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(54) Imaging apparatus comprising a fluid delivery arrangement and a pull-back arrangement

Bildgebungsgerät mit einer Fluidabgabevorrichtung und einer Pull-Back-Vorrichntung

Appareil d'imagerie comprenant un dispositif de distribution de fluide et un dispositif de rétraction

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus for imaging an anatomical structure in contact with a first fluid.

BACKGROUND INFORMATION

[0002] Acute myocardial infarction ("AMI") is the leading cause of death in the United States and industrialized countries. Research conducted for over the past 15 years has demonstrated that several types of minimally or modestly stenotic atherosclerotic plaques, termed vulnerable plaques, are precursors to coronary thrombosis, myocardial ischemia, and sudden cardiac death. Postmortem studies have identified one type of vulnerable plaque, i.e., the thin-cap fibroatheroma ("TCFA"), as the culprit lesion in approximately 80% of sudden cardiac deaths. Over 90% of TCFA's are found within the most proximal 5.0 cm segment of each of the main coronary arteries (left anterior descending - LAD; left circumflex - LCx; and right coronary artery - RCA). The TCFA is typically a minimally occlusive plaque characterized histologically by the following features: a) thin fibrous cap (<65 μm), b) large lipid pool, and c) activated macrophages near the fibrous cap. It is hypothesized that these features predispose TCFAs to rupture in response to biomechanical stresses. Following the rupture, the release of procoagulant factors, such as tissue factor, create a nidus for thrombus formation and the potential for an acute coronary event. While TCFAs are associated with the majority of AMIs, recent autopsy studies have shown that coronary plaques with erosions or superficial calcified nodules may also precipitate thrombosis and sudden occlusion of a coronary artery.

[0003] Although autopsy studies have been valuable in determining features of culprit plaques, the retrospective nature of these studies may limit their ability to quantify the risk of an individual plaque for causing acute coronary thrombosis. For instance, TCFAs are a frequent autopsy finding in asymptomatic or stable patients, and are found with equal frequency in culprit and non-culprit arteries in acute coronary syndromes. Moreover, disrupted TCFAs have been found in about 10% of non-cardiac deaths. Recent findings of multiple ruptured plaques and increased systemic inflammation in acute patients have challenged the notion of a single vulnerable plaque as the precursor for AMI. A better understanding of the natural history and clinical significance of these lesions may accelerate progress in the diagnosis, treatment and prevention of coronary artery disease.

[0004] An exemplary approach to studying the evolution of vulnerable plaques is a non-invasive or intracoronary imaging of individual lesions at multiple points in time. Unfortunately, the microscopic features that characterize vulnerable plaque are not reliably identified by the conventional imaging technologies, such as intravascular ultrasound ("IVUS"), catscan ("CT"), and magnetic resonance imaging ("MRI"). While experimental intracoronary imaging modalities such integrated backscatter IVUS, elastography, angioscopy, near-infrared spectroscopy, Raman spectroscopy and thermography have been investigated for the detection of vulnerable plaque, it is believed that no method other than optical coherence tomography ("OCT") has been shown to reliably identify the characteristic features of these lesions.

[0005] OCT is an optical analog of ultrasound that provides high-resolution (~10 μm) cross-sectional images of human tissue. OCT has been established as an accurate method for characterizing the microscopic features associated with vulnerable plaque. This technology can also be used to quantify macrophage content within atherosclerotic plaque. Intracoronary optical imaging using such technology is safe, and images obtained from patients have features substantially identical to those identified ex vivo. Thus, OCT has the ability to provide a large amount of information about plaque microstructure. This technology may play an important role in improving the understanding of vulnerable coronary plaques in patients.

[0006] Strong attenuation of light in blood may present a significant challenge for intravascular optical imaging methods. To overcome this potential obstacle, intermittent 10 cc flushes of saline through a guiding catheter can provide an average of 2 seconds of clear viewing during which effective images can be captured, as is shown in Fig. 1B. For example, Fig. 1B illustrates an analysis of the time of angiographic lumen attenuation following a 6 cc contrast injection at three separate locations, shown in part A of Fig. 1B. As can be seen from part B of Fig. 1B, the angiographic lumen attenuation following the 6 cc contrast injection at a rate of 3 cc/s demonstrates a complete filling for the duration of the purge (approximately 2 seconds) regardless of the location. Additionally, saline flushing of a blood vessel for a limited duration (for example, less than 30 seconds) is safe, and generally does not result in a myocardial ischemia. This approach can provide exceptional cross-sectional images of coronary vasculature. However, the combination of the limited flush duration and low image acquisition rate may reduce comprehensive coronary screening.

[0007] One proposed solution has been to change the optical properties of blood. The primary mechanism of optical attenuation in blood is optical scattering. For instance, matching the refractive index of the red blood cells, white blood cells and platelets with that of a serum decreases optical scattering. This approach has resulted in a 1.5-fold increase in penetration of OCT when diluting blood with Dextran. Unfortunately, since the optical attenuation of blood is so high, at least a 10-fold improvement would be preferable to allow for effective intracoronary OCT imaging in patients.

[0008] Another proposed solution is to completely occlude the artery, and replace blood with saline. This tech-

nique that is commonly deployed in angioscopic imaging requires proximal balloon occlusion. Following vascular occlusion, all of the remaining blood in the vessel is replaced with saline. This conventional method allows a cross-sectional optical imaging of the entire coronary tree. While this procedure is commonly conducted in Japan, the potential for coronary dissection and myocardial ischemia precludes widespread clinical application of this procedure.

[0009] Still another proposed solution is to purge the blood vessel with optically transparent blood substitutes. Blood substitutes that are transparent in the infrared can potentially provide clear imaging for an extended duration. This method has achieved significantly improved imaging in murine myocardium by replacing blood with Oxyglobin. Although these compounds may hold promise for future clinical application, they are not yet approved for human use.

[0010] A further proposed solution is to increase the frame rate of OCT scans. Since the goal is to acquire a sufficient number of images to comprehensively screen coronary arteries, a straightforward approach would be to accept the clear viewing time provided by conventional saline flushing, and increase the frame rate of OCT scans dramatically. Two possibilities exist for increasing the frame rate of OCT scans: a reduction of the number of A-lines per image, and an increase of the radial scan rate.

[0011] Similarly to many imaging methods, OCT images are acquired in a point sampling fashion and are composed of multiple radial scans or A-lines. To increase the image rate, it is possible to reduce the number of A-lines per image by increasing the catheter rotation rate. Image quality degrades rapidly in such case, however, manifested by a decrease in transverse resolution as can be seen in Fig. 1A. For example, image A of Fig. 1A depicts a sample image generated using OCT imaging at a rate of 4 frames per second having 500 A-line scans per frame. Image B of Fig. 1A depicts a sample image generated using OCT imaging at a rate of 40 frames per second having 50 A-line scans per frame. As can be clearly seen, the image quality of Image A far exceeds the image quality of Image B. This degradation is unacceptable for most clinical applications.

[0012] A second possibility is to increase the radial scan rate. For technical reasons specific to the current OCT paradigm, an increase in A-line rate may result in an unacceptable penalty in signal to noise ratio, and thus, images of sufficient quality for accurate diagnosis cannot be obtained.

[0013] Document US-A-2003/0135101 discloses an intravascular imaging apparatus for optical imaging, in particular OCT imaging. Rotational and longitudinal movements of the imaging element are configured so that the spiral-shaped path of the imaging element covers the entire region of interest within the body lumen. A transparent fluid may be introduced in the region adjacent the imaging components using a guiding catheter. The fluid injection may be automatically controlled and monitored during collection of image information.

[0014] There is a need to provide an apparatus that combine quality imaging of internal surfaces of blood vessels and other biological structures and effective imaging of segments of the internal surfaces of the blood vessels.

SUMMARY OF THE INVENTION

[0015] It is therefore one of the objects of the present invention to provide an apparatus that combines quality imaging of internal surfaces of blood vessels and other biological structures and effective imaging of segments of the internal surfaces of the blood vessels. Another object of the present invention is to provide an apparatus that provides quality images of internal surfaces of segments of blood vessels in order to offer an improved understanding of the natural history and clinical significance of these lesions which will accelerate progress in diagnosis, treatment and prevention of coronary artery disease.

[0016] The invention is defined in the independent claim 1. Preferred embodiments are defined in the appended dependent claims.

[0017] Features and advantages of the present invention will become apparent upon reading the following detailed description of embodiments of the invention, when taken in conjunction with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] For a more complete understanding of the present invention and its advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

Fig. 1A shows images of the interior surface of a blood vessel gathered using OCT imaging at different settings;

Fig. 1B illustrates an analysis of the time of angiographic lumen attenuation following a contrast injection at three separate locations in a given blood vessel;

Figs. 2A - 2B show an exemplary embodiment of an imaging catheter for conducting scans of a segment of a blood vessel;

Fig. 3 shows an exemplary flow chart depicting a process for gathering information representative of a helical scan of a segment of a blood vessel using the imaging catheter of Figs. 2A - 2B;

Fig. 4 shows the imaging catheter of Fig. 2A after retraction of a rotateable inner shaft of the imaging catheter;

Fig. 5 illustrates an exemplary embodiment of an enlarged section of the imaging catheter of Fig. 2A as defined by the dashed box A; and

Fig.6 shows the imaging catheter of Fig. 2A, enclosed within a guide catheter, whereby a transparent solution is injected into the guide catheter en-

closing the imaging catheter.

[0019] Throughout the drawings, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components, or portions of the illustrated embodiments. Moreover, while the present invention will now be described in detail with reference to the Figures, it is done so in connection with the illustrative embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Figs. 2A, 2B, 4, 5 and 6 illustrate various exemplary embodiments of an apparatus for obtaining an image of internal surfaces of a segment of an anatomic structure and Fig. 3 shows an exemplary method to implant the same. Generally, the apparatus according to the present invention performs a helical scan of the internal surfaces of the segment of the anatomic structure after injecting a bolus of transparent or semi-transparent fluid, so as to obtain an image of the internal surfaces of the segment of the anatomic structure using an imaging modality. Such technique combines the efficacy of the imaging modality and the process of injecting a bolus of transparent or semi-transparent fluid with the beneficial effect of imaging an entire segment of the anatomic structure. The exemplary embodiments of the apparatus according to the present invention utilize a further paradigm for imaging that provide a significant increase in the image acquisition rate, while preserving a good image quality. According to one exemplary embodiment, the dramatic increase represents at least an approximately 10-fold increase in the image acquisition rate. With this exemplary technology, comprehensive coronary imaging can be achieved using conventional methods of transparent or semi-transparent fluid flushing in conjunction with automatic catheter pullback. In one exemplary embodiment of the present invention, this new paradigm utilizes Optical Frequency Domain Imaging ("OFDI") as an imaging modality to obtain these images. In another exemplary embodiment, the anatomic structure can be a blood vessel.

[0021] It should be understood that alternate imaging modalities that detect single scattered light, such as time domain OCT and confocal microscopy, can also be used.

[0022] In a further exemplary embodiment of the present invention (as shown in Fig. 2A), the imaging module 224 utilizes OCT, visible light imaging, spectroscopy and/or thermography. In another exemplary embodiment, the OCT imaging modality used is time-domain OCT ("TD-OCT"), spectral-domain OCT ("SD-OCT"), optical frequency domain imaging ("OFDI"), and/or low-coherence interferometry. The visible light imaging modality used may be intracoronary angioscopy, speckle imaging, fluorescence imaging, and/or multi-photon imaging. The spectroscopy modality may use visible light having a spectrum of approximately 0.3 - 0.7 μm, near infrared light ("NIR") having a spectrum of approximately 0.7 - 2.2 μm, infrared light ("IR") having a spectrum of approximately 2.2-12 μm, Raman scattered light and/or fluorescent light. In a further exemplary configuration, the imaging module 224 utilizes ultrasound, particularly high-frequency ultrasound having a frequency of at least approximately 20 MHz. In an exemplary embodiment of the present invention, the imaging assembly 204 includes a lens, mirror and/or prism.

[0023] Figs. 2A and 2B illustrate an exemplary embodiment of an imaging system 200 including a specially modified optical catheter 202 having a distal end 220 and a proximal end 222. The imaging system 200 is capable of imaging long arterial segments by utilizing a rapid acquisition rate of imaging modalities and implementing automated pullback of the imaging catheter 202. These efforts may allow a proximal portion of each main coronary artery (LAD, LCx, and RCA) to be comprehensively imaged with a specific longitudinal image spacing, while administering a safe total amount of transparent or semi-transparent fluid to the patient.

[0024] Preferably, long arterial portion that is up to 10 cm in length can be examined. Preferably, the long arterial portion of up to 5.0 cm in length can be examined. Preferably, the proximal portion of each main coronary artery is up to 10 cm in length which is capable of being examined. Preferably, the proximal portion of each main coronary artery is up to 5 cm in length which is capable of being examined. Preferably, the specific longitudinal imaging spacing is between approximately 100 μm and approximately 150 μm, preferably approximately 125 μm. Preferably, the specific longitudinal imaging spacing matches the transverse spot diameter, and is therefore between approximately 15 μm and approximately 35 μm, preferably approximately 25 μm. Preferably, the safe total amount of transparent or semi-transparent fluid is at most 150 cc/artery, and preferably no more than 30 cc/artery. Preferably, the transparent or semi-transparent fluid can be normal saline, 1/2 normal saline, 1/4 normal saline, lactated ringers solution, phosphate buffered saline, blood substitute such as Oxyglobin, and/or coronary contrast media. Preferably, the imaging system 200 may image segments of any blood vessel including: carotid arteries, iliac arteries, femoral arteries, popliteal arteries, radial arteries, other peripheral arteries and veins.

[0025] Blood presents a challenge for any light-based intravascular imaging modality. As light propagates in blood, certain information is lost due to both scattering and absorption. At a wavelength of approximately 1.3 μm, the combined attenuation due to scattering and absorption can be minimized. Even at this optimal wavelength, however, imaging vascular structure through blood may not be feasible. Particular preferences for imaging may include a high signal-to-noise ratio ("SNR") and a high image quality requiring substantial amounts of detail. If OCT imaging is utilized as the imaging modality, a large number of A-lines are preferable in each OCT scan. Clear OCT imaging may be achieved for short

durations, e.g., on the order of three (3) seconds, by temporarily displacing blood using a bolus injection of transparent or semi-transparent fluid through the catheter 200. Therefore, at an imaging rate of four (4) frames per second, a single transparent or semi-transparent fluid purge may provide approximately 12 high-quality OCT images before blood reenters the field of view.

[0026] Preferably, the bolus injection of transparent or semi-transparent fluid can introduce approximately between 1 and 50 cc of transparent or semi-transparent fluid into the blood vessel. Preferably, the bolus injection of transparent or semi-transparent fluid introduces approximately 10 cc of transparent or semi-transparent fluid into the blood vessel.

[0027] A modified optical catheter 200, probe or other instrument may be inserted into a blood vessel (e.g., artery) to image the vessel. When plaque is located, the probe is moved into the proximity of the specific atherosclerotic plaque. Light reflected from the interior wall of the blood vessels and/or from a plaque is collected and transmitted to a detector 236 of an imaging module 224.

[0028] Pathologies other than plaque may be imaged, for example, thrombus, dissections, rupture, stents, and the like.

[0029] Referring to Fig. 2A, the specially modified optical catheter 202 may include a rotatable inner shaft 210 and an outer sheath 208. The rotatable inner shaft 210 houses a fiber array 218 and an imaging assembly 204 near the distal end 220 of the catheter 202. The outer sheath 208 includes an aperture 221 formed therethrough. The aperture 221 is connected to a fluid delivery channel 223, which is in turn connected to a fluid pump 225. The fluid pump 225 can cause the injection of a specific volume of transparent or semi-transparent fluid through the fluid delivery channel 223 and out from the aperture 221, thereby displacing the liquid surrounding the distal end 220 of the catheter 202 with the injected bolus. The fiber array 218 of the catheter 202 connects to a rotary junction 212, which is in turn connected to a fixed optical fiber 214 that it extends from the catheter 202 proximally to the imaging module 224. The rotary junction 212 is also connected to a pullback device 215. The pullback device 215 translates the rotatable inner shaft 210 within the outer sheath 208 when instructed by a processor 240 during imaging, such that a helical scan can be generated. Fig. 4 illustrates the catheter 202 after pullback of the rotatable inner shaft 210 has been completed, otherwise the system 200 of Fig. 4 is identical to the system 200 of Fig. 2A. The process 300 by which the imaging system 200 gathers data representative of a helical scan of a section of the blood vessel is illustrated in Fig. 3, and described in more detail herein.

[0030] In an exemplary configuration, the outer sheath 208 of the catheter 202 is not transparent. For example, during the pull-back the entire catheter 202, the outer sheath 208 is translated through the blood vessel, while the internal shaft 210 rotates. In this exemplary configuration, the internal shaft 210 is not translated relative to the outer sheath 208. In an exemplary embodiment, the fiber array 218 includes a single fiber. In another exemplary embodiment, the fiber array 218 includes a number of fibers.

[0031] The catheter 202 can be fabricated using an FDA approved 2.6-3.2F IVUS catheter. The inner core of the IVUS catheter is capable of rotating and obtaining cross-sectional images at, e.g., 40 frames per second. The ultrasound transducer and conductive wire, which are generally used in the IVUS catheter, may be removed and replaced with the imaging assembly 204, the fiber array 218, the inner shaft 210, the fluid delivery channel 223 and an aperture is formed through the aperture of the outer sheath of the IVUS catheter. The newly provided inner shaft 210 of the IVUS catheter rotates to provide circumferential scanning and may be pulled back for screening a segment of a blood vessel. The transparent outer sheath 208, which incorporates a monorail guide wire (not shown), does not rotate and is plugged at the distal end of the IVUS catheter using an FDA approved polymer. The catheter 202 is also attached to the rotary junction 212.

[0032] In an exemplary configuration, the catheter 202 includes a rotating optical fiber within a flexible inner cable. The flexible inner cable is contained within an outer transparent housing or sheath. The outer housing may include a monorail guide wire. The rotating optical fiber and the flexible inner cable each have a distal end and a proximal end. The rotating optical fiber and the flexible inner cable are oriented such that the distal end of the rotating optical fiber and the distal end of the flexible inner cable are adjacent to one another, and the proximal end of the rotating optical fiber and the proximal end of the flexible inner cable are adjacent to one another. Distal optics including a lens and a beam directing element are attached to the distal end of the flexible inner cable. An optical rotating junction is provided at the proximal end of the rotating optical fiber. The rotating optical fiber couples a static optical fiber to the rotating optical fiber within the flexible inner cable. The optical rotating junction rotates the rotating optical fiber, the flexible inner cable and the distal optics to provide circumferential optical sampling of the luminal surface of the vessel. The optical fiber, inner flexible cable, and distal optics rotate and an image is obtained for each catheter rotation. The inner optical cable is pulled back longitudinally within the outer transparent housing to form a helical scan of the vessel.

[0033] In an exemplary configuration, the beam directing element is a prism that directs the beam substantially perpendicular to the catheter axis and the lens focuses the beam to approximately 2 mm from the outer sheath. In another exemplary embodiment, the rotation rate ranges from approximately 10 per second to approximately 100 per second and preferably approximately 30 per second. According to the invention, the pull back rate is 10 mm/second.

[0034] The monorail guide wire may be similar to the guide wire as described in U.S. Patent No. 5,350,395,

entitled "Angioplasty Apparatus Facilitating Rapid Exchanges," to Paul G. Yock, issued September 27, 1994.

[0035] The entire shaft 210 of the catheter 202 can rotate 360 degrees, allowing the catheter 202 to gather images of the subject tissue 250 around the entire circumference of the catheter 202. In one exemplary embodiment of the present invention, the catheter 202 can obtain images of a plaque around the circumference of an interior vessel wall.

[0036] In operation, a coherent light, such as laser light, is transmitted from a light source 232 via beam-splitter 234, through the fixed optical fiber 214 and central fiber 226 and onto the imaging assembly 204. The light is directed via the imaging assembly 204 to a subject tissue 250 (arrow 206). The subject tissue 250 may be a layer of static tissue over a layer of moving tissue, such as an atherosclerotic plaque. The outer sheath 208 can be placed directly in contact with the sample 250 and/or can be positioned at a short distance (e.g., 1 mm to 10 cm) away from the sample. For example, light can enter sample 250, where it is reflected by molecules, cellular debris, proteins, compounds (e.g., cholesterol crystals), and cellular microstructures (such as organelles, microtubules) within the subject tissue 250. Light remitted from the subject tissue 250 (shown by arrows 228 in Fig. 2B, the remainder of Fig. 2B is identical to Fig. 2A) is conveyed through the imaging assembly 204 to the single optical fiber or fibers of the fiber array 218, and then transmitted by the optical fiber or fiber array 218 to the detection device 236, via the beam-splitter 234. In another embodiment, the device transmitting light to the catheter and receiving light from the catheter is an optical circulator.

[0037] In an exemplary embodiment of the present invention, the fiber array 218 may include one or multiple fibers for detection and illumination. In another exemplary embodiment of the present invention, the detection may occur using a single fiber. Alternatively, the illumination may occur via a fiber array, where each fiber is selectively illuminated to generate multiple focused spots as a function of position on the subject tissue 250. This exemplary method can provide a scanning of the incident light across the sample, while maintaining the probe in a stationary position. The fibers may be illuminated and/or detected simultaneously or illuminating and/or detecting light from one fiber after another in series.

[0038] The data produced by the detection device 236 may then be digitized by an analog-digital converter 238, and analyzed using imaging procedures executed by the processor 240. The imaging procedures applicable with the exemplary embodiments of the present invention are described in U.S. Provisional Patent Appn. No. 60/514,769, entitled "Method and Apparatus for Performing Optical Imaging Using Frequency-Domain Interferometry," filed October 27, 2003 (application WO-A-2005/04 7813 published on 26/05/05), and International Patent Application No. PCT/US03/02349 filed on January 24, 2003 (application WO-A-03/062802). The processor 240 is also operatively connected to the pullback device 215, the rotary junction 212 and the fluid pump 225.

[0039] The diameter of the catheter can be less than 500 μm. Larger diameters may also be utilized within the scope of the present invention.

[0040] Other types of instruments can be used to gather image data. For example, the optics of the catheter 200 can be integrated into other types of instruments, such as endoscopes or laparoscopes. The optics can also form a stand-alone unit passed into the accessory port of standard endoscopes or laparoscopes, and/or integrated into another type of catheter, such as dual-purpose intravascular ultrasound catheter.

[0041] In an exemplary embodiment of the present invention, the detector 236 may be a charge coupled device ("CCD"), a photographic plate, an array of photodetectors, and/or a single detector. In another exemplary configuration, the light source 232 can illuminate the sample with continuous light, continuous broad bandwidth light, wavelength scanning light, or synchronized pulses.

[0042] Fig. 3 illustrates a method/process 300 for gathering data representative of a helical scan if a screening segment of the subject tissue 250 according to the present invention. The process 300 begins in step 301 where the catheter 200 is inserted and positioned within the screening segment of the subject tissue 250. Once the catheter 200 is inserted and positioned properly, the imaging module 232 instructs the fluid pump or operator 225 to inject a bolus of transparent or semi-transparent fluid into the subject tissue 250, in step 302. Depending on the size of the subject tissue 250, the imaging module 232 may alter volume and/or rate of injection of the bolus of transparent or semi-transparent fluid. In an exemplary configuration, the subject tissue 250 is a blood vessel.

[0043] In step 304, the imaging module 232 determines whether the image received from the imaging assembly 204 is of a sufficient quality to begin scanning the subject tissue 250. If the imaging module 232 determines that the image is not of sufficient quality, the process 300 advances to step 302. Otherwise, the process 300 advances to step 306, where the rotary junction 212 begins rotating the rotateable inner shaft 210 and the pullback device 215 begins pulling back the shaft 210.

[0044] The imaging module 232 determines whether the image received from the imaging assembly 204 is of sufficient quality to begin scanning by attempting to detect the presence of blood. The imaging module 232 makes this determination by measuring the amount of scattering the imaging modality is experiencing and/or by analyzing the spectroscopy registered by the imaging modality. If the imaging modality is OCT, other methods may be used.

[0045] When the imaging module 232 measures the amount of scattering experienced by the imaging modality, the imaging module 232 determines whether the light received from the subject tissue 250 is scattered. Saline and other transparent perfusion liquids do not contain an appreciable amount of scattering. Blood on the other

hand, is highly scattering. Due to this effect, a method for determining the presence of blood may be to observe the intensity of the reflection of light back to the catheter. Preferentially, certain wavelengths of light may be used that have the property that the absorption penetration depth is small in both water and blood.

[0046] When the imaging module 232 is utilizing spectroscopy to determine whether blood is present, the imaging module 232 can measure the differential absorption experienced by the imaging modality. Blood adjacent to the subject tissue 250 can be detected by utilizing differential absorption of blood. In blood which is oxygenated, there are several absorption peaks in the visible spectrum, e.g., at 520-590 nm and 800-900 nm. A simple device may obtain the light scattered back from the catheter at these wavelengths, and compare such light to the light scattered back from an adjacent wavelength where blood absorption is low. This comparison can be accomplished by a linear combination of the intensity of light reflected back by the two wavelengths. For example if $R(\lambda_1)$ is the light reflected back to the catheter on the absorption peak and $R(\lambda_2)$ is the light reflected back to the tissue off of the absorption peak, blood can be estimated by several differential/ratiometric combinations of $R(\lambda_1)$ and $R(\lambda_2)$:

$$D1 = \frac{R(\lambda_1)}{R(\lambda_2)}$$

$$D2 = \frac{R(\lambda_1)}{\left[R(\lambda_1) + R(\lambda_2)\right]}$$

$$D3 = \frac{\left[R(\lambda_1) - R(\lambda_2)\right]}{\left[R(\lambda_1) + R(\lambda_2)\right]}$$

$$D4 = \frac{\left[R(\lambda_1) - R(\lambda_2)\right]}{R(\lambda_2)}$$

[0047] The device for delivery and detection can be a simple side firing single or multi-mode optical fiber.

[0048] If the imaging modality is OCT, another method for detecting blood can be used. Since OCT is capable of obtaining a cross-sectional image of the lumen, it is potentially more sensitive to the presence of small amounts of blood than is diffuse spectroscopy. The OCT signal from blood is fairly characteristic, and not commonly observed in other tissues. For example, blood can exhibit a rapid attenuation and a homogeneous appearance. As a result, in one exemplary embodiment, it is possible to process the OCT signal to determine if blood is present. A wide variety of image processing techniques known in the art, such as texture discrimination, pattern recognition, etc. can be used to identify blood. In one embodiment, in order to determine whether blood is present, two parameters are determined: (a) the slope of the logarithm of the OCT axial scan data (attenuation); and (b) the standard deviation of the logarithm of the OCT axial scan data (signal variance). These two parameters can differentiate most human tissue types. Other measures of attenuation and signal variance known in the art can also be utilized to differentiate blood from arterial wall tissue. Other measurements including probability distribution function statistics, Fourier domain analysis, high pass filtering, energy and entropy measurements, edge counting, and N-order moments can be utilized to determine the presence of blood in the lumen of the blood vessel. OCT can be combined with spectroscopy (e.g., performing OCT at two wavelengths), birefringence, and Doppler to further enhance the capability of OCT for identifying blood in the lumen. In one exemplary embodiment of the present invention, the fluid pump 225 continues injecting the bolus of transparent or semi-transparent fluid during the step 304.

[0049] Turning back to the process 300 of Fig. 3, in step 308, the imaging module 232 determines whether the image received from the imaging assembly 204 is of sufficient quality to continue scanning the subject tissue 250. If the imaging module 232 determines that the image is of sufficient quality, the process 300 advances to step 306. Otherwise, the process 300 advances to step 310. At step 310, the rotary junction 212 stops rotating the rotateable inner shaft 210, and the pullback device 215 halts the pullback of the shaft 210. If the fluid pump 225 is continuing to inject the bolus of transparent or semi-transparent fluid, the fluid pump 225 is instructed to discontinue injecting the transparent or semi-transparent fluid. If there is catheter motion, the catheter may be advanced or retracted substantially along the longitudinal axis of the vessel prior to the next bolus injection in order to ensure that the subsequent pullback imaging process does not skip over any areas of tissue.

[0050] This process represents a feedback control loop where a measure of image quality is utilized to control the process/conditions under which images are obtained. If the image is not of sufficient quality, action is taken to improve the image quality before additional images are taken. In an exemplary method, when image quality drops below a predetermined measure but image quality is still sufficient to continue imaging, additional transparent or semi-transparent fluid is injected via the fluid pump 225 improving image quality. In another exemplary method, when image quality drops below a predetermined measure and image quality is insufficient to continue imaging, imaging is halted. The feedback control loop may be set up many different ways in order to automate at least a part of the process 300. A wide variety of image processing techniques known in the art, such as texture discrimination, pattern recognition, etc. can be

used to determine whether or not image quality of the vessel wall is sufficient to continue imaging.

[0051] In an exemplary method, two parameters are determined: (a) the slope of the logarithm of the OCT axial scan data (attenuation); and (b) the standard deviation of the logarithm of the OCT axial scan data (signal variance). These two parameters can differentiate most human tissue types. Other measures of attenuation and signal variance known in the art can also be utilized to identify and characterize the quality of images obtained from arterial wall tissue. These other measurements including image segmentation and blob quantification, morphologic processing, probability distribution function statistics, Fourier domain analysis, high pass filtering, energy and entropy measurements, edge counting, N-order moments. OCT can be combined with spectroscopy (e.g., performing OCT at two wavelengths), birefringence, and Doppler to further enhance the capability of OCT for assessing image quality.

[0052] In step 312, the imaging module 232 determines whether the entire length of the screening segment of the subject tissue 250 has been imaged. If additional portions of the screening segment of the subject tissue 250 need to be imaged, the process 300 advances to step 302. Otherwise, the process 300 advances to step 314 where the imaging module 232 reconstructs the helical or three-dimensional scans of the screening segment of the subject tissue 250 based on the information gathered during the scan. After the helical scans are reconstructed, the imaging module 316 can display the reconstructed data (images) and the process 300 exits.

[0053] Fig. 6 illustrates an imaging system 600 including the specially modified optical catheter 202 disposed within a guide catheter 602. The optical catheter 202 is identical to the optical catheter 202 as illustrated in Fig. 2A, except that the fluid delivery channel 223 and the aperture 221 are not necessarily included in the optical catheter 202 as illustrated in Fig. 6. The fluid delivery channel 223 and the aperture 221 are replaced by the fluid delivery channel 606 and the aperture 604, respectively. In order to use the imaging system 600, the guide catheter 602 is inserted into a blood vessel and positioned adjacent to a target area to be imaged.

[0054] The optical catheter 202 is inserted into the guide catheter 602 until the distal end 220 of the optical catheter 202 protrudes beyond the guide catheter 602 (as shown in Fig. 6). Once the guide catheter 602 is positioned relative to the guide catheter 602, the optical catheter 202 operates in the same manner as discussed above in connection with Figs. 2A, 2B, 3, 4, and 5, with the exception that the fluid pump 225 injects transparent or semi-transparent fluid into the fluid delivery channel 606 and through the aperture 604 to the target area instead of utilizing the fluid delivery channel 223 and aperture 221.

[0055] In an exemplary configuration, the guide catheter 602 is used as the fluid delivery channel. The guide catheter 602 does not necessarily include a special purpose fluid delivery channel 606. The fluid pump 225 is connected directly to the guide catheter 602 and transparent or semi-transparent fluid is provided at the target area via the guide catheter 602. In another exemplary configuration, the imaging assembly 204 protrudes beyond the distal end of the guide catheter 602. The imaging of the target area takes place while the imaging assembly 204 of the optical catheter 202 protrudes from the distal end of the guide catheter 602. In a further exemplary configuration, the guide catheter 602 is transparent and the optical catheter 202 is inserted into the guide catheter 602 until it is adjacent to the target area. The imaging assembly 204 of the optical catheter 202 does not protrude beyond the guide catheter 602 and the imaging of the target area takes place while the optical catheter 202 is within the guide catheter 602.

[0056] The foregoing merely illustrates the principles of the invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous techniques which, although not explicitly described herein, embody the principles of the invention.

Claims

1. An apparatus for imaging an anatomical structure that is provided in contact with a first fluid, comprising:

a housing (208);
a fluid delivery arrangement (225) configured to deliver a volume of a second fluid to an external location with respect to the housing;
an imaging arrangement (224) configured to image the structure at least one of during or after the volume of the second fluid is delivered to the external location, wherein the imaging arrangement is configured to be translated relative to the housing along a path which approximately corresponds to an axis of extension of a surface while imaging the structure; and
a pull-back arrangement (216) operatively connected to the imaging arrangement and configured to translate the imaging arrangement relative to the housing, **characterised in that** the pull-back arrangement is configured to translate the imaging arrangement at a rate of 10mm/second; and
the fluid delivery arrangement comprises one of

- a pump (225) operatively connected to the housing,
- a syringe operatively connected to the housing.

2. The apparatus of claim 1, wherein the second fluid is substantially transparent.

3. The apparatus of claim 1, wherein the anatomical structure is a blood vessel.

4. The apparatus of claim 1, wherein the housing (208) includes an aperture (221) located at a distal end.

5. The apparatus of claim 1, wherein the housing (208) includes an aperture located adjacent to the imaging arrangement.

6. The apparatus of claim 1, wherein the imaging arrangement includes:

at least one optical fiber (214) operatively connected to a directing arrangement which is configured to direct light to the anatomical structure; and
an image processing arrangement (224) operatively connected to the at least one optical fiber.

7. The apparatus of claim 6, wherein the directing arrangement includes optics at the distal end of the imaging arrangement.

8. The apparatus of claim 6, wherein the directing arrangement includes a lens and a light directing element.

9. The apparatus of claim 8, wherein the light directing element is an optical arrangement which is configured to alter at least one direction of light, the optical arrangement capable of directing the light from a direction substantially parallel to the greater axis of the housing to a direction substantially perpendicular to the greater axis of the housing.

10. The apparatus of claim 8, wherein the lens is configured to focuse the light approximately 0.5 mm to 5 mm beyond the housing.

11. The apparatus of claim 1, further comprising a rotating arrangement (212) operatively connected to the imaging arrangement (224) and configured to rotate the imaging arrangement.

12. The apparatus of claim 11, wherein the rotating arrangement is configured to rotate at a rate of at least above approximately 30 rotations/second and at most approximately 1000 rotations/second.

13. The apparatus of claim 1, wherein at least a portion of the housing (208) is transparent.

14. The apparatus of claim 1, wherein the imaging modality is time domain optical coherence tomography, a spectral domain optical coherence tomography or a optical frequency domain imaging.

15. The apparatus of claim 1, further comprising a guide catheter (602) configured to receive the housing (208) therein.

16. The apparatus of claim 15, wherein the fluid delivery arrangement is configured to deliver the second fluid to a proximal end of the guide catheter, such that the second fluid flows through an aperture (604) formed through the guide catheter.

17. The apparatus of claim 1, wherein the imaging arrangement is configured to obtain data associated with the anatomical structure, and further comprising a processing arrangement receiving the data, and capable of controlling at least one of the fluid delivery arrangement or the imaging arrangement as a function of the data.

18. The apparatus of claim 17, wherein the processing arrangement is configured to control at least one of the fluid delivery arrangement and the imaging arrangement based on information previously received by the processing arrangement.

19. The apparatus of claim 18, wherein the processing arrangement is configured to control the translation of the imaging arrangement.

20. The apparatus of claim 18, wherein the processing arrangement is configured to control the fluid delivery of the fluid delivery arrangement (225).

21. The apparatus of claim 18, wherein the processing arrangement is configured to control the translation of the imaging arrangement (208) and the fluid delivery of the fluid delivery arrangement (225).

22. The apparatus of claim 1, further comprising a processing arrangement which is configured to control the translation of the imaging arrangement.

23. The apparatus of claim 1, further comprising a catheter (602) which includes at least one of the housing or the imaging arrangement.

24. The apparatus of claim 23, wherein the fluid delivery arrangement is configured to deliver the second fluid through an internal portion of the catheter.

25. The apparatus of claim 23, wherein the imaging arrangement includes imaging optics which is configured to emit a beam to obtain the image, the beam being transmitted outside of the catheter (602).

Patentansprüche

1. Vorrichtung zum Abbilden einer anatomischen Struktur, die für einen Kontakt mit einem ersten Fluid vorgesehen ist, welche aufweist:

   ein Gehäuse (208);
   eine Fluidzuführungseinrichtung (225), die zur Zuführung eines Volumens eines zweiten Fluids zu einer in Bezug auf das Gehäuse außerhalb liegenden Stelle konfiguriert ist;
   eine Abbildungseinrichtung (224), die konfiguriert ist, die Struktur während und/oder nachdem das Volumen des zweiten Fluids zu der außerhalb liegenden Stelle zugeführt ist, abzubilden, wobei die Abbildungseinrichtung konfiguriert ist, während der Abbildung der Struktur im Verhältnis zu dem Gehäuse entlang eines Pfades, der annähernd einer Verlängerungsachse einer Oberfläche entspricht, verschoben zu werden, und
   eine Rückzieheinrichtung (216), die mit der Abbildungseinrichtung verbunden und konfiguriert ist, die Abbildungseinrichtung im Verhältnis zum Gehäuse zu verschieben, **dadurch gekennzeichnet, dass** die Rückzieheinrichtung konfiguriert ist, die Abbildungseinrichtung mit einer Rate von 10 mm/Sekunde zu verschieben; und die Fluidzuführungseinrichtung eines aufweist aus

      - einer Pumpe (225), die mit dem Gehäuse verbunden ist,
      - einer Spritze, die mit dem Gehäuse verbunden ist.

2. Vorrichtung nach Anspruch 1, wobei das zweite Fluid im Wesentlichen transparent ist.

3. Vorrichtung nach Anspruch 1, wobei die anatomische Struktur ein Blutgefäß ist.

4. Vorrichtung nach Anspruch 1, wobei das Gehäuse (208) eine Öffnung (221) aufweist, die an einem distalen Ende angeordnet ist.

5. Vorrichtung nach Anspruch 1, wobei das Gehäuse (208) eine Öffnung aufweist, die benachbart zu der Abbildungseinrichtung angeordnet ist.

6. Vorrichtung nach Anspruch 1, wobei die Abbildungseinrichtung Folgendes aufweist:

   mindestens eine optische Faser (214), die mit einer Leiteinrichtung verbunden ist, welche konfiguriert ist, Licht auf die anatomische Struktur zu leiten; und
   eine Bildbearbeitungseinrichtung (224), die mit der mindestens einen optischen Faser verbunden ist.

7. Vorrichtung nach Anspruch 6, wobei die Leiteinrichtung eine Optik an dem distalen Ende der Abbildungseinrichtung aufweist.

8. Vorrichtung nach Anspruch 6, wobei die Leiteinrichtung eine Linse und ein Lichtleitelement aufweist.

9. Vorrichtung nach Anspruch 8, wobei das Lichtleitelement eine optische Einrichtung ist, welche konfiguriert ist, mindestens eine Richtung des Lichts zu ändern, wobei die optische Einrichtung in der Lage ist, das Licht aus einer Richtung, die im Wesentlichen parallel zu der größeren Achse des Gehäuses ist, in eine Richtung, die im Wesentlichen senkrecht zu der größeren Achse des Gehäuses ist, zu leiten.

10. Vorrichtung nach Anspruch 8, wobei die Linse konfiguriert ist, das Licht annähernd 0,5 mm bis 5 mm außerhalb des Gehäuses zu fokussieren.

11. Vorrichtung nach Anspruch 1, die ferner eine Dreheinrichtung (212) umfasst, die mit der Abbildungseinrichtung (214) verbunden und konfiguriert ist, die Abbildungseinrichtung zu drehen.

12. Vorrichtung nach Anspruch 11, wobei die Dreheinrichtung konfiguriert ist, sich mit einer Rate von mindestens oberhalb annähernd 30 Umdrehungen/Sekunde und höchstens annähernd 1.000 Umdrehungen/Sekunde zu drehen.

13. Vorrichtung nach Anspruch 1, wobei mindestens ein Teil des Gehäuses (208) transparent ist.

14. Vorrichtung nach Anspruch 1, wobei das Bildgebungsverfahren eine optische Kohärenztomographie in der Zeitdomäne, eine optische Kohärenztomographie in der Spektraldomäne oder eine optische Frequenzdomänen-Bildgebung ist.

15. Vorrichtung nach Anspruch 1, die ferner einen Führungskatheter (602) aufweist, der konfiguriert ist, das Gehäuse (208) darin aufzunehmen.

16. Vorrichtung nach Anspruch 15, wobei die Fluidzuführungseinrichtung konfiguriert ist, das zweite Fluid zu einem proximalen Ende des Führungskatheters derart zuzuführen, dass das zweite Fluid durch eine Öffnung (604) fließt, welche durch den Führungskatheter ausgebildet ist.

17. Vorrichtung nach Anspruch 1, wobei die Abbildungseinrichtung konfiguriert ist, Daten zu empfangen, die mit der anatomischen Struktur in Zusammenhang stehen, und ferner eine Verarbeitungseinrichtung

zum Empfangen der Daten aufweist und in der Lage ist, mindestens eine aus Fluidzuführungseinrichtung oder Abbildungseinrichtung als eine Funktion der Daten zu steuern.

18. Vorrichtung nach Anspruch 17, wobei die Verarbeitungseinrichtung konfiguriert ist, mindestens eine aus Fluidzuführungseinrichtung und Abbildungseinrichtung auf der Grundlage von Information zu steuern, die vorher durch die Verarbeitungseinrichtung empfangen wurde.

19. Vorrichtung nach Anspruch 18, wobei die Verarbeitungseinrichtung konfiguriert ist, das Verschieben der Abbildungseinrichtung zu steuern.

20. Vorrichtung nach Anspruch 18, wobei die Verarbeitungseinrichtung konfiguriert ist, die Fluidzuführung der Fluidzuführungseinrichtung (225) zu steuern.

21. Vorrichtung nach Anspruch 18, wobei die Verarbeitungseinrichtung konfiguriert ist, das Verschieben der Abbildungseinrichtung (208) und die Fluidzuführung der Fluidzuführungseinrichtung (225) zu steuern.

22. Vorrichtung nach Anspruch 1, die ferner eine Verarbeitungseinrichtung aufweist, die konfiguriert ist, das Verschieben der Abbildungseinrichtung zu steuern.

23. Vorrichtung nach Anspruch 1, die ferner einen Katheter (602) umfasst, der mindestens eines aus Gehäuse oder Abbildungseinrichtung aufweist.

24. Vorrichtung nach Anspruch 23, wobei die Fluidzuführungseinrichtung konfiguriert ist, das zweite Fluid durch einen inneren Teil des Katheters zuzuführen.

25. Vorrichtung nach Anspruch 23, wobei die Abbildungseinrichtung eine Abbildungsoptik aufweist, die konfiguriert ist, einen Strahl auszusenden, um die Abbildung zu erhalten, wobei der Strahl außerhalb des Katheters (602) übertragen wird.

Revendications

1. Appareil pour imager une structure anatomique qui est mise en contact avec un premier fluide, comprenant:

un boîtier (208),
un agencement de distribution de fluide (125) configuré pour distribuer un volume d'un second fluide à un emplacement externe par rapport au boîtier,
un agencement d'imagerie (224) configuré pour imager la structure au moins pendant ou après la distribution du volume du second fluide à l'emplacement externe, dans lequel l'agencement d'imagerie est configuré pour être transféré par rapport au boîtier le long d'un trajet qui correspond approximativement à un axe de prolongement d'une surface pendant l'imagerie de la structure, et
un agencement de retour (216) relié en fonctionnement à l'agencement d'imagerie et configuré pour transférer l'agencement d'imagerie par rapport au boîtier, **caractérisé en ce que** l'agencement de retour est configuré pour transférer l'agencement d'imagerie à une vitesse de 10 mm/seconde, et
l'agencement de distribution de fluide comprend l'une parmi :

- une pompe (225) reliée en fonctionnement au boîtier,
- une seringue reliée en fonctionnement au boîtier.

2. Appareil selon la revendication 1, dans lequel le second fluide est sensiblement transparent.

3. Appareil selon la revendication 1, dans lequel la structure anatomique est un vaisseau sanguin.

4. Appareil selon la revendication 1, dans lequel le boîtier (208) inclut une ouverture (221) positionnée à une extrémité distale.

5. Appareil selon la revendication 1, dans lequel le boîtier (208) inclut une ouverture positionnée de façon adjacente à l'agencement d'imagerie.

6. Appareil selon la revendication 1, dans lequel l'agencement d'imagerie inclut

au moins une fibre optique (214) reliée en fonctionnement à un agencement d'orientation lequel est configuré pour diriger la lumière vers la structure anatomique, et
un agencement de traitement d'images (224) relié en fonctionnement à au moins une fibre optique.

7. Appareil selon la revendication 6, dans lequel l'agencement d'orientation inclut une unité optique au niveau de l'extrémité distale de l'agencement d'imagerie.

8. Appareil selon la revendication 6, dans lequel l'agencement d'orientation inclut une lentille et un élément d'orientation de lumière.

9. Appareil selon la revendication 8, dans lequel l'élément d'orientation de lumière est un agencement op-

tique qui est configuré pour modifier au moins une direction de lumière, l'agencement optique étant capable de diriger la lumière depuis une direction sensiblement parallèle à l'axe supérieur du boîtier jusqu'à une direction sensiblement perpendiculaire à l'axe supérieur du boîtier.

10. Appareil selon la revendication 8, dans lequel la lentille est configurée pour focaliser la lumière approximativement 0,5 mm à 5 mm au-delà du boîtier.

11. Appareil selon la revendication 1, comprenant en outre un agencement de rotation (212) relié en fonctionnement à l'agencement d'imagerie (224) et configuré pour mettre en rotation l'agencement d'imagerie.

12. Appareil selon la revendication 11, dans lequel l'agencement de rotation est configuré pour tourner à une vitesse minimale supérieure à environ 30 rotations/seconde et à une vitesse maximale égale à environ 1000 rotations/seconde.

13. Appareil selon la revendication 1, dans lequel au moins une partie du boîtier (208) est transparente.

14. Appareil selon la revendication 1, dans lequel la modalité d'imagerie est une tomographie par cohérence optique de domaine temporel, une tomographie par cohérence optique de domaine spectral ou une imagerie optique de domaine fréquentiel.

15. Appareil selon la revendication 1, comprenant en outre un cathéter de guidage (602) configuré pour recevoir le boîtier (208) dans celui-ci.

16. Appareil selon la revendication 15, dans lequel l'agencement de distribution de fluide est configuré pour distribuer le second fluide à une extrémité proximale d'un cathéter de guidage, de sorte que le second fluide circule à travers une ouverture (604) formée dans le cathéter de guidage.

17. Appareil selon la revendication 1, dans lequel l'agencement d'imagerie est configuré pour obtenir des données associées à la structure anatomique, et comprenant en outre un agencement de traitement recevant les données, et pouvant commander au moins l'un de l'agencement de distribution de fluide ou de l'agencement d'imagerie en fonction des données.

18. Appareil selon la revendication 17, dans lequel l'agencement de traitement est configuré pour commander au moins l'un de l'agencement de distribution de fluide et de l'agencement d'imagerie sur la base d'informations reçues au préalable par l'agencement de traitement.

19. Appareil selon la revendication 18, dans lequel l'agencement de traitement est configuré pour commander le transfert de l'agencement d'imagerie.

20. Appareil selon la revendication 18, dans lequel l'agencement de traitement est configuré pour commander la distribution de fluide de l'agencement de distribution de fluide (225).

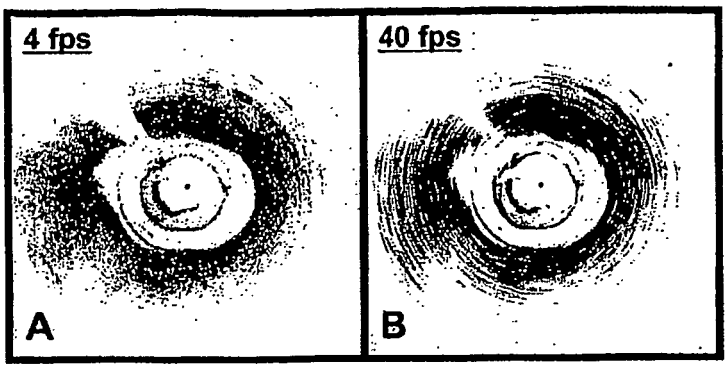
21. Appareil selon la revendication 18, dans lequel l'agencement de traitement est configuré pour commander le transfert de l'agencement d'imagerie (208) et la distribution de fluide de l'agencement de distribution de fluide (225).

22. Appareil selon la revendication 1, comprenant en outre un agencement de traitement lequel est configuré pour commander le transfert de l'agencement d'imagerie.

23. Appareil selon la revendication 1, comprenant en outre un cathéter (602) lequel inclut au moins l'un du boîtier ou de l'agencement d'imagerie.

24. Appareil selon la revendication 23, dans lequel l'agencement de distribution de fluide est configuré pour distribuer le second fluide à travers une partie interne du cathéter.

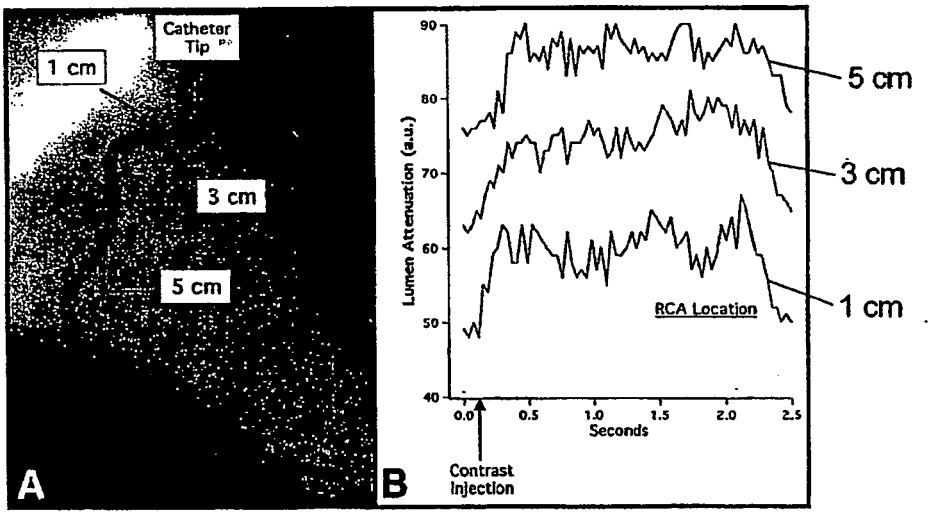
25. Appareil selon la revendication 23, dans lequel l'agencement d'imagerie inclut une unité optique d'imagerie laquelle est configurée pour émettre un faisceau afin d'obtenir l'image, le faisceau étant transmis à l'extérieur du cathéter (602).



100

(PRIOR ART)

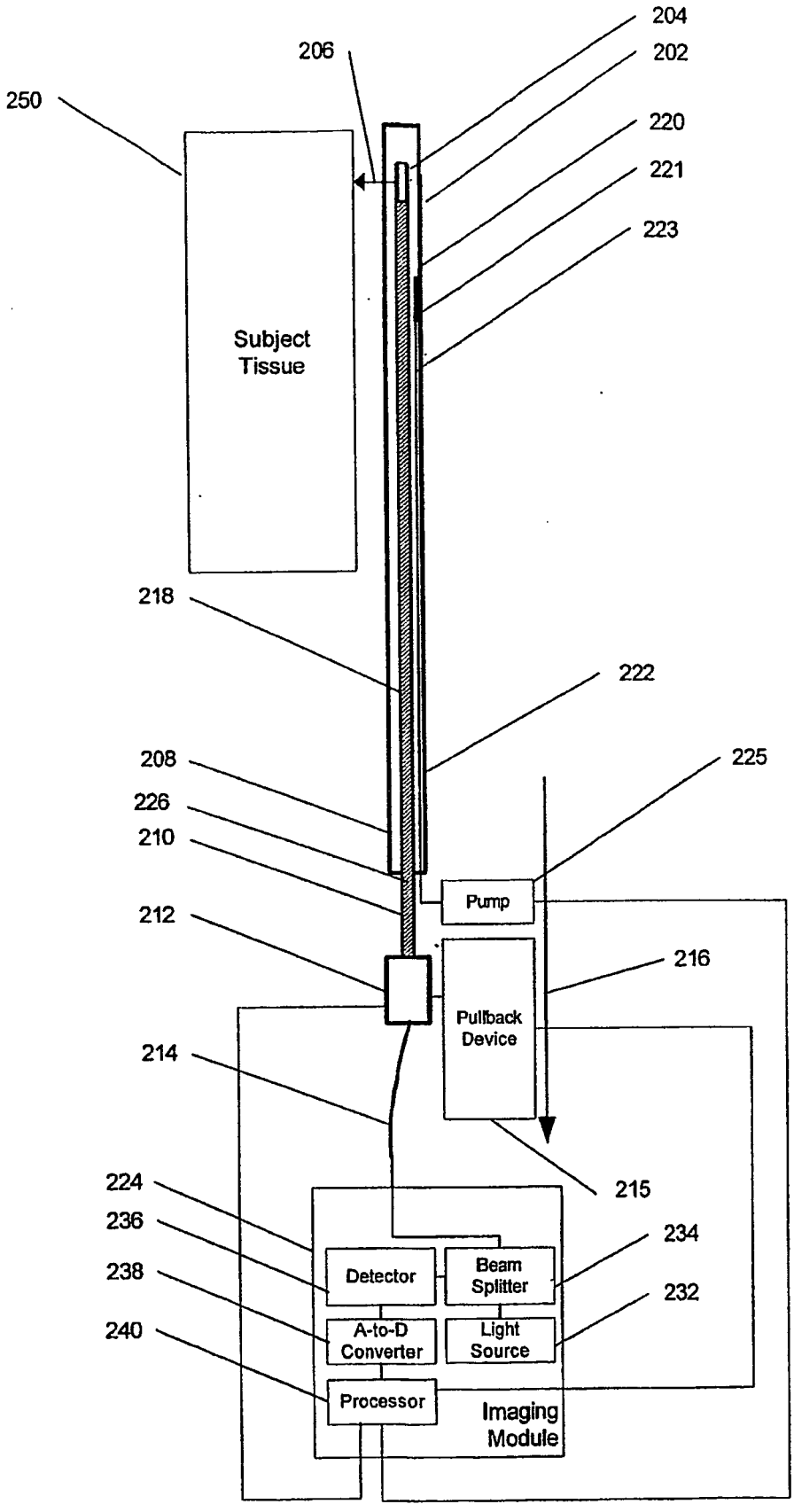
FIG. 1A



150

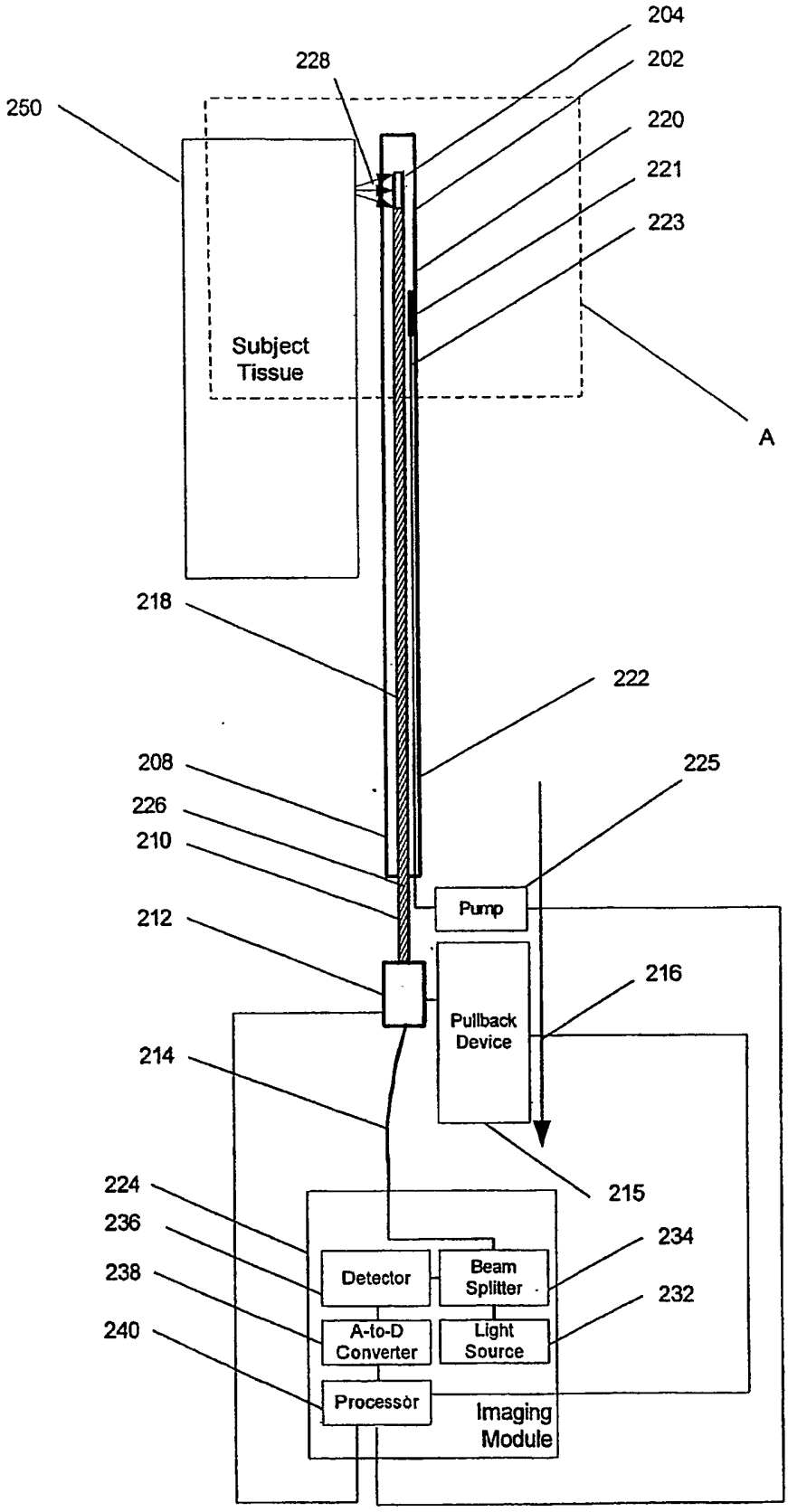
(PRIOR ART)

FIG. 1B


204
206
202
250
220
221
223
Subject Tissue
218
222
208
225
226
210
Pump
212
216
Pullback Device
214
215
224
236
234
Detector
Beam Splitter
238
232
A-to-D Converter
Light Source
240
Processor
Imaging Module

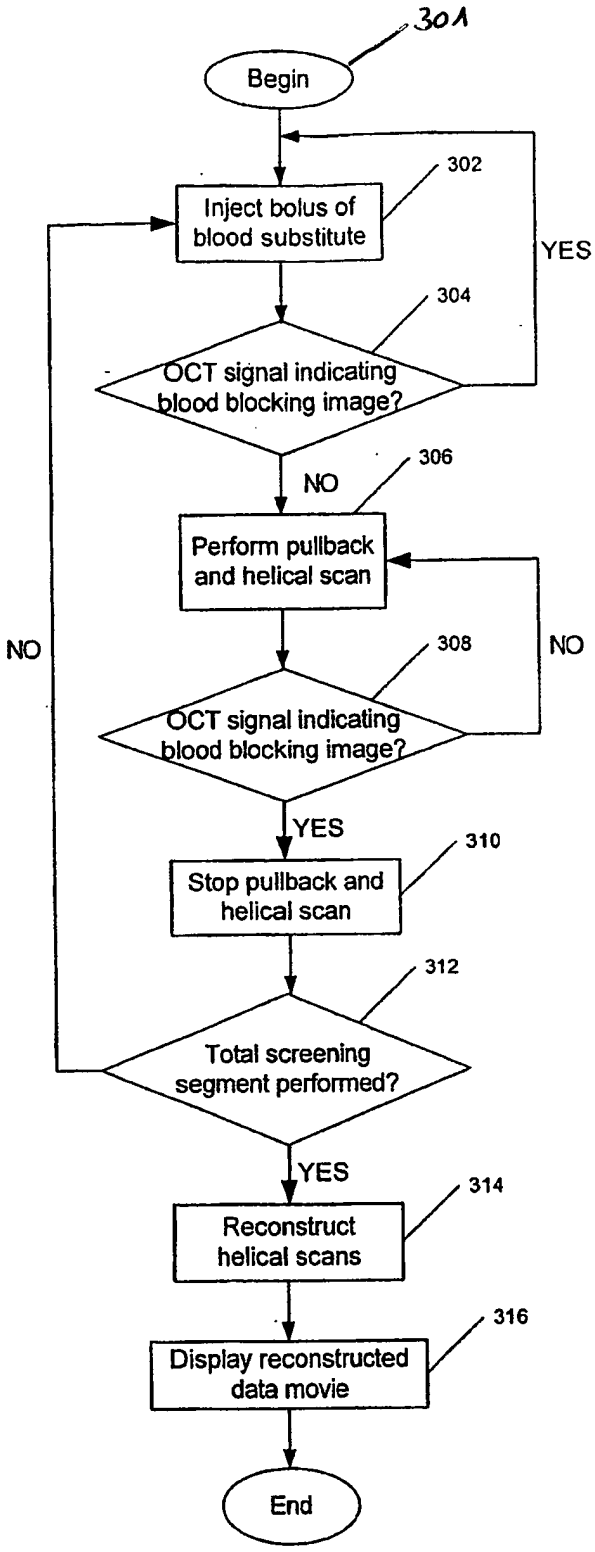
200

FIG. 2A


204
202
228
250
220
221
223
Subject Tissue
A
218
222
208
225
226
210
Pump
212
216
Pullback Device
214
215
224
236
234
Detector
Beam Splitter
238
232
A-to-D Converter
Light Source
240
Processor
Imaging Module

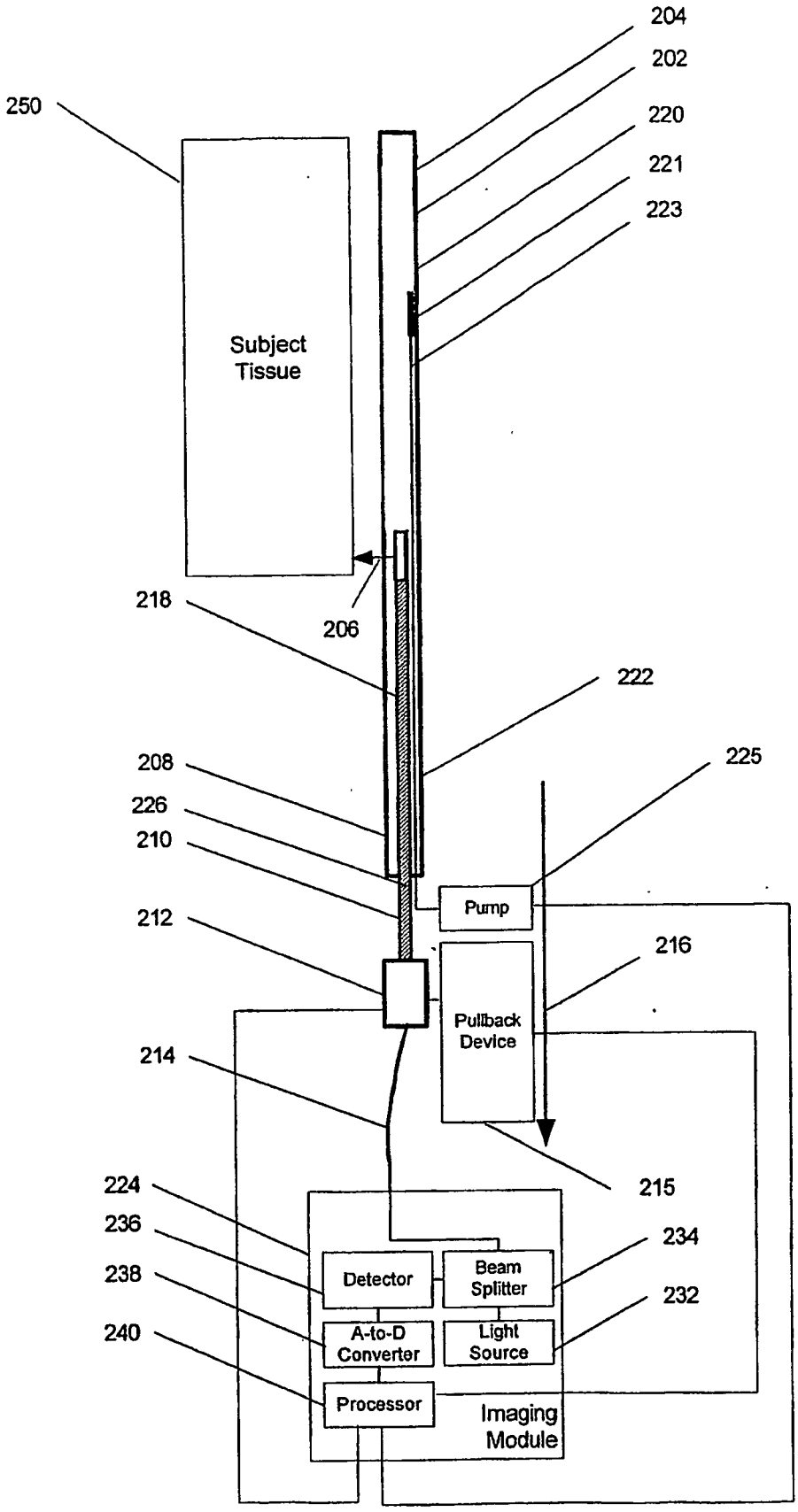
200

FIG. 2B


301
Begin
302
Inject bolus of blood substitute
YES
304
OCT signal indicating blood blocking image?
NO
306
Perform pullback and helical scan
NO
308
OCT signal indicating blood blocking image?
NO
YES
310
Stop pullback and helical scan
312
Total screening segment performed?
NO
YES
314
Reconstruct helical scans
316
Display reconstructed data movie
End

300

FIG. 3


204
202
250
220
221
223
Subject Tissue
218
206
222
208
225
226
210
Pump
212
216
Pullback Device
214
215
224
236
234
Detector
Beam Splitter
238
232
A-to-D Converter
Light Source
240
Processor
Imaging Module

200

FIG. 4

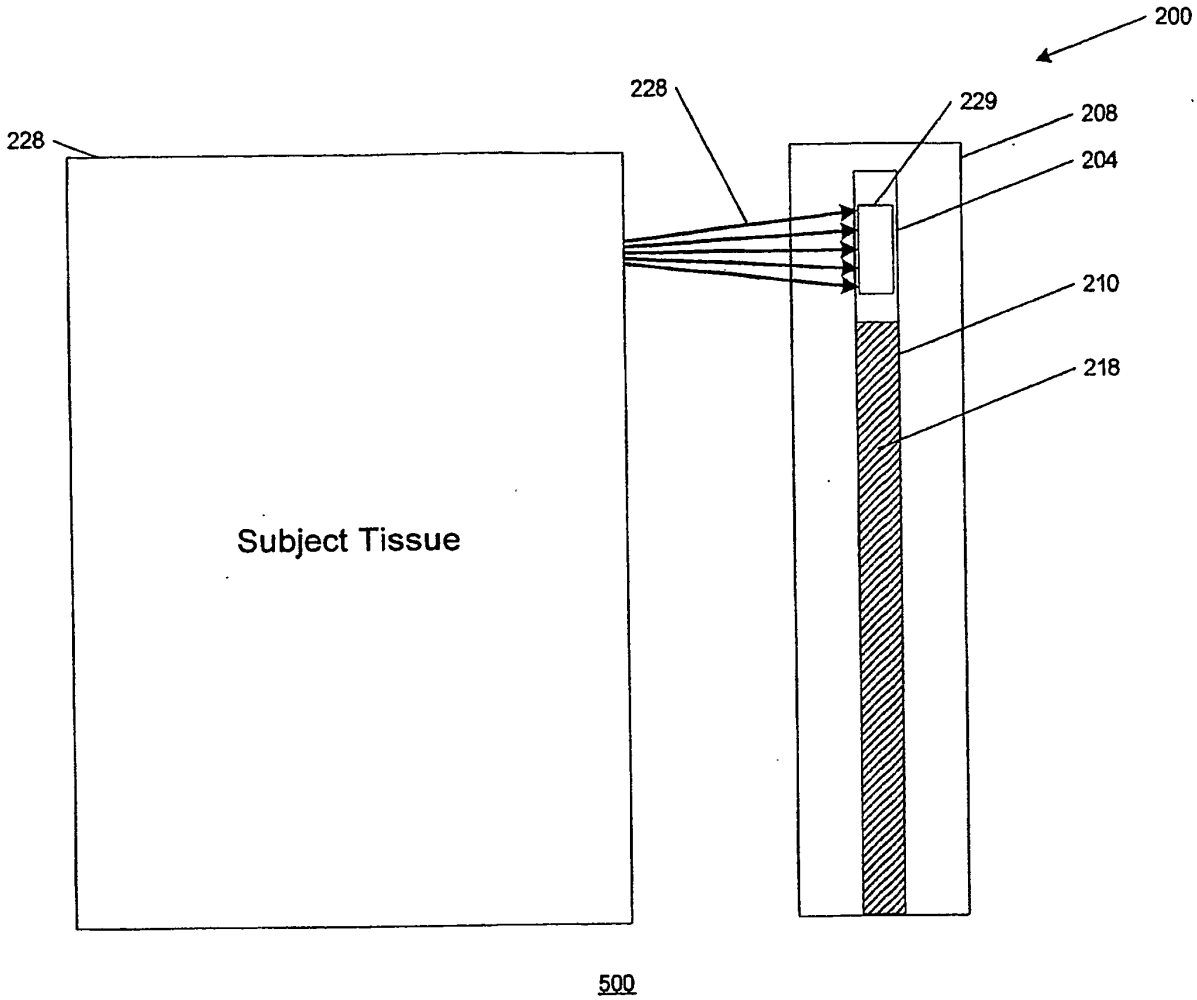


FIG. 5A

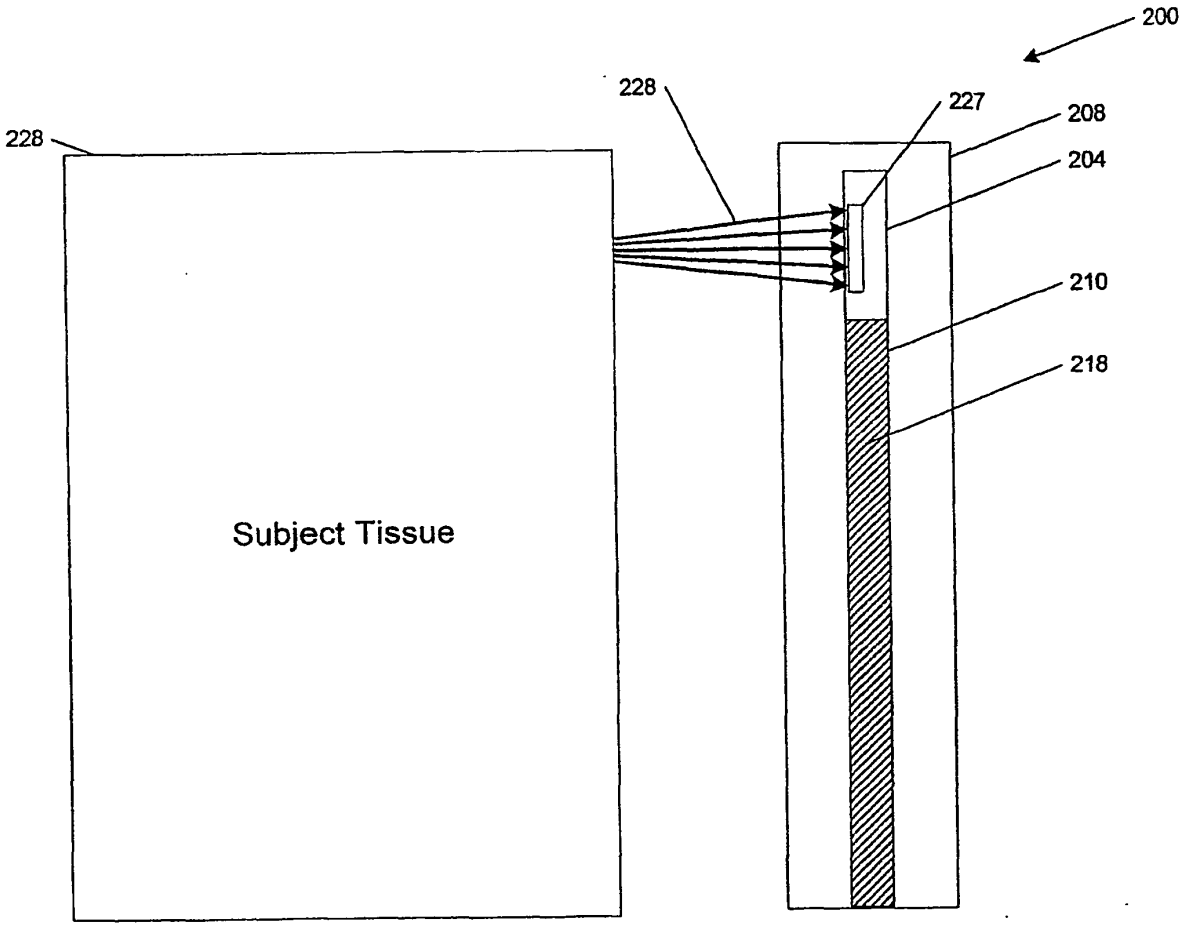
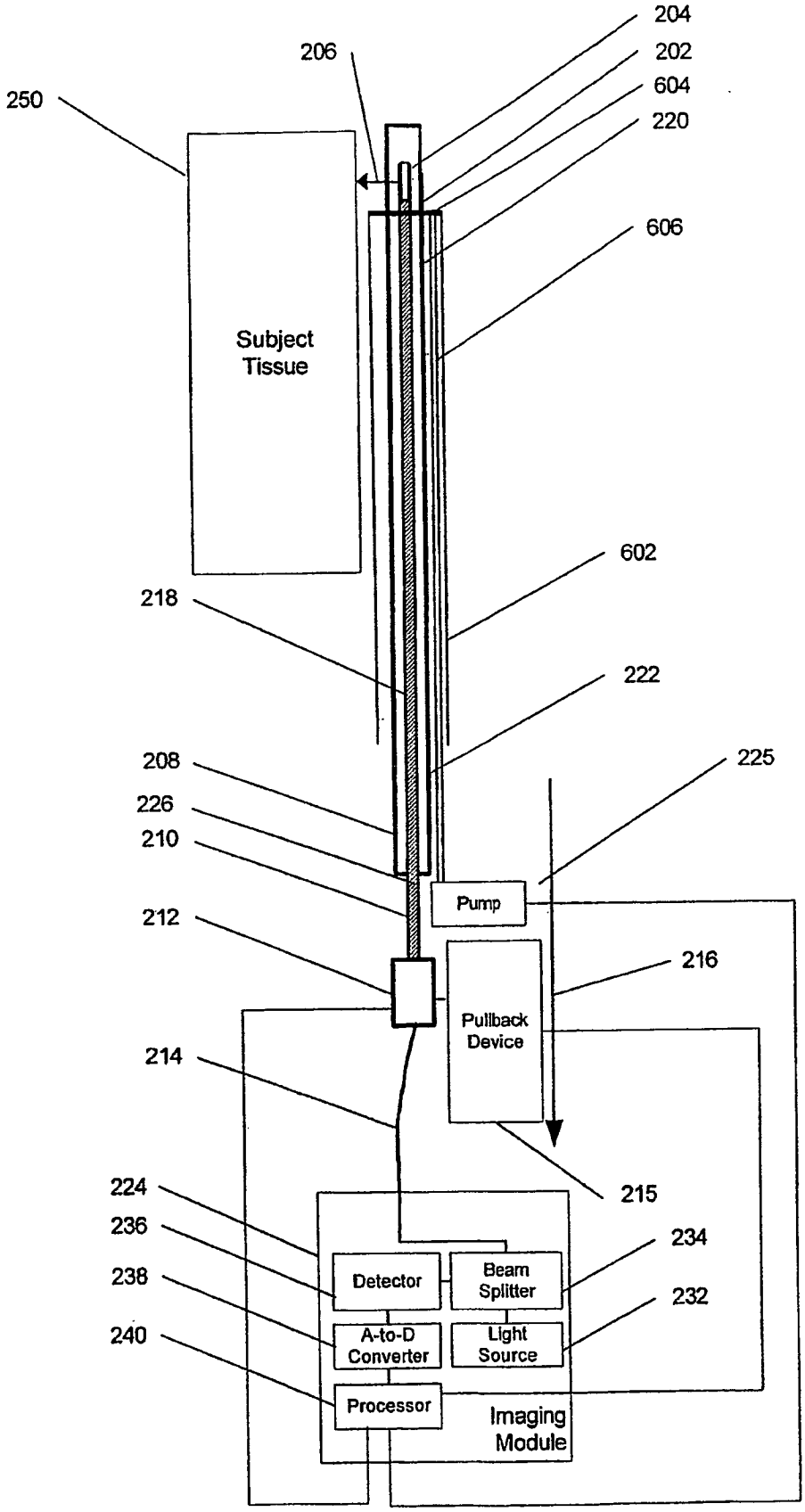


FIG. 5B


204
206
202
250
604
220
606
Subject Tissue
602
218
222
208
225
226
210
Pump
212
216
Pullback Device
214
215
224
234
236
Detector
Beam Splitter
238
232
A-to-D Converter
Light Source
240
Processor
Imaging Module

600

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	成像设备包括流体输送装置和回拉装置		
公开(公告)号	EP1793731B1	公开(公告)日	2013-12-25
申请号	EP2005792862	申请日	2005-08-24
[标]申请(专利权)人(译)	通用医疗公司		
申请(专利权)人(译)	总医院CORPORATION		
当前申请(专利权)人(译)	总医院CORPORATION		
[标]发明人	TEARNEY GUILLERMO J SHISHKOV MILEN BOUMA BRETT E		
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摘要(译)

提供了一种用于对与不透明流体接触的结构的表面成像的装置，方法和软件布置。该装置包括制品（208）（例如，壳体），流体输送装置和成像装置（204）。壳体包括形成在制品中的孔（221）。流体输送装置构造成将一定体积的基本上透明的流体输送到形成在壳体中的孔。成像装置被配置成在透明流体的体积被输送到孔之后使用成像模态对结构的表面成像，其中成像装置和/或制品被平移（通过回拉装置-215）沿着结构的表面，同时对结构的表面进行成像。