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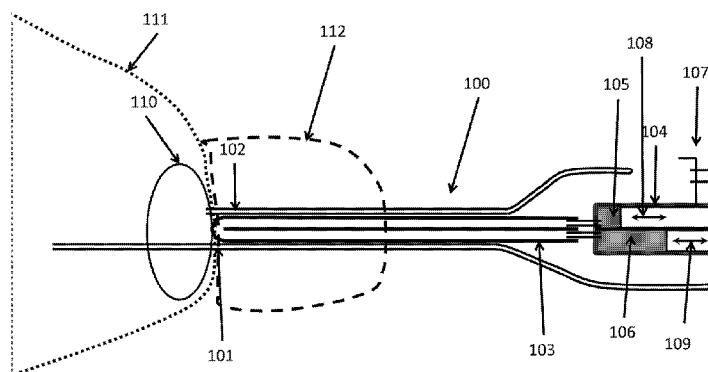


Figure 3

(57) **Abstract:** An exemplary system, method and computer-accessible medium for determining a location of a urethra of a patient, can be provided, which can include, for example, receiving first imaging information related to a portion(s) of a prostate of the patient, causing an injection of a contrast composition into a catheter in the urethra, receiving second imaging information related to the portion(s) and the urethra having the contrast composition therein, and determining the location of the urethra based on the first and second imaging information. The contrast composition can include an aerated gel. The location can be determined based on a difference between the first and second imaging information. The first and second imaging information can be generated using a computed tomography arrangement.



**APPARATUS AND METHOD FOR VISUALIZATION AND AUTOMATIC
LOCALIZATION OF HOLLOW ORGAN FOR IMAGE GUIDED PRECISION
MEDICINE**

CROSS-REFERENCE TO RELATED APPLICATION(S)

- 5 **[0001]** This application relates to and claims priority from U.S. Patent Application No. 62/142,032, filed on April 2, 2015, the entire disclosure of which is incorporated herein by reference.

FIELD OF THE DISCLOSURE

- 10 **[0002]** The present disclosure relates generally to catheters, and more specifically, to exemplary embodiments of an urinary catheter configured to facilitate imaging of the urethra in order to facilitate, for example, a high precision image guided radiation therapy ("IGRT").

BACKGROUND INFORMATION

- 15 **[0003]** Radiation therapy can be an important treatment modality for cancer. Such therapy can be delivered as external beam radiation or brachytherapy, which can usually be performed under transrectal ultrasound imaging. External beam radiation therapy ("EBRT") provided to the prostate can be performed under image guidance, such as cone-beam computerized tomography ("CT"). However, visualization of the urethra using ultrasound
20 signals, or CT scanning, may not always be simple, and can usually require the use of a contrast agent (e.g., an aerated gel for ultrasound imaging) to be injected through a Foley catheter into the bladder to facilitate urethral visualization. While this can result in an acceptable visualization of the urethra, one of the drawbacks can be that this visualization can be limited to the time period in which the gel is injected, and the time period may not be
25 continuous.

- [0004]** EBRT for the treatment of prostate cancer can provide high doses of radiation to the prostate, while attempting to limit the dose to the normal tissue structures bordering it (e.g., to the bladder and/or to the rectum). The treatment can be planned using CT simulation scan, and a cone-beam CT can be performed before each treatment fraction to facilitate
30 patient positioning. Because the pelvis content may not be stable, fusing the cone-beam CT with the CT simulation scan can result in excellent bone fusion. However, the location of the prostate within this fusion can be variable. Such differences can stem from the fact that the shape of the rectum and the bladder can vary daily depending upon the stool and urine

contents, respectively. IGRT to the prostate gland generally aims to have the prostate, rather than the pelvis, aligned in the same position during the treatment simulation, as well as at each of the treatment fractions delivery time. This can be achieved by having three fiducial markers implanted in the prostate gland. Each day, before treatment, the prostate can be
5 imaged using fluoroscopy or using cone-beam CT, and the fiducial markers can be identified. The images obtained before the treatment fraction can be delivered, and can then be manually fused or combined with the images from the CT simulation scan. The treatment table position can then be automatically modified, which can result in the prostate being in the same position on the treatment day as on the simulation day.

10 **[0005]** An alternative to the use of the fiducial marker implantation and alignments can be the Calypso tracking system, which utilizes three electromagnetic transponder beacons permanently placed in the prostate gland. These beacons can send information to a four dimensional (“4D”) tracking system that can continuously monitor the location of the prostate. If the prostate moves beyond a given range, radiation delivery can be paused,
15 realignment can be performed, and treatment can be resumed when the prostate location is back in range.

[0006] Both fiducial markers and Calypso beacons can provide good localization of the prostate. The main drawback of both, however, relates to the fact that foreign bodies need to be implanted permanently into the prostate gland. In addition to the infection that can be
20 associated with implanting these foreign bodies, calypso markers can obscure further magnetic resonance imaging of the prostate due to significant artifact distortion of the image caused by the markers. Another drawback can be the fact that if these markers move or migrate from their implanted position after the simulation, and such movement goes undiscovered, the whole treatment can be inaccurate.

25 **[0007]** For the treatment of neck and thoracic malignancies, such as esophageal cancer, a high dose of radiation can be delivered to the tumor, while limiting the radiation dose exposure to as minimal a volume of normal surrounding tissues as possible. The treatment can be planned on a CT simulation scan, and can utilize a cone-beam CT before each treatment fraction to facilitate patient positioning. This is usually achieved by fusing the
30 planning CT with the cone-beam CT, relying on the bony landmarks and the tumor location, if visible. The images, obtained before the treatment fraction is delivered, can be manually fused or combined with the images from the CT simulation scan. The treatment table position can then be automatically modified, resulting in the tumor being in the same position

at the treatment day, as in the simulation day. However, such a positioning system has similar drawbacks to the described above.

[0008] Thus, it may be beneficial to provide an exemplary method for visualizing hollow organs such as the urethra or the esophagus, which can overcome at least some of the deficiencies described herein above.

SUMMARY OF EXEMPLARY EMBODIMENTS

[0009] An exemplary system, method and computer-accessible medium for determining a location of a urethra of a patient, can be provided, which can include, for example, receiving first imaging information related to a portion(s) of a prostate of the patient, causing an injection of a contrast composition into a catheter in the urethra, receiving second imaging information related to the portion(s) and the urethra having the contrast composition therein, and determining the location of the urethra based on the first and second imaging information. The contrast composition can include an aerated gel, iodine, barium or a gadolinium based contrast. The location of the urethra can be determined based on a difference between the first and second imaging information. The first and second imaging information can be generated using a computed tomography arrangement.

[0010] In some exemplary embodiment of the present disclosure, the injection of the contrast composition into the catheter can be caused using a pump arrangement attached to the catheter. The catheter can have (i) a first end attached to the pump arrangement at a first location, and (ii) a second end attached to the pump arrangement at a second location, where the second location is different from the first location. A first activation of the pump arrangement can be caused to provide the contrast composition into the catheter from the first end, and a second activation of the pump arrangement can be caused to provide the contrast composition into the catheter from the second end, and the opposite way for both, meaning the pump can be bidirectional.

[0011] In some exemplary embodiment of the present disclosure, the catheter can have (i) a first end attached to the pump arrangement, and (ii) a second end attached to a balloon which can be configured to be inserted into a bladder of the patient. A first activation of the pump arrangement can be caused to provide the contrast composition into the catheter, and a second activation of the pump arrangement can be caused to provide the contrast composition out of the catheter. A further location of the urethra can be determined, which can be

compared to a further location, and a movement of a table having the patient thereon can be caused until the further location substantially matches the location.

[0012] A further exemplary embodiment of the present disclosure can include an exemplary system, method and computer-accessible medium for determining a location of a hollow organ, which can include, for example, receiving first imaging information related to the hollow organ, causing an injection of a contrast composition into the hollow organ, receiving second imaging information related to the hollow organ having the contrast composition therein, and determining the location of the hollow organ based on the first and second imaging information.

[0013] A further exemplary embodiment of the present disclosure can include an apparatus, which can include, for example, a catheter configured and structured to be inserted into a urethra of a patient, a contrast composition and an automatic pump arrangement coupled to the catheter, and configured to inject the contrast composition into the catheter. The catheter can include (i) a first end attached to a first chamber of the automatic pump arrangement, and (ii) a second end attached to a second chamber of the automatic pump arrangement. The automatic pump arrangement can be configured to (i) provide the contrast composition from the first chamber to the second chamber through the catheter, and (ii) provided the contrast composition from the second chamber to the first chamber through the catheter. The automatic pump arrangement can include a first pump coupled to the first chamber, and a second pump coupled to the second chamber. The catheter can include a first end attached to the automatic pump arrangement, and a second end attached to a balloon that is configured to be inserted into a bladder of the patient.

[0014] Another exemplary embodiment of the present disclosure can be an exemplary system, method and computer-accessible medium for determining a location of an esophagus of a patient, which can include, for example, receiving first imaging information related to a portion(s) of the esophagus, causing a release of a contrast composition into the mouth of the patient, where the contrast composition is provided at least partially within a food substance, receiving second imaging information related to the portion(s) having the contrast composition therein, and determining the location of the esophagus based on the first and second imaging information. The food substance can include a liquid candy. A table having the patient thereon can be moved based on the location.

[0015] Another exemplary embodiment of the present disclosure can be an apparatus, which can include, for example, a first chamber containing a food substance, a second

chamber containing a contrast, and a signal processing arrangement configured to selectively release the food substance and the contrast.

[0016] These and other objects, features and advantages of the exemplary embodiments of the present disclosure will become apparent upon reading the following detailed description of the exemplary embodiments of the present disclosure, when taken in conjunction with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Further objects, features and advantages of the present disclosure will become apparent from the following detailed description taken in conjunction with the accompanying Figures showing illustrative embodiments of the present disclosure, in which:

[0018] Figure 1A is a diagram of a side cross-sectional view of the exemplary catheter according to an exemplary embodiment of the present disclosure;

[0019] Figure 1B is a diagram of a front cross-sectional view of the exemplary catheter from Figure 1 according to an exemplary embodiment of the present disclosure;

[0020] Figure 2 is a diagram of the side cross-sectional view of the exemplary catheter from Figure 1 inserted into the urinary bladder of a patient according to an exemplary embodiment of the present disclosure;

[0021] Figure 3 is a diagram of the side cross-sectional view of the exemplary catheter from Figure 2 with the bidirectional pumps operating, while the catheter is inserted into the urinary bladder of a patient according to the exemplary embodiment of the present disclosure;

[0022] Figures 4A and 4B are diagrams of side cross-sectional views of the exemplary catheter according to another exemplary embodiment of the present disclosure, in an exemplary operation thereof;

[0023] Figures 5A and 5B are exemplary views illustrating the identification of the urethra via a CT procedure utilizing the exemplary catheter according to an exemplary embodiment of the present disclosure;

[0024] Figures 6A and 6B are exemplary views of an exemplary device for use in esophageal imaging according to an exemplary embodiment of the present disclosure; and

[0025] Figure 7 is an illustration of an exemplary block diagram of an exemplary system in accordance with certain exemplary embodiments of the present disclosure.

[0026] Throughout the drawings, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the

illustrated embodiments. Moreover, while the present disclosure will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments and is not limited by the particular embodiments illustrated in the figures and the appended claims.

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DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0027] The exemplary method/apparatus is described below in relation to imaging of the urethra or esophagus. However, the exemplary method/apparatus can be further applied and/or used to image any hollow organ, and can facilitate the finding of the organ location in relation to the body of the patient by first imaging the organ, injecting a contrast into the hollow organ, repeating the imaging, and determining the location of the hollow organ.

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[0028] Figure 1A - Figure 3 illustrate an exemplary catheter 100 including a urine drainage tube 101, and a balloon 110 which can be inflated through tube 102 after the catheter 100 is inserted in the urinary bladder 111 so as to anchor the catheter 100 inside the urinary bladder 111. A tube having a contrast agent (e.g., a contrast tube 103) can traverse the prostate 112, without draining into the urinary bladder 111. The contrast tube 103 can be, and/or can include, for example, a U shaped tube, in which the first end of contrast tube 103 can be attached to a contrast cartridge 104 (e.g., to a first chamber 105 of the contrast cartridge 104) and the second end of the contrast tube 103 can be attached to the contrast cartridge 104, (e.g., to a second chamber 106 of the contrast cartridge 104). The first chamber 105 of the contrast cartridge 104 can have a first bidirectional pump 108 and the second chamber 106 of the contrast cartridge 104 can have a second bidirectional pump 109. The pumps 108 and 109 can pump the contrast out of, or into, the first chamber 105 and the second chamber 106 of the contrast cartridge 104, respectively. A communications (e.g., Wi-Fi, Blue tooth, infrared, or other suitable communication method) detector 107 can facilitate remote control of the functions of the pumps 108 and 109 in the first chamber 105 and the second chamber 106 of the contrast cartridge 104 by an exemplary computer system described herein.

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[0029] It should be understood that while reference is made hereto to two pumps 108 and 109, a single pump can be used to pump the contrast in and out of the first chamber 105 and the second chamber 106.

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[0030] For visualization of the urethra under ultrasound, a contrast cartridge 104 containing aerated gel, and/or any other contrast material visible under ultrasound, can be

utilized. For example, the bidirectional pumps 108 and 109 in the first chamber 105 and the second chamber 106 of the contrast cartridge 104 can function reciprocally, such that when the first pump 108 in the first chamber 105 pumps the aerated gel out of the first chamber 105, the second pump 109 in the second chamber 106 pumps the gel from the contrast tube 103 into the second chamber 106 of the contrast cartridge 104. When the first chamber 105 becomes empty, and the second chamber 106 becomes full of gel, then the directions in which the pumps 108 and 109 in the first chamber 105 and second chamber 106 function can reverse. Alternatively, or in addition, a hole between the first chamber 105 and the second chamber 106 in the contrast cartridge 104 can result in the contrast cartridge 104 being continuously filled with contrast, as the contrast gel can continuously move in a closed cycle from the first chamber 105 to the second chamber 106 through the contrast tube 103.

[0031] Figures 4A and 4B illustrate a catheter arrangement 400 according to another exemplary embodiment of the present disclosure having a balloon 420 and/or vacuum chamber, which can connect to the contrast cartridge 404, via a contrast tube 403. A bidirectional pump 419 can pump the contrast agent from the contrast cartridge 404 through the contrast tube 403, into the balloon 420. Figure 4A shows the exemplary catheter 400 before the pump 419 is activated. Figure 4B shows the exemplary catheter after the pump 419 has been activated. For a visualization of the urethra under ultrasound, aerated gel and/or ultrasound contrast can be used, and the pump 419 can continuously pump the contrast in and out of the balloon 420. A communication (e.g., Wi-Fi, Bluetooth, infrared, etc.) detector 407 can facilitate a wireless control of the functions of pump 419. For a visualization of the urethra under CT, a contrast cartridge 404 containing a contrast, such as Iohexol, barium and/or water, can be used together with the exemplary catheter 400. For example, two CT scans can be obtained, one before the activation of the contrast pump, after which the pump can immediately be activated, and a second CT scan can be obtained immediately thereafter.

[0032] For a visualization of the urethra under CT, and for an automatic identification of the urethra, two or more scans of the prostate can be obtained, for example, one immediately after the other, as shown in Figures 5A and 5B. After a first scan can be obtained (*see, e.g.*, Figure 5A), an exemplary computer system 501, which can control the CT scanner 503, can send wireless (e.g., Wi-Fi) signals to the communication detector 507 of the exemplary urinary catheter 100. While exemplary catheter 100 is described herein, exemplary catheter 400 can also be used as the exemplary catheter in Figure 5. When the signals can be received by the communication detector 507, the CT contrast media in the contrast chamber of the

catheter can be pumped into the contrast tube of the catheter, which can be instilled or inserted into the urethra. After the pumping has been performed, the exemplary computer system 501 can cause a repeat of the CT imaging of the same exact cuts of the prostate, as the patient remains in the same exact position. Each CT slice of the first scan 505 can be fused and/or combined with the corresponding slice of the second CT scan 506 by such exemplary computer system 501, and/or by another ex-computer system. The exemplary computer system 501 can compare each pair of slices, and identify the pixels that can be different as being the contrast in the contrast tube, which can be the only change that has occurred between the two scans. By subtracting the slice pairs, the first one 505 from second one 506 of each pair, the urethra can be identified in each slice. By combining all the slices, a three dimensional ("3D") reconstruction of the urethra can be achieved. Due to this process being performed at the treatment planning simulation, and at each treatment fraction, the urethral location can be identified at each of these occasions, for example, by the exemplary computer system 501, and/or by another ex-computer system.

[0033] The exemplary computer system 501 can calculate the modifications in the position of the radiation therapy treatment bed 502 that can be needed to be performed in to order to have the location of the urethra, at the day of the radiation treatment delivery, to be in the same identical position as in the treatment planning simulation day. The exemplary computer system 501 can move the radiation therapy treatment bed 502 by providing the appropriate signals through the cable 504 connecting the exemplary computer system 501 to the treatment bed 502. After the appropriate positioning of the patient can be performed, radiation therapy can be delivered, or caused to be delivered by the exemplary computer system 501, and/or by another ex-computer system.

[0034] If, for example, the catheter 100 can be intended to be used for a number of days (e.g., the exemplary catheter described for CT scanning herein above), then the exemplary computer system 501, at the end of delivering the radiation treatment fraction, can send the communication (e.g., wireless communication) signals to the communication detector 107, and activate the pump in the second chamber, such that the contrast in the contrast tube of the catheter can be pumped into the second chamber 106 from the contrast tube. In order to better clean the contrast tube from contrast material at the end of the treatment, the contrast cartridge 104 can be replaced by an exemplary cleaning cartridge. The exemplary cleaning cartridge can contain cleaning material, such as water. When the cleaning cartridge is installed, the exemplary computer system 501, through the communication (e.g., wireless)

signals, can activate the pumps in the first and second chambers of the cleaning cartridge, such that the cleaning solution in the first chamber 105 can be pumped into the contrast tube 103, and into the second chamber 106, cleaning the contrast tube from residual contrast material. At the end of the cleaning procedure, the cleaning cartridge can be discarded. For example, the whole cleaning process can be repeated at each treatment fraction.

[0035] The exemplary catheter described herein, and shown in Figures 3, 4A and 4B can be used to visualize the urethra under ultrasound, CT, MRI or other similar imaging modality, depending on the type of contrast in the contrast cartridge.

[0036] To further visualize the urethra under ultrasound, a Doppler mechanism of the ultrasound can be utilized, according to an exemplary embodiment of the present disclosure. The exemplary catheter described herein, and shown in Figures 4A and 4B, can be used for such exemplary procedure. The exemplary pump 419, and the ultrasound machine, can be synchronized through an exemplary computer system. The exemplary catheter, via the communication (e.g., Wi-Fi, Bluetooth, infrared etc.) system, can deliver information to computer system regarding the direction of flow of contrast in the contrast tube 403 in real time. The exemplary pump, using an exemplary computer system, can provide orders or commands to the catheter through the communication system to change the direction of the flow in the contrast catheter 403 in order to facilitate detection and verification of the Doppler signals, and to enhance the automatic identification of the urethra on the ultrasound screen. When the Doppler signals can detect the location of the urethra on the screen, the exemplary computer system can analyze the signals, determine the location of the exemplary catheter and, for example, apply a specific color to it in order to assist in differentiating it from the rest of the prostate.

[0037] Figures 6A and 6B illustrate an exemplary device/arrangement for releasing a contrast agent into the esophagus of a patient according to an ex-embodiment of the present disclosure. For example, during the localization of the esophagus for use in IGRT, the esophagus can be fixed in place, and generally does not move. Localizing the esophagus can aid in positioning the patient for radiation treatments of malignancies that can arise in the neck and chest. This can be effectuated by performing a CT scan before inserting a contrast agent/material into the esophagus, and repeating the CT scan immediately after the contrast agent is inserted into the esophagus. A computer assisted combination, or fusion, of the images before and after the contrast is released can result in the identification of the esophagus in each of the CT slices. As the location of the esophagus can be fixed inside the

neck and chest, the identification of the location of the esophagus can be utilized to guide EBRT to neck and chest malignancies.

[0038] For example, as shown in Figures 6A and 6B, to generate the first and second CT scans, images can be generated before and immediately after the insertion of the contrast into the esophagus through, for example, an exemplary contrast dispenser 600 (e.g., a lollipop or lollipop like device/arrangement). The contrast dispenser 600 can include a first material 602 which can be similar to sweets and/or candies (e.g., sucking candies), and/or a second material 603 that can include various contrast agents (e.g., barium, gastrografin, gadolinium, etc.). The candy component (e.g., the first material 602) of the exemplary contrast dispenser 600 can be released when the patient sucks on the dispenser 600 before it can be activated. The second material 603 (e.g., the contrast agent/material) can be released into the patient after the contrast dispenser 600 can be activated.

[0039] The exemplary contrast material 603 can be located inside a chamber 604 which can be inside the first material 602. Once the contrast dispenser 600 can be activated, for example through a signal sent to a signal detector (e.g., Wi-Fi or wireless detector 607), holes in the chamber 604 can open, and the second material 603 (e.g., the contrast agent) can be released into the mouth of the patient while he is sucking on the contrast dispenser 600. (*See, e.g.,* Figure 6B). An activation of the contrast dispenser 600 can be performed remotely by, for example, an exemplary computer system that can coordinate the timing of the first and second scans. After the first scan, the contrast dispenser 600 can be activated. After a passage of a predetermined period of time, the second scan can be performed. The patient can be instructed to suck the exemplary contrast dispenser 600 during both scans, holding the exemplary contrast dispenser 600 through a handle 601.

[0040] The exemplary urinary catheter can include three or more lumens, where the first lumen can be an open lumen which can drain the patient bladder into an external urinary bag. The second lumen can have a valve on the outside end, and can connect to a balloon at the tip, which can be inflated once inside of the bladder. The other lumen can have a blunt inner lumen, with the outer end of the lumen connected to a reservoir containing a material such as contrast, fluid, mercury, metal wire or any other material that can be radioopaque under CT. The blunt lumen's end in the bladder neck can be proximal to the anchoring balloon. A pump or pressure machine or a temperature activated pump, can be connected to the reservoir to facilitate pumping of the reservoir's content from the reservoir to the blunt lumen when

needed. The pump on the exemplary catheter can have a remote activation control mechanism that can facilitate coordination between the pump activation and the CT scanner.

[0041] The exemplary catheter can be inserted prior to the CT scanning to facilitate a simulation for prostate cancer patients. A first scan of the pelvis can be performed prior to the catheter pump activation. The pump on the catheter can be activated after the first scan, and a second scan of the pelvis can be performed after the pump has been activated and scans of the same slices that were captured in the first scan can be captured in the second scan. A computer system can combine, or fuse, each slice of the first scan with the corresponding slice of the second scan, and compare them to determine the location of the urethra.

[0042] An exemplary process in which a urinary catheter and CT scan can be performed to facilitate the simulation of treatment of prostate cancer patients with external beam radiation, and an identical catheter can be inserted prior to administration of each fraction of radiation therapy. For example, first and second CT scans can be captured before and after pump activation, and can be fused, and/or combined, to determine the location of the urethra.

Patient position at the treatment session can be modified (e.g., automatically) to achieve the same exact position of the urethra as in the simulation. Moving the patient at treatment day can be done such that the images of the urethra reconstructed before treatment can be superimposed on the urethral images reconstructed at the CT simulation.

[0043] The exemplary urinary catheter can be U-shaped, and the middle of the U shaped tube can be at the base of the prostate, and the two ends of the U-shaped tube can be outside the body of the patient. Both ends of the U-shaped tube can be connected to a contrast cartridge where the contrast can include aerated gel. Pumps inside the cartridge can mobilize the gel continuously from the cartridge to the contrast tube, and back to the cartridge, such that continuous flow of the gel through the contrast tube can be achieved, facilitating better visualization of the urethra under ultrasound. According to an exemplary embodiment of the present disclosure, the exemplary second end of the tube can drain to a balloon inside the bladder, and the first end of the tube can connect to a contrast cartridge outside the body of the patient.

[0044] A vacuum tube can span the urethra from the penis orifice to the bladder neck.

The blunt end can be at the bladder neck, and the open end can be outside of the penis, connected to a contrast cartridge outside the body of the patient. The contrast can be aerated gel, Iodine, barium or any type of known contrast. Pumps inside the cartridge can mobilize the gel continuously from the cartridge to the blunt tube, back and forth, such that continuous

flow of the gel through the contrast tube can be achieved, facilitating better visualization of the urethra under ultrasound.

[0045] According to an exemplary embodiment of the present disclosure, the exemplary catheter having three or more lumens can include an open lumen which can drain the patient's bladder into an external urinary bag. The second lumen can have a valve on the outside end, and can connect to a balloon at the tip, which can be inflated once in the bladder. The other lumens can have a blunt inner lumen that can end in a balloon in the urinary bladder with the outer end of the lumen being connected to a reservoir containing material such as contrast, fluid, mercury, metal wire or any other material that can be radioopaque under CT. The blunt lumen can end in a balloon other than the anchoring balloon, which can be inflated and deflated by the contrast. A pump, or pressure machine, or a temperature activated pump, can be connected to the reservoir to facilitate pumping of the reservoir's content from the reservoir to the blunt lumen balloon when needed. The pump on the catheter can have a remote activation control mechanism that can facilitate coordination between the pump activation and the CT scanner.

[0046] Figure 7 shows a block diagram of an exemplary embodiment of a system according to the present disclosure. For example, exemplary procedures in accordance with the present disclosure described herein can be performed by a processing arrangement and/or a computing arrangement 702. Such processing/computing arrangement 702 can be, for example entirely or a part of, or include, but not limited to, a computer/processor 704 that can include, for example one or more microprocessors, and use instructions stored on a computer-accessible medium (e.g., RAM, ROM, hard drive, or other storage device).

[0047] As shown in Figure 7, for example a computer-accessible medium 706 (e.g., as described herein above, a storage device such as a hard disk, floppy disk, memory stick, CD-ROM, RAM, ROM, etc., or a collection thereof) can be provided (e.g., in communication with the processing arrangement 702). The computer-accessible medium 706 can contain executable instructions 708 thereon. In addition or alternatively, a storage arrangement 710 can be provided separately from the computer-accessible medium 706, which can provide the instructions to the processing arrangement 702 so as to configure the processing arrangement to execute certain exemplary procedures, processes and methods, as described herein above, for example.

[0048] Further, the exemplary processing arrangement 702 can be provided with or include an input/output arrangement 714, which can include, for example a wired network, a

wireless network, the internet, an intranet, a data collection probe, a sensor, etc. As shown in Figure 7, the exemplary processing arrangement 702 can be in communication with an exemplary display arrangement 712, which, according to certain exemplary embodiments of the present disclosure, can be a touch-screen configured for inputting information to the processing arrangement in addition to outputting information from the processing arrangement, for example. Further, the exemplary display 712 and/or a storage arrangement 710 can be used to display and/or store data in a user-accessible format and/or user-readable format.

[0049] The foregoing merely illustrates the principles of the disclosure. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous systems, arrangements, and procedures which, although not explicitly shown or described herein, embody the principles of the disclosure and can be thus within the spirit and scope of the disclosure. Various different exemplary embodiments can be used together with one another, as well as interchangeably therewith, as should be understood by those having ordinary skill in the art. In addition, certain terms used in the present disclosure, including the specification, drawings and claims thereof, can be used synonymously in certain instances, including, but not limited to, for example, data and information. It should be understood that, while these words, and/or other words that can be synonymous to one another, can be used synonymously herein, that there can be instances when such words can be intended to not be used synonymously. Further, to the extent that the prior art knowledge has not been explicitly incorporated by reference herein above, it is explicitly incorporated herein in its entirety. All publications referenced are incorporated herein by reference in their entireties.

WHAT IS CLAIMED IS:

1. A non-transitory computer-accessible medium having stored thereon computer-executable instructions for determining a location of a urethra of a patient, wherein, when a computer arrangement executes the instructions, the computer arrangement is configured to perform
5 procedures comprising:
 - receiving first imaging information related to at least one portion of a prostate of the patient;
 - causing an injection of a contrast composition into a catheter in the urethra;
 - receiving second imaging information related to the at least one portion and the
10 urethra having the contrast composition therein; and
 - determining the location of the urethra based on the first and second imaging information.
2. The computer-accessible medium of claim 1, wherein the contrast composition includes
15 an aerated gel.
3. The computer-accessible medium of claim 1, wherein the computer arrangement is further configured to determine the location based on a difference between the first and second imaging information.
20
4. The computer-accessible medium of claim 1, wherein the first and second imaging information are generated using a computed tomography arrangement.
5. The computer-accessible medium of claim 1, wherein the computer arrangement is
25 configured to cause the injection of the contrast composition into the catheter using a pump arrangement attached to the catheter.
6. The computer-accessible medium of claim 5, wherein the catheter has (i) a first end attached to the pump arrangement at a first location, and (ii) a second end attached to the
30 pump arrangement at a second location, and wherein the second location is different from the first location.

7. The computer-accessible medium of claim 6, wherein the computer arrangement is further configured to:

cause a first activation of the pump arrangement to provide the contrast composition into the catheter from the first end; and

5 cause a second activation of the pump arrangement to provide the contrast composition into the catheter from the second end.

8. The computer-accessible medium of claim 5, wherein the catheter has (i) a first end attached to the pump arrangement, and (ii) a second end attached to a balloon which is
10 configured to be inserted into a bladder of the patient.

9. The computer-accessible medium of claim 8, wherein the computer arrangement is further configured to:

15 cause a first activation of the pump arrangement to provide the contrast composition into the catheter; and

cause a second activation of the pump arrangement to provide the contrast composition out of the catheter.

10. The computer-accessible medium of claim 1, wherein the computer arrangement is
20 further configured to:

determine a further location of the urethra;

compare the location to the further location; and

cause a movement of a table having the patient thereon until the further location substantially matches the location.

25

11. A system for determining a location of a urethra of a patient, comprising:

a computer hardware arrangement configured to:

- receive first imaging information related to at least one portion of a prostate of the patient;
- 30 • cause an injection of a contrast composition into a catheter in the urethra;
- receive second imaging information related to the at least one portion of the urethra having the contrast composition therein; and

- determine the location of the urethra based on the first and second imaging information.

12. The system of claim 11, wherein the contrast composition includes an aerated gel.

5

13. The system of claim 11, wherein the computer hardware arrangement is further configured to determine the location based on a difference between the first and second imaging information.

10 14. The system of claim 11, wherein the first and second imaging information are generated using a computed tomography arrangement.

15 15. The system of claim 11, wherein the computer arrangement is configured to cause the injection of the contrast composition into the catheter using a pump arrangement attached to the catheter.

16. The system of claim 15, wherein the catheter has (i) a first end attached to the pump arrangement at a first location, and (ii) a second end attached to the pump arrangement at a second location, and wherein the second location is different from the first location.

20

17. The system of claim 16, wherein the computer hardware arrangement is further configured to:

cause a first activation of the pump arrangement to provide the contrast composition into the catheter from the first end; and

25 cause a second activation of the pump arrangement to provide the contrast composition into the catheter from the second end.

18. The system of claim 15, wherein the catheter has (i) a first end attached to the pump arrangement, and (ii) a second end attached to a balloon which is configured to be inserted into a bladder of the patient.

30

19. The system of claim 18, wherein the computer hardware arrangement is further configured to:

cause a first activation of the pump arrangement to provide the contrast composition into the catheter; and

5 cause a second activation of the pump arrangement to provide the contrast composition out of the catheter.

20. The system of claim 11, wherein the computer hardware arrangement is further configured to:

10 determine a further location of the urethra;

compare the location to the further location; and

cause a movement of a table having the patient thereon until the further location substantially matches the location.

15 21. A method for determining a location of a urethra of a patient, comprising:

receiving first imaging information related to at least one portion of a prostate of the patient;

injecting a contrast composition into a catheter in the urethra;

receiving second imaging information related to the at least one portion of the urethra

20 having the contrast composition therein; and

determining the location of the urethra based on the first and second imaging information.

22. The method of claim 21, wherein the contrast composition includes an aerated gel.

25

23. The method of claim 21, further comprising determining the location based on a difference between the first and second imaging information.

24. The method of claim 21, further comprising generating the first and second imaging
30 information using a computed tomography arrangement.

25. The method of claim 21, further comprising injecting the contrast composition into the catheter using a pump arrangement attached to the catheter.

26. The method of claim 25, wherein the catheter has (i) a first end attached to the pump arrangement at a first location, and (ii) a second end attached to the pump arrangement at a second location, and wherein the second location is different from the first location.

5

27. The method of claim 26, further comprising:

activating the pump arrangement to provide the contrast composition into the catheter from the first end; and

10 activating the pump arrangement to provide the contrast composition into the catheter from the second end.

28. The method of claim 25, wherein the catheter has (i) a first end attached to the pump arrangement, and (ii) a second end attached to a balloon which is configured to be inserted into a bladder of the patient.

15

29. The method of claim 28, further comprising:

activating the pump arrangement to provide the contrast composition into the catheter; and

20 activating the pump arrangement to provide the contrast composition out of the catheter.

30. The method of claim 21, further comprising:

determining a further location of the urethra;

comparing the location to the further location; and

25 moving a table having the patient thereon until the further location substantially matches the location.

31. An apparatus comprising:

a catheter configured and structured to be inserted into a urethra of a patient;

30 a contrast composition; and

an automatic pump arrangement coupled to the catheter, and configured to inject the contrast composition into the catheter.

32. The apparatus of claim 31, wherein the catheter includes (i) a first end attached to a first chamber of the automatic pump arrangement, and (ii) a second end attached to a second chamber of the automatic pump arrangement.

5 33. The apparatus of claim 32, wherein the automatic pump arrangement is configured to (i) provide the contrast composition from the first chamber to the second chamber through the catheter, and (ii) provided the contrast composition from the second chamber to the first chamber through the catheter.

10 34. The apparatus of claim 32, wherein the automatic pump arrangement includes a first pump coupled to the first chamber, and a second pump coupled to the second chamber.

35. The apparatus of claim 31, wherein the catheter includes a first end attached to the automatic pump arrangement, and a second end attached to a balloon that is configured to be inserted into a bladder of the patient.

15

36. A non-transitory computer-accessible medium having stored thereon computer-executable instructions for determining a location of an esophagus of a patient, wherein, when a computer arrangement executes the instructions, the computer arrangement is configured to perform procedures comprising:

20 receiving first imaging information related to at least one portion of the esophagus; causing a release of a contrast composition into the mouth of the patient, wherein the contrast composition is provided at least partially within a food substance;

receiving second imaging information related to the at least one portion having the contrast composition therein; and

25 determining the location of the esophagus based on the first and second imaging information.

37. The computer-accessible medium of claim 36, wherein the food substance includes a liquid candy.

30

38. The computer-accessible medium of claim 36, wherein the computer arrangement is further configured to move a table having the patient thereon based on the location.

39. A system for determining a location of an esophagus of a patient, comprising:
a computer hardware arrangement configured to:

receive first imaging information related to at least one portion of the
esophagus;

5 cause a release of a contrast composition into the mouth of the patient,
wherein the contrast composition is provided at least partially within a food
substance;

receive second imaging information related to the at least one portion having
the contrast composition therein; and

10 determine the location of the esophagus based on the first and second imaging
information.

40. The system of claim 39, wherein the food substance includes a liquid candy.

15 41. The system of claim 39, wherein the computer hardware arrangement is further
configured to move a table having the patient thereon based on the location.

42. A method for determining a location of an esophagus of a patient, comprising:

receiving first imaging information related to at least one portion of the esophagus;

20 releasing a contrast composition into the mouth of the patient, wherein the contrast
composition is provided at least partially within a food substance;

receiving second imaging information related to the at least one portion having the
contrast therein; and

25 determining the location of the esophagus based on the first and second imaging
information.

43. The method of claim 42, wherein the food substance includes a liquid candy.

30 44. The method of claim 42, further comprising moving a table having the patient thereon
based on the location.

45. An apparatus comprising:

a first chamber containing a food substance;

a second chamber containing a contrast; and
a signal processing arrangement configured to selectively release the food substance and the contrast.

- 5 46. A non-transitory computer-accessible medium having stored thereon computer-executable instructions for determining a location of a hollow organ of a patient, wherein, when a computer arrangement executes the instructions, the computer arrangement is configured to perform procedures comprising:
- receiving first imaging information related to the hollow organ;
10 causing an injection of a contrast composition into a catheter in the hollow organ;
receiving second imaging information related to the at least one hollow organ having the contrast composition therein; and
determining the location of the hollow organ based on the first and second imaging information.
- 15 47. A system for determining a location of a hollow organ of a patient, comprising:
a computer hardware arrangement configured to:
receive first imaging information related to the hollow organ;
cause an injection of a contrast composition into the hollow organ;
20 receive second imaging information related to the at least one hollow organ having the contrast composition therein; and
determine the location of the hollow organ based on the first and second imaging information.
- 25 48. A method for determining a location of a hollow organ of a patient, comprising:
receiving first imaging information related to the hollow organ;
injecting a contrast composition into a catheter in the hollow organ;
receiving second imaging information related to the at least one hollow organ having the contrast composition therein; and
30 determining the location of the hollow organ based on the first and second imaging information.

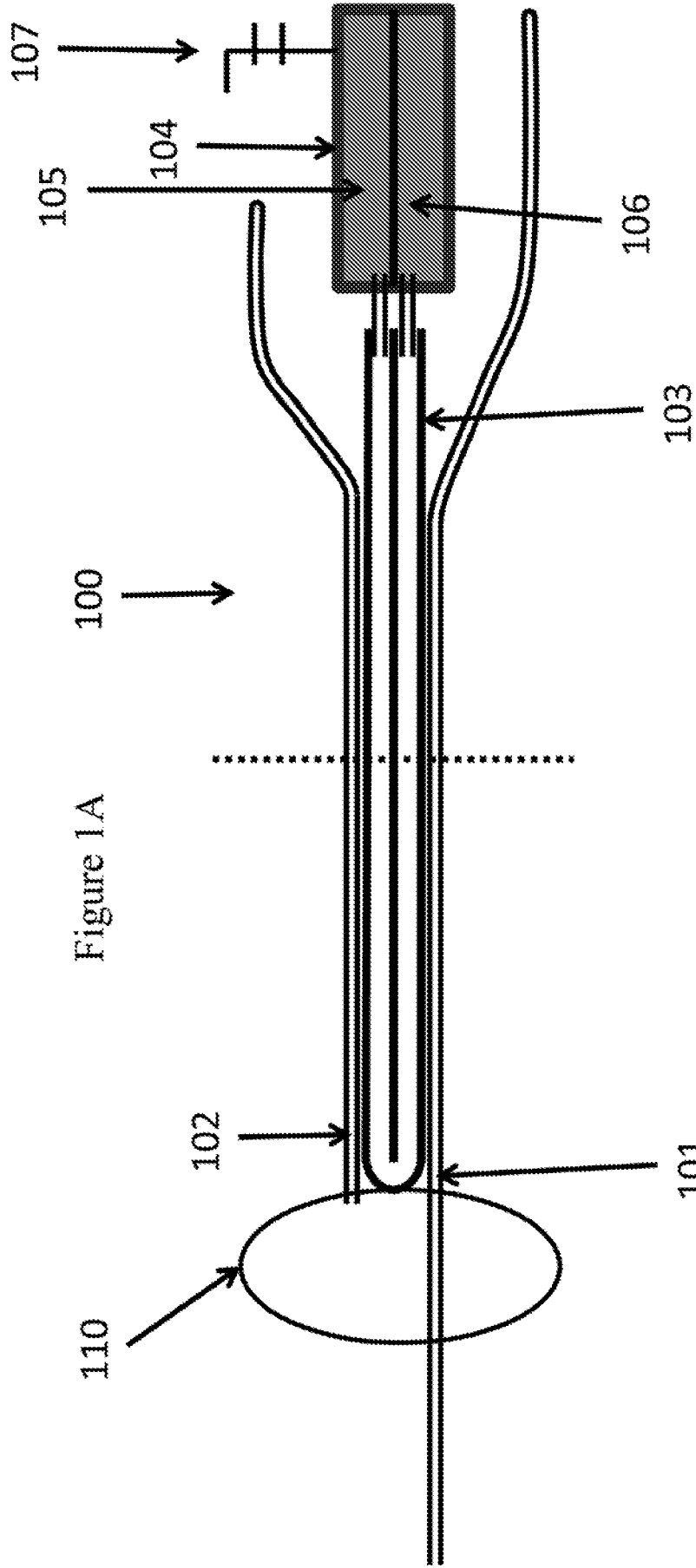


Figure 1A

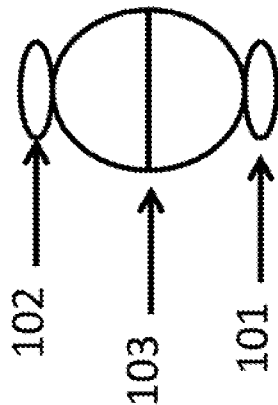


Figure 1B

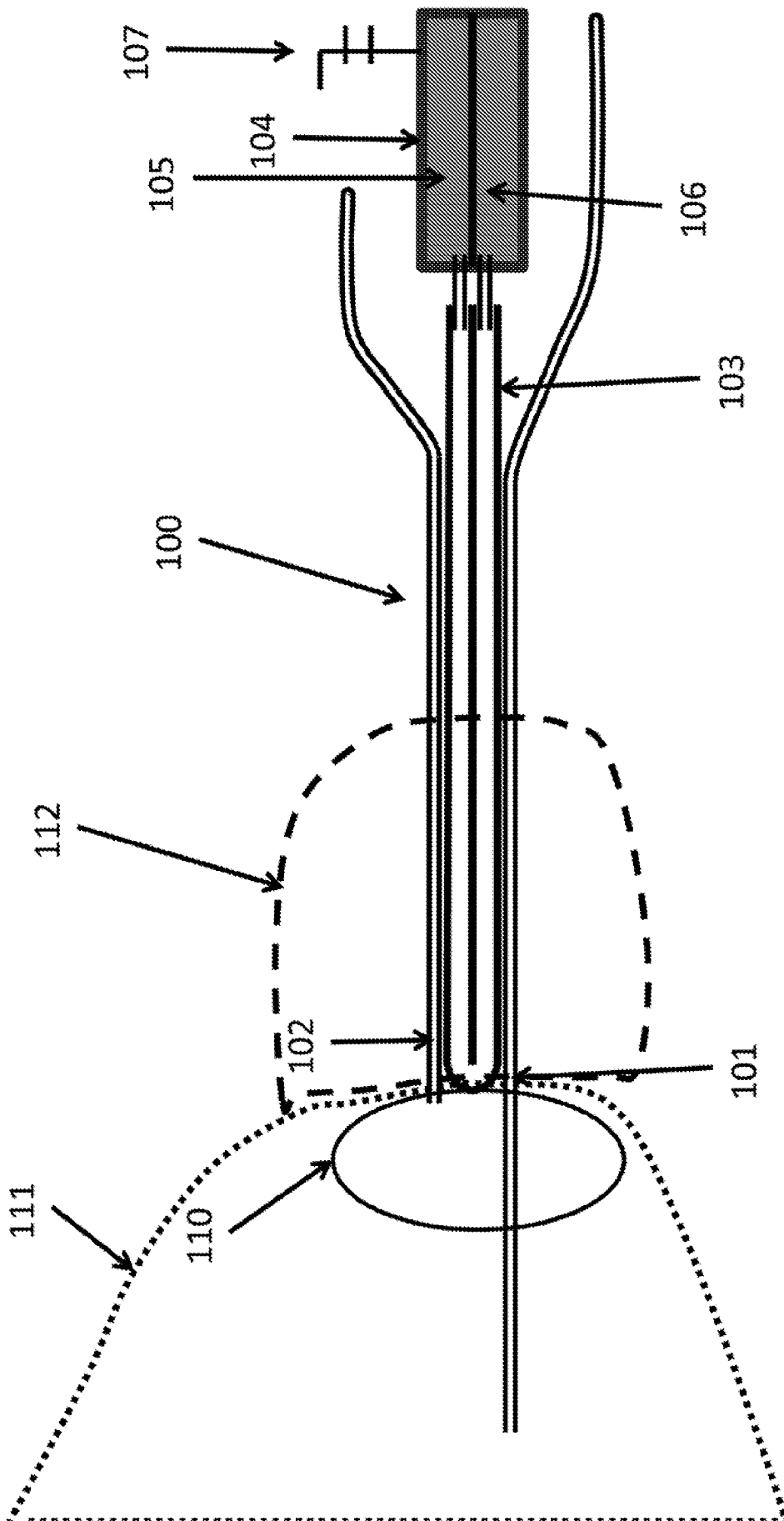


Figure 2

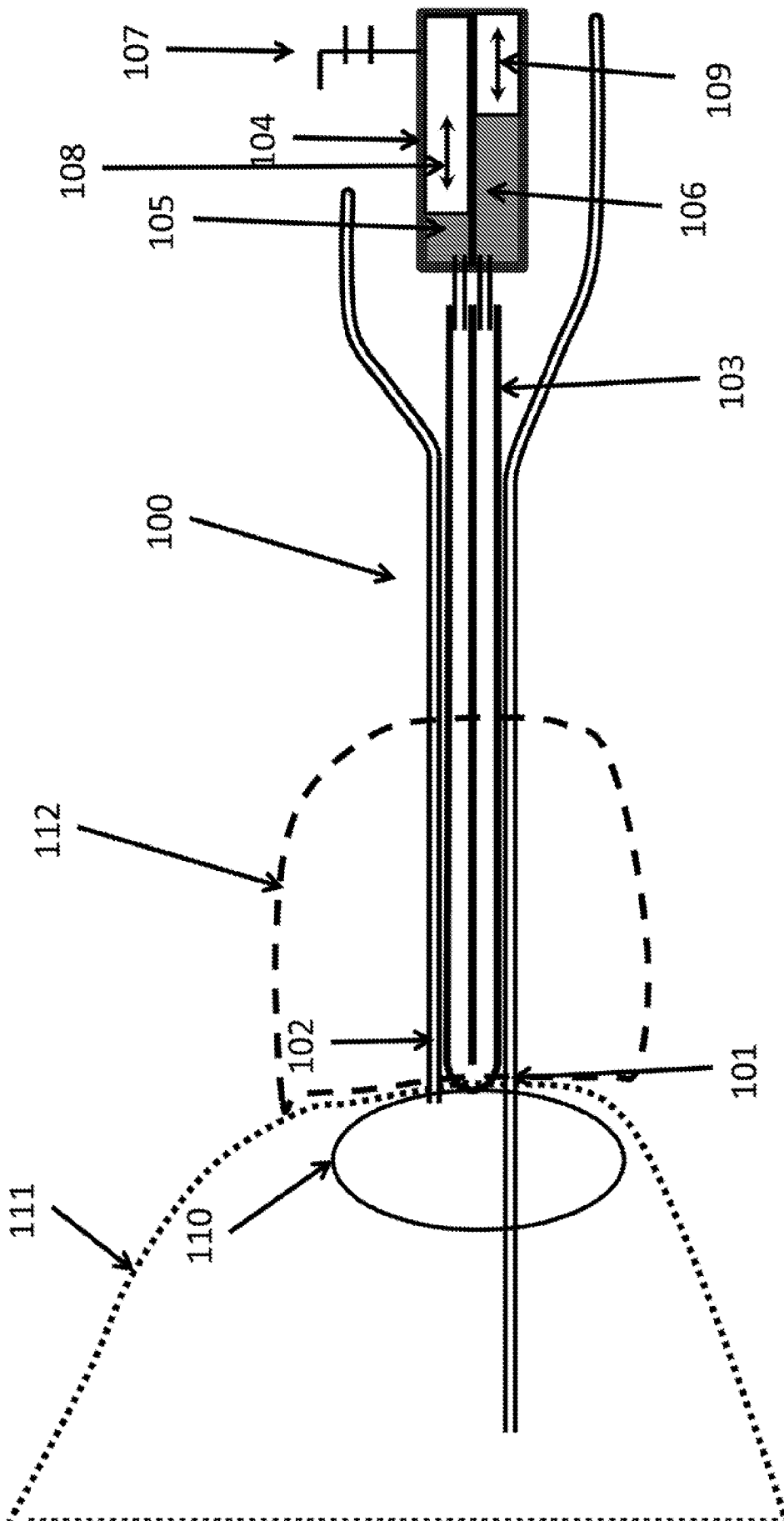
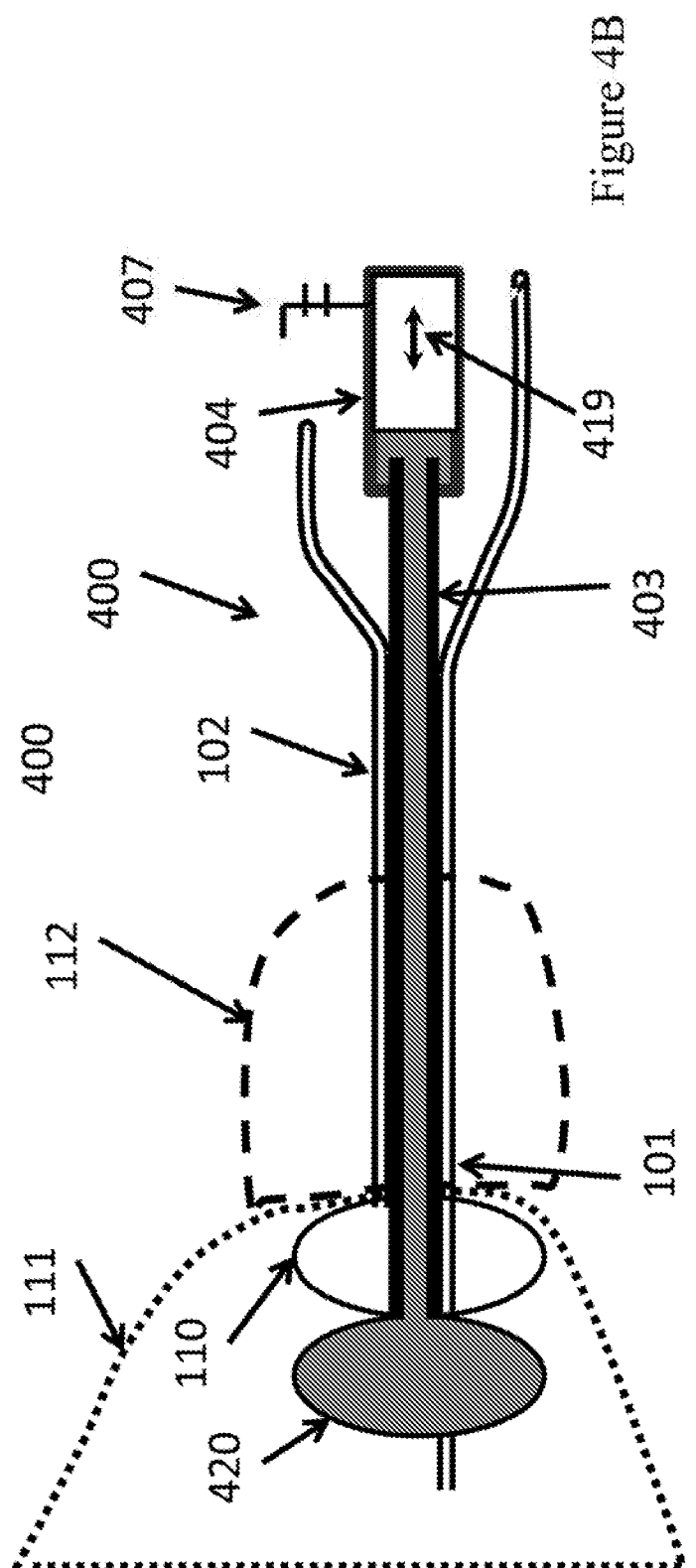
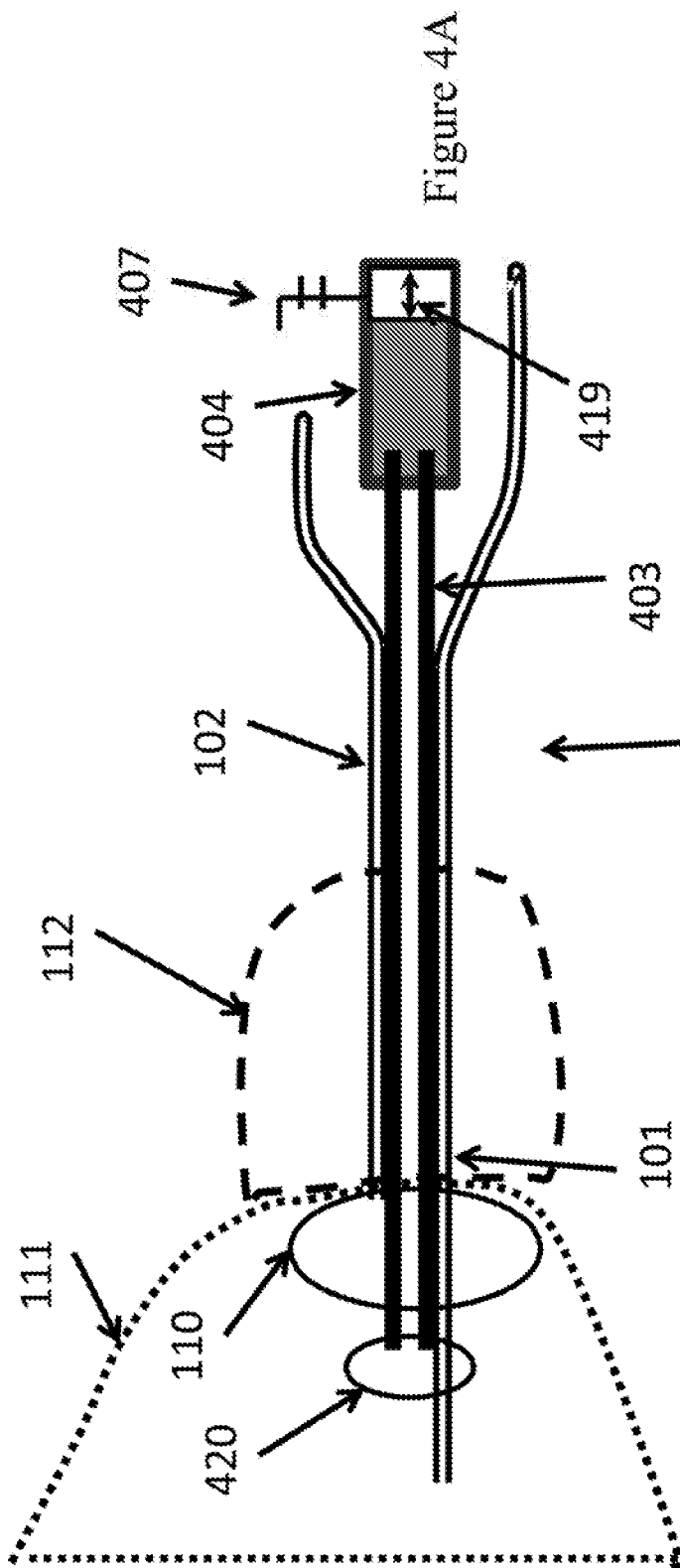
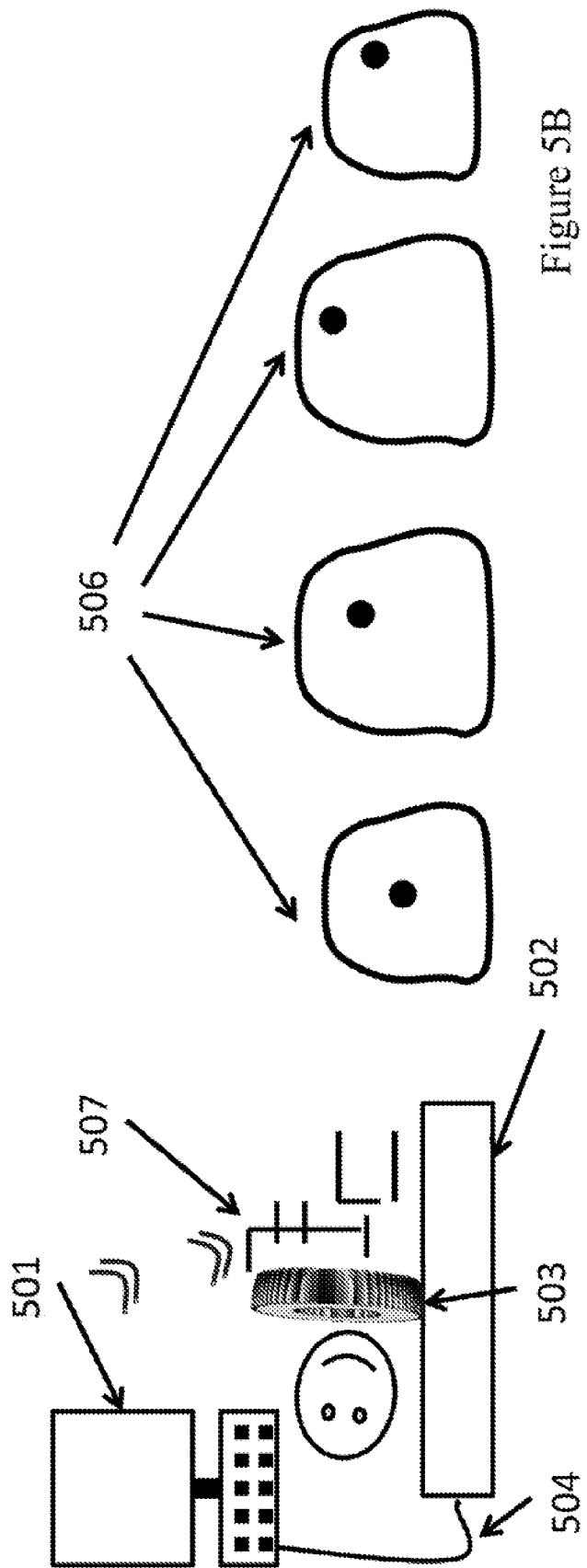
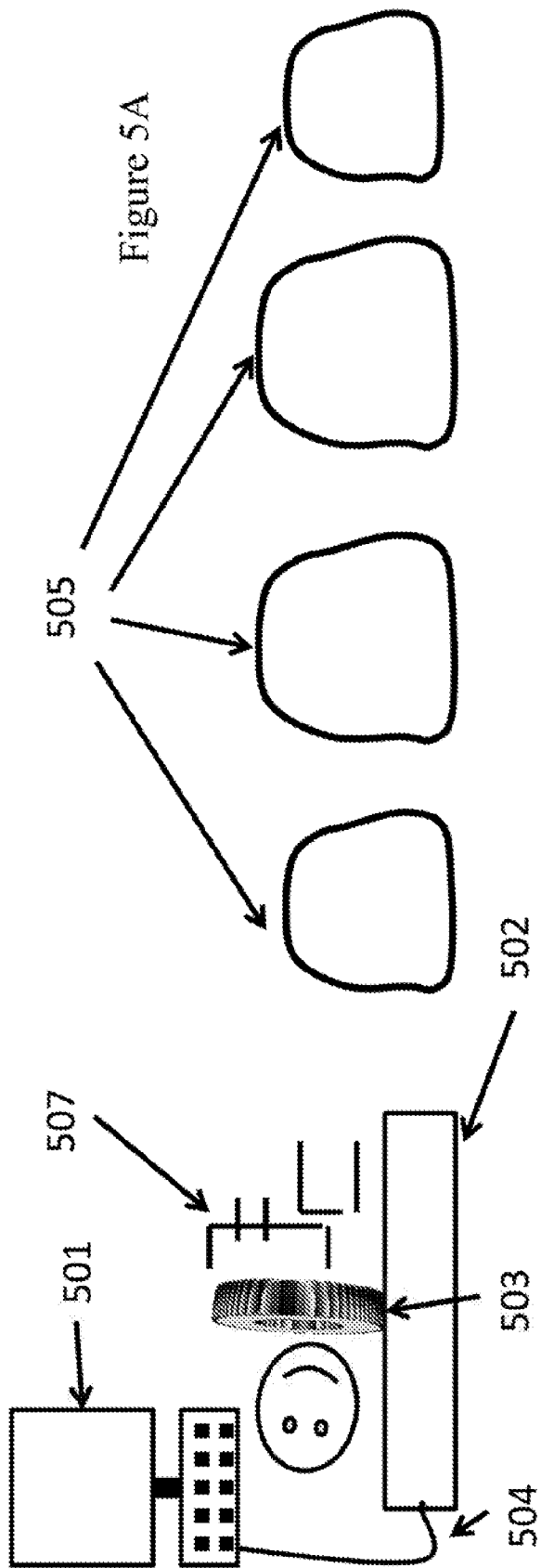
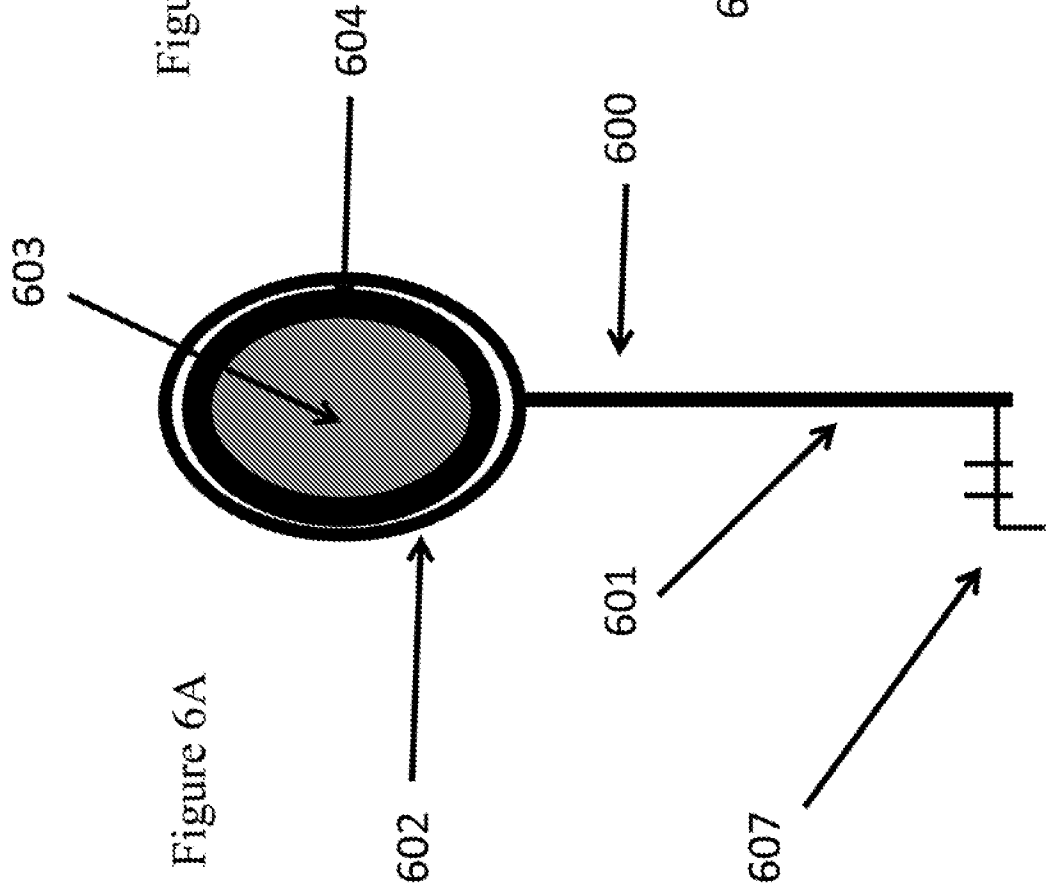
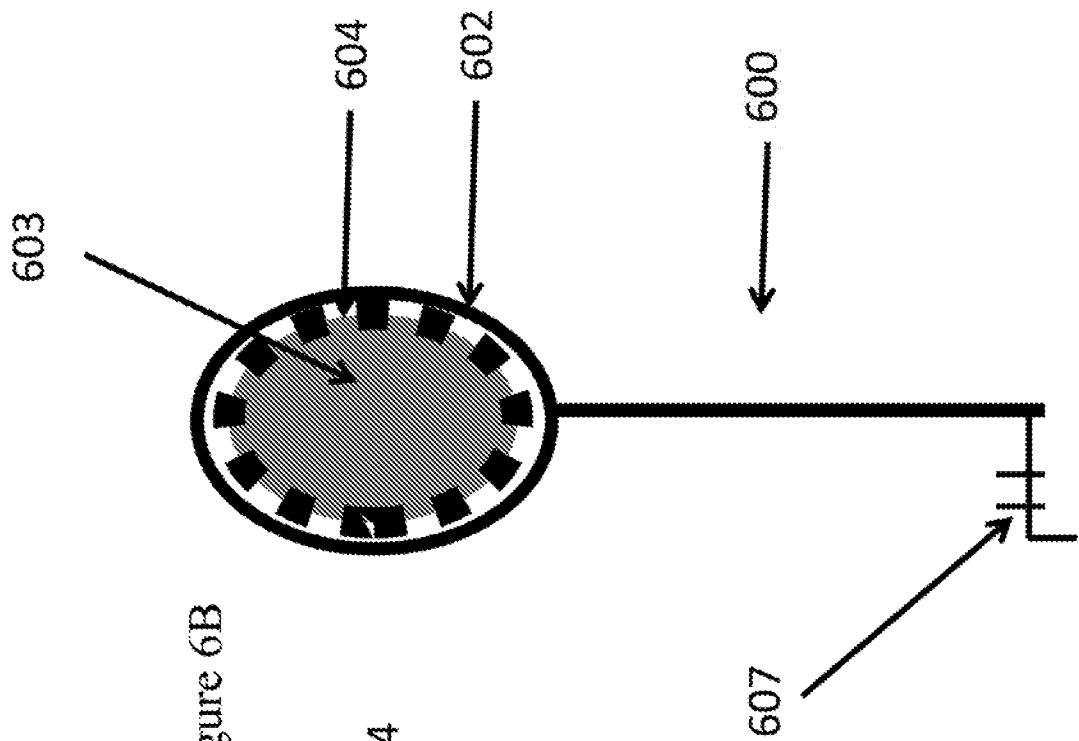


Figure 3







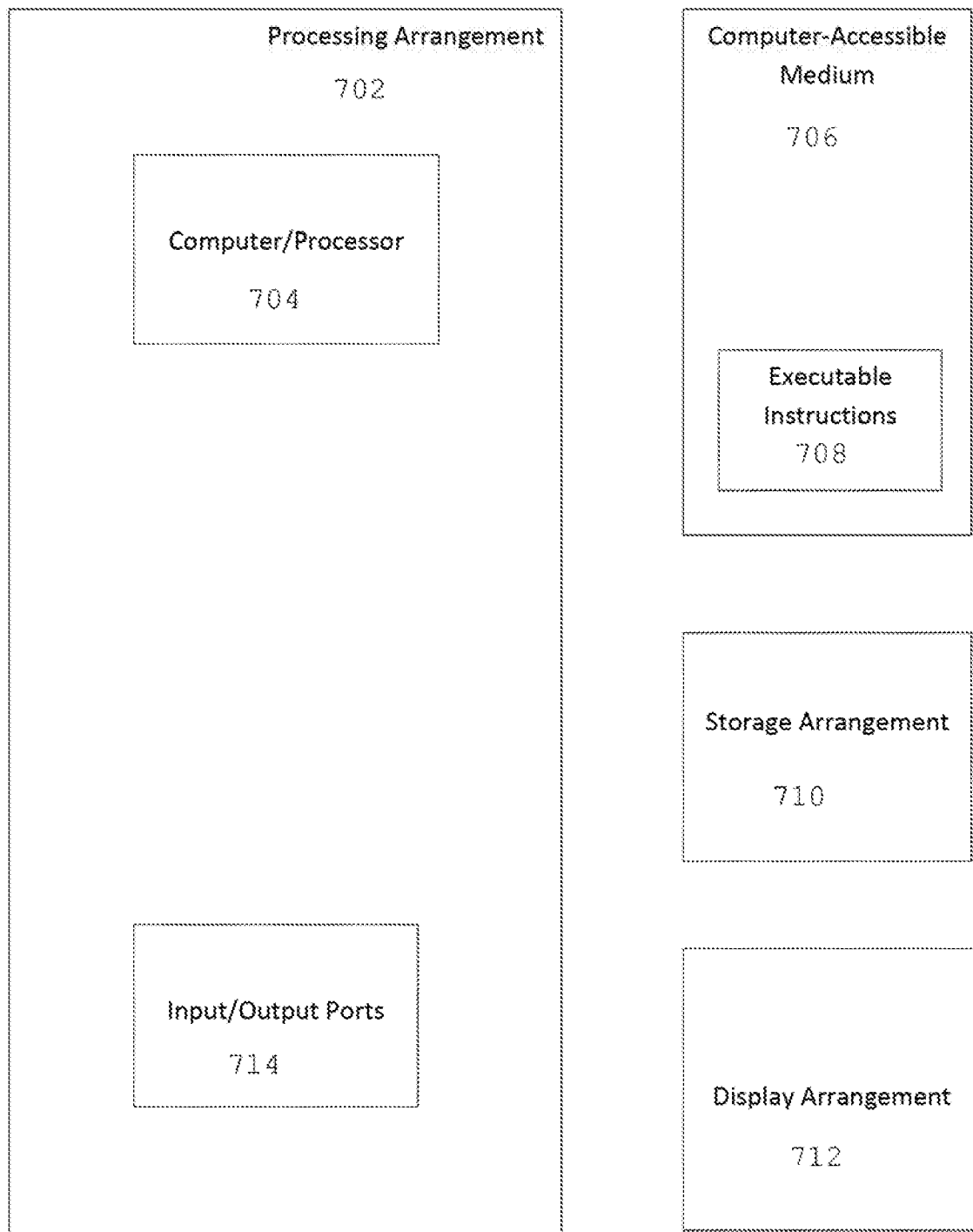


Figure 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/25607

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61B 1/00 (2016.01)

CPC - G06T 7/0012

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)

IPC: A61B 1/00 (2016.01)

CPC: G06T 7/0012

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC: A61B 1/00, G06T 7/0002, G06T 7/0014, G06T 7/0016, G06T 5/20, G06T 7/00 (keyword limited search below)Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Scholar, Google Patents; Search Terms: urethra*, imag*, contrast, prostate, catheter, aerated gel, computed tomography, CT scan, computerized tomography, computerized axial tomography, CAT scan, Memorial Sloan-Kettering Cancer Center, NASSER, ZELEFSKY

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003/0050526 A1 (Hogendijk et al.) 13 March 2003 (13.03.2003) entire document especially Abstract, para [0019]-[0020], para [0033]-[0035], para [0037]-[0044]	1-30
Y	US 6,561,980 B1 (Gheng et al.) 13 May 2003 (13.05.2003) entire document especially Abstract, col 9, ln 33 to col 10, ln 23	1-30
A	US 2014/0369465 A1 (Meyer et al.) 18 December 2014 (18.12.2014) entire document	1-30

☐ Further documents are listed in the continuation of Box C.

* 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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

02 August 2016

Date of mailing of the international search report

25 AUG 2016

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/25607

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-- See extra sheet --

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Claims 1-30

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 16/25607

Continuation of Box No. III: Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

Reasons for Lack of Unity of Invention:

This application contains the following inventions or groups of inventions that are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-30 directed to a non-transitory computer-accessible medium/system/method for determining a location of a urethra of a patient based on the first imaging information related to at least one portion of a prostate of the patient and second imaging information related to the at least one portion and the urethra having the contrast.

Group II: Claims 31-35 directed to an apparatus comprising a catheter configured and structured to be inserted into a urethra of a patient and an automatic pump arrangement coupled to the catheter to inject the contrast composition.

Group III: Claims 36-44 directed to a non-transitory computer-accessible medium/system/method for determining a location of an esophagus of a patient based on the first imaging information related to at least one portion of the esophagus and second imaging information related to the at least one portion having the contrast.

Group IV: Claim 45 directed to an apparatus comprising a first chamber containing a food substance; a second chamber containing a contrast; and a signal processing arrangement configured to selectively release the food substance and the contrast.

Group V: Claims 46-48 directed to a non-transitory computer-accessible medium/system/method for determining a location of a hollow organ of a patient based on the first imaging information related to the hollow organ and second imaging information related to the at least one hollow organ having the contrast.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the Group I invention is directed to a non-transitory computer-accessible medium/system/method for determining a location of a urethra of a patient not required by Groups II, III, IV and V.

The special technical feature of the Group II invention is directed to an apparatus comprising a catheter and an automatic pump arrangement coupled to the catheter to inject the contrast composition not required by Groups I, III, IV and V.

The special technical feature of the Group III invention is directed to a non-transitory computer-accessible medium/system/method for determining a location of an esophagus not required by Groups I, II, IV and V.

The special technical feature of the Group IV invention is directed to an apparatus comprising a first chamber containing a food substance; a second chamber containing a contrast; and a signal processing arrangement configured to selectively release the food substance and the contrast not required by Groups I, II, III and V.

The special technical feature of the Group V invention is directed to a non-transitory computer-accessible medium/system/method for determining a location of a hollow organ of a patient not required by Groups I, II, III and IV.

The only common technical feature shared by the above groups is adding contrast in to an organ for visualization.

The common technical feature does not represent an improvement over the prior art of US 2014/0369465 A1 to Meyer et al (Published 18 December 2014) that discloses adding contrast in to an organ for visualization in para [0023]-[0026] (at least two x-ray images are advantageously acquired during a contrast agent perfusion through the hollow organ. Via the contrast agent perfusion, the visibility and the contrast of the hollow organs in the x-ray image are improved, which ensures a good registration due to a good ability to recognize the structures ... accurately positioned visualization of x-ray images and center line and/or three-dimensional lumen of the hollow organ is advantageously displayed).

As the above technical feature of as taught by Meyer et al was known, this cannot be considered a special technical feature that would otherwise unify the groups.

Therefore, the inventions of Groups I-V lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature.