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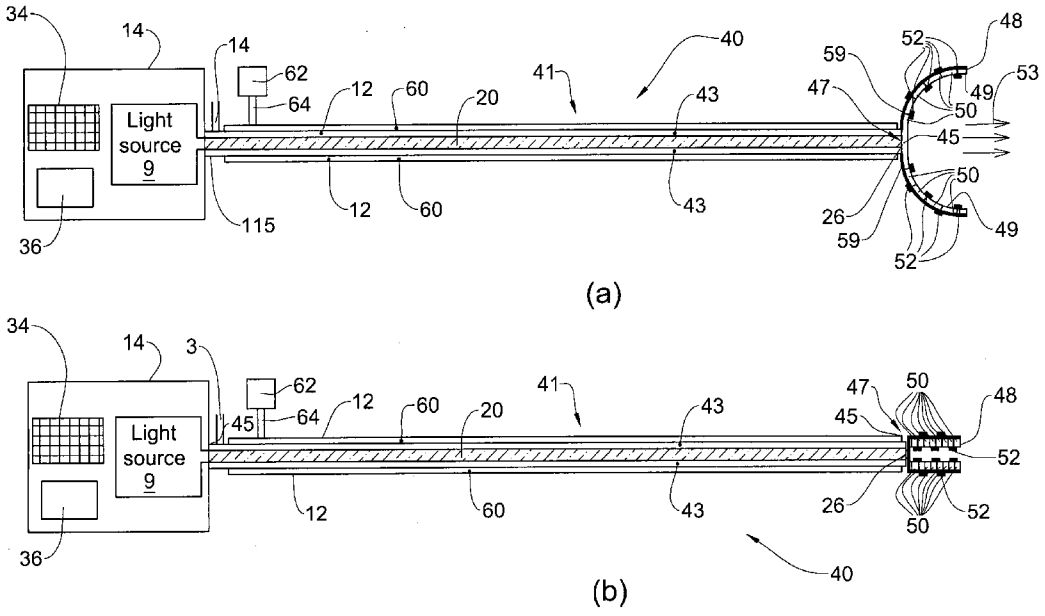
(54) **Title:** DEVICE FOR IRRADIATING AN INTERNAL BODY SURFACE



(57) **Abstract:** The invention provides a device and method for illuminating a body surface. A light source is optically coupled to the proximal end of a light guide and a light scatterer is optically coupled to the distal end of the light guide. The device includes a deployment mechanism that is configured to bring the light scatterer from a small caliber configuration in which the light scatterer is delivered to the body surface to a large caliber configuration in which the light scatterer irradiates the body surface. The invention may be used, for example, irradiate the periadventitial surface of an aneurysmal blood vessel.

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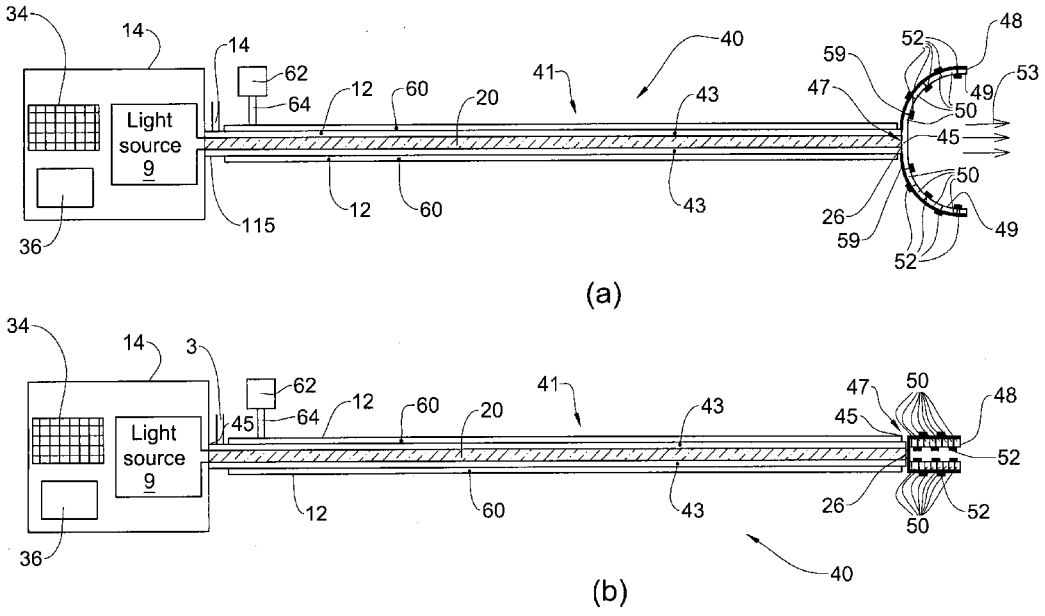

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DEVICE FOR IRRADIATING AN INTERNAL BODY SURFACE

FIELD OF THE INVENTION

This invention relates to medical devices and more specifically to such devices for internal irradiation of the body.

BACKGROUND OF THE INVENTION

Application of light to a tissue surface has been used in several medical treatments. For example, it is known to apply light to a tissue surface in order to heal a pathological state, to remove a stenosis in a blood vessel or for laser welding of tissues, for example in order to treat a rupture in a vessel wall or to perform an anastomosis of two blood vessels. It is also known to use application of light for tissue regeneration and therapy. For example low level laser irradiation in the visible to far-red range of the light spectrum has been shown clinically to accelerate wound healing in skin wounds, and reduce pain and inflammation in musculoskeletal disorders. The underlying mechanisms are initiating (biostimulating) processes such as collagen synthesis, cell proliferation, and reducing secretion of inflammatory markers. Gavish et al., *Lasers in Surgery and Medicine* (2006) 38:779-786, which is incorporated herein by reference, discloses that low level laser *in vitro* stimulates vascular smooth muscle cell proliferation and collagen synthesis, modulates the equilibrium between regulatory matrix remodeling enzymes, and inhibits pro-inflammatory IL-1-β gene expression.

US patent No. 7051738 to Oron et al discloses an apparatus for applying light to the heart tissue for a biostimulative and cytoprotective effect. US patent No. 5370608 to Sahota et al discloses a light angioplasty catheter for exposing

the vessel wall to light from an intravascular approach for the prevention of restenosis.

US Patent No. 7,108,692 to Frenz et al discloses an apparatus for applying light to the interior surface of a vessel wall for laser welding of two vessels. Light generated by an extracorporeal light source is guided to the interior of the blood vessel to be treated by a light guide. A light deflector directs the light in a substantially radial fashion onto the vessel wall.

Abdominal Aortic Aneurysm (AAA) formation is an arteriosclerotic process characterized by marked disruption of the musculoelastic lamellar structure of the media. Extensive destruction of the elastic tissue is associated with marked inflammatory cell infiltration and progressive diminution in the number of viable smooth muscle cells. With time, and aggravated by contributory risk factors such as systolic hypertension, aneurysm growth occurs through a complicated, but insidious, imbalance between matrix protein production and degradation, favoring expansion, thereby increasing the risk of rupture of the weakened wall.

AAA is present in approximately 10% of individuals over the age of 65 years, with its frequency increasing as the proportion of elderly individuals in the general population continues to rise. It is widely known that the risk of rupture increases in approximate proportion to aneurysm size, which can be monitored by computed tomography (CT), ultrasound, or magnetic resonance imaging (MRI). The estimated risk of rupture ranges from 10-20% for an abdominal aneurysm 6-7 cm in diameter, to 30-50% if the maximum diameter is greater than 8 cm. Overall mortality from a ruptured AAA is greater than 90%.

Current forms of aneurysm treatment focus either on the open abdomen, surgical, graft-based repair or endovascular exclusion of the diseased segment of aorta with large, membrane-covered, e.g. Gortex covered stents. Both techniques have major side effects with potentially life-threatening consequences, particularly in patients of advanced age (the majority of patients) or others at high risk or compromised cardiac function.

SUMMARY OF THE INVENTION

In its first aspect, the present invention provides a device for illuminating a tissue surface. The device of the invention may be used to radiate a tissue surface, for example, for treatment of an aneurysm, tissue welding, or removal of a stenosis in a blood vessel. The illuminating device of the invention has a slender shaft that may be rigid or flexible, as required in any application. Light is irradiated from the distal end of the shaft. In one preferred embodiment, the shaft is connected at its proximal end to a light source, that may be, for example, a laser. Light generated by a light source at the proximal end of the shaft is conducted through the shaft via a light guide to the distal end of the shaft. Alternatively, a light source, such as a light emitting diode (LED) may be positioned at the distal end of the shaft. A light scatterer is positioned at the distal end of the shaft that is optically coupled to the light guide. Light emerging from the distal end of the light guide is scattered by the light scatterer so that light emerges from the light scatter from an illuminating surface having an area that is larger than the cross-sectional area of the light guide The illuminating surface is transformable between an undeployed, small caliber configuration in which it is delivered to the tissue surface to be treated, and a deployed, large caliber configuration in which the treatment is delivered. In the deployed configuration, the illuminating surface is preferably shaped to conform to the surface to be radiated so that the illuminating surface can be applied onto the surface to be radiated. For example, for illuminating the perivascular (adventitial) surface of a blood vessel, the deployed illuminating surface would preferably have a partial cylindrical surface. As explained below, this enhances coupling and homogeneity of the light radiated from the illuminating surface and radiation of the surface to be treated. At the conclusion of the treatment, the illuminating surface is brought to its small caliber undeployed configuration, and the device is removed from the body.

The illuminating device of the invention may be provided with means for firmly attaching the deployed illuminating surface to the tissue surface to be

treated. Such means may comprise, for example, use of suction or attachment hooks.

The light source is selected in accordance with the requirements of the particular application. For example, in order to treat an aneurysm, low level laser irradiation (also known as *"low energy laser"*, *"photo-biostimulation"* and *"red-light therapy"*) in the range of 500 to 900 nm, and more preferably in the range of 600 to 900 nm, may be used that is preferably emitted from the illuminating surface with an energy flux in the range of about 0.01 to about 50 Joules/cm^2, and more preferably from about 0.1 to about 5 Joules/cm^2. For surgical welding, light in the 780 to 2010 nm range may be used, in which case the light source may be a semiconductor diode laser that generates 808nm light or a diode-pumped Ho:Y AG laser which generates 2010 nm light.

In its second aspect, the invention provides a method for treating a tissue surface. In accordance with this aspect of the invention, the distal end of the illuminating device of the invention is delivered, with the light illuminating surface in its undeployed configuration to the body site to be treated. The light illuminating surface is then brought to its deployed configuration and is applied to the surface to be treated, and the surface to be treated is radiated. At the conclusion of the radiation, the light illuminating surface is removed from the body surface and the light illuminating surface is brought into its undeployed configuration and the device is removed from the body.

The device and method of the invention may be used for illuminating the perivascular surface of a blood vessel, for example, in order to treat an aneurysm. Without wishing to be bound by a particular theory, it is believed that irradiating an aneurysmal blood vessel with low level laser irradiation retards progression of the aneurysm by bio-stimulating the vessel wall to produce extracellular matrix and reduce inflammation.

Thus, in its first aspect, the invention provides a device for illuminating a body surface, comprising:

(a) a shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

(b) a light source optically coupled to the proximal end of the light guide;

(c) a light scatterer optically coupled to the distal end of the light guide, the light scatterer having a small caliber configuration and a large caliber configuration, and further having an illuminating surface having an area greater than the cross sectional area of the light guide; and

(d) a deployment mechanism configured to bring the light scatterer from the small caliber configuration to the large caliber configuration.

In its second aspect, the invention provides a method for illuminating a body surface, comprising:

(a) providing a device for illuminating the body surface, the device comprising:

a shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

a light source optically coupled to the proximal end of the light guide;

a light scatterer optically coupled to the distal end of the light guide, the light scatterer having a small caliber configuration and a large caliber configuration, and further having an illuminating surface having an area greater than the cross sectional area of the optic fiber; and

a deployment mechanism configured to bring the light scatterer from the small caliber configuration to the large caliber configuration ;

(b) delivering the distal end of the shaft to the body surface with the light scatterer in the small caliber configuration;

(c) activating the deployment mechanism to bring the light scatterer into the large caliber configuration;

(d) applying the illuminating surface to the body surface; and

(e) illuminating the body surface from the light source.

In its third aspect, the invention provides a method for treating an aneurysmal blood vessel comprising irradiating the blood vessel with radiation having a wavelength from 500 to 900 nm.

In its fourth aspect, the invention provides a device for illuminating a body surface , comprising:

(a) an elongated shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

(b) a light source optically coupled to the proximal end of the light guide and illuminating light having a wavelength in the range of 500 to 900 nm; and

(c) a light scatterer optically coupled to the distal end of the light guide,.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a device for illuminating a tissue surface in accordance with one embodiment of the invention;

Fig. 2 shows a device for illuminating a tissue surface in accordance with a second embodiment of the invention;

Fig. 3 shows a device for illuminating a tissue surface in accordance with a third embodiment of the invention; and

Fig. 4 shows use of the device of the invention for treating an aneurysm.

DETAILED DESCRIPTION OF EMBODIMENTS

Fig. 1 shows a device, generally indicated by **10**, for illuminating a tissue surface to be treated, in accordance with one embodiment of the invention. The tissue surface may be, for example, the outer surface of a blood vessel where an aneurysm has formed. The illuminating device has a slender shaft **11**, shown in longitudinal section in Fig. 1, having a proximal end **15** and a distal end **17**. The shaft **11** may be rigid or flexible, as required in any application. The shaft **11** has a sheath **13** surrounding a light guide **20** that may consist of a single optical fiber or a bundle of optical fibers. The optical fiber is typically made from glass.

The shaft **11** is connected at its proximal end **15** to a control unit **14** that houses a light source **9**, that may be, for example, a laser. Light generated by the light source **9**, enters the light guide **20** and is conducted through the light guide **20** to the distal end of the light guide **20**. Since the end face **26** of the distal end of the light guide **20** is flat, the pencil of light emerging from the end face **26** will have a cross-sectional area essentially equal to the cross-sectional area of the light guide **20**. . Thus, in accordance with the invention, in order to increase the radiated area, the radiation device **10** further comprises a light scatterer **23** positioned at the distal end of the light guide **20**, that is optically coupled to the light guide **20**. The light scatterer **23** has a deployed configuration shown in Fig. 1a in which an illuminating surface **29** has a large caliber. Light emitted from the end face **26** of the light guide **20** enters the light scatterer **23** at a first surface **25** and is scattered through the light scatterer **23**. The light is then emitted from the illuminating surface **29**, as indicated by the arrows **27** to radiate the site to be treated, as described below. The illuminating surface has an area that is greater than the cross-sectional area of the light guide 20. In the deployed configuration, the illuminating surface **29** is preferably shaped to conform to the surface to be radiated so that the illuminating surface can be applied onto the surface to be radiated. For example, for illuminating the outer surface of a blood vessel, the illuminating surface **29** would be a partial cylindrical surface, as shown in Fig. 1a. As explained below, this enhances coupling of the light radiated from the illuminating surface and radiation of the surface to be treated. The light scatterer

is preferably provided with a light reflecting coating **32** on its rear surface in order to reflect back scattered light in the light scatterer in the direction of the arrows **27**.

The light scatterer **23** also has an undeployed configuration shown in Fig. 1b in which the illuminating surface **29** is collapsed into a small caliber. In the embodiment shown in Fig. 1, the light scatterer **23** is formed from a resiliently flexible material. The light scatterer may be made, for example, from transparent silicon rubber in which a light scattering substance is embedded. Alternatively, the light scatter may include one or more lenses (not shown). In this embodiment, the shaft **11** includes a constraining sleeve **30** that surrounds the sheath **13**. In the undeployed configuration shown in Fig. 1b, the light scatterer **23** is constricted into its small caliber undeployed configuration and is maintained in the undeployed configuration by means of the constraining sleeve **30**. The constraining sleeve **30** is slidable axially along the shaft **11** from a forward position shown in Fig. 1b and a rearward position shown in Fig. 1a. In the forward position (Fig. 1b), the sleeve **30** extends beyond the end of the optic fiber **20** with the light scatterer **23** collapsed in the interior of the sleeve **30**. When the sleeve **30** is brought to its rearward position (Fig. 1a) the sleeve **30** is retracted from the light scatterer **30** and the light scatterer **23** spontaneously assumes its deployed, large caliber configuration due to the resiliently flexible character of the light scatterer **23**. In order to slide the sleeve **30** between its forward and rearward position, a user may grasp the sleeve **30** at its proximal end and manually slide the sleeve over the sheath **13**.

The illuminating device **10** may further be configured for connection to a source of negative pressure. As shown in Fig. 1, for this purpose, the shaft may include a channel **12** extending from a valve **3** adapted for connection to a source of negative pressure (not shown) at the proximal end of the shaft **11** through the shaft **11** to the distal end of the shaft. As explained below, generation of negative pressure at the distal end of the light scatterer **23** is used to attach the light

scatterer **23** to the tissue surface and to immobilize the light scatterer on the tissue surface during radiation.

The shaft **11** may optionally contain a working channel (not shown) in order to accommodate a guide wire or working tool, as required in any application.

. The control unit **14** is provided with a user input device, such as a keypad **34** to allow the user to select one or more parameters of the treatment, such as the radiation intensity or fluency. The control unit may also have a display **36** such as a screen **38** displaying the selected parameters and other relevant information.

Fig. 2 shows a device, generally indicated by **40**, for illuminating a tissue surface to be treated, in accordance with another embodiment of the invention. The tissue illuminating device **40** has several components in common with the device **10** described above in reference to Fig. 1, and similar components are indicated by the same reference numerals in Figs. 1 and 2 without further comment. The illuminating device has a slender shaft **41**, shown in longitudinal section in Fig. 2, having a proximal end **45** and a distal end **47**. The shaft **41** may be rigid or flexible, as required in any application. The shaft **41** has a sheath **43** surrounding a light guide **20** that may consist of a single optical fiber or a bundle of optical fibers.

The device **40** includes a light scatterer **48** at the distal end **47** of the shaft that is optically coupled to the light guide **20**. The light scatterer **48** has a large caliber deployed configuration shown in Fig. 2a, and a small caliber undeployed configuration shown in Fig. 2b. In this embodiment, the light scatterer **48** includes a pleated sheet containing two or more panels **50** that are hinged together by hinges **52**. In the undeployed configuration (Fig. 2b) the pleated sheet is folded into the small caliber, while in the deployed configuration (Fig. 2a) the pleated sheet is extended. The panels may be formed from transparent silicone rubber in which a light scattering substance is embedded. Light emitted from the end face **26** of the light guide **20** enters the light scatterer **48** at a first surface **45**

and is scattered through the light scatterer **48**. The light is then emitted from an illuminating surface **49** on each panel in an essentially forward direction, as indicated by the arrows **53** to radiate the site to be treated. In the deployed configuration, the illuminating surface **49** is preferably shaped to conform to the surface to be radiated so that the illuminating surface can be applied onto the surface to be radiated. The light scatterer is preferably provided with a light reflecting coating **59** on its rear surface in order to reflect back scattered light in the light scatterer in the direction of the arrows **53**. The reflecting coating **59** may be made, from a biocompatible shiny material, deposited on the rear surface of the light scatterer.

The light scatterer **48** further includes an actuating mechanism for transforming the light scatterer **48** between its deployed and undeployed configurations. The hinges **52** comprise one or more elements formed from a shape memory material such as Nitinol that has been trained to behave as described below. The hinges have a deployed configuration shown in Fig. 2a, and an undeployed configuration shown in Fig. 2b. The hinges are attached to the panels so that passage of the elements from their undeployed to their deployed configurations drives the passage of the light scatterer **48** between its undeployed configuration and its deployed configuration, and vice versa.

The shaft **41** has a channel **60** for delivering a pressurized liquid such as physiological saline from a fluid source **62** located adjacent to, or inside, the control unit **14**. The fluid source 62 includes a temperature controlling system that allows the temperature of the fluid to be selected by a user. The fluid source **62** is in fluid contact with the channel **60** via a connecting hose **64**. When the light scatterer 48 in its undeployed configuration is to be brought to its deployed configuration, a pressurized fluid is used at a first temperature. The fluid is delivered to the distal end **47** of the shaft where it brings the temperature of the hinge elements to a temperature at which the shape memory material undergoes a first shape transition bringing the hinges **52** into their deployed configuration. When the light scatterer **48** in its deployed configuration is to be brought to its

undeployed configuration, a pressurized fluid is used at a second temperature that is delivered to the distal end of the shaft where it brings the temperature of the hinges **52** to a temperature at which the shape memory material undergoes a second shape transition bringing the hinges **52** into their undeployed configuration.

Fig. 3 shows a device, generally indicated by **70**, for illuminating a tissue surface to be treated, in accordance with yet another embodiment of the invention. The tissue illuminating device **70** has several components in common with the device **10** described above in reference to Fig. 1, and similar components are indicated by the same reference numerals in Figs. 1 and 3 without further comment. The illuminating device has a slender shaft **71**, shown in longitudinal section in Fig. 3, having a proximal end **75** and a distal end **77**. The shaft **71** may be rigid or flexible, as required in any application. The shaft **71** has a sheath **73** surrounding a light guide **20** that may consist of a single optical fiber or a bundle of optical fibers.

The device **70** includes a light scatterer **78** at the distal **77** of the shaft that is optically coupled to the light guide **20**. In this embodiment, the light scatterer **78** is an inflatable balloon that may be formed, for example, from transparent silicone rubber in which a light scattering substance is embedded. The light scatterer **78** has a large caliber deployed configuration shown in Fig. 3a in which the balloon is inflated, and a small caliber undeployed configuration shown in Fig. 3b in which the balloon is deflated. In the deployed configuration, light emitted from the end face **26** of the light guide **20** enters the light scatterer **78** at a first surface **75** and is scattered through the light scatterer **78**. The light is then emitted from an illuminating surface **79** of the light scatterer **78** in an essentially forward direction, as indicated by the arrows **83** to radiate the site to be treated. In the deployed configuration, the illuminating surface **79** is preferably shaped to conform to the surface to be radiated so that the illuminating surface can be applied onto the surface to be radiated. The light scatterer is preferable provided

with a light reflecting coating **89** on its rear surface in order to reflect back scattered light in the light scatterer in the direction of the arrows **83**.

The shaft **71** has a channel **80** for delivering a pressurized fluid such as water or air from a fluid source **82** located adjacent to, or inside, the control unit **14**. The fluid source **82** is in fluid contact with the channel **80** via a connecting hose **84**. When the light scatterer **78** in its undeployed configuration is to be brought to its deployed configuration, the pressurized fluid is delivered to the distal end **47** of the shaft and inflates the balloon. When the light scatterer **78** in its deployed configuration is to be brought to its undeployed configuration, the fluid is pumped from the balloon back to the fluid source **82**.

Fig. 4 depicts use of the device **40** in a surgical procedure in which an internal body surface is to be radiated. In the example of Fig. 4, the surgical procedure is treatment of an aneurysm in the abdominal aorta **102.** This is by way of example only, and the device of the invention may be used to radiate any body surface. As shown in Fig. 4a, the shaft **41** of the device **40**,with the light scatterer **48** in its undeployed configuration, is introduced through an incision at a first location **96** on the body surface of a subject **95** into a body cavity, which in this example, is an abdomen **99**. The surgical procedure may utilize laparoscopy, in which case an endoscope **97** is introduced into the abdomen **99** through a second incision at a second location **98** on the body surface. Abdominal body organs (not shown in Fig. 4) are moved aside in order to allow access to the aorta **102.** The endoscope **97** illuminates the abdomen **99** including the outer surface of the aorta **102.** The endoscope **97** is part of a laparoscopic imaging system that displays on a display screen (not shown), an image of the abdomen **99**, so as to allow a user **110** to observe the cavity **99** during the procedure. The abdomen **99** may temporarily be expanded in order to facilitate the maneuverability of the device **40** and the endoscope **97** in the abdomen **99.**

In Fig. 4a, the device **40** has been maneuvered so as to bring the distal end **47** of the shaft **41** and the light scatterer **48** into proximity with the aorta **102.** At this point, the fluid in the fluid source **62** (Fig. 2) is brought to the first

temperature, and the fluid source **62** is then activated in order to deliver the fluid at the first temperature through the connecting hose **64** (Fig. 2) and the channel **60** (Fig. 2) to the distal end **47** of the shaft where it brings the hinge elements to a temperature in which they assume their deployed configuration. This brings the light scatterer **48** to its deployed configuration, as shown in Fig. 4b. The illuminating surface **49** of the light scatterer **48** in the deployed configuration of the light scatterer **48** has the shape of a partial cylindrical surface with a radius approximately equal to the outer radius of the aorta **102** to be radiated. The device **40** is then maneuvered in the abdomen **99** so as to apply the illuminating surface **49** to the outer surface of the aorta **102,** as shown in Fig. 4c. The valve **3** is then opened to deliver negative pressure to the light scatterer **48** so as to firmly apply the illuminating surface **49** to the aorta and to immobilize the light scatterer **48** on the outer surface of the aorta. The light source in the control unit **14** is then activated. Light from the light source is conducted along the light guide **20** to the light scatterer **48**. Essentially the entire surface area of the aorta that is in contact with the illuminating surface **49** is simultaneously radiated.

When the radiation is completed, the negative pressure is discontinued to release the light scatterer 48 from the aorta. The fluid in the fluid source **62** is brought to the second temperature, and the fluid source **62** is then activated in order to deliver the fluid at the second temperature through the connecting hose **64** and the channel **60** to the distal end **47** of the shaft where it brings the hinge elements to a temperature in which they assume their undeployed configuration. This brings the light scatterer **48** back to its undeployed configuration, as shown in Fig. 4d. The device **40** is then removed from the abdomen **99.**

CLAIMS:

1. A device for illuminating a body surface , comprising:

(a) a shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

(b) a light source optically coupled to the proximal end of the light guide;

(c) a light scatterer optically coupled to the distal end of the light guide, the light scatterer having a small caliber configuration and a large caliber configuration, and further having an illuminating surface having an area greater than the cross sectional area of the light guide; and

(d) a deployment mechanism configured to bring the light scatterer from the small caliber configuration to the large caliber configuration.

2. The device according to Claim 1 wherein the deployment mechanism is further configured to bring the light scatterer from the large caliber configuration to the small caliber configuration.

3. The device according to any one of the previous claims wherein the illuminating surface is adapted to conform to the body surface.

4. The device according to Claim 3 wherein the radiation surface is a partial cylindrical surface.

5. The device according to Claim 1 or 2 wherein the light source generates light from 500 to 900 nm. .

6. The device according to Claim 3 wherein the light source has fluency between 0.01 and 50 Joules/cm^2.

7. The device according to Claim 4 wherein the light source has fluency between 0.1 and 5 Joules/cm^2.

8. The device according to any one of Claims 1 to 4 wherein the light source generates light in a frequency range from about 780 nm to about 2010 nm.

9. The device according to any one of the previous claims wherein the light scatterer is formed from a resiliently flexible material.

10. The device according to Claim 9 wherein the deployment device comprises a sleeve surrounding the shaft, the sleeve being slidable between a first position in which the light scatterer is constrained by the sleeve in the small caliber configuration and a second position in which the light scatterer adapts the large caliber configuration.

11. The device according to any one of Claims 1 to 8 wherein the light scatterer is inflatable.

12. The device according to Claim 11 wherein the deployment mechanism delivers a pressurized fluid to the light scatterer to inflated the light scatterer.

13. The device according to any one of Claims 1 to 8 wherein the illuminating surface is a pleated sheet.

14. The device according to Claim 13 wherein the deployment mechanism comprises elements formed from a shape memory alloy trained to have a first configuration coupled to the large caliber configuration of the light scatterer and a second configuration coupled to the small caliber configuration of the light scatterer.

15. The device according to Claim 14 wherein the deployment mechanism further comprises a liquid delivery system delivering a liquid from a source to the light scatter.

16. The device according to Claim 15 wherein the deployment mechanism further comprises a temperature controlling system controlling the temperature of the liquid.

17. The device according to any one of the previous claims further comprising attachment means attaching the illuminating surface to the body surface.

18. The device according to any one of the previous claims adapted for illuminating a perivascular surface of a blood vessel.

19. A method for illuminating a body surface, comprising:

(a) providing a device for illuminating the body surface, the device comprising:

a shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

a light source optically coupled to the proximal end of the light guide;

a light scatterer optically coupled to the distal end of the light guide, the light scatterer having a small caliber configuration and a large caliber configuration, and further having an illuminating surface having an area greater than the cross sectional area of the optic fiber; and

a deployment mechanism configured to bring the light scatterer from the small caliber configuration to the large caliber configuration ;

(b) delivering the distal end of the shaft to the body surface with the light scatterer in the small caliber configuration;

(c) activating the deployment mechanism to bring the light scatterer into the large caliber configuration;

(d) applying the illuminating surface to the body surface; and

(e) illuminating the body surface from the light source.

20. The method according to Claim 1 wherein the deployment mechanism is further configured to bring the light scatterer from the large caliber configuration to the small caliber configuration, and the method further comprises activating the deployment mechanism to bring the light scatterer to the small caliber configuration at the termination of the radiation.

21. The method according to Claim 19 or 20 wherein the body surface is a perivascular surface of a blood vessel.

22. The method according to Claim 21 wherein the blood vessel is an aneurysmal blood vessel.

23. The method according to Claim 22 wherein the radiation surface of the illuminating device is a partial cylindrical surface.

24. The method according to any one of Claims 21 to 23 wherein the light source generates light having a wavelength from 500 to 900 nm.

25. The method according to Claim 24 wherein the light source has a fluence between 0.01 and 50 Joules/cm^2.

26. The method according to Claim 25 wherein the light source has a fluency between 0. 1 and 5 Joules/cm2.

27. The method according to Claim 21 for tissue welding the body surface.

28. The method according to Claim 27 the light source generates light in a frequency range from about 780 nm to about 2010 nm.

29. The method according to any one of Claims 19 to 28 further comprising attaching the light scatterer to the body surface.

30. The method according to any one of Claims 19 to 29 further comprising laparoscopic imaging of the body surface.

31. A method for treating an aneurysmal blood vessel comprising irradiating the blood vessel with radiation having a wavelength from 500 to 900 nm.

32. The method according to Claim 31 wherein the irradiation has a wavelength from 600 to 900 nm.

33. The method according to Claim 31 wherein the light source has fluency between 0.001 and 50 Joules/cm^2.

34. The method according to Claim 31 wherein the light source has fluency between 0.01 and 5 Joules/cm^2.

35. The method according to Claim 31 wherein a peri-adventitial surface of the blood vessel is irradiated.

36. A device for illuminating a body surface , comprising:

(a) an elongated shaft having a proximal end and a distal end, the shaft including a light guide having a cross-sectional area and guiding light from the proximal end to the distal end;

(b) a light source optically coupled to the proximal end of the light guide and illuminating light having a wavelength in the range of 500 to 900 nm; and

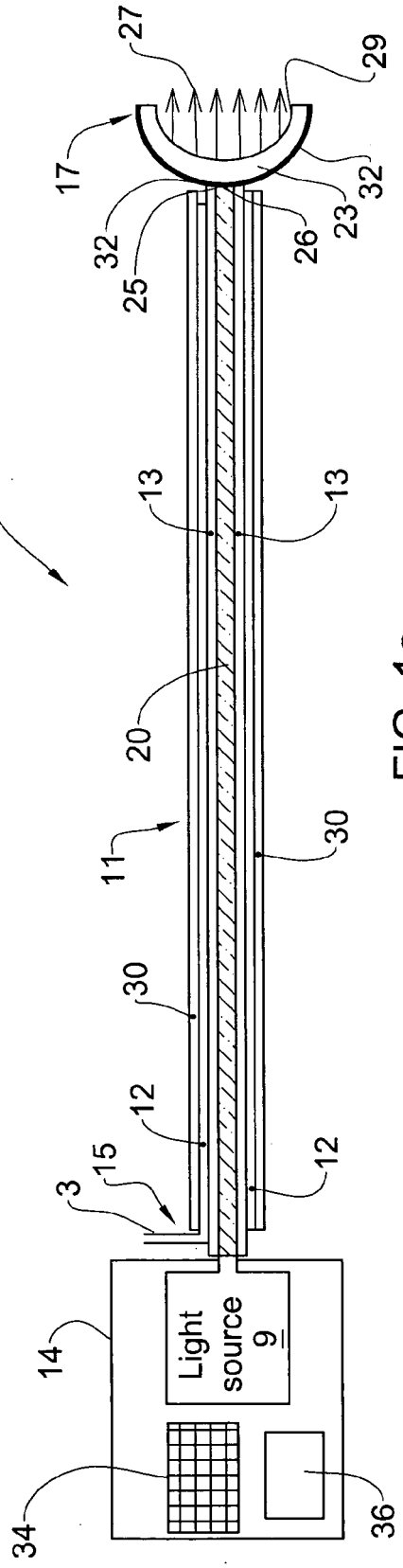
(c) a light scatterer optically coupled to the distal end of the light guide,.

37. The device according to Claim 36 wherein the light source has a wavelength from 600 to 900 nm.

38. The device according to Claim 36 wherein the light source has fluency between 0.001 and 50 Joules/cm^2.

39. The device according to Claim 38 wherein the light source has fluency between 0.01 and 5 Joules/cm^2.

40. The device according to Claim 36 adapted to irradiate a peri-adventitial surface of a blood vessel.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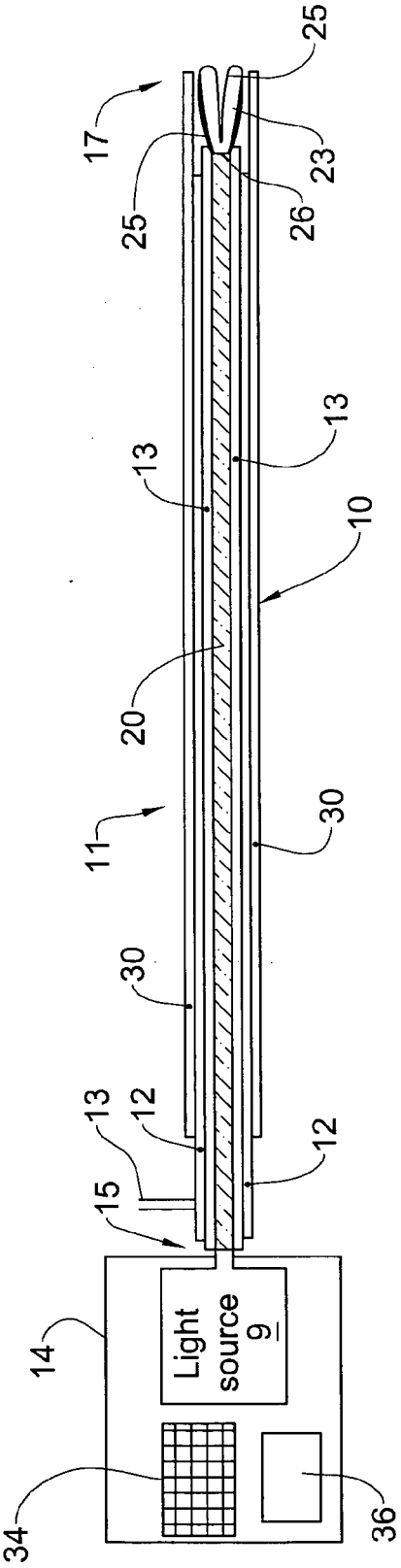
Light source 9

FIG. 1a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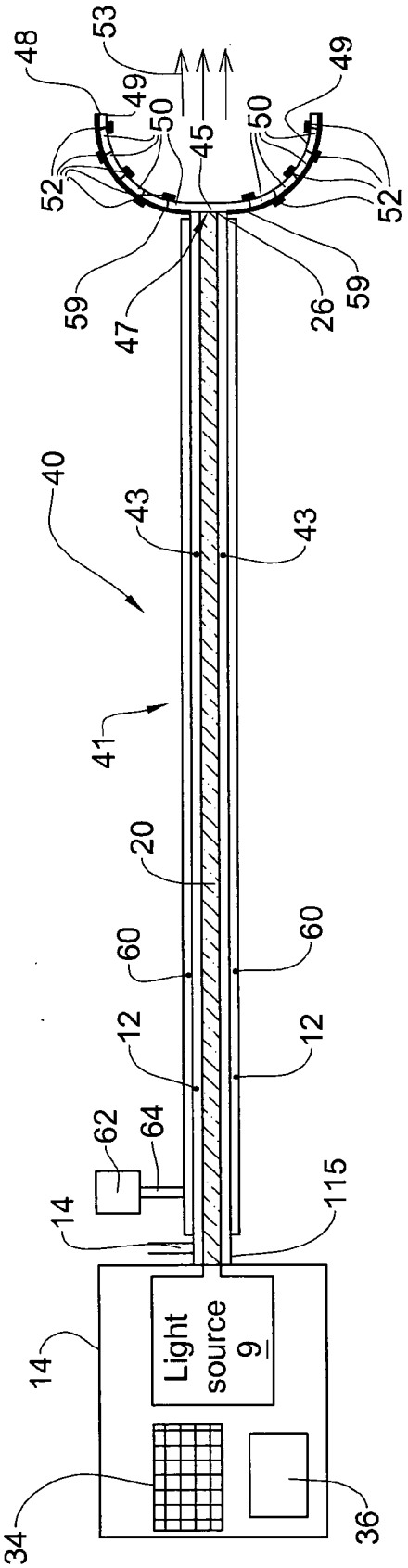
Light source 9

FIG. 1b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Light source 9
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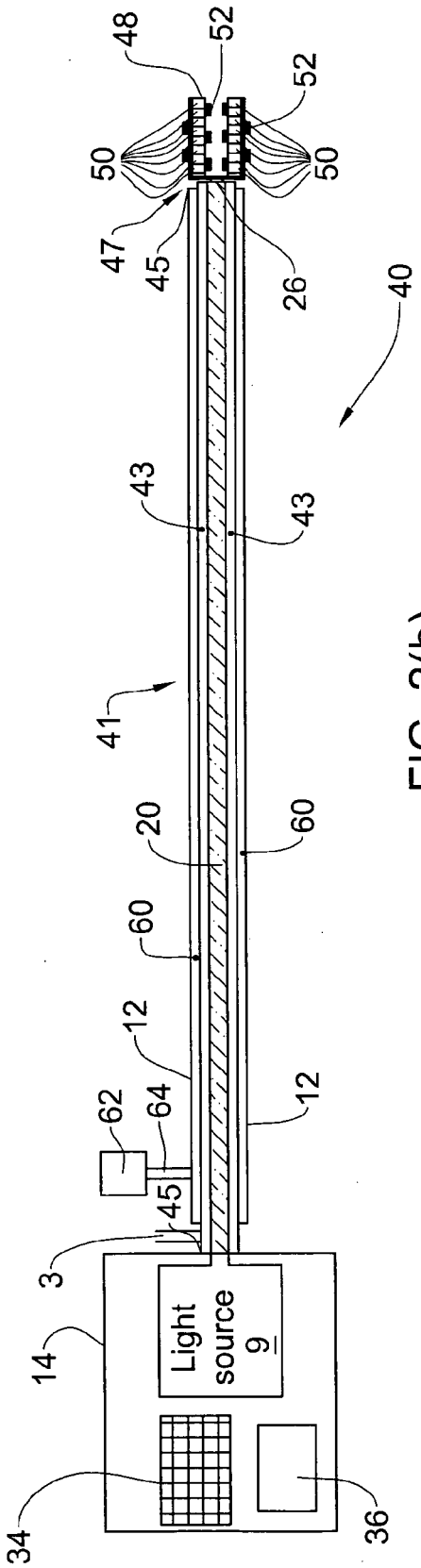
FIG. 2(a)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Light source 9
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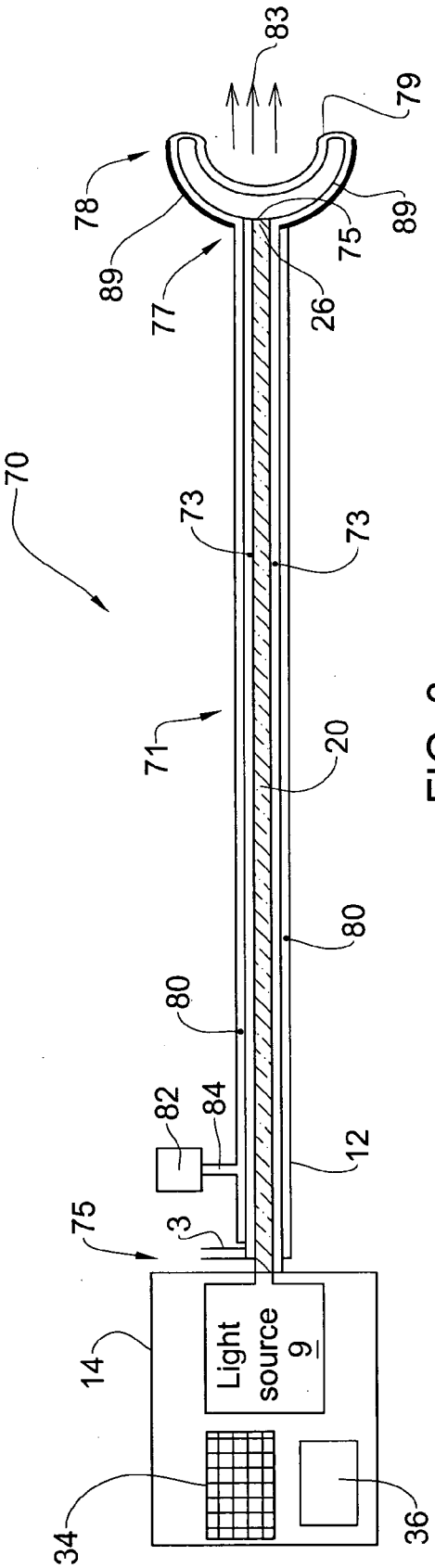
FIG. 2(b)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Light source 9
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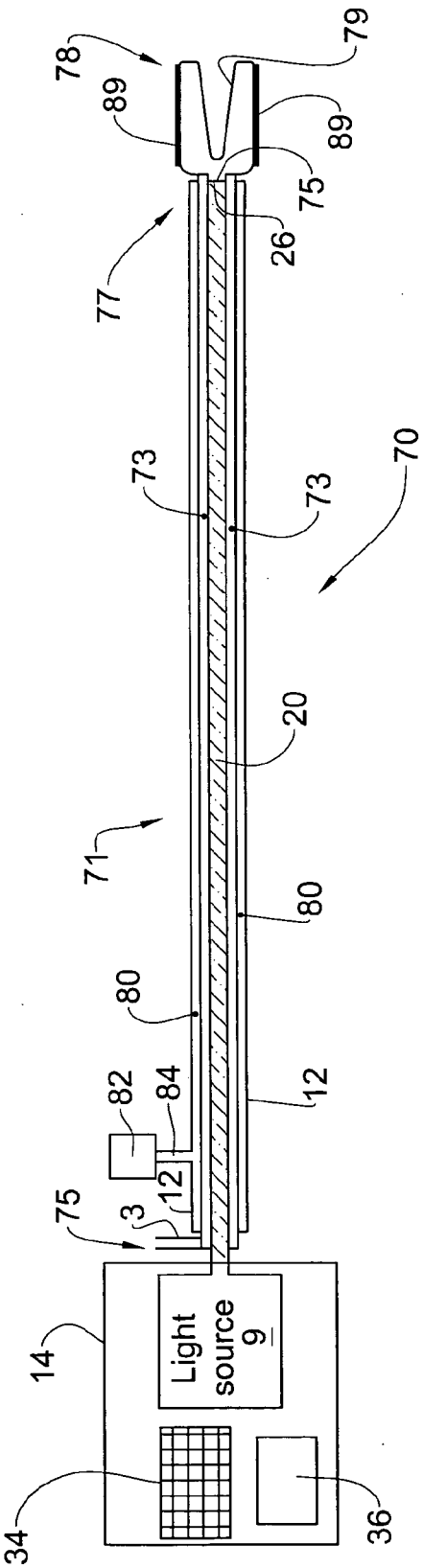
FIG. 3a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Light source 9
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FIG. 3b

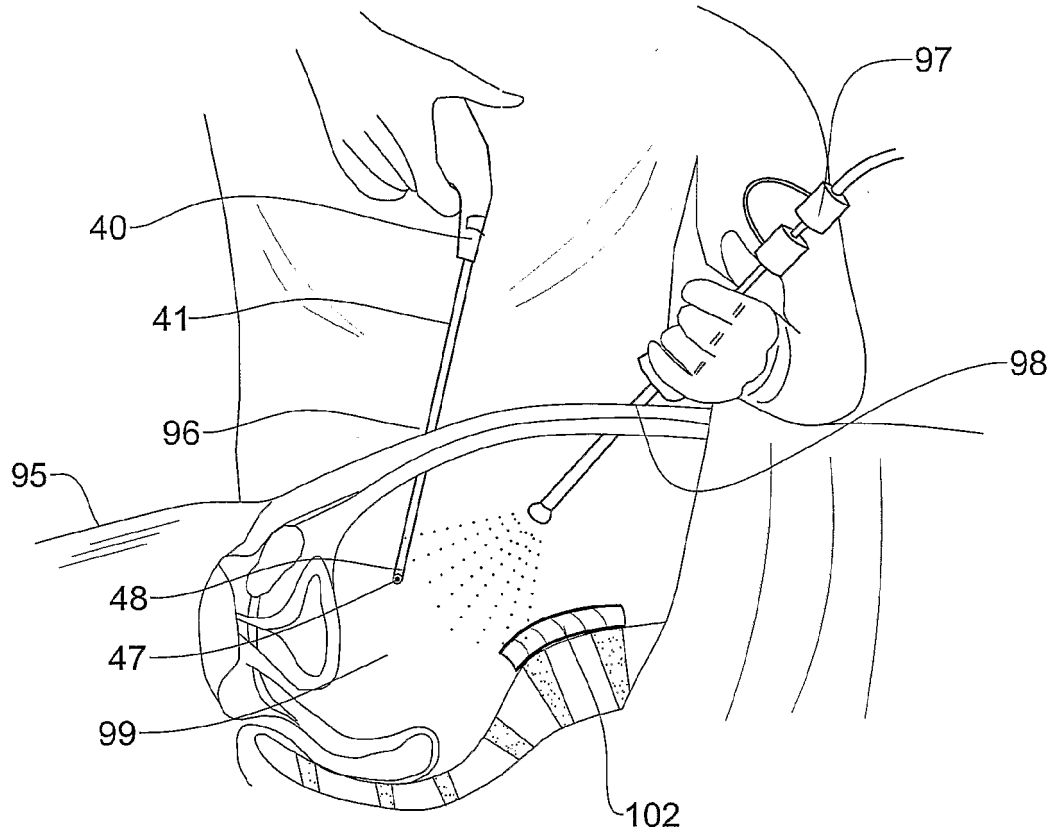

FIG. 4a

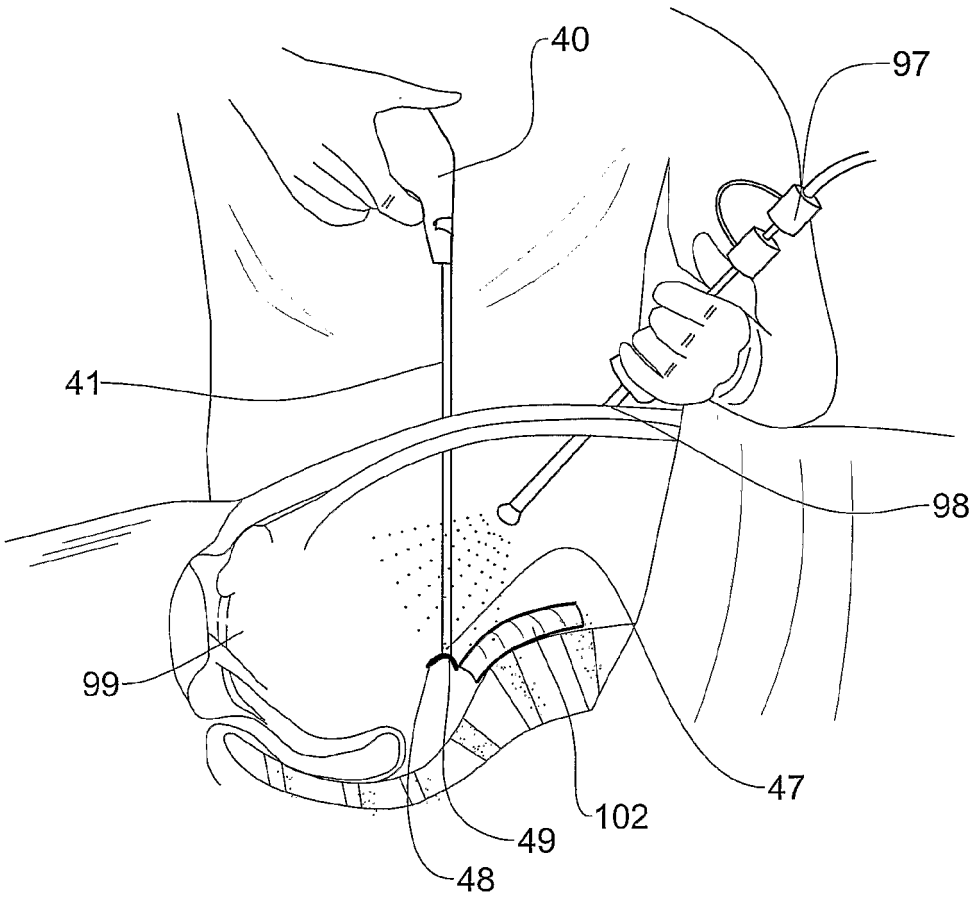

FIG. 4b

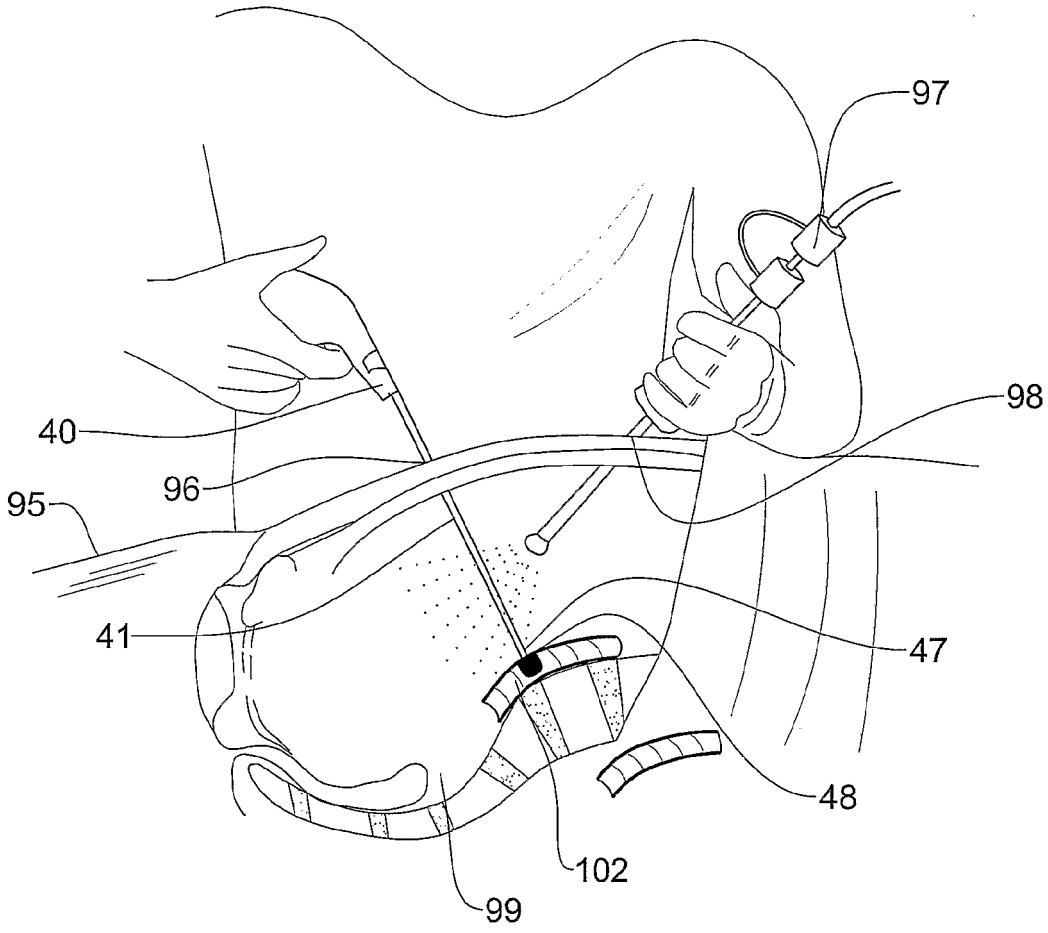

Fig. 4c

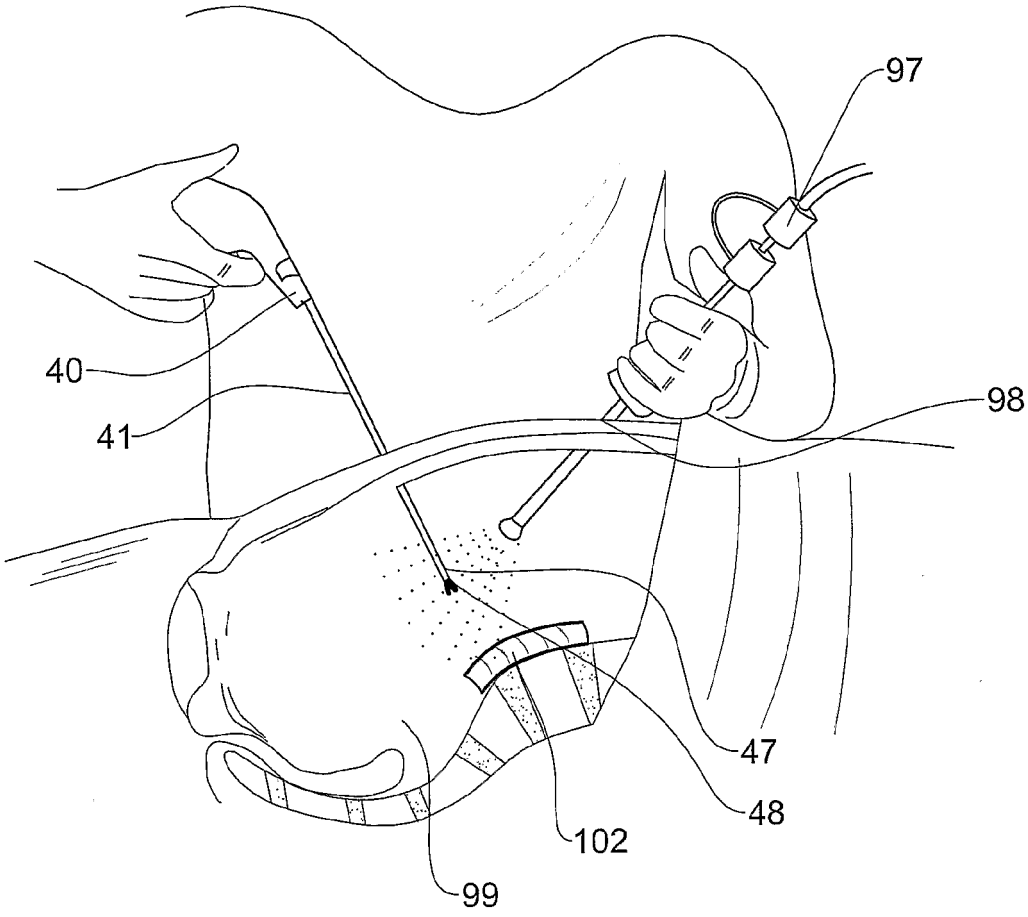

Fig. 4d

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2007/000448

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B18/24 A61N5/06
ADD. A61B18/22

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)
A61B A61N

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2005/049127 A (LUMERX INC [US]; ZALESKY PAUL J [US]; FRIEDMAN MARC D [US]; EVANS STEP) 2 June 2005 (2005-06-02) paragraphs [0055], [0096], [0097]	1-18, 36-40
X	US 6 071 302 A (SINOFSKY EDWARD L [US] ET AL) 6 June 2000 (2000-06-06) column 4 - column 5	36-40
A	EP 1 527 798 A (CARDIOFOCUS INC [US]) 4 May 2005 (2005-05-04)	
A	US 5 344 419 A (SPEARS JAMES R [US]) 6 September 1994 (1994-09-06)	

☐ 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 document 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	Date of mailing of the international search report
5 July 2007	18/07/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	RODRIGUEZ COSSIO, J

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2007/000448

Box 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. [X] Claims Nos.: 19-35
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgeryRule 39.1(iv) PCT - Method for treatment of the human or animal body by therapy

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 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:

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 an additional fee, this Authority did not invite payment of any additional fee.

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.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2007/000448

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005049127 A	02-06-2005	AU 2004291100 A1	02-06-2005
		CA 2545932 A1	02-06-2005
		EP 1696992 A1	06-09-2006
		US 2005131500 A1	16-06-2005
US 6071302 A	06-06-2000	NONE	
EP 1527798 A	04-05-2005	NONE	
US 5344419 A	06-09-1994	WO 9425098 A1	10-11-1994

专利名称(译)	用于照射体表内部的装置		
公开(公告)号	EP2046222A1	公开(公告)日	2009-04-15
申请号	EP2007736188	申请日	2007-04-10
[标]申请(专利权)人(译)	耶路撒冷希伯来大学伊森姆研究发展公司		
申请(专利权)人(译)	YISSUM研究开发公司		
当前申请(专利权)人(译)	YISSUM研究开发公司		
[标]发明人	GERTZ DAVID GAVISH LILACH REISSMAN PETACHIA		
发明人	GERTZ, DAVID GAVISH, LILACH REISSMAN, PETACHIA		
IPC分类号	A61B18/24 A61N5/06 A61B18/22		
CPC分类号	A61B18/24 A61B2018/2261 A61N5/0603		
优先权	174858 2006-04-06 IL		
外部链接	Espacenet		

摘要(译)

本发明提供了一种用于照射体表的装置和方法。光源光学耦合到光导的近端，光散射器光学耦合到光导的远端。该装置包括展开机构，该展开机构被配置成将光散射器从小口径配置带入，其中光散射体被递送到身体表面到大口径配置，其中光散射体照射身体表面。例如，可以使用本发明照射动脉瘤血管的外膜周表面。