

(19)



(11)

EP 2 470 103 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

01.01.2014 Bulletin 2014/01

(21) Application number: **10757899.9**

(22) Date of filing: **16.09.2010**

(51) Int Cl.:

A61B 19/00 (2006.01)

(86) International application number:

PCT/US2010/049081

(87) International publication number:

WO 2011/037813 (31.03.2011 Gazette 2011/13)

(54) **ECHOGENIC NEEDLE MECHANISM**

ECHOGENER NADELMECHANISMUS

MÉCANISME À AIGUILLE ÉCHOGENE

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO SE SI SK SM TR**

(30) Priority: **24.09.2009 US 245454 P**

(43) Date of publication of application:

04.07.2012 Bulletin 2012/27

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Description

Background

[0001] Needle catheters are often employed to inject fluids and/or obtain fluid or tissue samples for diagnosis and/or treatment. In these procedures, a needle is advanced to a target tissue site within a catheter under ultrasound guidance. The needle may be advanced distally from the catheter to penetrate the target site. The ultrasound image can allow a user to visualize the position of the needle in relation to the target and surrounding structures and aids in ensuring that a correct tissue portion is treated, sampled, etc. to minimize the risk of trauma or injury to non-targeted tissue. A common challenge associated with the use of ultrasound imaging is the relatively low echogenicity of the needle and the lack of clarity in the resulting images.

[0002] As would be understood by those skilled in the art, several factors play a role in the echogenicity of the needle including needle gauge, the difference in acoustic impedance between the needle and the surrounding tissue, the angle of the needle relative to the transducer, the frequency being used and various characteristics of the processing algorithm.

A device according to the preamble of claim 1 is known from US 4,977,897.

Summary of the Invention

[0003] A medical device according to the present invention is defined in claim 1.

Brief Description of the Drawings

[0004]

Fig. 1 shows a side view of an exemplary device according to the present invention;

Fig. 2 shows a side view of a needle according to a first exemplary embodiment for use with the device of Fig. 1;

Fig. 3 shows a side view of a needle according to a second exemplary embodiment for use with the device of Fig. 1;

Fig. 4 shows a side view of a needle according to a third exemplary embodiment for use with the device of Fig. 1; and

Fig. 5 shows a side view of a needle according to a fourth exemplary embodiment of the present invention.

Detailed Description

[0005] The present invention, which may be further understood with reference to the following description and the appended drawings, relates to a device to enhance the ultrasonic visibility of a needle when deployed within

the body to perform a procedure such as, for example, a needle biopsy. It is noted, however, that although the exemplary embodiments of the present invention are described with respect to particular procedures, the description is not meant to limit the application of the invention, which may be employed in any of a number of procedures requiring the insertion of a needle to a target site within the body.

[0006] Devices and methods according to exemplary embodiments of the invention enhance the visibility of a needle when deployed, for example, from a catheter to a target site within the body. Specifically, exemplary embodiments of the present invention seek to enhance the echogenicity of a needle in situ by providing resonating features thereupon, the resonating features designed to resonate at a predetermined frequency which may be applied thereto via an ultrasound transducer or another means known in the art. Any of a variety of known mechanical arrangements may be employed to generate a mechanical force at a distal portion of the catheter for the deployment of the needle therefrom. This invention is not restricted to needles but may also be applicable to any number of cannulas or catheters to a visualized remotely by, for example, ultrasound. In one example, the present invention may be employed in an ablation device.

[0007] As shown in Figs. 1 and 2, a device 100 according to a first exemplary embodiment of the present invention comprises a needle 102 having a tubular body with a lumen 104 extending therethrough from a proximal end extending into a handle 120 to a distal end comprising a puncturing tip 106. It is noted that the use of the term distal herein refers to a direction away from a user of the device while the term proximal refers to a direction approaching a user of the device. The proximal portion of the device 100, including the handle 120, remains external to the body and accessible to the user while the distal portion, when in an operative position, extends into the body to a target site from which tissue samples are to be obtained in accordance with the biopsy procedure. A shaft 116 of the device 100 and the needle 102 may be rigid or, alternatively, may be longitudinally flexible and axially rigid to allow for the insertion of the shaft 116 and the needle 102 along a tortuous path (e.g., through a body lumen) to a target site within the body. The needle 102 may be formed of any suitable biocompatible material known in the art depending on the desired properties of the needle (e.g., rigidity/flexibility, etc.).

[0008] A series of circumferentially aligned beams 108 are formed along at least one longitudinal length of the needle 102. In a preferred embodiment, two sets of beams 108 are formed on opposite sides A and B (shown in phantom) of the needle 102, as shown in Fig. 2. The beams 108 may be provided over any part of the needle 102 without deviating from the scope of the present invention. The beams 108 may be cantilever beams formed, for example, by laser micromachining or micro-stamping the outer surface of the needle 102. Alternatively, a surface micromachining process may be used

to deposit or etch beams 108 onto the surface of the needle 102. In an alternate embodiment, the beams 108 located on opposite sides A and B may also be formed in different configurations, so as to distinguish an orientation of the needle 102 in situ, as those skilled in the art will understand. Specifically, shapes and sizes of the beams 108 on opposite sides A and B may be distinguishably varied from one another so that an orientation of the needle 102 can be determined based on the location of sides A and B in situ. It is preferred, however, to maintain similar resonance requirements on each side A and B so that both sides are locatable at least one predetermined frequency.

[0009] The dimensions of each of the beams 108 may also be varied depending on the type of procedure being performed so that the natural frequency of the beams 108 coincides with the ultrasonic frequency of interest, as those skilled in the art will understand. If a particular procedure requires the targeting of more than one ultrasound frequency (i.e., to overcome excessive noise encountered at a first frequency, etc.), the beams 108 may be formed with different dimensions to accommodate the plurality of frequencies. Such an embodiment will aid in the location of the needle 102 in the body when any of the plurality of target frequencies are employed. Furthermore, in a preferred embodiment, beams 108 of different natural frequencies are evenly distributed along the needle 102, such as, for example, in an alternating pattern. In one embodiment, the frequencies may include 5 MHz and 7.5 MHz, although any other frequencies may be employed without deviating from the scope of the present invention. Furthermore, the beams 108 may have varying geometries including, but not limited to rectangular, square and triangular and may also have varying thickness, widths and heights. The beams 108 may also comprise any combination and plurality of holes, cutouts, slots, slits, bends and other surface features (e.g., peaks, valleys, etc.) without deviating from the scope of the present invention.

[0010] The beams 108 function as resonators in the needle, as those skilled in the art will understand. When used under ultrasound guidance, the acoustic energy from an ultrasound transducer located external to the body when in an operative configuration causes the beams 108 to resonate, thus providing an ultrasonic image of the needle 102.

[0011] Those skilled in the art will understand that cantilever beams can resonate to any multiple of their fundamental frequency. Altering the geometry of the beams 108 can increase the fundamental frequency. For example, as shown with respect to Fig. 2, beams 108' can be formed to resemble two adjacent arced pieces lying along a longitudinal length of the needle 102, wherein the adjacent pieces are separated from one another by a distance D_1 . The distance D_1 , along with other dimensional values of the beams 108' is indicative of the resonating frequency thereof. Since the two arced pieces are not joined together at a proximal end, resonance can be in-

creased, as those skilled in the art will understand. It is noted that any configuration of the beams 108 may be employed without deviating from the spirit and scope of the present invention.

[0012] Resonance in the device of the present invention may also be improved by providing a resonating stylet 110 to be used with the needle 102. The resonating stylet 110 would not have to be employed in conjunction with the needle 102 comprising the beams 108. Rather, the resonating stylet 110 may function with any medical device within which the stylet 110 may be received. Specifically, as shown in Fig. 3, the stylet 110 is formed in a cantilever shape, wherein a distal portion of the stylet 110 is formed with two legs 112 spaced from one another and joined to a proximal portion of the stylet at a juncture 114. The legs 112 may be formed as a unitary element with the stylet 110 or, alternatively, may be formed separately and attached thereto via a means known in the art such as bonding, welding, etc. A distal portion of the stylet 110 serves as a resonator, wherein the dimensions of the legs 112 may dictate the appropriate resonance frequency for the ultrasound. In one embodiment, the resonance frequency of the cantilever may be approximately 5 MHz to conform to available ultrasound systems, although any other frequency may also be employed without deviating from the scope of the present invention. In a further embodiment of the present invention, the stylet 110 may also be provided with beams 108 or 108' to further improve imaging or to enable visualization of the stylet 110 under a plurality of frequencies, as explained earlier. Specifically, the beams 108 or 108' may be formed as cut-outs formed in the stylet or may be abutments bonded or otherwise attached to the outer surface of the stylet 110. It is noted that the device of the present invention is not limited to the stylet 110 as depicted but may employ any stylet known in the art. Similarly, the stylet of the present invention may be employed with any device comprising ultrasonic resonators.

[0013] In an alternate embodiment of the present invention, fabrication of the beams 108 of the present invention may be done using the same manufacturing technology used for electrical circuit or micro-electrical mechanical systems ("MEMS"). In this manner, a resonant mechanical system may be produced for one or more frequencies of interest. In yet another alternate embodiment, a micro-miniature ultrasonic transducer may be mounted on one or both of the needle 102 or the stylet 110 of the present invention. The micro-miniature ultrasonic transducer may function as a transmitter insertable into the body, with the external ultrasound device functioning as a receiver, as those skilled in the art will understand.

[0014] In use, the needle 102 is received within a lumen 118 extending through a catheter shaft 116, the lumen 118 is sized to slidably receive the needle 102 with a clearance between the needle 102 and an inner wall of the lumen 118.

[0015] Once the catheter shaft 116 is positioned in a

desired location relative to a target tissue site in the body, an ultrasonic scanner 124 transmits a predetermined ultrasonic frequency. Specifically, a probe 126 generates the designated frequencies to the target area in the body via a path 132. That is, a transducer 128 may be attached to an end of the probe 126. In another embodiment, a separate handheld probe (not shown) may be employed. The transducer 128 may be coupled to the probe 126 using a means known in the art and may employ a known material (e.g., water, jelly, etc.) to reduce impedance by the skin. Upon receipt of these frequencies, the beams 108 may resonate and return the frequencies to the ultrasonic scanner 124. A transducer 128 may then convert the received frequencies into electrical pulses that can be processed and transformed into a digital image. The ultrasonic scanner 124 then displays the image on a screen 124 visible to a user of the device and operable in real-time. In a preferred embodiment, the image is visible to the user in real time to aid in proper positioning of the catheter shaft 116 in the body. Once a distal portion of the device 100 is properly positioned within the body, actuation of an actuator (not shown) on the handle 120 the needle 102 out of the lumen 118 using a mechanical means known in the art. A stylet may be housed in the needle 102 during insertion to prevent unwanted foreign materials from entering the needle, as those skilled in the art will understand. A designated procedure such as a biopsy may then be performed. After a procedure has been completed, the user of the device 100 retracts the needle 102 by, for example, withdrawing the actuator (not shown) in the opposite direction until the puncturing tip 106 of the needle 102 is again fully housed within the catheter shaft 116.

[0016] It is noted that the design of the handle 120 may take any desired shape as dictated, for example, by ergonomics, etc. and is not limited to the arrangement shown in the embodiment of Fig. 1. The handle 120 is configured to control actuation of the needle 102 via telescoping tubular configuration. Furthermore, it is noted that the catheter shaft 106 may extend proximally from the handle 130 of the device 100 by any desired length, which length may, for example, be selected to conform to the specific requirements for a procedure being performed.

[0017] Fig. 5 depicts a system according to an alternate embodiment of the present invention, wherein the device is formed substantially similarly to the device 100 of Fig. 1 with the exception of a sheath 200 provided over an outer surface of the needle 102. The sheath 200 may be provided with resonators 208 distributed thereover in any configuration. The resonators 208 may be formed as cut-outs on the sheath 200 or abutments bonded or otherwise attached to the sheath 200 and may be configured to enhance the resonance of the beams 108 of the needle 102, as those skilled in the art will understand. In use, the sheath (not shown) may be provided over the needle 102 and, once the catheter shaft 116 is positioned in a desired location relative to a target site in the body, the

ultrasonic scanner 124 and transducer 128 may be operated as described above to aid in visualization of the needle 102.

[0018] The present invention may be applied to any procedure requiring the insertion of a needle into tissue via a device traversing a tortuous path. Though the present invention has been described with respect to the retrieval of tissue samples, it is submitted that devices for alternate uses such as, for example, needles for injection of fluids to or the withdrawal of fluids from the body may employ to invention without deviating from the spirit and scope of the present invention. Thus, these embodiments have been described in an exemplary manner and are not intended to limit the invention which is intended to cover all modifications and variations of this invention that come within the scope of the appended claims and their equivalents. For example, the beams of the present invention may be formed separately from the needle and can be subsequently bonded to the needle via a means known in the art. Furthermore, it is noted that the ultrasonic resonators of the present invention are not restricted for use with needles and rather, may be employed in any medical device visualized by the use of ultrasound. It is therefore submitted that the embodiments disclosed herein are not limited to limit the scope of the present invention.

Claims

1. A medical device (100), comprising:

a cannula (102) configured to be inserted into a target location in a body, the cannula (102) including a lumen (104) extending therethrough; at least one resonator situated on a surface of the cannula (102), the resonator resonating in response to an ultrasonic frequency applied to the target location to indicate the location of the cannula (102) in the body, wherein the ultrasonic frequency is generated by a transducer (128) located external to the body; and a device (124) converting resonated frequencies into an image;

characterized by

a stylet (110) configured to be inserted into the lumen (104), a distal portion thereof including two legs (112) spaced from one another and joined at a proximal position of the stylet at a juncture and configured as a resonating feature for resonating when actuated by sound waves.

2. The medical device (100) according to claim 1, further comprising:

a handle (120) located at a proximal end of the cannula (102).

3. The medical device (100) according to claim 1, wherein the at least one resonator is formed as a cantilever beam (108).
4. The medical device (100) according to claim 1, wherein the at least one resonator is formed as one of a cut-out and an abutment on an outer surface of the cannula (102). 5
5. The medical device (100) according to claim 1, wherein the at least one resonator is etched into an outer surface of the cannula (102). 10
6. The medical device (100) according to claim 1, wherein the at least one resonator is formed via one of laser micromachining, microstamping, MEMS and surface machining 15
7. The medical device (100) according to claim 6, wherein the at least one resonator is bonded to the cannula (102). 20
8. The medical device (100) according to claim 1, wherein the at least one resonator is dimensioned to resonate at least one predetermined frequency. 25
9. The medical device (100) according to claim 1, wherein the at least one resonator is formed as a cantilever.
10. The medical device (100) according to claim 1, wherein the stylet (110) includes at least one further resonator situated on a surface of the stylet (110). 30
11. The medical device (100) according to claim 1, wherein a resonator is bonded to an outer wall of the stylet (110). 35
12. The medical device (100) according to claim 1, wherein a plurality of resonators are formed on the cannula (102). 40
13. The medical device (100) according to claim 12, wherein the resonators are aligned along a longitudinal axis of the lumen (104). 45

Patentansprüche

1. Medizinische Vorrichtung (100), welche aufweist: 50

eine Kanüle (102), die ausgestaltet ist, in einen Zielort in einem Körper eingeführt zu werden, wobei die Kanüle (102) ein sich durch diese erstreckendes Lumen (104) enthält; 55

zumindest einen Resonator, der sich auf einer Oberfläche der Kanüle (102) befindet, wobei der Resonator im Resonanzzustand ist als Antwort

auf eine Ultraschallfrequenz, die auf den Zielort ausgeübt wird, um den Ort der Kanüle (102) in dem Körper anzuzeigen, wobei die Ultraschallfrequenz durch einen Wandler (128) erzeugt wird, der sich außerhalb des Körpers befindet; und

eine Vorrichtung (124), die Resonanzfrequenzen in ein Bild umwandelt;

gekennzeichnet durch

ein Stilett (110), das ausgestaltet ist, in das Lumen (104) eingeführt zu werden, einen distalen Bereich von diesem, enthaltend zwei Beine (112), die einen gegenseitigen Abstand aufweisen und an einem proximalen Bereich des Stillets an einer Verbindungsstelle verbunden sind und als ein Resonanzmerkmal ausgestaltet sind, das im Resonanzzustand ist, wenn es **durch** Schallwellen betätigt wird.

2. Medizinische Vorrichtung (100) nach Anspruch 1, weiterhin aufweisend:

einen Handgriff (120), der sich an einem proximalen Ende der Kanüle (102) befindet.
3. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator als ein Auslegerbalken (108) ausgebildet ist.
4. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator als einer aus einem Ausschnitt und einem Widerlager auf einer äußeren Oberfläche der Kanüle (102) gebildet ist.
5. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator in eine äußere Oberfläche der Kanüle (102) geätzt ist.
6. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator über eines von Lasermikrobearbeiten, Mikrostanzen, MEMS und Oberflächenbearbeiten gebildet ist.
7. Medizinische Vorrichtung (100) nach Anspruch 6, bei der der zumindest eine Resonator mit der Kanüle (102) verbunden ist.
8. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator so bemessen ist, dass er bei zumindest einer vorbestimmten Frequenz in Resonanz ist.
9. Medizinische Vorrichtung (100) nach Anspruch 1, bei der der zumindest eine Resonator als ein Ausleger gebildet ist.
10. Medizinische Vorrichtung (100) nach Anspruch 1, bei der das Stilett (110) zumindest einen weiteren

Resonator enthält, der sich auf einer Oberfläche des Stilett (110) befindet.

11. Medizinische Vorrichtung (100) nach Anspruch 1, bei der ein Resonator mit einer äußeren Wand des Stilett (110) verbunden ist.

12. Medizinische Vorrichtung (100) nach Anspruch 1, bei der mehrere Resonatoren auf der Kanüle (102) gebildet sind.

13. Medizinische Vorrichtung (100) nach Anspruch 12, bei der die Resonatoren entlang einer Längsachse des Lumens (104) ausgerichtet sind.

Revendications

1. Dispositif médical (100) comprenant :

une canule (102) configurée de manière à pouvoir être insérée au niveau d'une position cible dans un corps, la canule (102) incluant une lumière (104) s'étendant au travers ;
au moins un résonateur situé sur une surface de la canule (102), le résonateur résonant en réponse à une fréquence ultrasonore appliquée sur l'emplacement cible afin d'indiquer la position de la canule (102) dans le corps, dans lequel la fréquence ultrasonore est générée par un transducteur (128) situé à l'extérieur du corps ;
et
un dispositif (124) convertissant des fréquences résonnées selon une image,
caractérisé par :

un stylet (110) configuré de manière à pouvoir être inséré dans la lumière (104), sa partie distale incluant deux jambages (112) espacés l'un de l'autre, joints au niveau d'une partie proximale du stylet au niveau d'une jonction et configurés en tant que caractéristique résonante pour résonner lorsqu'ils sont actionnés par des ondes sonores.

2. Dispositif médical (100) selon le revendication 1, comprenant en outre :

un manche (120) positionnée au niveau d'une extrémité proximale de la canule (102).

3. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est formé en tant que poutre en porte-à-faux (108).

4. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est formé en

tant qu'un élément pris parmi une découpe et une butée sur une surface externe de la canule (102).

5. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est gravé dans une surface externe de la canule (102).

6. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est formé via un processus pris parmi un micro-usinage laser, un micro-estampage, un MEMS et un usinage de surface.

7. Dispositif médical (100) selon le revendication 6, dans lequel l'au moins un résonateur est lié à la canule (102).

8. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est dimensionné de manière à résonner à au moins une fréquence prédéterminée.

9. Dispositif médical (100) selon le revendication 1, dans lequel l'au moins un résonateur est formé en tant qu'élément en porte-à-faux.

10. Dispositif médical (100) selon le revendication 1, dans lequel le stylet (110) inclut au moins un autre résonateur situé sur une surface du stylet (110).

11. Dispositif médical (100) selon le revendication 1, dans lequel un résonateur est lié à une paroi externe du stylet (110).

12. Dispositif médical (100) selon le revendication 1, dans lequel une pluralité de résonateurs sont formés sur la canule (102).

13. Dispositif médical (100) selon le revendication 12, dans lequel les résonateurs sont alignés suivant un axe longitudinal de la lumière (104).

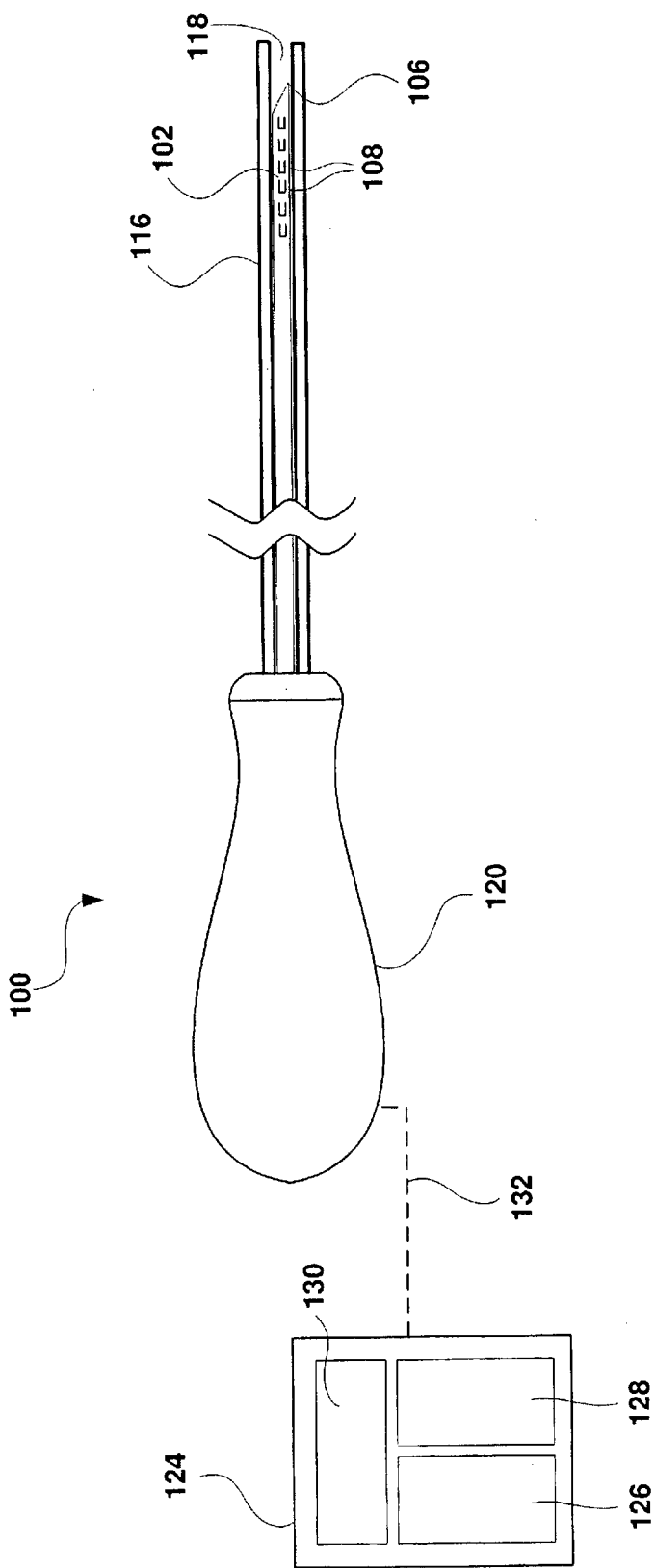


FIG. 1

FIG. 2

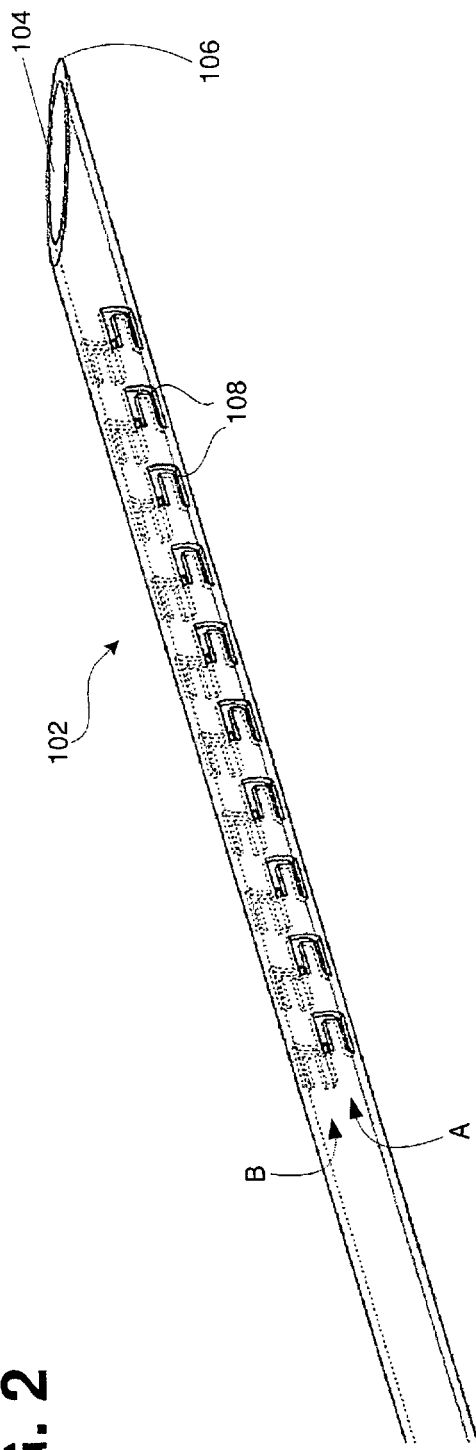
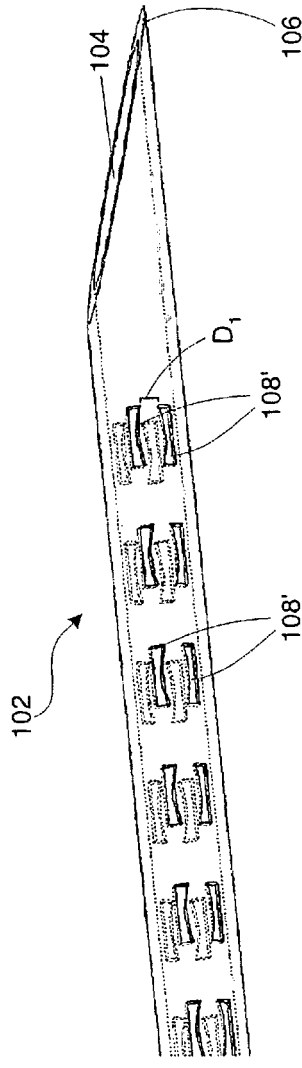


FIG. 3



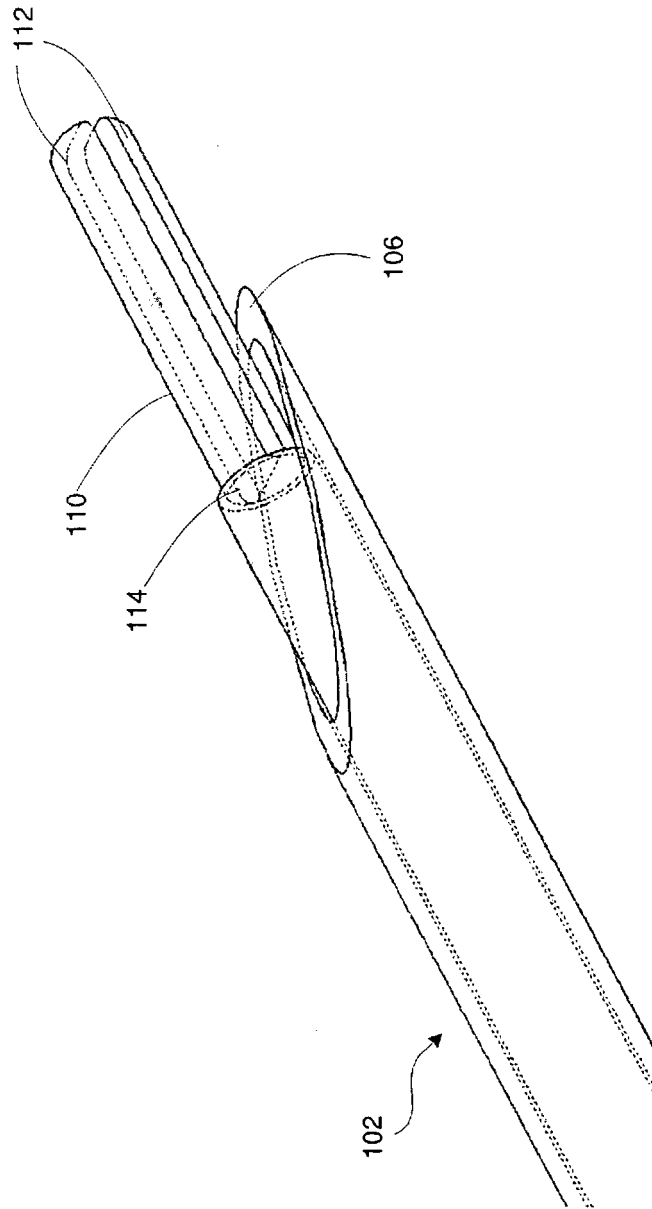


FIG. 4

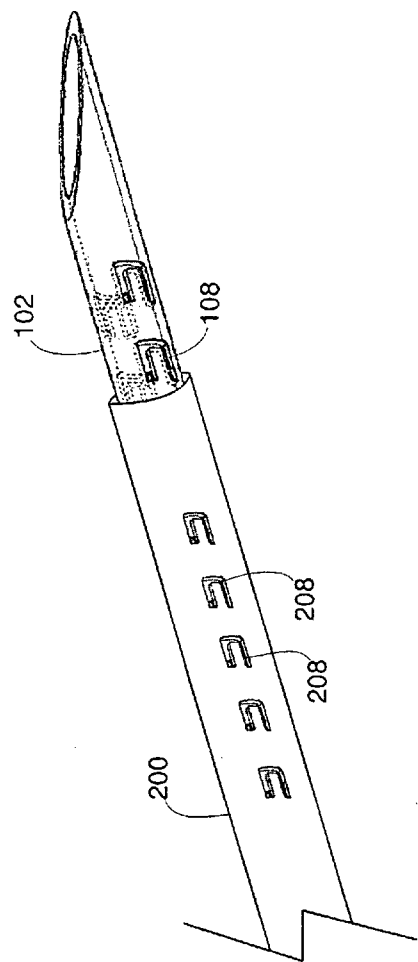


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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专利名称(译)	回声针机制		
公开(公告)号	EP2470103B1	公开(公告)日	2014-01-01
申请号	EP2010757899	申请日	2010-09-16
[标]申请(专利权)人(译)	波士顿科学西美德公司		
申请(专利权)人(译)	BOSTON SCIENTIFIC SCIMED , INC.		
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IPC分类号	A61B19/00		
CPC分类号	A61B17/3403 A61B8/0833 A61B2017/3413 A61B2090/378 A61B2090/3782 A61B2090/3925 A61B2090/3983		
优先权	61/245454 2009-09-24 US		
其他公开文献	EP2470103A1		
外部链接	Espacenet		

摘要(译)

医疗装置 (100) 包括用于插入身体中的目标位置的套管 (102) 和位于套管表面上的至少一个谐振器 (108)。谐振器响应于施加到目标位置的超声频率而谐振，以指示套管在体内的位置。超声频率由位于身体外部的换能器 (128) 产生。该医疗设备还包括将共振频率转换为图像的设备 (124)。

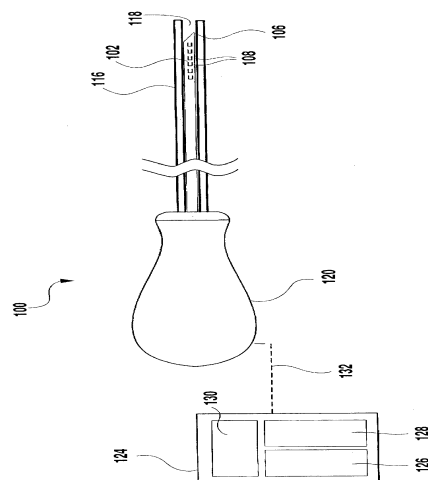


FIG. 1