(12) STANDARD PATENT APPLICATION (11) Application No. **AU 2012202388 A8**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Methods utilizing triangulation in metrology systems for in-situ surgical applicaitons

(51) International Patent Classification(s)
A61B 1/05 (2006.01)

(21) Application No: **2012202388** (22) Date of Filing: **2012.04.24**

(30) Priority Data

(31) Number	(32) Date	(33) Country
13/448,429	**2012.04.17**	**US**
61/487,750	**2011.05.19**	**US**

(43) Publication Date: **2012.12.06**
(43) Publication Journal Date: **2012.12.06**
(48) Corrigenda Journal Date: **2014.08.28**

(71) Applicant(s)
Covidien LP

(72) Inventor(s)
Sharonov, Alexey;Pinto, Candido Dionisio

(74) Agent / Attorney
Spruson & Ferguson, L 35 St Martins Tower 31 Market St, Sydney, NSW, 2000

(56) Related Art
US 4660982 A
US 2004/0223118

2012202388 24 Apr 2012

METHODS UTILIZING TRIANGULATION IN METROLOGY SYSTEMS FOR IN-SITU SURGICAL APPLICATIONS

Abstract

A first metrology method includes the steps of projecting a first image (120a) and a second image (120b), aligning the first image (120a) and the second image (120b) to form an aligned image (122) of a known size, and determining a dimension of a target object ("S") by comparing the aligned image (122) to the target object ("S"). A second metrology method includes the steps of projecting a first image (310a) and a second image (310b), aligning the first image (310a) and the second image (310b) to form an aligned image (322) of a known size by synchronously adjusting a zoom factor ("M") for projecting the first image (310a) and an angle ("α_n") for projecting the second image (310b), and determining a dimension of a target object ("S") by comparing the aligned image (322) to the target object ("S").

20122202388 24 Apr 2012

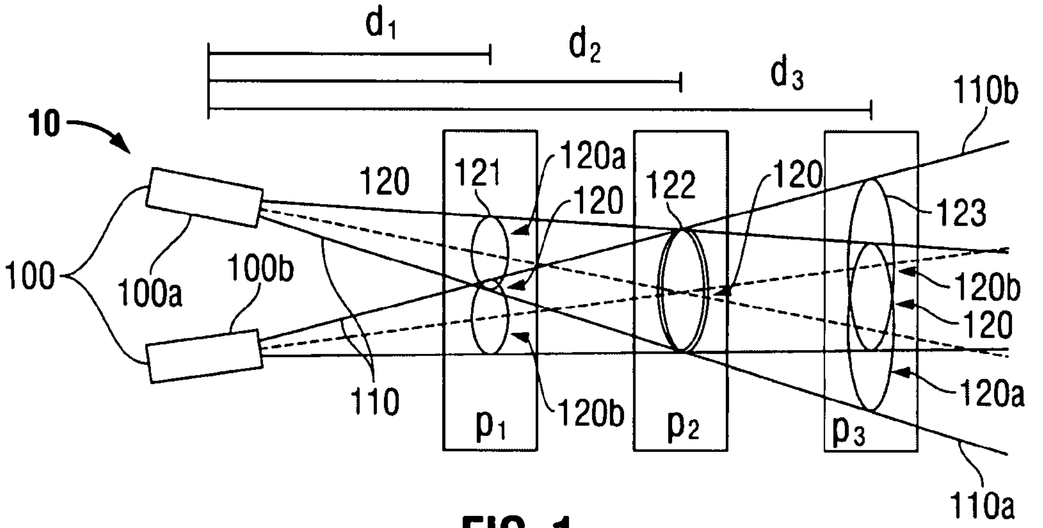

FIG. 1

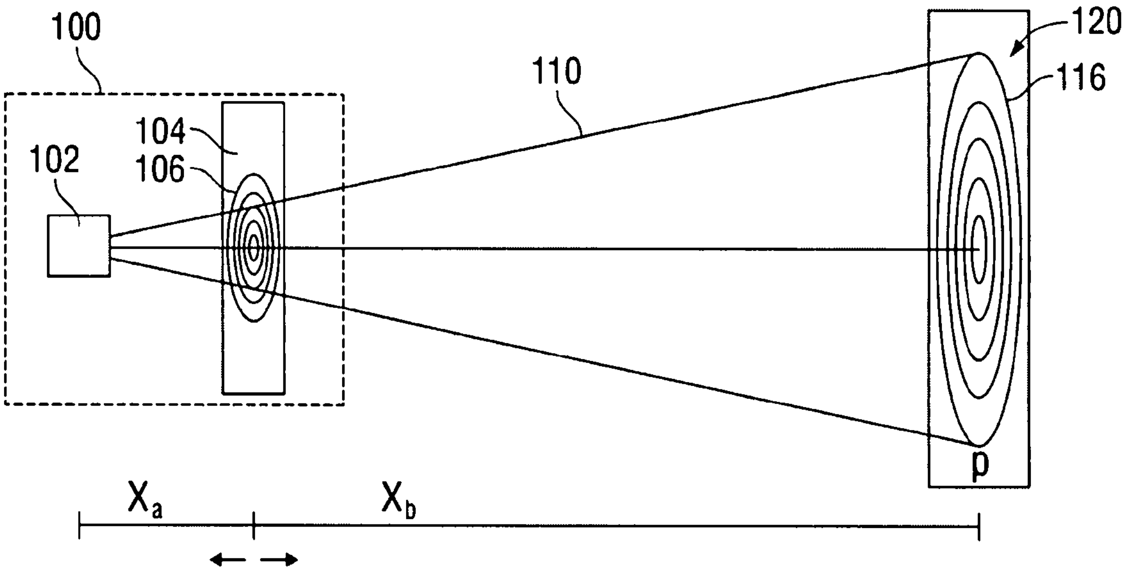

FIG. 2

2012202388 24 Apr 2012

S&F Ref: P033735

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

Name and Address of Applicant :	Tyco Healthcare Group LP, of 15 Hampshire Street, Mansfield, Massachusetts, 02048, United States of America
Actual Inventor(s):	Alexey Sharonov Candido Dionisio Pinto
Address for Service:	Spruson & Ferguson St Martins Tower Level 35 31 Market Street Sydney NSW 2000 (CCN 3710000177)
Invention Title:	Methods utilizing triangulation in metrology systems for in-situ surgical applications

The following statement is a full description of this invention, including the best method of performing it known to me/us:

2012202388 24 Apr 2012

METHODS UTILIZING TRIANGULATION IN METROLOGY SYSTEMS FOR IN-SITU SURGICAL APPLICATIONS

Technical Field

[0001] The present disclosure relates to a method for measuring a dimension of a target site. More particularly, the present disclosure relates to a method of triangulation for creating an image of a predetermined size for use in measuring a dimension of a target site.

Background

[0002] Minimally invasive surgery, *e.g.*, laparoscopic, endoscopic, and thoroscopic surgery, has many advantages over traditional open surgeries. In particular, minimally invasive surgery eliminates the need for a large incision, thereby reducing discomfort, recovery time, and many of the deleterious side effects associated with traditional open surgery.

[0003] The minimally invasive surgeries are performed through small openings in a patient's skin. These openings may be incisions in the skin or may be naturally occurring body orifices (e.g., mouth, anus, or vagina). In general, insufflation gas is used to enlarge the area surrounding the target surgical site to create a larger, more accessible work area.

[0004] During minimally invasive procedures, it is often difficult for a surgeon to determine sizes of various organs, tissues, and other structures in a surgical site. Various in-situ surgical metrology methods exist for measurement in a surgical site. Such methods require many moving parts and projection images that change size and/or focus quickly as projectors move in or out of a surface of projection. A continuing need exists for in-situ surgical metrology methods that operate with a stable focus and no moving parts.

24 Apr 2012 2012202388

Object of the Invention

[0005] It is an object of the present invention to substantially overcome or at least ameliorate one or more of the disadvantages of the prior art, or to at least provide a useful alternative.

Summary of the Invention

[0006] A first metrology method includes the steps of projecting a first image and a second image, aligning the first image and the second image to form an aligned image of a known size by moving an instrument towards and away from a target object, and determining a dimension of a target object by comparing the aligned image to the target object. The aligned image may include aligned circles. The aligned image may include a single point aligned with a centre point of a circle. The projecting of at least one of the first image and second image may be achieved by a point source projector. A single beam may be split to project the first image and the second image.

[0007] A second metrology method includes the steps of projecting a first image and a second image, aligning the first image and the second image to form an aligned image of a known size by synchronously adjusting a zoom factor for projecting the first image and an angle for projecting the second image, and determining a dimension of a target object by comparing the aligned image to the target object. The aligned image may include aligned circles. The aligned image may include a single point aligned with a centre point of a circle. The projecting of at least one of the first image and second image may be achieved by a point source projector. A single beam may be split to project the first image and the second image.

[0008] In other embodiments the metrology system may be a standalone device, while projected pattern is observed through a separate endoscope.

2012202388 24 Apr 2012

Brief Description of the Drawings

[0009] Preferred embodiments of the invention will be described hereinafter, by way of examples only, with reference to the accompanying drawings, wherein:

[0010] FIG. 1 is a side, schematic view of a metrology system;

[0011] FIG. 2 is a side, schematic view of a projector of the metrology system of FIG. 1;

[0012] FIG. 3 is a side, perspective view of a method of use of the metrology system of FIG. 1;

[0013] FIG. 4 is a side, schematic view of a metrology system according to another embodiment of the present disclosure;

[0014] FIG. 5 is a side, schematic view of a metrology system according to another embodiment of the present disclosure; and

[0015] FIG. 6 is a side, perspective view of a method of use of the metrology system of FIG. 5.

Detailed Description

[0016] Particular embodiments of the present disclosure are described hereinbelow with reference to the accompanying drawings; however, it is to be understood that the disclosed embodiments are merely exemplary of the disclosure and may be embodied in various forms. Well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the present disclosure in virtually any appropriately detailed structure.

[0017] Like reference numerals may refer to similar or identical elements throughout the description of the figures. As shown in the drawings and described throughout the following description, as is traditional when referring to relative positioning on a surgical instrument, the term "proximal" refers to the end of the apparatus which is closer to the user and the term "distal" refers to the end of the apparatus which is farther away from the user. The term "clinician" refers to any medical professional (i.e., doctor, surgeon, nurse, or the like) performing a medical procedure involving the use of embodiments described herein.

[0018] As seen in **FIG. 1**, a metrology system **10** according to an embodiment of the present disclosure is illustrated. Metrology system **10** utilizes projectors **100** for projecting light beams **110** at intersecting angles. Projectors **100** include a projector **100a** and a projector **100b**. Some embodiments may utilize more than two projectors **100**. Other embodiments may only have one projector **100**, as will be described in greater detail hereinbelow. In metrology system **10**, projector **100a** and projector **100b** are substantially identical and project substantially identical light beams **110a**, **110b**, respectively.

[0019] Light beams **110** form an image **120** including an image **120a** from light beam **110a** and an image **120b** from light beam **110b**. Images **120a**, **120b** substantially align to form a substantially aligned image **122** having a predetermined size on an image plane $\mathbf{p_2}$ at a distance $\mathbf{d_2}$ from point sources **102** (**FIG. 2**) of projectors **100**. Image plane $\mathbf{p_2}$ is the only image plane on which images **120a**, **120b** align. On an image plane $\mathbf{p_1}$ at a distance $\mathbf{d_1}$ less than distance $\mathbf{d_2}$ from point sources **102** of projectors **100**, an unaligned image **121** is formed. Likewise, on an image plane $\mathbf{p_3}$ at a distance $\mathbf{d_3}$ greater than distance $\mathbf{d_2}$ from point sources **102** of projectors **100**, an

2012202388 24 Apr 2012

unaligned image **123** is formed. Distance $\mathbf{d}_2$ may be calculated geometrically using a distance between point sources **102** and angles of projectors **100**. Distance $\mathbf{d}_2$ may also be determined experimentally. Similarly, the predetermined size of aligned image **122** may be determined geometrically or experimentally.

[0020] Images **120a, 120b** may be any shapes appropriate for determining an alignment of thereof. For example, images **120a, 120b** may be circles that concentrically overlap on image plane $\mathbf{p}_2$. Images **120a, 120b** have uniformly spaced markings. In other embodiments, an endoscope or other device may provide uniformly spaced markings. When image **122** is formed, the uniformly spaced markings have a predetermined distance therebetween to assist in determining a measurement of a dimension on image plane $\mathbf{p}_2$. The predetermined distance of the uniformly spaced markings may be determined geometrically or experimentally. Although images **120a, 120b** are substantially identical in metrology system **10**, other embodiments may have differing shapes of images **120a, 120b**.

[0021] As seen in **FIG. 2**, a projector **100** includes a point source **102** and a mask **104**. Point source **102** emits a light beam **110**. Various embodiments of point source **102** include a laser diode, a light-emitting diode, and a lens for shaping a beam of light. Mask **104** is positioned between point source **102** and the target site. Mask **104** has a pattern **106** disposed thereon in a shape of a desired image **120**, such as a series of concentric, uniformly spaced circles. Light beam **110** may be collimated for increased sharpness of image **120**. Light beam **110** is partially blocked upon incidence with mask **104**. A portion of light beam **110** that passes through mask **104** forms a magnified pattern **116** as a portion of image **120**.

[0022] A magnification factor of pattern **106** to pattern **116** is calculated according a formula: $\mathbf{M} = 1 + \mathbf{x}_b/\mathbf{x}_a$, where $\mathbf{M}$ is the magnification factor, $\mathbf{x}_a$ is a distance between point source **102** and mask **104**, and x_b is a distance between mask **104** and the target site. Accordingly, image **120** may be enlarged when x_b is increased or x_a is decreased. Image **120** may shrink upon an increase of x_a or a decrease of x_b. Mask **104** may be translated with respect to the target site to increase or decrease x_a and x_b. Metrology system **10** may be translated to increase or decrease x_b. Point source **102** is sufficiently small for edges of image **120** to remain substantially sharp as a size of image **120** changes.

[0023] A method of use of metrology system **10** will now be described. As seen in **FIG. 3**, metrology system **10** may be attached to a distal end of an endoscope "E". Endoscope "E" is inserted into a body cavity "C" through an opening in a tissue "T". Endoscope "E" may be inserted through a seal anchor "R" positioned in the opening in tissue "T". Projectors **100** project image **120** onto a target site "S" within cavity "C". A clinician may observe image **120** through endoscope "E". If images **120a, 120b** are not aligned, endoscope "E" is translated distally or proximally until point sources **102** of projectors **100** are at distance d_2 from target site "S". Once aligned image **122** is formed on target site "S", the predetermined size of aligned image **122** and the predetermined distance of the uniformly spaced markings thereon may be used to measure a dimension of target site "S". A dimension of target site "S" is measured by visually inspecting and counting a number of uniformly spaced markings appearing along the dimension of target site "S". The number of uniformly spaced markings is multiplied by the predetermined distance therebetween to calculate the measure of the dimension of target site "S".

[0024] Turning to **FIG. 4**, a metrology system in accordance with an alternate embodiment of the present disclosure is generally designated as **20**. Metrology system **20** is similar to metrology system **10** and thus will only be discussed as necessary to identify the differences in construction and operation thereof.

2012202388 24 Apr 2012

[0025] Metrology system **20** has a projector **200**, a splitter **212**, and a reflector **214**. Projector **200** is substantially identical to projector **100** (**FIG. 2**) and projects a light beam **210**. Splitter **212** splits light beam **210** into light beams **210a**, **210b**. Embodiments of splitter **212** include prisms and mirrors. Light beam **210a** passes through splitter **212**. Light beam **210b** is reflected by splitter **212** onto reflector **214**. Reflector **214** reflects light beam **210b** at an angle α for intersection with light beam **210a**.

[0026] Light beams **210** form a substantially aligned image **222** on an image plane $\mathbf{p_2}$ at a distance $\mathbf{d_2}$ from a point source of projector **200**. Image plane $\mathbf{p_2}$ is the only image plane on which a substantially aligned image is formed. Light beams **210** project a pattern having uniformly spaced markings onto image plane $\mathbf{p_2}$. Distance $\mathbf{d_2}$, a distance of the uniformly spaced markings, and a size of aligned image **222** may be determined geometrically or experimentally.

[0027] Light beams **210** produce images of any shapes appropriate for determining an alignment of thereof. In some embodiments, a total overlap of certain elements of the images of light beams **210** may not occur due to light beam **210a** travelling a shorter total distance than light beam **210b** to reach image plane $\mathbf{p_2}$. In such embodiments, an alignment of a point or a line may be an ideal indicator of alignment. For example, light beam **210a** may project a circle with a center point, and light beam **210b** may project a single point for aligning with the center point of the image projected by light beam **210a**.

[0028] A method of use of metrology system **20** is substantially identical to the method of use of metrology system **10** described hereinabove.

[0029] Turning to **FIG. 5**, a metrology system in accordance with an alternate embodiment of the present disclosure is generally designated as **30**. Metrology system **30** is similar to metrology system **20** and thus will only be discussed as necessary to identify the differences in construction and operation thereof.

[0030] Metrology system **30** includes a projector **300**, a splitter **312**, a reflector **314**, and an actuator **330** (**FIG. 6**). Projector **300** includes a point source **302** and a mask **304**. Mask **304** is a distance $\mathbf{x_{an}}$ away from point source **302** and distances $\mathbf{x_{bn}}$ away from image planes $\mathbf{p_n}$. Point source **302** emits a light beam **310** that passes through a pattern **306** on mask **304**. Splitter **312** splits light beam **310** into light beams **310a, 310b**. Light beam **310a** passes through splitter **312** and forms a first image on an image plane $\mathbf{p_n}$. Light beam **310b** is reflected by splitter **312** onto reflector **314**. Reflector **314** is rotatable to reflect light beam **310b** at any of angles $\boldsymbol{\alpha_n}$ onto image planes $\mathbf{p_n}$ to form a second image. The first image and the second image form a substantially aligned image **322** on an image plane $\mathbf{p_n}$ having a distance $\mathbf{d_n}$ from point source **302** when reflector **314** reflects light beam **310b** at a particular angle $\boldsymbol{\acute{\alpha}_n}$. For each image plane $\mathbf{p_n}$, only angle $\boldsymbol{\alpha_n}$ provides for a projection of substantially aligned image **322**. Substantially aligned image **322** has a magnified pattern **316** thereon. Magnified pattern **316** is a magnification of pattern **306** and includes uniformly spaced markings thereon having a predetermined distance on image plane $\mathbf{p_n}$.

[0031] Actuator **330** is operably coupled to mask **304** and reflector **314**. A manipulation of actuator **330** rotates reflector **314**, thus changing an angle $\boldsymbol{\alpha_n}$ and an image plane $\mathbf{p_n}$ on which aligned image **322** is formed. Actuator **330** translates mask **304** a distance to maintain a predetermined size of image **322**. The translation of mask **304** and the rotation of reflector **314** are synchronous upon a manipulation of actuator **330**. A relationship between the translation of mask **304** and the rotation of reflector **314** is described according to the following formulas:

$$\mathbf{d_2/d_1 = \tan(\alpha_1)/\tan(\alpha_2) = M_1/M_2}$$

2012202388 24 Apr 2012

$$\mathbf{M = 1 + x_b/x_a}$$

$$\mathbf{d = x_a + x_b}$$

[0032] In the formulas above, the values of $\mathbf{d_1}$, $\boldsymbol{\alpha_1}$, and $\mathbf{M_1}$ respectively represent an initial distance $\mathbf{d_n}$, angle $\boldsymbol{\alpha_n}$, and magnification $\mathbf{M_n}$ of system **30**. The values of $\mathbf{d_2}$, $\boldsymbol{\alpha_2}$, and $\mathbf{M_2}$ respectively represent a resulting distance $\mathbf{d_n}$, angle $\boldsymbol{\alpha_n}$, and magnification $\mathbf{M_n}$ of system **30** after actuator **330** is manipulated.

[0033] A method of use of metrology system **30** is similar to the method of use of metrology system **10** described hereinabove. As seen in **FIG. 6**, metrology system **30** is attached to a distal end of an endoscope "E". Endoscope **"E"** is inserted into a body cavity "C" through an opening in a tissue "T". Projector **300** projects light beams **310a, 310b** onto a target site "S" within cavity "C". A clinician may observe an image formed by light beams **310a**, **310b** through endoscope "E". If substantially aligned image **322,** is not formed on target site "S", actuator **330** is rotated until substantially aligned image **322** is formed on target site "S". The predetermined size of substantially aligned image **322** and the uniformly spaced markings of magnified pattern **316** may then be used to measure a dimension of target site "S".

[0034] It should be understood that the foregoing description is only illustrative of the present disclosure. Various alternatives and modifications can be devised by those skilled in the art without departing from the disclosure. Accordingly, the present disclosure is intended to embrace all such alternatives, modifications and variances. The embodiments described with reference to the attached drawing figs. are presented only to demonstrate certain examples of the disclosure. Other elements, steps, methods and techniques that are insubstantially different from those described above and/or in the appended claims are also intended to be within the scope of the disclosure.

2012202388 24 Apr 2012

The claims defining the invention are as follows:

1. A metrology method, comprising the steps of:

projecting a first image and a second image;

aligning the first image and the second image to form an aligned image of a known size; and

determining a dimension of a target object by comparing the aligned image to the target object.

2. A method as in claim 1, wherein the aligned image includes aligned circles.

3. A method as in claim 1, wherein the aligned image includes a single point aligned with a centre point of a circle.

4. A method as in claim 1, wherein the projecting of at least one of the first image and second image is achieved by a point source projector.

5. A method as in claim 1, wherein a single beam is split to project the first image and the second image.

6. A metrology method, comprising the steps of:

projecting a first image and a second image;

aligning the first image and the second image to form an aligned image of a known size by synchronously adjusting a zoom factor for projecting the first image and an angle for projecting the second image; and

determining a dimension of a target object by comparing the aligned image to the target object.

7. A method as in claim 6, wherein the aligned image includes aligned circles.

8. A method as in claim 6, wherein the aligned image includes a single point aligned with a centre point of a circle.

2012202388 24 Apr 2012

9. A method as in claim 6, wherein the projecting of at least one of the first image and second image is achieved by a point source projector.

10. A method as in claim 6, wherein a single beam is split to project the first image and the second image.

11. A metrology method substantially as hereinbefore described with reference to the accompanying drawings.

Dated 23 April, 2012
Tyco Healthcare Group LP
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

20122202388 24 Apr 2012

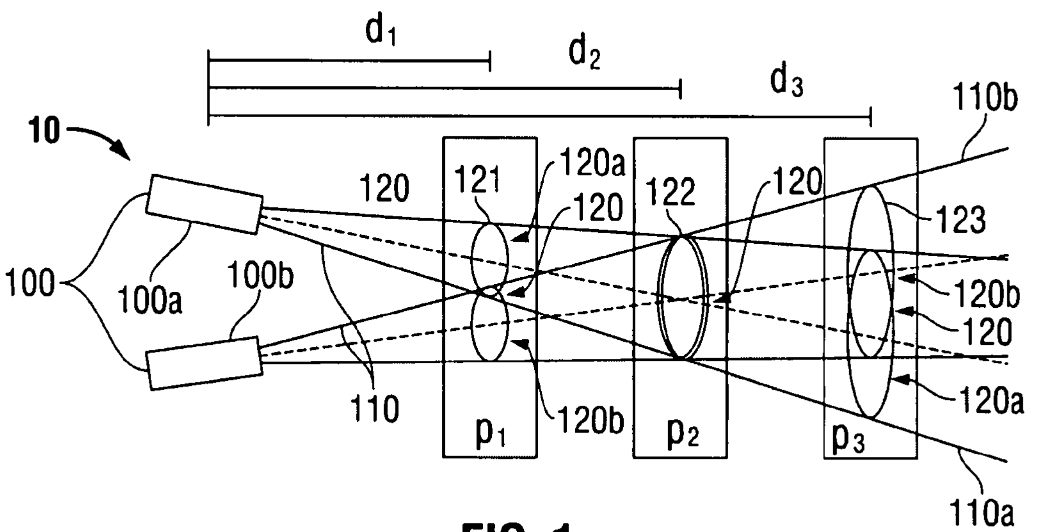

FIG. 1

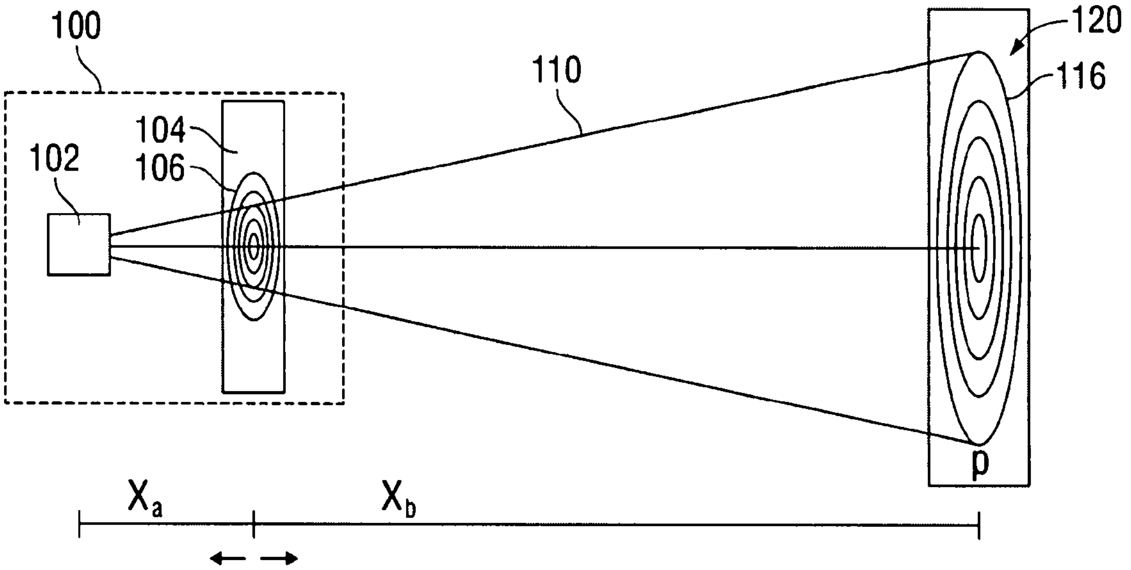

FIG. 2

20122202388 24 Apr 2012

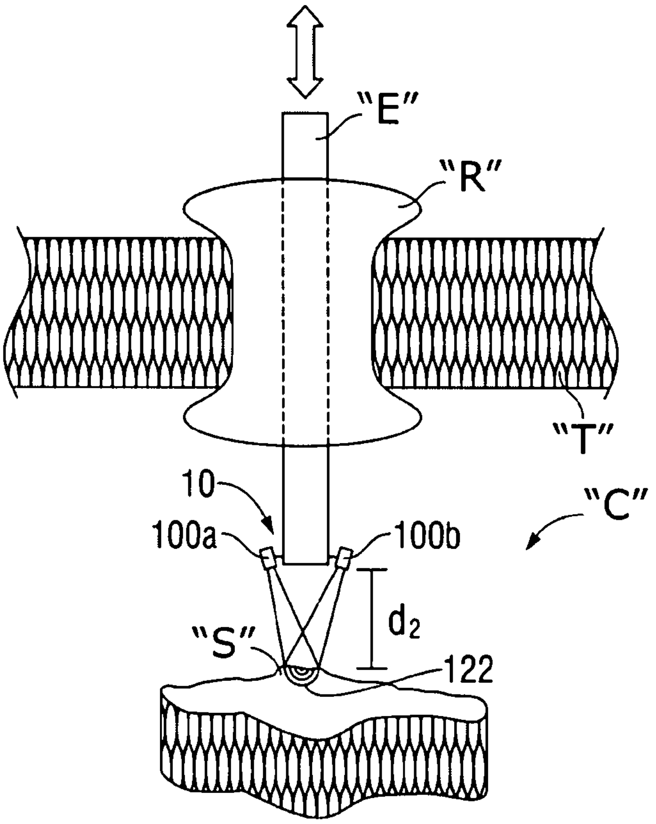

FIG. 3

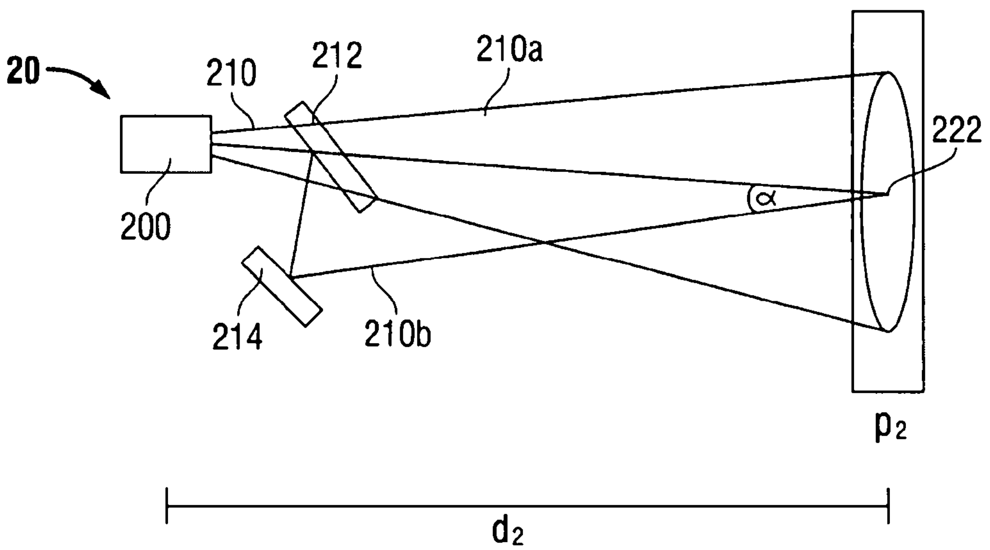

FIG. 4

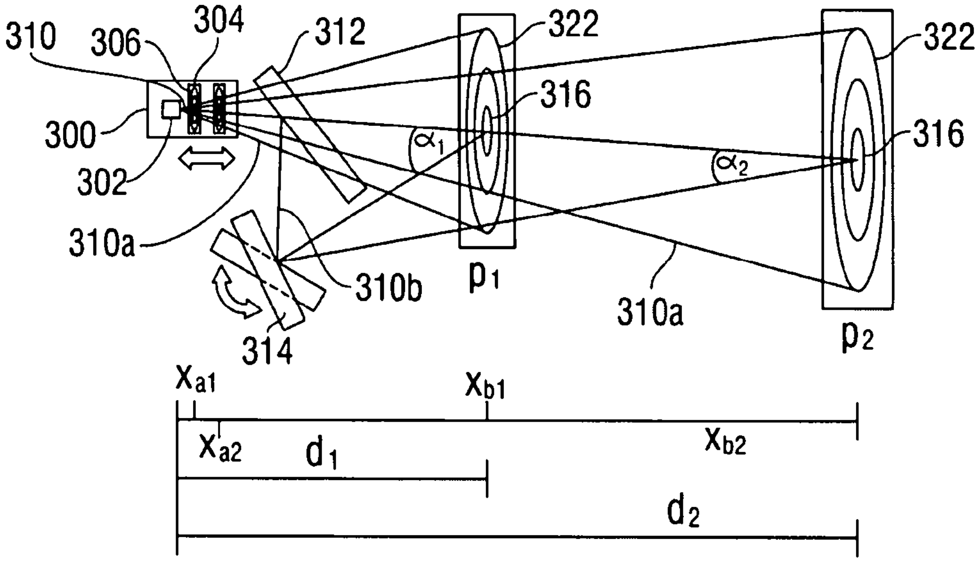
30
310
306
304
312
322
322
316
316
300
302
310a
310b
314
p1
p2
310a
α1
α2
Xa1
Xb1
Xa2
d1
Xb2
d2

FIG. 5

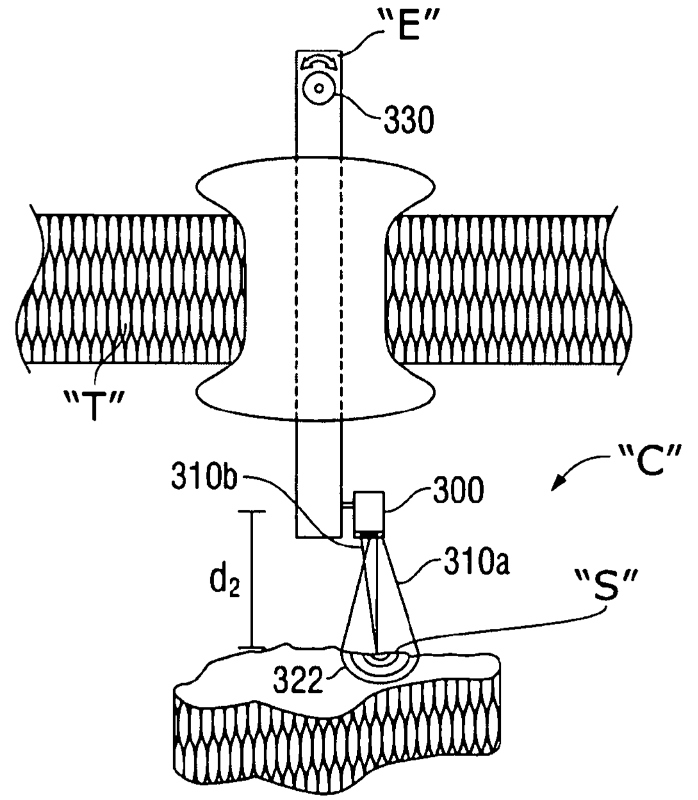
"E"
330
"T"
"C"
310b
300
310a
d2
"S"
322

FIG. 6