

INTERVENTIONAL APPARATUS
ACTIVATED COMPUTED TOMOGRAPHY (CT)

FIELD OF THE INVENTION

The following generally relates to imaging and more particular to activating an imaging scanner to scan a region of interest of a subject and an interventional instrument (of an interventional apparatus) therein based on movement of the interventional instrument within the region of interest as determined by the interventional apparatus, and is described with particular application to a computed tomography (CT) imaging scanner; however, the following is also amenable to other imaging modalities.

BACKGROUND OF THE INVENTION

Interventional imaging includes using images to guide minimally invasive interventional procedures such as diagnostic, treatment, and/or other interventional procedures.

By way of example, with one transcatheter interventional procedure, a local anesthetic is injected or applied into the skin of a patient at an entry area to numb the entry area, a puncture is made to the entry area with a needle, scalpel, etc., and a plastic sheath is inserted into the artery. A catheter supporting an interventional instrument is then inserted and feed through the sheath and into the vessel, and moved to an area of interest of the patient, such as the heart, the brain, the lungs or other anatomical structure of interest, where the interventional procedure is performed.

The interventional instrument can then be employed to perform the interventional procedure. During the interventional procedure, images are periodically acquired and used to give the interventionalist orientation and update information on the progress of the procedure. Computed tomography (CT) images have been used to guide interventional procedures. However, since CT data acquisitions can deposit a relatively high amount of x-ray radiation dose, images in CT guided interventional procedures generally are acquired very rarely and only when needed. For example, typically, an image update is only acquired after the catheter has been moved or translated, forward or backward, a certain distance, since such movement may result in a change in the interventional situation.

Unfortunately, the interventionalist performing the interventional procedure has to determine when to acquire an image and manually trigger the CT scanner to acquire the image. As such, the interventionalist may error on the conservative side and initiate scanning before necessary, which may increase patient dose relative to initiating scanning a little later in time, while mitigating initiating scanning later than desired. Furthermore, the interventionalist is tasked with acts outside of the interventional procedure (i.e., determining when to scan and initiating scanning), and time consumed performing these acts could otherwise be used to perform the interventional procedure and/or interact with the patient.

SUMMARY OF THE INVENTION

Aspects of the present application address the above-referenced matters and others.

According to one aspect, a system includes an interventional apparatus and an imaging scanner. The interventional apparatus includes an interventional instrument configured to perform an image-guided interventional procedure for a patient. The interventional apparatus includes a position detector that detects a position of the interventional instrument within a region of the patient at which the image-guided interventional procedure is performed from outside of the region of interest and generates a signal indicative of the detected position. The imaging scanner includes a controller that activates the imaging scanner to scan the region of interest and the interventional instrument therein for one or more data acquisition cycles based on the movement signal.

According to another aspect, a method includes generating, with a position detector of an interventional apparatus, a movement signal indicative of a distance an interventional instrument of the interventional apparatus moves within a region of interest of a patient during an image-guided interventional procedure. The method further includes conveying the movement signal from the interventional apparatus to an imaging scanner used to generate images for the image-guided interventional procedure. The method further includes controlling, with a controller of the imaging scanner, scanning by the imaging scanner of the region of interest and the interventional instrument therein based on the movement signal for the image-guided interventional procedure.

According to another aspect, a computing readable storage medium encoded with computer readable instructions, which, when executed by one or more processors of a computing system, cause an imaging scanner to automatically scan a region of interest of a patient and an interventional instrument, of an interventional apparatus, therein in response to the a signal generated by the interventional apparatus, which is indicative of a movement of the interventional instrument within the region of interest, satisfying a predetermined threshold.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 schematically illustrates an example imaging system in connection with an interventional apparatus.

FIGURE 2 illustrates an example of an interventional apparatus that includes a position detector that senses a position of a moveable portion of the interventional apparatus moveable during an image-guided procedure to facilitate performing the procedure.

FIGURE 3 illustrates an example of the position detector including a mechanical motion sensor.

FIGURE 4 illustrates another example of the position detector including a mechanical motion sensor.

FIGURE 5 illustrates an example of the position detector including an optical motion sensor.

FIGURE 6 illustrates another example of the position detector including an optical motion sensor.

FIGURE 7 illustrates an example of the position detector including a radio frequency motion sensor.

FIGURE 8 illustrates example method for activating scanning with the interventional apparatus during an image-guided interventional procedure performed using the interventional apparatus.

DETAILED DESCRIPTION

FIGURE 1 illustrates a system 100 including an imaging scanner 101, such as a computed tomography (CT) imaging scanner, in connection with an interventional apparatus 102.

The illustrated imaging scanner 101 includes a stationary gantry 104 and a rotating gantry 106, which is rotatably supported by the stationary gantry 104. The rotating gantry 106 rotates around an examination region 108 about a longitudinal or z-axis. A patient support 110, such as a couch, supports a patient in the examination region 108 and is movable along the x, y and/or z-axis in coordination with the rotation of the rotating gantry 106.

A radiation source 112, such as an x-ray tube, is supported by and rotates with the rotating gantry 106 around the examination region 108. A controller ("CTRLR") 114 controls the radiation source 112. By way of non-limiting example, the illustrated controller 114 is configured to activate the radiation source 112 (i.e., turn the radiation source 112 "on" such that the radiation source 112 emits radiation that traverses the examination region 108) and deactivate the radiation source 112 (i.e., turn the radiation source 112 "off" such that such radiation does not traverse the examination region 108). A radiation sensitive detector array 116 detects radiation that traverses the examination region 108 and generates projection data indicative of the detected radiation.

A reconstructor 118 reconstructs the projection data and generates volumetric image data indicative of the examination region 108. The image data can be displayed, filmed, etc. A general purpose computing system serves as an operator console 120, and includes an output device such as a display and an input device such as a keyboard, mouse, and/or the like. The console 120 includes a processor(s) and computer readable storage medium (e.g., physical memory) encoded with computer readable instructions, which, when executed by the processor allows a user to operate the scanner 101 such as initiating scanning, display reconstructed images, etc. Additionally or alternatively, the processor can execute computer readable instructions carried in signal medium (e.g., a carrier wave).

As briefly discussed above, the illustrated imaging scanner 101 is shown in connection with the interventional apparatus 102. As described in greater detail below, the

interventional apparatus 102 includes a position detector 122 that is configured to communicate with the imaging scanner 101, for example, to convey a signal to the imaging scanner 101 (e.g., the console 120 and/or the source controller 114) that triggers the imaging scanner 101 (e.g., with or without user interaction) to perform an action, such as activate the radiation source 112 and acquire data (i.e., perform a scan), based on a state such as a movement state or other state of the interventional apparatus 102 with respect to predetermined scan activation criteria, and/or other action.

As such, in one non-limiting embodiment, during an image-guided interventional procedure utilizing the interventional apparatus 102, the interventionalist does not have to determine when to scan a region of interest of the subject (and the interventional instrument therein) positioned in the examination region 108 or manually trigger the imaging scanner 101 to scan the region of interest. Instead, the position detector 122 senses information about the position state of the interventional procedures and this information is utilized to determine when to scan the portion of the subject in the examination region 108 and to automatically trigger the scanner 101 to scan the subject. The foregoing allows the interventionalist to focus on the procedure and the patient, and may facilitate reducing patient dose relative to a configuration in which the position detector 122 is omitted. Of course, the interventionalist can still manually initiate scanning via the imaging scanner 101 to scan the subject and/or pause or terminate an automatically triggered scan.

FIGURE 2 schematically illustrates an example of the interventional apparatus 102 in connection with an example image guided procedure.

In this example, the interventional apparatus 102 includes an elongate flexible catheter 202 with an interventional instrument 204 affixed to an end 205 of the catheter 202 that enters an object or subject 208 and a sheath 206 through which the catheter 202 enters the object or subject 208. The illustrated sheath 206 includes a first end 210, which is inserted into the object or subject 208, and a second end 212 which remains outside of the object or subject 208. The second end 212 includes a hub or port 214, which, generally, is geometrically larger than the first end 210 and sits or rests about an entry or access point 216 into the object or subject 208 created by the sheath 206.

The object or subject 208 includes a tubular structure 218 that provides a pathway 220 to a region of interest 222 of the object or subject 208. In the illustrated

embodiment, the position detector 122 is disposed in connection with the hub 214 of the sheath 206 and can sense positional (e.g., translational, rotational, etc.) information about the catheter 202 relative to the sheath 206. For example, the illustrated position detector 122 senses movement of the catheter 202 in and out of the sheath 206, rotation of the catheter 202 within the sheath 206, etc., and generates a movement signal indicative of the sensed movement.

The position detector 122 may be variously affixed to the sheath 206. For example, in one embodiment, the position detector 122 may be part of the sheath 206. In another embodiment, the position detector 122 is separate from but fixedly attached to the sheath 206 via an adhesive such as glue. In yet another embodiment, the position detector 122 is removeably attached to the sheath 206. With this embodiment, a position detector 122 may be cleanable (e.g., sterilizeable, disinfectable, etc.) and alternately used with more than one sheath 206. The position detector 122 conveys the movement signal to the controller 114, directly and/or to the console 120, via a wireless or wired (e.g., a cable) communications channel.

At least one of the console 120 or the controller 114 executes computer readable instructions for evaluating the movement signal and determining whether to activate the imaging scanner 101 to scan. In the illustrated embodiment, the computer readable instructions compute a distance that the catheter 202 has traveled (e.g., from the beginning of the procedure, relative to a last scan, relative to an identified landmark within the object or subject, etc.) based on the movement signal and compares this distance with a stored predetermined threshold distance. In one instance, where the distance in the movement signal satisfies the threshold, the controller 114 transmits a command signal that activates the source 112 to scan for a predetermined number of data acquisition cycles. Optionally, the console 120 can provide a notification indicating that the source 112 will be activated within a predetermined time period before activating the source 112. Otherwise, the controller 114 does not activate the source 112 to scan.

In a variation of the above, the console 120 visually presents or provides a notification that indicates that data should be acquired and waits for a user confirmation. Such confirmation could be through an audible command such as a voice command from the user. Additionally or alternatively, the confirmation could be through a joystick, a foot pedal, a keyboard, a mouse, and/or other known input device. Additionally or

alternatively, the user can manually invoke the imaging scanner 101 to acquire data independent of the trigger signal via an audible command and/or a joystick, a foot pedal, a keyboard, a mouse, the console 120, and/or other known input device.

In a non-limiting application of the above, the subject 208 is a human patient, the entry point 216 is the femoral artery via the groin, and thus the sheath 206 is partially inserted into the femoral artery at the groin, with a sub-portion of the sheath 206 including the hub 214 remaining outside of the patient at the groin. In this example, the region of interest 222 is anatomical structure such as the heart (or brain, lungs, etc.), and the interventional device 204 affixed to the end of the catheter 202 is configured for performing an interventional procedure at the structure of interest. Examples of cardiac interventional procedures include, but are not limited to, angioplasty, angiography, balloon septostomy, etc.

The position detector 122 senses movement of the catheter 202 within the region of interest 222 based on movement of the catheter 202 with respect to the position detector 122, and, if it is determined the movement of the catheter 202 corresponds to a distance that satisfies the predetermined distance threshold value, then the controller 114 invokes the scanner 101 to acquire data. The resulting displayed image visually shows the location of the interventional instrument 204 within the region of interest 222. The interventionalist performing the procedure can utilize the displayed image to facilitate guiding and employing the interventional instrument 204 in connection with the interventional procedure.

FIGURE 3 schematically illustrates a non-limiting embodiment of the position detector 122 including a mechanical based motion sensor.

In this embodiment, the position detector 122 includes at least one element 300 configured to rotate. For explanatory purposes, the at least one element 300 includes a wheel 302. However, other elements such as a ball, a roller, or other rotating element 300 may additionally or alternatively be used.

The illustrated wheel 302 is rotatably supported by the position detector 122, for example, via a pin, rod, or the like through a center axis of the wheel 302. Furthermore, the position detector 122 is affixed to the hub 214 such that the wheel 302 physically contacts an outer surface of the catheter 202 in response to the catheter 202 in

the sheath 206. A mechanism such as a spring or the like may be used to exert a force that facilitates ensuring physical contact of the wheel 302 with the catheter 202.

A transducer 304, such as a rotary encoder or the like, senses the rotational position of the wheel 302 relative to a predetermined reference position. The transducer 304 generates an analog or digital signal indicative of the rotational position of the wheel 302 relative to the reference position. The position detector 122 conveys the signal to the console 120 and/or controller 114.

With this embodiment, each angular increment of the wheel 302 corresponds to a translational distance along the catheter 202. As such, the signal from the position detector 102 is indicative of a translational movement distance of the catheter 202 in the sheath 206 and hence in the region of interest of the subject 208. The wheel 302 is free to rotate in either direction, and the signal indicates the direction and magnitude of the movement, into or out of the sheath 206.

In the illustrated embodiment, the position detector 122 includes single wheel 302. In a variation, the position detector 122 may include more than one wheel 302 and/or other rotating element 300. With this variation, one or more of the wheels 302 and/or other rotating element 300 may be used to determine the rotational position.

FIGURE 4 schematically illustrates another non-limiting embodiment of the position detector 122 including a mechanical based motion sensor.

In this embodiment, the catheter 202 includes a plurality of protrusions or nubs 402, protruding outward from the catheter 202. The plurality of protrusions 402 are separated from each other by a known distance, which correspond to a length of catheter 202 between protrusions 402. The protrusions 402 may be part of the catheter 202 (e.g., ribs) or affixed thereto. The position detector 122 includes a transducer 404 or the like which, in response to physically contacting one of the protrusions 402, generates a signal indicative of the physical contact.

The position detector 122 conveys the signal to the console 120 and/or controller 114. With this embodiment, since the plurality of protrusions 402 are spaced at known distances, each signal indicating a protrusion 402 has been detected corresponds to a translational distance of the catheter 202. As such, the signal from the position detector 122 is indicative of a translational movement distance of the catheter 202 in the sheath 206 and the region of interest of the object or subject 208. As with the wheel 302, the

transducer 404 can indicate the direction and magnitude, and rotational or other motion of the catheter 202 in the sheath 206.

FIGURE 5 schematically illustrates another non-limiting embodiment of the position detector 122 including an optical based motion sensor.

In this embodiment, the position detector 122 includes a transmitter 502 and a receiver 504, and the catheter 202 includes a predetermined pattern 506 with a known reflective characteristic. By way of non-limiting example, the illustrated pattern 506 includes a plurality of bars 508 of alternating different colors (e.g., white and black, or red, green, blue, etc.) in which a distance between a given set of bars corresponds to a known translation distance. In other embodiment, the pattern 506 includes other reflective indicia. A power source 510 such as a battery provides power to energize the transmitter 502 and the receiver 504.

In operation, the transmitter 502 (e.g., a light emitting diode (LED) or other light source) transmits light which illuminates the catheter 202 and reflects off the pattern 506. The receiver 504 receives the reflected light and generates a signal indicative thereof. Since the bars 508 are spaced at known distances, the signal generated by the receiver 504 corresponds to a distance moved by the catheter 202. As such, the signal from the position detector 122 is indicative of a movement distance of the catheter 202 in the sheath 206 and hence in the region of interest of the object or subject 208.

In a variation, each bar 508 could also have a pattern, which can be used to determine rotational motion of the catheter 202. Similar to above, the pattern can be determined based on the detected reflected signal, and a rotational distance can be determined based on the detected reflected signal.

FIGURE 6 schematically illustrates a variation of FIGURE 5 in which a plurality of light transmitters 602, powered by a battery or otherwise, are located along the catheter 202 at known distances apart and emit light that is detected by the receiver 504. Since the light transmitters 602 are spaced at known distances, the signal from the receiver 504 corresponds to a translational distance of the catheter 202. As such, the signal from the position detector 122 is indicative of a translational movement distance of the catheter 202 in the sheath 206 and hence in the region of interest of the object or subject 208.

FIGURE 7 schematically illustrates another non-limiting embodiment of the position detector 122 including a radio frequency based motion sensor.

In this embodiment, a passive emitter 700 is attached to (e.g., embedded in, affixed to, etc.) the catheter 202, near the interventional instrument 204, and the position detector 122 includes a transceiver 702 that transmits signals having a wavelength within a predetermined wavelength range. The passive emitter 700, in response to receiving signal in the predetermined wavelength range, emits a characteristic signal, which is received by the transceiver 702.

A signal strength of the received signal indicates a relative distance between the passive emitter 700 and the transceiver 702, and the transceiver 702 generates a signal indicative of the signal strength. Where the distance between the passive emitter 700 and the transceiver 702 corresponds to an length of the catheter 202 inserted into the sheath 206, the signal from transceiver 702 is indicative of the translational movement of the catheter 202.

It is to be understood that the examples of FIGURES 3-7 are non-limiting and other approaches are contemplated herein. In addition, one or more of the approaches of FIGURES 3-7 and/or other approaches can be combined, modified, etc.

FIGURE 8 illustrates a method for activating scanning by an imaging scanner during an image-guided interventional procedure by the interventional apparatus.

It is to be appreciated that the ordering of the following acts is non-limiting. As such, other orderings are also contemplated herein. Furthermore, one or more of the following acts may be omitted and/or one or more acts may be added.

At 802, an interventional instrument of an interventional apparatus is positioned within a region of interest within a patient as described herein.

At 804, the interventional instrument is moved within the region of interest, for example, by an interventionalist performing the interventional procedure with the interventional apparatus.

At 806, a sensor of the interventional apparatus senses the movement and generates a signal indicative thereof.

At 808, the signal is conveyed to the imaging scanner.

At 810, the signal is evaluated to determine a relative distance the interventional instrument has moved within the patient.

At 812, the distance is compared with a predetermined scanning threshold distance.

At 814, the scanner is activated to scan only in response to the distance satisfying the threshold. As such, scans are performed automatically only when needed.

At 816, one or more images generated from the scan are displayed.

Otherwise and/or afterwards, acts 804-814 are repeated one or more times.

Although described above in connection with computed tomography (CT), it is to be appreciated that the above is also applicable to other imaging modalities such as, but not only, positron emission tomography (PET), single photon emission tomography (SPECT), magnetic resonance imaging (MRI), ultrasound (US), three dimensional (3D) x-ray, and/or other imaging modalities.

The invention has been described herein with reference to the various embodiments. Modifications and alterations may occur to others upon reading the description herein. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

CLAIMS

What is claimed is:

1. A system (100), comprising:
 - an interventional apparatus (102) including an interventional instrument (204) configured to perform an image-guided interventional procedure for a patient, the interventional apparatus including a position detector (122) that detects a position of the interventional instrument within a region of the patient at which the image-guided interventional procedure from outside of the region of interest is performed and generates a movement signal indicative of the detected position; and
 - an imaging scanner (101) including a controller (114) that activates the imaging scanner to scan the region of interest and the interventional instrument therein for one or more data acquisition cycles based on the movement signal.
2. The system of claim 1, the interventional apparatus, comprising:
 - a sheath (206) configured to provide an entry point into a vessel of the patient when inserted into the patient;
 - a catheter (202), to which the interventional instrument is affixed, configured to be fed through the sheath and into the vessel and routed through the vessel to position of the interventional instrument within the region of interest; and
 - a position detector (122), affixed to the sheath and located outside of the patient, that senses movement of the catheter in and out of the entry point with respect to the sheath and generates the movement signal, which is indicative of the sensed movement of the catheter.
3. The system of claim 2, wherein the movement signal indicates a distance that the catheter has traveled in the region of interest, and the controller activates the imaging scanner to scan the region of interest and the interventional instrument therein in response to the distance satisfying a predetermined distance threshold.
4. The system of any of claims 1 to 3, wherein the controller automatically activates the imaging scanner without user interaction.

5. The system of any of claims 1 to 4, wherein position detector includes a mechanical based motion sensor that senses the movement of the catheter.
6. The system of any of claims 1 to 5, the position detector, comprising:
 - at least one element (300, 302) configured to rotate, wherein the position detector is positioned with respect to the catheter such that the at least one element is in physical contact with the catheter and rotates in coordination with the movement of the catheter into and out of the entry point of the sheath; and
 - a transducer (304) that senses a rotation of the at least one element and generates the movement signal, which is indicative of the sensed rotation.
7. The apparatus of claim 6, wherein a rotational distance of the at least one element corresponds to a translational distance of the catheter.
8. The system of any of claims 1 to 4,
 - the catheter, comprising: a plurality of protrusions (402), spaced apart along a long axis of the catheter at predetermined distances from each other; and
 - the position detector, comprising: a transducer (404) that detects a presence of a protrusion passing the transducer and generates the movement signal, which is indicative of the detected protrusion.
9. The system of any of claims 1 to 4, wherein the position detector includes an optical based motion sensor that senses the movement of the catheter.
10. The system of any of claims 1 to 4 or 9, wherein the catheter includes a pattern thereon that is responsive to light, and the motion sensor, comprising:
 - a transmitter (502) that transmits first light that illuminates the pattern on the catheter; and
 - a receiver (504) that receives second light reflected off the pattern and generates the movement signal, which is indicative of the detected second light.

11. The apparatus of claim 10, wherein the pattern indicates to a movement distance of the catheter.
12. The system of any of claims 1 to 4, wherein the position detector includes a radio frequency based motion sensor that senses the movement of the catheter.
13. The system of any of claims 1 to 4 or 12, the catheter, comprising:
 - an emitter (700) configured to respond to reception of a signal having a predetermined wavelength, wherein, upon receiving the signal having the predetermined wavelength, the emitter emits a signal;
 - the position detector, comprising:
 - a transmitter (502) that transmits the signal based on a predetermined periodicity and receives the emitted signal, and generates the movement signal, which is indicative of a signal strength of the received emitted signal.
14. The apparatus of claim 13, wherein the signal strength of the emitted signal is indicative of a distance between the emitter and the transceiver and indicates a movement distance of the catheter.
15. A method, comprising:
 - generating, with a position detector of an interventional apparatus, a movement signal indicative of a distance an interventional instrument of the interventional apparatus moves within a region of interest of a patient during an image-guided interventional procedure;
 - conveying the movement signal from the interventional apparatus to an imaging scanner used to generate images for the image-guided interventional procedure; and
 - controlling, with a controller of the imaging scanner, scanning by the imaging scanner of the region of interest and the interventional instrument therein based on the movement signal for the image-guided interventional procedure.
16. The method of claim 15, the interventional apparatus, comprising:

a sheath configured to provide an entry point for the interventional apparatus into a vessel of the patient;

a catheter carrying the interventional instrument and configured to be fed through the sheath and into the vessel and routed through the vessel to the region of interest; and

a position detector, affixed to the sheath, that senses movement of the catheter in and out of the entry point and generates the movement signal based thereon.

17. The method of any of claims 15 to 16, further comprising:

comparing the movement signal with a predetermined scanner activation threshold value; and

activating the image scanner to scan the region of interest and the interventional instrument therein only in response to the movement signal satisfying the predetermined scanner activation threshold value.

18. The method of claim 17, wherein the image scanner is automatically activated without human interaction.

19. The method of any of claims 15 to 17, further comprising:

displaying one or more images generated by the imaging scanner in response to scanning the region of interest and the interventional instrument therein.

20. A computing readable storage medium encoded with computer readable instructions, which, when executed by one or more processors of a computing system, cause an imaging scanner to automatically scan a region of interest of a patient and an interventional instrument, of an interventional apparatus, therein in response to the a signal generated by the interventional apparatus, which is indicative of a movement of the interventional instrument within the region of interest, satisfying a predetermined threshold.

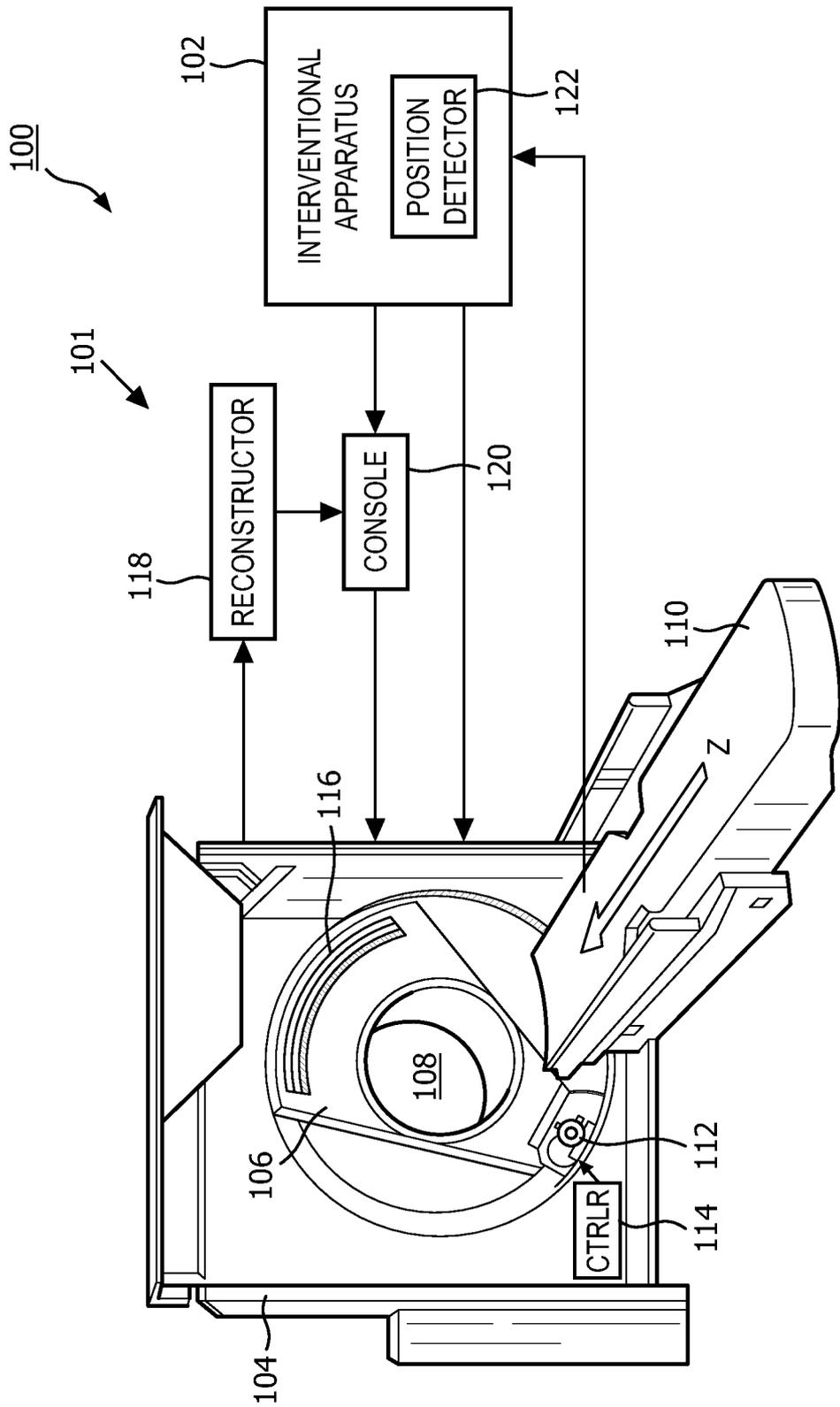


FIG. 1

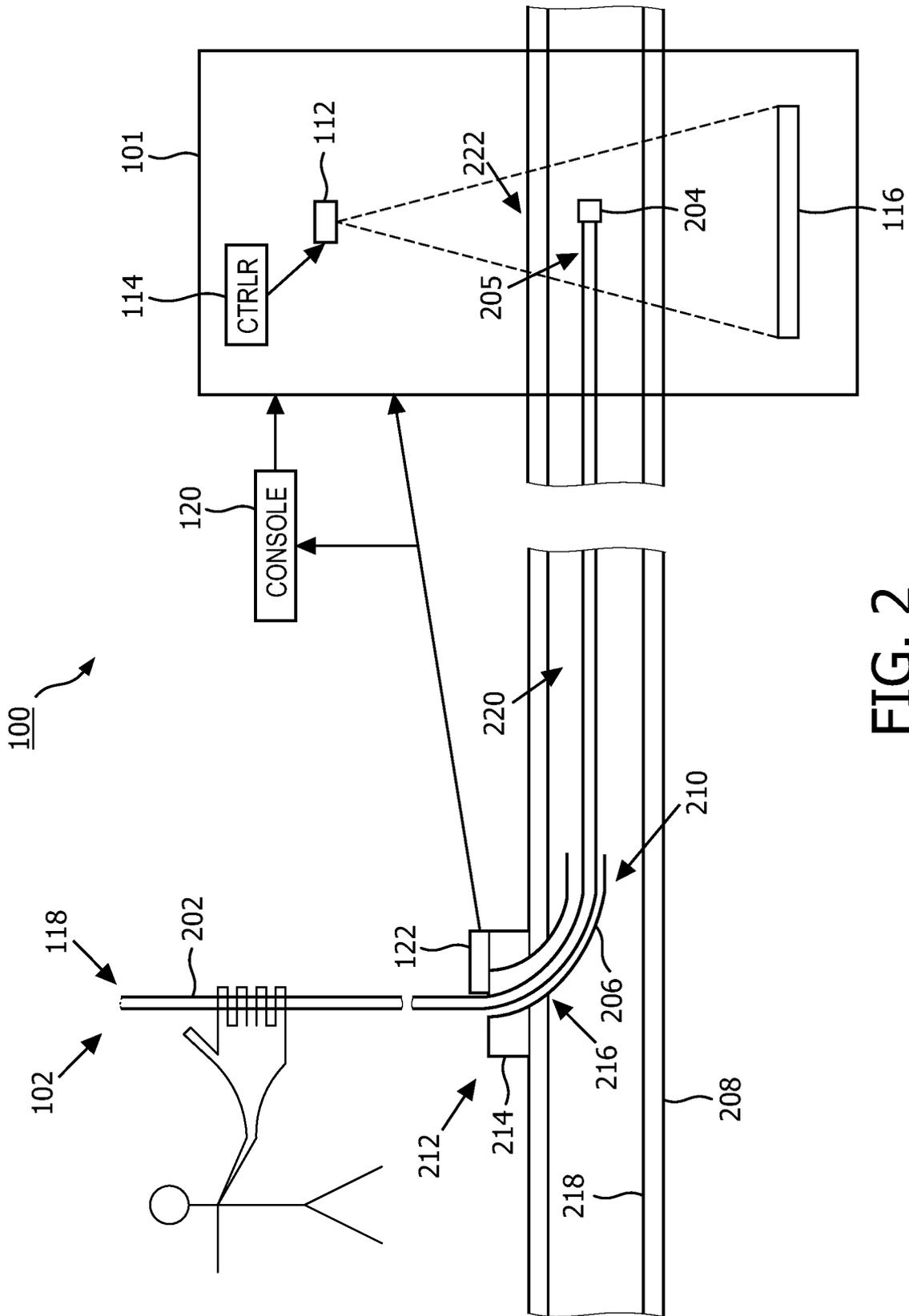


FIG. 2

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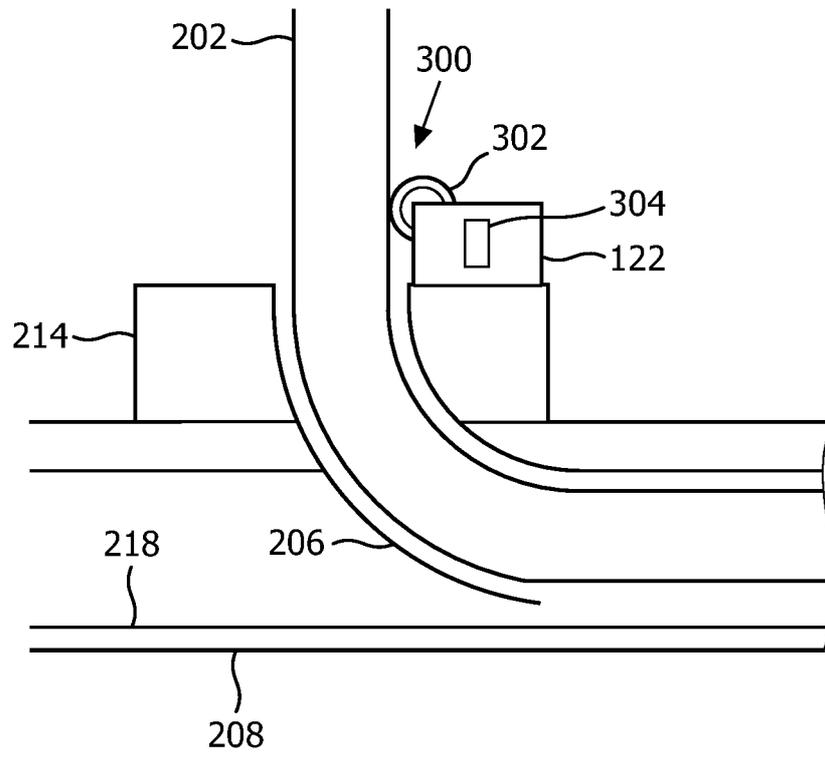


FIG. 3

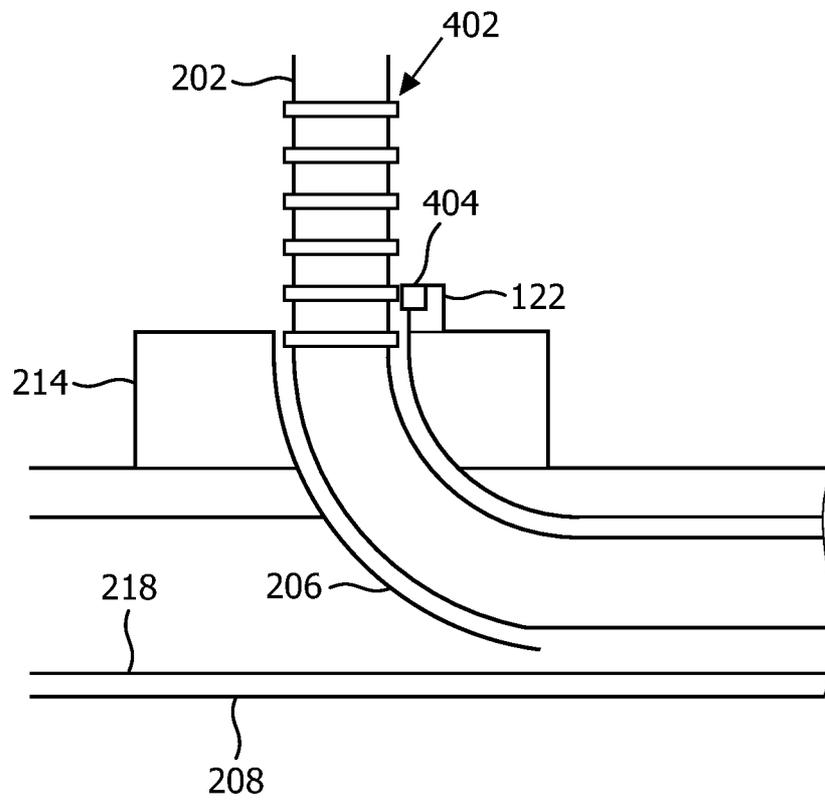


FIG. 4

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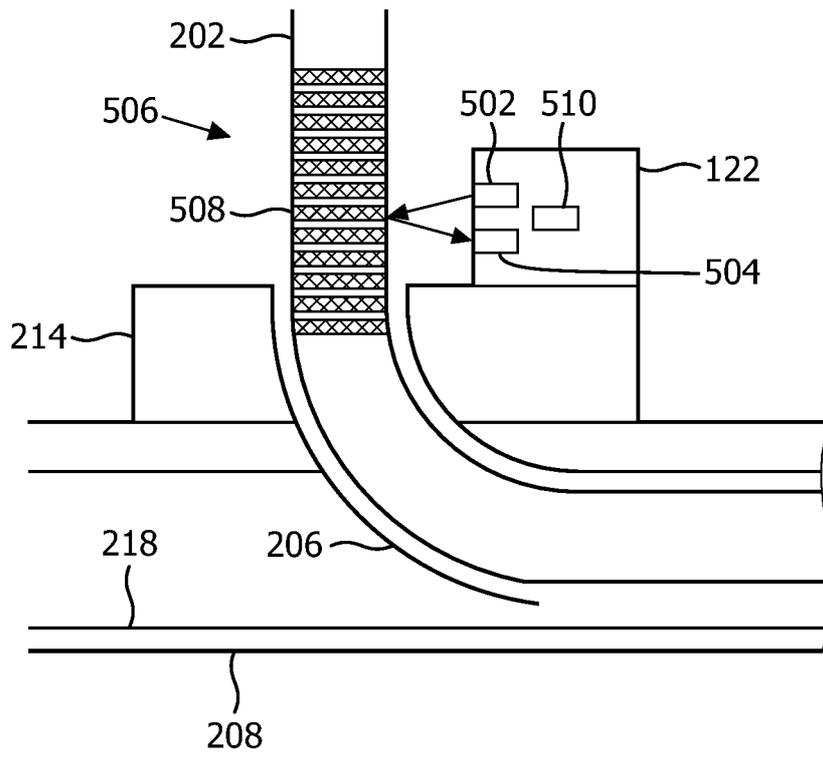


FIG. 5

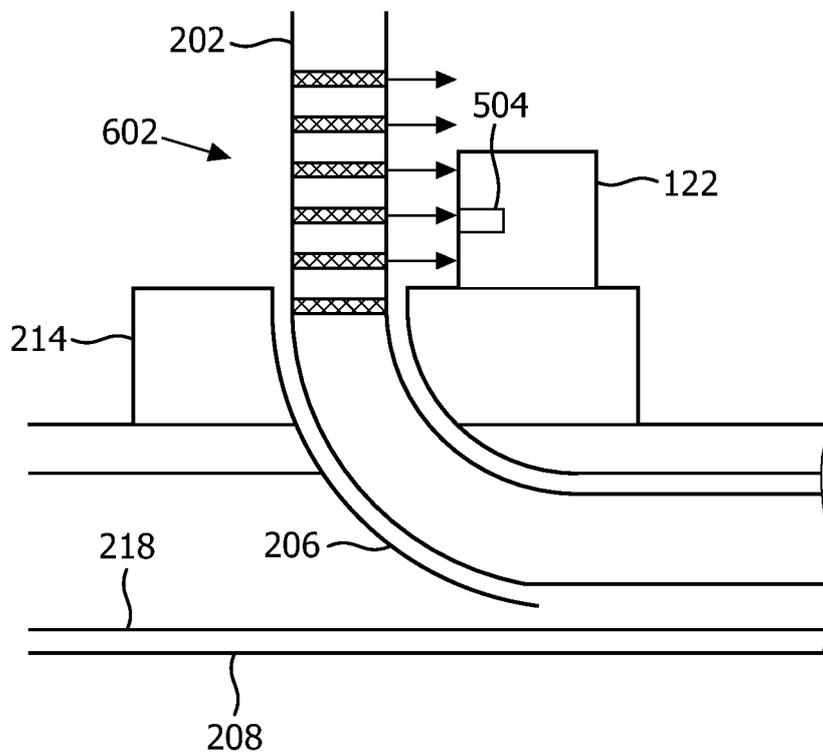


FIG. 6

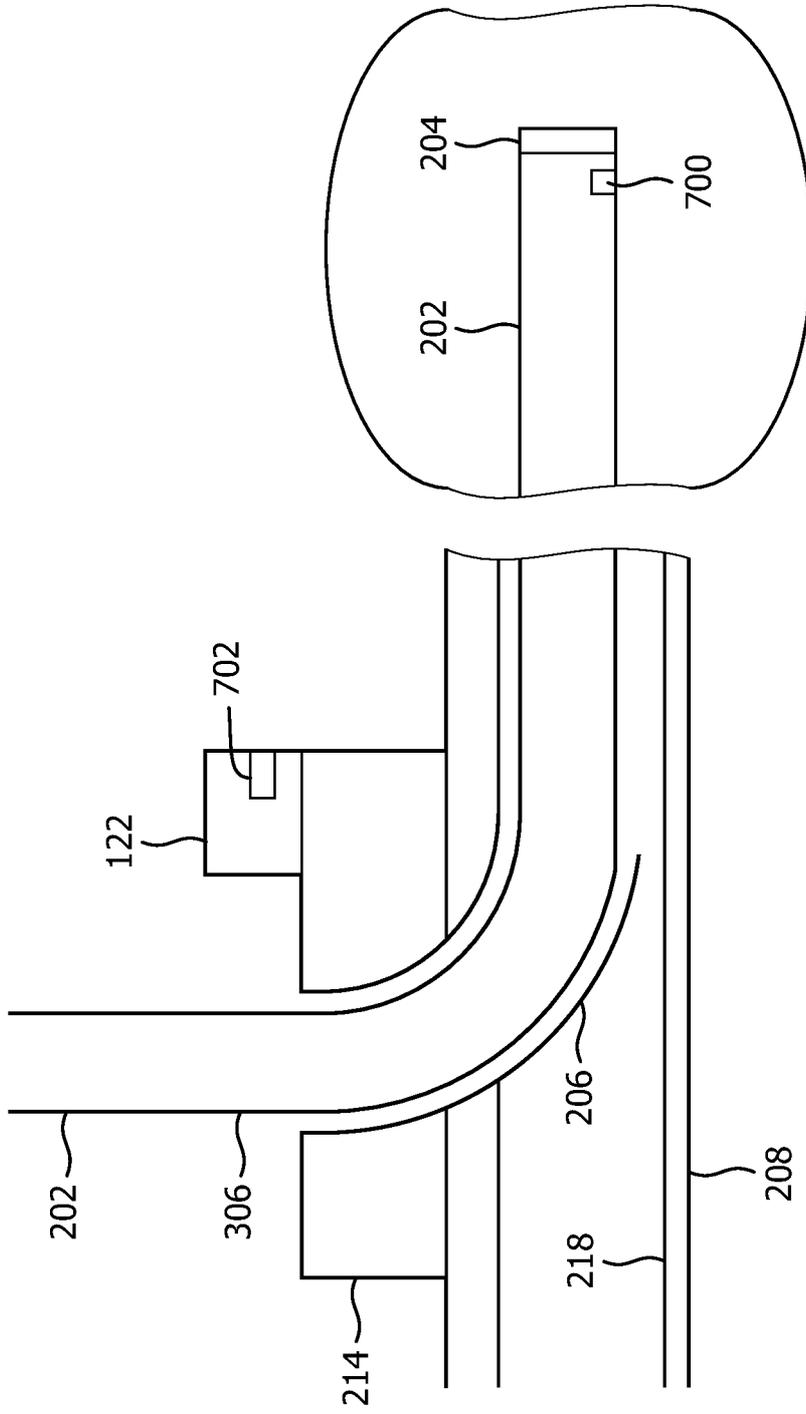


FIG. 7

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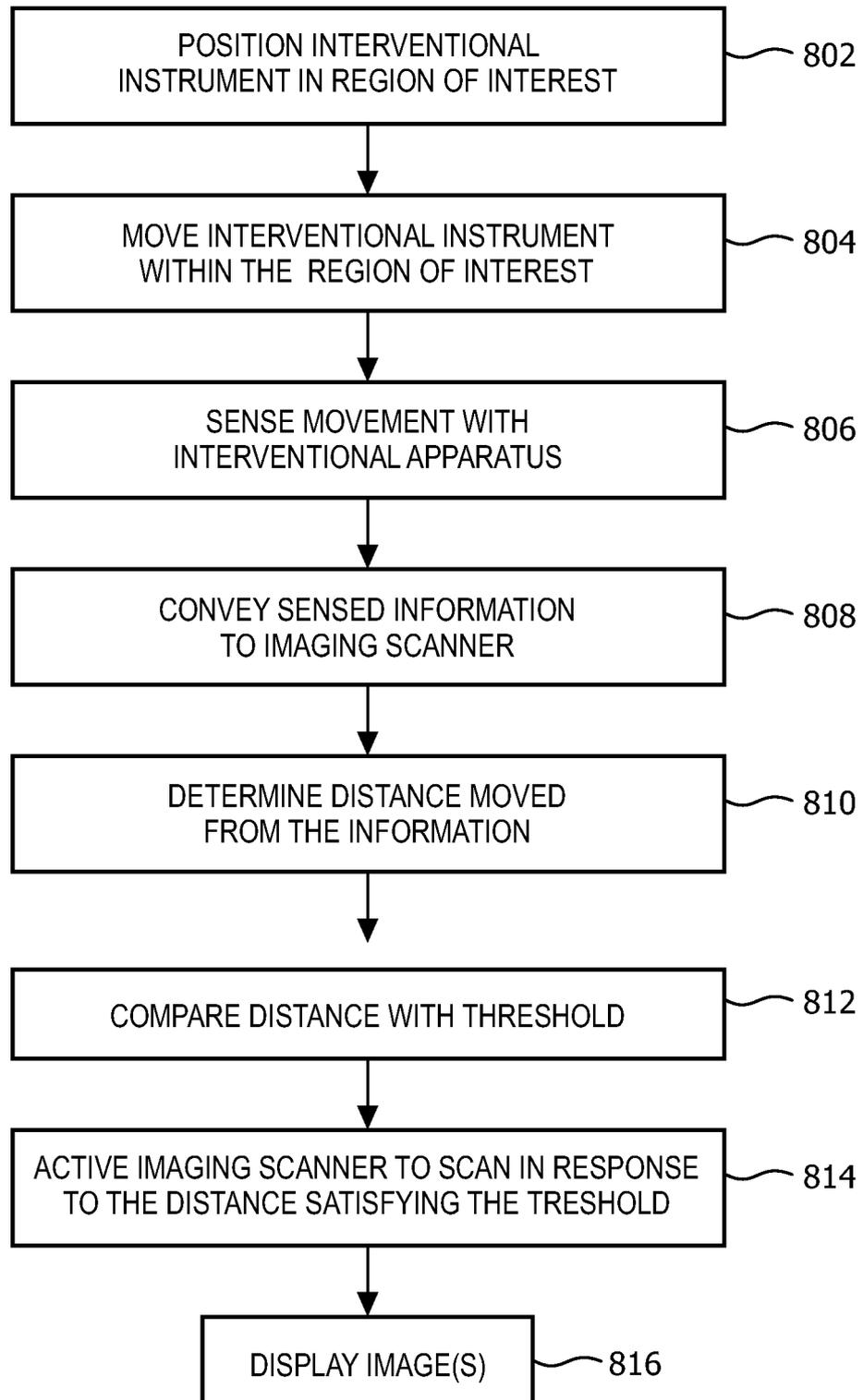


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No PCT/ I B201 1/Q55295

A. CLASSIFICATION OF SUBJECT MATTER INV. A61B 19/ 00 A61B6/54 ADD.				
According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A61B				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO- Internal				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	US 2007/ 167700 AI (RAHN NORBERT [DE] ET AL) 19 July 2007 (2007-07 - 19) paragraph s [0001] , [0023] - [0Q34] ; cl ai ms ; f i g u r e s -----	1- 14 , 20		
A	US 2007/ 103437 AI (ROSENBERG LOUIS B [US]) 10 May 2007 (2007-05 - 10) paragraph s [0001] - [0002] , [0019] - [002 1] , [0036] , [0039] - [0040] ; cl ai ms ; f i g u r e s -----	1- 14 , 20		
A	US 2005/ 197557 AI (STROMMER GERA [I L] ET AL) 8 September 2005 (2005-09 -08) paragraph s [0013] - [0016] , [0028] - [0033] , [0042] - [0046] ; cl ai ms ; f i g u r e s -----	1- 14 , 20		
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.				
* Special categories of cited documents : <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;"> "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document 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 </td> <td style="width: 50%; border: none;"> "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 </td> </tr> </table>			"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document 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
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document 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	Date of mailing of the international search report			
20 March 2012	29/03/2012			
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Mundakapadam, S			

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2011/055295

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.: 15-19
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Methods for treatment of the human or animal body by surgery
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 64(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:

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 an 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 the additional search 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.:

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 fees were not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2011/055295

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