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(54) **Title**: SYSTEM FOR DETERMINING SURGICAL TARGET AREA AND AUTOMATIC POSITIONING SYSTEM FOR OPERATING ROOM LAMPS

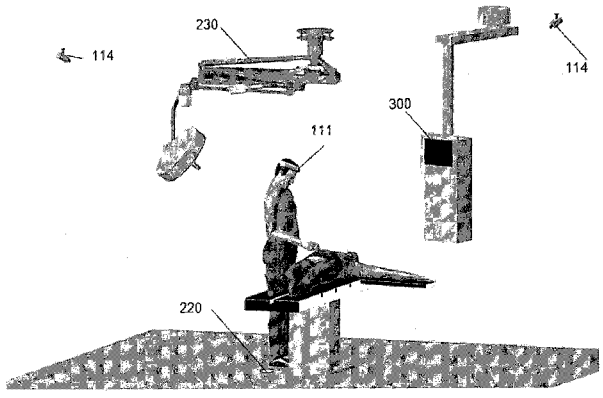

Fig. 2

(57) **Abstract**: The automatic positioning system (200) according to the invention comprises a system for determining the spatial arrangement of the operation field, a unit for determining the spatial position and orientation of the operating theatre light on the basis of the determined operation field, and a control unit for controlling the powered driving units of the operating theatre light (230) on the basis of the spatial position and orientation of the operating theatre light (230). The system for determining the operation field comprises a head-strap (111) adapted to be mounted on the head of a surgeon, said head-strap comprising an optical transmitter (112) and a power supply (115), wherein said optical transmitter (112) includes at least three point light sources, and wherein the spatial positions of the light sources uniquely define a viewing point and a viewing direction; a plurality of optical detectors (114) for receiving the light signals of the transmitter; and an image processing unit for computing said viewing point and said viewing direction in response to said signals of the optical detectors (114) and for determining the spatial arrangement of the operation field from said viewing point and said viewing direction.

WO 2012/172383 A1

System for determining surgical target area and automatic positioning system for operating room lamps

The present invention relates to a system for determining surgical target area and an automatic positioning system for operating theatre lights, in particular for power-driven operating theatre lights.

The U.S. Patent No. 5,347,431 discloses a remote-controlled positioning system for operating theatre lights. Operation of this positioning system is inconvenient because the positions of the light sources are to be controlled by means of 10 to 15 switches.

The U.S. Patent No. 7,706,683 discloses a positioning system for an operating theatre light wherein power-driven positioning of the light may be performed by means of a hand-held remote controller. The drawback of this solution is that for adjusting the light, the surgeon must hold the remote controller in his hands, which encumbers the continuous execution of the operation.

Document US 2005/0195587 A1 discloses a positioning system wherein automatic positioning of the operating theatre lamp is assisted by a hand-held pointing device. This solution also has the drawback that while holding the pointing device in hand, the surgeon can work using only either of his hands.

It is an object of the present invention to avoid the drawbacks of the known solutions and to provide an automatic positioning system for power-driven operating theatre lights that allows a more convenient and more precise adjustment of the operating theatre lamps without manual intervention.

The above objects are achieved by providing a system for determining a operation field for automatic positioning of an operating theatre light, in particular for a multiple-arm operating theatre light, each of its arms being associated with a respective powered driving unit. The system further comprises a head-strap adapted to be mounted on the head of a surgeon, said head-strap comprising an optical transmitter and a power supply, wherein said optical transmitter includes at least three point light sources, and wherein the spatial positions of the

light sources uniquely define a viewing point and a viewing direction, a plurality of optical detectors for receiving the light signals of the transmitter, and an image processing unit for computing said viewing point and said viewing direction in response to said signals of the optical detectors and for determining the spatial arrangement of the operation field from said viewing point and said viewing direction.

The above objects are further achieved by providing an automatic positioning system for an operating theatre light, in particular for a multiple-arm operating theatre light, wherein the system comprises the aforementioned system for determining the spatial arrangement of the operation field, a unit for determining the spatial position and orientation of the operating theatre light on the basis of the determined operation field, and a control unit for controlling the powered driving units of the operating theatre light on the basis of the spatial position and orientation of the operating theatre light.

Preferred embodiments of the systems according to the invention are defined by the depending claims.

The automatic positioning system according to the invention has the advantage that after starting the positioning process, the position and orientation of the operating lamp may be automatically adjusted in the desired manner, without using any remote-controller or pointing device, by means of an optical detection and image processing system.

The invention will now be described in detail with reference to the accompanying drawings, in which

Figure 1.a is a functional block diagram of the system for determining the spatial arrangement of the operation field, in accordance with the present invention used for power-driven operating theatre lights,

Figure 1.b is functional block diagram of the automatic positioning system according to the present invention,

Figure 2 schematically illustrates an arrangement for the application of the automatic positioning system according to the invention,

Figure 3 schematically illustrates the major parts of a preferred embodiment of the head-strap holding the transmitters of the system for determining the operation field, according to the present invention, and

Figure 4 schematically illustrates the major parts of another preferred embodiment of the head-strap holding the transmitters of the system for determining the operation field, according to the present invention.

The structure of the system for determining the operation field according to the present invention is shown by the schematic block diagram in Figure 1.a.

The system for determining the operation field, in accordance with the invention, is primarily adapted to move power-driven operating theatre lights having multiple degrees of freedom. The precise adjustment of the spatial position and the illumination direction of such lamps, as well known in the art, is provided by a multiple-arm system, wherein each arm is associated with a powered driving unit, which is typically a stepper motor or a servo-motor. The control signals of the driving units are generated by a central motion controller, which transmits the control signals to each of the driving units via appropriate communication lines. Such operating theatre lights typically comprise a multiple-segment supporting arm, as well as rails and/or articulations, to allow displacement or rotation of the segments of the supporting arm relative to each other. The light fitting, which contains the high-performance light sources used to illuminate the surgical operation, is fixed to the last segment of the supporting arm.

The automatic operation of the system for determining the operation field according to the invention is provided by an innovatively configured and arranged optical detection and image processing system that is capable of determining the spatial arrangement of the operation field, in particular the spatial position and orientation thereof, without manual intervention, and that may be simply coupled to any conventional control system used in the prior art for positioning operating theatre lights.

The system 100 for determining the operation field, according to the present invention, comprises an optical detection system 110 and an image processing system 120 receiving the signals of said optical detection system 110, which comprises an optical transmitter 112 and a plurality of optical detectors 114. The optical transmitter 112, in the present case, is mounted on a head-strap 111 that may be fixed to the head of the operating surgeon. The optical transmitter 112 contains a plurality of positioning light sources 113. Power supply of said

light sources is preferably provided by a power source 115, such as a battery or a solar cell, fixed to the head-strap 111.

The transmitter 112 arranged on the head-strap 111 comprises at least three separate point light sources 113, preferably light emitting diodes (LEDs). It is preferred that said light sources 113 emit infrared radiation, while another embodiment of the transmitter 112 may emit visible light. In this latter case, the positioning light sources should emit a visible light having a wave length which can be definitely distinguished from the light of the operating theatre light by the optical detectors. The positioning light sources 113 are arranged on the head-strap 111 so that they can be well visible for the optical detectors arranged in the surrounding room from the most possible directions.

The detection range of the optical detectors 114 suits to the wave length of the light sources 113 of the transmitter 112, meaning that when the transmitter 112 includes infrared LEDs, the optical detectors 114 are also infrared detectors, preferably infrared video cameras generating images from the signals of the infrared LEDs, in which images the LEDs appear substantially in a point-like manner. The optical detectors 114 operate in a continuous mode and they continuously forward the detected signals (in case of infrared video cameras, the motion pictures detected in the infrared range) to the image processing unit 120, which in response to the signals of the two or more optical detectors 114, determines the spatial position of the light sources 113 of the transmitter 112 by using a method well known in the art. The image processing unit 120 computes the spatial arrangement of the head-strap 111 from the spatial positions of the light sources 113. In this way, motion of the surgeon's head can be continuously tracked. The optical detector system 110 and the associated image processing system 120 are calibrated so that the spatial positions of the point light sources 113 of the transmitter 112 (i.e. the corresponding spatial arrangement of the head-strap 111 mounted on the surgeon's head) always uniquely define a viewing point and a viewing direction. In this regard, it is assumed that the viewing direction of the surgeon is substantially defined by the situation of the surgeon's head.

In response to the signals of the optical transmitter 112, the image processing unit 120 computes the viewing point and the viewing direction of the surgeon, and subsequently, from the viewing point and the viewing direction, as well as the spatial parameters of the operating-table (or, in a particular case, the body of the patient or a member of the patient subject to the

operation), the image processing unit 120 computes the spatial position (and in specific cases, also the spatial orientation) of the operation field, and then forwards those computed parameters to the central control unit performing the adjustments of the operating theatre light.

The structure of the automatic positioning system according to the invention is depicted by the functional block diagram shown in Figure 1.b.

In the system 200 used for automatic adjustment of a power-driven operating theatre light, the data of the image processing unit of the above described system 100 for determining the operation field are received by a central control unit 210, a unit 205 of which determines the position and the orientation (and the focal distance, if needed) of the light fitting of the operating theatre light on the basis of the spatial arrangement of the operation field, and then from these data, another unit 206 thereof determines the actual values of the motion parameters (translation, rotation) for each of the driving units, said parameters being forwarded by the central control unit to the respective driving units in real time.

During positioning the operating theatre light, the central processing unit 210 normally takes the location of the operating surgeon into account, and it controls the adjustment of the lamp so that the surgeon does not cast shadow on the surgical area. For example, in case of back-light illumination, to avoid casting shadow of the head, the central control unit 210 adjusts the operating theatre light by using a pre-programmed algorithm in such a manner that the light thereof traverses above the left or right shoulder of the surgeon.

Operation of the automatic positioning system 200 may be configured so that the light of the operating theatre light is always focused on the surgical area, or it may be configured in a manner that the extent of focusing is a pre-set parameter. For a particular direction of illumination, the extent of focusing can be adjusted by moving the operating theatre light closer to or farther from the operation field.

To avoid any unnecessary positioning of the lamp, the automatic positioning system 200 preferably comprises a trigger unit 220, after the activation of which the system 200 directs the light of the operating theatre light to the point (or the operation field corresponding to the viewing direction of the surgeon) determined in response to the signals of the transmitter 112. Furthermore, the positioning system 200 may also be configured so that it takes the signals of the transmitter 112 into account only if they define a direction that points substantially

towards the patient (or the operating-table), which also allows to avoid unnecessary positioning of the operating theatre light when the surgeon looks up or walks away from the patient during the operation for any reason.

When the system 200 comprises a trigger unit 220, after receiving a trigger signal, the operating theatre light, depending on the operational mode of the system 200, may either continuously follow the motion of the spatial point determined on the basis of the signals of the transmitter 112, or moves into a position and orientation corresponding to the target area actually determined, and the lamp will change its position and orientation only after a succeeding activation of the trigger unit 220 if it is necessary at all. In the positioning system 200 according to the invention, it is preferred that the trigger unit 220 is a foot-operated triggering device, such as a pedal or a push-button, thereby the surgeon can use both of his hands during the entire operation.

Figure 2 schematically illustrates a possible arrangement of the automatic positioning system 200 according to the invention, said arrangement being particularly preferred from the aspect of carrying out the invention in practice. Accordingly, in this arrangement of the automatic positioning system 200 of the present invention, the image processing unit 120 of the system 110 for determining the target area and the central control unit 210 are both integrated into a single central computer 300, wherein determination of the arrangement of the operation field, determination of the position and orientation of the operating theatre light 230, as well as generation of control signals for the drivers are all performed by the same processor device. In case of integrating said functions, only the optical detector system 110 shown in Figure 1, and, if necessary, the trigger unit 220 are to be coupled to the central computer 300.

In a preferred embodiment of the system for determining the operation field, according to the present invention, the head-strap 111 carrying the transmitter 112 may comprise, in addition to the positioning light sources 113, a low-performance laser pointing unit 116 (shown by dashed lines in Figure 1.a) that emits a laser beam into a direction that is fixed relative to the head-strap 111. The pointing unit 116 is configured so that it radiates the laser beam to the surface under operation. In this case, for determining the spatial arrangement of the operation field, the image processing unit 120 also uses the spatial position of the point marked by the pointing unit 116. If the detectors 114 are capable of detecting the light emitted by the pointing unit 114, there will be no need of additional detectors 114 in this embodiment.

Figure 3 illustrates a schematic view of the major parts of an exemplary embodiment of the head-strap used in the system for determining the operation field according to the invention.

As shown in Figure 3, the head-strap 111 is formed as a relatively rigid strap fitting to the shape of the head, said strap having two free ends adjacent to each other. By moving said end portions away from each other, the head-strap 111 may be slightly widened and mounted on the head of the surgeon. Along the upper edge of the head-strap 111, three light sources 113 are placed equidistantly, preferably by an angular distance of approximately 90 degrees, wherein the power supply of said light sources is provided by a button-cell arranged at either end portion of the head-strap 111. The electrical wires powering the light sources 113 are led inside the head-strap 111.

Figure 4 illustrates a schematic view of the major parts of another exemplary embodiment of the head-strap used in the system for determining the operation field according to the invention. The head-strap 111' shown in Figure 4 is formed in substantially the same way as the head-strap 111 shown in Figure 3, but the head-strap 111' further comprises a laser pointing unit 116 arranged on the side of the head-strap opposite to its free end portions, i.e. on the front surface of the strap. The power consumption of the pointing unit 116 is low enough so that a button-cell used to power the light source 113 be also capable of powering the laser source, at least for short time periods.

It is obvious for a skilled person that the head-straps schematically illustrated in Figures 3 and 4 are only exemplary embodiments thereof, and with respect to both of its design and the number and arrangement of its light sources, the head-strap may have several other embodiments within the scope of the invention.

Claims

1. A system (100) for determining a operation field for automatic positioning of an operating theatre light, in particular for a multiple-arm operating theatre light (230), each of its arms being associated with a respective powered driving unit,

characterized in that the system further comprises

- a head-strap (111) adapted to be mounted on the head of a surgeon, said head-strap comprising an optical transmitter (112) and a power supply (115), wherein said optical transmitter (112) includes at least three point light sources (113), and wherein the spatial positions of the light sources (113) uniquely define a viewing point and a viewing direction,

- a plurality of optical detectors (114) for receiving the light signals of the transmitter (112), and

- an image processing unit (120) for computing said viewing point and said viewing direction in response to said signals of the optical detectors (114) and for determining the spatial arrangement of the operation field from said viewing point and said viewing direction.

2. The system according to claim 1, wherein said plurality of optical detectors (114) includes at least two video cameras.

3. The system according to claim 2, wherein the light sources (113) of the transmitter (112) are infrared LEDs and the optical detectors (114) are infrared video cameras.

4. The system according to any one of claims 1 to 3, wherein the head-strap (111) comprises a laser pointing unit (116) radiating into a direction fixed relative to the head-strap (111), and wherein the image processing unit (120) is configured so that for determining the spatial arrangement of the operation field, it additionally uses the spatial position of a point marked by said pointing unit (116).

5. Automatic positioning system (200) for an operating theatre light, in particular for a multiple-arm operating theatre lights, each of its arms being associated with a respective powered driving unit,

characterized in that the system comprises

- a system (100) for determining the spatial arrangement of the operation field according to any one of claims 1 to 4,

- a unit (205) for determining the spatial position and orientation of the operating theatre light (230) on the basis of the determined operation field,

- a control unit (206) for controlling the powered driving units of the operating theatre light (230) on the basis of the spatial position and orientation of the operating theatre light (230).

6. The system according to claim 5, wherein it further comprises a triggering unit (220) for starting the positioning process.

7. The system according to claim 6, wherein said triggering unit (220) includes a foot pedal or a push-button.

8. The system according to any one of claims 5 to 7, wherein the image processing unit (120) of the system (100) for determining said target area, the unit (205) for determining the spatial arrangement of the operating theatre light and the control unit (206) for controlling the motion of the operating theatre light are integrated into a central computer (300).

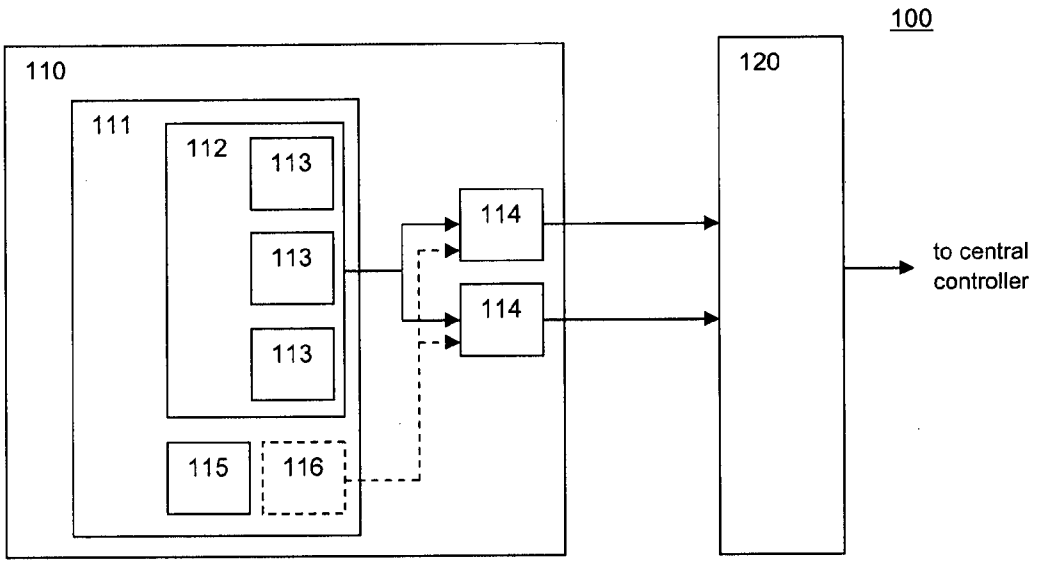
100
110
111
112
113
113
113
114
114
120
to central controller
115
116

Fig. 1.a

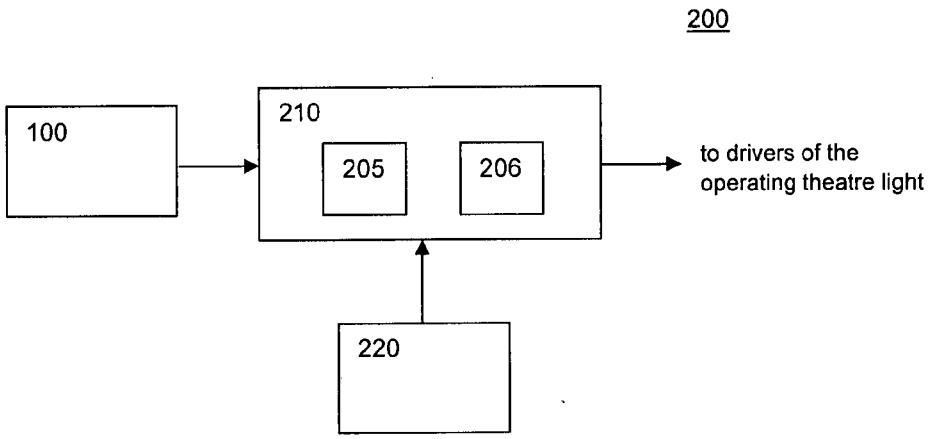
200
100
210
205
206
to drivers of the operating theatre light
220

Fig. 1.b

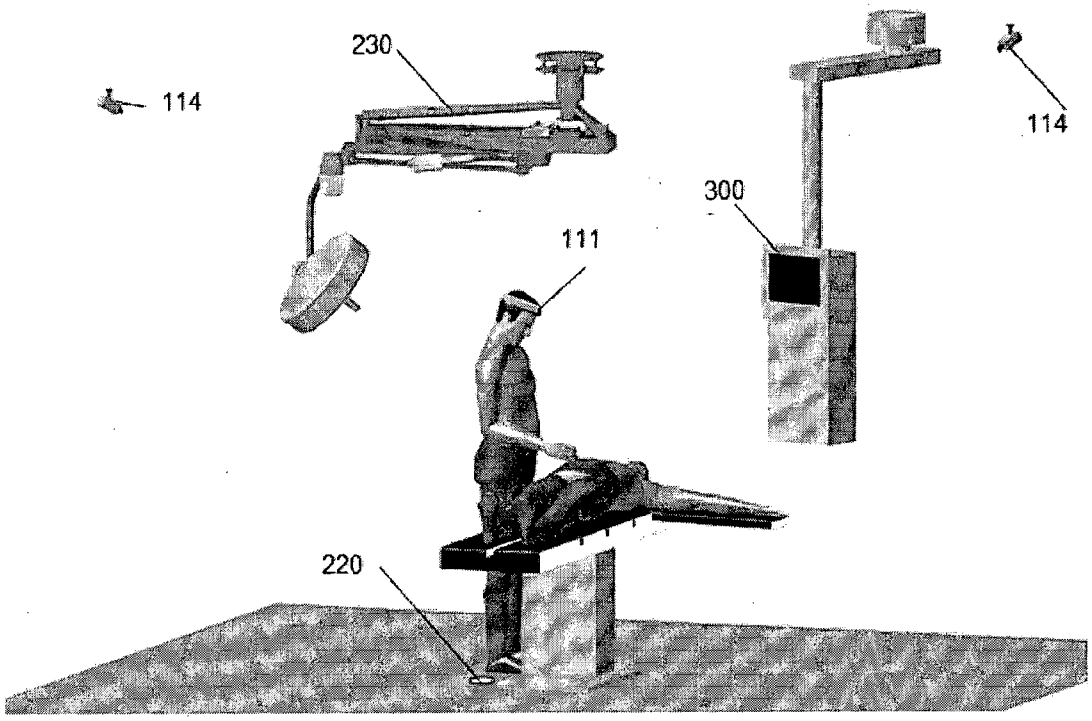

Fig. 2

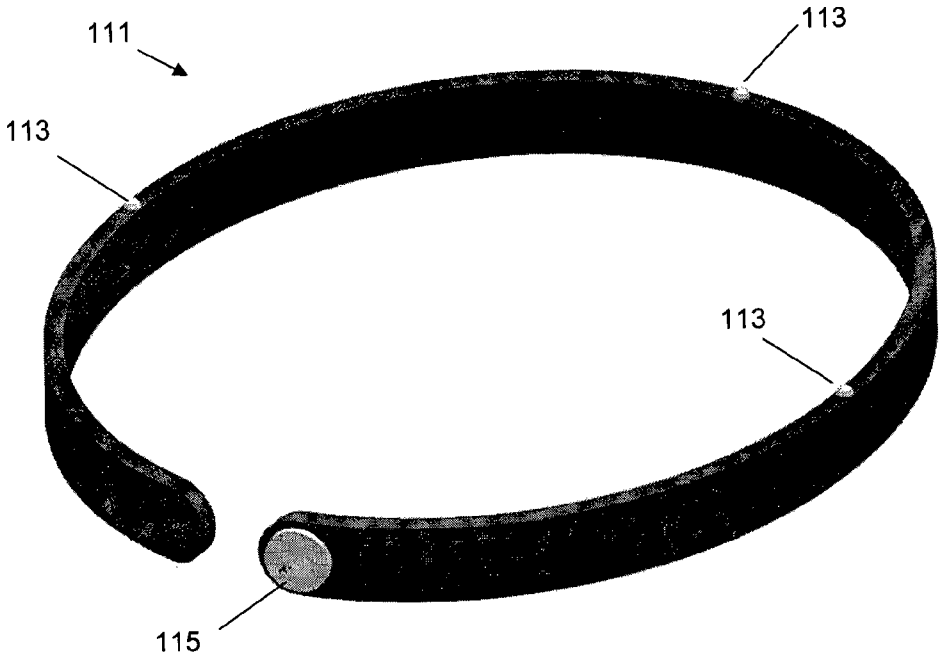

Fig. 3

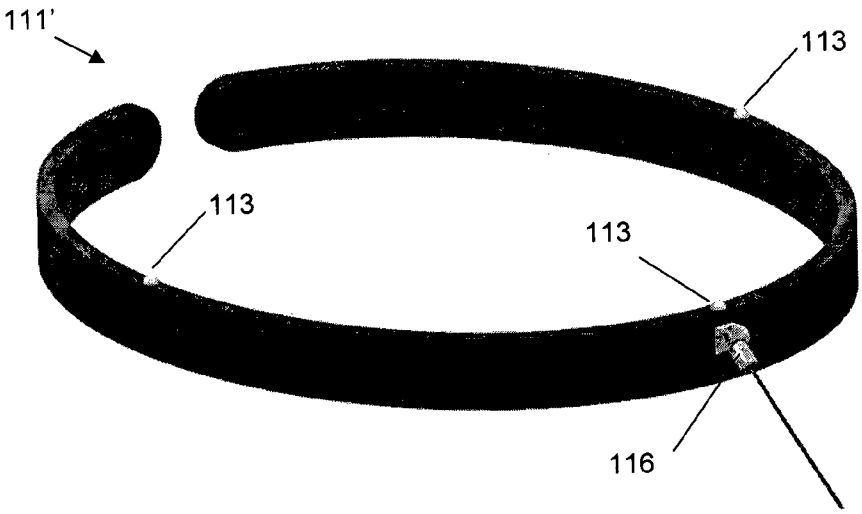

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B19/00
ADD.

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

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2012	07/11/2012

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, Fax: (+31-70) 340-3016	Moers, Roelof

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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