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(54) Title: X-RAY IMAGING APPARATUS AND IMAGING METHOD

FIG. 2A

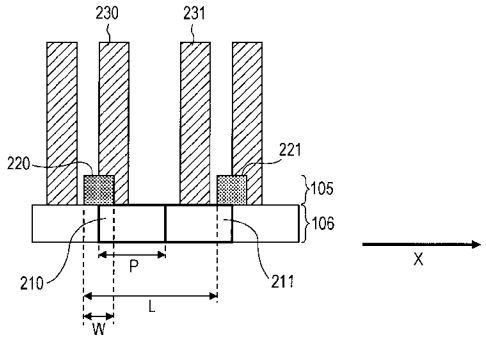
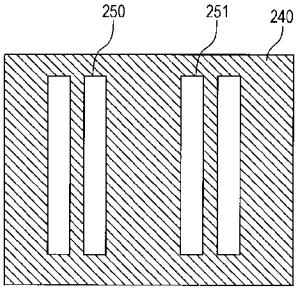


FIG. 2B



(57) Abstract: An X-ray imaging apparatus and an imaging method capable of acquiring an image of a test object associated with a phase shift in consideration of X-ray absorption is provided. A splitting element configured to spatially split an X-ray into multiple X-ray beams is provided. A shielding unit including a plurality of shielding elements configured to block part of an X-ray acquired by the splitting element is provided. Part of X-ray beams detected at the first detection pixels is blocked by the shielding elements. The X-ray beams detected by the second detection pixels adjoining the first detection pixels are not blocked by the shielding elements.

WO 2012/008287 A1

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DESCRIPTION

X-RAY IMAGING APPARATUS AND IMAGING METHOD

Technical Field

[0001] The present invention relates to an X-ray imaging apparatus and an imaging method.

Background Art

[0002] A non-destructive inspection method using X-ray is applied to various areas ranging from industrial use to medical use. An X-ray beam is an electromagnetic wave having a wavelength between approximately 1 pm (10^{-12} m) to approximately 10 nm (10^{-8} m). An X-ray beam having a shorter wavelength is referred to as a hard X-ray beam, and an X-ray having a longer wavelength is referred to as soft X-ray beam.

[0003] In an absorption contrast method, which uses the difference in transmittance when an X-ray beam transmits a test object, the absorption image acquired in this method exhibits high penetrating power of the X-ray and is put to practical use in internal crack inspection on steel material etc., and security measures, such as baggage inspection.

[0004] For a test object that consists of a material having a small density difference, which generates a small contrast due to X-ray absorption, it is effect to use X-ray phase contrast imaging in which a phase shift in the X-ray

due to a test object is detected.

[0005] As a type of X-ray phase contrast imaging, imaging using an imaging apparatus including a mask that blocks X-ray beams and installed on the edge area of the pixels in the detector unit is disclosed in PTL 1. By setting the apparatus such that an X-ray beam is incident on part of the mask when a test object is not disposed, the positional change of the X-ray due to refraction at the test object can be detected as a change in intensity.

[0006] Figs. 7A and 7B are enlarged views of the detector unit in PTL 1. Fig. 7A is a view of the detector unit in the incident direction of an X-ray beam. Fig. 7B is a view of the detector unit in a direction orthogonal to the incident direction of the X-ray beam.

[0007] A shielding element 720 that blocks an X-ray beam is disposed on the edge region of a detection pixel 710 (at the boundary with the adjoin pixel) in the detector unit. An X-ray beam 730 is incident on each pixel such that part of the X-ray beam 730 is incident on the shielding element 720. With such an arrangement, when an X-ray beam is incident on a test object, the position of the incident X-ray beam 730 changes on the detection pixel 710 due to refraction. Since the area of incident X-ray beam blocked by the shielding element 720 changes due to a positional change, the detected intensity of the X-ray beam changes.

Therefore, by detecting the changes in the intensity of the X-ray, refraction can be measured.

Citation List

Patent Literature

[0008] PTL 1 International Publication No. 2008/029107

Summary of Invention

Technical Problem

[0009] PTL 1 has a problem in that when a test object sufficiently absorbs an X-ray beam, the effect of the absorption and information about phase shift due to the test object are mixed and cannot be acquired separately. Specifically, when a change in the intensity of an X-ray beam is detected, it cannot be determined whether the change is due to absorption by the test object or due to a position change in the X-ray beam incident on a shielding element. As a result, the imaging precision of an image associated with phase shift decreases.

[0010] Accordingly, the present invention provides an X-ray imaging apparatus and an imaging method capable of acquiring an image associated with phase shift, e.g., a differential phase contrast image or a phase contrast image, in consideration of the X-ray absorption of a test object.

Solution to Problem

[0011] An X-ray imaging apparatus according to the present invention includes a splitting element configured to

spatially split an X-ray into multiple X-ray beams; a shielding unit including a plurality of shielding elements configured to block part of an X-ray acquired by the splitting element; and a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel, the pixels being configured to detect the intensity of the X-ray beam transmitted through the shielding unit, wherein part of the X-ray beam detected at the first detection pixel is blocked by the shielding elements and the X-ray beam detected at the second detection pixel adjoining the first detection pixel is not blocked by the shielding elements.

[0012] An imaging method for an X-ray imaging apparatus according to the present invention includes the steps of blocking part of spatially split X-ray beams by a shielding unit having a plurality of shielding elements; detecting the intensity of the X-ray beams transmitted through the shielding unit by a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel; and detecting an X-ray beam of which part is blocked by the shielding elements by the first detection pixel and detecting an X-ray beam of which part is not blocked by the shielding elements by the second detection pixel adjoining the first detection pixel.

Advantageous Effects of Invention

[0013] Accordingly, the present invention provides an X-ray imaging apparatus and an imaging method capable of acquiring an image associated with phase shift, e.g., a differential phase contrast image or a phase contrast image, in consideration of the X-ray absorption of a test object.

Brief Description of Drawings

[0014] Fig. 1 illustrates the configuration of an X-ray imaging apparatus according to first, second, third, and fourth embodiments.

[0015] Figs. 2A and 2B illustrate a shielding unit according to the first embodiment.

[0016] Fig. 3 illustrates a processing flow of a computing unit according to the first embodiment.

[0017] Figs. 4A and 4B illustrates the configuration of a shielding unit according to the second embodiment.

[0018] Figs. 5 illustrate the configuration of a shielding unit according to the third embodiment.

[0019] Figs. 6A and 6B illustrates the configuration of the shielding unit according to the third embodiment.

[0020] Figs. 7A and 7B illustrate the configuration of an X-ray imaging apparatus according to PTL 1.

Description of Embodiments

First Embodiment

[0021] With reference to Fig. 1, an X-ray imaging apparatus and an imaging method according to this embodiment

will be described below. An X-ray generated at an X-ray source 101, which is an X-ray generating unit, is split into, for example, line beams at a splitting element 103.

[0022] The splitting element 103 is, for example, a slit array having lines and spaces. The splitting element 103 may be two-dimensional slits or a pinhole array in a direction orthogonal to the split pitch direction. The shape of the slits may be L-shaped or annular or may be a combination of these shapes. The slits in the splitting element 103 may be the same shape or may be different shapes. The slits or pinholes, which are regions transmitting the X-ray, are also referred to as transmitting parts.

[0023] The slits in the splitting element 103 do not have to penetrate the substrate of the splitting element 103 so long as they transmit the X-ray. The material of the splitting element 103 may be selected from elements having a high X-ray absorption, such as Pt, Au, Pb, Ta, or W, or may be a compound of these elements.

[0024] The X-ray beams acquired through spatial splitting at the splitting element 103 go through a phase shift and are refracted by a test object 104. The X-ray beams are absorbed by the test object 104. The refracted X-ray beams enter a shielding unit 105. The shielding unit 105 includes a plurality of shielding elements.

[0025] The intensity of the X-ray beams transmitted

through the shielding unit 105 is detected by a detecting unit 106. Information related to the X-ray beams acquired by the detecting unit 106 is numerically processed at a computing unit 107 and is output to a display unit 108, such as a monitor.

[0026] The test object 104 may be a human body, an inorganic material, or an organic/inorganic composite. Moving units 109, 110, 111, and 112, such as stepping motors, that move the splitting element 103, the test object 104, the shielding unit 105, and the detecting unit 106, respectively, may be provided. For example, by providing the moving unit 110, the test object 104 can be moved as desired, and an image of a specific site of the test object 104 can be acquired.

[0027] The detecting unit 106 can be any type of indirect or direct X-ray detector. For example, the detecting unit 106 may be selected from an X-ray CCD camera, an indirect-conversion-type flat panel detector, and a direct-conversion-type flat panel detector.

[0028] The detecting unit 106 may be disposed close to the shielding unit 105 or may be disposed a certain distance apart from the shielding unit 105. The shielding unit 105 may be integrated in the detecting unit 106.

[0029] When monochromatic X-ray is used, a monochromatizing unit 102 may be disposed between the X-ray

source 101 and the splitting element 103. The monochromatizing unit 102 may be a monochrometer or an X-ray multilayer mirror combined with slits.

[0030] To prevent image obscuration due to X-rays scattering from the test object 104, a grid, which is used in diagnostic X-ray system, may be disposed between the test object 104 and the shielding unit 105.

[0031] With reference to Figs. 2A and 2B, the shielding unit 105 according to this embodiment will be described in detail. In Fig. 2A, the shielding unit 105 includes shielding elements 220 and 221, having a width of W, are disposed on the detecting unit 106 at a pitch L. The detecting unit 106 includes a plurality of pixel groups, which each includes a detection pixel 210, which is a first detection pixel, and a detection pixel 211, which is a second detection pixel. The shielding elements 220 and 221 may be selected from elements having a high X-ray absorption, such as Pt, Au, Pb, Ta, or W. The shielding elements 220 and 221 do not have to complete absorb the incident X-ray beams but may transmit part of the X-ray beams.

[0032] The pitch L of the shielding elements 220 and 221 is equal to 2P (L=2P), where P represents the size of the detection pixels 210 and 211. The shielding element 220 is disposed at the boundary (edge region) between the detection pixel 210 and the adjoining pixel on the left. The

shielding element 221 is disposed at the edge region between the detection pixel 211 and the adjoining pixel on the right.

[0033] In Fig. 2A, the shielding unit 105 and the detecting unit 106 are integrated. When the shielding unit 105 is disposed a certain distance apart from the detecting unit 106, the pitch L of the shielding elements 220 and 221 is 2P/M, where M represents the projection magnitude of the shielding unit 105 to the detecting unit 106, and the shielding unit 105 and the detecting unit 106 are arranged such that the shadows of the shielding elements are projected on the edge regions of the detection pixels.

[0034] Part of an X-ray beam 230 is incident on the shielding element 220, whereas an X-ray beam 231 is not incident on the shielding element 221.

[0035] Fig. 2B illustrates the example configuration of the splitting element 103. A splitting element 240 includes slits 250 and 251, which are transmitting parts. An X-ray beam that transmits the slit 250 is the X-ray beam 230, and an X-ray beam that transmits the slit 251 is the X-ray beam 231. The width and pitch of the slits are set appropriately in consideration of the X-ray divergence angle, the X-ray width on a detection pixel, and so on.

[0036] By arranging the splitting element 240, the shielding elements 220 and 221, and the detection pixels in this way, the intensity of the X-ray beam 231 detected by

the detection pixel 211 changes due to the absorption of the test object 104. The intensity of the X-ray beam 230 detected by the detection pixel 210 changes due to the absorption of the test object 104 and the positional change caused by refraction. Specifically, an image (absorption image) corresponding to the X-ray transmittance of the test object 104 and an image (phase contrast image) corresponding to the displacement of the X-ray beam due to a phase shift can be acquired on the basis of changes in the intensity of the X-ray beams 230 and 231 detected by the detection pixels 210 and 211, respectively.

[0037] The detected intensity I of the X-ray beam 231 when the test object 104 is disposed and the detected intensity I_0 when the test object 104 is not disposed can be represented by Expression 1.

[Math. 1]

$$\frac{I}{I_0} = T \qquad (1)$$

where T represents transmittance. Transmittance can be determined from the intensity data acquired with and without the test object 104.

[0038] The detected intensity of the X-ray beam 230 can be determined by Expression 2 if the detected intensity changes linearly with respect to the minute positional change ΔX in the X direction.

$$\Delta X = aI_0 + b \qquad (2)$$

where a and b are coefficients. The a and b can be determined by measuring the intensity I_0 without the test object 104 while moving the splitting element 103 and substituting the measured data to Expression 2. The displacement ΔX at each point on the test object 104 can be determined by substituting Expression 1 into Expression 2.

[0039] In this case, since two different data sets about the X-ray beam 230 incident on a shielding element and the X-ray beam 231 not incident on a shielding element are acquired, the spatial resolution in the X direction is 1/2.

[0040] In addition to the above-described measurement, the same measurement is performed by after moving the splitting element 103, the shielding unit 105, the detecting unit 106, or the test object 104 in the X direction by the moving unit 109, 111, 112, or 110, respectively. In this way, the spatial resolution can be improved.

[0041] Fig. 3 is a flow chart illustrating the computation performed at the computing unit 107. First, intensity data for each X-ray beam is acquired (S110). Then, X-ray transmittance (T) is calculated from the detected intensity of X-ray beam not incident on a shielding element. Using Expression 2, the positional change (ΔX) of the X-ray is determined on the basis of the X-ray transmittance (T) and the detected intensity (I) of the X-ray beam partially

incident on the shielding element (S120).

Next, the refraction angle ($\Delta\theta$) of each X-ray is calculated using Expression 3 (S130).

[Math. 2]

$$\Delta\theta = \tan^{-1}\left(\frac{\Delta X}{Z}\right) \qquad (3)$$

where Z represents the distance between the test object 104 and the shielding unit 105.

[0042] Next, the differential phase ($\partial\phi/\partial X$) of an X-ray beam is calculated using Expression 4 (S140).

[Math. 3]

$$\frac{\partial\phi}{\partial X} = \frac{2\pi}{\lambda}\Delta\theta \qquad (4)$$

where λ represents the wavelength of the X-ray beam and represents an effective wavelength when a continuous X-ray beam is used.

[0043] Next, the phase (ϕ) is calculated by integrating the acquired differential phases ($\partial\phi/\partial X$) in the X direction (S150).

[0044] The computing unit 107 outputs a transmittance image (distribution of T), a positional change image (distribution of ΔX), a differential phase contrast image (distribution of $\partial\phi/\partial X$), and a phase contrast image (distribution of ϕ), which are calculated as described above, to the display unit 108 (S160).

[0045] The transmittance image, the phase contrast image, and so on may be displayed adjacent to each other or may be displayed individually on display unit 108.

[0046] According to this embodiment, the effect of the X-ray being absorbed by the test object 104 and the effect of the phase shift can be separated. Therefore, an X-ray imaging apparatus and an imaging method capable of acquiring a differential phase contrast image, a phase contrast image, etc., in consideration of the X-ray absorption of the test object can be provided.

[0047] In the first embodiment, the shielding elements are disposed between pixels. However, the shielding elements do not necessarily have to be disposed on the edge regions of the pixels.

[0048] The first detection pixel and the second detection pixel may each be multiple pixels.

Second Embodiment

[0049] In Fig. 4A, the positional relationship of detection pixels 410 and 411 and shielding elements 420 and 421 is the same as that in the first embodiment. However, the positional relationship of an incident X-ray beam 430 with respect to the detection pixels 410 and 411 differs from that in the first embodiment. That is, in this embodiment, the X-ray beam 430 is incident on the area between the shielding element 420 and the shielding element

421.

[0050] Fig. 4B illustrates a splitting element 440. The splitting element 440 includes a slit 450, which is a transmitting part. An X-ray beam that transmits through the slit 450 is emitted as the X-ray beam 430 illustrated in the drawing. Part of the X-ray beam 430 is blocked in the X direction by the shielding element 420 and is incident on the detection pixels 410 and 411.

[0051] By arranging the splitting element 440, the shielding element 420, and the detection pixels 410 and 411 in this way, the intensity of the X-ray beam 430 detected by the detection pixels 410 and 411 changes due to the absorption of the test object 104. The intensity detected by the detection pixels 410 and 411 changes due to the positional change of the X-ray beam 430 caused by refraction by the test object 104.

[0052] The change in the detected intensity due to absorption is the same in the detection pixels 410 and 411. The change in the detected intensity due to positional change differs in the detection pixels 410 and 411. For example, when a change in the detected intensity due to the positional change occurs linearly, the positional change corresponding to the changes of intensity detected by the detection pixels 410 and 411 can be represented by Expressions 5 and 6.

[Math. 4]

$$\Delta X = a\frac{I_{410}}{T} + b \qquad (5)$$

[Math. 5]

$$\Delta X = c\frac{I_{411}}{T} + d \qquad (6)$$

where I_{410} and I_{411} represent the intensities detected by the detection pixels 410 and 411 and T represents the X-ray transmittance of the test object 104. Specifically, by measuring the intensities I_{410} and I_{411} while moving the splitting element 103 without the test object 104 disposed and substituting the measured data to Expressions 5 and 6, coefficients a, b, c, and d are determined. When the test object 104 is measured, the X-ray transmittance T and the displacement ΔX can be determined by solving the simultaneous equations.

[0053] The computation flow is the same as that according to the first embodiment and is illustrated in Fig. 3. According to this embodiment, the effect of the X-ray absorption of the test object and the effect of the phase shift can be separated. Therefore, an X-ray imaging apparatus and an imaging method capable of acquiring a differential phase contrast image, a phase contrast image, etc., in consideration of the X-ray absorption of the test object can be provided.

Third Embodiment

[0054] The two-dimensional arrangement according to this embodiment will be described. Fig. 5A is a view from the incident direction of an X-ray beam. Shielding elements 520 are disposed on the edge regions of the detection pixels 510 and 511. The pitch of the shielding elements 520 is P, which is equal to the length of one side of a detection pixel.

[0055] Fig. 5B illustrates the configuration of a splitting element 540. The splitting element 540 has pinholes 550 and 551. The X-ray transmitted through the pinhole 550 is an X-ray beam 530, and the X-ray transmitted through the pinhole 551 is an X-ray beam 531.

[0056] The incident position of the X-ray beam 530 is set such that part of the X-ray beam 530 is blocked by the shielding element 520. By changing the incident position of the X-ray beam 530, the intensity of the X-ray beam 530 detected at the detection pixel 510 changes. In this case, the intensity changes not only when the displacement of the incident position is in the X direction but also in the Y direction.

[0057] The incident position of the X-ray beam 531 is set to the center part of the detection pixel 511 such that the X-ray beam 531 is not blocked by the shielding element 520. Therefore, the intensity detected by the detection pixel 511

changes only by the absorption of the test object 104. Accordingly, the transmittance T of the test object 104 can be determined by the detection pixel 511. By using the determined transmittance T, the positional change of the X-ray beam 531 can be accurately determined from the intensity detected by the detection pixel 511. The center part of the detection pixel 511 does not have to be exactly at the center of the detection pixel 511 so long as the transmittance T can be calculated.

[0058] As illustrated in Fig. 5A, when detection pixels not shielded by the shielding elements are arranged in a first direction (e.g., Y direction) and in a second direction (e.g., X direction) orthogonal to the first direction, the splitting element is configured as illustrated in Fig. 5B. Specifically, the pinholes, which are transmitting parts, of the splitting element are linearly aligned in the first direction but arranged in a zigzag pattern in the second direction.

[0059] Fig. 6A illustrates a variation of Fig. 5A. To prevent part of the X-ray beam 531 from being blocked by a shielding element 620 even when the incident position of the X-ray beam 531 used for determining the X-ray transmittance of the test object 104 changes, the size of the shielding element 620 is reduced, and space for the detection pixel 511 is increased.

[0060] Fig. 6B illustrates the shielding element 630 set smaller than that illustrated in Fig. 6A and not disposed on the detection pixel 511. In this way, the shielding element 630 can be disposed on the edge regions of the pixels.

[0061] As described above, a transmittance image (distribution of T) can be calculated from the intensity detected by the detection pixel 511. By calculating the intensity detected by the detection pixel 510 using the intensity detected by the detection pixel 511, an image associated with the change in X-ray intensity with respect to the phase shift can be calculated. These images can be displayed on the display unit 108.

[0062] According to this embodiment, the effect of the X-ray absorption of the test object and the effect of the phase shift can be separated. Therefore, an X-ray imaging apparatus and an imaging method capable of acquiring a differential phase contrast image, a phase contrast image, etc., in consideration of the X-ray absorption of the test object can be provided.

[0063] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0064] This application claims the benefit of Japanese Patent Application No. 2010-158133, filed July 12, 2010, which is hereby incorporated by reference herein in its entirety.

Reference Signs List

[0065] 101 X-ray source

102 monochromatizing unit

103 splitting element

104 test object

105 shielding unit

106 detecting unit

107 computing unit

108 display unit

CLAIMS

[1] An X-ray imaging apparatus comprising:

a splitting element configured to spatially split an X-ray into multiple X-ray beams;

a shielding unit including a plurality of shielding elements configured to block part of an X-ray acquired by the splitting element; and

a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel, the pixels being configured to detect the intensity of the X-ray beam transmitted through the shielding unit,

wherein part of the X-ray beam detected at the first detection pixel is blocked by the shielding elements and the X-ray beam detected at the second detection pixel adjoining the first detection pixel is not blocked by the shielding elements.

[2] The X-ray imaging apparatus according to Claim 1, further comprising:

a computing unit configured to compute the X-ray transmittance of a test object on the basis of the intensity of the X-ray detected by the second detection pixel.

[3] The X-ray imaging apparatus according to Claim 2, wherein the computing unit computes an image of the test object associated with a phase shift on the basis of the

intensities of the X-ray beams detected at the first detection pixel and the second detection pixel.

[4] The X-ray imaging apparatus according to Claim 1, wherein the shielding element is not disposed on the boundary between the first detection pixel and the second detection pixel.

[5] The X-ray imaging apparatus according to Claim 1, wherein the X-ray beam incident on the first detection pixel and the X-ray beam incident on the second detection pixel are split.

[6] The X-ray imaging apparatus according to Claim 1, wherein the X-ray beam incident on the first detection pixel and the X-ray beam incident on the second detection pixel are not split.

[7] The X-ray imaging apparatus according to Claim 1, wherein,

the detection pixels not blocked by the shielding elements are linearly aligned in a first direction and a second direction orthogonal to the first direction, and

transmitting parts of the splitting element are linearly aligned in the first direction and disposed in a zigzag pattern in the second direction.

[8] An imaging method for an X-ray imaging apparatus, comprising the steps of:

blocking part of spatially split X-ray beams by a

shielding unit having a plurality of shielding elements;

detecting the intensity of the X-ray beams transmitted through the shielding unit by a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel; and

detecting an X-ray beam of which part is blocked by the shielding elements by the first detection pixel and detecting an X-ray beam of which part is not blocked by the shielding elements by the second detection pixel adjoining the first detection pixel.

[9] The imaging method according to Claim 8, further comprising a step of:

calculating the X-ray transmittance of a test object on the basis of the intensity an X-ray beam detected by the second detection pixel.

[10] The imaging method according to Claim 9, further comprising a step of:

computing a differential phase contrast image or a phase contrast image of the test object on the basis of the intensities of X-ray beam detected by the first detection pixel and the second detection pixel.

[11] An X-ray imaging apparatus comprising:

a splitting element configured to spatially split an X-ray;

a shielding unit including a plurality of shielding

element configured to block part of X-ray beams acquired by the splitting element; and

a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel, the pixels being configured to detect the intensity of the X-ray beam transmitted through the shielding unit,

wherein the shielding elements are disposed on the first detection pixel and are not disposed on the second detection pixel.

[12] An X-ray imaging apparatus comprising:

a splitting element configured to spatially split an X-ray;

a shielding unit including a plurality of shielding element configured to block part of X-ray beams acquired by the splitting element; and

a detecting unit including a plurality of pixel groups, each pixel group including a first detection pixel and a second detection pixel, the pixels being configured to detect the intensity of the X-ray beam transmitted through the shielding unit,

wherein the positions of X-ray beams incident on the first detection pixels differ from the positions X-ray beams incident on the second detection pixels, and part of the X-ray beams incident on the first detection pixels is blocked

by the shielding elements.

FIG. 1

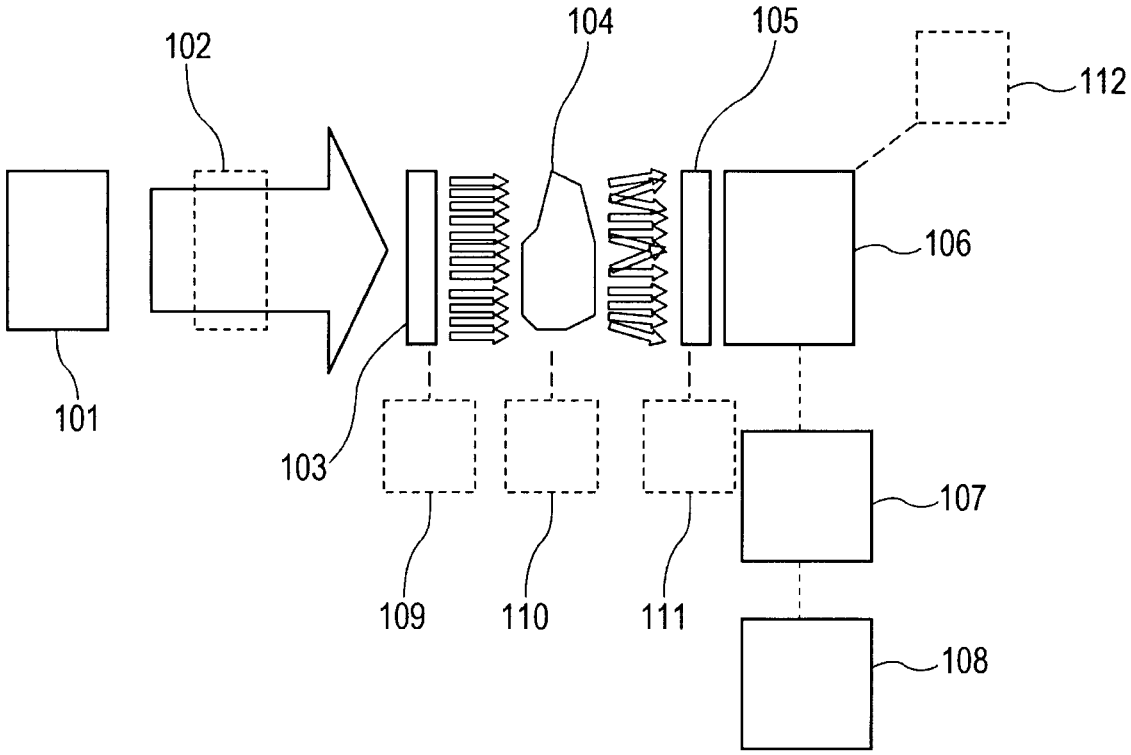


FIG. 2A

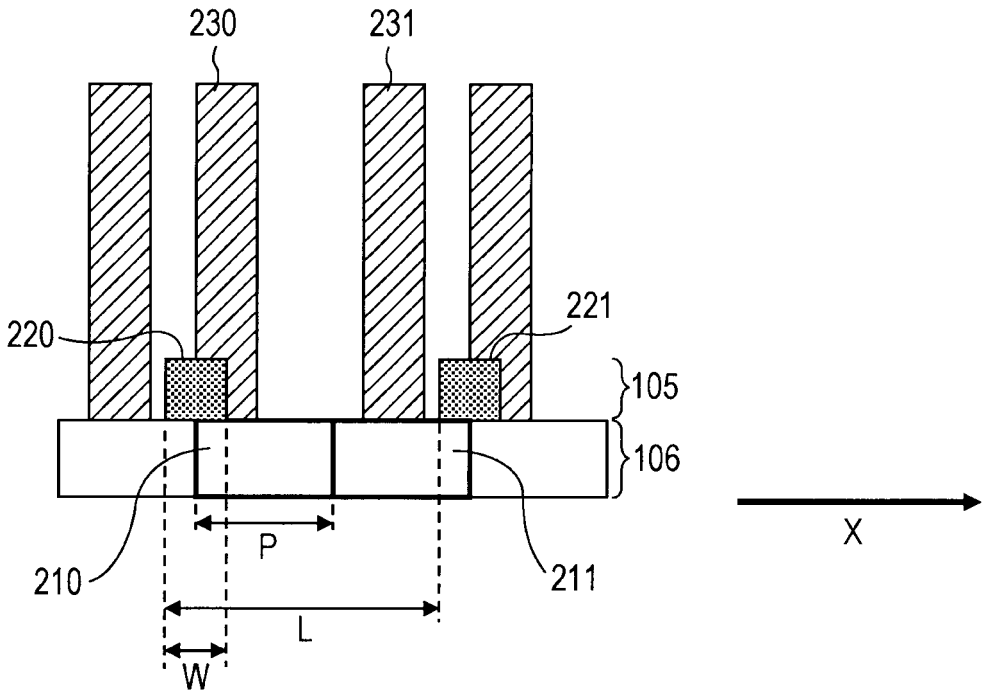


FIG. 2B

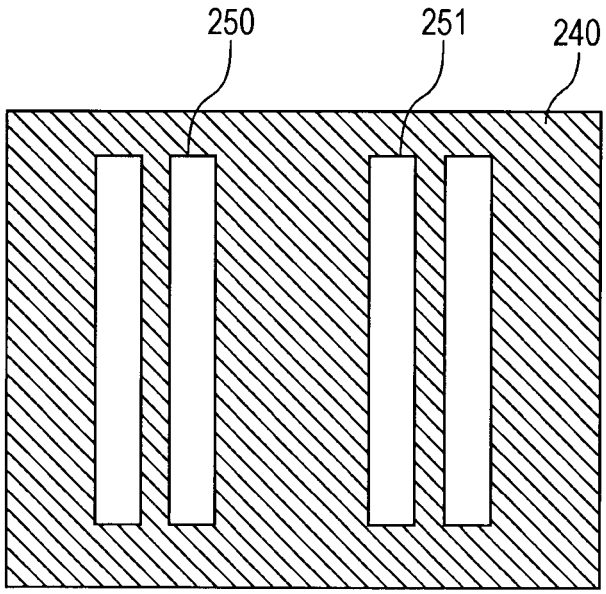


FIG. 3

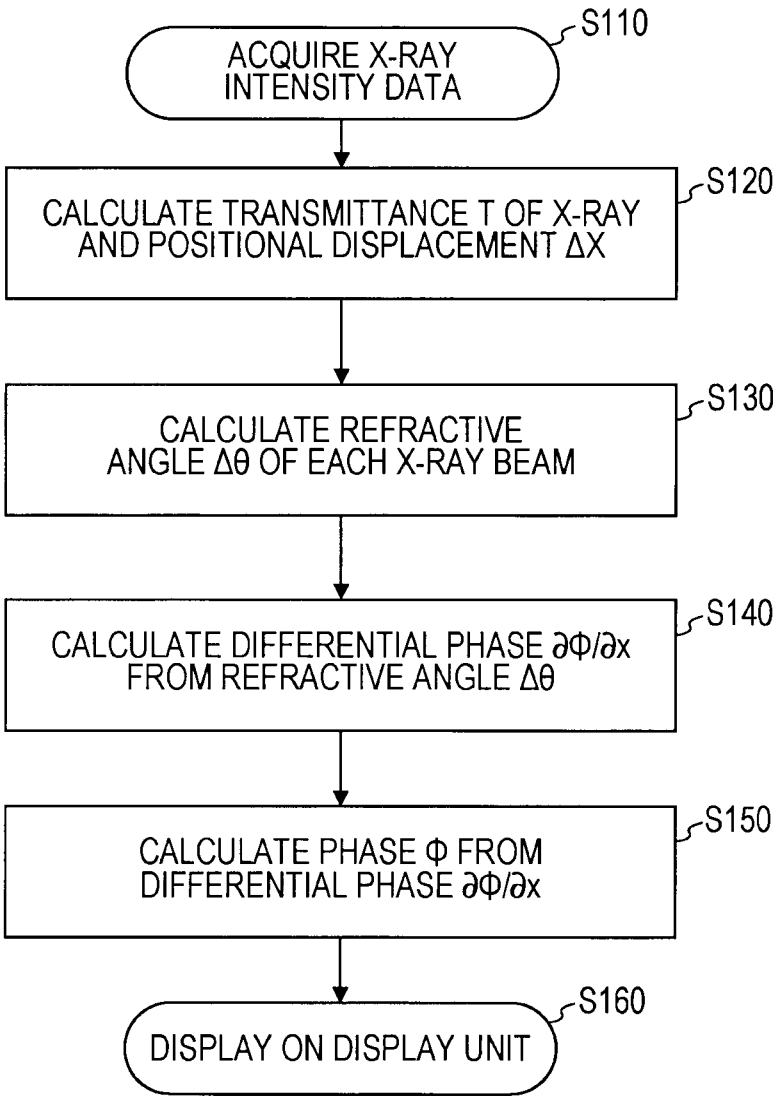

S110
ACQUIRE X-RAY INTENSITY DATA
S120
CALCULATE TRANSMITTANCE T OF X-RAY AND POSITIONAL DISPLACEMENT ΔX
S130
CALCULATE REFRACTIVE ANGLE Δθ OF EACH X-RAY BEAM
S140
CALCULATE DIFFERENTIAL PHASE ∂Φ/∂x FROM REFRACTIVE ANGLE Δθ
S150
CALCULATE PHASE Φ FROM DIFFERENTIAL PHASE ∂Φ/∂x
S160
DISPLAY ON DISPLAY UNIT

FIG. 4A

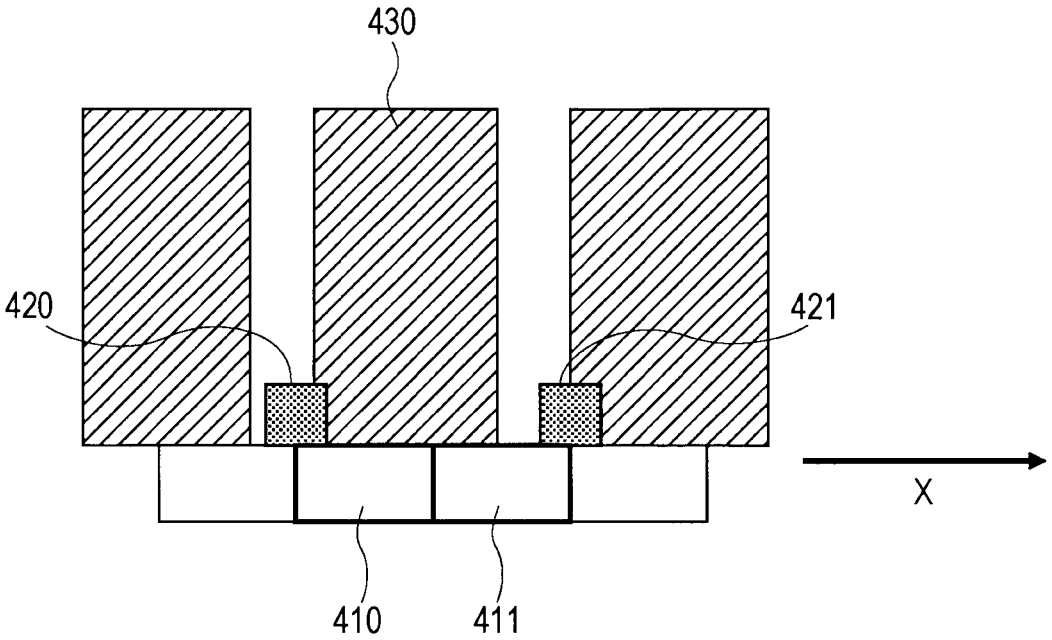


FIG. 4B

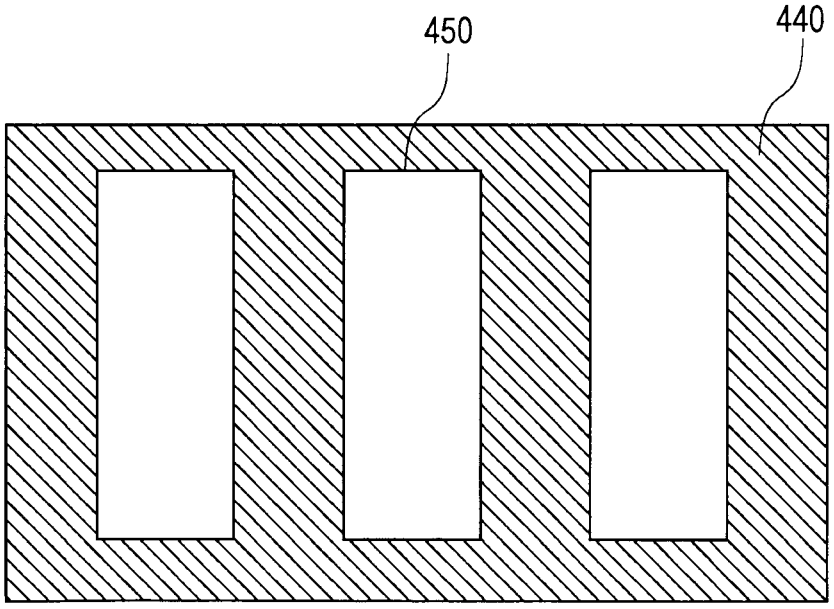


FIG. 5A

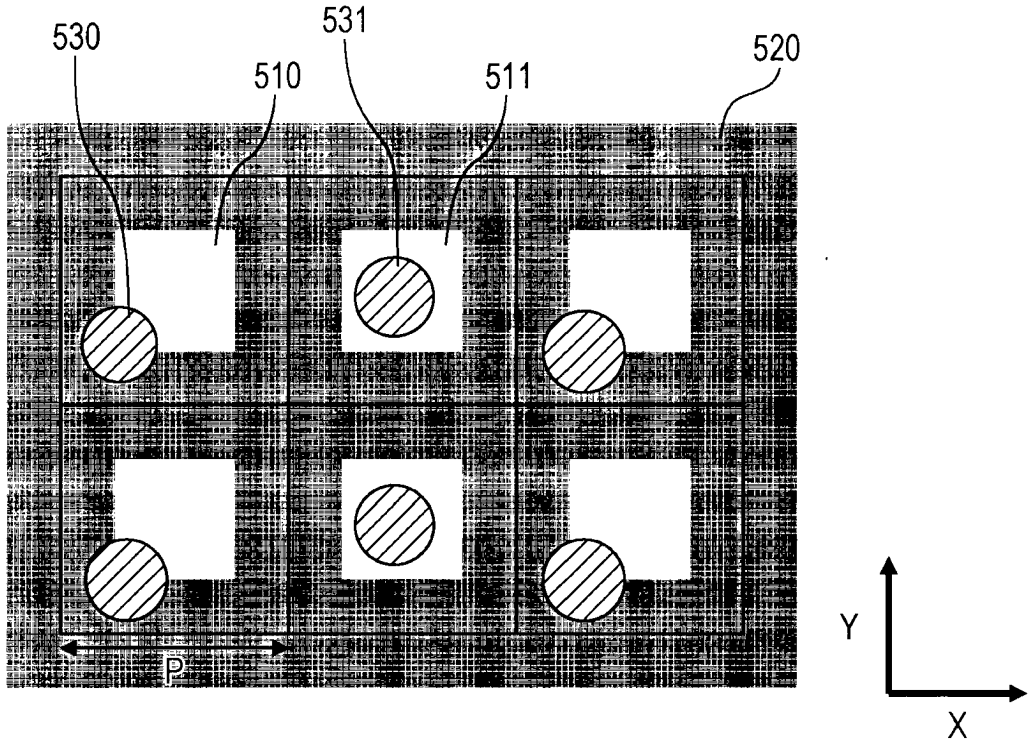


FIG. 5B

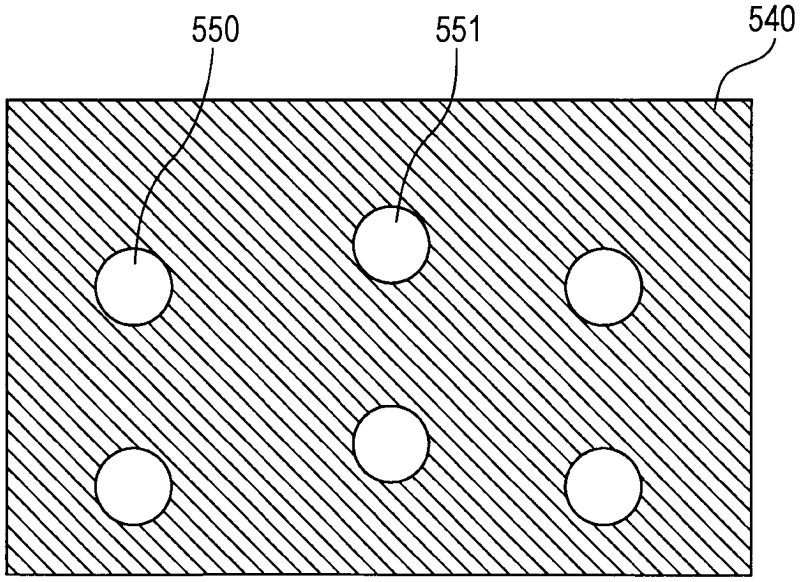


FIG. 6A

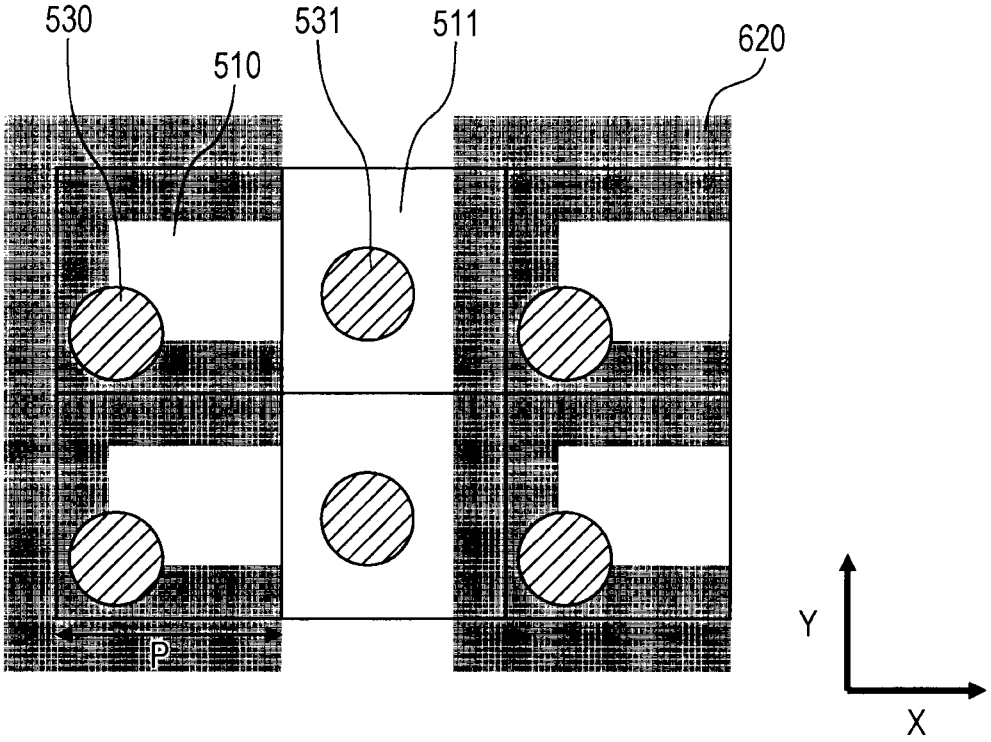


FIG. 6B

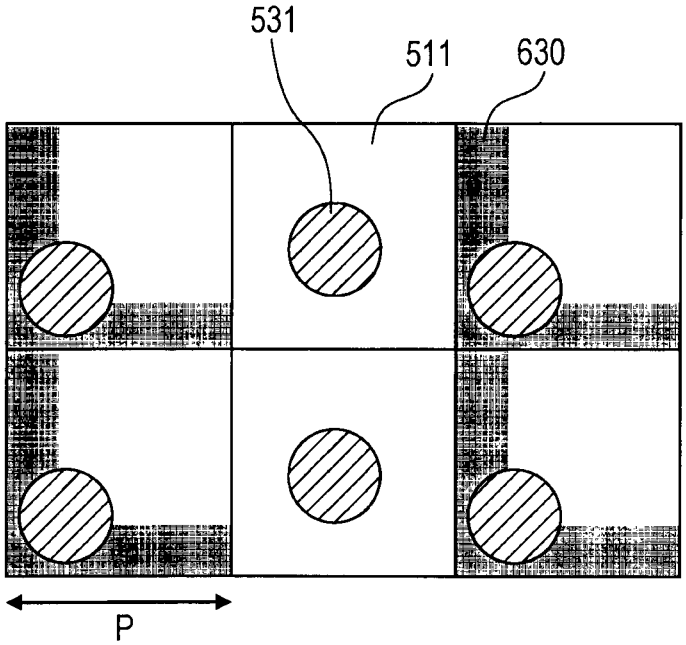


FIG. 7A

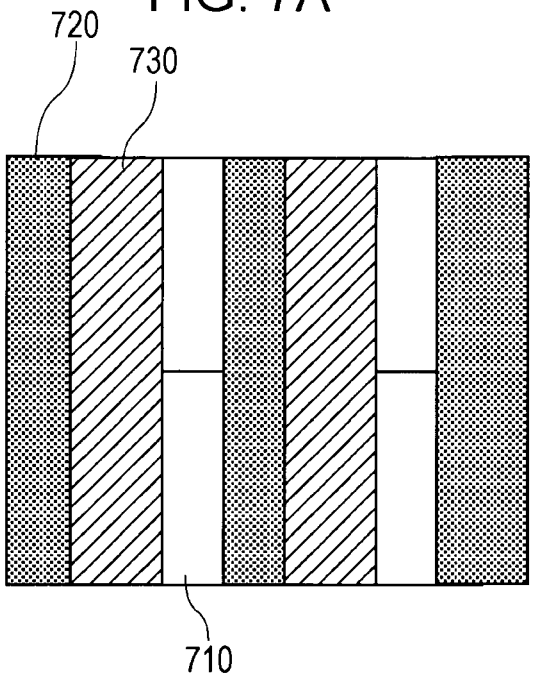
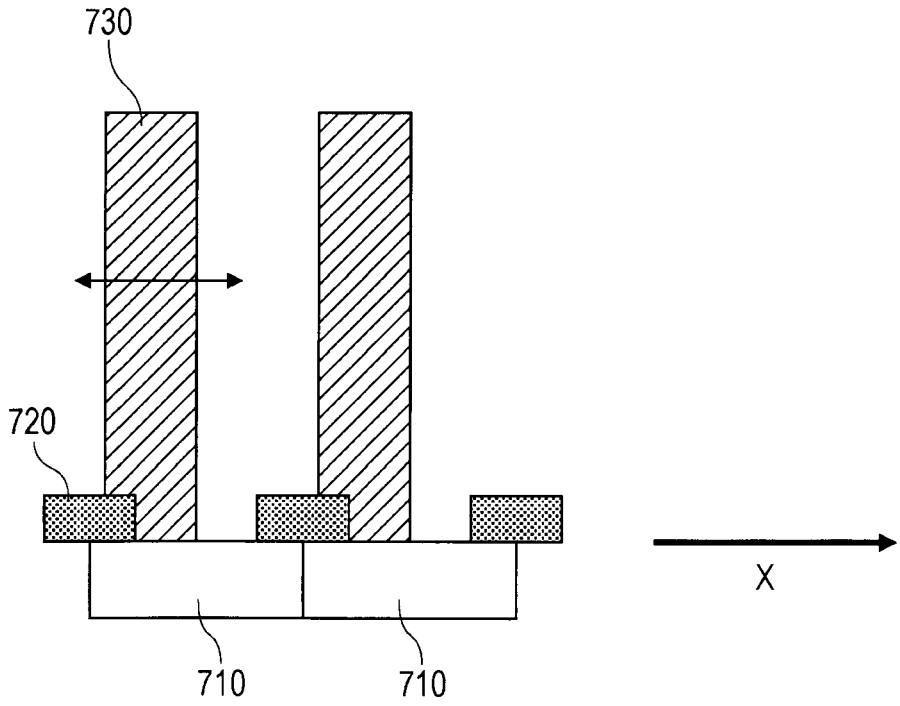


FIG. 7B



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2011/064606

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B6/03 G01N23/04 G01N23/20 G21K1/06
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 G01N G21K G01T

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	WO 2008/029107 A2 (UCL BUSINESS PLC [GB]; OLIVO ALESSANDRO [GB]; SPELLER ROBERT D [GB]) 13 March 2008 (2008-03-13) cited in the application the whole document	1,3,5,8, 10
X,P	WO 2010/147125 A1 (CANON KK [JP]; MUKAIDE TAIHEI [JP]; TAKADA KAZUHIRO [JP]; FUKUDA KAZUN) 23 December 2010 (2010-12-23) abstract page 6, line 27 - page 8, line 27 page 21, line 12 - page 22, line 9 figures 1, 7	1-6,8-12

-/--

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
8 November 2011	17/11/2011

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2011/064606

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 2011/093523 A2 (CANON KK [JP]; MUKAIDE TAIHEI [JP]; NOMA TAKASHI [JP]; FUKUDA KAZUNORI) 4 August 2011 (2011-08-04) abstract paragraph [0036] - paragraph [0040] paragraph [0092] - paragraph [0107] figures 1, 7, 8 -----	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/JP2011/064606

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 2011206184 A1	25-08-2011
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