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(54) **METHOD AND APPARATUS FOR CEPHALOMETRIC IMAGING**

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Filed: **Mar. 8, 2004**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
A61B 6/14 (2006.01)

(52) **U.S. Cl.** **378/38**; 378/191; 378/197
(58) **Field of Classification Search** 378/38–40, 378/196, 197, 191
See application file for complete search history.

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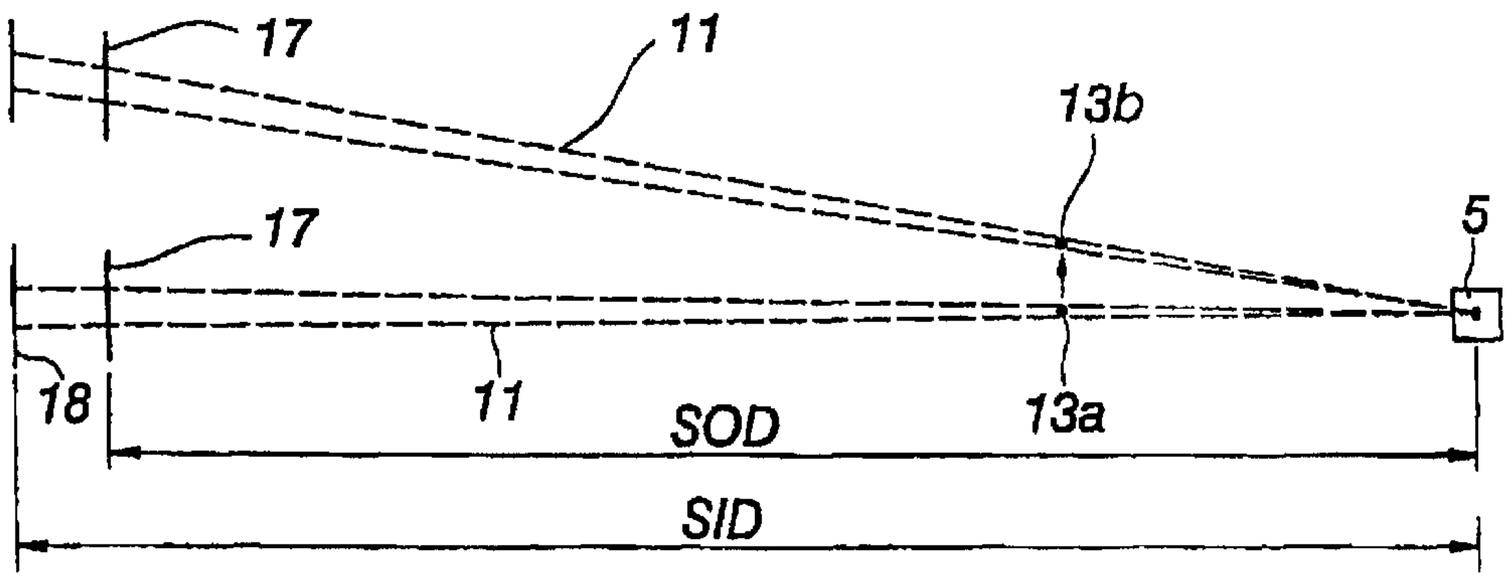
(57) **ABSTRACT**

The invention relates to a method for cephalometric imaging using an apparatus (**1**) which comprises an X-ray source (**5**), a line detector camera (**8**) equipped with a digital detector, which line detector camera is located to a position far away from the X-ray source (**5**) for carrying out cephalometric imaging while the slot of the line detector camera is substantially vertical. In cephalometric imaging, an X-ray beam (**11**) located substantially on the vertical plane is directed from the X-ray source (**5**) through the object being imaged, and the X-ray source (**5**) is at the same time turned about the rotation center (**13**) located between the X-ray source and the line detector camera (**8**) in order to scan the object being imaged in the horizontal direction, whereby the line detector camera (**8**) is moved during the scanning movement in such a way that the ray beam (**11**) meets the slot (**14**) of the line detector camera. In the method, the effective focal spot is transferred from the rotation center (**13**) to the focal spot of the X-ray source (**5**) by transferring the rotation center by means of a transverse linear movement (A) with respect to the ray beam (**11**).

19 Claims, 3 Drawing Sheets



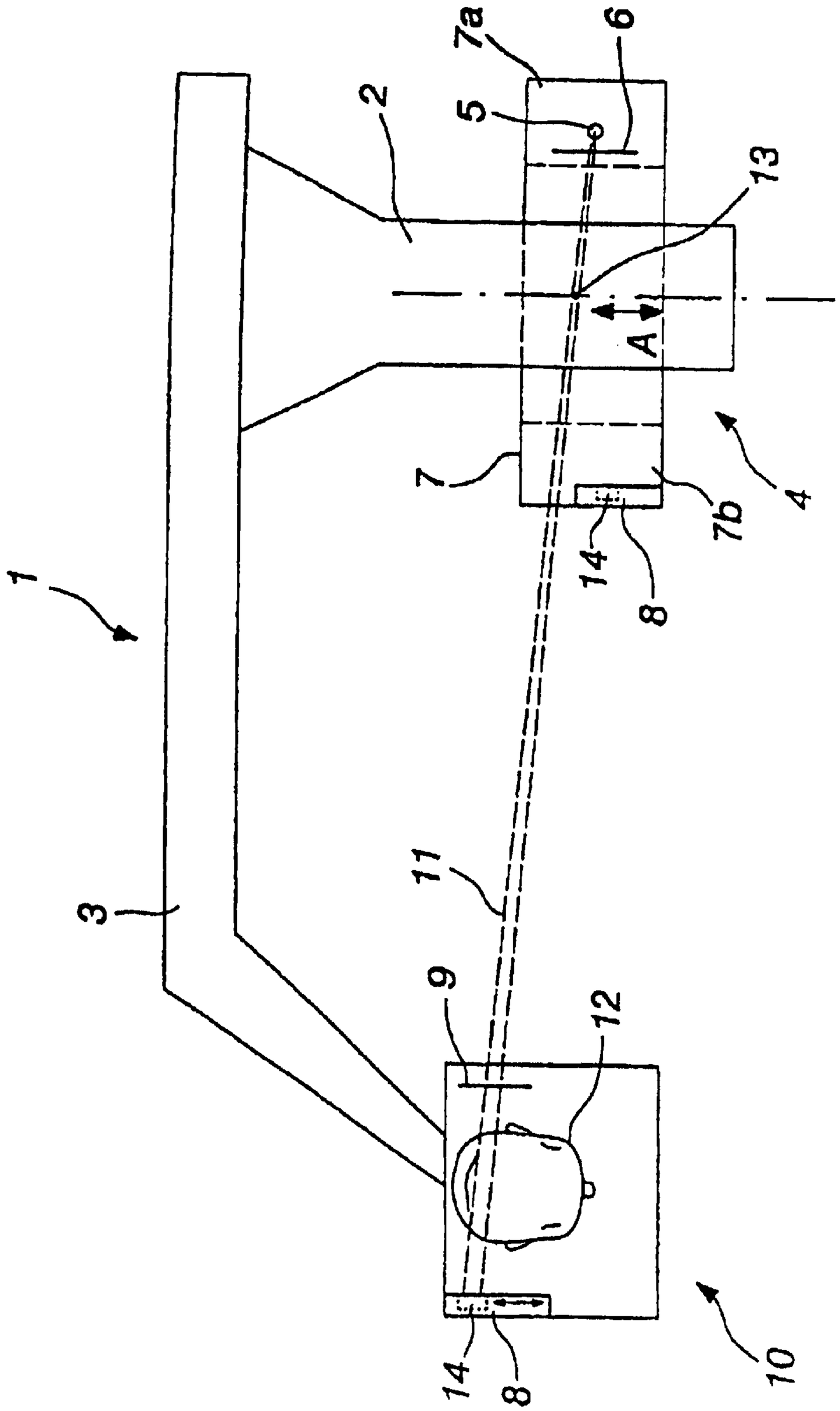


Fig. 1

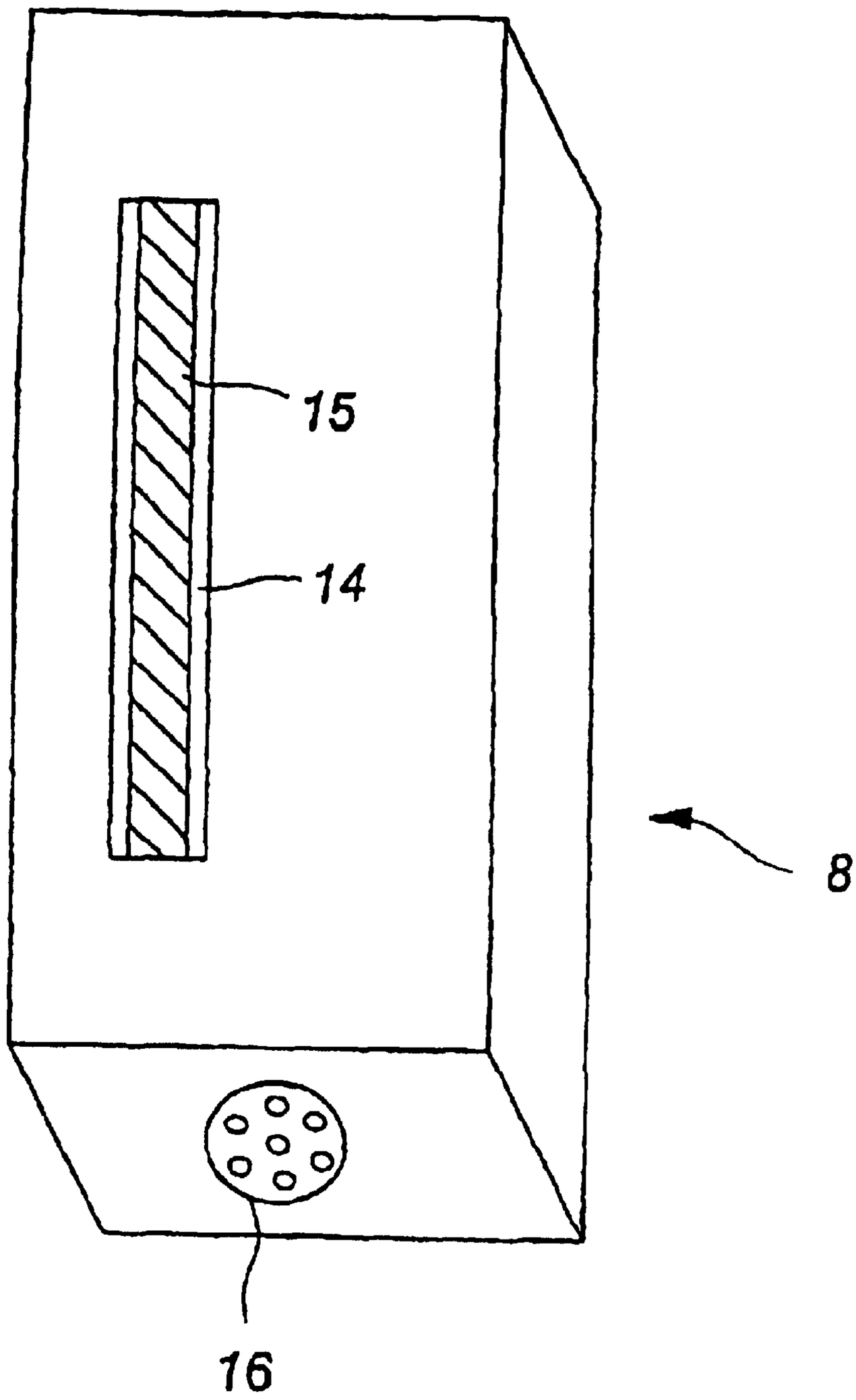


Fig.2

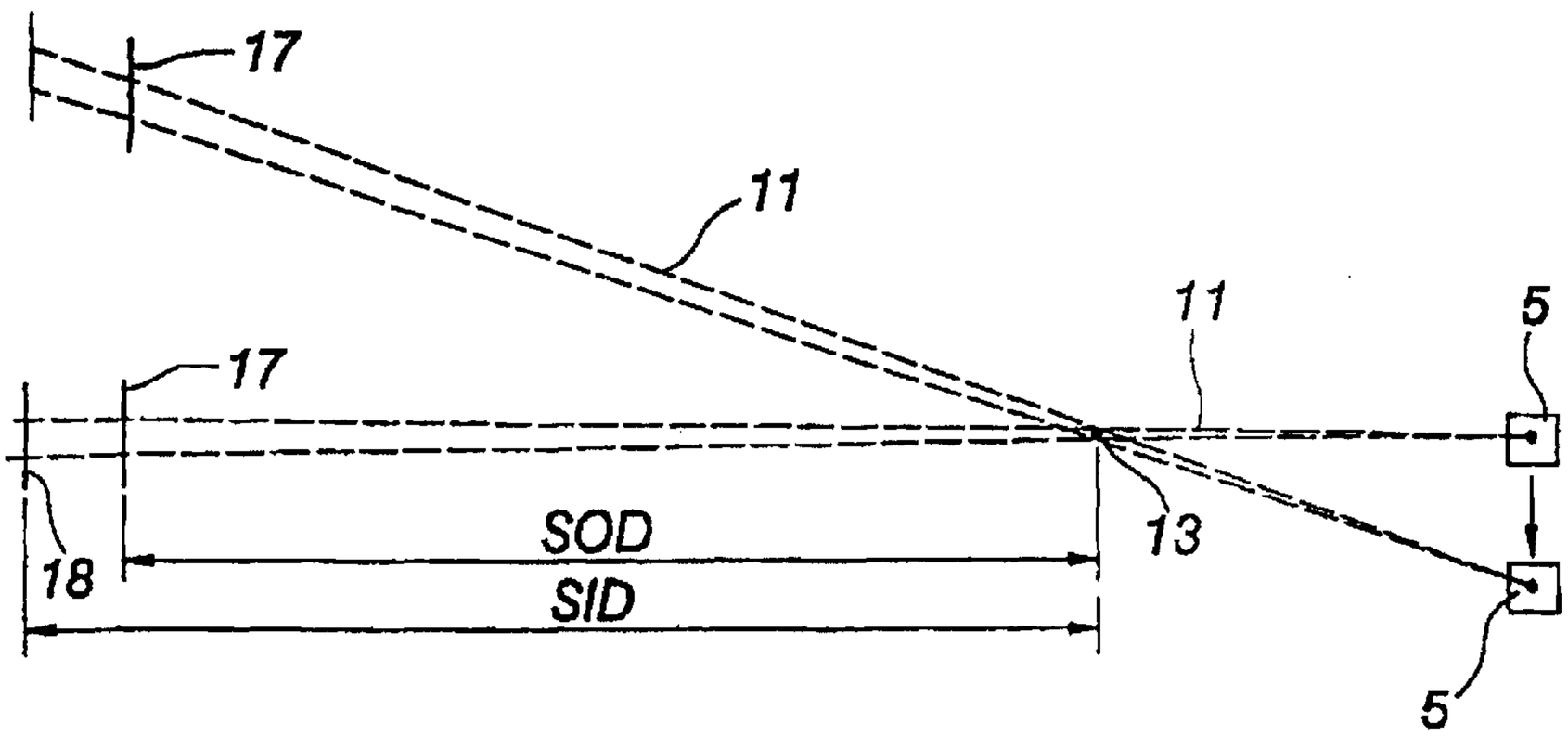


Fig.3
Prior Art
Amended

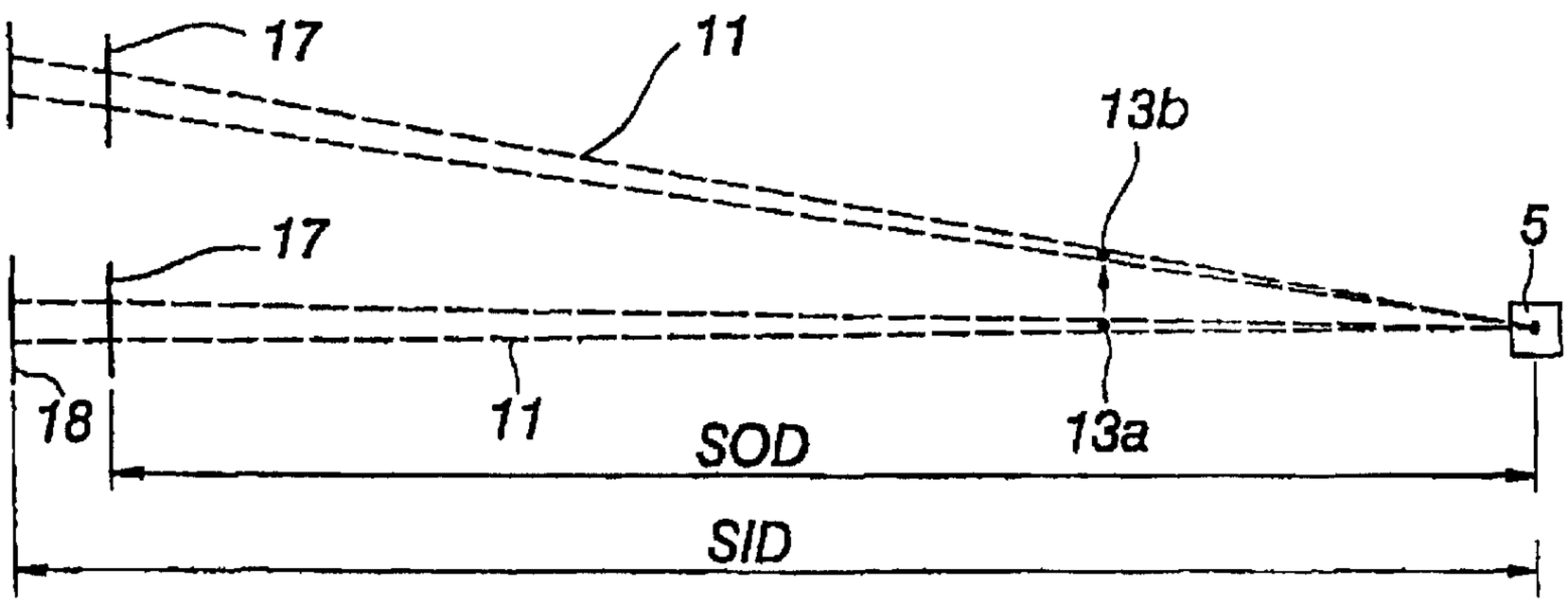


Fig.4

METHOD AND APPARATUS FOR CEPHALOMETRIC IMAGING

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS REFERENCE TO RELATED APPLICATIONS

[The present application is a continuation application of U.S. patent application Ser. No. 10/204,104, filed Oct. 10, 2002, now U.S. Pat. No. 6,731,717.That application is the U.S. national stage application of International Application PCT/FI01/00137, filed Feb. 14, 2001, which application was published on Aug. 23, 2001 as International Publication WO 01/60257. The International Application claims the priority of Finnish Patent Application 20000369, filed Feb. 18, 2000.]

The present application is a reissue application of U.S. patent application Ser. No. 10/795,638, filed Mar. 8, 2004, now U.S. Pat. No. 6,891,921. That application is a continuation of application Ser. No. 10/204,104, filed as Application No. PCT/FI01/00137 on Feb. 14, 2001, now U.S. Pat. No. 6,731,717. The International Application claims the priority of Finnish Patent Application 20000369, filed Feb. 18, 2000.

BACKGROUND OF THE INVENTION

The present invention relates to a method for cephalometric imaging using an apparatus which comprises an X-ray source, a line detector camera equipped with a digital detector, which line detector camera is located to a position far away from the X-ray source for carrying out cephalometric imaging while the slot of the line detector camera is substantially vertical, whereby in cephalometric imaging, an X-ray beam located substantially on the vertical plane is directed from the X-ray source through the object being imaged, and the X-ray source is at the same time turned about the rotation centre located between the X-ray source and the line detector camera in order to scan the object being imaging in the horizontal direction, whereby the line detector camera is moved during the scanning movement in such a way that the ray beam meets the slot of the line detector camera. The publication U.S. Pat. No. 5,511,106 discloses this type of scanning method for cephalometric imaging.

SUMMARY OF THE INVENTION

When cephalometric imaging is carried out in the manner described above, the vertical ratio of enlargement remains the same as without the scanning movement, but the horizontal ratio of enlargement, on the other hand, changes because the rotation centre changes into the effective focal spot instead of the focal spot of the X-ray source. Accordingly, the object of the present invention is to provide a method by means of which the ratios of enlargement in cephalometric imaging can be maintained the same in the vertical and horizontal directions in cephalometric imaging, which is carried out by means of the turning movement taking place about the rotation centre of the X-ray source. A further object is to provide a method which can be implemented by using existing panoramic X-ray imaging apparatuses, which already comprise the means needed to perform the required movements. To achieve this object, the method relating to the invention is characterised in that in the method, the effective focal spot is transferred from the rotation centre to the focal spot of the X-ray source by transferring the rotation centre by means of a transverse linear movement with respect to the ray beam.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in greater detail in the following, with reference to the accompanying drawings, in which:

FIG. **1** shows a diagrammatic top view of an apparatus applicable for the method according to the invention,

FIG. **2** shows diagrammatically a view in principle of a camera used in the apparatus according to FIG. **1**,

FIG. **3** shows diagrammatically the effect of the rotary movement of the X-ray source on the effective focus, and

FIG. **4** shows diagrammatically the effect of the transfer of the rotation centre of the rotary movement of the X-ray source on the effective focus.

DETAILED DESCRIPTION OF THE INVENTION

The apparatus **1** according to FIG. **1** comprises a support part **2**, beneath which is connected a panoramic imaging apparatus **4** which turns in a pivoting manner around the rotation centre **13**, the imaging apparatus comprising a C arm **7**, on one vertical branch **7**a of which is arranged an X-ray source **5** and the primary collimator **6** in its vicinity, and on the other branch **7**b a line detector camera **8**.

FIG. **2** shows diagrammatically one implementation of a line detector camera **8**, wherein on one side of the camera is formed a slot **14**, behind which, inside the camera **8**, is a digital detector **15**, for example, a CCD sensor. The panoramic imaging apparatus **4** and its operation are, as such, known to a person skilled in the art. In panoramic imaging, the object to be imaged is placed between the branch parts **7**a, **7**b of the C arm by means of appropriate guides and supports, after which the X-ray source **5** is switched on and the C arm is rotated about the rotation centre **13**, whereby the aperture of the primary collimator **6** is selected in such a way that the ray beam **11**, which is substantially on the vertical plane, is directed at the detector **15** behind the substantially vertical slot **14** of the line detector camera **8** on the branch part **7**b of the C arm **7**, from which detector the image data is transmitted further, for example, to a microprocessor. This process of panoramic imaging will not be described in greater detail in this connection.

To the support part **2** is connected a supporting arm **3**, at the other end of which is the cephalometric imaging apparatus **10**, which comprises a line detector camera **8** to be placed behind the object being imaged, and a secondary collimator **9** to be placed in front of the object being imaged. In cephalometric imaging, the patient's head is scanned by means of the ray beam **11** from right to left or vice versa.

In the method according to the invention, cephalometric imaging is carried out by turning the X-ray source **5** about a rotation centre **13** to image the patient's head **12** by means of a vertically positioned ray beam **11**. FIG. **3** shows a situation where the rotation centre **13** remains in place, in which case, when the X-ray source **5** turns about the rotation centre, the X-ray beams **11** travel in each angular position via the rotation centre **13**, whereby the rotation centre **13** becomes the effective focal spot for the radiation coming through the object in the layer **17** being imaged on the image plane (detector) **18**. In this case, the ratio of enlargement, which is determined by the ratio of the distance (SID) between the focus and the image plane to the distance (SOD) between the focus and the object, is the ratio of the distance between the rotation centre **13** and the image layer **17** to the distance between the rotation centre **13** and the image plane **18**.

It is for this reason that, according to the invention, in cephalometric imaging the rotation centre **13** is arranged to be transferred by linear movement transversely with respect to the ray beam **11**, as shown by reference marking A in FIG. **1**. FIG. **4** shows a situation where the rotation centre has been transferred by linear movement from position **13**a to position **13**b, whereby the focal spot is transferred to the X-ray source **5**, in which case also the horizontal ratio of enlargement remains the same.

What is claimed is:

1. A method for operating a panoramic imaging apparatus to provide improved **[**tomographic**]** cephalometric images, the panoramic imaging apparatus being capable of operating in a mode in which an X-ray source and radiation sensor, spaced from said **[**radiation**]** *X-ray* source at a first distance, are rotated about an intermediate vertical rotation center to provide a panoramic image from a subject positioned between the X-ray source and the radiation sensor, said method comprising the steps of:

positioning a radiation receiver to receive radiation from said X-ray source, said radiation receiver being located at a second distance from said X-ray source greater than said first distance;

placing a subject for cephalometric imaging in front of the radiation receiver;

projecting radiation from the X-ray source along a horizontal radiation path to apply radiation from the X-ray source to the radiation receiver;

carrying out a first motion comprising rotating the X-ray source **[**about the center of rotation**]** *while otherwise maintaining the X-ray source generally stationary*;

carrying out a second motion comprising horizontally translating the center of rotation in a direction generally transverse to the radiation path during application of the radiation to the radiation receiver;

wherein the effective focal spot of the X-ray source is transferred to the general location of the X-ray source; and

carrying out a third motion comprising translating the radiation receiver in a horizontal direction generally transverse to the radiation path, said first, second, and third motions producing a **[**tomographic**]** cephalometric image from the panoramic imaging apparatus for which the effective focal point for the X-ray source has been altered in a manner to reduce differences in vertical and horizontal ratios of enlargement.

2. The method according to claim **1** further including the step of collimating the radiation applied to the radiation receiver.

3. An apparatus for providing a **[**tomographic**]** cephalometric image comprising:

a radiation receiver;

a panoramic imaging X-ray source providing radiation along a generally horizontally extending radiation path for application to said radiation receiver;

a support for said X-ray source, said support having a vertical rotation center for rotating said X-ray source, said rotation center being positioned intermediate said radiation receiver and said X-ray source and closer to said X-ray source than to said radiation receiver;

means for rotating said X-ray source **[**about said rotation center**]** *while otherwise maintaining the X-ray source generally stationary*;

means for generally horizontally translating said rotation center in a direction generally transverse to the radiation path;

wherein the effective focal spot of the X-ray source is transferred to the general location of the X-ray source; and

means for translating said radiation receiver in a horizontal direction generally transverse to the radiation path during application of the radiation to said radiation receiver,

the motions provided to said **[**radiation**]** *X-ray* source, rotation center, and radiation receiver by the respective means producing a **[**tomographic**]** cephalometric image from a subject positioned in front of said radiation receiver for which the effective focal length of the X-ray source has been altered in a manner to reduce differences in the vertical and horizontal ratios of enlargement.

4. The apparatus according to claim **3** wherein said radiation receiver comprises a line detection camera.

5. The apparatus according to claim **3** further including a collimator for being placed in front of the subject.

6. A method for operating imaging apparatus to provide improved cephalometric images having reduced differences in vertical and horizontal ratios of enlargement, the method comprising the steps of:

providing an imaging apparatus comprising an X-ray source configured to apply radiation to a radiation receiver spaced apart from the X-ray source by a first distance in a lateral direction and to a radiation receiver spaced apart from the X-ray source by a second distance in the lateral direction, the second distance being greater than the first distance;

the imaging apparatus being capable of operating in a mode in which the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance are rotated about an intermediate rotation center to provide an image of an object positioned between the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance;

placing a subject for cephalometric imaging between the X-ray source and the radiation receiver spaced apart from the X-ray source by the second distance; and

taking a cephalometric image of the subject by applying radiation from the X-ray source to the radiation receiver spaced apart from the X-ray source by the second distance and simultaneously translating said rotation center in a direction generally transverse to the lateral direction so as to transfer the effective focal spot of the X-ray source towards the X-ray source in the lateral direction;

wherein the X-ray source remains substantially stationary and the effective focal spot of the X-ray source is transferred to the general location of the X-ray source.

7. The method according to claim 6, wherein the imaging apparatus comprises a first radiation receiver spaced apart from the X-ray source by the first distance and a second radiation receiver spaced apart from the X-ray source by the second distance.

8. The method according to claim 6, further comprising the step of translating the radiation receiver spaced apart from the X-ray source by the second distance generally transverse to the lateral direction so that the radiation receiver is positioned to continuously receive radiation applied by the X-ray source.

9. The method according to claim 6, further comprising the step of operating the imaging apparatus in the first mode by rotating the X-ray source and the radiation sensor spaced

apart from the X-ray source by the first distance about the intermediate rotation center to provide an image of the object positioned between the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance.

10. The method according to claim 9, wherein the image of the object is a panoramic image.

11. The method according to claim 6, wherein the imaging apparatus comprises a panoramic imaging apparatus configured to also take cephalometric images.

12. The method according to claim 6, further comprising the step of collimating the radiation applied to the radiation receiver spaced apart from the X-ray source by the second distance.

13. A method for operating an imaging apparatus to provide improved cephalometric images having reduced differences in vertical and horizontal ratios of enlargement, the method comprising the steps of:

providing an imaging apparatus extending in three dimensions, including a length dimension, a width dimension that is generally perpendicular to the length dimension, and a height dimension that is generally perpendicular to the length dimension and generally perpendicular to the width dimension;

wherein the imaging apparatus comprises an X-ray source configured to apply radiation in the length dimension to a radiation receiver spaced apart from the X-ray source by a first distance in the length dimension and to a radiation receiver spaced apart from the X-ray source by a second distance in the length dimension, the second distance being greater than the first distance;

the imaging apparatus being capable of operating in a mode in which the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance are rotated about an intermediate rotation center to provide an image of an object positioned between the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance;

placing a subject for cephalometric imaging between the X-ray source and the radiation receiver spaced apart from the X-ray source by the second distance; and

taking a cephalometric image of the subject by applying radiation from the X-ray source to the radiation receiver spaced apart from the X-ray source by the second distance and simultaneously translating said rotation center generally in the width dimension so as to transfer the effective focal spot of the X-ray source towards the X-ray source in the length dimension;

wherein the X-ray source remains substantially stationary and the effective focal spot of the X-ray source is transferred to the general location of the X-ray source.

14. The method according to claim 13, wherein the imaging apparatus comprises a first radiation receiver spaced apart from the X-ray source by the first distance and the second radiation receiver spaced apart from the X-ray source by the second distance.

15. The method according to claim 13, wherein the imaging apparatus comprises a panoramic imaging apparatus configured to also take cephalometric images.

16. The method according to claim 13, further comprising the step of translating the radiation receiver spaced apart from the X-ray source by the second distance generally in the width dimension so that the radiation receiver is positioned to continuously receive radiation applied by the X-ray source.

17. The method according to claim 13, further comprising the step of operating the imaging apparatus in the first mode by rotating the X-ray source and the radiation sensor spaced apart from the X-ray source by the first distance about the intermediate rotation center to provide an image of the object positioned between the X-ray source and the radiation receiver spaced apart from the X-ray source by the first distance.

18. The method according to claim 17, wherein the image of the object is a panoramic image.

19. The method according to claim 13, further comprising the step of collimating the radiation applied to the radiation receiver spaced apart from the X-ray source by the second distance.

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