(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 March 2005 (24.03.2005)

PCT

(10) International Publication Number
WO 2005/025424 A1

(51) International Patent Classification[7]: A61B 8/00, A61N 7/00

(21) International Application Number: PCT/AU2004/001239

(22) International Filing Date: 10 September 2004 (10.09.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2003904973 12 September 2003 (12.09.2003) AU

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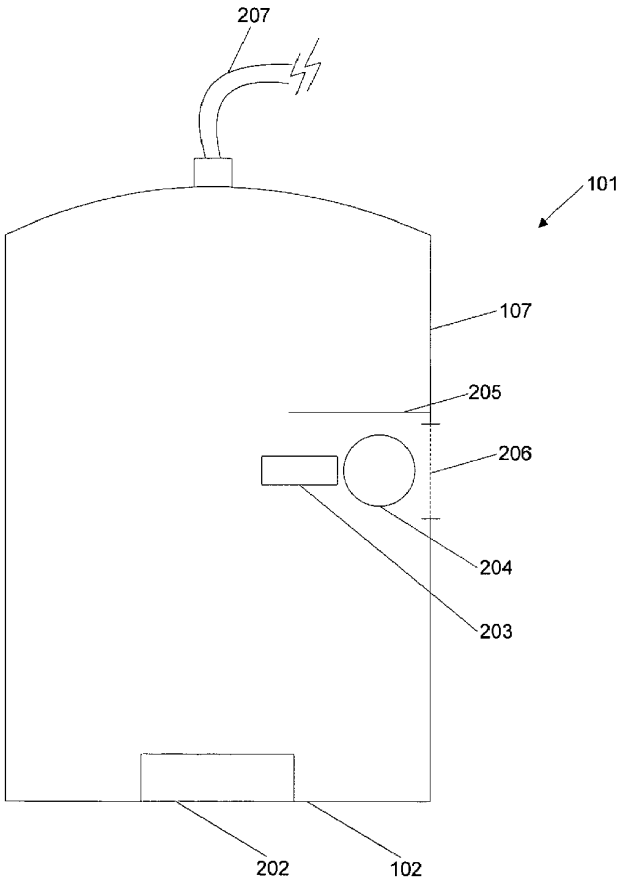
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

[Continued on next page]

(54) Title: ULTRASOUND APPARATUS

(57) Abstract: There is disclosed an ultrasound apparatus comprising an ultrasound transducer (202) that operates in a target plane (105), and a light source (203,204,205) that emits a broad, planar light beam (206) that is co-planar with said target plane and directed relative to said ultrasound transducer (202) to illuminate at least a region where an instrument (150) is to be aligned with said target plane.



WO 2005/025424 A1

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ULTRASOUND APPARATUS

Field of the Invention

The present invention relates to an ultrasound apparatus and method of assisting in alignment of an instrument relative to an ultrasound transducer probe. One application of the invention is to assist the puncturing of internal body organs, vessels and the like, through the utilization of a puncturing cannula or hollow needle that will reflect ultrasound waves.

Discussion of the Prior Art

It is presently known that one can remove tissues or body fluids from internal body organs for example, the liver or kidney, for diagnostic purposes by means of suitable puncturing needles. By the same method amniotic fluid may be removed from the uterus during a pregnancy or, for example, blood or a medication may be injected into the fetal body or the organs of an adult human.

In all of these instances it is extremely important to know the precise position of the puncturing cannula or needle relative to the organs or vessels that are to be punctured so as to avoid any unnecessary injuries of endangered areas (for example, the heart during puncture of the left lobe of the liver), and also to prevent a tissue withdrawal from an erroneous body region or a misplaced injection.

An ultrasound-echo sectional view apparatus having an ultrasonic transducer probe for the ultrasonic scanning of the body region which is to be punctured, and a display for viewing the ultrasound echo-section images, allows continuous puncturing control through the assistance of ultrasound, in particular, through rapid display

ultrasound-section images. The ultrasound transducer probe can be adjusted while observing the display of the ultrasound-echo sectional view apparatus to select, in the body region which is to be punctured, a sectional plane that is preferred for the puncture target or aim direction. Once the target direction is chosen, this is displayed as an echo-sectional view. If the puncturing cannula or needle is inserted in the plane of the ultrasound beam it is also easily visible on the display, since the cannula material has a distinguishable ultrasound contrast to the surrounding biological tissue.

Notwithstanding good visual control in the scanning region there are, however, further aiming problems. The movement of the cannula in the tissue may be directly followed by eye on the display only when the cannula actually reaches into the region of the ultrasound-scanning waves in the scanning sectional plane. If the plane of insertion of the cannula is different to that of the scanning sectional plane then the entire needle will not be seen. If the entire needle is not seen then there is a risk that the incorrect organ or tissue may be punctured, with a higher risk of unwanted injury to the patient or removal of incorrect tissue. A factor that potentially exacerbates this problem is that until the needle passes through any subcutaneous fat, the needle can be difficult to observe. Hence, the needle may be significantly misplaced before this is determined.

US Patent no. 4,058,114 describes a guide that is attached to the ultrasonic transducer probe. The needle is inserted through the guide, and the guide constrains the pathway of the needles such that it remains in the plane of the ultrasound beam.

Such guides limit the ability of the operator to angle the needle independently of the ultrasound transducer probe.

Accordingly, if the needle is inserted at the wrong angle or it is necessary to negotiate an obstacle such as a rib, the constraints of the guide make it difficult or impossible to realign the needle. This necessitates withdrawal of the needle and reinsertion and can cause additional and undesirable trauma to the patient.

Summary of the Invention

The invention provides an ultrasound apparatus comprising:

an ultrasound transducer that operates in a target plane; and

a light source that emits a broad, planar light beam that is co-planar with said target plane and directed relative to said ultrasound transducer to illuminate at least a region where an instrument is to be aligned with said target plane.

The invention also provides a method of assisting in alignment of an instrument relative to an ultrasound transducer that operates in a target plane comprising directing a broad, planar light beam in the same plane as said target plane to illuminate at least a region where said instrument is to be aligned.

The invention provides a method of aligning an instrument relative to an ultrasound transducer that operates in a target plane comprising directing a broad planar light beam in the same plane as said target plane and to illuminate at least a region where said instrument is to be aligned; and

adjusting the position of said instrument by monitoring light from said light source reflected from said instrument to determine whether said instrument is in said target plane.

Embodiments of the invention facilitate the insertion of a

puncturing cannula into the body region that is to be punctured, in the same plane as the ultrasound beam, while allowing the operator to angle the needle as desired during the procedure without moving the ultrasonic transducer probe.

Brief Description of the Drawings

Further advantages and details of the invention may be ascertained from the following description of embodiments thereof, taken in conjunction with the accompanying drawings in which:

Figure 1 is a schematic diagram of an ultrasound apparatus being used to assist in a puncturing procedure;

Figure 2 is a schematic diagram illustrating the ultrasound transducer probe of the first embodiment; and

Figure 3 is a schematic diagram illustrating the ultrasound transducer probe of a second embodiment.

Detailed Description

Figure 1 illustrates schematically how an ultrasound apparatus 100 of a first embodiment can be used to align an instrument with the target plane.

Herein, the term "instrument" is used to refer to any item that may be desired to be monitored or guided using an ultrasound including puncturing cannulae, needles and the like.

The term "target plane" is used to refer to the plane in which the ultrasound operates - i.e., the plane from which the ultrasound transducer receives reflected sound waves that are subsequently processed and displayed.

The apparatus 100 comprises a transducer probe 101 that generates and receives sound waves by means of

piezoelectric crystals. As is well known in the art, by applying appropriate electric currents to the crystals, sound waves are produces which travel outward from the crystals. Reflected sound waves are transformed by the piezoelectric crystals into electric current. The processor/controller 103 of the ultrasound apparatus converts these electric currents into ultrasound images as is well known to persons skilled in the art. The ultrasound images are then displayed on display 104. Processor/controller 103 also contains control means for controlling the ultrasound transducer which is typically mounted at the contact end 102 of the ultrasound transducer probe 101.

A coupling medium, for example, a precedent water section, is applied on the skin surface of a patient in the elevation of a target organ that is to be punctured, for example, the liver or the uterus of a pregnant woman to couple the transducer to the skin. The ultrasound beam is radiated in the direction of the target organ and reflected back to the ultrasound scanning probe. The reflected ultrasound beam 105, thereby scans this body region and, in particular, the target organ 121 that is to be punctured - i.e. the transducer probe 101 is adjusted until the target organ 121 is displayed.

Through the corresponding linewise reproduction of the ultrasound echo impulses emanating from each ultrasound line in the examination region, on the display 104 there is obtained a visual image of the target plane of the target organ, that has been presently scanned by the ultrasonic beam. In order to assist in the insertion of an instrument along the plane of the ultrasound beam the ultrasound transducer probe incorporates a light source in the form of a laser assembly that emits a laser beam 106. The laser beam is a broad, planar laser beam 106. The laser is mounted so that the plane of the emitted light is

co-planar with the target plane.

To successfully intersect the target 121, the needle is inserted in the plane of the laser beam and is thereby colinear with the target plane. The needle will thus be visible on the display as it lies in the plane of the ultrasound beam when it is within the patient. The operator can monitor light reflected from the needle to align the needle appropriately, i.e. the longer the line of reflected light, the closer the needle is to the correct plane. This is particularly advantageous where the needle is being inserted into a body that has a layer of subcutaneous fat as the needle or other instrument can be difficult to observe in the region of subcutaneous fat and therefore will not appear on the ultrasound until it has been displaced some distance into the body. Accordingly, if the needle is offline, without the guidelight of the transducer probe of the present embodiment, the operator will not expect to see the needle until sometime after the needle has been inserted, and accordingly, an operator can be tempted to continue to insert the needle further into the body in situations where the needle is not visible because it is in the wrong plane rather than it is obscured by subcutaneous fat. Using the apparatus and inserting a needle in accordance with the aid of the apparatus of the preferred embodiment, allows the operator a greater degree of certainty that the needle will appear in the target plane while maintaining flexibility for the operator to adjust the needle position. This allows the operator to negotiate obstacles - for example, a bone such as a rib.

Further details of an ultrasound probe 101 of a first preferred embodiment are illustrated in Figure 2. In Figure 2 the ultrasound transducer probe 101 is connected by cable 207 to processor/controller 103. The ultrasound transducer 202 is mounted in the contact end 102 of the

ultrasound transducer 101 probe. The control circuitry for the transducer 202 is well known to persons skilled in the art and is accordingly not illustrated.

The laser 203 is mounted within casing 107. The laser 203 is also turned on or off under operation of the controller 103.

Cylindrical lens 204 is mounted within the casing and turns the linear light beam produced by laser 203 to a broad planar light beam. In order to conveniently direct as much light as possible to the region where the instrument is to be aligned, mirror 205 is placed above window 206. Thus, light is emitted from window 206 to a region near the ultrasound device in order to enable alignment of an instrument.

A second embodiment of the invention is shown in Figure 3 where a laser assembly consisting of a laser module 308, a laser 303 and a cylindrical lens 304 are mounted externally to the casing 307 of an ultrasound transducer probe. The laser assembly may be permanently or demountably mounted to the probe. The laser module, incorporates a power source and switch for turning laser 303 on or off. In all other respects, the apparatus operates as in the first embodiment. While making the laser assembly demountable offers certain advantages, it would also be appreciated that mounting the light source within the casing of the transducer probe provides the advantage that the transducer probe is otherwise shaped as conventional probes. This is convenient in terms of supply of disposable covers which can be used to keep the transducer probe sterile.

While there has been shown what is considered to be the preferred embodiment of the invention, it will be obvious that modifications may be made which come within the scope

of the disclosure of the specification.

For example, while a laser light source is convenient it will be appreciated that other light sources could be used such as light emitting diodes with appropriate focussing optics. These and other modifications should be understood as falling within the scope of the invention.

CLAIMS:

1. An ultrasound apparatus comprising:

an ultrasound transducer that operates in a target plane; and

a light source that emits a broad, planar light beam that is co-planar with said target plane and directed relative to said ultrasound transducer to illuminate at least a region where an instrument is to be aligned with said target plane.

2. An ultrasound apparatus as claimed in claim 1, wherein said ultrasound transducer is contained in a casing.

3. An ultrasound apparatus as claimed in claim 2, wherein said light source is located within said casing, said casing further comprising a window through which said light beam is emitted.

4. An ultrasound apparatus as claimed in claim 2, wherein said light source is mounted to said casing.

5. An ultrasound apparatus as claimed in claim 1, wherein said light source comprises a point laser beam and one or more optical elements for transforming the point laser beam into a broad, planar beam.

6. An ultrasound apparatus as claimed in claim 5, wherein there are two optical elements, a first optical element for transforming said point laser beam into a planar beam and a second optical element for broadening said planar beam.

7. An ultrasound apparatus as claimed in claim 6, wherein said first optical elements comprises a cylindrical lens.

8. An ultrasound device as claimed in claim 6, wherein said second optical element comprises a mirror.

9. An ultrasound apparatus as claimed in claim 1, further comprising:

a processor for processing signals from said ultrasound transducer to produce ultrasound images; and

a display for displaying said ultrasound images.

10. A method of assisting in alignment of an instrument relative to an ultrasound transducer that operates in a target plane comprising directing a broad, planar light beam in the same plane as said target plane to illuminate at least a region where said instrument is to be aligned.

11. A method as claimed in claim 10, comprising providing a light source that produces said broad planar light beam, and mounting said light source relative to said ultrasound transducer such that the light beam maintains alignment with said target plane when said ultrasound transducer is moved.

12. A method of aligning an instrument relative to an ultrasound transducer that operates in a target plane comprising directing a broad planar light beam in the same plane as said target plane and to illuminate at least a region where said instrument is to be aligned; and

adjusting the position of said instrument by monitoring light from said light source reflected from said instrument to determine whether said instrument is in said target plane.

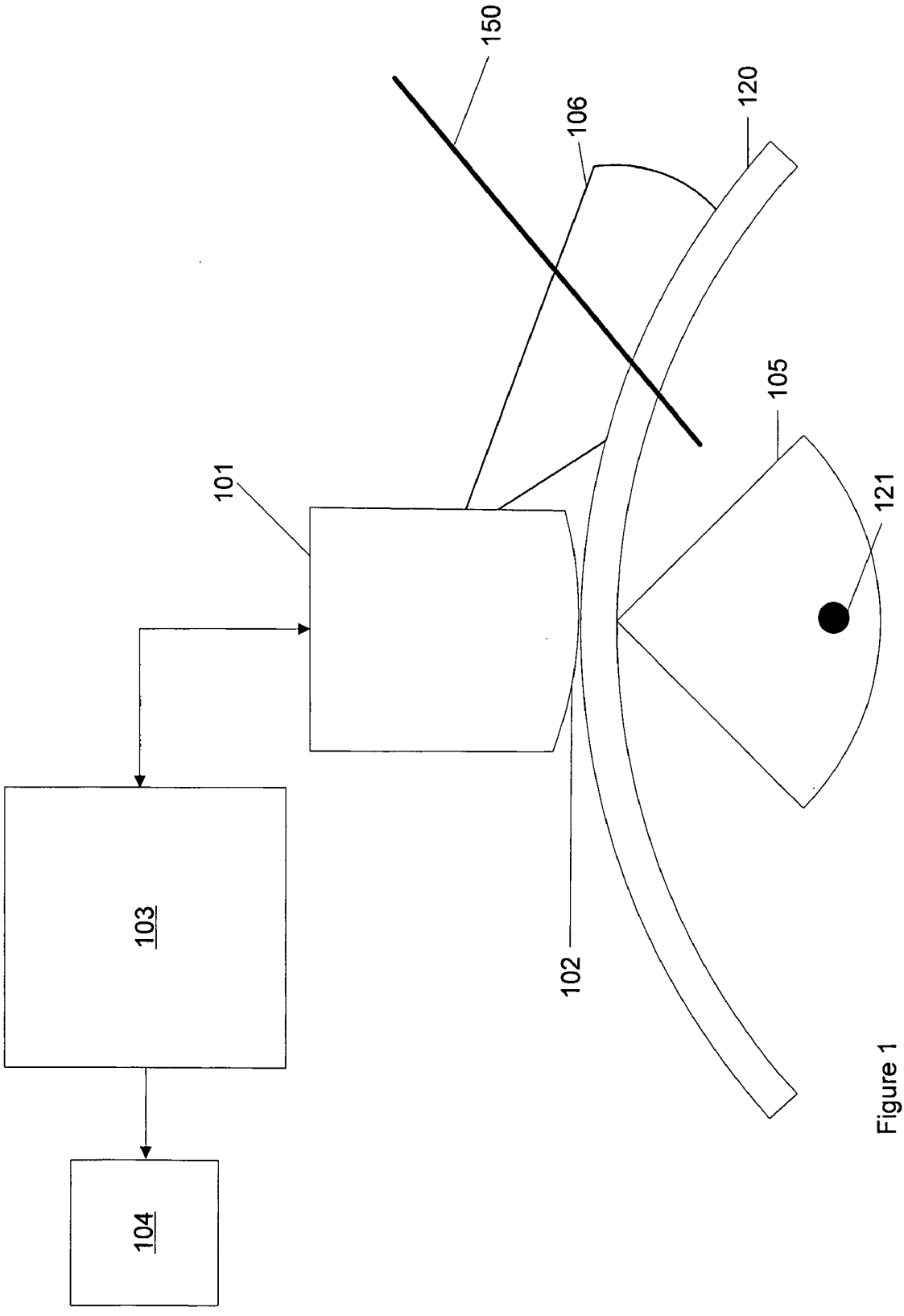


Figure 1

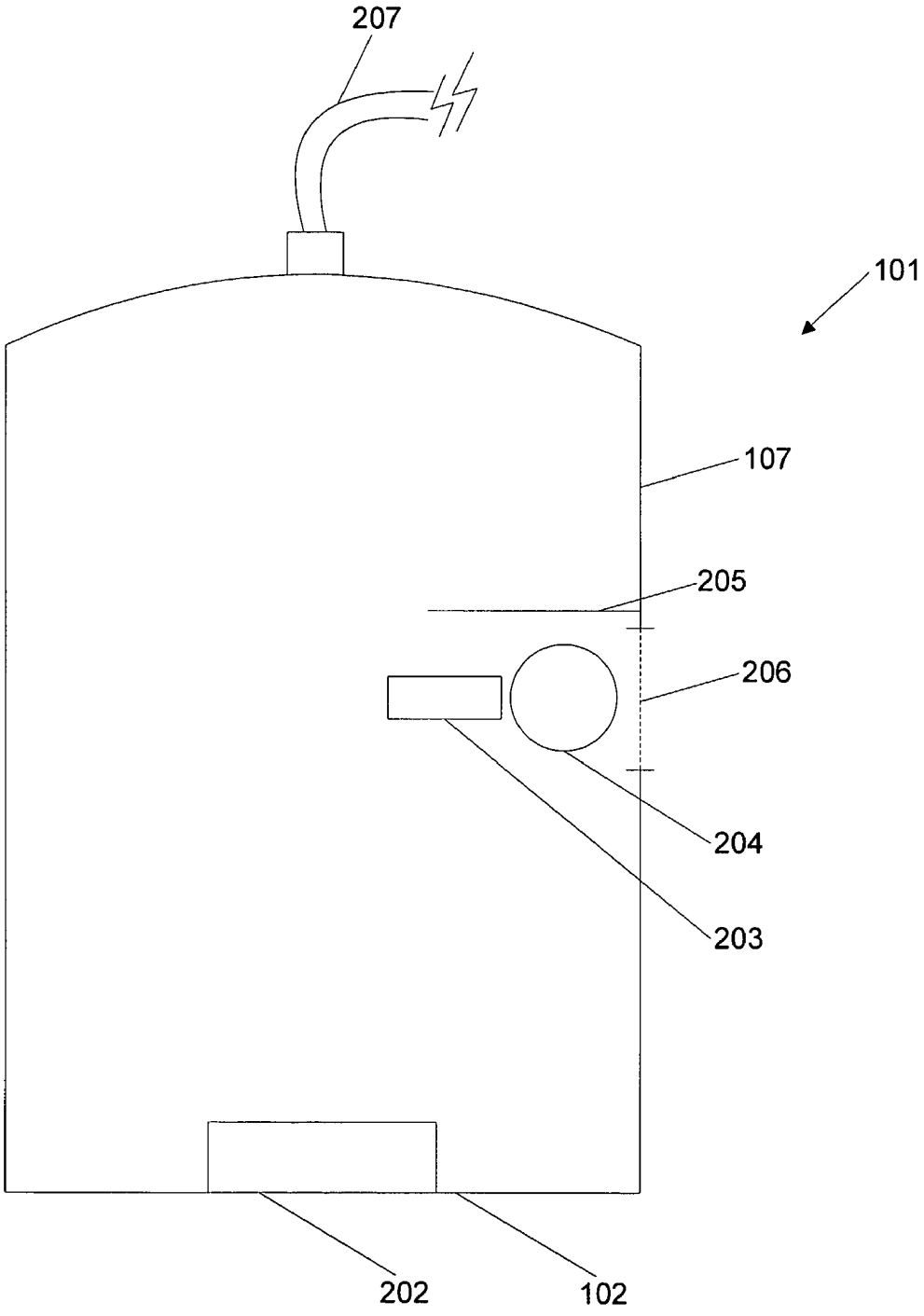


Figure 2

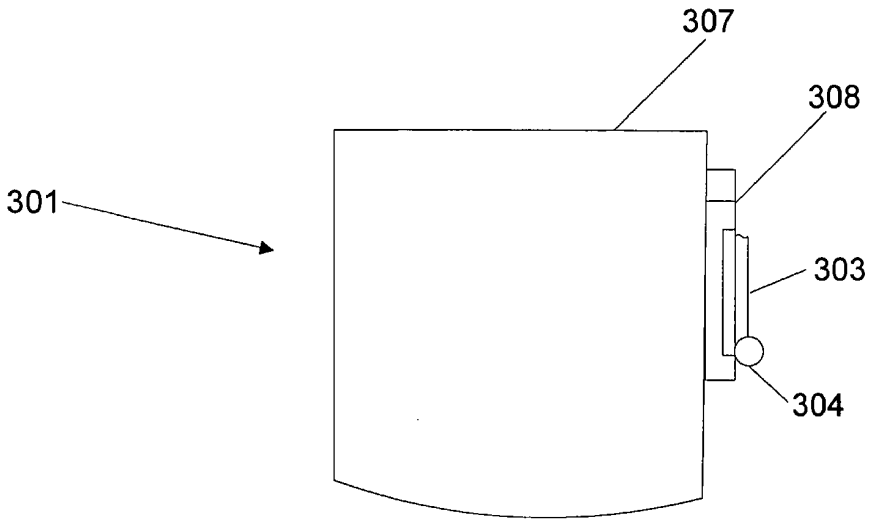


Figure 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2004/001239

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: A61B 8/00, A61N 7/00

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)

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)
DWPI: IPC: A61B, A61M, A61N; Keywords: ultrasound, ultrasonic, light, illumination, laser, visible, LED, planar, plane, line, axis, straight, align, target, guide, direct, trajectory

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6689067 B2 (SAUER et al) 10 February 2004 See entire document	1-12
X	US 4484569 A (DRILLER et al) 27 November 1984 See entire document	1-12
X	US 6702749 B2 (PALADINI et al) 9 March 2004 See entire document	1-12

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

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

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

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"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
15 December 2004	22 DEC 2004
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **SUE THOMAS** Telephone No : (02) 6283 2604

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2004/001239

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	RU 2221489 C2 (ORENBURG MED ACAD) 20 January 2004 See entire document	1-12
X	US 2003/0097066 A1 (SHELBY et al) 22 May 2003 See in particular abstract; paragraph 007	1-12
A	US 4787394 A (OGURA) 29 November 1988 See entire document	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2004/001239

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	6689067	US	2003120154		
US	4484569	DE	3208827	US	5024233
US	6702749	US	2003028112	US	2003139610
RU	2221489				
US	20030097066				
US	4787394	DE	3713816	JP	63046147

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

专利名称(译)	超声仪器		
公开(公告)号	EP1663005A4	公开(公告)日	2008-11-19
申请号	EP2004761274	申请日	2004-09-10
申请(专利权)人(译)	AUSTIN HEALTH		
当前申请(专利权)人(译)	AUSTIN HEALTH		
[标]发明人	BROOKS MARK DUNCAN MOORHOUSE ANDREW BRUCE SAMIR ANTHONY EDWARD U PAUL LYKHUN		
发明人	BROOKS, MARK, DUNCAN MOORHOUSE, ANDREW, BRUCE SAMIR, ANTHONY, EDWARD U, PAUL, LYKHUN		
IPC分类号	A61B8/00 A61N7/00 A61B8/08 A61B17/34 A61B19/00		
CPC分类号	A61B8/0841 A61B8/0833 A61B17/3403 A61B2017/3413 A61B2090/3937		
代理机构(译)	HARRISON GODDARD FOOTE		
优先权	2003904973 2003-09-12 AU		
其他公开文献	EP1663005A1		
外部链接	Espacenet		

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