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APPARATUS FOR MAKING X-RAY IMAGES
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- (56) Prior Art Documents
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- (57) Claim

1. Apparatus for making X-ray images having a luminescent screen arranged to provide a visible image by the effect of X-rays sent out by an X-ray source, the apparatus including and a CCD camera for receiving and storing the image formed on the luminescent screen, imaging optics including a mirror for reflecting the image of the luminescent screen to the CCD camera, the apparatus having, in optical communication with the luminescent screen and separate from the CCD camera, a photosensor which is connected to computing and control means which are connectable in signal transfer communication with a control means of the X-ray source for adjusting a correct quantity of exposure, characterized in that the photosensor is positioned so that the illumination power of the luminescent screen falls on the photosensor substantially from within the area of the entire image, and the mirror is arranged so the mirror reflects the image without splitting the image in parts.



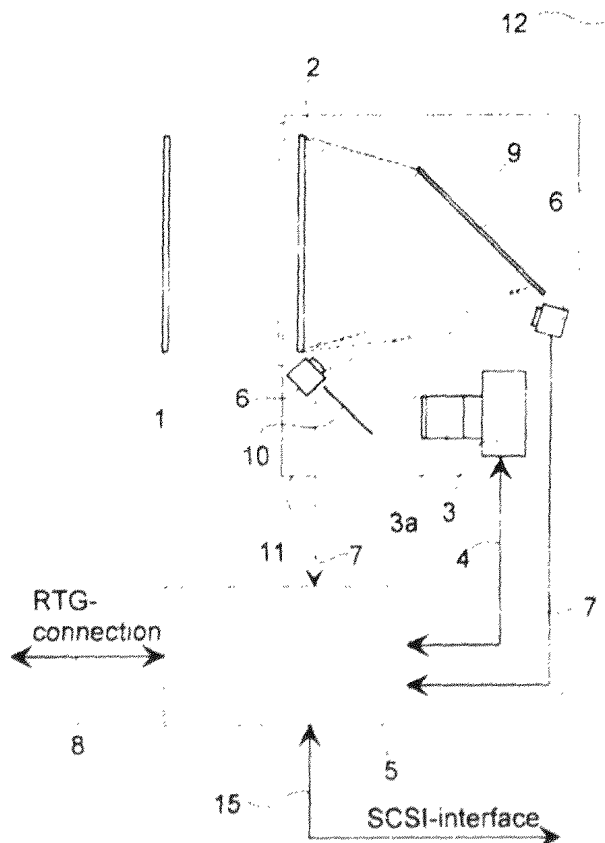
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(74) Agents: HAKOLA, Unto et al.; Tampereen Patenttitoimisto Oy, Kanslerinkatu 6, FIN-33720 Tampere (FI).			Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments. In English translation (filed in Finnish).		

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(54) Title: APPARATUS FOR MAKING X-RAY IMAGES

(57) Abstract

The apparatus for making X-ray images comprises a luminescent screen (2), like a phosphor screen, arranged to provide a visible image by the effect of X-rays sent out by an X-ray source and a CCD camera (3) for receiving and storing the image forming on the luminescent screen (2). The apparatus further comprises, in optical communication with the luminescent screen and separate from the CCD camera, a photosensor (6) which is connected to computing and control means which are connectable in signal transfer communication with the control means (14) of the X-ray source for adjusting a correct quantity of exposure.



penetrate the reflecting mirror and the X-rays may cause damage to the CCD. Only a part of the fluorescent light is reflected to the photosensor so the quantity-of-light controller may use incorrect values in controlling the X-ray generator.

An X-ray imaging system including brightness control is also known from European Patent Application 547679. In this application, the image from the X-ray image intensifier is conducted through prisms. Part of the beam is reflected to a photodiode for automatic dose control or exposure timing. Also in this apparatus there is the disadvantage that some X-rays may penetrate through the prisms to the CCD sensor which may be damaged. Another disadvantage lies in that the photosensitive sensor sees only part of the light beam from the image intensifier.

An apparatus is also known from the European patent 264218 for making an image of an object by X-rays in which the image formed on a phosphor screen by the X-rays is stored by means of a CCD camera after which the image can be processed digitally. Exposure time is controlled by a shutter and the CCD is operated in slow scan mode which involves cooling down to a least - 40°C to decrease noise due to slow exposure of the picture and/or the read-out. Exposure times with this apparatus are generally minutes or even hours. The apparatus is purposed for X-ray inspection of objects and the needs of clinical X-raying have not been taken into account in it.

The purpose of the invention is to obtain a new kind of apparatus for making X-ray images which is particularly suitable for X-raying patients in clinical examinations like for X-raying lungs and bones. To accomplish this objective the invention provides apparatus for making X-ray images having a luminescent screen arranged to provide a visible image by the effect of X-rays sent out by an X-ray source, the apparatus including and a CCD camera for receiving and storing the image formed on the luminescent screen, imaging optics including a mirror

for reflecting the image of the luminescent screen to the
CCD camera, the apparatus having, in optical communication
with the luminescent screen and separate from the CCD
camera, a photosensor which is connected to computing and
5 control means which are connectable in signal transfer
communication with a control means of the X-ray source for
adjusting a correct quantity of exposure, characterized in
that the photosensor is positioned so that the illumination
power of the luminescent screen falls on the photosensor
10 substantially from within the area of the entire image and
the mirror is arranged so the mirror reflects the image
without splitting the image in parts.

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used for adjusting a correct efficiency of exposure, time or quantity of exposure by connecting the sensor to the X-ray generator which controls the X-ray source. At the same time, a scale can be automatically set in a correct position in terms of the image processing and digitizing. The imaging optics also includes a mirror for reflecting the image on the luminescent screen to the CCD camera. The optical reflecting surface formed by the mirror also prevents X-rays which may have got through from hitting the sensitive imaging electronics.

10 As to the other advantageous embodiments of the invention reference is made to the enclosed dependent claims 2-8 and to the following description.

15 The invention will be described in more detail in the following referring to the enclosed drawings in which

Fig.1 shows the apparatus according to the invention as a section,

Fig.2 shows a second embodiment of the invention as a section,

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Fig.3 shows how the dynamical range is extended in the apparatus according to the invention, and

Fig.4 shows the location of the apparatus in a larger system.

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preferred embodiment of the
Fig.1 shows the apparatus according to the invention as a section. The figure shows the grid 1 of the apparatus arranged to diminish the injurious effect of the secondary radiation from the patient. The X-rays that have passed through the patient are incident on the luminescent screen 2 forming thereon a visual image which sends out radiation at visible wavelength. The luminescent screen 2 may be a phosphor screen known per se which gets the necessary energy to generate the image from the X-ray radiation, in other words, no amplification is performed by means of any other externally supplied energy although it is sometimes called also an intensifier screen. The beam cone of the image to be stored is in the figure marked with dashed lines and the image is received with a 2-dimensional charge coupled device image transducer (CCD) which is part of the CCD camera 3 which also

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comprises a conventional imaging optics 3a. An interface 4 leads from the camera to the electronic unit 5 of the apparatus which performs image processing, e.g. digitizing, and transmission of control signals along the communication line 15 further to various auxiliary devices 16.

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The apparatus is provided with a photosensor 6 which may be any known sensor measuring intensity of visible light. The sensor is connected with a data transfer line 7 to said electronic unit 5 which is provided with computing and control means for processing the data supplied by the sensor. From this part leads also a data transfer line 8 to the X-ray generator (RTG) which controls the X-ray source.

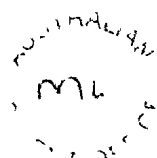
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Fig. 1 shows how the cone of the light beams to be imaged are turned by the mirror 9 to the camera 3 located at the lower part of the apparatus. The photosensor 6 is located beside the light cone of the light beams which accomplish storage of the image, for example in the manner shown in the figure opposite to the mirror 9 beside the CCD camera. The photosensor 6 may also be positioned in the apparatus so that it directly "sees" the image on the luminescent screen 2, in other words it is then opposite to the luminescent screen 2 beside the mirror 9. Fig.2 shows the alternative wherein the mirror 9 reflects the cone incident from the luminescent screen 2 to an additional mirror 10 located opposite thereto, arranged below the lower part of the luminescent screen and which finally reflects the cone to the CCD camera 3 at the lower part of the apparatus. In this case the apparatus will have a more compact structure when the above components are placed into the frame housing 11. The figure further shows how the sensor 6 may also in this alternative be located opposite to the mirror 9 and be placed beside the mirror 10.

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Dashed lines indicate the cone of those light beams which leave the luminescent screen 2 at a different angle to the sensor than the cone of the light beams which go to the actual image storage. Thus the sensor 6 is not in the way of the light beams and no prisms or the like are needed in the apparatus to split the light for storing and measuring the image.

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AMENDED SHEET

In the invention, the mirror or mirrors make it possible to prevent X-rays which may have got through from hitting the sensitive electronics because the optically reflecting surface accomplished by the mirror directs only the beams of visible light into the imaging electronics. The frame housing 11 may be arranged to be movable along a vertical guide 12 to the right height. A correct dosage is automatically accomplished by the photosensor 6 because its measuring signal is transmitted to the computing and control means which control the X-ray source for obtaining a correct exposure. In practice, this may take place so that as a predetermined quantity of exposure is reached, a signal is transmitted to the control means of the X-ray source which switch off the X-ray generator. Exposure times in clinical X-raying may in this case be of the order of 10 ms. At the same time, a scale is automatically established in a correct range from the point of view of image processing. No mechanical shutters are needed in the optical path between the luminescent screen 2 and the 2-dimensional CCD image transducer because between exposures the image transducer is practically in darkness inside the frame housing and it can be calibrated by measuring the output signal at this situation.

Fig.3 shows a typical characteristic curve of a CCD element which represents the signal strength of the element as a function of dosage. So the question is the image obtained from a single image point or pixel. At high dosage the effect of the anti-blooming action of the CCD camera manifests itself preventing the electrons from escaping to nearby elements and "smearing" of the image at high dosage. In the apparatus, the effect of this so-called saturation region S to the image is eliminated so that the dynamic range is extended in accordance with the straight portion of the graph in the linear range L so that when the obtained signals are in the saturation region S, they are numerically corrected to correspond actual values. In this case, high accuracy is obtained in the image processing in regions of high dosage, like in pneumography in those areas of the image obtained particularly from the patient's peripheral areas, the corresponding CCD elements of which receive dosage above normal. The correction in question can be performed in the electronic unit 5 of the apparatus by a suitable program before the image data is sent out for further processing.



Fig. 4 finally shows the apparatus in the environment in which the picture is taken. The apparatus comprises the aforementioned frame housing 11 and the aforementioned electronic unit 5 which communicates with the control means 14 of the X-ray source 13, in other words the X-ray generator RTG. The system further comprises auxiliary devices 16 for storing the image data, displaying them on the screen or outputting them, or transmitting the image data further.

The invention utilizes a high-resolution CCD camera 3 with several image points or pixels. This kind of camera is temperature stabilized but because it operates as a quick camera (flash mode) with exposure times typically below 100 ms, it needs no cooling to improve the signal-to-noise ratio. The apparatus suits well for use in connection with conventional X-ray instruments which require no changes due to the apparatus.

In connection with the present invention it is advantageous to employ a CCD camera in which the CCD image transducer is as sensitive as possible so that in the X-raying the patient is exposed to a minimum amount of X-ray radiation. One such sensitive CCD image transducer is a thinned CCD image transducer used in for instance astronomical imaging instruments. In the image transducer of this type, the rear surface of the of the CCD image transducer has been thinned so that light beams can be directed into the image transducer from the rear side whereas in conventional CCD image transducers the light beams are directed from the front side of the image transducer. Sensitivity of the CCD image transducer may be further increased by adding a phosphorescent layer, most advantageously to the front side of the CCD image transducer. The CCD image transducers described above have sensitivities even 2 - 3 times higher compared to conventional CCD image transducers.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Apparatus for making X-ray images having a luminescent screen arranged to provide a visible image by the effect of X-rays sent out by an X-ray source, the apparatus including and a CCD camera for receiving and storing the image formed on the luminescent screen, imaging optics including a mirror for reflecting the image of the luminescent screen to the CCD camera, the apparatus having, in optical communication with the luminescent screen and separate from the CCD camera, a photosensor which is connected to computing and control means which are connectable in signal transfer communication with a control means of the X-ray source for adjusting a correct quantity of exposure, characterized in that the photosensor is positioned so that the illumination power of the luminescent screen falls on the photosensor substantially from within the area of the entire image, and the mirror is arranged so the mirror reflects the image without splitting the image in parts.
2. Apparatus according to claim 1, characterized in that the imaging optics and the photosensor are positioned apart so that the cone collected by the imaging optics and the cone collected by the photosensor leave at an angle to each other from the luminescent screen.
3. Apparatus according to claim 2, characterized in that the photosensor is positioned opposite to the mirror so that the illumination power reflected by the mirror is directly transmitted to it.
4. Apparatus according to claim 3, characterized in that the photosensor is positioned beside the CCD camera to receive light reflected by the same mirror.
5. Apparatus according to claim 3, characterized in that the apparatus includes an additional mirror to reflect the image reflected by the mirror to the CCD camera, the photosensor being disposed beside the additional mirror.
6. Apparatus according to any of the above claims, characterized in that the computing and control means of

the apparatus contains a program which is arranged to correct at high quantities of exposure the signal obtained from a luminous point in the saturation range to correspond to the dependence of the signals in the linear range on the quantity of exposure.

7. Apparatus according to any of the above claims, characterized in that the CCD camera comprises a thinned CCD-image transducer.

10 DATED this 28th day of November 1997

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15 Fellows Institute of Patent
Attorneys of Australia

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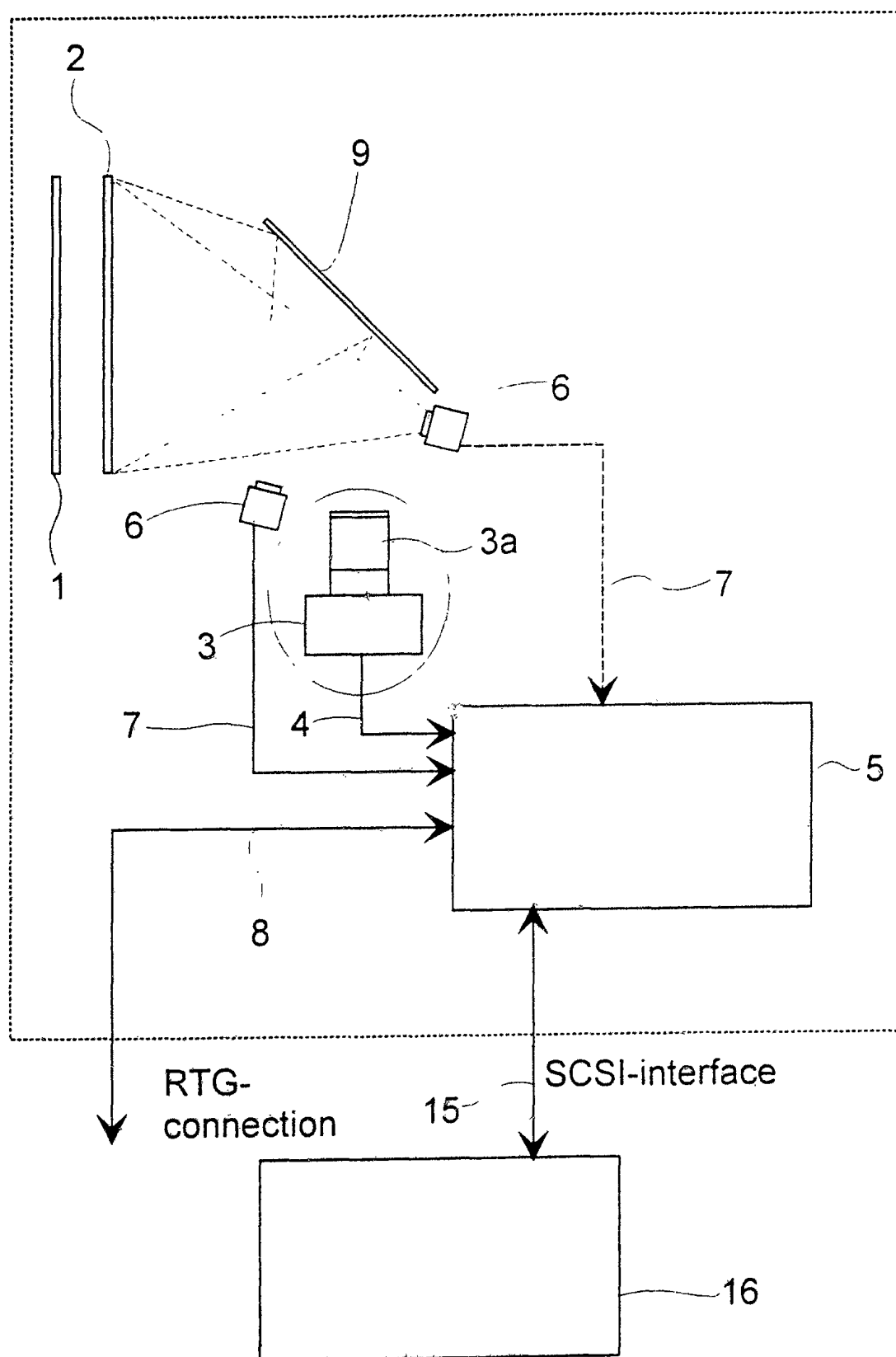


Fig. 1

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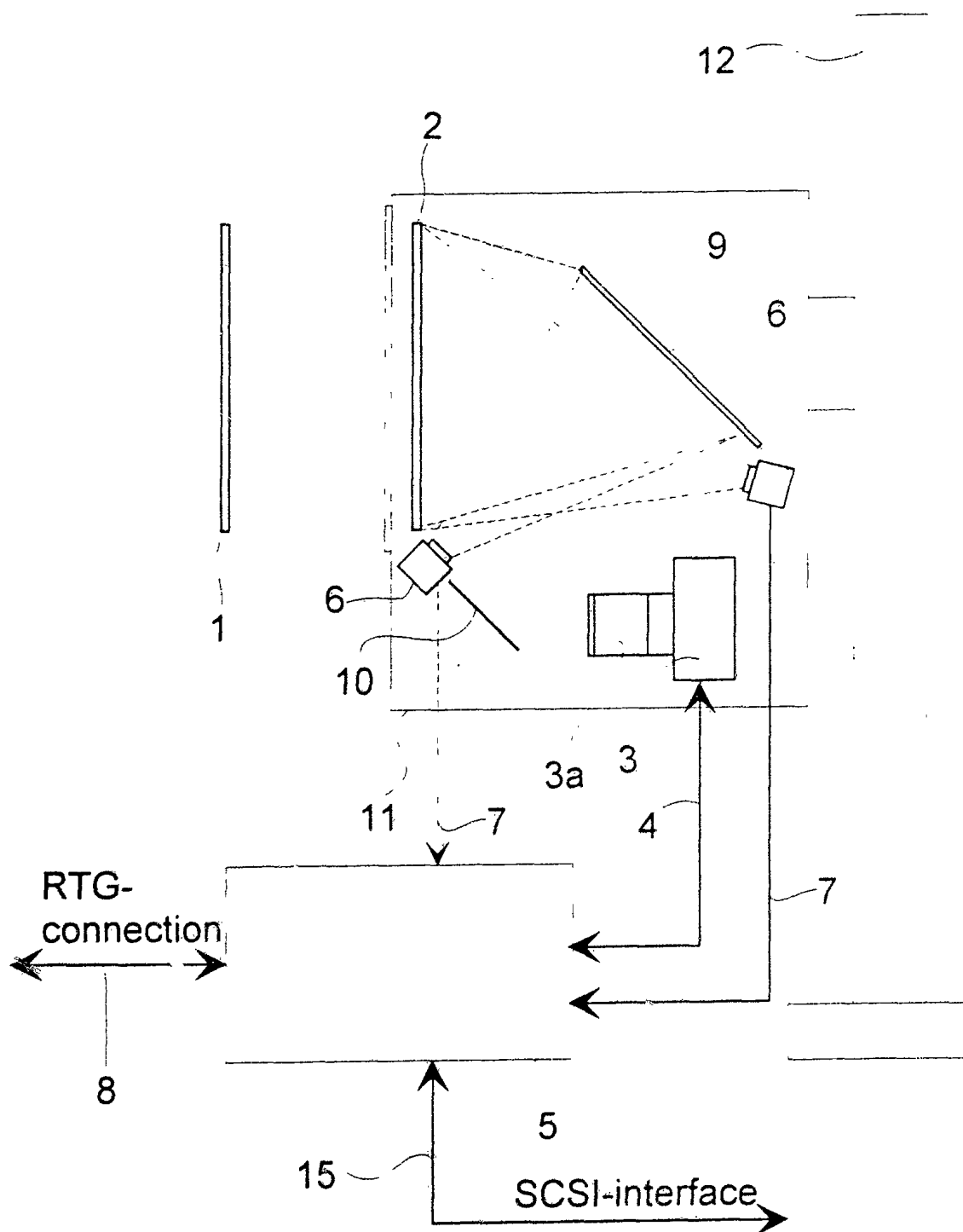


Fig. 2

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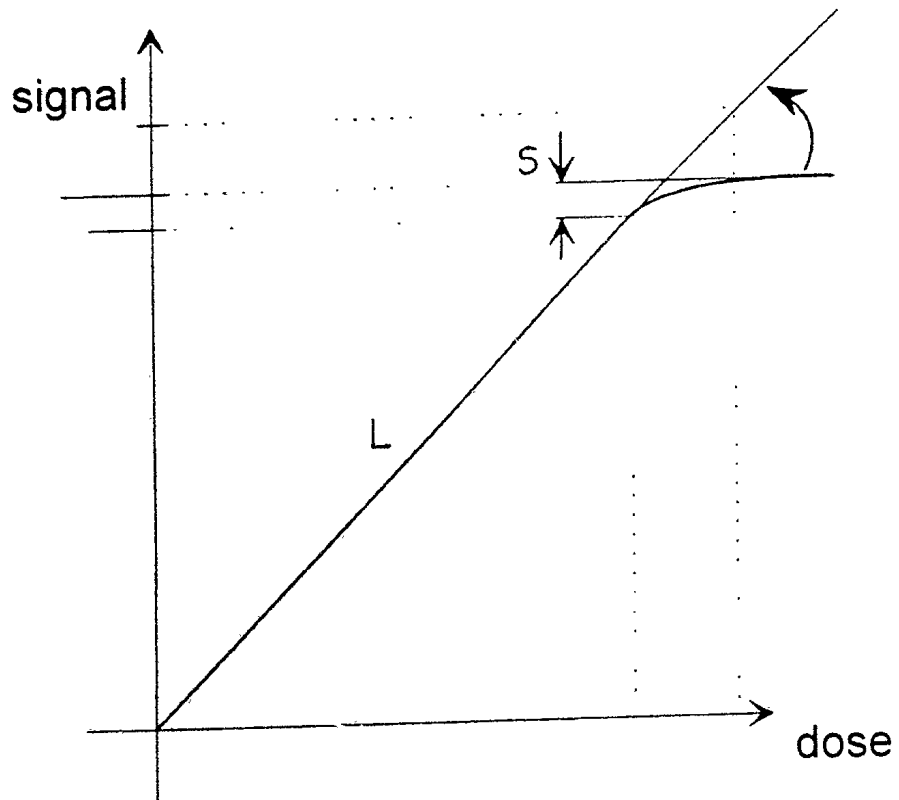


Fig. 3

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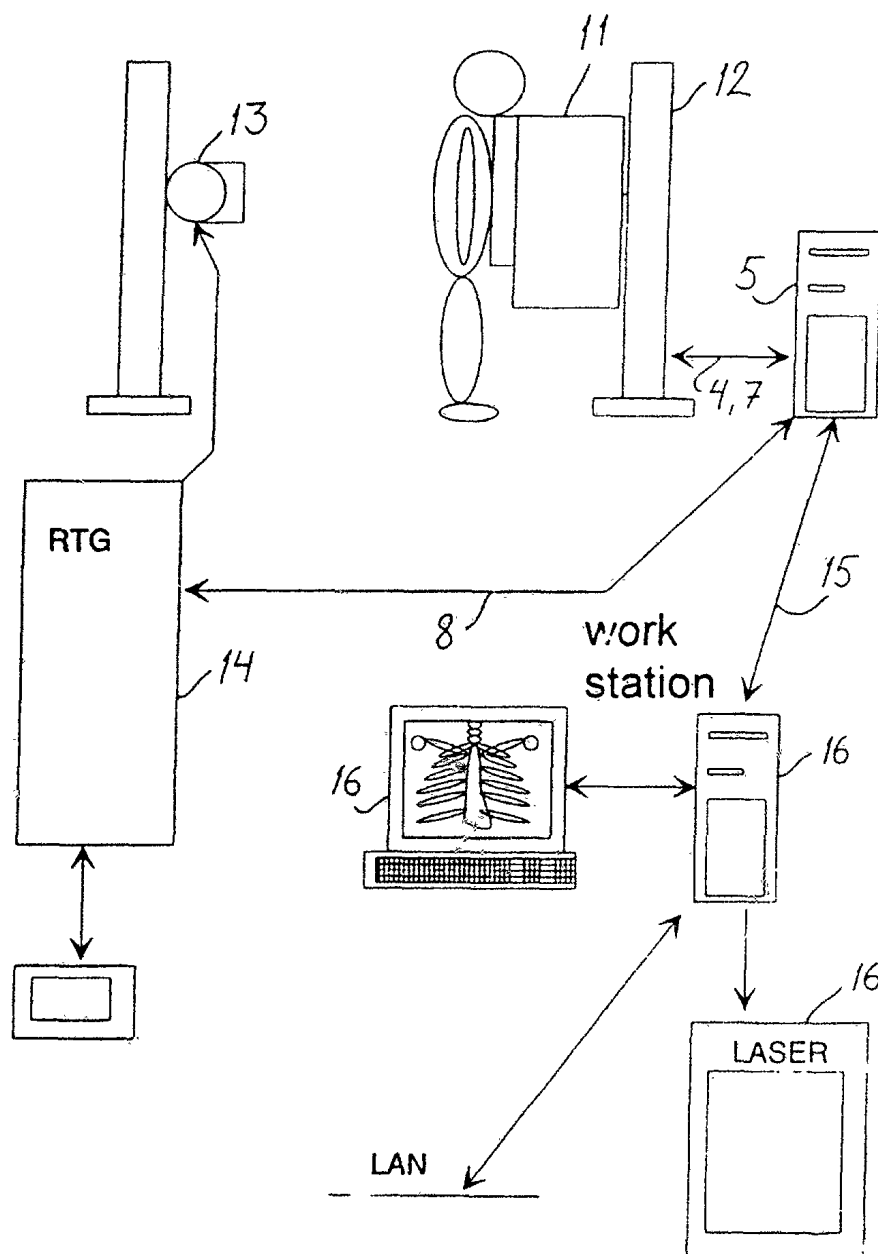


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 95/00193

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G03B 42/02, A61B 6/00

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)

IPC6: A61B, G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CLAIMS, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0547679 A1 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN), 23 June 1993 (23.06.93), figure 1 --	1
A	US 4952794 A (KEMNER ET AL.), 28 August 1990 (28.08.90), abstract --	1-8
X	US 5187730 A (FUJIHARA), 16 February 1993 (16.02.93), figures 1,6 A	1,3,4 2,5-8

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

Date of mailing of the international search report

3 August 1995

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INTERNATIONAL SEARCH REPORT
Information on patent family members

29/05/95

International application No.

PCT/FI 95/00193

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP-A1-	0547679	23/06/93	JP-A-	5269121	19/10/93
US-A-	4952794	28/08/90	DE-D,T-	68914367	17/11/94
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			JP-A-	2087878	28/03/90
			NL-A-	8801946	01/03/90
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