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(54) Title: MEDICAL RADIOGRAPHY IN 3D

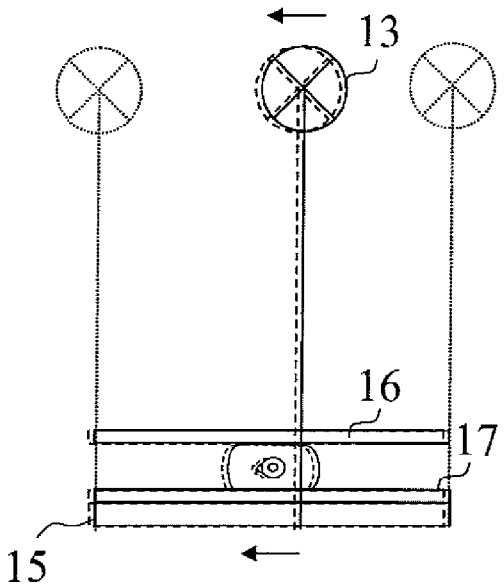

Fig. 4 a

(57) Abstract: The present invention relates to medical 3D radiography, such as mammography, in which individual images of an object are taken at different projection angles and a 3D image subsequently synthesized from this image information. According to the invention, the object to be imaged is arranged locked in a object positioning means (16, 17) and during the imaging process, the x-ray source (13) is continuously moved with respect to location of the object and the object is irradiated at a number of different positions of the x-ray source (13). During an irradiation period of the imaging process, the object positioning means (16, 17) is moved as synchronized with the movement of the x-ray source (13). The imaging process preferably further includes such non-irradiation periods during which the object positioning means (16, 17) is moved in a direction opposite to that when turned as synchronized with the movement of the x-ray source (13) during an irradiation period.

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MEDICAL RADIOGRAPHY IN 3D

FIELD OF THE INVENTION

The present invention relates to medical 3D imaging, such as mammography, in which individual images of an object are taken at different projection angles and in which a 3D image is subsequently synthesized from this image information by an applicable image processing software.

DESCRIPTION OF PRIOR ART

Breast cancer is the most common type of cancer in women. According to investigations, about one in every ten women contract breast cancer at some point in their lives. When breast cancer is detected on the basis of symptoms, the illness often has already developed to a stage where the prognosis for recovery is relatively poor. Some of the cases are detected in screening programs arranged in many countries for women over the age of 40. Screening often reveals a cancer at a very early stage, so its treatment can be started in time and recovery is thus more likely.

Mammography is a widely used method in breast cancer screening as a clinical investigation method and also in follow-up diagnosis. Mammography is an X-ray imaging method wherein an apparatus specifically designed for this purpose is used. In screening studies, mammography has been reported to have a sensitivity of 90 - 93 % and a specificity of 90 - 97 %. This indicates that screening studies are useful and that early detection of breast cancer by screening can save human lives. It has been established that mammography reduces breast cancer mortality by 35 percent among women over 50 and by 25 - 35 percent among women at the age of 40 - 50 years.

The mammography images are examined to detect various anomalies in the breast, such as calcifications, i.e. small deposits of calcium in the soft breast tissue. A calcification generally cannot be detected by feeling the breast, but it is visible in the x-ray image. Large calcifica-

tions are generally not associated with cancer, but clusters of small calcium deposits, i.e. so-called micro-calcifications, are an indication of extra breast cell activity, which may be associated with breast cancer. Other features to be detected by mammography include cysts and fibroadenomas, which, however, are generally not associated with cancer.

In conventional screening mammography, typically the breast gland is compressed between two compression plates and exposed to radiation at least twice, from above and from an oblique direction. If necessary, additionally a third image is taken squarely from the side. As in such imaging the tissue layers lie on top of each other in the direction of the x-ray beam, these irradiations produce two-dimensional images in which strongly absorbing structures may hinder the detection of structures lying beneath them.

Continual improvement in the mammography has led to novel type of mammography methods and devices that produce a 3D image of the patient's breast. Here, several projections of the breast at different angles are produced and a 3D distribution of it is created by using an applicable reconstruction algorithm. From the image information, i.e. the individual images, typically several images are constructed which represent layers of the breast oriented in parallel with the surface of the x-ray detector, thus making possible to detect tissue structures laying on top of each other.

A typical digital mammography apparatus comprises a frame part and a C-arm or a corresponding structure rotatably connected to the frame part. At the first end of the C-arm, there is arranged an x-ray source and at the second end, a radiation detector. A term imaging means is often used for these devices. Disposed substantially in the region between said x-ray source and detector, typically at close proximity to the detector, compression plates are arranged which are designed for positioning the breast as compressed for the duration of the exposure.

In prior art, in the context of 3D mammography, various ways to image the breast at a number of different projection angles have been used or suggested. These include continuously turning the x-ray source, with a constant or an alternating speed, along a curved path about the breast, turning the x-ray source step by step between exposures during which the x-ray source remains still, and using multiple stationary x-ray sources. As for the detector, it may be kept stationary, moved linearly and/or tilted such that it remains at right angles to the center ray of the x-ray beam for each exposure.

The x-ray source, located at the (upper) end of the C-arm, is a relatively heavy component. In the case of step-by-step movement of the x-ray source, prior to each exposure the imaging apparatus should have reached a vibration free status. Thus, the structures of the mammography apparatus should be optimized in view of the number of accelerations, decelerations and stops (stabilization times) comprised in the multi-phase imaging procedure. The overall time needed for an imaging procedure like this tends to become quite long.

On the other hand, in the case of continuous movement of the x-ray source, remarkably short exposure times, such as less than 50 ms, must be used in order to avoid creating movement artefacts. This in turn calls for using a powerful enough radiation source, which means using an even heavier x-ray source than those typically used in prior art 2D mammography apparatus and, consequently, other constructions of the imaging apparatus must be designed in view of this greater mass as well.

As for arranging several x-ray sources in a mammography apparatus, this obviously calls for a completely new type of design for a mammography apparatus in order to make it possible to implement such a specific 3D imaging modality. With this kind of a mechanical design as a basis, it would be a challenge to be able to come up with a construction that would make the apparatus practical for use in conventional 2D screening mammography as well.

SUMMARY OF THE INVENTION

The object of the current invention is focused on eliminating or reducing at least some of the problems of the imaging systems discussed above. The object of the invention is reached by the method and apparatus of the independent claims attached hereto. Some preferable embodiments of the invention are presented in the attached dependent claims. The invention may be applied in the context of both rotational and linear movement of the imaging means.

The invention makes 3D mammography possible with the existing type of mammography apparatus, i.e. with the same kind of x-ray sources and C-arm and related construction as typically used, by enabling the use of substantially long exposure times even though continuously moving the x-ray source during the imaging procedure. This is made possible by arranging for the breast to follow the movement of the x-ray source during at least one exposure phase of the imaging procedure. As the tomographic angle (the angle between the extreme exposure positions of the x-ray source) used in the imaging process may be of several tens of degrees, to make turning of the breast during a number of exposures possible in practise, a preferable embodiment of the procedural cycle of the invention includes a step of turning the breast back to its previous/initial position during a (each) non-exposure period of the imaging process.

One of the basic advantages of the invention is that constructing such a means in a mammography apparatus which enables repeated turning and stopping of the breast (i.e. turning and stopping of the breast holding means, such as the compression plates) during the imaging procedure is considerably simpler than arranging a corresponding movement procedure for the radiation source. In the invention, as far as the radiation source as such and the constructions for moving the radiation source are concerned, there is no need for any specific arrangements or fundamental re-design of the apparatus but the conventional design used in prior art 2D mammography may be made use of.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following, some embodiments of the invention and their benefits will be described in more detail, also with help of the attached figures, of which figures

- figure 1 represents a construction of a typical mammography apparatus,

- figures 2a and 2b represent movements of an x-ray source according to prior art methods to acquire image information for 3D mammography,

- figures 3a and 3b represent movements of certain constructions of one medical x-ray imaging apparatus according to the invention,

- figures 3a and 3b represent movements of certain constructions of another medical x-ray imaging apparatus according to the invention, and

- figure 4 represents a C-arm of a mammography apparatus fitted with an arrangement for drawing tissue into the volume between compression plates of the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

A typical mammography apparatus 1 as presented in figure 1 consists of a body part 11 and a C-arm construction 12 connected to it. Typically, a radiation source 13 and an image data receiving means 15, arranged e.g. inside a so-called lower shelf structure 14, are placed at the opposite ends of the C-arm 12. These depicting means 13, 15, being located inside the cover of the apparatus, are actually not visible in figure 1.

Further, within the area between the depicting means 13, 15, typically in the proximity of the image data receiving means 15, a means 16, 17 for positioning/locking the object to be imaged within the imaging area has been placed. Nowadays, typically, this kind of an apparatus is motorized such that the C-arm 12 is arranged movable in a vertical direction and

rotatable about an axis, typically a physical horizontal axis connecting the C-arm to the body part 11. The positioning/locking means 16, 17 typically consist of an upper compression plate 16 and a lower compression plate 17, which lower compression plate 17 may be arranged integrated with the lower shelf structure 14. Inside the lower shelf, a grid structure may be located above the image data receiving means 15, which grid structure limits entry of radiation scattered from the tissue to the image data receiving means 15. In the context of the current invention, it is in practise a necessity that the rotation axis of the C-arm 12 be arranged in such manner with respect to the location of the compression plates 16, 17 (locking means) that the patient can remain at the same position for exposures regardless of the inclination angle of the C-arm. Such a construction for this type of mammography apparatus has been taught in the European patent publication 370089.

Figures 2a and 2b represent prior art systems to acquire image information for 3D mammography. For the sake of clarity, in Figs. 2a, 2b, 3a, 3b not an actual cone-shaped x-ray beam originating from the focus of the x-ray source 13 but only the central ray is shown.

In the prior art system according to Fig. 2a, the x-ray source 13 is arranged to move in a continuous fashion from a starting position of the imaging procedure to an end position of the imaging procedure, and during this movement, the x-ray source 13 is energized for the duration of a number of short exposure periods, while the compression plates 16, 17 (and in Fig. 2a, also the detector 15) remain stationary. The image information detected at the detector 15 is stored and/or sent to image processing. In this kind of construction, use of a conventional anti-scatter grid is not possible as the grid would absorb a portion of the desired x-ray quanta as well at all the other exposure angles but that which is parallel with orientation of the grid lamella.

In the prior art system according to Fig. 2b, on the other hand, the x-ray source 13 is moved in a stepwise manner such that for each exposure, the x-ray source is stopped at a predefined angular position. In Fig. 2b,

three such stationary exposure positions of the x-ray source 13 are shown.

Figures 3a and 3b show two basic operational phases of the current mammography imaging invention. Fig. 3a can be regarded as showing one exposure phase and Fig. 3b as showing one non-exposure phase of the system, together with the extreme positions of the x-ray source 13. In these Figs, these extreme positions of the x-ray source 13 with respect to the vertical indicate the width of the tomographic angle of the system, whereas in Fig. 3a the two close to vertical positions of the x-ray source 13, and the corresponding positions of the breast locking means 16, 17 and the detector 15, depict the core operational phase of the system according to the invention, and in Fig. 3b those of a certain preferable embodiment of the invention. In the embodiment of the invention shown as a whole in Figs. 3a and 3b, during an exposure phase (Fig. 3a), the compression plates 16, 17 are arranged to turn as synchronized with the movement of the x-ray source 13, while during a non-exposure phase (Fig. 3b), they are turned in the opposite direction. In this embodiment of the invention, the detector 15 is arranged to turn together with the compression plates 16, 17.

The synchronized movement of the x-ray source 13 and the compression plates 16, 17 according to the invention makes possible avoiding creating such movement artefacts that are always present when the breast is imaged according to a prior art method of Fig 2a, where there is mutual movement between the x-ray source 13 and the breast during an exposure. As compared to that method, the invention also makes possible using longer exposure times and does not necessitate using an extra-powerful and thus heavier x-ray source.

On the other hand, because of not having to stop the x-ray source 13 for the duration of an (each) exposure, the time needed for the whole imaging process will be considerably shorter than that needed for a prior art process according to Fig. 2b.

As there are a number of exposures in 3D mammography, simply repeatedly turning the compression plates 16, 17 in the direction of the movement of the x-ray source 13 during each exposure period (and keeping them still during the non-exposure periods) would add up turning the compression plates 16, 17 say 15 degrees, for example, which as far as the patient is concerned would make the imaging process uncomfortable. To avoid this, preferable embodiments of the invention include an operational phase during which the x-ray source 15 is not energized (a non-irradiation period) and the compression plates 16, 17 (and the detector 15) are turned in the direction opposite to that of the movement of the x-ray source 13. According to the preferable embodiment of the invention as shown in Fig. 3b, the compression plates 16, 17 and the detector 15 are turned back to their initial position at the beginning of the preceding irradiation period.

The angle through which the compression plates 16, 17 will be turned can be arranged to be very small and the periods of non-exposure to be longer than the exposure periods so that there will be plenty of time to establish a stable starting situation for a subsequent exposure period. In other words, according to preferable embodiments of the invention, there will be plenty of time for counter-turning the breast as the periods when the x-ray source 13 is not energized are arranged to be considerably longer than the periods during which it is energized. Thinking of an example of having a typical prior art mammography apparatus and using 12 exposures starting at intervals of 5 degrees, the compression plates 16, 17 could be turned through 2 degrees or even less, which would easily leave enough time for backwards turning even when taking into account the time needed for acceleration and deceleration of the movements.

As shown in Fig. 3a, in one preferable embodiment of the invention, both the radiation source 13 and the image detector 15 are moved at the same essentially regular angular velocity around the breast whilst it is compressed between the compression plates 16, 17 - or locked otherwise in a means arranged for this purpose.

In practise, regarding embodiments of the invention as shown in Figs. 3a and 3b, it is essential that the compression plates 16, 17, or said other locking means for the breast, are arranged to turn at a short distance from the rotation centre of the radiation source 13 for the most, since during the imaging procedure according to the invention, it would be impossible to reposition the patient for irradiations at different projection angles.

According to a specific preferable embodiment of the invention, first, during exposure of each of the projection images, the compression plates 16, 17, or said other locking means, are turned as synchronized with the movement of the radiation source 13. Thus, the breast will remain still with respect to the radiation source 13 during each such irradiation period. Then, second, between the irradiation periods, the compression plates 16, 17 are turned back to their position at the beginning of the preceding irradiation period. As a consequence, the total angle the locking means 16, 17 shall turn needs to be only as small as the angle of turn needed for creating synchronization of movements during an individual exposure of one projection image. This angle may be arranged to be e.g. less than 2 degrees, such as 0,5 - 2 degrees, which in view of the strain to a patient will be tolerable. Thus, even when taking into account the required accelerations and decelerations, as discussed, in case images are taken at 5 degree intervals, for example, over a tomographic angle of say 50 degrees, there will still be plenty of time for returning the locking means (e.g. upper and lower compression plate 16, 17) back to their initial position at the beginning of an exposure phase.

More generally speaking, in the system according to the invention, the breast to be imaged is arranged locked in a locking means 16, 17 and during the imaging process, an x-ray source 13 is moved with respect to the location of the breast to be imaged and the breast is irradiated during a number of irradiation periods which begin at a number of angular positions of the x-ray source 13. During the imaging process, the x-ray source 13 is moved continuously and the breast is irradiated during a number of short irradiation periods and, during a period when the breast

is being irradiated, the locking means 16, 17 is moved as synchronized with the movement of the x-ray source 13. Regarding a mammography apparatus according to the invention, it comprises a body part 11 and arranged thereto an x-ray source 13, an image detector 15 as well as within an area between the x-ray source 13 and the image detector 15, a means arranged for locking a breast 16, 17, the x-ray source 13 being arranged movable with respect to the location of said locking means 16, 17. Further, the apparatus comprises a control system arranged to control operation of the apparatus. The locking means 16, 17 is arranged turnable and movement of the locking means 16, 17 and the x-ray source 13 is arranged motorised, and the operation of the x-ray source controlled by said control system such that during an imaging process, the x-ray source 13 moves continuously and the breast is irradiated during a number of short irradiation periods and, during an irradiation period, said locking means 16, 17 turns as synchronized with the movement of the x-ray source 13.

The imaging procedure may include a phase prior to the first irradiation period wherein said locking means 16, 17 is turned in a direction opposite to that when moved as synchronized with the movement of the x-ray source 13. There may be periods of backwards movement of the locking means 16, 17 in between any number of successive irradiation periods. The length of the turning-back movement of the locking means 16, 17 (and possibly also that of the image detector 15) may be either exactly the same as during an exposure period, i.e. the locking means 16, 17 may be moved back to its initial position at the beginning of a preceding exposure period, or the backwards movement may be shorter or longer than the one having taken place during a preceding exposure. The length of the backwards movement does not have to be any exact multiple of the steps of the movement during an exposure. As an exemplary embodiment of the invention, the imaging procedure may consist of steps of two exposure periods between which the locking means 16, 17 do not turn in any direction but after the second of these exposure periods, the backwards movement will correspond to the total movement of the locking means 16, 17 during these two exposure periods.

The extreme positions of the x-ray source 13 with respect to the breast during the imaging process may be arranged to make up a tomographic angle of several tens of degrees, such as about 50 degrees. In one preferable embodiment, the overall movement of the x-ray source 13 is arranged to be symmetrical with respect to the vertical, i.e. the overall tomographic angle to be about plus-minus 25 degrees with respect to the vertical. Preferably, the movement of the x-ray source 13 is arranged to follow a curved path as in the case of typical existing mammography apparatus, yet the principle of the invention may be realized also when moving the x-ray source linearly.

Considering the angles from another point of view, the ratio between the angle of the minute individual turns of the locking means 16, 17 during exposure periods with respect to the overall displacement of the x-ray source 13 may be arranged to be of the order of 1/10. The imaging procedure may be arranged to consist of about 11 - 15 exposure periods.

Even though varying breast thicknesses and the desired velocity of the x-ray source 13 may affect what is optimal, preferable embodiments of the invention include using an x-ray source 13 comprising a tungsten anode which, with proper arrangements such as using a selenium based imaging detector and especially a silver filter of proper thickness to absorb those low energy x-ray quanta which would not be able to penetrate the breast tissue, can result in a reduced radiation dose when compared to some other arrangements. In the context of preferable embodiments of the invention, exposure times for the projection images of around 50 - 100 ms may be used, and imaging parameter values for the x-ray tube voltage of around 35 - 40 kV, even up to 45 kV, and about 5 mAs. With kV values of about 30 - 34, mAs values of about 10 - 13 may be used.

One preferable embodiment of the invention includes an arrangement in which in functional connection with the locking means, there has been arranged a means for pulling tissue into the space between the compression plates 16, 17. Such a means may be arranged to comprise e.g. an arrangement as shown in Fig. 4, wherein an upper and a lower stretching device

30 are integrated with both of the compression plates 16, 17. The stretching devices 30 may be arranged to comprise a means for engaging and pulling a stretching means, such as a plastic sheet 31, so that in connection with compressing the breast between the compression plates 16, 17, breast tissue will be drawn in between the compression plates 16, 17 upon positioning of the breast for imaging. Such an arrangement enables using perhaps 10 % less compression in the context of the current invention than typically used in the art of mammography, which makes the imaging procedure including both compressing and turning a breast less awkward.

In the above, the invention has been primarily discussed in the context of mammography, and by referring to Figs. in which the x-ray source turns about a rotation axis. The basic idea of the invention may be applied in other kinds of medical x-ray imaging applications as well, i.e. in imaging other objects than the breast and also in the context of the exposure of the object being a linear scanning movement by a wide x-ray beam. In Figs. 4a and 4b, there is presented how the x-ray source 13 is arranged to move linearly from its initial location to its end location and during such movement, whenever the x-ray source is energized, the locking means 16, 17 moves at the same velocity and in the same direction as the x-ray source 13 (Fig. 4 a). During the periods of non-exposure, the locking means 16, 17 are then moved in the opposite direction than during the exposure periods. During exposure periods, also the detector preferably moves as syncronized with the movement of the x-ray source 13. The dimensions of the construction and the width of the x-ray beam define the tomographic angle achievable. The length of the linear movement during exposure periods may be e.g. 0,5 - 2 mm.

In view of various conceivable other applications of the invention than mammography, actually, a term object positioning means 16, 17 could perhaps be used rather than object locking means 16, 17.

The current invention is applicable for use both in the context of so called full-field sized and smaller imaging detectors used in mammography.

CLAIMS

1. An x-ray imaging method for mammography or other medical imaging, in which an object to be imaged is positioned by an object positioning means 16, 17 within an area between an x-ray source 13 and an image detector 15 of an x-ray imaging apparatus and in which during the imaging process, the x-ray source 13 is moved with respect to location of the object and the object is irradiated at a number of different positions of the x-ray source 13 with respect to location of the object, characterized in that during the imaging process, the x-ray source 13 is moved continuously and the object is irradiated during a number of short irradiation periods and, during an irradiation period, said object positioning means 16, 17 is moved as synchronized with the movement of the x-ray source 13.

2. The method according to claim 1, characterized in that prior to the first irradiation period, and/or in between any number of subsequent irradiation periods, that is during a period when the object is not being irradiated, said object positioning means 16, 17 is moved in a direction opposite to that when moved as synchronized with the movement of the x-ray source 13.

3. The method according to claim 1 or 2, characterized in that after an irradiation period during which said object positioning means 16, 17 is moved as synchronized with the movement of the x-ray source 13 and prior to at least one subsequent irradiation period, said object positioning means 16, 17 is moved at least substantially back to its initial position, i.e. at least substantially to its position at the beginning of said preceding irradiation period.

4. The method according to any of the claims 1 - 3, characterized in that the imaging process includes a number of irradiation periods during which said object positioning means 16, 17 is moved as synchronized with the movement of the x-ray source 13, and during each non-irradiation period subsequent to such irradiation periods, the object po-

sitioning means 16, 17 is moved at least substantially back to its position at the beginning of such preceding irradiation period.

5. The method according to any of the claims 1 - 4, characterized in that the movement of the object positioning means 16, 17 during an irradiation period includes turning the object positioning means 16, 17, or linearly moving the object positioning means 16, 17.

6. The method according to any of the claims 1 - 5, characterized in that the extreme positions of the x-ray source 13 with respect to the breast during the imaging process make up a tomographic angle of several tens of degrees.

7. The method according to any of the claims 1 - 6, characterized in that the overall movement of the x-ray source 13 is arranged to be symmetrical with respect to the vertical, or with respect to center of the object.

8. The method according to any of the claims 1 - 7, characterized in that the movement of the detector 15 is arranged to follow the movement of the object positioning means 16, 17.

9. The method according to any of the claims 1 - 8, characterized in that the object positioning means 16, 17 comprises compression plates 16, 17 between which the object is compressed for the duration of the imaging process, and/or a stretching means 30, 31 is arranged to be used for drawing breast tissue in between the locking means 16, 17 / the compression plates 16, 17.

10. The method according to any of the claims 1 - 9, characterized in that during an irradiation period, the x-ray source 13 is operated depending on the object tissue characteristics by using imaging parameter values for the x-ray tube including a tungsten anode of about 35 - 45 kV and about 5 mAs, or about 30 - 34 kV and 10 - 13 mAs.

11. The method according to any of the claims 1 - 10, characterized in that the method includes about 11 - 15 irradiation periods and/or a ratio between the distance through which the object positioning means 16, 17 is moved during an irradiation period and the total tomographic angle of the imaging process is less than 1/10.

12. An x-ray imaging apparatus for mammography or other medical imaging, comprising a body part 11 and arranged thereto an x-ray source 13, an image detector 15 as well as within an area between the x-ray source 13 and the image detector 15, a means arranged for positioning an object 16, 17, the x-ray source 13 being arranged movable with respect to location of said object positioning means 16, 17, the apparatus further comprising a control system arranged to control operation of the apparatus, characterized in that said object positioning means 16,17 is arranged movable and movement of the object positioning means 16, 17 and the x-ray source 13 is arranged motorised and operation of the x-ray source controlled by said control system such that during an imaging process, the x-ray source 13 moves continuously and the breast is irradiated during a number of short irradiation periods and, during an irradiation periods, said object positioning means 16, 17 moves as synchronized with the movement of the x-ray source 13.

13. The apparatus according to claim 12, characterized in that the control system is arranged to control operation of the apparatus such that prior to the first irradiation period, and/or in between any number of subsequent irradiation periods, that is during a period when the breast is not being irradiated, said object positioning means 16, 17 moves in a direction opposite to that when moving as synchronized with the movement of the x-ray source 13.

14. The apparatus according to claim 11 or 12, characterized in that the control system is arranged to control operation of the apparatus such that after an irradiation period during which said object positioning means 16, 17 is moved as synchronized with the movement of the x-ray source 13 and prior to at least one subsequent irradiation period,

said object positioning means 16, 17 moves at least substantially back to its initial position, i.e. at least substantially to its position at the beginning of said preceding irradiation period.

15. The apparatus according to any of the claims 12 - 14, characterized in that the control system is arranged to control operation of the apparatus such that there are a number of irradiation periods during which said object positioning means 16, 17 moves as synchronized with the movement of the x-ray source 13, and during each of the non-irradiation periods subsequent to such irradiation periods, the object positioning means 16, 17 moves at least substantially back to its position at the beginning of such preceding irradiation period.

16. The apparatus according to any of the claims 12 - 15, characterized in that the control system is arranged to control operation of the apparatus such that the radiation source 13 and the object positioning means 16, 17 move linearly during an irradiation period, for about 0,5 - 2 mm, for example.

17. The apparatus according to any of the claims 12 - 16, characterized in that the detector 15 is arranged to move and to follow the movement of the object positioning means 16, 17.

18. The apparatus according to any of the claims 12 - 17, characterized in that the object positioning means 16, 17 comprises compression plates 16, 17 between which a breast is compressed for the duration of the imaging process and/or a stretching means 30, 31 has been arranged to the apparatus for pulling breast tissue in between the locking means 16, 17 / the compression plates 16, 17.

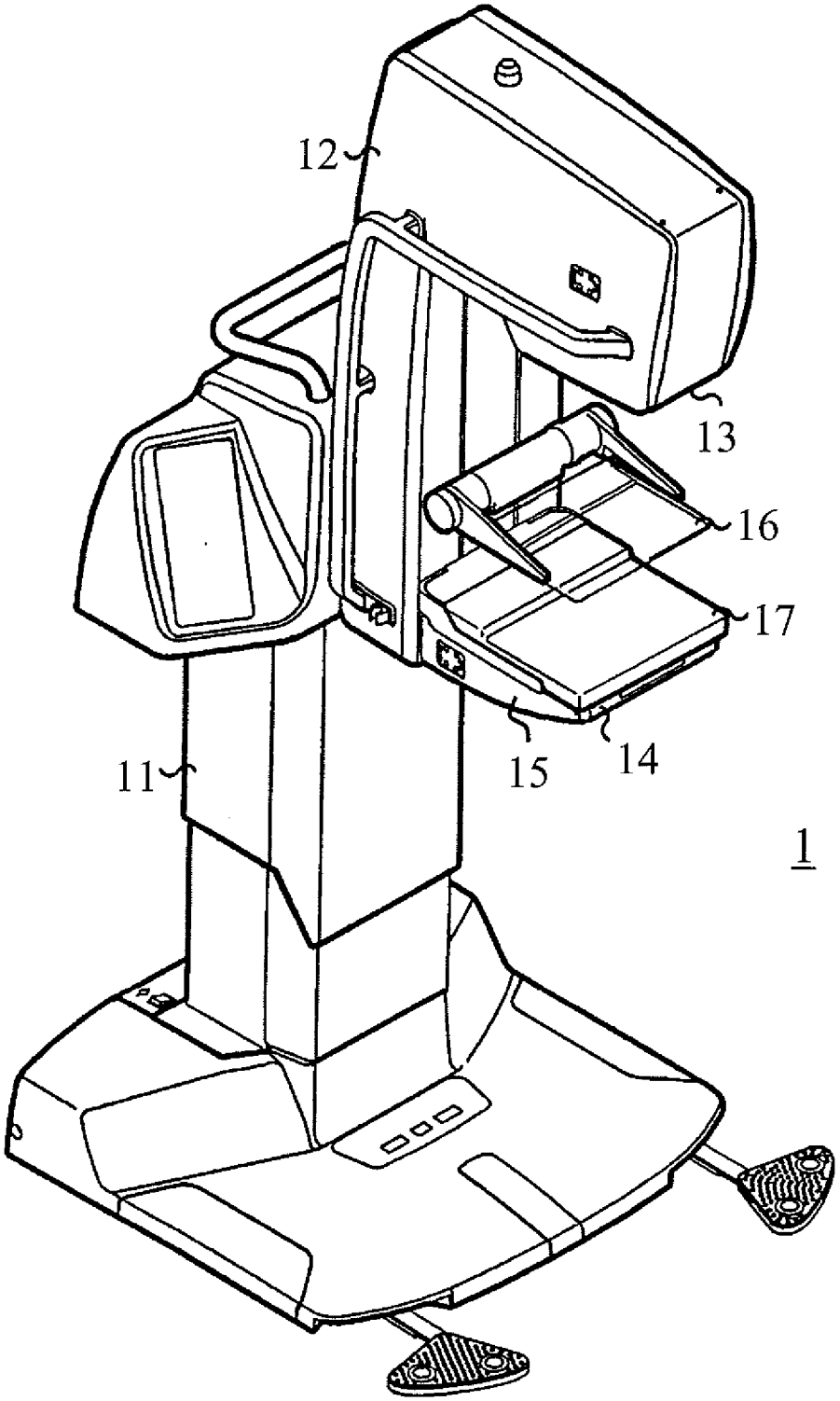
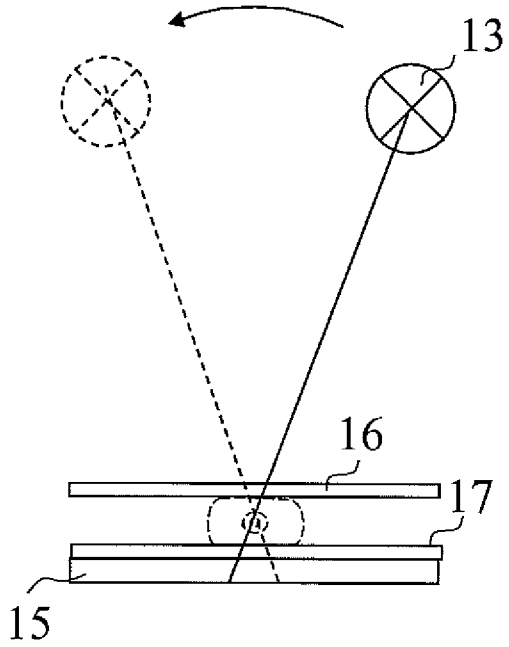
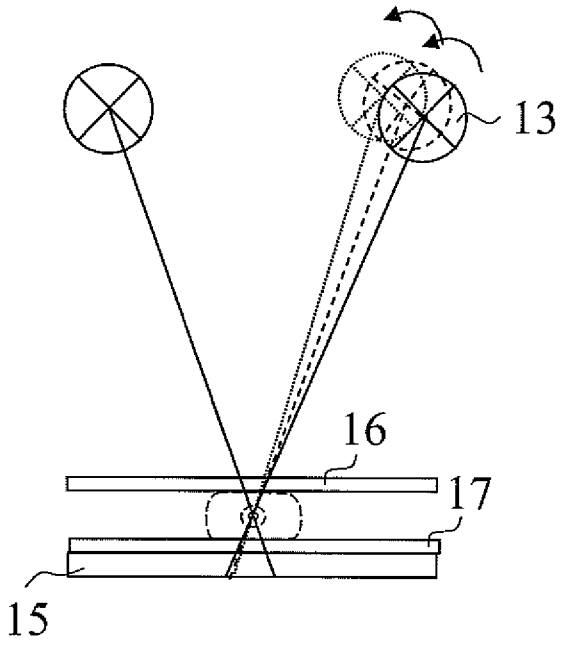


Fig. 1



prior art

Fig. 2 a



prior art

Fig. 2 b

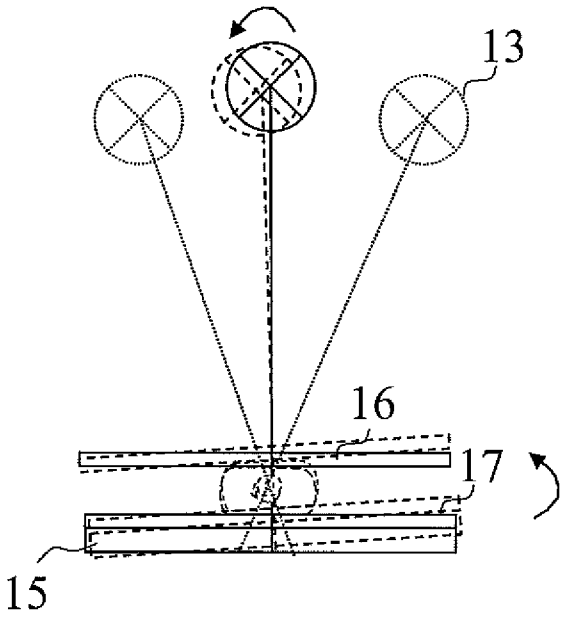


Fig. 3 a

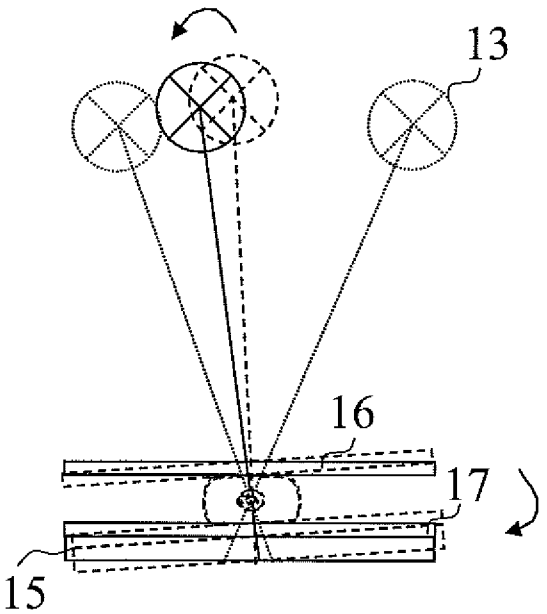


Fig. 3 b

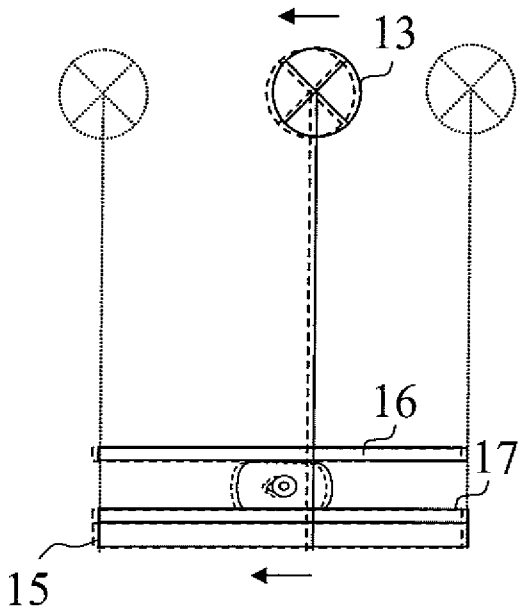


Fig. 4 a

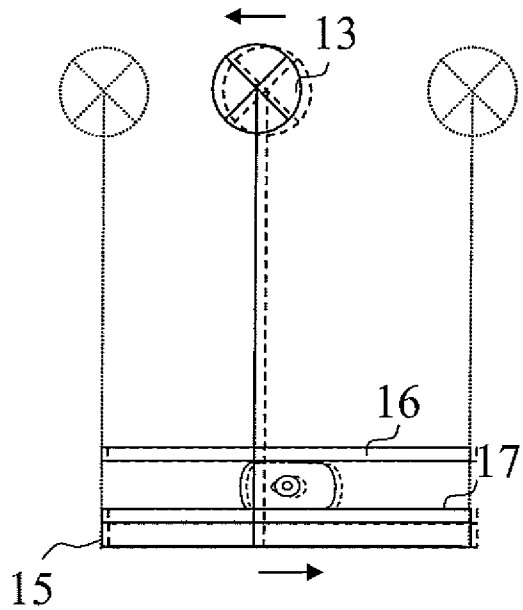


Fig. 4 b

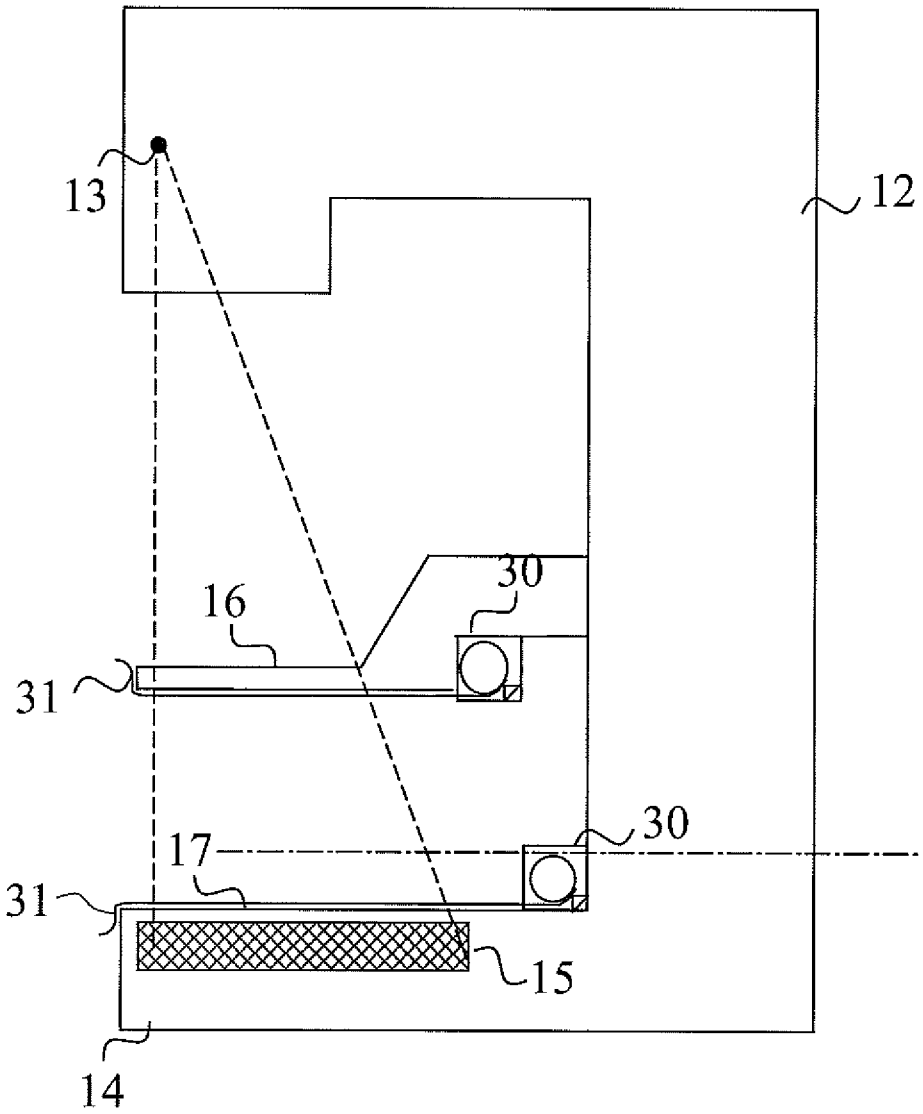


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/066051

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B6/00 A61B6/04
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 G01T G06T

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, WPI Data, BIOSIS, COMPENDEX, EMBASE, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 825 842 A (TAGUCHI KATSUYUKI [JP]) 20 October 1998 (1998-10-20) column 6, line 39 - column 7, line 11 figure 1	1,5,10, 12
X Y	US 3 809 886 A (COCHRAN G ET AL) 7 May 1974 (1974-05-07) column 3, line 29 - column 4, line 18 column 4, line 40 - line 51 column 6, line 36 - line 44 figures 2,4	1-7, 10-16 8,9,17, 18
Y	US 3 984 684 A (WINNEK DOUGLAS FREDWILL) 5 October 1976 (1976-10-05) column 3, line 66 - column 5, line 38 figures 1,2	8,17

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 April 2010	19/04/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Görlach, Tobias

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/066051

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 4 789 929 A (NISHIMURA HIROSHI [JP] ET AL) 6 December 1988 (1988-12-06) figures 1,5,11,16 column 3, line 15 - column 5, line 15 column 10, line 46 - column 12, line 3 column 14, line 1 - column 15, line 9	1-18
A	JP 2004 236915 A (HITACHI MEDICAL CORP) 26 August 2004 (2004-08-26) paragraph [0007] claim 1 figures 1,2	1-18

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