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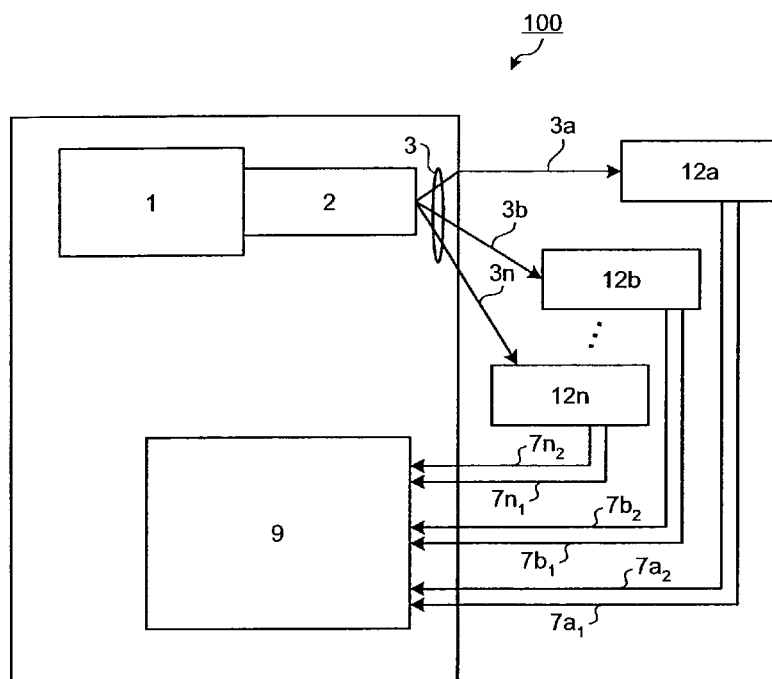
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(54) Title: METHOD AND APPARATUS FOR DETECTING ABNORMAL LIVING TISSUE

FIG.1



(57) Abstract: Light scattering and absorption techniques for the detection of possible abnormal living tissue. Apparatus and methods for utilizing multiple blood content detection sensors and/or contact sensors (12a to 12n) for beneficially providing data to better guide an endoscope or colonoscope to locate abnormal tissue, tumors, or tissues that precede the development of such lesions or tumors.



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DESCRIPTION

METHOD AND APPARATUS FOR DETECTING
ABNORMAL LIVING TISSUE

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TECHNICAL FIELD

The present invention relates generally to the utilization of light scattering and absorption techniques to detect possible abnormal living tissue. More specifically, the invention relates to an apparatus and method for utilizing multiple blood content sensors to guide a probe or endoscope to more advantageously detect abnormal tissue within a living body.

15 BACKGROUND ART

Scientists have discovered that a detectible increase in the blood content of superficial mucous membrane occurs proximate cancerous and precancerous lesions in the colon relative to the blood content of healthy tissue as described in, for example, R. K. Wali, H. K. Roy, Y. L. Kim, Y. Liu, J. L. Koetsier, D. P. Kunte, M. J. Goldberg, V. Turzhitsky and V. Backman, *Increased Microvascular Blood Content is an Early Event in Colon Carcinogenesis*, Gut Vol. 54, pp 654-660 (2005), which is incorporated by reference herein. This phenomenon is referred to as early increase in blood supply (EIBS).

Relying on this phenomenon, it has been discovered that it is possible to predict an area of potential abnormality based on early increase in blood supply (EIBS) in the area of abnormality. Further, it has been discovered, that by using a probe applying collimated light to an area of interest, and detecting the amount of absorbed and reflected light it is possible to provide

information to a clinician to guide an endoscope to detect a possible abnormality in vivo without an invasive procedure. Such techniques have been described for example in U.S. Patent Application Serial No. 11/937,133 filed on
5 November 8, 2007, entitled "Blood Content Detecting Capsule", assigned to the assignee of the present invention, which is incorporated by reference herein.

However, particular types of optical blood content sensors require contact between the detection sensors and
10 the mucosa of the underlying tissue for accurate detection of blood content. When a gap is present between these detection sensor types and the tissue of interest, a reduced amplitude of light interacted with the illuminated tissue will be received by the sensor and may be of little
15 value in detecting abnormalities. Accordingly, in order to improve the likelihood that an abnormal area of tissue will be detected, it is important to ensure that the measurement sensor remains in contact with the tissue under investigation. Prior contemplated configurations have not
20 addressed this issue. As a result, areas of abnormality may be missed or not detected with such systems.

DISCLOSURE OF INVENTION

The present invention advantageously increases data
25 accuracy from detection sensors based on systems and methods that increase the desired sensor contact and/or identify collected data during the instances when such contact with the tissue under investigation occurs. This increase is accomplished in the present invention by
30 employing, for example, contact detectors associated with the blood content detectors as part of a probe for insertion into a cavity of a living body, such as an endoscope or endoscopic sheath, and/or employing multiple

blood content detectors for beneficially providing data to better guide an endoscope, colonoscope, or other probe, to locate abnormal tissue, tumors, or tissues that precede the development of such lesions or tumors.

5 In one aspect of the invention, contact detectors are employed with optical blood content detectors that provide more accurate blood content data when such sensors are in direct contact with the subject tissue. The contact detectors beneficially indicate when such sensors are in
10 contact with tissue and correspondingly indicate that the generated blood content information signals at that instance are more likely to have improved accuracy than during instances when such sensors are not in contact with tissue. Further, the contact sensors may generate signals
15 or power to the blood content sensors such that the illuminators and collectors within the blood content sensors are energized or powered on only during periods when the contact sensors are in contact with the tissue mucosa.

20 In another aspect of the invention, improved blood content detection is achieved by the use of multiple blood content sensors advantageously positioned in or on the surface of the probe or endoscope. The detection and locating of abnormal tissue is enhanced based on the blood
25 detection data from the multiple sensors. It is particularly advantageous to use substantially simultaneously generated data from such sensors which can be statistically processed or otherwise to better and more accurately provide information for use in guiding the probe
30 or endoscope.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram of an exemplary system in

accordance with one aspect of the invention utilizing multiple blood content detector sensors;

Fig. 2 is an exemplary diagram of a system in accordance with the invention utilizing at least three
5 optical blood content detectors;

Fig. 3 is an exemplary embodiment of an optical blood content sensor useable with the present invention;

Fig. 4 illustrates an alternative exemplary embodiment of the optical blood content sensor useable with the
10 present invention;

Fig. 5 illustrates an exemplary embodiment of a polarizer useable with the present invention;

Fig. 6 illustrates a representative block diagram of a exemplary processor useable with the present invention;

15 Fig. 7 illustrates an exemplary embodiment of a first endoscope configuration utilizing the present invention;

Fig. 8 illustrates an exemplary embodiment of a second endoscope configuration utilizing the present invention;

Fig. 9 illustrates an exemplary embodiment of a third
20 endoscope configuration utilizing the present invention;

Fig. 10 illustrates an exemplary embodiment of a fourth endoscope configuration utilizing the present invention;

Fig. 11 illustrates an embodiment of an exemplary
25 portion of an endoscope utilizing the present invention;

Fig. 12 illustrates an exemplary endoscope and sheath configuration utilizing the present invention;

Fig. 13 illustrates a second exemplary endoscope and sheath configuration utilizing the present invention; and

30 Fig. 14 illustrates an exemplary light fiber bundle useable with the present invention.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

The present invention relates generally to improvements in blood flow detection due to the improved contact and possibility of improved contact between the various detection sensors and the living tissue mucosa under investigation.

Referring to the drawings, like numbers indicate like parts throughout the views as used in the description herein, the meaning of "a" "an," and "the" includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein, the meaning of "in" includes both "in" and "on" unless the context clearly dictates otherwise. Also, as used in the description herein, the meanings of "and" and "or" include both the conjunctive and disjunctive and may be used interchangeably unless the context clearly dictates otherwise.

Figure 1 depicts a schematic diagram of blood detection system 100 containing three detection sensors.

However, as will be appreciated by those skilled in the art, the number of detection sensors or windows is not limited to three. Light source 1 is in contact with single fiber rod 2. The light emanating from light source 1 is focused on the end face of single fiber rod 2. Due to the internal configuration of single fiber rod 2, the beams of light are repeatedly reflected off the inner walls of the single fiber's core resulting in a light source of uniform intensity, i.e., collimated light.

Single fiber rod 2 is further in contact with fiber bundle 3. Fiber bundle 3 is made up of the independent illumination fibers 3a to 3n. The transmitted light is communicated on the respective illumination fibers 3a to 3n to measurement units 12a to 12n. In each measurement unit 12a to 12n, the transmitted light passes through a series

of polarizers, lenses and prisms before exiting. The exiting light illuminates the areas of living tissue under examination. Interacted light from the illuminated tissue mucosa is correspondingly detected by the measurement units 12a to 12n. In each measurement unit 12a to 12n, received interacted light passes through the measurement unit prism, lens, and polarizer as seen in Fig. 3 and is transmitted via one of corresponding collection fibers 7a₁ and 7a₂ to collection fibers 7n₁ and 7n₂ back to spectroscope 9 for analysis.

Fig. 2 depicts a block diagram of an exemplary configuration of the system 100 of Fig. 1. Referring to Fig. 2, the exemplary system seen in Fig. 2 contains light source 1 for generating light of sufficient intensity and frequency to illuminate the tissue under investigation so as to ascertain the blood content within the illuminated tissue mucosa. Single fiber rod 2 may be, for example, a fiber optic conductor containing an optical core or similarly designed to equalize and collimate the light emitted from light source 1 to ensure uniform intensity and frequency of the light entering the illumination fibers. Illumination fibers 3a to 3n are individual optical transmission lines that convey the light from single fiber rod 2 to the measurement units 12a to 12n. Light source 1 may be, for example, a xenon lamp, a halogen, lamp, an LED, or any other light source capable of providing a light of adequate intensity and frequency.

In addition to light source 1, each of measurement units 12a to 12n further includes polarizer 4, lens 5, prism 6 and measurement window 15. Polarizer 4 is a linear polarizer designed to ensue that the transmitted light waves are aligned in a linear fashion, i.e., horizontally or vertically. Lens 5 is an optical lens that conveys

light waves in a parallel orientation. Light waves exit lens 5 in a generally parallel direction and strike the surface of prism 6. Prism 6 is an optical prism with a coated reflective surface. Light waves striking the surface of prism 6 are orthogonally reflected through measurement window 15 into the underlying living tissue. Measurement window 15 is an optical window typically, glass or other transmissive material in the detection wavelength range, that does not adversely interact with or attenuate transmitted or reflected light waves.

Light that interacts with or is reflected off of the underlying tissue is conveyed through measurement window 15 back through prism 6, lens 5 and polarizer 4 onto corresponding collection fibers $7a_1$ and $7a_2$ to collection fibers $7n_1$ and $7n_2$. Collection fibers $7a_1$ and $7a_2$ to collection fibers $7n_1$ and $7n_2$ each convey the reflected light back to spectroscopy processing unit (spectroscopy) 9. It should be noted that as a result of the placement of collection fibers $7a_1$ and $7a_2$ to collection fibers $7n_1$ and $7n_2$ with respect to polarizer 4, collection fibers $7a_1$ and $7a_2$ to collection fibers $7n_1$ and $7n_2$ each convey either horizontally or vertically polarized light waves back to spectroscopy 9. Each collection fibers $7a_1$ and $7a_2$ to collection fibers $7n_1$ and $7n_2$ enter spectroscopy 9 at slot 8 and convey there respective blood content data to the data receiver located in spectroscopy 9.

An exemplary detailed operation of the system 100 is now described with respect to a single measurement unit 12a with regard to Figs. 1 and 2. However, it shall be understood that this operation may be carried out simultaneously or otherwise by the measurement units 12a to 12n depicted in Fig. 1. Referring to Fig. 2, light emitted from light source 1 passes through single fiber rod 2 to

reach the individual illumination fibers 3a. As light
emanating from light source 1 passes through single fiber
rod 2, the rod 2 equalizes and collimates the intensity and
wavelength of the light emitted from light source 1 and
5 guides the equalized and collimated light into the
individual illumination fibers 3a.

Once the collimated light enters a single fiber 3a it
is communicated to the individual measurement unit 12a.
Measurement unit 12a is comprised of an illuminator fiber,
10 a polarizer 4, a lens 5, a prism 6, and measurement window
15. The transmitted light exits the measurement unit 12a
via measurement window 15 and illuminates a region of
tissue within the living body.

Certain light interacted with the illuminated tissue
15 is reflected back and collected by the corresponding
measurement unit 12a through its corresponding measurement
window 15 and passes back through prism 6, lens 5, and
polarizer 4 to the collection fibers 7a₁ and 7a₂.

Measurement unit 12a has two optical receiving or
20 collection fibers 7a₁ and 7a₂ that direct the received or
collected interacted light to pass-through slit 8 in
spectroscope 9 for analysis. As an alternative to the
collection fibers 7a₁ and 7a₂ of measurement units 12a,
directly entering spectroscope processing unit 9 via a slit
25 8, a lens may be provided between collection fibers 7a₁ and
7a₂ and the slit 8 for an improved and more efficient light
transmission. An exemplary configuration for such a lens
is cylindrical. However, alternative shapes or other
configurations may be employed in accordance with the
30 invention.

As depicted in and later described with respect to Fig.
14, individual fibers 3a to 3n may have a diameter as small
as, for example, 100 μ m, resulting in a fiber bundle 3 in

Fig. 1 as small as 1mm. In this example, the diameter of a single fiber should likewise be of sufficient size to receive light emitted from light source 1 to produce light emitted from the various windows of a desired intensity.

5 In order to maintain each of the illumination fibers 3a to 3n of the fiber bundle 3 of sufficiently small size, each individual fiber end may have a tapered shape and the area of the core at the end face close to the light source is greater than that of the other end face close to the
10 respective single measurement unit 12a to 12n.

Fig. 3 depicts an exemplary configuration of measurement unit 12a. Other measurement units 12b to 12n may contain similar optical configurations. Referring to Fig. 3, measurement unit 12a contains illumination fibers 3,
15 collection fibers 7a₁ and 7a₂, linear polarizer 41 and 42, lens 5, prism 6, and measurement window 15.

In operation of the measurement unit of Fig. 3, light emitted from light source 1 (shown in Figs. 1 and 2) travels through illumination fiber 3a and passes through
20 linear polarizer 4. Polarizer 4 is comprised of two linear polarizers 41 and 42. Linear polarizer 41 may be oriented for polarization in a horizontal direction and linear polarizer 42 may be oriented for polarization in a perpendicular direction relative to the linear polarization
25 produced by polarizer 41. The transmitted linear polarized light beams 301 pass through linear polarizer 41 and enter lens 5. Due to the shape of lens 5, the light beams 301 exit the lens parallel to each other before being refracted by prism 6. The light is reflected off prism surface 21
30 and is conveyed through measurement window 15 and illuminates the target tissue mucosa 17. Prism surface 21 may contain, for example, a vapor-deposited coating of silver, aluminum, or other material in order to produce the

preferred reflectivity.

In the instance when measurement window 15 is in contact with the target tissue mucosa 17, the transmitted light is interacted with by the tissue mucosa 17. Portions of the interacted light 302 and 303 reenter prism 6 and again refracted off of the prism surface 21 and back through lens 5. The interacted light 302 and 303 passes through lens 5 and into polarizer 4, passing through either linear polarizer 41 or linear polarizer 42. After passing through the respective polarizer 41 or 42, the light 302 and 303 enters the respective collection fibers 7a₁ and 7a₂ depending on which linear polarizer 41 or 42, the light has passed through.

Because of this lens, prism, and polarizer configuration, only light that interacts with tissue mucosa 17 at specific angles enters the collectors or collection fibers 7a₁ and 7a₂. More specifically, light entering collector or collection fiber 7a₁ is oriented at the same polarization direction as the transmitted light, since both transmitted and reflected light are passing through linear polarizer 41. In contrast, the light entering collector or receiving fiber 7a₂ is always perpendicular to the transmitted light since it passes through linear polarizer 42 which is oriented in a perpendicular direction relative to that of linear polarizer 41.

Fig. 4 depicts an alternative embodiment of the polarizer, lens, prism combination of measurement unit 12a of Fig. 3. In Fig. 4, the lens 5 and the prism 6 of Fig. 3 are integrated into a single lens prism unit 19. The integration of the two components decreases the number of sides the individual lens and prism combination has, thereby reducing the amount of stray light generated by reflection on the sides and accordingly, the stray light

that reaches the light receiving fibers. A further advantage of utilizing a single lens prism combination may be realized due to the reduced number of optical components required, the reduced cost in manufacturing and assembly.

- 5 In another embodiment, the flat reflection surface 21 of the prism may be spherical or ellipsoidal so as to achieve the same effect as the lens itself, thereby further reducing the number of components and manufacturing costs.

In operation, the measurement unit of Fig. 4 operates
10 in a similar manner to that described with respect to Fig. 3. Light emitted from light source 1 travels through illumination fiber 3a and passes through linear polarizer 41. Linear polarizer 41 may be oriented for polarization in a horizontal direction and linear polarizer 42 may be
15 oriented for polarization in a perpendicular direction relative to the linear polarization produced by polarizer 41. The transmitted linear polarized light beams 301 pass through linear polarizer 41 and enter lens prism unit 19. Due to the shape of the lens portion of lens prism unit 19,
20 light beams 301 are oriented parallel to each other before being refracted by surface 21 of lens prism unit 19. The light is reflected off surface 21 and is conveyed through measurement window 15 and illuminates the target tissue mucosa 17. Prism surface 21 may contain, for example, a
25 vapor-deposited coating of silver, aluminum, or other material in order to produce the preferred reflectivity.

In the instance when measurement window 15 is in contact with the target tissue mucosa 17, the transmitted light interacts with the tissue mucosa 17. Portions of the
30 interacted light 302 and 303 reenter lens prism unit 19 and are again refracted off of surface 21 and back through the lens portion of lens prism unit 19. The light 302 and 303 pass through lens prism unit 19 and into either linear

polarizer 41 or linear polarizer 42. After passing through the respective polarizer 41 or 42, the light enters the respective collectors or collection fibers 7a₁ or 7a₂, accordingly.

5 Because of the configuration of lens prism unit 19 and polarizers 41 and 42 only light that interacts with tissue mucosa 17 at specific angles enters the collectors or collection fibers 7a₁ and 7a₂. More specifically, light entering collection fiber 7a₁ is oriented at the same
10 polarization direction as the transmitted light, since both transmitted and reflected light are passing through linear polarizer 41. In contrast, the light entering receiving fiber 7a₂ is always perpendicular to the transmitted light since it passes through linear polarizer 42 which is
15 oriented in a perpendicular direction relative to that of linear polarizer 41.

Fig. 5 depicts an exemplary configuration of the linear polarizer 4 of Figs. 2 to 4. Fig. 5 illustrates that the linear polarizers 41 and 42 of Figs. 2 through 4
20 may be composed of a glass substrate 51 with a polymer material 52 bonded to a first side and an aluminum wire vapor-deposited on an opposite, second side 53. The polarizing surfaces i.e., polymer side or aluminum-wire side, may preferably be bonded on the surface of the light
25 receiving fibers. Due to the thermostability of the polarizing surface, the surface is preferably formed from an aluminum wire, such as, for example, the aluminum-wire grid polarizing filter manufactured by Edmunds Optics Inc. of Barnington, New Jersey.

30 In the present invention, calculations are computed based on the detection of interacted light received by each individual measurement unit. Fig. 6 shows a schematic diagram of an exemplary spectroscope 9. In Fig. 6, the

spectroscope 9 includes a spectrometer 620, a data preprocessor 621, a blood content estimator 622 (or blood content calculator), a data validator 623, a power supply 624, an optional display or indicator 625 and a data
 5 comparator 626. Spectrometer 620 receives information from the collection fibers 7a₁ and 7a₂ to information from the collection fibers 7n₁ and 7n₂.

In operation, the data received by the spectrometer 620 of the spectroscope 9 in Fig. 6 is provided to a data
 10 preprocessor 621. The data preprocessor 621 executes, for example, a data correction algorithm, such as white correction represented in the following equation (1).

$$(1) \quad \Delta I_c(\lambda) = \frac{\Delta I(\lambda)}{\Delta I_w(\lambda)} = \frac{I_{\Pi}(\lambda) - I_{\perp}(\lambda)}{I_{w\Pi}(\lambda) + I_{w\perp}(\lambda)}$$

Where the symbols Π and $\perp$ used in the numerator and
 15 denominator of equation (1) represent the spectrum of horizontally polarized light and the spectrum of vertically polarized light, respectively. In equation (1), λ represents wavelength, $\Delta I(\lambda)$ indicates the measured difference polarization spectrum, $\Delta I_w(\lambda)$ is the spectrum
 20 measured using a standard white plate and is calculated by summing the white horizontal polarization spectrum $I_{w\Pi}(\lambda)$ and the white perpendicular polarization spectrum $I_{w\perp}(\lambda)$, as shown in the denominator of equation (1). In the numerator of equation (1), the difference between the
 25 horizontal polarization spectrum $I_{\Pi}(\lambda)$ and the perpendicular polarization spectrum $I_{\perp}(\lambda)$ is calculated and a signal indicative of $\Delta I(\lambda)$.

Based on the generated results of the data preprocessor 621, the blood content estimator 622
 30 calculates the blood content by using equation (2) below, which is shown in, for example, M. P. Siegel et al.

Assessment of blood supply in superficial tissue by polarization-gated elastic light-scattering spectroscopy, Applied Optics, Vol. 45, Issue 2, pp. 335-342 (2006), which is incorporated by reference herein.

5 (2) $\Delta I(\lambda) = \Delta I_{\text{scattering}}(\lambda) \exp[-\alpha A_{\text{PG}}(\lambda)]$

The blood content estimator 622 calculates the blood quantity by using a model equation, such as equation (2), and may provide a corresponding blood content value to optional display 625. Alternatively, the blood content
10 estimator 622 may also provide the blood content value to data validator 623 as a check on the integrity of the collected data. Further, blood content estimator 622 may provide the results from the various measurement units 12a to 12n to comparator 626 to determine the validity of a
15 measurement and to improve the accuracy of detection based on the numerous measurement units 12a to 12n. In particular, the comparator 626 compares signals indicative of light interacted with the tissue for each of the measurement units 12a to 12n, and generates at least one
20 comparison signal. Then, the blood content estimator 622 that is coupled to the comparator 626 calculates information indicative of the blood content in the illuminated tissue based on the comparison signal.

Various configurations of exemplary endoscopes with
25 multiple measurement units in accordance with the invention are depicted in Figs. 7 to 13. More specifically, Fig. 7 depicts an endoscope tip 71 with multiple measurement units. Endoscope tip 71 is generally concave in shape with the multiple measuring units 72 deployed along the concave
30 surface of the tip. In operation, by pressing an endoscope tip 71 into living tissue, the tissue is drawn into, or aspirated into contact with the multiple measuring units 72. The placement of numerous measurement units on the concave

surface ensures contact by one or more of the measurement units. Contact with multiple measurement units would tend to provide a more accurate reading than a probe with a single measurement unit. In additional, greater accuracy in blood content detection is achievable by comparing the data obtained from the multiple measuring units 72. In the configuration of Fig. 8 multiple measurement units 84 are employed with a traditional flexible endoscope 8. Endoscope 8 contains a rigid tip 81, a connecting portion 82, angled portion 83, and measurement units 84 in accordance with the invention. By placing the measurement units 84 on the outer circumference of the insertion portion of the flexible endoscope, the detection windows are advantageously more likely to contact the tissue mucosa upon insertion and removal of the device.

Fig. 9 depicts a variation of the configuration of the invention shown in Fig. 8. A second ring of measurement units 184 is longitudinally located on the circumference of the connecting portion 82. By utilizing a second ring of measurement units 184 on the circumference of the flexible endoscope, a user is able to obtain measurement results at two different locations along the longitudinal access of the endoscope. By analyzing the data from the two different regions on the living tissue, an operator can more accurately determine the proximity of the abnormal lesion by utilizing the differences between the two areas of measurement.

Fig. 10 depicts an alternative embodiment to those disclosed in Figs. 8 and 9. As seen in Fig. 10, the measurement units 184 may be arranged in a substantially helical arrangement about the circumference of the insertion portion of a flexible endoscope. Such an arrangement significantly increases the coverage area of

the multiple detection windows.

Fig 11 depicts an embodiment of the present invention wherein the connecting portion of the endoscope has a thread-like or helical protruded portion 112. In this
5 embodiment, the multiple measurement units 111 are placed in the outer circumference of the helical protrusion 112. In operation of this configuration, the multiple measurement units 111 tend to serially come into contact with the same areas of tissue mucosa as the insertion
10 portion is rotated upon insertion or extraction.

Fig. 12 depicts an endoscope 122 covered by a sheath 121 with measurement units 123 disposed therein. Sheath 121 is essentially a tube into which, for example, an endoscope 122, such as a conventional endoscope is inserted.
15 Multiple measurement units 123 are arranged along the circumference of sheath 121 and contact living tissue mucosa 124. This type of sheath configuration allows the user to employ a conventional endoscope while at the same time advantageously utilizing blood content detection
20 methods for guiding the endoscope to abnormal tissue. It will be appreciated by one skilled in the art that sheath 121 may also be configured with the thread-like protrusions 112 and the multiple measurement units 123 may likewise be configured in a spiral configuration along the
25 circumference of the thread-like shape.

Fig. 13 depicts an embodiment with sheath 131, endoscope 132, and balloon 133 having multiple measurement units 134 disposed therein. Sheath 131 is typically a hollow tube through which, for example, a endoscope 132
30 will be inserted. Balloon 133 is attached to or formed integral with the sheath 131 and is inflated by either air or water pressure. Upon placement of sheath 131, balloon 133 is inflated to contact the target tissue mucosa 135.

The inflation of balloon 133 ensures contact between the multiple measurement units 134 and tissue mucosa 135.

Further, a sensor 136 may be employed to start the blood detection process based on inflation of balloon 133. As
5 will be appreciated by those skilled in the art, sensor 136 may be located internally or externally to the sheath 131 or balloon 133. For example a sensor could be located on the surface of balloon 136 or within sheath 131 and may sense the back pressure exerted by the balloon 133 when it
10 inflates and contacts living tissue 135.

In an alternative embodiment, two or more balloons may be utilized, each with its own set of measurement units 134. By utilizing multiple balloons 133, the multiple measurement units 134 can be spread out along sheath 131.

15 In the manner, the blood content detection data can be analyzed to determine which of the balloons 133 is closest to an area of interest. Such information will aid in isolating and detecting potential areas of interest.

In another exemplary embodiment of the present invention,
20 blood data collection is triggered upon the sensing of contact between balloon 133 and tissue mucosa 135. Such sensing of contact may be the result of back pressure sensed in the balloon inflation mechanism or as a result of surface sensors 136 located in balloon 133.

25 While the foregoing description and drawings represent the preferred embodiments of the present invention, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the present invention. For example, although the improved
30 method and apparatus described herein as part of or in conjunction with an endoscope, it is also possible to use the invention with a stand alone probe or other medical device.

CLAIMS

1. An apparatus comprising:
a probe (8; 122; 132) for insertion into a cavity of a living body, the probe (8; 122; 132) including a plurality of illuminators (3a to 3n) and a plurality of collectors (7a to 7n);
the illuminators (3a to 3n) adapted for illuminating regions of tissue within the living body,
the collectors (7a to 7n) adapted for receiving
10 interacted light from respective illuminated tissue regions and generating signals indicative of blood content measurements.
2. The apparatus of claim 1 further comprising a
15 processing unit (9) coupled to the collectors (7a to 7n) and adapted for determining blood content within the illuminated tissue regions based on the generated signals.
3. The apparatus of claim 2 further comprising an
20 indicator (625) coupled to the processing unit (9) for indicating a parameter based on the determined blood content to assist in guidance of the probe (8; 122; 132).
4. The apparatus of claim 1, wherein the probe (8; 122; 132) is cylindrically-shaped with the illuminators (3a to 3n) and the collectors (7a to 7n) included on an outer
25 surface thereof.
5. The apparatus of claim 4, wherein the cylindrically-shaped probe (8) includes a raised helical portion (112) having the illuminators (3a to 3n) and the collectors (7a to 7n) included thereon.
30

6. The apparatus of claim 5, wherein the raised helical portion (112) is sufficiently large to contact the tissue forming the intended cavity of the living body.

5 7. The apparatus of claim 1, wherein the processing unit (9) comprises:

a comparator (626) for comparing signals indicative of light interacted with the tissue for each of the plurality of the collectors (7a to 7n), and generating at least one
10 comparison signal, and

a processor (622) coupled to the comparator (626), the processor (622) for calculating information indicative of the blood content in the illuminated tissue based on the comparison signal.

15

8. The apparatus of claim 1, wherein the illuminators (3a to 3n) emit collimated light.

9. The apparatus of claim 8, wherein the illuminators (3a
20 to 3n) emit polarized light.

10. The apparatus of claim 1, further comprising at least one polarizer (4) that is proximate to the collectors (7a to 7n).

25

11. The apparatus of claim 10, wherein two polarizers (41, 42) are located proximate to the collectors (7a to 7n) and wherein the polarizers (41, 42) have substantial orthogonal polarizations to one another.

30

12. The apparatus of claim 1 further comprising an endoscope.

13. The apparatus of claim 12, wherein the illuminators (3a to 3n) and the collectors (7a to 7n) are positioned proximate to a distal tip (71) of the endoscope.

5 14. An apparatus for determining a characteristic of a living tissue comprising:

a probe (8; 122; 132) for insertion into a cavity of the living body, the probe (8; 122; 132) including a plurality of illuminators (3a to 3n) and a plurality of
10 collectors (7a to 7n), the illuminators (3a to 3n) being disposed on the probe (8; 122; 132) for lighting respective portions of the tissue within the living body, the collectors (7a to 7n) being disposed on the probe (8; 122; 132) adapted for receiving interacted light from the
15 respective portions of the tissue;

a contacting unit adapted to facilitate contact between the probe (8; 122; 132) and the tissue forming the cavity of the living body; and

a processor (9) coupled to the collectors (7a to 7n)
20 for providing an indication of blood content within the illuminated tissue to assist in guidance of the probe (8; 122; 132).

15. The apparatus of claim 14, wherein the illuminators (3a to 3n) and the collectors (7a to 7n) are positioned on
25 a surface or aligned with the contacting unit.

16. The apparatus of claim 15, wherein the contacting unit axially surrounds the probe (8; 122; 132).

30

17. The apparatus of claim 15, wherein the contacting unit is inflatable.

18. The apparatus of claim 14, wherein at least one of the illuminators (3a to 3n) and collectors (7a to 7n) are energized in accordance with a received signal from the contacting unit.

5

19. An apparatus for use with an endoscope comprising a sheath (121; 131) for insertion into a cavity of a living body, the sheath (121; 131) including an inner surface with an inner circumference and an outer surface with an outer
10 circumference, a plurality of illuminators (3a to 3n) and a plurality of collectors (7a to 7n) being located on the outer surface, the illuminators (3a to 3n) being adapted for illuminating regions of tissue within the living body, the collectors (7a to 7n) being adapted for receiving
15 interacted light from respective illuminated tissue regions and generating signals indicative of blood content measurements.

20. The apparatus of claim 19 further comprising a
20 processing unit (9) coupled to the collectors (7a to 7n) and adapted for determining blood content within the illuminated tissue regions based on the generated signals.

21. The apparatus of claim 20 further comprising an
25 indicator (625) coupled to the processing unit (9) for indicating a parameter based on the determined blood content to assist in guidance of the probe (8; 122; 132).

22. The apparatus of claim 19, wherein the outer
30 circumference of the sheath is larger than the cavity of the living tissue.

23. The apparatus of claim 19 further comprising a

contacting unit to ensure contact between the sheath and tissue forming the cavity of the living body.

24. The apparatus of claim 19, wherein at least one of the
5 illuminators (3a to 3n) and the collectors (7a to 7n) are energized in accordance with a received signal from the contacting unit.

25. The apparatus of claim 23, wherein the illuminators
10 (3a to 3n) and the collectors (7a to 7n) are positioned on or aligned with a surface of the contacting unit.

26. The apparatus of claim 25 wherein the contacting unit axially surrounds the sheath.

15

27. The apparatus of claim 25 wherein the contacting unit is inflatable.

28. The apparatus of claim 19 wherein the sheath has a
20 helically raised portion (112) on the outer circumference of the sheath.

29. The apparatus of claim 28 wherein the illuminators (3a to 3n) and the collectors (7a to 7n) are located on the
25 helically raised portion (112).

30. A method for guiding an endoscope within a cavity of a living organism comprising:

inserting a probe (8; 122; 132) into a cavity of a
30 living organism;

contacting the probe (8; 122; 132) with a surface of tissue forming the cavity;

illuminating portions of the contacted tissue surface;

receiving interacted light from the illuminated contacted tissue surface; and

processing the received interacted light to determine a parameter indicative of blood content of the illuminated tissue to assist in guiding said probe.

31. The method of claim 30, wherein the contacting is achieved by inflating an inflatable cuff surrounding the probe (8; 122; 132).

32. The method of claim 30 further comprising repositioning the probe (8; 122; 132) within the living body based on the determined parameter.

33. The method of claim 31, wherein the probe (8; 122; 132) is disposed within an endoscope and wherein the determined parameter is used for guiding the probe (8; 122; 132).

34. The method of claim 30, wherein the contacting further comprises contacting the tissue with at least one of a plurality of detection sensors disposed on the probe (8; 122; 132).

35. A method for guiding a blood content detector within a cavity of a living organism comprising:

inserting a sheath into a cavity of a living organism;

contacting the sheath with a surface of tissue forming the cavity;

illuminating portions of the contacted tissue surface; receiving interacted light from the illuminated contacted tissue surface; and

processing the received interacted light to determine

a parameter indicative of blood content of the illuminated tissue to assist in guiding the sheath.

36. The method of claim 35 further comprising inserting an
5 endoscope through the sheath to aid in the guidance of the sheath.

FIG.1

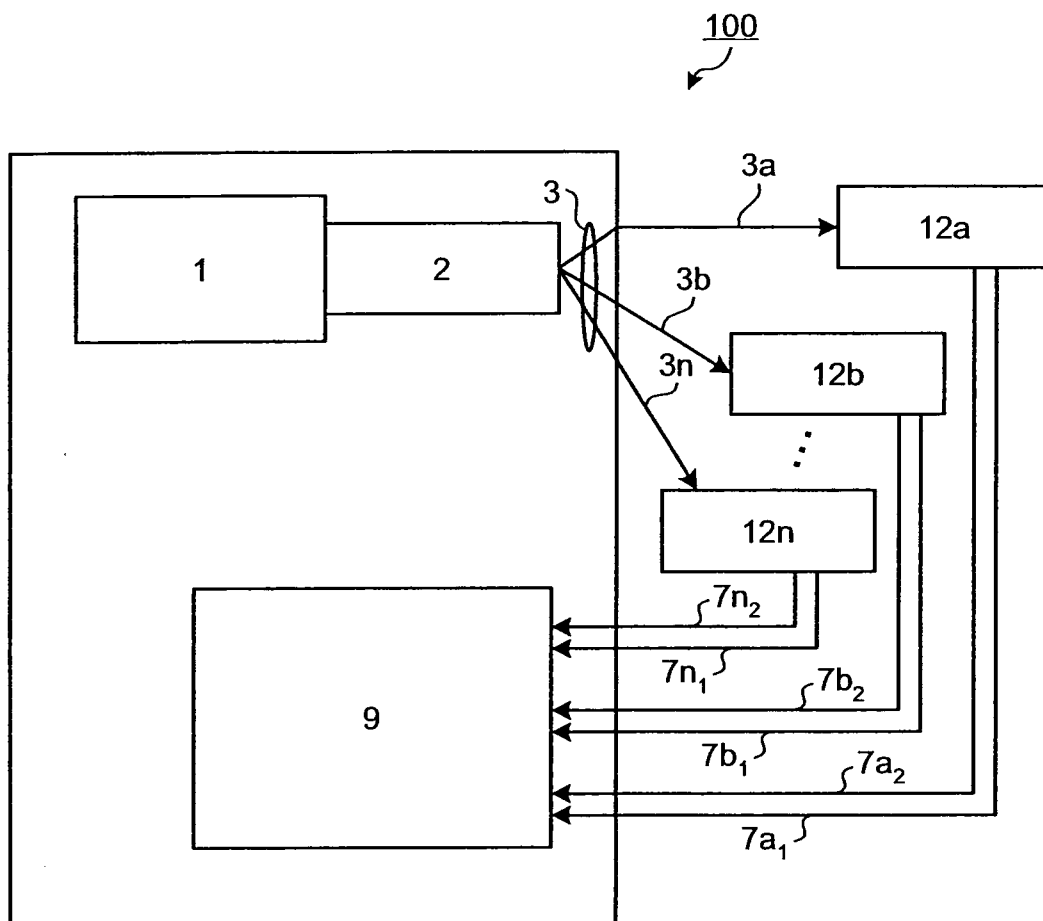


FIG.2

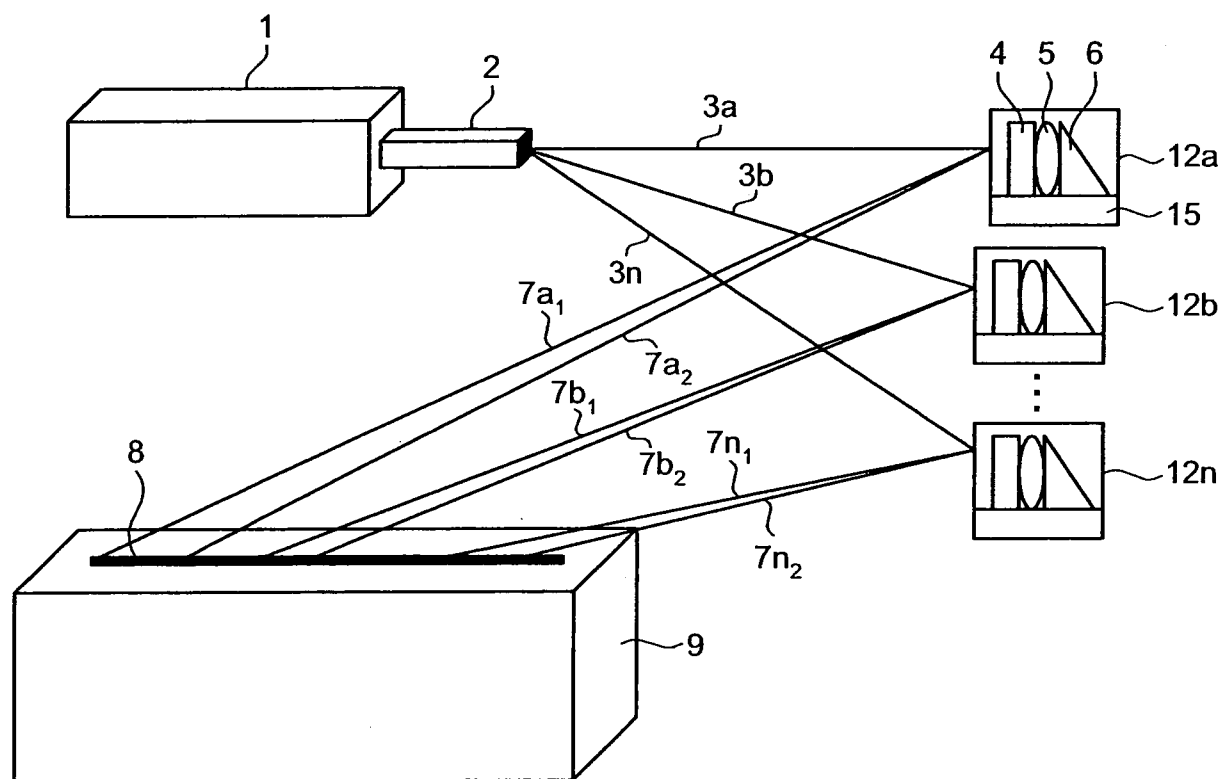


FIG.3

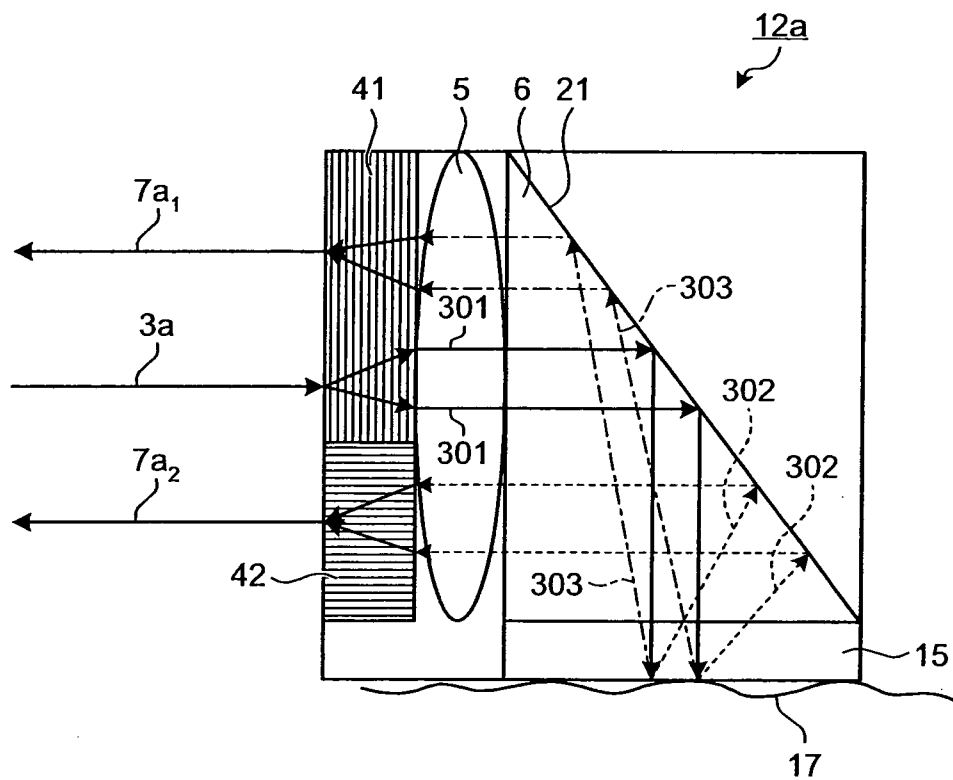
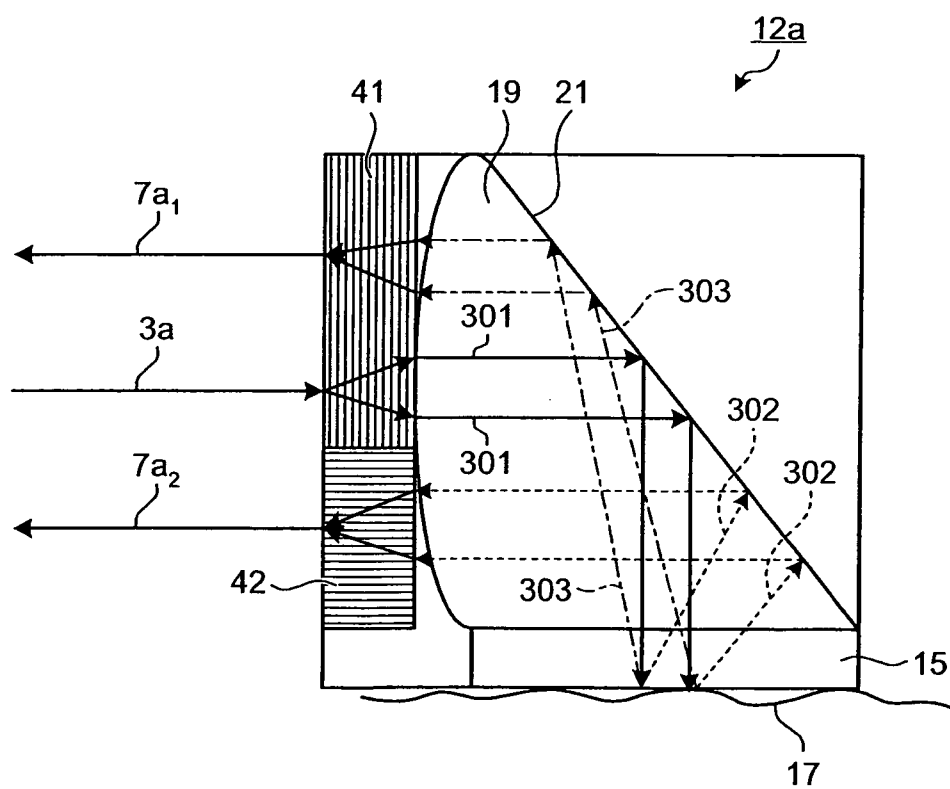


FIG.4



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FIG.5

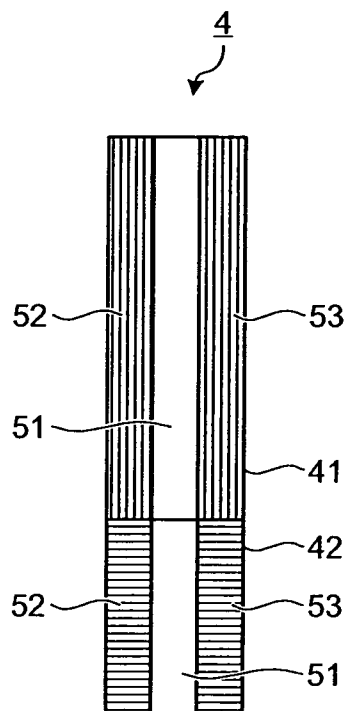
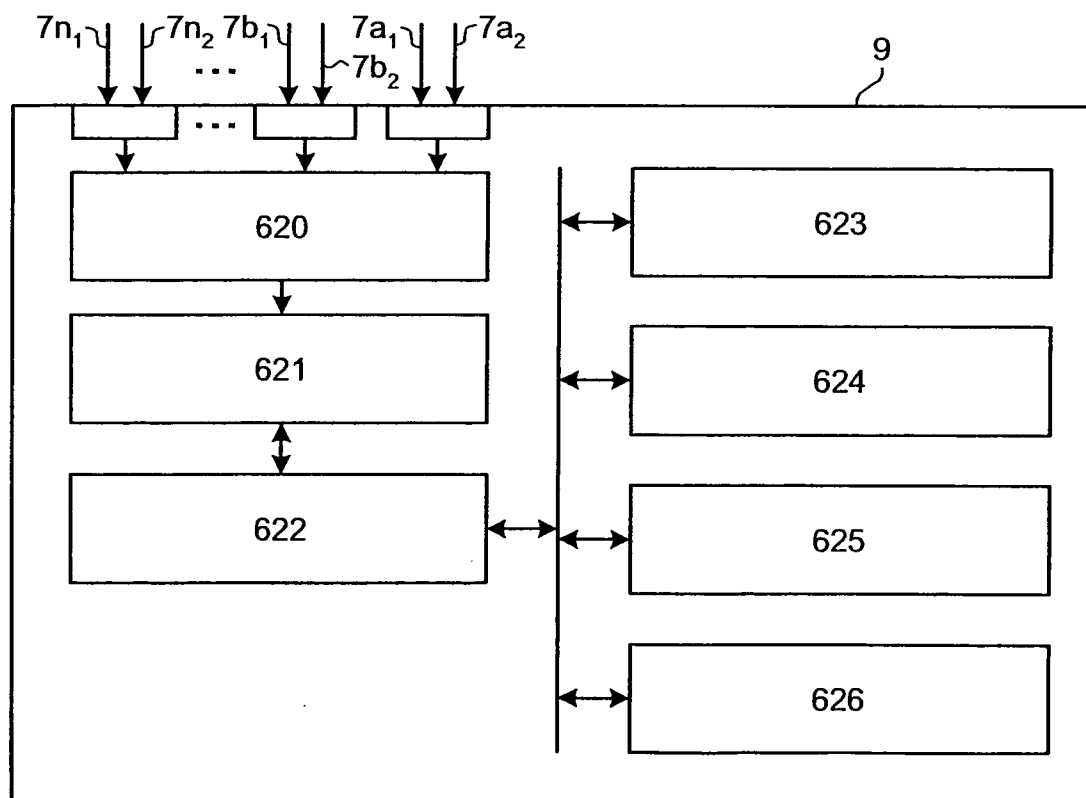


FIG.6



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FIG.7

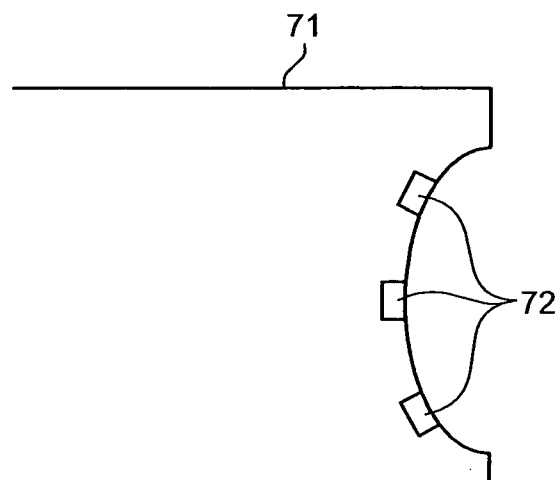


FIG.8

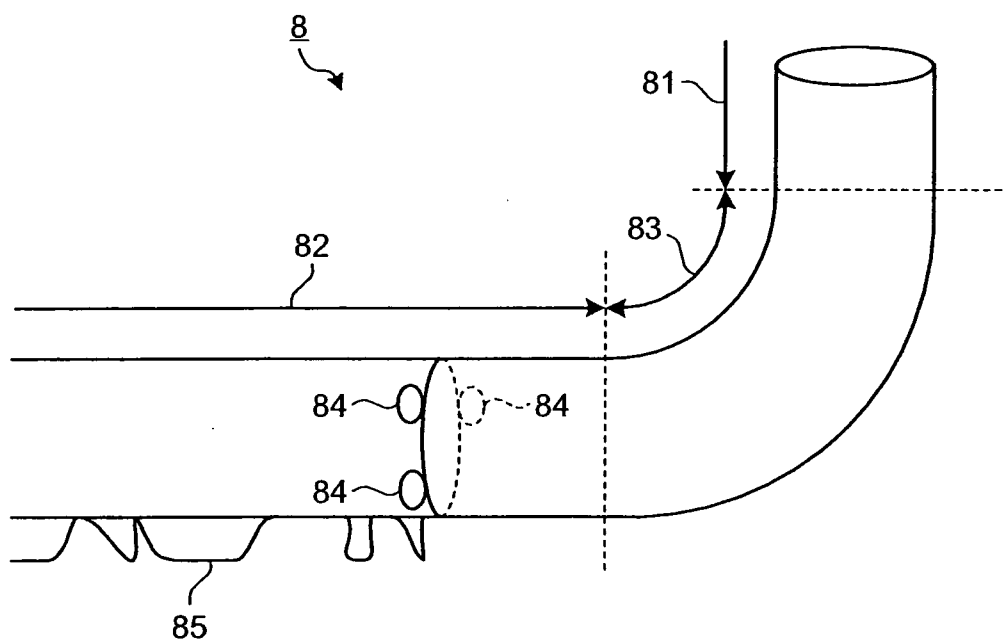


FIG.9

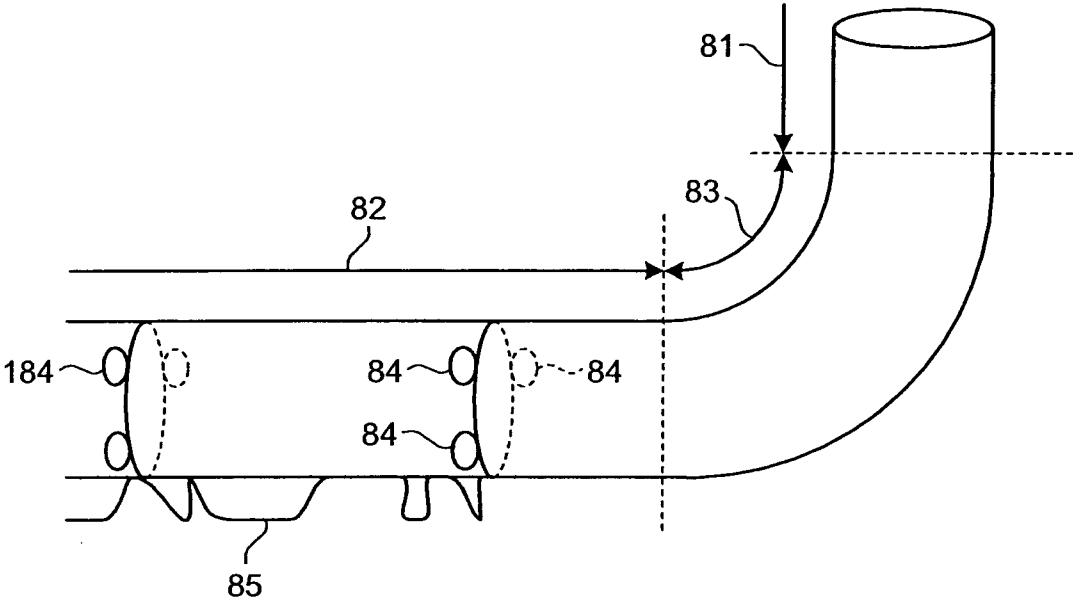


FIG.10

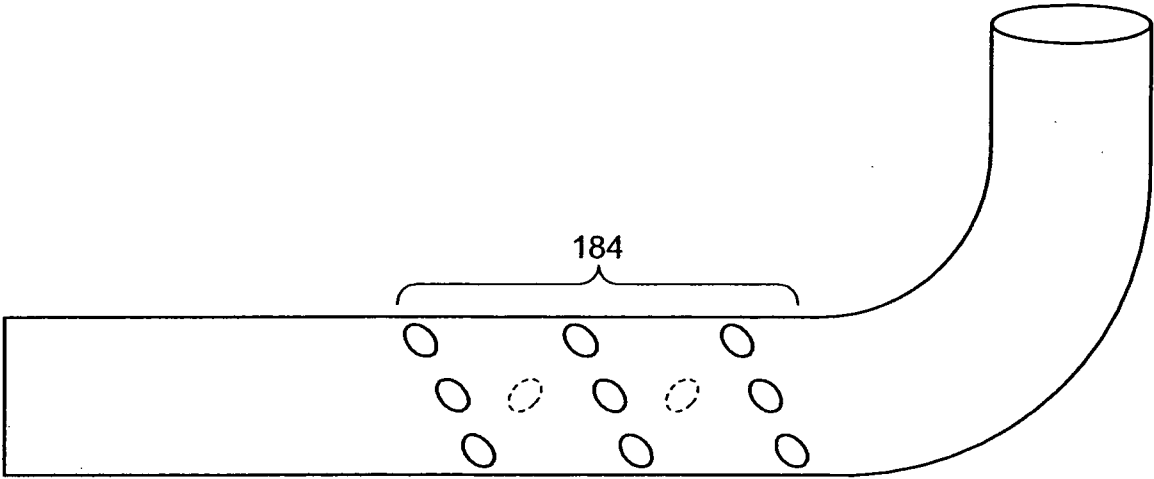


FIG.11

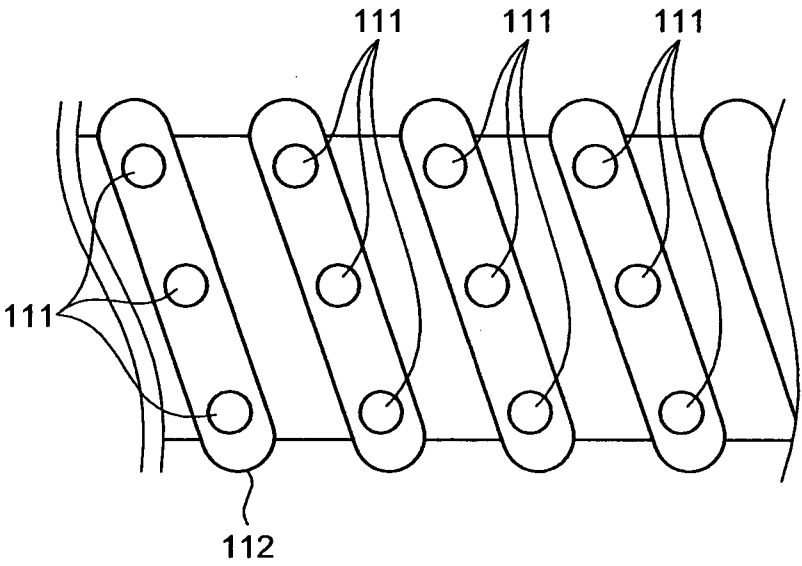


FIG.12

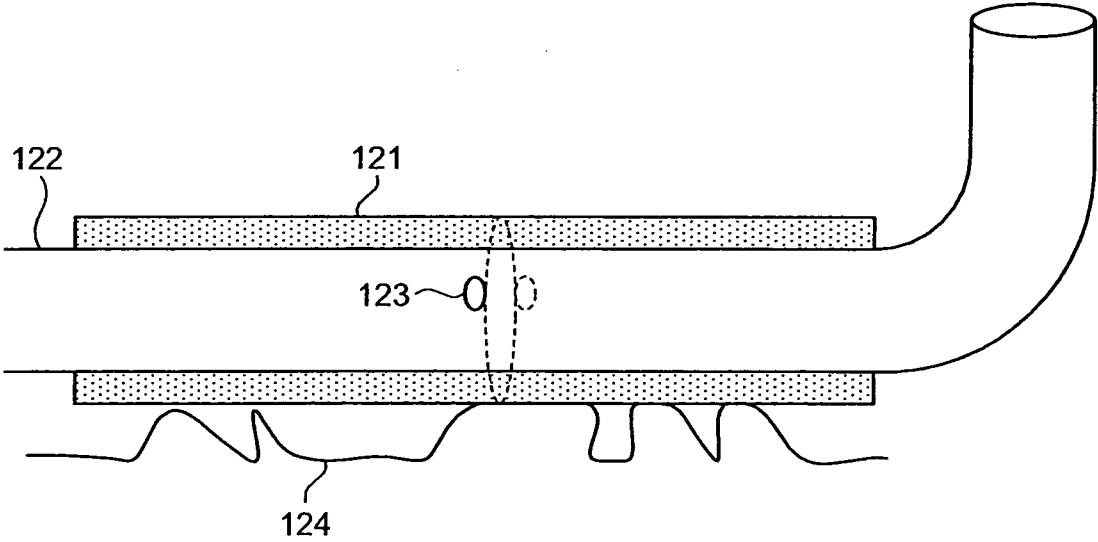


FIG.13

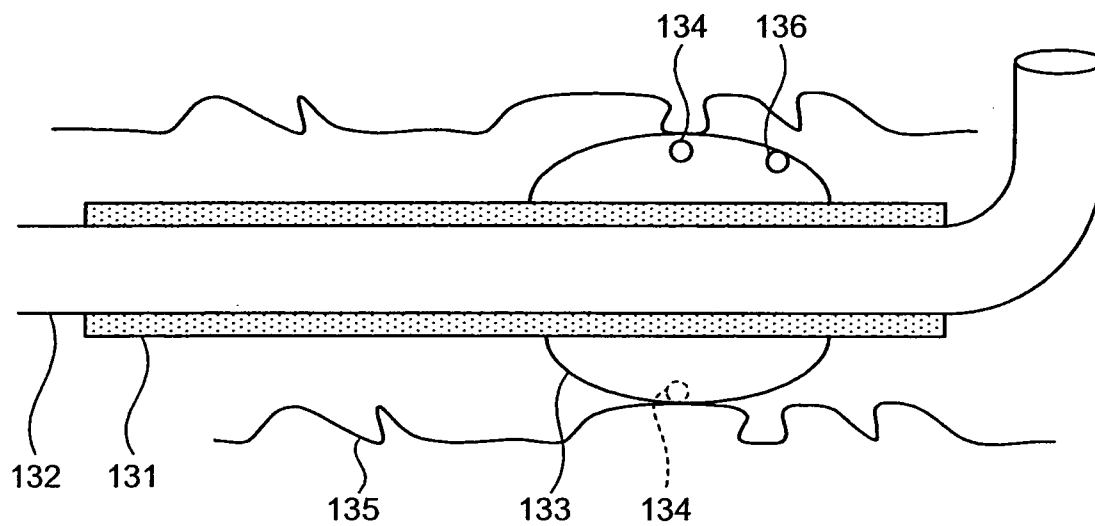
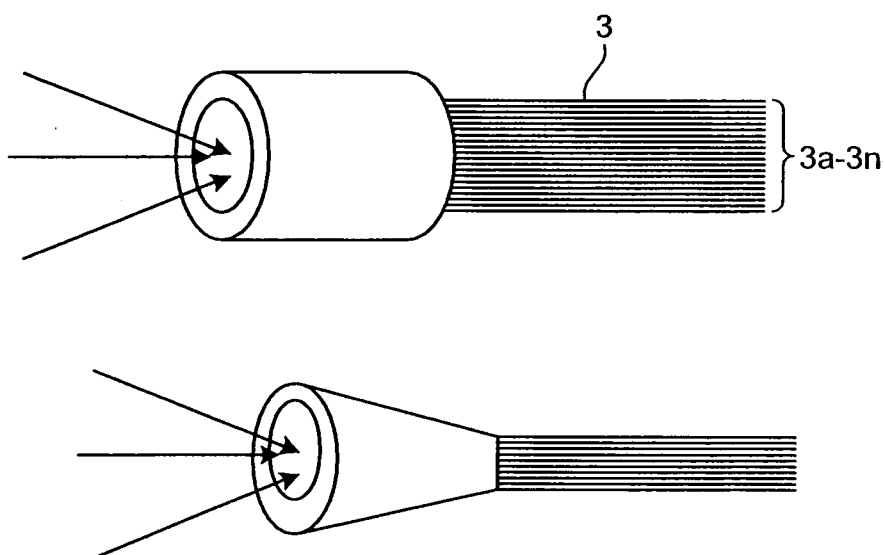


FIG.14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/060570

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. A61B1/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. A61B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2009
Registered utility model specifications of Japan 1996-2009
Published registered utility model applications of Japan 1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005-328990 A (Olympus Corporation) 2005.12.02, 【0031】 - 【0040】, Fig.1,3,4 & US 2005/0267340 A1	1-3
X	JP 2001-204685 A (SHIMADZU CORPORATION) 2001.07.31, 【0025】 - 【0036】, Fig.1-5 (No Family)	1-3
X	JP 5-115463 A (Olympus Corporation) 1993.05.14, whole document (No Family)	1-3

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

02.09.2009

Date of mailing of the international search report

15.09.2009

Name and mailing address of the ISA/JP

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2Q 3410

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/060570

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The subject matter of claim 1 does not appear to be novel with respect to D1-D3. Therefore, the subject matter of claim 1 lacks the special technical feature. The application contains a plurality of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-3

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.