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Published:

— with international search report (Art. 21(3))

(54) Title: CONTROLLER FOR IMAGING APPARATUS

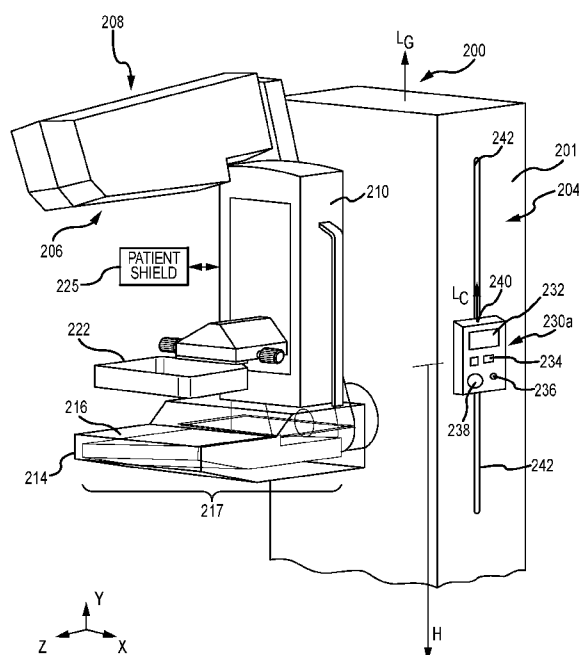


FIG. 5

(57) Abstract: An apparatus has an upright gantry. A tube arm assembly and a compression arm assembly are rotatably coupled to the gantry. The tube arm assembly independently rotates relative to the compression arm assembly. A controller disposed on the gantry is operably connected to at least one of the tube arm assembly and the compression arm assembly.

## CONTROLLER FOR IMAGING APPARATUS

### Cross-Reference to Related Applications

[0001] This application is being filed on 22 November 2017, as a PCT International patent application, and claims priority to U.S. Provisional Patent Application No. 62/426,349, filed November 25, 2016, the disclosure of which is hereby incorporated by reference herein in its entirety.

### Background

[0002] X-ray mammography has long been a screening modality for breast cancer and other lesions, and also has been relied on for diagnostic and other purposes. For mammograms, a cone-shaped or pyramid-shaped x-ray beam passes through the compressed breast and forms a two-dimensional projection image. Any one of a number of orientations can be used, such as cranial-caudal (CC) or mediolateral-oblique (MLO) orientation. Another imaging modality is breast x-ray tomosynthesis. The technology typically involves taking two-dimensional (2D) projection images of the immobilized breast at each of a number of angles of the x-ray beam relative to the breast and processing the resulting x-ray measurements to reconstruct images of breast slices that typically are in planes transverse to the x-ray beam axis, such as parallel to the image plane of a mammogram of the same breast.

### Summary

[0003] In one aspect, the technology relates to an apparatus having: an upright gantry; a tube arm assembly rotatably coupled to the upright gantry; a compression arm assembly rotatably coupled to the upright gantry, wherein the tube arm assembly is at least partially independently rotatable relative to the compression arm assembly; and a controller disposed on the upright gantry and operably connected to at least one of the tube arm assembly and the compression arm assembly. In an example, the controller includes a first controller disposed on a first side of the upright gantry and a second controller disposed on a second side of the upright gantry. In another example, the controller includes two controllers disposed on opposite sides of the gantry. In yet another example, the controller is at least partially flush with an outer housing of the gantry. In still another example, the controller includes a longitudinal axis substantially parallel to a longitudinal axis of the upright gantry.

[0004] In another example of the above aspect, a first side of the controller projects a first distance from an outer housing of the gantry and wherein a second side of the controller

projects a second distance from the outer housing of the gantry, wherein the first distance is less than the second distance. In an example, the controller includes at least one of a button, a dial, a knob, and a graphic user interface. In another example, a front face of the controller is disposed at an angle to an outer housing of the gantry. In yet another  
5 example, the controller includes a substantially D-shaped outline. In still another example, the controller is disposed a distance above a floor surface greater than one-half a total height of the gantry.

[0005] In another example of the above aspect, the controller includes a locating feature. In an example, the locating feature includes at least one of a recess, a raised feature, and a  
10 button. In another example, the controller faces away from a patient station.

[0006] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

#### **Brief Description of the Drawings**

[0007] FIG. 1 is a perspective view of a gantry and an acquisition workstation in accordance with the prior art.

[0008] FIG. 2 is an enlarged view of a portion of the system of FIG. 1, with a tube arm assembly in a rotated position.

[0009] FIG. 3 is a front elevation of the apparatus of FIG. 2.

[0010] FIG. 4 is a side view of the apparatus of FIG. 2 with an optional biopsy station.

[0011] FIG. 5 is an enlarged view of an imaging apparatus, with a tube arm assembly in a rotated position.

[0012] FIGS. 6A and 6B depict partial top views of a controller of an imaging apparatus.

[0013] FIG. 7 depicts a top view of an imaging apparatus.

[0014] FIG. 8 depicts a front view of a controller.

#### **Detailed Description**

[0015] The present technology relates to a breast imaging systems that are used to generate mammograms and/or tomosynthesis images of the breast. In use, a technician  
30 places a breast of a patient on a platform of an imaging system and compresses the breast against the platform with a breast compression plate or paddle. One or more x-ray images are then taken of the breast and processed for analysis.

[0016] FIGS. 1-4 illustrate a non-limiting example of a multi-mode mammography/tomosynthesis system comprising a floor-mounted, upright gantry 100 and

a data acquisition work-station 102. Gantry 100 includes a housing 104 supporting a tube arm assembly 106 rotatably mounted thereon to pivot about a horizontal axis 402 (FIG. 4) and carrying an x-ray tube assembly 108. X-ray tube assembly 108 includes (1) an x-ray tube generating x-ray energy in a selected range, such as 20-50 kV, at mAs such as in the range 3-400 mAs, with focal spots such as a nominal size 0.3 mm large spot and nominal size 0.1 mm small spot (2) supports for multiple filters such as molybdenum, rhodium, aluminum, copper, and tin filters, and (3) an adjustable collimation assembly selectively collimating the x-ray beam from the focal spot in a range such as from 7×8 cm to 24×29 when measured at the image plane of an x-ray image receptor included in the system, at a maximum source-image distance such as 75 cm. Also mounted on housing 104, for rotation about the same axis 402, is a compression arm assembly 110 that includes a compression device 112 having to a compression plate or paddle 122 and a receptor housing 114 having an upper surface 116 serving as a breast plate and enclosing a receptor subsystem system 117 comprising a flat panel x-ray receptor 119, a retractable anti-scatter grid 121, and a mechanism (not shown) for driving and retracting anti-scatter grid 121. Housing 104 also encloses the following components: a vertical travel assembly 404 for moving tube arm assembly 106 and compression arm assembly 110 up and down to accommodate a particular patient or imaging position, a tube arm assembly rotation mechanism 406 to rotate tube arm assembly 106 about axis 402 for different imaging positions, a receptor subsystem rotation mechanism 408 for rotating components of receptor subsystem 117 (such as x-ray receptor 119) about axis 402 to accommodate different operation modes, and couple/uncouple mechanism 410 to selectively couple or uncouple tube arm assembly 106 and compression arm assembly 110 to and from each other, and tube arm assembly 106 and receptor subsystem 117 to and from each other. Housing 104 also encloses suitable motors and electrical and mechanical components and connections to implement the functions discussed here. A patient shield 125, schematically illustrated in FIG. 2, can be secured to compression arm assembly 110 to provide a mechanical interlock against patient contact with the rotating x-ray tube arm assembly 106. A spacer 1002 (FIG. 4) may be used for different degrees of magnification.

[0017] Work-station 102 comprises components similar to those in the Selenia® Dimensions® mammography system, including a display screen (typically a flat panel display that may include touch-screen functionality), user interface devices such as a keyboard, possibly a touch-screen, and a mouse or trackball, and various switches and indicator lights and/or displays. Work-station 102 also includes computer facilities similar

to those of the Selenia® Dimensions® system (but adapted through hardware, firmware and software differences) for controlling gantry 100 and for processing, storing and displaying data received from gantry 100. A power generation facility for x-ray tube assembly 108 may be included in housing 104 or in work-station 102. A power source 118  
5 powers work-station 102. Gantry 100 and work-station 102 exchange data and controls over a schematically illustrated connection 120.

**[0018]** The gantry 100 may also include one or more controllers 130 that may be used for certain functions of the gantry 100. The controller 130 is disposed on the compression arm assembly 110 and may be used by a technician to raise or lower the compression arm  
10 assembly 110 (e.g., for patients of different heights), raise or lower the compression device 112, rotate the tube arm assembly 106, or perform other functions. A controller 130a, 130b is located on either side of the compression arm assembly 110, so as to be more easily accessible by a technician. While locating the controller 130a, 130b on the compression arm assembly 110 may be convenient for the technician, rotation of the tube  
15 arm assembly 106 and/or compression arm assembly 110 may make access thereto difficult, as described below.

**[0019]** In standard mammography mode, typically used for screening mammography, tube arm assembly 106 and compression arm assembly 110 are coupled and locked together by  
20 410 in a relative position such as seen in FIG. 1, such that an x-ray beam from x-ray tube assembly 108 illuminates x-ray receptor 119 when the patient's breast is compressed by compression device 112. In this mode, the system operates in a manner similar to said Selenia® Dimensions® system to take a mammogram. Vertical travel assembly 404 and tube arm rotation mechanism 406 can make vertical adjustments to accommodate a patient, and can rotate tube arm assembly 106 and compression arm assembly 110 together  
25 as a unit about axis 402 for different image orientations such as for CC and for MLO images. For example, tube arm assembly 106 and compression arm assembly 110 can rotate between  $-195^\circ$  and  $+150^\circ$  about axis 402. FIG. 4 depicts rotation of the tube arm assembly 106, which may limit access to the controller 130b. As in the Selenia® Dimensions® system, compression device 112 includes a compression paddle 122 that can  
30 move laterally, in a direction along the chest wall of a patient, to adjust for different imaging orientations. Typically, anti-scatter grid 121 is over x-ray receptor 119 in the standard mammography mode to reduce the effect of x-ray scatter.

**[0020]** As noted above, both of the tube arm assembly 106 and the compression arm assembly 110 can rotate between  $-195^\circ$  and  $+150^\circ$  about axis 402. FIG. 3 depicts rotation

of the tube arm assembly 106. In the depicted position, the rotated position of the tube arm assembly 106 may limit technician access to the controller 130b. Moreover, in circumstances where the compression arm assembly 110 is rotated, access may be further limited. For example, if the compression arm assembly 110 rotates counterclockwise from the position depicted in FIG. 3, the controller 130a will be extremely difficult to view, let alone activate, especially for technicians that are short of stature. As such, workflow may be impeded if either controller 130a, 130b becomes obstructed or otherwise difficult to reach.

**[0021]** FIG. 5 is an enlarged view of an imaging apparatus 200, with a tube arm assembly 206 in a rotated position. The imaging apparatus 200 may include any or all of the components depicted and described with regard to FIGS. 1-4. As such, not all of those components are necessarily depicted or described further in the following figures. A compression arm assembly 210 and patient shield 225 are also depicted. As in the previous figures, both the tube arm assembly 206 and compression arm assembly 210 may rotate relative to an upright housing 204 (in the form of a pillar having a rectangular, curved, or other shape) of a gantry 201. Rotation of the tube arm assembly 206 changes a position of the x-ray tube assembly 208 and an enclosed receptor subsystem system 217. Rotation of the compression arm assembly 210 changes a position of a receptor housing 214 and an upper surface 216 thereof, as well as a compression paddle 222. The imaging apparatus 200 of FIG. 5, however, incorporates a controller 230a on at least one side of the housing 204 of the upright gantry 201. A second controller may be disposed on an opposite side of the gantry 201, but is not visible in FIG. 5. The positioning of the controller 230a in such a location allows a technician to easily access the controller 230a, regardless of the position of the tube arm assembly 206, position of the compression arm assembly 210, height or reach of the technician, etc. For example, the controller 230a may be easily accessed whether the tube arm assembly 206 and compression arm assembly 210 are oriented for a CC or MLO orientation for an examination.

**[0022]** The controller 230a may include one or more components required to perform various actions or procedures. Such actions may include but are not limited to, rotation of the tube arm assembly 206, rotation or elevation change of the compression arm assembly 210, compression by the paddle 222 to the breast, and so on. Such components may include a graphic user (or touch-sensitive) interface 232, a button 234, a knob or dial 236, a fingerprint scanner 238 (to confirm authorized usage, e.g. or other type of biometric login), or other components. These components are supported in a controller housing 240

that may at least partially protrude from the housing 204 of the gantry 201. In the example of FIG. 5, the controller housing 240 is disposed proximate a slot 242 defined by the housing 204. The controller housing 240 may engage with a projection that extends from an interior of the gantry 201, through the slot 242, so as to be slidably moved along the slot 242. This may further increase the usability of the controller 230a, for technicians of different heights or reaches, for example. In other examples, however a vertical position of the controller 230a may be fixed relative to the gantry 201. In examples where the vertical position of the controller 230a is fixed, it may be desirable that the controller is disposed at a height H above a floor that is greater than one-half of the total height of the gantry 201, since technicians of different heights may be able to easily access a controller 230a so positioned.

**[0023]** Vertical sides of the controller housing 240 may be longer than top and bottom sides of the controller housing 240. As such, the controller housing 240 may define a longitudinal axis  $L_C$  that is substantially parallel to a longitudinal axis  $L_G$  of the gantry 201. Such a longer, narrower controller housing 240 may allow the controller to have a lower profile extending away from the gantry housing 204. This may prevent the controller 230a from being inadvertently bumped or contacted as a technician moves about the imaging apparatus 200. Other shapes are contemplated. For example, the controller 230a is depicted as having a rectangular outline. Controllers having circular, oval, D-shaped, or polygonal outlines are also contemplated. Such outlines may be utilized to match the aesthetics of the gantry 201.

**[0024]** FIGS. 6A and 6B depict partial top views of a controller 330a, 330b of an imaging apparatus 300a, 300b. In FIG. 6A, the controller 330a is pivotable P about one or more brackets 350 that extend from a housing 304a of a gantry 301a. This allows the controller 330a to be more easily viewable by a technician working with a patient standing near the front F of the gantry 301a (e.g., a patient having a breast compressed for imaging).

**[0025]** In FIG. 6B, a front face 352b of a controller 330b is disposed at an angle  $\alpha$  relative to a housing 304b of a gantry 301b. A first side 354b has a first length measured from the housing 304b, while a second side 356b has a second length measured therefrom. The second length is greater than the first length. By disposing the front face 352b at an angle, visibility of the front face 352b, which contains the control components, is increased. This is particularly useful for a technician working with a patient standing near a front face F of the gantry 301b. In certain examples, the first length of the first side 356b may be short enough such that the first side 356b is substantially flush with the housing 304b.

[0026] FIG. 7 depicts a top view of an imaging apparatus 400, including an upright gantry 401, a tube arm assembly 406, and a compression arm assembly 410. A patient P is located at a patient station (e.g., proximate the compression arm assembly 410 where a breast imaging procedure may be performed). An axis A extends through a collar 470 that extends from the gantry 401. Mechanisms within the collar 470 allow for rotation of both the tube arm assembly 406 and the compression arm assembly 410 about the axis A. Two controllers 430a, 430b are disposed on either side of the gantry 401. The front face 452a, 452b of each controller 430a, 430b face in a direction substantially away from the axis A. As such, the front faces 452a, 452b are generally out of view of the patient P. This may be advantageous, as flashings lights or other elements on the controllers 430a, 430b may cause the patient unnecessary anxiety if visible.

[0027] FIG. 8 depicts a front view of a controller 530, specifically a substantially D-shaped controller. The front face 552 of the controller includes a display screen 532 which may act as a graphic user interface or a simple display. The front face 552 also includes a plurality of buttons 534. Certain buttons 534a may have an outer contour shaped to match an outer perimeter or contour 580 of the controller 530. The controller 530 also includes features that allow a technician to orient herself during use of the controller 530, without necessarily seeing the front face 552 and the components disposed thereon. Under such circumstances, the controller 530 may be used without being visible to the user. For example, the outer perimeter or contour 580 may define one or more recesses or cutouts 582 that, when touched, give an indication to a technician of the location of their hand relative to the front face 552. In the depicted example, contacting the recess 582 would indicate to the technician that her hand is disposed proximate the display screen 532. A raised feature 584, for example, disposed near or between buttons 534 may also be used to orient a technician to the controller 530 when the controller 530 is not visible. In another example, the controller 530 may include buttons 534 that are raised, lowered, or flush with the front face 552, to increase usability thereof.

[0028] This disclosure described some examples of the present technology with reference to the accompanying drawings, in which only some of the possible examples were shown. Other aspects can, however, be embodied in many different forms and should not be construed as limited to the examples set forth herein. Rather, these examples were provided so that this disclosure was thorough and complete and fully conveyed the scope of the possible examples to those skilled in the art.



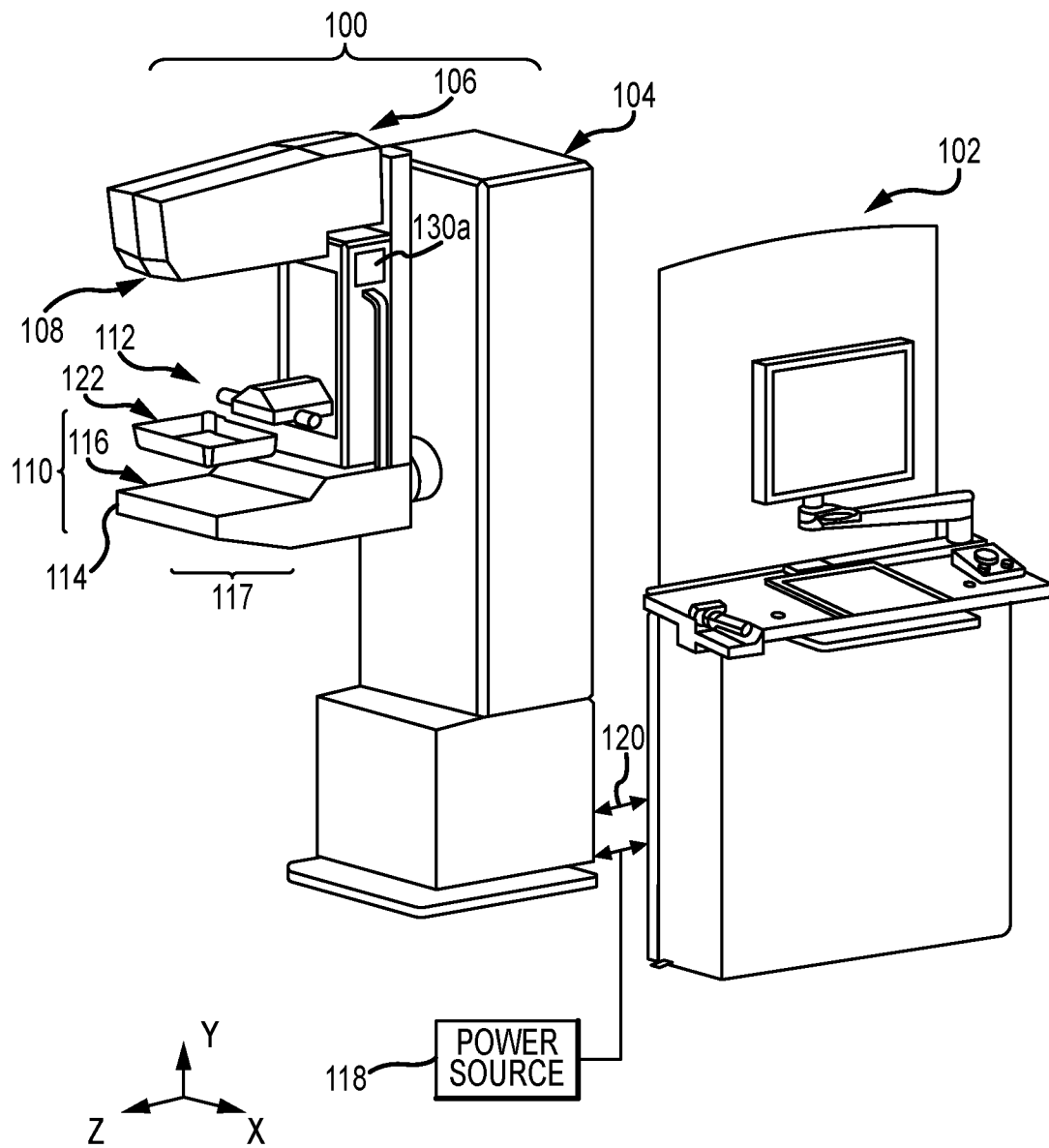
[0029] Although specific examples were described herein, the scope of the technology is not limited to those specific examples. One skilled in the art will recognize other examples or improvements that are within the scope of the present technology. Therefore, the specific structure, acts, or media are disclosed only as illustrative examples. Examples  
5 according to the technology may also combine elements or components of those that are disclosed in general but not expressly exemplified in combination, unless otherwise stated herein. The scope of the technology is defined by the following claims and any equivalents therein.

## Claims

1. An apparatus comprising:  
an upright gantry;  
a tube arm assembly rotatably coupled to the upright gantry;  
a compression arm assembly rotatably coupled to the upright gantry, wherein the tube arm assembly is at least partially independently rotatable relative to the compression arm assembly; and  
a controller disposed on the upright gantry and operably connected to at least one of the tube arm assembly and the compression arm assembly.
2. The apparatus of claim 1, wherein the controller comprises a first controller disposed on a first side of the upright gantry and a second controller disposed on a second side of the upright gantry.
3. The apparatus of claim 1, wherein the controller comprises two controllers disposed on opposite sides of the gantry.
4. The apparatus of any of claims 1-3, wherein the controller is at least partially flush with an outer housing of the gantry.
5. The apparatus of any of the preceding claims, wherein the controller comprises a longitudinal axis substantially parallel to a longitudinal axis of the upright gantry.
6. The apparatus of any of the preceding claims, wherein a first side of the controller projects a first distance from an outer housing of the gantry and wherein a second side of the controller projects a second distance from the outer housing of the gantry, wherein the first distance is less than the second distance.
7. The apparatus of any of the preceding claims, wherein the controller comprises at least one of a button, a dial, a knob, and a graphic user interface.
8. The apparatus of any of the preceding claims, wherein a front face of the controller is disposed at an angle to an outer housing of the gantry.

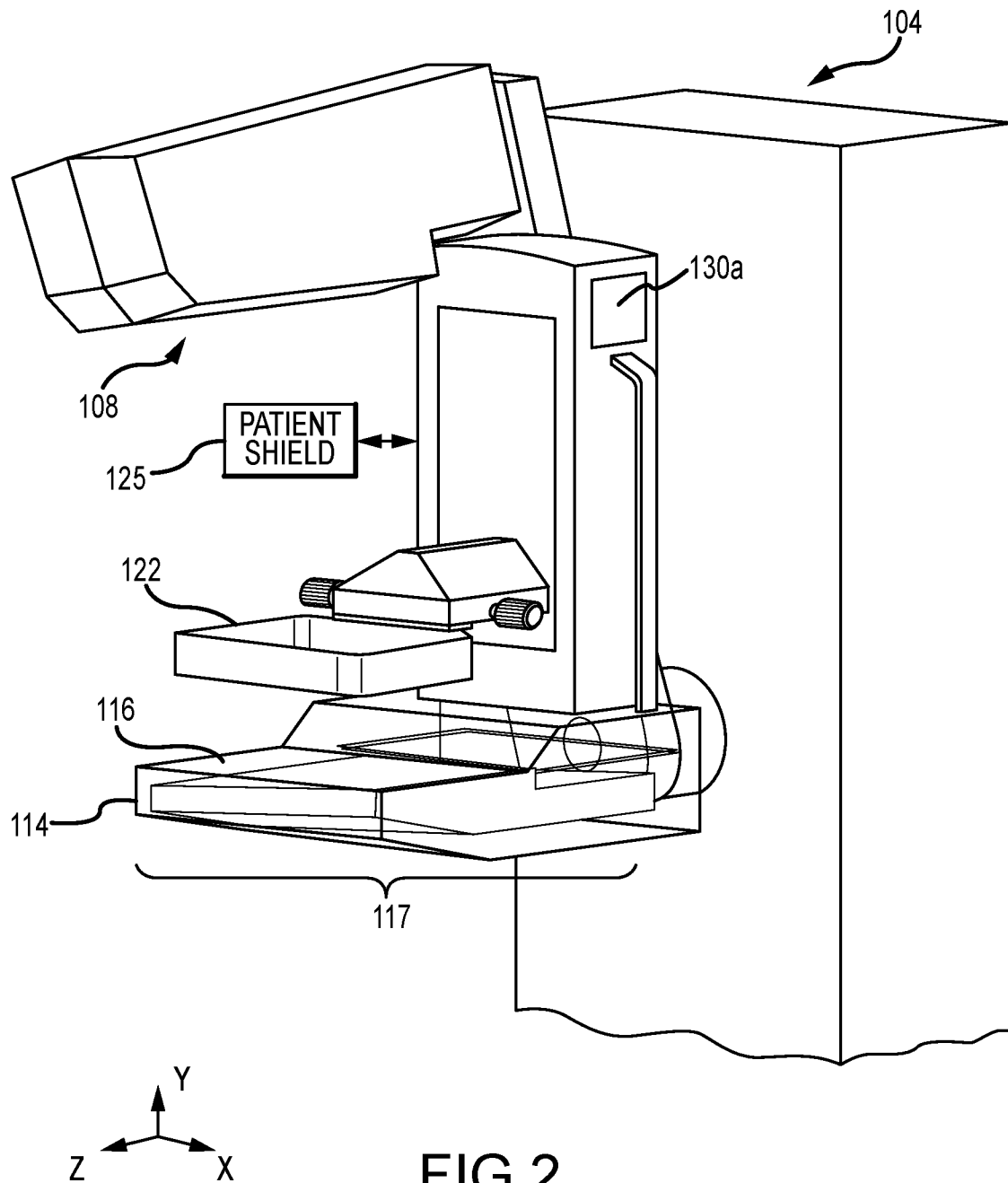
9. The apparatus of any of the preceding claims, wherein the controller comprises a substantially D-shaped outline.
10. The apparatus of any of the preceding claims, wherein the controller is disposed a distance above a floor surface greater than one-half a total height of the gantry.
11. The apparatus of any of the preceding claims, wherein the controller comprises a locating feature.
12. The apparatus of claim 11, wherein the locating feature comprises at least one of a recess, a raised feature, and a button.
13. The apparatus of any of the preceding claims, wherein the controller faces away from a patient station.

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**FIG. 1**  
PRIOR ART

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**FIG. 2**  
PRIOR ART

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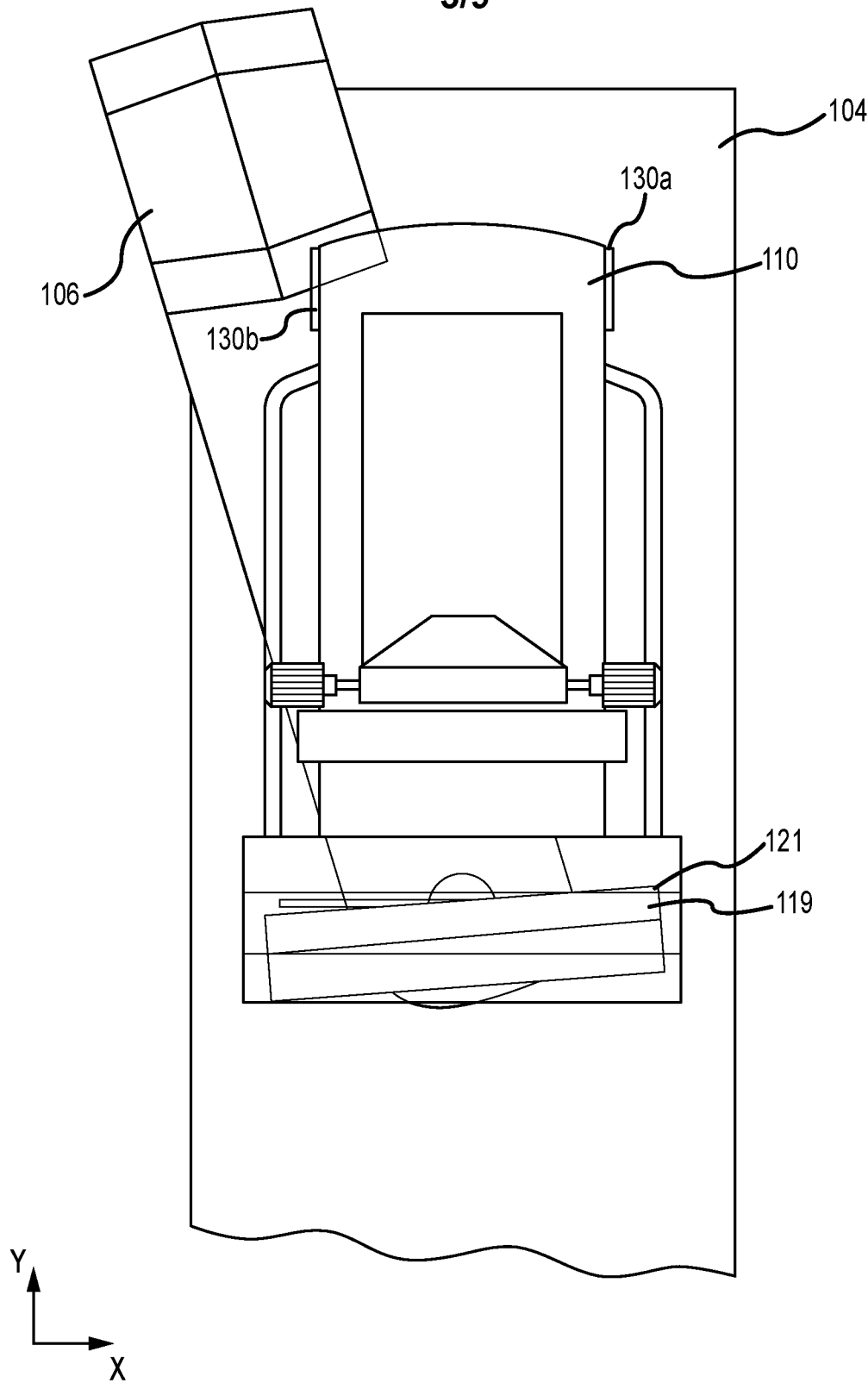
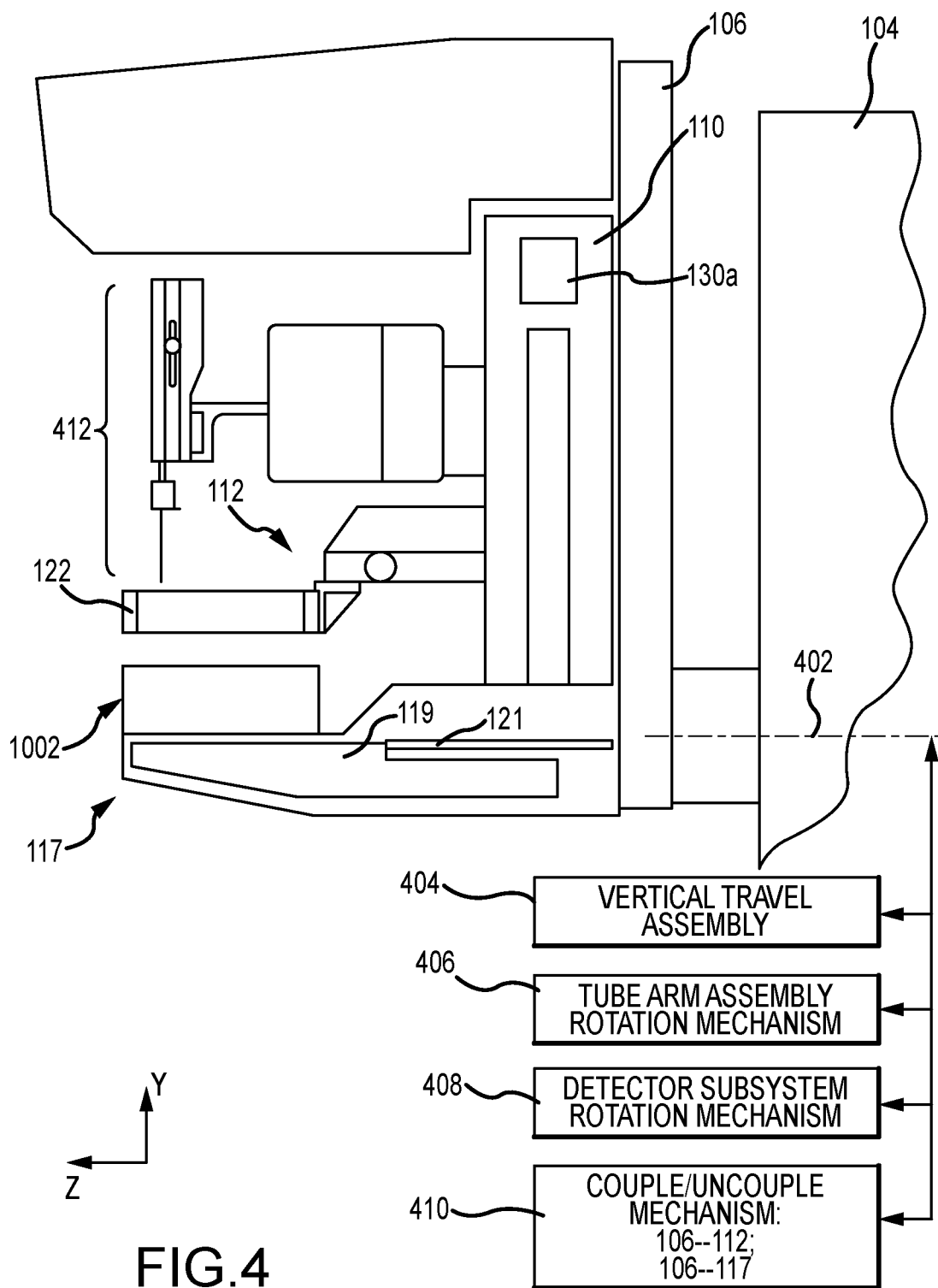


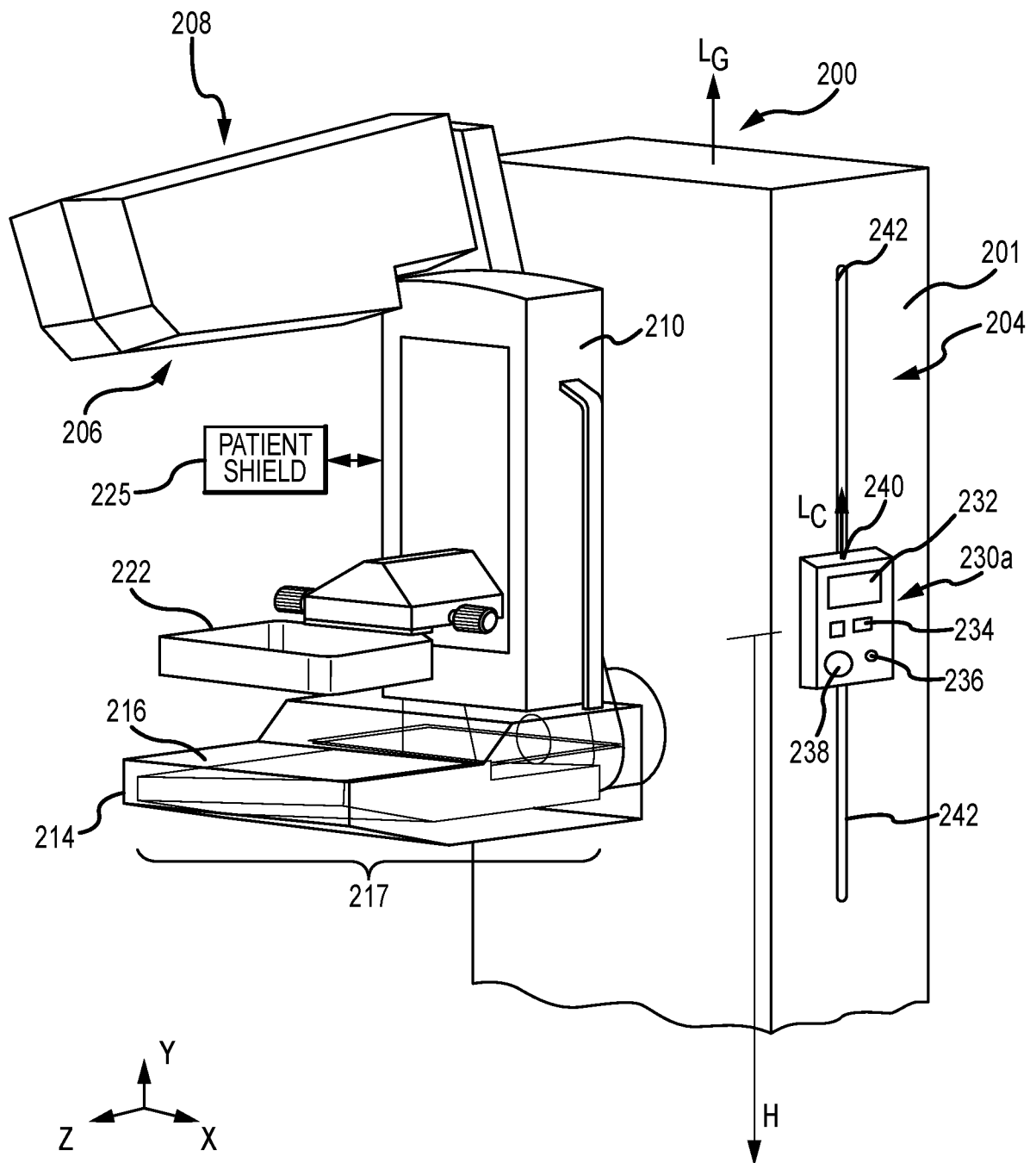
FIG.3  
PRIOR ART

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**FIG.4**  
PRIOR ART

**5/9**



**FIG.5**



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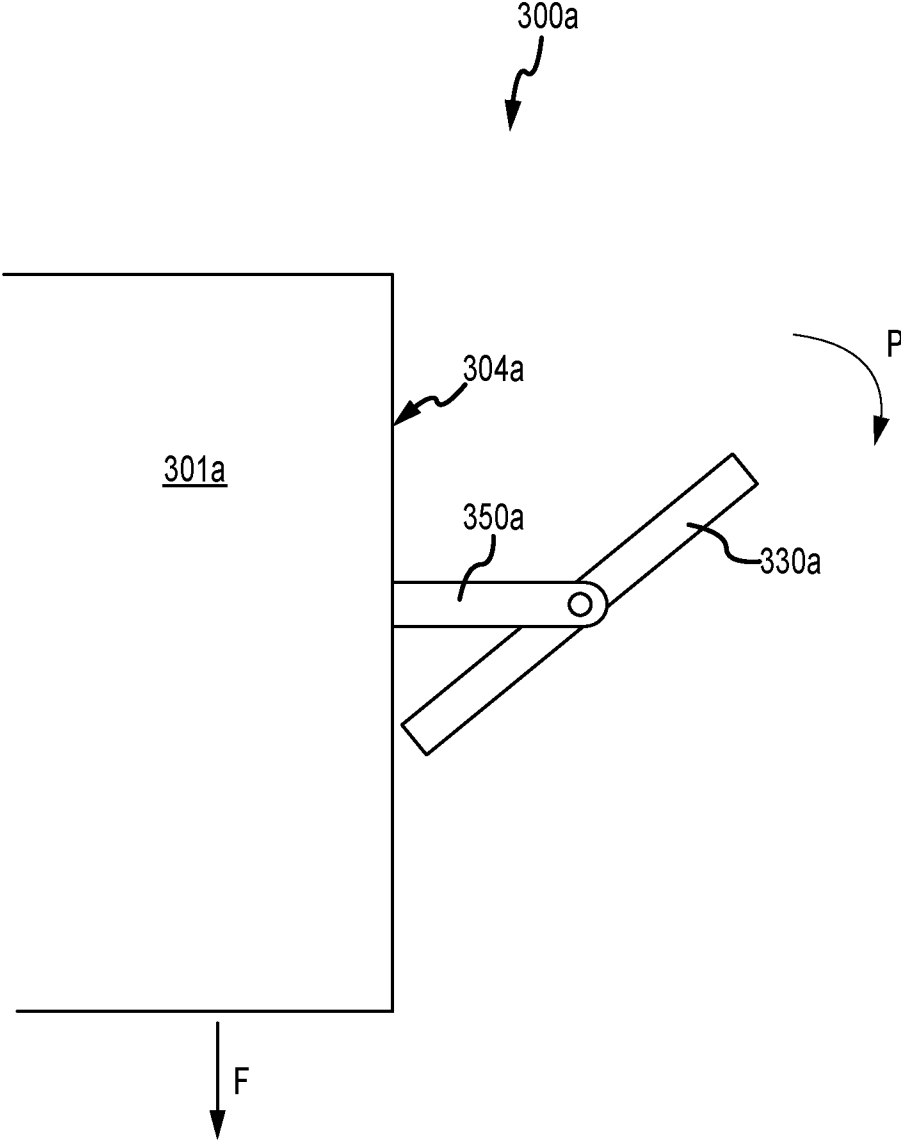


FIG.6A

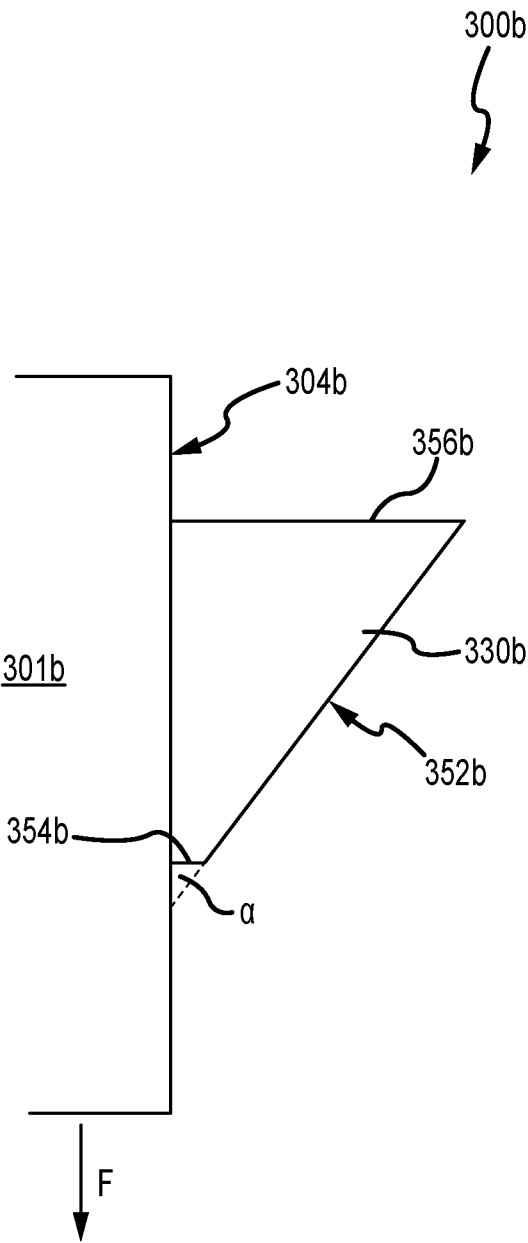


FIG.6B

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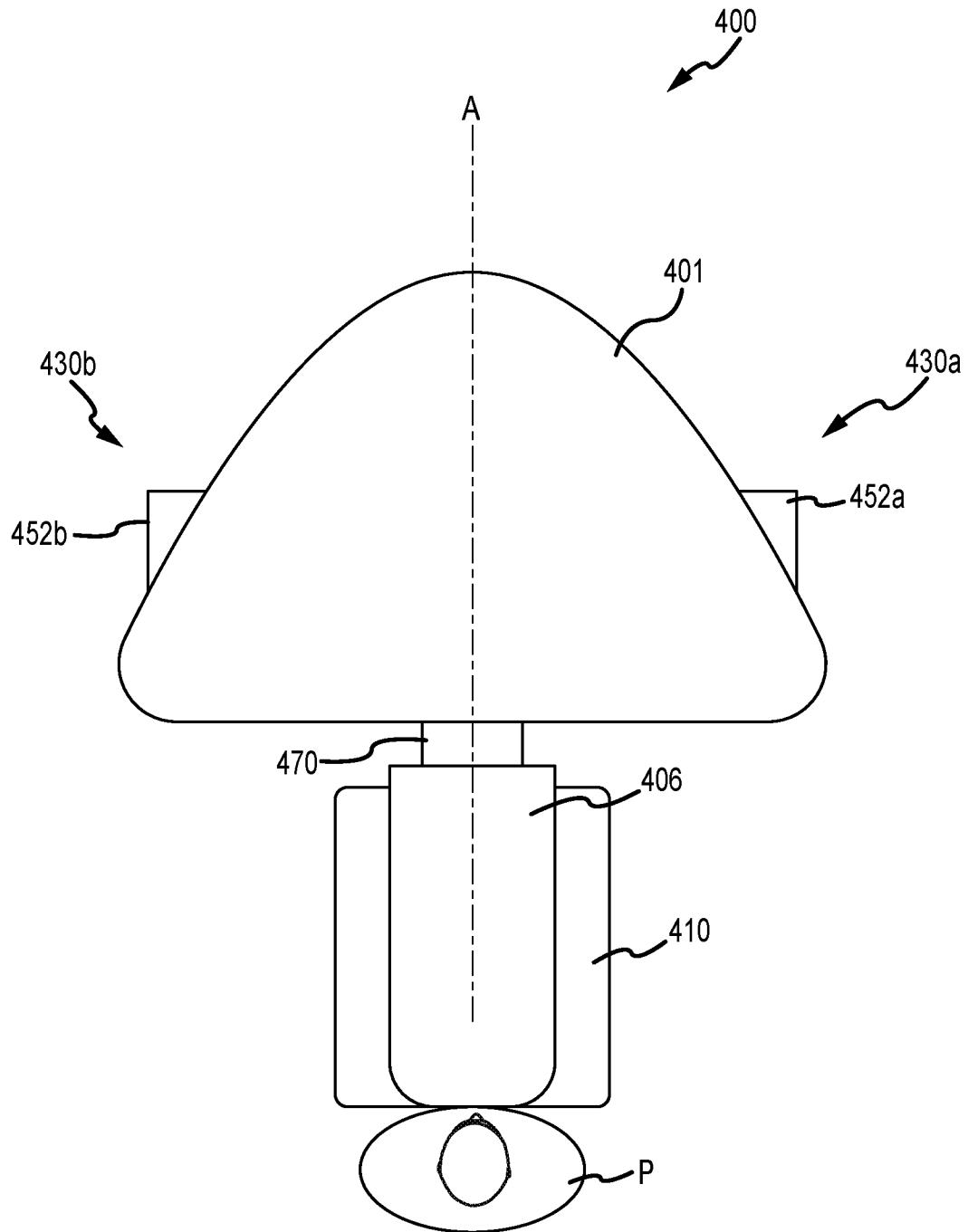


FIG.7

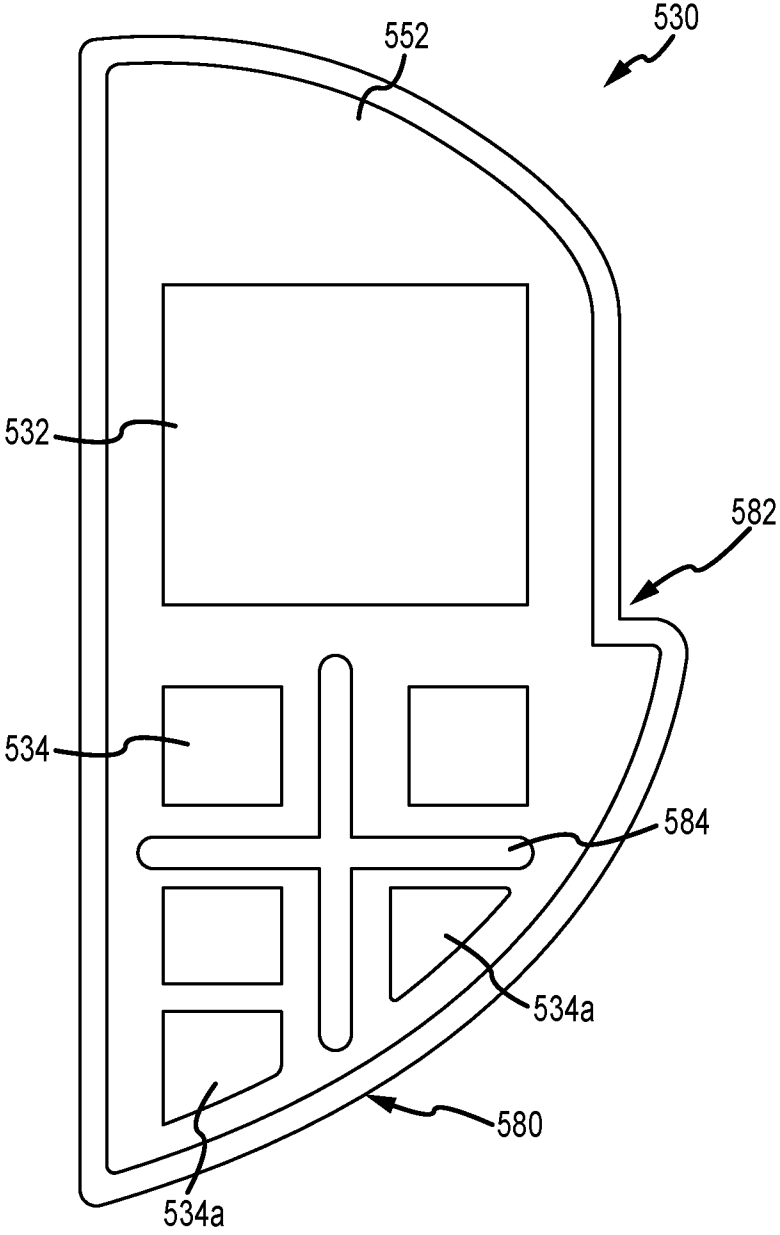


FIG. 8

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2017/063069****A. CLASSIFICATION OF SUBJECT MATTER****A61B 6/00(2006.01)i**

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 6/00; A61B 6/04; A61B 10/02Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
Korean utility models and applications for utility models  
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
eKOMPASS(KIPO internal) & Keywords: x-ray, mammography, breast, stand, controller**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2016-0091958 A (PLANMED OY) 03 August 2016 See paragraphs [14]-[17],[21],[25] and figures 1-2c.	1-4
Y	US 2015-0049859 A1 (HOLOGIC, INC.) 19 February 2015 See paragraphs [28],[34] and figures 1-4.	1-4
A	EP 0775467 A1 (PLANMED OY) 28 May 1997 See column 5, line 39 - column 7, line 2 and figures 1,7,8.	1-4
A	US 2013-0331682 A1 (FUJIFILM CORPORATION) 12 December 2013 See paragraphs [35]-[37],[69],[70] and figure 1.	1-4
A	US 2011-0021947 A1 (NAKAYAMA et al.) 27 January 2011 See paragraph [66] and figure 1.	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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

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

"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

08 February 2018 (08.02.2018)

Date of mailing of the international search report

**09 February 2018 (09.02.2018)**

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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**INTERNATIONAL SEARCH REPORT**

International application No.

**PCT/US2017/063069****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.: 12  
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:  
Claim 12 is unclear, because it refers to the multiple dependent claim which does not comply with PCT Rule 6.4(a).
3. ☒ Claims Nos.: 5-11,13  
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:

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 any 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.:

**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**

Information on patent family members

International application No.

**PCT/US2017/063069**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 10-2016-0091958 A	03/08/2016	CN 105939664 A	14/09/2016
		EP 3073923 A1	05/10/2016
		FI 126217 B	31/08/2016
		FI 20130360 A	30/05/2015
		JP 2016-538075 A	08/12/2016
		US 2017-0020471 A1	26/01/2017
		WO 2015-079119 A1	04/06/2015
US 2015-0049859 A1	19/02/2015	AT 554707 T	15/05/2012
		AU 2003-291189 A1	23/06/2004
		CA 2702782 A1	21/05/2010
		CN 102763137 A	31/10/2012
		CN 102763137 B	06/04/2016
		CN 105832360 A	10/08/2016
		CN 1738573 A	22/02/2006
		CN 1738573 B	04/07/2012
		DE 202007019608 U1	17/04/2014
		EP 1569556 A1	07/09/2005
		EP 1569556 B1	25/04/2012
		EP 1792569 A2	06/06/2007
		EP 1792569 A3	19/09/2007
		EP 1792569 B1	26/08/2015
		EP 1815388 A2	08/08/2007
		EP 1815388 B1	06/03/2013
		EP 1816965 A2	15/08/2007
		EP 1816965 B1	29/06/2016
		EP 1925255 A1	28/05/2008
		EP 1925255 B1	01/02/2017
		EP 2215600 A2	11/08/2010
		EP 2602743 A2	12/06/2013
		EP 2602743 A3	10/07/2013
		EP 2602743 B1	05/11/2014
		EP 2782505 A1	01/10/2014
		EP 2974663 A1	20/01/2016
		EP 3106094 A2	21/12/2016
		EP 3106094 A3	04/01/2017
		JP 2006-519625 A	31/08/2006
		JP 2007-130487 A	31/05/2007
		JP 2012-512669 A	07/06/2012
		JP 2014-128716 A	10/07/2014
		JP 2014-534042 A	18/12/2014
		JP 2016-032674 A	10/03/2016
		JP 2017-056358 A	23/03/2017
		JP 4628793 B2	09/02/2011
		JP 5501370 B2	21/05/2014
		JP 5702041 B2	15/04/2015
		JP 5837116 B2	24/12/2015
		JP 6208731 B2	04/10/2017
		KR 10-2014-0098087 A	07/08/2014

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2017/063069**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2004-0101095 A1	27/05/2004
		US 2005-0113681 A1	26/05/2005
		US 2006-0098855 A1	11/05/2006
		US 2007-0030949 A1	08/02/2007
		US 2008-0019581 A1	24/01/2008
		US 2008-0130979 A1	05/06/2008
		US 2009-0003519 A1	01/01/2009
		US 2009-0010384 A1	08/01/2009
		US 2009-0123052 A1	14/05/2009
		US 2009-0141859 A1	04/06/2009
		US 2009-0213987 A1	27/08/2009
		US 2009-0268865 A1	29/10/2009
		US 2009-0296882 A1	03/12/2009
		US 2010-0135456 A1	03/06/2010
		US 2010-0135558 A1	03/06/2010
		US 2010-0195882 A1	05/08/2010
		US 2011-0069808 A1	24/03/2011
		US 2011-0069809 A1	24/03/2011
		US 2011-0135185 A1	09/06/2011
		US 2011-0216879 A1	08/09/2011
		US 2012-0093285 A9	19/04/2012
		US 2012-0195484 A1	02/08/2012
		US 2012-0219111 A1	30/08/2012
		US 2012-0263273 A9	18/10/2012
		US 2013-0028374 A1	31/01/2013
		US 2013-0223591 A1	29/08/2013
		US 2013-0272494 A1	17/10/2013
		US 2014-0044230 A1	13/02/2014
		US 2014-0044231 A1	13/02/2014
		US 2014-0086471 A1	27/03/2014
		US 2014-0232752 A1	21/08/2014
		US 2014-0301529 A1	09/10/2014
		US 2014-0327702 A1	06/11/2014
		US 2014-0376690 A1	25/12/2014
		US 2015-0160848 A1	11/06/2015
		US 2015-0182181 A1	02/07/2015
		US 2015-0310611 A1	29/10/2015
		US 2015-0317538 A1	05/11/2015
		US 2016-0220210 A1	04/08/2016
		US 2016-0270742 A9	22/09/2016
		US 2017-0024113 A1	26/01/2017
		US 2017-0128028 A1	11/05/2017
		US 2017-0135650 A1	18/05/2017
		US 7123684 B2	17/10/2006
		US 7430272 B2	30/09/2008
		US 7577282 B2	18/08/2009
		US 7616801 B2	10/11/2009
		US 7702142 B2	20/04/2010
		US 7760853 B2	20/07/2010
		US 7760924 B2	20/07/2010



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

**PCT/US2017/063069**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 7831296 B2	09/11/2010
		US 7869563 B2	11/01/2011
		US 7916915 B2	29/03/2011
		US 7949091 B2	24/05/2011
		US 8155421 B2	10/04/2012
		US 8175219 B2	08/05/2012
		US 8285020 B2	09/10/2012
		US 8416915 B2	09/04/2013
		US 8452379 B2	28/05/2013
		US 8565372 B2	22/10/2013
		US 8565374 B2	22/10/2013
		US 8571289 B2	29/10/2013
		US 8712127 B2	29/04/2014
		US 8768026 B2	01/07/2014
		US 8831171 B2	09/09/2014
		US 8897535 B2	25/11/2014
		US 9042612 B2	26/05/2015
		US 9066706 B2	30/06/2015
		US 9084579 B2	21/07/2015
		US 9095306 B2	04/08/2015
		US 9456797 B2	04/10/2016
		US 9460508 B2	04/10/2016
		US 9498175 B2	22/11/2016
		US 9549709 B2	24/01/2017
		US 9808215 B2	07/11/2017
		US 9811758 B2	07/11/2017
		US 9851888 B2	26/12/2017
		WO 2004-049949 A1	17/06/2004
		WO 2006-055830 A2	26/05/2006
		WO 2006-055830 A3	11/12/2008
		WO 2006-058160 A2	01/06/2006
		WO 2006-058160 A3	12/10/2006
		WO 2010-059920 A2	27/05/2010
		WO 2010-059920 A3	03/04/2014
		WO 2010-102011 A1	10/09/2010
		WO 2013-078476 A1	30/05/2013
EP 0775467 A1	28/05/1997	FI 955636 A0	23/11/1995
		JP 09-168537 A	30/06/1997
US 2013-0331682 A1	12/12/2013	CN 103402431 A	20/11/2013
		CN 103402431 B	29/06/2016
		EP 2679157 A1	01/01/2014
		EP 2679157 B1	18/10/2017
		JP 2012-175997 A	13/09/2012
		JP 5490038 B2	14/05/2014
		US 9155511 B2	13/10/2015
		WO 2012-114765 A1	30/08/2012
US 2011-0021947 A1	27/01/2011	EP 2277445 A1	26/01/2011

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2017/063069**

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		JP 2011-024748 A	10/02/2011
		JP 5355271 B2	27/11/2013
		US 8838207 B2	16/09/2014