



(11) **EP 1 769 744 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Description Paragraph(s) 5-7
Claims EN 1

(51) Int Cl.:
A61B 6/03 (2006.01)

(48) Corrigendum issued on:
04.04.2012 Bulletin 2012/14

(45) Date of publication and mention
of the grant of the patent:
12.10.2011 Bulletin 2011/41

(21) Application number: **06016878.8**

(22) Date of filing: **11.08.2006**

(54) **X-ray computer tomography system**
System für Röntgencomputertomographie
Système de tomographie à rayons X par ordinateur

(84) Designated Contracting States:
DE

(30) Priority: **28.09.2005 JP 2005281702**

(43) Date of publication of application:
04.04.2007 Bulletin 2007/14

(73) Proprietors:
• **Kabushiki Kaisha Toshiba**
Tokyo 105-8001 (JP)
• **Toshiba Medical Systems Corporation**
Otawara-shi
Tochigi 324-8550 (JP)

(72) Inventor: **Yamazaki, Masahiko**
Toshiba Medical Systems Corp.
Otawara-shi
Tochigi 324-8550 (JP)

(74) Representative: **Kramer - Barske - Schmidtchen**
Landsberger Strasse 300
80687 München (DE)

(56) References cited:
WO-A-98/04193 WO-A-2006/035328
JP-A- 2003 000 587 JP-A- 2005 185 335
US-A- 5 510 622 US-A- 6 118 840
US-A- 6 118 841 US-A1- 2002 054 659

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 769 744 B9

Description

[0001] The present invention relates to an X-ray computer tomography system equipped with two-dimensional arrays of X-ray detectors.

[0002] A multi-slice X-ray computer tomography system is equipped with a detector in which a plurality of rows of detector elements are juxtaposed in the slice direction. A still improved, so-called two-dimensional array of detectors has appeared. In particular, plural detector modules are arrayed in the direction of channel. Each detector module consists of a matrix of semiconductor detector elements formed on a substrate.

[0003] In these X-ray detectors, contrivances are often made to shorten the apparent center-to-center distance (actual spatial resolution) between detector elements adjacent to each other in the direction of channel. One contrivance is to adopt an offsetting means for offsetting the center position of the detector relative to the slice centerline connecting the focal point of X-rays and the axis of rotation by a distance equal to a fraction of the channel pitch. Another is to adopt a zigzaggedly combtoothed collimator.

[0004] However, where the offsetting means is used, the apparent resolution can be improved only up to a half of the actual resolution. Even where the offsetting means is used in combination with the zigzaggedly combtoothed collimator, the apparent resolution can be improved only up to a quarter of the actual resolution. Where the zigzaggedly combtoothed collimator is adopted, the light reception efficiency decreases in inverse proportion to increase in the shielded area caused by the used collimator. In other words, the sensitivity is deteriorated.

[0005] US 5 510 622 relates to a volumetric CT scanner system in which the effective detector pitch is reduced with roughly 30% by rotating square detector elements 45° about their centres.

[0006] WO 2006/035328 A1 belongs to the state of the art pursuant to Art. 54(3) EPC and relates to a CT apparatus comprising detection modules which are skewed in an axial direction by a selected angle, such as 26,565° or 45°.

[0007] JP 2005 185335 A relates to a CT apparatus with aligned detector elements such that a boundary between the detecting elements is included. In some embodiments, the detector modules are shifted a predetermined distance d_2 relative to each other, in other embodiments, the detector modules are tilted a predetermined angle.

[0008] JP 2003 000587 A relates to an X-ray sensor unit in which a problem caused by a joint between imaging devices can be solved while using a directly connected two-dimensional X-ray imaging device.

[0009] It is an object of the present invention to provide an X-ray computer tomography system equipped with a multi-slice X-ray detector or a two-dimensional array X-ray detector, the system being capable of greatly improving the spatial resolution intrinsic to the X-ray detector by a simple structural modification.

[0010] This is achieved by the X-ray computer tomography system according to claim 1. Further advantageous embodiments are set forth in the dependent claims.

[0011] The X-ray detector has plural detector elements arranged in rows and columns.

[0012] The invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram showing the configuration of a main portion of an X-ray computer tomography system according to an embodiment of the present invention.

FIG. 2 is a plan view showing the array of plural detector modules constituting the X-ray detector of FIG. 1.

FIG. 3A is a detailed view of the detector modules of FIG. 2.

FIG. 3B is a horizontal cross section of the X-ray detector of FIG. 1.

FIG. 3C is a plan view showing the manner in which detector modules are mounted to a support member from the rear side under the condition where the back plate of FIG. 3B has been removed.

FIG. 4 is a detailed view of portion A of FIG. 2.

FIG. 5 is a view supplementarily illustrating improvement of the apparent spatial resolution in the overlap helical scanning mode in the present embodiment.

FIG. 6 is a diagram illustrating the apparent spatial resolution corresponding to FIG. 5.

FIG. 7 is a diagram illustrating a modified example of detector elements of FIG. 3.

FIG. 8 is a plan view of the whole detector corresponding to FIG. 7.

FIG. 9 is a view illustrating coordinate conversion involved in tilting detector modules of the reconstruction unit of FIG. 1.

[0013] Embodiments of the present invention are hereinafter described with reference to the drawings. To reconstruct one slice of tomographic image data by an X-ray computer tomography system, projection data about one revolution (approximately 360°) around a subject to be examined are necessary. Furthermore, where the half scanning technique is used, projection data about 180° + fan angle are necessary. The present invention can be applied to either reconstruction method.

[0014] FIG. 1 shows the configuration of an X-ray computer tomography system associated with the present invention.

The system has an X-ray tube 1 for producing X-rays and an X-ray detector 2 for detecting the X-rays transmitted through a subject to be examined. The X-ray tube 1 and the X-ray detector 2 are supported to a support mechanism (not shown) such that the tube and detector can rotate about an axis of rotation RA while the tube and detector are maintained in mutually opposite positional relationship. The detector 2 is opposite to the X-ray tube 1. When a tube voltage is continuously or intermittently applied to the X-tube 1 from a high voltage-generating device (not shown) via a slip ring during rotation, X-rays are emitted from the X-ray tube 1 continuously or intermittently.

[0015] A data collection portion 3 that is generally known as a data acquisition system (DAS) converts the output signal corresponding to each channel from the X-ray detector 2 into a voltage signal, amplifies it, and converts the signal into a digital signal. The raw data are sent through a noncontacting data transfer device (not shown) and then to a pretreatment device accommodated within a console mounted outside the gantry. In the pretreatment device, the signal undergoes a correction operation such as sensitivity correction. Then, the data are sent as so-called projection data to a reconstruction unit 4. The reconstruction unit 4 reconstructs data about a spatial distribution of X-ray absorption coefficients (hereinafter referred to simply as the images) in a slice or volume based on the projection data. The data are sent to a display device 5, arbitrarily processed such as cross section conversion (MPR), and displayed as images.

[0016] A planar structure of the X-ray detector 2 of FIG. 1 is shown in FIGS. 2 and 3A. The detector 2 has plural detector modules 6, each of which has plural detector elements 7 arranged in rows and columns. The plural detector elements 7 are arranged regularly at a constant center-to-center spacing (channel pitch) in one direction (channel direction). The center-to-center distance (channel pitch) between the detector elements 7 adjacent to each other in this one direction (channel direction) is denoted by Pch. The plural detector elements 7 are regularly arranged at a constant center-to-center spacing (slice pitch) in the other direction (slice direction) perpendicular to the channel direction. The center-to-center distance (slice pitch) of the detector elements 7 adjacent to each other in the other direction (slice direction) is denoted by Psl.

[0017] As shown in FIG. 3B, each of the detector modules 6 consists of a single photodiode array substrate 10 and a single scintillator plate 11 mounted on the surface of the substrate 10. The scintillator plate 11 converts incident X-rays into light. A matrix of photodiodes are formed on the surface of the photodiode array substrate 10. Typically, one photodiode forms one channel. Each detector module 6 is sandwiched among support blocks 13, 14 and a back plate 12 and fixed with screws 20. If necessary, spacers 16 and 17 are disposed between the support blocks 13 and 14, respectively, and the substrate 10 of the detector module 6. As described later, the centerline DL of the detector module 6 is tilted relative to the axis of rotation RA. The centerline DL is a line which passes through the center C of the detector module 6 and is parallel to the longitudinal axis of the photodiode array. The centerline DL is defined as the symmetrical line of the photodiode array. Typically, the angle of tilt θ of the centerline DL of each detector module 6 relative to the axis of rotation RA is constant. However, in an arrangement not according to the present invention, the angle of tilt θ of the centerline DL of each detector module 6 relative to the axis of rotation RA does not need to be constant. For example, the angle of tilt θ of the centerline DL of each detector module 6 relative to the axis of rotation RA may be smallest in the center of array and increase toward either end. The angle of tilt θ of the centerline DL of each detector module 6 relative to the axis of rotation RA may be greatest in the center of array and decrease toward either end.

[0018] As shown in FIG. 3C, positioning holes 18 are formed in one support block 13 at regular intervals. Positioning holes 19 are formed in the other support block 14 at the same intervals. Similar holes are formed also in the spacers 16, 17, substrate 10, and back plate 12. Positioning pins are inserted in the holes to improve the positioning accuracy. The positioning holes 19 and the positioning holes 18 make pairs. The holes 19 are shifted in the direction perpendicular to the axis of rotation RA by a distance DS corresponding to the angle of tilt of each detector module 6.

[0019] The detector modules 6 are arranged along the channel direction perpendicular to the axis of rotation RA. The centerline DL of each module 6 is tilted at a given angle (angle selected, for example, from a range from 2° to 10°) relative to the axis of rotation RA or a line substantially parallel to it. Additionally, the plural detector modules 6 are arranged along a reference line CL perpendicular to the axis of rotation RA. Furthermore, each detector module 6 is so arranged that its center position C is located on the reference line CL. As shown in FIG. 3C, the positions where the detector modules 6 are mounted relative to the slice direction are designed according to the angle of tilt.

[0020] Let N be the number of rows of the elements of the X-ray detector 2. The angle of tilt is set to

$$\tan^{-1} \left(\frac{Pch}{m \cdot Psl} \right)$$

where Pch is the center-to-center distance (channel pitch) between detector elements adjacent to each other in the channel direction, Psl is the center-to-center distance (slice pitch) between detector elements adjacent to each other in the slice direction, and m is an integer that is greater than 2 and less than N. The highest apparent spatial resolution is

achieved when $m = N$, i.e., when the angle of tilt is given by

$$\tan^{-1} \left(\frac{Pch}{N \cdot Psl} \right)$$

[0021] As shown in FIG. 4, the highest apparent spatial resolution is given by

$$\frac{Pch}{N}$$

That is, the spatial resolution can be reduced to $1/N$ of the actual spatial resolution Pch of the detector 2. In other words, the apparent resolution is improved to a value higher than the actual resolution of the detector 2 by a factor of N . If a QQ offset means for offsetting the center position of the detector relative to the projection centerline connecting the focal point of X-rays and the axis of rotation RA by a distance equal to a fraction of the channel pitch Pch is used in combination, the apparent spatial resolution can be reduced to $1/(2 \cdot N)$, and the apparent resolution can be improved by a factor of $(2 \cdot N)$.

[0022] In an arrangement not according to the present invention, the plural detector modules 6 may be arrayed in a line in the same way as in the prior art and the whole X-ray detector 2 may be tilted relative to the axis of rotation RA by a predetermined angle of tilt.

[0023] In the helical scanning mode, too, the helical pitch (distance traveled by the top plate per revolution) is set such that partial overlap occurs as shown in FIG. 5. Thus, the apparent spatial resolution in the overlapped portions can be reduced to $1/m$ and the apparent resolution can be improved by a factor of $2 \cdot m$, as shown in FIG. 6. Furthermore, the apparent spatial resolution can be reduced to $1/(2 \cdot N)$ and the apparent resolution can be improved by a factor of $2 \cdot N$ by optimizing the helical pitch to $\{Ps1 \times (N - 1)\}/N$.

[0024] In an arrangement not according to the present invention, similar effect can be produced by shaping the light-sensitive region of each detector element 7, i.e., the planar geometry of the scintillator chip 8, into a parallelogram, as shown in FIGS. 7 and 8, tilted by an angle of tilt given by

$$\tan^{-1} \left(\frac{Pch}{N \cdot Psl} \right)$$

[0025] Because of the tilt of the modules 6, it is almost unnecessary to improve the processing for reconstruction. As shown in FIG. 9, it is only necessary to perform coordinate conversions as a pretreatment for the reconstruction. A positional vector R of each element (channel) when there is no tilt is given by

$$R(i, j) = R(N) + r(i, j)$$

where N is a module number, i is a channel number, and j is a row number.

[0026] Let θ be the angle of tilt. Let $M(N, \theta)$ be a rotation matrix when the sensitive surface of module number N is rotated through an angle of rotation θ . The positional vector R' of each rotated element is given by

$$R'(i, j) = R(N) + M(N, \theta) \cdot r(i, j)$$

[0027] At the position of the converted positional vector $R'(i, j)$ of each element, back projection is performed during cone-beam reconstruction. The back projection is the same as the processing performed heretofore. As a result, volume data can be obtained.

[0028] As described so far, according to the present invention, the spatial resolution intrinsic to the detector can be

improved greatly by a simple structural modification consisting of mounting the X-ray detector modules at an angle to the axis of rotation.

[0029] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. An X-ray computer tomography system comprising:

an X-ray tube (1) for producing X-rays;
 an X-ray detector (2) having a plurality of detector modules (6) each having a plurality of detector elements (7) arranged in perpendicular rows and columns of a matrix, the detector elements (7) being adapted to detect X-rays transmitted through a subject to be examined;
 a support mechanism by which the X-ray tube and the X-ray detector are held so as to be rotatable about an axis (RA) of rotation;
 a reconstruction unit (4) for reconstructing images based on an output from the X-ray detector; and
 a display portion (5) for displaying the reconstructed images;
 wherein the detector modules (6) are contiguously arranged along a reference axis (CL) the reference axis (CL) being substantially perpendicular to the axis of rotation (RA), the detector modules (6) being tilted relative to the axis of rotation (RA) by an angle of tilt within a plane that is substantially perpendicular to an incident direction of the X-rays,
 wherein said detector modules have their center located on said reference axis (CL), and **characterised in that** said angle of tilt is set to

$$\tan^{-1}\left(\frac{Pch}{m \cdot Psl}\right)$$

where N is the number of columns in the X-ray detector (2) along said axis of rotation (RA), Pch is the center-to-center distance between detector elements (7) adjacent to each other along, the reference axis (CL), Psl is the center-to-center distance between detector elements (7) adjacent to each other along said axis of rotation (RA), and m is an integer that is not less than 2 and not more than N.

2. The X-ray computer tomography system of claim 1, wherein said angle of tilt is set to

$$\tan^{-1}\left(\frac{Pch}{N \cdot Psl}\right)$$

3. The X-ray computer tomography system of claim 2, wherein each of said detector modules (6) has a substrate (10), a photodiode array formed on the substrate, and a scintillator plate (11) disposed over the photodiode array.

4. The X-ray computer tomography system of claim 2 or 3, wherein said detector modules (6) are sandwiched among a pair of support blocks (13, 14) and a back plate (12).

5. The X-ray computer tomography system of claim 4, wherein plural collimator plates are laid between said one pair of support blocks (13, 14).

6. The X-ray computer tomography system of claim 4 or 5, wherein said one pair of support blocks (13, 14) is provided with plural pairs of positioning holes (18, 19) which have been shifted by a given distance with respect to said reference line.

7. The X-ray computer tomography system of any one of claims 2 to 6, wherein said reconstruction unit (4) has a function of converting coordinates of the position of each of said detector elements (7) by a rotation matrix corresponding to the angle of tilt of said detector modules (6).

5

Patentansprüche

1. Röntgen-Computertomografiesystem mit
einer Röntgenröhre (1) zum Erzeugen von Röntgenstrahlen,
einem Röntgendetektor (2), der eine Vielzahl von Detektormodulen (6) enthält, die jeweils eine Vielzahl von Detektorelementen (7) enthalten, die in zueinander senkrechten Reihen und Spalten einer Matrix angeordnet sind, wobei die Detektorelemente (7) zum Detektieren von Röntgenstrahlen, die durch ein zu untersuchendes Subjekt transmittiert werden, angepasst sind,
einer Stützvorrichtung, durch die die Röntgenröhre und der Röntgendetektor derart gehalten werden, dass sie um eine Rotationsachse (RA) rotierbar sind,
einer Rekonstruktionseinheit (4) zum Rekonstruieren von Bildern basierend auf einer Ausgabe von dem Röntgendetektor, und
einem Anzeigeteil (5) zum Anzeigen der rekonstruierten Bilder,
bei dem die Detektormodule (6) aneinander angrenzend entlang einer Referenzachse (CL) angeordnet sind, wobei die Referenzachse (CL) im Wesentlichen senkrecht zu der Rotationsachse (RA) ist, wobei die Detektormodule (6) relativ zu der Rotationsachse mit einem Kippwinkel innerhalb einer Ebene, die im Wesentlichen senkrecht zu der Einfallrichtung der Röntgenstrahlen ist, gekippt sind,
bei dem die Detektormodule ihre Zentren an der Referenzachse (CL) haben, und
dadurch gekennzeichnet, dass der Kippwinkel auf

25

$$\tan^{-1}\left(\frac{Pch}{m \cdot Psl}\right)$$

30

festgelegt ist, wobei N die Anzahl der Spalten entlang der Rotationsachse (RA) in dem Röntgendetektor (2) ist, Pch die Mittenentfernung zwischen aneinandergrenzenden Detektorelementen (7) entlang der Referenzachse (CL) ist, Psl die Mittenentfernung zwischen aneinandergrenzenden Detektorelementen (7) entlang der Rotationsachse (RA) ist, und m eine ganze Zahl ist, die nicht kleiner als 2 und nicht größer als N ist.

35

2. Röntgen-Computertomografiesystem nach Anspruch 1, bei dem der Kippwinkel auf

40

$$\tan^{-1}\left(\frac{Pch}{N \cdot Psl}\right)$$

45

festgelegt ist.

3. Röntgen-Computertomografiesystem nach Anspruch 2, bei dem jedes der Detektormodule (6) ein Substrat (10), ein auf dem Substrat gebildetes Photodiodenarray und eine über dem Photodiodenarray angeordnete Szintillatorplatte (11) enthält.

50

4. Röntgen-Computertomografiesystem nach Anspruch 2 oder 3, bei dem die Detektormodule (6) zwischen einem Paar von Stützblöcken (13, 14) und einer Rückplatte (12) eingeschoben sind.

5. Röntgen-Computertomografiesystem nach Anspruch 4, bei dem mehrere Kollimatorplatten zwischen dem Paar von Stützblöcken (13, 14) eingelegt ist.

55

6. Röntgen-Computertomografiesystem nach Anspruch 4 oder 5, bei dem das eine Paar von Stützblöcken (13, 14) mit mehreren Paaren von Positionierungslöchern (18, 19) ausgestattet ist, die mit Bezug auf die Referenzlinie um

einen gegebenen Abstand verschoben worden sind.

7. Röntgen-Computertomographiesystem nach einem der Ansprüche 2 bis 6, bei dem die Rekonstruktionseinheit (4) eine Funktion zum Konvertieren der Koordinaten der Position jedes Detektorelementes (7) mittels einer Rotationsmatrix aufweist, die dem Kippwinkel der Detektormodule (6) entspricht.

Revendications

1. Système de tomographie à rayons X par ordinateur, comprenant :

un tube à rayons X (1) pour produire des rayons X ;
 un détecteur de rayons X (2) ayant une pluralité de modules de détection (6) ayant chacun une pluralité d'éléments détecteurs (7) aménagés en rangées et colonnes perpendiculaires d'une matrice, les éléments détecteurs (7) étant à même de détecter des rayons X transmis à travers un patient à examiner ;
 un mécanisme de support par lequel le tube à rayons X et le détecteur de rayons X sont maintenus de manière à pouvoir tourner autour d'un axe de rotation (RA) ;
 une unité de reconstruction (4) pour reconstruire des images sur la base d'une sortie du détecteur de rayons X ; et
 une portion d'affichage (5) pour afficher les images reconstruites ;
 dans lequel les modules de détection (6) sont aménagés de manière contiguë le long d'un axe de référence (CL), l'axe de référence (CL) étant sensiblement perpendiculaire à l'axe de rotation (RA), les modules de détection (6) étant inclinés par rapport à l'axe de rotation (RA) d'un angle d'inclinaison dans un plan qui est sensiblement perpendiculaire à une direction incidente des rayons X,
 dans lequel lesdits modules de détection ont leur centre situé sur ledit axe de référence (CL) et **caractérisé en ce que** ledit angle d'inclinaison est réglé à :

$$\operatorname{tg}^{-1}\left(\frac{Pch}{m.Psl}\right)$$

où N est le nombre de colonnes dans le détecteur de rayons X (2) le long dudit axe de rotation (RA), Pch est la distance de centre à centre entre les éléments détecteurs adjacents l'un de l'autre le long de l'axe de référence (CL), Psl est la distance de centre à centre entre des éléments détecteurs (7) adjacents l'un à l'autre le long dudit axe de rotation (RA), et m est un nombre entier qui n'est pas inférieur à 2 et pas supérieur à N.

2. Système de tomographie à rayons X par ordinateur selon la revendication 1, dans lequel ledit angle d'inclinaison est réglé à :

$$\operatorname{tg}^{-1}\left(\frac{Pch}{N.Psl}\right)$$

3. Système de tomographie à rayons X par ordinateur selon la revendication 2, dans lequel chacun desdits modules de détection (6) a un substrat (10), un réseau de photodiodes formé sur le substrat et une plaque de scintillation (11) disposée par-dessus le réseau de photodiodes.

4. Système de tomographie à rayons X par ordinateur selon la revendication 2 ou 3, dans lequel lesdits modules de détection (6) sont pris en sandwich entre une paire de blocs de support (13, 14) et une plaque d'appui (12).

5. Système de tomographie à rayons X par ordinateur selon la revendication 4, dans lequel de multiples plaques collimatrices sont déposées entre ladite une paire de blocs de support (13, 14).

6. Système de tomographie à rayons X par ordinateur selon la revendication 4 ou 5, dans lequel ladite une paire de blocs de support (13, 14) est pourvue de multiples paires de trous de positionnement (18, 19) qui ont été décalés d'une distance donnée par rapport à ladite ligne de référence.

EP 1 769 744 B9

7. Système de tomographie à rayons X par ordinateur selon l'une quelconque des revendications 2 à 6, dans lequel ladite unité de reconstruction (4) a une fonction de conversion de coordonnées de la position de chacun des éléments détecteurs (7) par une matrice de rotation correspondant à l'angle d'inclinaison desdits modules de détection (6).

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

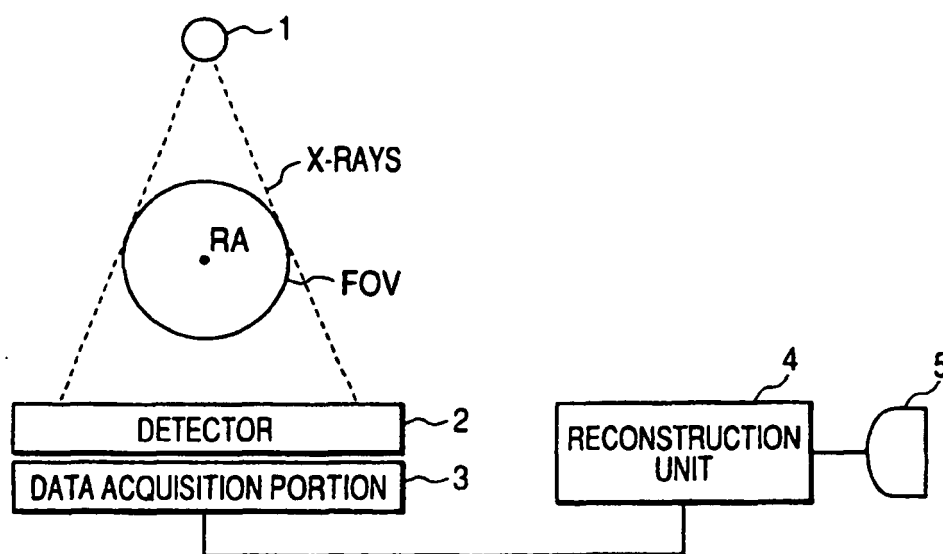


FIG. 2

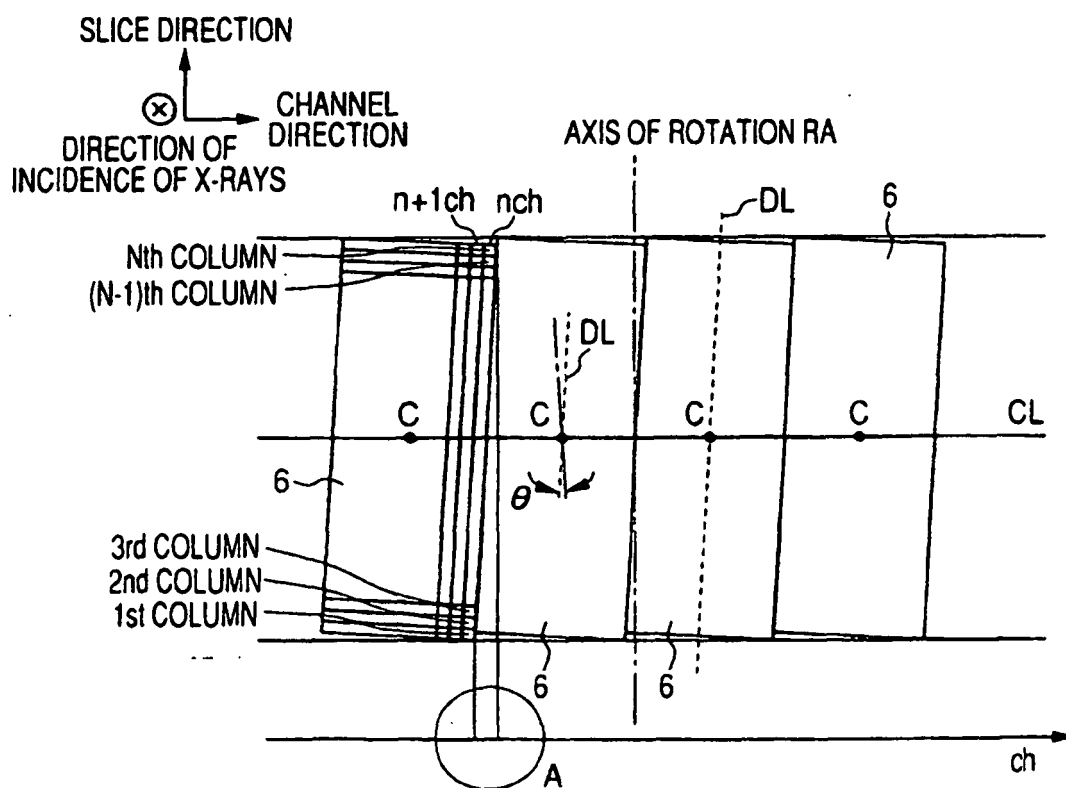


FIG. 3A

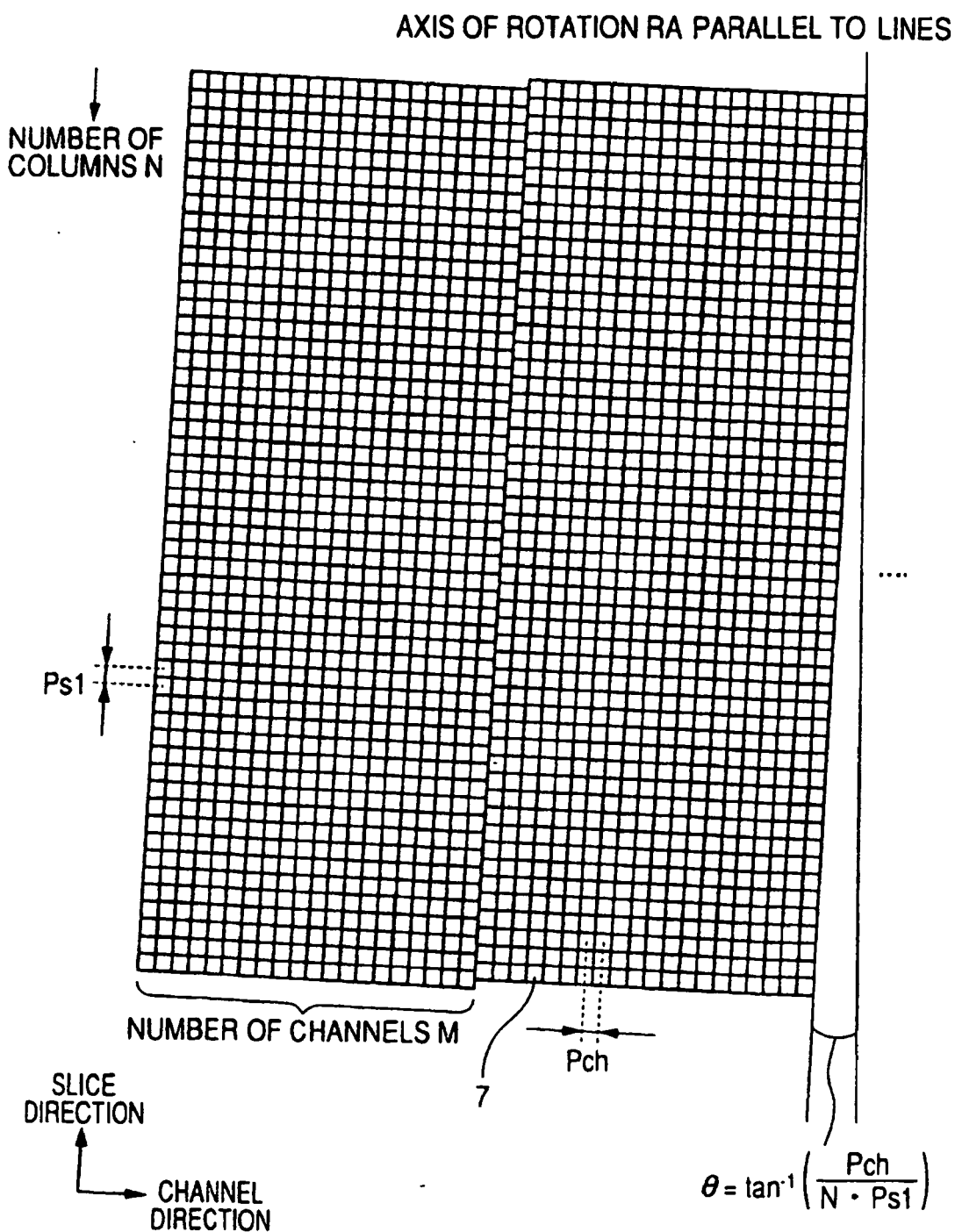


FIG. 3B

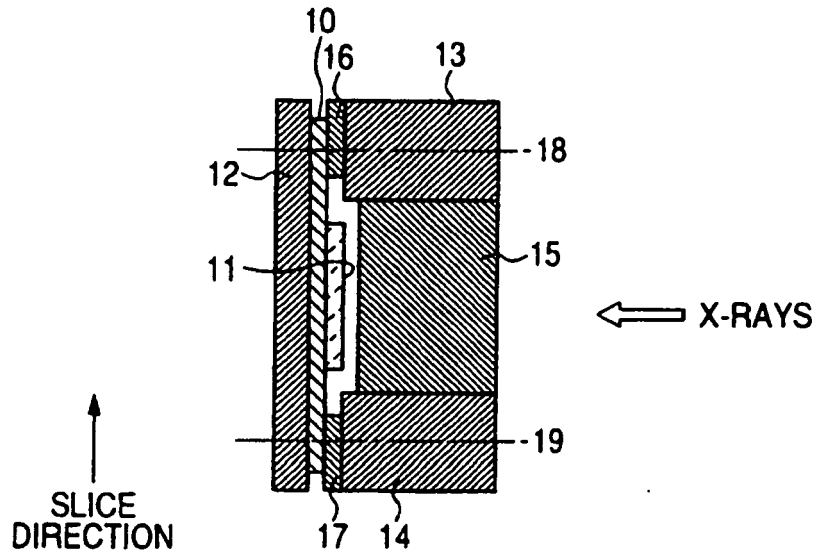


FIG. 3C

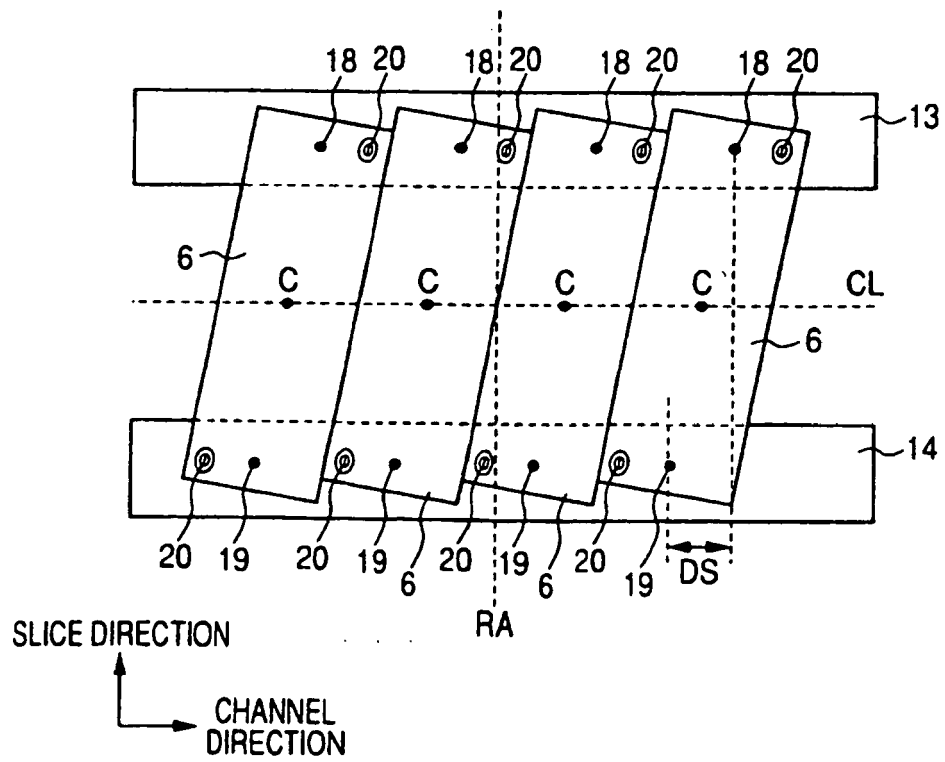


FIG. 4

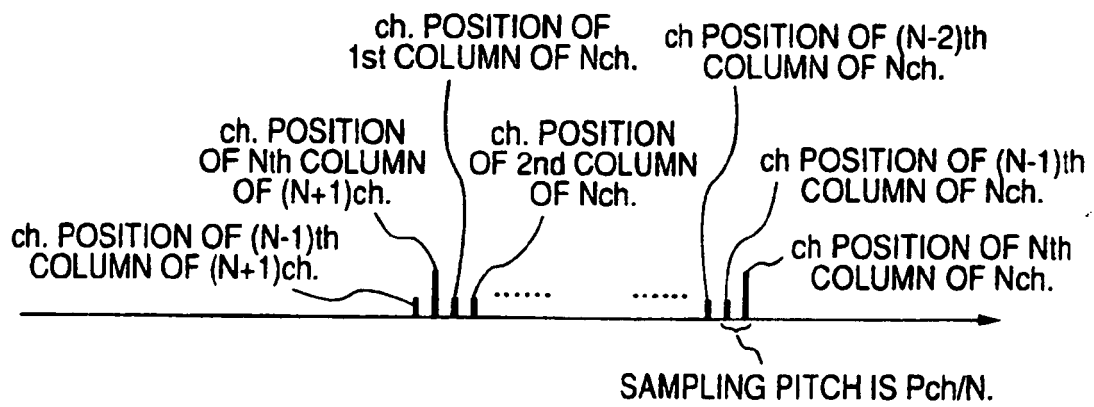


FIG. 5

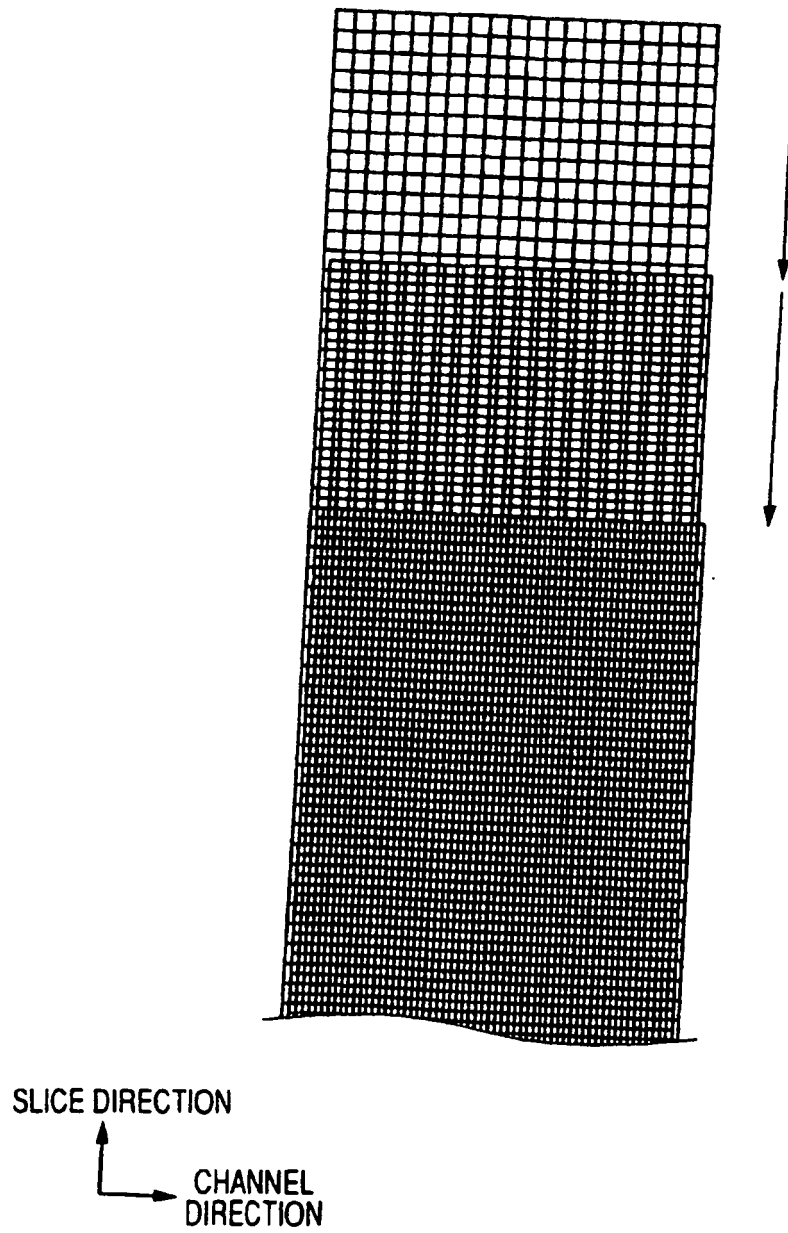


FIG. 6

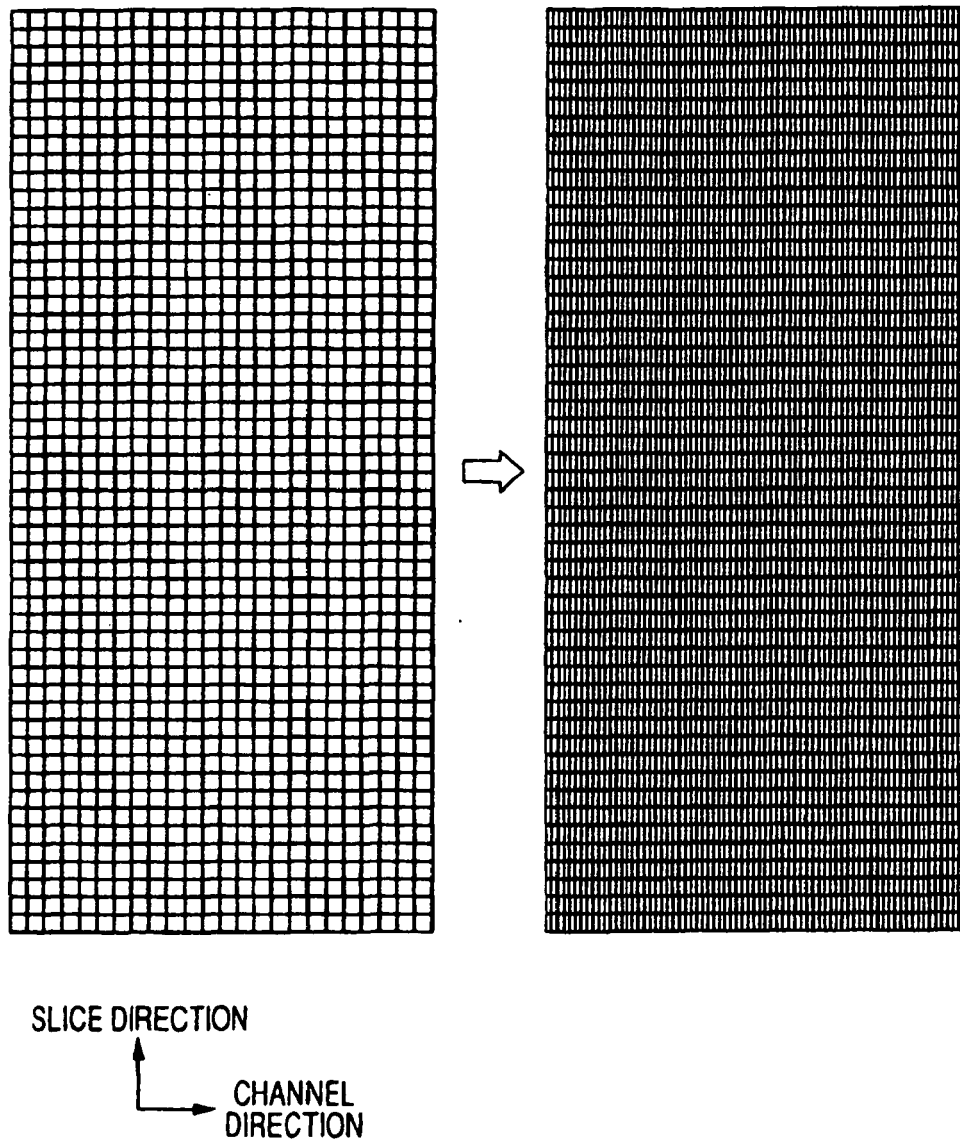


FIG. 7

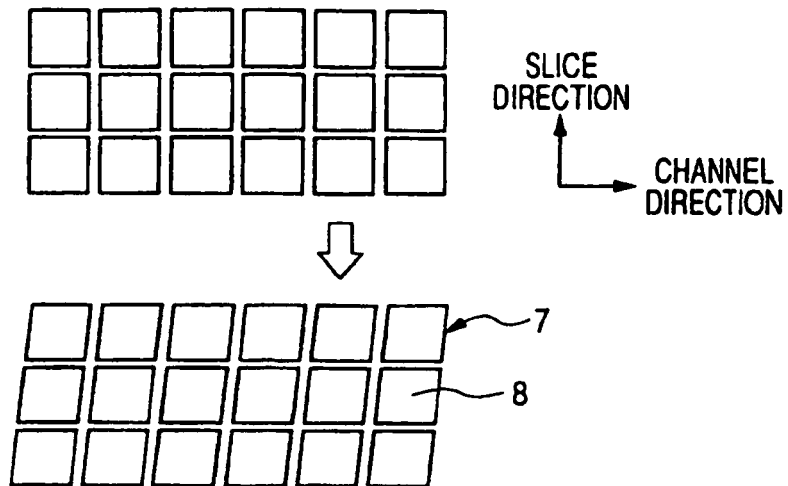


FIG. 8

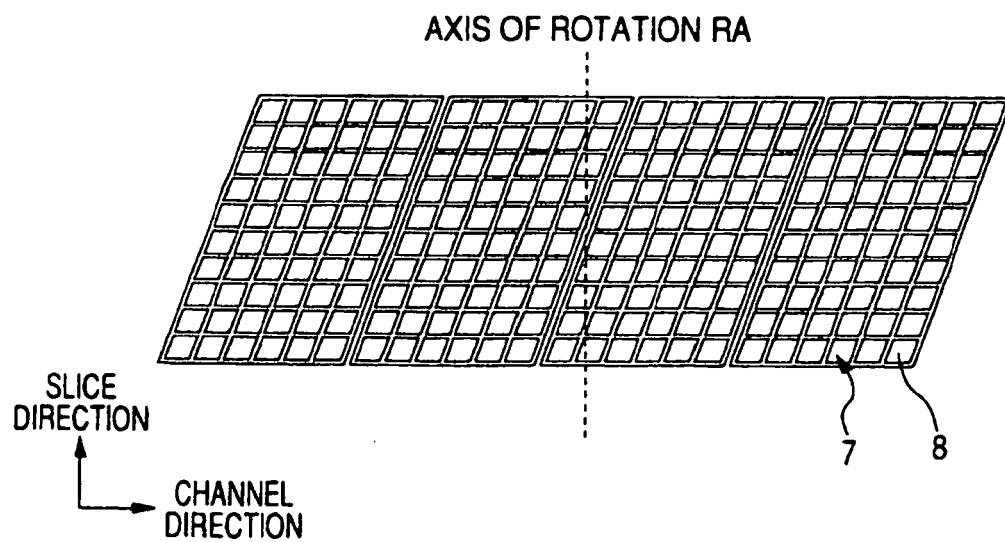
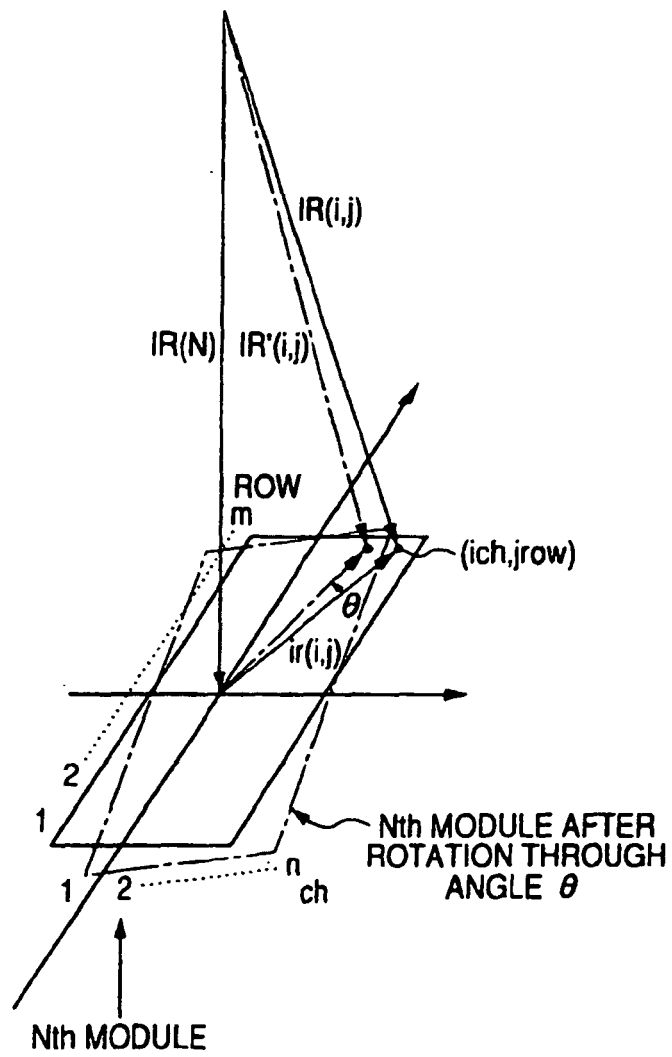


FIG. 9



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5510622 A [0005]
- WO 2006035328 A1 [0006]
- JP 2005185335 A [0007]
- JP 2003000587 A [0008]