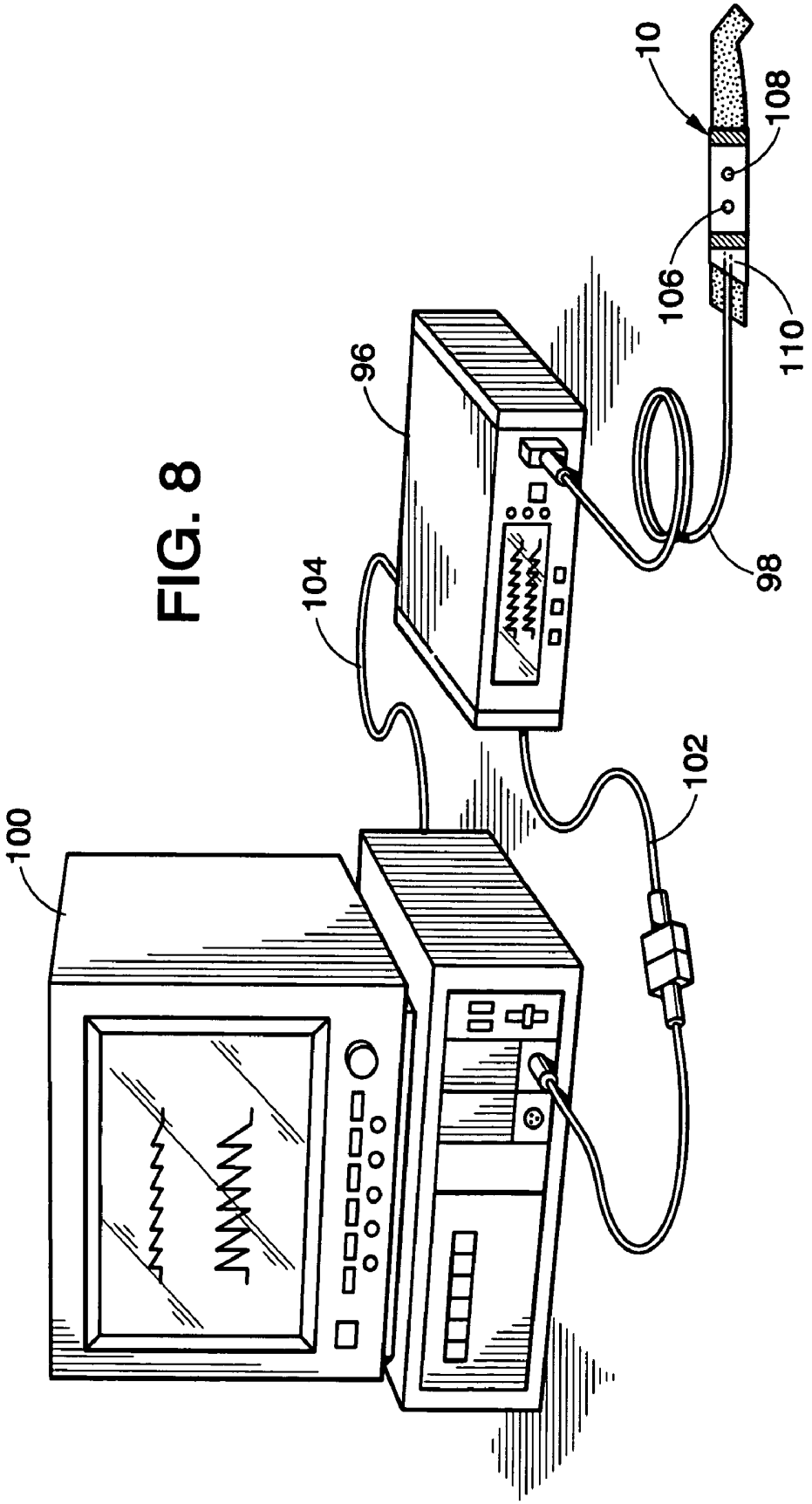


FIG. 8

MEDICAL SENSOR AND TECHNIQUE FOR USING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to medical devices and, more particularly, to sensors used for sensing physiological parameters of a patient.

[0003] 2. Description of the Related Art

[0004] This section is intended to introduce the reader to various aspects of art that may be related to certain aspects of the present invention, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present invention. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

[0005] In the field of medicine, doctors often desire to monitor certain physiological characteristics of their patients. Accordingly, a wide variety of devices have been developed for monitoring many such characteristics of a patient. Such devices provide doctors and other healthcare personnel with the information they need to provide the best possible healthcare for their patients. As a result, such monitoring devices have become an indispensable part of modern medicine.

[0006] One technique for monitoring certain physiological characteristics of a patient is commonly referred to as pulse oximetry, and the devices built based upon pulse oximetry techniques are commonly referred to as pulse oximeters. Pulse oximetry measures various blood flow characteristics, such as the blood-oxygen saturation of hemoglobin in arterial blood, the volume of individual blood pulsations supplying the tissue, and/or the rate of blood pulsations corresponding to each heartbeat of a patient. In fact, the "pulse" in pulse oximetry refers to the time varying amount of arterial blood in the tissue during each cardiac cycle.

[0007] Pulse oximeters typically utilize a non-invasive sensor that emits light into a patient's tissue and that photoelectrically detects the absorption and/or scattering of the transmitted light in such tissue. One or more of the above physiological characteristics may then be calculated based upon the amount of light absorbed or scattered. More specifically, the light passed through the tissue is typically selected to be of one or more wavelengths that may be absorbed or scattered by the blood in an amount related to the amount of a blood constituent present in the blood. The amount of light absorbed and/or scattered may then be used to estimate the amount of the blood constituent in the tissue using various algorithms.

[0008] The pulse oximetry measurement depends in part on the assumptions that the contribution of outside light sources is negligible and that the detected light is transmitted through relatively homogeneous tissue. However, outside light may leak into a sensor, causing detection of light that is not related to the amount of blood constituent present in the blood. Additionally, these assumptions fail to take into account that human tissue is by nature heterogeneous, and that within any given tissue site there may be variations in the size and location of large blood vessels, bones, connective tissue, and other subcutaneous anatomic structures. These structures affect the path of the light as it passes through the tissue, causing measurement variations that do not relate to amount of the blood constituent.

SUMMARY

[0009] Certain aspects commensurate in scope with the originally claimed invention are set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of certain forms that the invention might take and that these aspects are not intended to limit the scope of the invention. Indeed, the invention may encompass a variety of aspects that may not be set forth below.

[0010] There is provided a sensor that includes: a sensor body; an emitter disposed on the sensor body, wherein the emitter is adapted to transmit light into tissue; a detector disposed on the sensor body, wherein the detector is adapted to detect the light; a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

[0011] There is provided a sensor that includes: an emitter adapted to deliver light into a tissue, wherein the tissue comprises relatively large subcutaneous anatomic structures and relatively small subcutaneous anatomic structures; a detector adapted to detect the light; and a sensor body on which the emitter and detector are disposed, the sensor body having a tissue-contacting surface, wherein the tissue-contacting surface is adapted to absorb light proximate to the relatively large subcutaneous anatomic structures and to reflect light proximate to the relatively small subcutaneous anatomic structures.

[0012] There is also provided a pulse oximetry system that includes a pulse oximetry monitor and a pulse oximetry sensor adapted to be operatively coupled to the monitor. The sensor includes a sensor body; an emitter disposed on the sensor body, wherein the emitter is adapted to transmit light into tissue; a detector disposed on the sensor body, wherein the detector is adapted to detect the light; a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

[0013] There is also provided a method of operating a sensor that includes: delivering light through a patient's tissue; absorbing the light with an absorptive material proximate to relatively large vascular structures; and reflecting the light with a reflective material proximate to relatively small vascular structures.

[0014] There is also provided a method of manufacturing a sensor that includes: providing a sensor body; providing an emitter adapted to transmit light into tissue; providing a detector adapted to detect the light; providing a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and providing a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

[0015] There is also provided a method that includes: delivering light through a patient's tissue; and reflecting the light with a temperature-sensitive material adapted to have increased reflectivity when exposed to relatively low temperatures.

[0016] There is also provided a method that includes: delivering light through a patient's tissue; and absorbing the light with a material adapted to have increased absorption after receiving a feedback related to pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Advantages of the invention may become apparent upon reading the following detailed description and upon reference to the drawings in which:

[0018] FIG. **1** illustrates an exemplary patient's finger illustrating the location of blood vessels, bone, and connective tissue;

[0019] FIG. **2**A illustrates an embodiment of an exemplary clip-style sensor adapted for placement on a patient's digit with absorptive portions and reflective portions in accordance with the present invention;

[0020] FIG. **2**B illustrates a top perspective view of the sensor of FIG. **2**A in the open position;

[0021] FIG. **2**C illustrates a fingertip cross-section of the sensor of FIG. **2**A after placement on a patient's digit;

[0022] FIG. **2**D illustrates a non-fingertip cross-section of the sensor of FIG. **2**A after placement on a patient's digit;

[0023] FIG. **2**E illustrates a perspective view of the sensor of FIG. **2**A after application to a patient digit;

[0024] FIG. **3**A illustrates an exemplary embodiment of a bandage-style sensor with an absorptive region along the perimeter of the tissue-contacting surface of the sensor in accordance with the present invention;

[0025] FIG. **3**B illustrates a cross-sectional view of the sensor of FIG. **3**A applied to a patient's digit in accordance with the present invention;

[0026] FIG. **3**C illustrates a fingertip region cross-section of the sensor of FIG. **3**A after placement on a patient's digit;

[0027] FIG. **4**A illustrates an exemplary pulse oximetry sensor with absorptive portions, reflective portions, and a transitional zone in accordance with the present invention;

[0028] FIG. **4**B and **4**C illustrate exemplary embodiments of transitional zones depicted with the sensor of FIG. **4**A in accordance with the present invention;

[0029] FIG. **5**A illustrates an exemplary embodiment of a wrap-style sensor in accordance with the present invention;

[0030] FIG. **5**B illustrates the sensor of FIG. **5**A with a shunt block;

[0031] FIG. **6**A illustrates a perspective view of an exemplary clip-style sensor applied to an earlobe with absorptive portions surrounding the perimeter of the tissue-contacting surface of the sensor in accordance with the present invention;

[0032] FIG. **6**B illustrates a cross-sectional view of the clip-style sensor if FIG. **6**A;

[0033] FIG. **7**A illustrates a view of an exemplary bandage-style sensor applied to a finger with a pressure-sensitive absorptive portion surrounding the upper nail bed in accordance with the present invention;

[0034] FIG. **7**B illustrates the sensor of FIG. **7**A after pressure has been applied to the finger; and

[0035] FIG. **8** illustrates a pulse oximetry system coupled to a multi-parameter patient monitor and a sensor according to embodiments of the present invention.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0036] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0037] It is desirable to eliminate, reduce, or account for the possible influence of outside light sources and anatomic structures, which may cause variability in pulse oximetry measurements. For example, in accordance with some aspects of the present technique, sensors for pulse oximetry or other applications utilizing spectrophotometry are provided that reflect light proximate to areas of the tissue that do not contain dynamic anatomic structures, such as large blood vessels or connective tissue, thereby increasing the likelihood that the reflected light will be detected and provide useful data. In accordance with other aspects of the present technique, a sensor is provided that absorbs light proximate to dynamic anatomic structures, thereby preventing light modulated by the dynamic structures from being detected and providing erroneous or inaccurate data. Similarly, in accordance with other aspects of the present technique, a sensor absorbs outside light, i.e. light not provided by the sensor components that may leak into a sensor's interior.

[0038] Pulse oximetry sensors are typically placed on a patient in a location that is normally perfused with arterial blood to facilitate measurement of the desired blood characteristics, such as arterial oxygen saturation measurement (SaO_2). The most common sensor sites include a patient's fingertips, toes, earlobes, or forehead. Regardless of the placement of the sensor **10** used for pulse oximetry, the reliability of the pulse oximetry measurement is related to the accurate detection of transmitted light that has passed through the perfused tissue and has not been supplemented by outside light sources or unduly modulated by subcutaneous anatomic structures. Such supplementation and/or modulation of the light transmitted by the sensor **10** can cause variability in the resulting pulse oximetry measurements.

[0039] More specifically, light from the outside environment that is detected by the sensor **10** may adversely effect the measurement of the particular blood constituent, such as SpO_2. Additionally, larger blood vessels within the optically probed tissues may influence the relationship between the modulation ratio of the time-varying light transmission signals of the wavelengths transmitted and SpO_2. Thus, a sensor **10** may detect differences in signal modulations unrelated to the underlying SaO_2 level. In turn, this may impact the detected red-to-infrared modulation ratio and, consequently, the measured blood oxygen saturation (SpO_2) value. Other subcutaneous structures that may affect resulting pulse oximetry measurements include dynamic structures, which may move within the tissue. For example, connective tissue, such as tendons and ligaments, may move relative to bones during bending or flexing at joints. Larger blood vessels are also dynamic in response to arterial pressure. Changes in arterial pressure cause these vessels to expand, contract, and become distorted within the tissue. These dynamic structures may cause motion artifacts in pulse oximetry measurements. For example, when a patient bends a finger it may cause variations in the path of the light scattered and/or absorbed by the tendon during the bending movement. Additionally, surface structures of the finger may also affect the path of light. For example, the nail bed may change color when the finger presses down as blood pools under the nail. The skin may crease during finger motion, which may also affect the path of transmitted light.

[0040] By way of example, the hand structure **12** shown in FIG. **1** indicates that the density of larger diameter arteries in the digit **14** diminishes towards a fingertip region **16**, which contain areas of relatively small vascular structures, including arterioles and capillaries. Thus, light transmitted through the distal end of the fingertips is not affected by the relatively large blood vessels present in other areas of the finger. In contrast, the relatively larger diameter arteries and tendons present in other areas contribute non-linearly to the optical density of the tissue. Hence, a sensor **10** designed to selectively absorb light near these larger diameter arteries, but to reflect light near the microvascular region of the fingertips would result in a reduction in variability of the SaO_2 measurement. Further, a sensor **10** designed to selectively absorb light near dynamic structures such as finger tendons, would result in a reduction in motion artifacts, which may also cause variability of the SaO_2 measurement.

[0041] Turning more specifically to FIG. **1**, a digit **14** showing the locations of arteries **18**, tendons **20**, ligaments **22**, and bone structure **24** is illustrated. These structures are much larger in diameter than the vasculature in the fingertip region **16** of the digit. Because the fingertip region contains relatively smaller vascular structures, the light from a pulse oximeter sensor will scatter through the tissue to probe the microvasculature **26**, such as arterioles and capillaries, more uniformly, since the light fully penetrates these vessels. It is believed that this manner in which the light probes the more uniform tissue results in a more linear relationship between the modulating, i.e., cardiac-induced time-varying, optical density of the tissue and the underlying arterial blood oxygen saturation. As a result, the collected light presumably correlates better with the characteristics of the blood that the pulse oximeter is attempting to measure, since the collected light is not as adversely affected by strongly light-absorbing or scattering structures, such as bones, tendons, ligaments, and larger blood vessels.

[0042] Keeping in mind the preceding points, the following exemplary sensor designs are provided as examples of sensors that increase the amount of light collected by a sensor **10** while reducing or eliminating outside light and/or light modulated by dynamic anatomic structures. It should be appreciated that a sensor **10** according to the present teachings may be adapted for use on any digit, and may also be adapted for use on a forehead, earlobe, or other sensor site. For example, a sensor **10** may be a clip-style sensor, appropriate for a patient earlobe or digit. Alternatively, a sensor **10** may be a bandage-style or wrap-style sensor for use on a digit or forehead.

[0043] In accordance with exemplary embodiments, a sensor **10**A having an emitter **28** and detector **30** is provided that is configured to selectively absorb light in the region of a digit that corresponds to relatively large vascular or dynamic structures. FIGS. **2**A through **2**E illustrate an exemplary pulse oximetry sensor **10**A of this type. The sensor **10**A includes regions that differ in the manner in which they reflect and/or absorb light from the emitter **28**. More specifically, FIG. **2**A illustrates a sensor **10**A having on a tissue-contacting surface **32** of the sensor body **33** absorptive portions **34** of relatively light absorbing material in the areas of the sensor **10**A configured to be proximate to the large vascular structures when the sensor **10**A is applied to a digit. The sensor **10**A has reflective portions **36** of relatively reflective material on a tissue-contacting surface **32** of the sensor body **33** proximate to the fingertip region when the sensor **10**A is applied to a digit **38**.

[0044] FIG. **2**B shows a top perspective view of a transmission-type clip-style sensor **10**A in the open position. Absorptive portions **34** are disposed on a region of the sensor body that generally will contact patient tissue that is proximate to large vascular structures. A reflective portion **36** is disposed on a region of the sensor body that generally will contact patient tissue that does not contain large vascular structures. An emitter **28** and detector **30** are disposed on the sensor body **33** proximate to the reflective portion **36**. As depicted, the absorptive portions **34** and reflective portion **36** are superficially disposed on respective surfaces of the sensor body **33** in contact with patient tissue. It should be appreciated the sensor body **33** may be configured such that the absorptive portions **34** and reflective portion **36** extend through the sensor body to the opposing surface (not shown).

[0045] FIG. **2**C shows a cross-sectional view of the sensor at a fingertip region (e.g. fingertip region **16** as shown in FIG. **1**), whereby the sensor **10**A is secured to the digit **38** such that the emitter **28** and the detector **30** are on opposing sides of the digit **38**. The reflective portion **36** surrounds the digit **38** at a region containing microvasculature **40**. FIG. **2**D shows a cross-sectional view of the sensor **10**A at a region of the digit **38** proximate to large vascular structures. FIG. **2**E is a perspective view of the sensor **10**A applied to a patient digit **38**. As shown in FIGS. **2**A-**2**E, absorptive portions **34** are disposed on opposing faces of the sensor body **33**. When applied to the digit **38**, absorptive portions **34** substantially surround the digit **38** at a region containing arteries, tendons, ligaments, and bone (e.g. arteries **18**, tendons **20**, ligaments **22**, and bone **24** as shown in FIG. **1**), generically referred to here as relatively larger subcutaneous anatomic structures **42**. Additionally, the absorptive portions **34** correspond to areas of the skin that may crease

in response to flexing of the joint, causing heterogeneity in the surface of the digit in the area covered by the sensor **10**A. Consequently, it is more likely that light detected by the detector **30** has passed through tissue in the fingertip region of the patient's finger as opposed to areas containing large vascular structures. Hence, the collected light presumably correlates better with the characteristics of the blood that the pulse oximeter is attempting to measure, since the collected light is not as adversely affected by relatively large vascular structures in the of the digit **38**.

[**0046**] In certain embodiments, it may be useful to provide an absorptive portion around a perimeter of a sensor to absorb any outside light that might otherwise leak into the sensor. FIG. **3**A depicts a transmission-type bandage sensor **10**B. As shown in FIG. **3**A, the sensor **10**B may also include an absorptive portion **44** on a tissue-contacting surface **48** of the sensor body **50** that extends on either side of the emitter **52** and the detector **54** around the perimeter of the sensor body **50**. The absorptive portion **44** of the sensor body **50** may serve to absorb incidental outside light that might otherwise leak in and cause variability in measurement. A reflective portion **56** surrounds the emitter **52** and the detector **54**. FIG. **3**B shows a cross-sectional view of a transmission-type bandage sensor **10**B applied to a patient digit **58**. When applied to a digit **58**, the absorptive portion **44** is proximate to relatively large vascular structures, and further extends along the sides of the digit along the sides of a fingertip region (e.g. fingertip region **16** as shown in FIG. **1**), in order to prevent light from leaking into the sensor body. FIG. **3**C shows a cross-sectional view of fingertip region of a digit **58**, after application the sensor of FIG. **3**A. The reflective portion **56** is proximate to the region of the digit containing microvasculature. Absorptive portions **44** are shown as meeting on the sides of the digit **58**

[**0047**] In other embodiments, it may be desirable to provide a transitional region of a sensor that is neither strongly absorptive nor strongly reflective. In FIG. **4**A, it can be seen that a sensor **10**C with a tissue-contacting surface **60** of the sensor body **62** includes a transitional zone **64** of intermediate reflective and/or absorptive ability situated between the absorptive portion **66**, and the reflective portion **68**. The transitional zone material that is neither strongly absorptive nor strongly reflective may absorb approximately 30%-49% of the emitted light. For example, a transitional zone may be substantially gray in color. Alternatively, a transitional zone may be transition from an absorptive region by forming a gradient **69** (depicted as two regions which may be sections of the gradient) of black to white as it transitions towards a reflective region, as shown in FIG. **4**B. In another embodiment, a transitional zone may have a pattern **70**, such as a pattern of black and white stripes, as shown in FIG. **4**C.

[**0048**] As discussed above, in certain embodiments, it may be useful to use a reflectance-type pulse oximetry sensor. FIG. **5**A illustrates one wrap-style configuration of a reflectance-type sensor **10**D on a patient's finger **72**. When using reflectance type sensors, it may be useful to block light that may "shunt" directly between the emitter and detector of such a sensor. In one embodiment, the sensor **10**D may be adapted to block light that may shunt directly between the emitter **74** and the detector **76**, i.e., light that does not travel through the blood perfused tissue of the finger **72**. For example, a light shunt may occur when light travels from the emitter **74** to the detector **76** through the sensor body **78**. In certain embodiments, as illustrated in FIG. **5**B, such a light shunt may be addressed by placing an absorptive region **80** on the sensor body **78** between the emitter **74** and the detector **76**. Such an absorptive region **80** would not interfere with the optical path of the signal light, illustrated by wavy arrow **79**, as it passes through the patient's finger **72**

[**0049**] As discussed above, it may be useful to adapt a sensor for use on an earlobe, such as the clip-style sensor **10**E that is illustrated in FIGS. **6**A and **6**B. The sensor **10**E is illustrated as having portions **82** and **84** that are configured to be applied to a patient's earlobe **86**. In this embodiment, the sensor **10**E is configured to operate in transmission mode, so the emitter **88** resides in one portion **82** and the detector **90** resides in the other portion **84**. The sensor **10**E includes a reflective portion **92** and an absorptive portion **94** on the face of each portion **82** and **84** of the clip-style sensor **10**E. In the illustrated embodiment, as shown in FIG. **6**B, the absorptive portion **94** is configured to ring the perimeter of portions **82** and **84** of the sensor **10**E to prevent outside light from leaking into the sensor. In an alternate embodiment (not shown), the sensor **10**E may be configured to operate in reflectance mode, in which case the emitter **88** and the detector **90** would reside in the same portion, **82** or **84**. In either case, the sensor **10**E may be spring loaded so that the sensor **10**E is biased in a closed position about an earlobe **86**, as illustrated.

[**0050**] It should be appreciated that providing a sensor with the ability to selectively reflect light in certain portions and to selectively absorb light in other portions may be accomplished in a number of ways. For example, a tissue-contacting surface of a sensor body may be formed from, coated with, or impregnated with a light absorbing material (e.g absorptive portions **34**, **44**, **66**, **80**, or **94**) in certain regions and a light reflective material (e.g. reflective portions **36**, **56**, **68**, or **92**) in other regions. It should also be appreciated that, as discussed above, a the sensor body may contain light absorbing material and light reflecting material only on a tissue-contacting surface, or, in alternate embodiments, the sensor body may be constructed entirely from light absorbing material and light reflecting material in appropriate regions. It should be appreciated that the light absorbing material may be adapted to absorb light at a particular wavelength. For example, a light absorbing material may absorb at least about 50% of one or more wavelengths of light from the emitter. A light absorbing material may also absorb at least about 90% or at least 95% of one or more wavelengths of visible light and near-infrared light. Examples of light absorbing materials may include, but are not limited to, black or dark pigment, black or dark woven fabric or cloth, and infrared blockers. A light reflecting material may also reflect at least about 80% of one or more wavelengths of visible light or near-infrared light. Examples of light reflecting materials may include, but are not limited to, white or substantially light pigment, white or light woven fabric or cloth, and metals or metallic foils. Another example of a light reflective material is light reflecting ceramic, such as Accuflect, available from Accuratus.

[**0051**] In certain embodiments, it may be advantageous to provide light absorbing portions and light reflecting portions from a material that varies in its ability to absorb or reflect light in response to certain stimuli. For example, Thermex temperature indicating paper (Sensor Product, Inc., East Hanover, N.J.) changes color in response to variations in

temperature. Upon exposure to heat, Thermex paper changes to a blue color. The surface of a patient's tissue corresponding to relatively large subcutaneous structures, such as veins and arteries, may be generally warmer due to an increased volume of blood flow as compared to other tissue sites. Hence, a sensor having Thermex paper on a tissue-contacting surface may be blue, and thus more absorptive, in areas of the sensor corresponding to subcutaneous veins and arteries. A sensor that includes such a temperature-sensitive material incorporated into the sensor body may be useful for improving the signal to noise ratio if a patient experiences low perfusion, such as low perfusion associated with cold temperatures. For example, the temperature-sensitive material may have increased reflectivity in relatively cold temperatures, which may serve to intensify a weaker signal typically associated with low perfusion. Cold temperatures may be temperatures lower than room temperature, or lower than 20-25° C. In a room temperature environment, the temperature-sensitive material may return to a default level of reflectivity. In certain embodiments, the temperature-sensitive material may turn silver upon exposure to relatively cold temperatures and may be white or light grey at room temperature.

[0052] In another embodiment, light absorbing portions and light reflecting portions of a tissue-contacting surface of a sensor body are made from a pressure-sensitive material, such as PressureX® (Sensor Product, Inc., East Hanover, N.J.), which increases in color intensity in response to increased pressure. As tissue under pressure may become exsanguinated, and thus may shunt light, it may be advantageous to absorb light in areas of the tissue subjected to pressure. In an alternative embodiment, shown in FIGS. **7**A and **7**B, a sensor **10**F may include a pressure-sensitive material **129** that may trigger a color darkening in areas of the sensor body **124** that correspond to areas of the tissue where blood pools after the application of pressure. For example, a pressing down motion of the finger **120** against a rigid object **122** may lead to a pooling of the blood and darkening of an upper portion **127** of the nail bed, while the lower portion **126** of the nail bed experiences no change in color. The color change of the color-changing material **128** may be throughout the sensor body **124**, as depicted, or may occur on the tissue-contacting surface of the sensor body **124**. The color-changing material **128** is pressure-sensitive, and darkens upon application of pressure. Thus, although the finger **120** may exhibit a change of blood pooling as a function of pressure, the effects of such change on the transmitted light signal may be mitigated by increasing the absorption of light surrounding the pooled blood. Generally, areas of the tissue that are unaffected by an increase in pressure may be surrounded by reflective or intermediately reflective portions of the sensor body **124**. The color-changing material may include Pressurex® film, available from Sensor Products Inc. (East Hanover, N.J.), which increases in red color intensity in relation to the amount of force applied.

[0053] A sensor, illustrated generically as a sensor **10**, may be used in conjunction with a pulse oximetry monitor **96**, as illustrated in FIG. **8**. It should be appreciated that the cable **98** of the sensor **10** may be coupled to the monitor **96** or it may be coupled to a transmission device (not shown) to facilitate wireless transmission between the sensor **10** and the monitor **96**. The monitor **96** may be any suitable pulse oximeter, such as those available from Nellcor Puritan Bennett Inc. Furthermore, to upgrade conventional pulse oximetry provided by the monitor **96** to provide additional functions, the monitor **96** may be coupled to a multi-parameter patient monitor **100** via a cable **102** connected to a sensor input port or via a cable **104** connected to a digital communication port.

[0054] The sensor **10** includes an emitter **106** and a detector **108** that may be of any suitable type. For example, the emitter **106** may be one or more light emitting diodes adapted to transmit one or more wavelengths of light in the red to infrared range, and the detector **108** may one or more photodetectors selected to receive light in the range or ranges emitted from the emitter **106**. Alternatively, an emitter may also be a laser diode or a vertical cavity surface emitting laser (VCSEL). An emitter and detector may also include optical fiber sensing elements. An emitter **106** may include a broadband or "white light" source, in which case the detector could include any of a variety of elements for selecting specific wavelengths, such as reflective or refractive elements or interferometers. These kinds of emitters **106** and/or detectors **108** would typically be coupled to the rigid or rigidified sensor via fiber optics. Alternatively, a sensor **10** may sense light detected from the tissue is at a different wavelength from the light emitted into the tissue. Such sensors may be adapted to sense fluorescence, phosphorescence, Raman scattering, Rayleigh scattering and multi-photon events or photoacoustic effects. For pulse oximetry applications using either transmission or reflectance type sensors the oxygen saturation of the patient's arterial blood may be determined using two or more wavelengths of light, most commonly red and near infrared wavelengths. Similarly, in other applications, a tissue water fraction (or other body fluid related metric) or a concentration of one or more biochemical components in an aqueous environment may be measured using two or more wavelengths of light, most commonly near infrared wavelengths between about 1,000 nm to about 2,500 nm. It should be understood that, as used herein, the term "light" may refer to one or more of ultrasound, radio, microwave, millimeter wave, infrared, visible, ultraviolet, gamma ray or X-ray electromagnetic radiation, and may also include any wavelength within the radio, microwave, infrared, visible, ultraviolet, or X-ray spectra.

[0055] The emitter **106** and the detector **108** may be disposed on a sensor body **110**, which may be made of any suitable material, such as plastic, foam, woven material, or paper. Alternatively, the emitter **106** and the detector **108** may be remotely located and optically coupled to the sensor **10** using optical fibers. In the depicted embodiments, the sensor **10** is coupled to a cable **98** that is responsible for transmitting electrical and/or optical signals to and from the emitter **106** and detector **108** of the sensor **10**. The cable **78** may be permanently coupled to the sensor **10**, or it may be removably coupled to the sensor **10**—the latter alternative being more useful and cost efficient in situations where the sensor **10** is disposable.

[0056] The sensor **10** may be a "transmission type" sensor. Transmission type sensors include an emitter **106** and detector **108** that are typically placed on opposing sides of the sensor site. If the sensor site is a fingertip, for example, the sensor **10** is positioned over the patient's fingertip such that the emitter **106** and detector **108** lie on either side of the patient's nail bed. In other words, the sensor **10** is positioned

so that the emitter **106** is located on the patient's fingernail and the detector **108** is located 180° opposite the emitter **106** on the patient's finger pad. During operation, the emitter **106** shines one or more wavelengths of light through the patient's fingertip and the light received by the detector **108** is processed to determine various physiological characteristics of the patient. In each of the embodiments discussed herein, it should be understood that the locations of the emitter **106** and the detector **108** may be exchanged. For example, the detector **108** may be located at the top of the finger and the emitter **106** may be located underneath the finger. In either arrangement, the sensor **10** will perform in substantially the same manner.

[**0057**] Reflectance type sensors also operate by emitting light into the tissue and detecting the light that is transmitted and scattered by the tissue. However, reflectance type sensors include an emitter **106** and detector **108** that are typically placed on the same side of the sensor site. For example, a reflectance type sensor may be placed on a patient's fingertip or forehead such that the emitter **106** and detector **108** lie side-by-side. Reflectance type sensors detect light photons that are scattered back to the detector **108**. A sensor **10** may also be a "transflectance" sensor, such as a sensor that may subtend a portion of a baby's heel.

[**0058**] While the invention may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Indeed, the present techniques may not only be applied to measurements of blood oxygen saturation, but these techniques may also be utilized for the measurement and/or analysis of other blood and/or tissue constituents using principles of pulse oximetry. For example, using the same, different, or additional wavelengths, the present techniques may be utilized for the measurement and/or analysis of carboxyhemoglobin, methemoglobin, total hemoglobin, fractional hemoglobin, intravascular dyes, and/or water content. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the following appended claims.

What is claimed is:

1. A sensor comprising:

a sensor body;

an emitter disposed on the sensor body, wherein the emitter is adapted to transmit light into tissue;

a detector disposed on the sensor body, wherein the detector is adapted to detect the light;

a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and

a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

2. The sensor, as set forth in claim 1, wherein the sensor comprises at least one of a pulse oximetry sensor or a sensor for measuring a water fraction.

3. The sensor, as set forth in claim 1, wherein the emitter comprises at least one light emitting diode.

4. The sensor, as set forth in claim 1, wherein the detector comprises at least one photodetector.

5. The sensor, as set forth in claim 1, wherein the emitter and detector are adapted to operate in a reflectance mode, and wherein the light absorbing material is disposed in a region between the emitter and the detector.

6. The sensor, as set forth in claim 1, wherein the light absorbing material is disposed around a perimeter of the tissue-contacting surface of the sensor body.

7. The sensor, as set forth in claim 1, wherein the light reflecting material comprises a substantially white material.

8. The sensor, as set forth in claim 1, wherein the light reflecting material comprises a metal.

9. The sensor, as set forth in claim 1, wherein the light absorbing material comprises a substantially dark material.

10. The sensor, as set forth in claim 1, wherein the light absorbing material comprises a temperature-sensitive material.

11. The sensor, as set forth in claim 1, wherein the light absorbing material comprises a pressure-sensitive material.

12. The sensor, as set forth in claim 1, comprising a material of intermediate absorptive and reflective ability disposed between the light reflecting material and the light absorbing material.

13. The sensor, as set forth in claim 1, wherein the sensor comprises a clip-style sensor body on which the emitter and detector are disposed.

14. The sensor, as set forth in claim 1, wherein the sensor comprises a bandage-style sensor body on which the emitter and detector are disposed.

15. The sensor, as set forth in claim 1, wherein the sensor comprises a wrap-style sensor body on which the emitter and detector are disposed.

16. The sensor, as set forth in claim 1, wherein the sensor body is adapted for use on a patient's forehead.

17. A sensor comprising:

an emitter adapted to deliver light into a tissue, wherein the tissue comprises relatively large subcutaneous anatomic structures and relatively small subcutaneous anatomic structures;

a detector adapted to detect the light; and

a sensor body on which the emitter and detector are disposed, the sensor body having a tissue-contacting surface, wherein the tissue-contacting surface is adapted to absorb light proximate to the relatively large subcutaneous anatomic structures and to reflect light proximate to the relatively small subcutaneous anatomic structures.

18. The sensor, as set forth in claim 17, wherein the sensor comprises at least one of a pulse oximetry sensor or a sensor for measuring a water fraction.

19. The sensor, as set forth in claim 17, wherein the emitter comprises at least one light emitting diode.

20. The sensor, as set forth in claim 17, wherein the detector comprises at least one photodetector.

21. The sensor, as set forth in claim 17, wherein the relatively large subcutaneous anatomic structures comprise arteries, and wherein the relatively small subcutaneous anatomic structures comprise arterioles or capillaries.

22. The sensor, as set forth in claim 17, wherein the relatively large subcutaneous anatomic structures comprise dynamic structures.

23. The sensor, as set forth in claim 22, wherein the dynamic structures comprise tendons or ligaments.

24. The sensor, as set forth in claim 17, wherein the emitter and detector are adapted to operate in a reflectance mode, and wherein the light absorbing material is disposed in a region between the emitter and the detector.

25. The sensor, as set forth in claim 17, wherein a first portion of the tissue-contacting surface comprises a substantially white material that is adapted to reflect light.

26. The sensor, as set forth in claim 17, wherein a second portion of the tissue-contacting surface comprises a substantially dark material that is adapted to absorb light.

27. The sensor, as set forth in claim 17, wherein a second portion of the tissue-contacting surface comprises a temperature-sensitive material.

28. The sensor, as set forth in claim 17, wherein a second portion of the tissue-contacting surface comprises a pressure-sensitive material.

29. The sensor, as set forth in claim 17, comprising a clip-style sensor body on which the emitter and detector are disposed.

30. The sensor, as set forth in claim 17, wherein the sensor comprises a bandage-style sensor body on which the emitter and detector are disposed.

31. The sensor, as set forth in claim 17, wherein the sensor comprises a wrap-style sensor body on which the emitter and detector are disposed.

32. A pulse oximetry system comprising:

a pulse oximetry monitor; and

a pulse oximetry sensor adapted to be operatively coupled to the monitor, the sensor comprising:

a sensor body;

an emitter disposed on the sensor body, wherein the emitter is adapted to transmit light into tissue;

a detector disposed on the sensor body, wherein the detector is adapted to detect the light;

a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and

a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

33. The pulse oximetry system, as set forth in claim 32, wherein the emitter comprises at least one light emitting diode.

34. The pulse oximetry system, as set forth in claim 32, wherein the detector comprises at least one photodetector.

35. The pulse oximetry system, as set forth in claim 32, wherein the emitter and detector are adapted to operate in a reflectance mode, and wherein the light absorbing material is disposed in a region between the emitter and the detector.

36. The pulse oximetry system, as set forth in claim 32, wherein the light absorbing material is disposed around a perimeter of the tissue-contacting surface of the sensor body.

37. The pulse oximetry system, as set forth in claim 32, wherein the light reflecting material comprises a substantially white material.

38. The pulse oximetry system, as set forth in claim 32, wherein the light reflecting material comprises a metal.

39. The pulse oximetry system, as set forth in claim 32, wherein the light absorbing material comprises a substantially dark material.

40. The pulse oximetry system, as set forth in claim 32, wherein the light absorbing material comprises a temperature-sensitive material.

41. The pulse oximetry system, as set forth in claim 32, wherein the light absorbing material comprises a pressure-sensitive material.

42. The pulse oximetry system, as set forth in claim 32, comprising a material of intermediate absorptive and reflective ability disposed between the light reflecting material and the light absorbing material.

43. The pulse oximetry system, as set forth in claim 32, wherein the sensor comprises a clip-style sensor body on which the emitter and detector are disposed.

44. The pulse oximetry system, as set forth in claim 32, wherein the sensor comprises a bandage-style sensor body on which the emitter and detector are disposed.

45. The pulse oximetry system, as set forth in claim 32, wherein the sensor comprises a wrap-style sensor body on which the emitter and detector are disposed.

46. The pulse oximetry system, as set forth in claim 32, wherein the sensor comprises a sensor body on which the emitter and detector are disposed, wherein the sensor body is adapted for use on a patient's forehead.

47. A method comprising:

delivering light through a patient's tissue;

absorbing the light with an absorptive material proximate to relatively large vascular structures; and

reflecting the light with a reflective material proximate to relatively small vascular structures.

48. The method, as set forth in claim 47, wherein absorbing the light proximate to relatively large vascular structures comprises absorbing the light proximate to veins or arteries and wherein reflecting the light proximate to relatively small vascular structures comprises reflecting the light proximate to arterioles or capillaries.

49. The method, as set forth in claim 47, wherein absorbing the light proximate to relatively large vascular structures comprises absorbing the light proximate to tendons or ligaments.

50. The method, as set forth in claim 47, wherein reflecting the light with a reflective material light comprises reflecting the light with a substantially white material.

51. The method, as set forth in claim 47, wherein the patient's tissue comprises a finger, and wherein reflecting the light proximate to relatively small vascular structures comprises reflecting the light proximate to the fingertip region of the finger.

52. The method, as set forth in claim 47, wherein absorbing the light with an absorbing material comprises absorbing the light with a substantially dark pigmented material.

53. The method, as set forth in claim 47, further comprising absorbing the light from outside sources.

54. A method of manufacturing a sensor, the method comprising:

providing a sensor body;

providing an emitter adapted to transmit light into tissue;

providing a detector adapted to detect the light;

providing a light reflecting material disposed proximate to the emitter and detector on a first portion of a tissue-contacting surface of the sensor body; and

providing a light absorbing material disposed on a second portion of the tissue-contacting surface of the sensor body.

55. The method, as set forth in claim 54, comprising:

disposing the emitter and the detector on a clip-style sensor body.

56. The method, as set forth in claim 54, comprising:

disposing the emitter and the detector on a on a wrap-style sensor body.

57. The method, as set forth in claim 54, comprising:

disposing the emitter and the detector on a on a bandage-style sensor body.

58. A method comprising:

delivering light through a patient's tissue; and

reflecting the light with a temperature-sensitive material adapted to have increased reflectivity when exposed to relatively low temperatures.

59. The method, as set forth in claim 58, wherein the temperature-sensitive material has increased reflectivity at temperatures lower that 20° C.

60. A method comprising:

delivering light through a patient's tissue; and

absorbing the light with a material adapted to have increased absorption after receiving a feedback related to pressure.

61. The method, as set forth in claim 60, wherein the increased absorption comprises an increase in color intensity.

* * * * *

专利名称(译)	医疗传感器及其使用技术		
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[标]申请(专利权)人(译)	HOARAU CARINE		
申请(专利权)人(译)	HOARAU CARINE		
当前申请(专利权)人(译)	COVIDIEN LP		
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摘要(译)

传感器可以适于考虑导致传感器测量不规则的因素。传感器可以选择性地吸收来自外部光源的光。传感器可以选择性地吸收具有相对大的皮下解剖结构（例如大血管）的组织区域附近的光，并选择性地反射相对没有大血管或其他结构的组织区域附近的光。该传感器适于减少大的皮下解剖结构和外部光对脉搏血氧仪或其他分光光度技术的测量的影响。