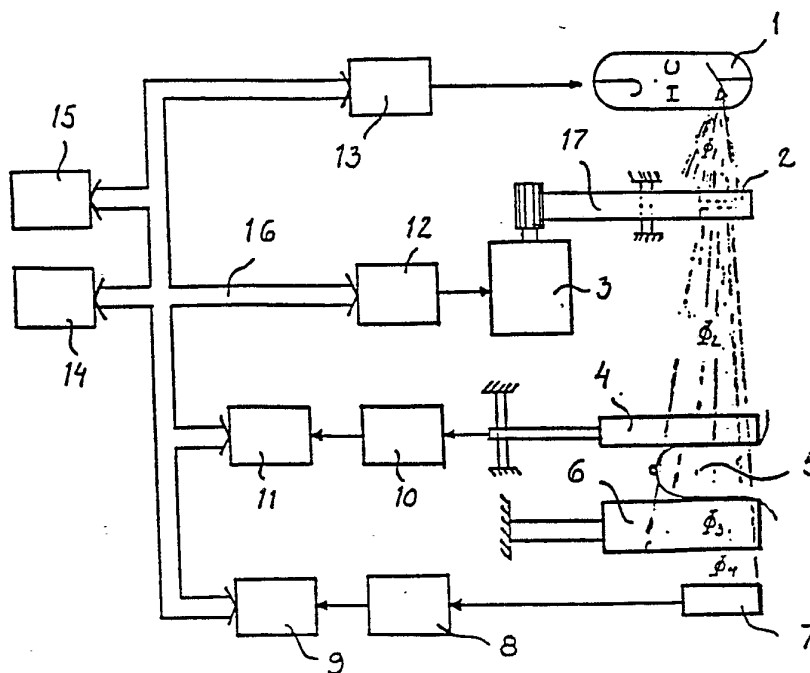




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(54) Title: A METHOD AND DEVICE FOR CONTROLLING THE X-RADIATION OF AN X-RAY APPARATUS, IN PARTICULAR THAT OF A MAMMOGRAPHIC APPARATUS

**(57) Abstract**

A method and a device for adjusting the X-radiation of an X-ray apparatus, in particular that of a mammographic apparatus, in which the radiation (Φ_4) having penetrated the photographed object (5) is examined in the beginning of the photography in order to avoid over-exposure of the patient, and on the basis of this the energy spectrum of the radiation is adjusted by regenerative coupling (8, 9, 14, 15).

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A method and device for controlling the X-radiation of an X-ray apparatus, in particular that of a mammographic apparatus

The invention relates to a method and device for controlling the X-radiation of an X-ray apparatus, in particular a mammographic apparatus. The purpose of the control is an automatic optimization of the ratio of the X-ray dose received by the patient to the information value of the x-rayogram.

When X-raying the tissue, a certain portion of the radiation spectrum constitutes the main part of the information contained in the photograph. Too soft a radiation is too much absorbed into the tissue, thus unnecessarily increasing the patient's radiation dose. On the other hand, too hard a radiation passes through the tissue nearly without being absorbed, whereby no information on the tissue is formed in the photograph, but the radiation only weakens the contrast of the photograph, i.e. the information value.

In mammography, it is known (cf. e.g. the patent SE 420 459) to adjust the exposure according to the object to be measured, i.e. the compression thickness of the breast. However, e.g. the texture of the tissue or corresponding circumstances influencing the penetration of the rays, have not then been considered. Thus it has often been necessary to repeat the X-photography with other values, whereby the radiation received by the patient has grown unnecessarily.

The purpose of the invention is to achieve a method and a device for mammography, in which the correct radiation spectrum is secured according to the respective tissue quality.

The invention is based on the observation, that considering the entire X-raying sequence, even a very short sample of the penetrated radiation provides sufficient information on the quality of the tissue, and thus the spectrum may be correctly adjusted on the basis of the sampling carried out during the first moments of the X-photography. It may be noted in this context that it is prior known through panoramic X-ray devices (cf. e.g. patent specification JA-142 045/1983) to continuously adjust the voltage of an X-ray tube on the basis of the penetrated radiation, however in this case, the purpose of the control is to create a homogenous degree of blackening throughout the entire panoramic area.

The method of the present invention is characterized in that a very short sample with regard to the entire X-raying sequence is taken, at the very beginning of the X-photography, of the radiation having penetrated the object, and on the basis of this the radiation spectrum is adjusted for the period of the main sequence of the X-photography.

The short sampling may take place at the very beginning of the X-photography, as soon as the voltage of the tube has reached its initial set value, or then as a separate phase immediately preceding the X-raying phase itself. As the voltage of the X-ray tube rises to its final value e.g. in less than 10 ms, and a few ms being enough for the sampling, it is understandable that this duration is of insignificant importance to the total exposure, which takes at least a few hundred milliseconds. Performing the sampling as a separate phase becomes relevant especially when one wishes to correct the filtering as well, since it is not possible to change the filter during the X-photography without special filter constructions.

Another possibility of adjusting the spectrum is to rectify the focus point in the anode, if the various areas of the anode plate have a different material composition.

The preferred embodiments of the method according to the invention are presented in the dependent claims 2-6.

A device according to the invention is correspondingly characterized in that a sensor detecting the radiation having penetrated the object of X-photography is provided, as well as a regenerative coupling starting from the sensor for adjusting the voltage of the X-ray tube or the filter, or for adjusting the focus point on the basis of radiation detected at the beginning of the radiation sequence in an anode of a non-homogenous material.

The preferred embodiments of the device according to the invention are presented in claims 8-10.

According to the invention, it is advantageous to control the X-photography with microprocessors, which regulate any of the above parameters on the basis of the penetration effect measured at the beginning of the radiation, as well as the time of exposure on the basis of the total radiation integrated with regard to the time.

The beneficial spectrum is a function of the thickness of the object to be X-photographed, i.e. as the thickness grows, the spectrum constituting information becomes harder. Correspondingly, the optimal spectrum is also a function of the composition of the object. When X-photographing a close texture, the spectrum has to be harder than e.g. when X-photographing a fat tissue. For instance in mammography, the term "equivalent thickness" may be used, by which is meant the combined effect of the compression thickness of the breast and the composition on the optimal spectrum.

The spectrum can be hardened by increasing the voltage of the X-ray tube, thus increasing the maximum energy of the radiation, and simultaneously the radiation filter is changed so as to filtrate a low-energy radiation more

efficiently. By doing the contrary, the spectrum gets correspondingly softer. It is advantageous to choose the starting voltage, as well as the possibly used filter, on the basis of the thickness of the object of X-photography measured with the aid of a thickness gauge.

The invention is described in detail below with reference to the enclosed drawings, in which figure 1 is a schematic perspective of the mammographic device according to the invention and figure 2 is a block diagram of the adjusting method.

The following reference numerals are used in figure 1:

1. X-ray tube
2. Filter disposed on the periphery of the disc
3. Motor rotating the disc
4. Clamping sheet which provides the control compression thickness of the gauge
5. Breast to be X-rayed
6. Cassette casing containing the film to be exposed
7. Exposure automation sensor giving the signal to be amplified to the exposure automation unit
8. Exposure automation amplifier and voltage-to-frequency converter
9. Timer (Motorolan 6840 or equiv) for the exposure automation (8)
10. Compression thickness gauge and voltage-to-frequency converter
11. Timer (Motorolan 6840 or equiv.) for the compression thickness gauge
12. Control logic of the motor, determining the position of the motor and thus also that of the disc
13. Efficiency generator adjusting the voltage (U) and the current (I) of the X-ray tube 1
14. Microprocessor (Motorolan 6803 or equiv.)
15. Program store (Intel 2764 or equiv.)

16. Address and data channel, along which the instructions and controls are transmitted
17. Filter disc.

For the adjustment, a compression thickness gauge 10 for the breast and a filter unit 17 are provided in the device, the filter unit comprising filters 2 which are of various materials and automatically replaceable. Additionally, the device comprises the exposure automation unit 7, 8, which measures the exposure rate of the radiation having penetrated the breast 5 in relative units.

Before the X-photography, the microprocessor unit 14 selects on the basis of the compression thickness of the breast 5 the appropriate filter and a first approximation for the voltage of the X-ray tube 1.

The most reliable information about the texture is obtained during the X-photography from the response of the exposure automation 7, 8. From the voltage and current I of the X-ray tube as well as the filtering of the radiation, the spectrum of the radiation attaining the breast and the exposure rate may be concluded. From the exposure automation response, i.e. the starting signal of the sensor 7, the exposure rate of the radiation having penetrated the breast, and further the equivalent thickness of the breast, may be concluded. On the basis of this, a possible correction of the voltage U of the X-ray tube 1 may be carried out at the beginning of the X-photography, in order to optimize the X-photography result and the radiation dose of the patient.

The correction may be done e.g. in the following manner:

When the voltage of the X-ray tube has risen to its initial set value, for instance 5-10 ms after switching it on, a sample is taken from the starting signal of the sensor 7 for a short period of e.g. a few ms. As the output signal is

converted into pulses by the converter 8, the sample comprises in practice a certain number of pulses. This is compared with the number programmed in the microprocessor, considered appropriate, and if necessary, a correction of the voltage is carried out. It is naturally even possible to carry out a correction of the filter during the X-photography, provided that the filter exchange is fast enough. As stated above, the sampling can however in this case take place as a prephase of the X-photography, upon which the voltage is temporarily interrupted for the change of the filter. This does not change the device, but merely concerns the programming of the microprocessor.

An alternative embodiment of the above filter construction would be a unit consisting of superposed filters, in which each filter can be transferred into the radiation path e.g. by means of a controllable solenoid.

Claims

1. A method for adjusting the X-radiation of an X-ray device, in particular that of a mammographic device, characterized in that a sample, which is very short with regard to the entire X-raying sequence, is taken at the very beginning of the X-photography, of the radiation having penetrated the object, and on the basis of this the radiation spectrum is adjusted for the main sequence of the X-photography.
2. A method according to claim 1, characterized in that a short sample is taken at the beginning of an integral X-photography, as the voltage of the X-ray tube has risen to the initial set value, and in that the spectrum is adjusted on the basis of a sample by correcting the voltage of the tube.
3. A method according to claim 1, characterized in that a short sample is taken in a separate prephase of the X-photography, upon which the X-photography is interrupted and the filter is exchanged, and the set voltage is possibly also altered, and the X-photography itself is carried out.
4. A method according to claim 1, characterized in that the radiation spectrum is adjusted by changing the focus point of the cathode ray in the anode of the X-ray tube (1) having a non-homogenous material.
5. A method according to claim 1, characterized in that the observation of the penetrated radiation is carried out by a radiation detector (7), which can be e.g. a semiconductor detector or an ionization chamber.
6. A method according to claim 5, characterized in that the output of the radiation detector (7) is converted in the voltage-to-frequency converter (8) into pulses, by

which with the aid of the regenerative circuit (9, 14, 15) the voltage source (13), the filter (2) or focus point of the X-ray tube (1) is conducted in the anode of a non-homogenous material.

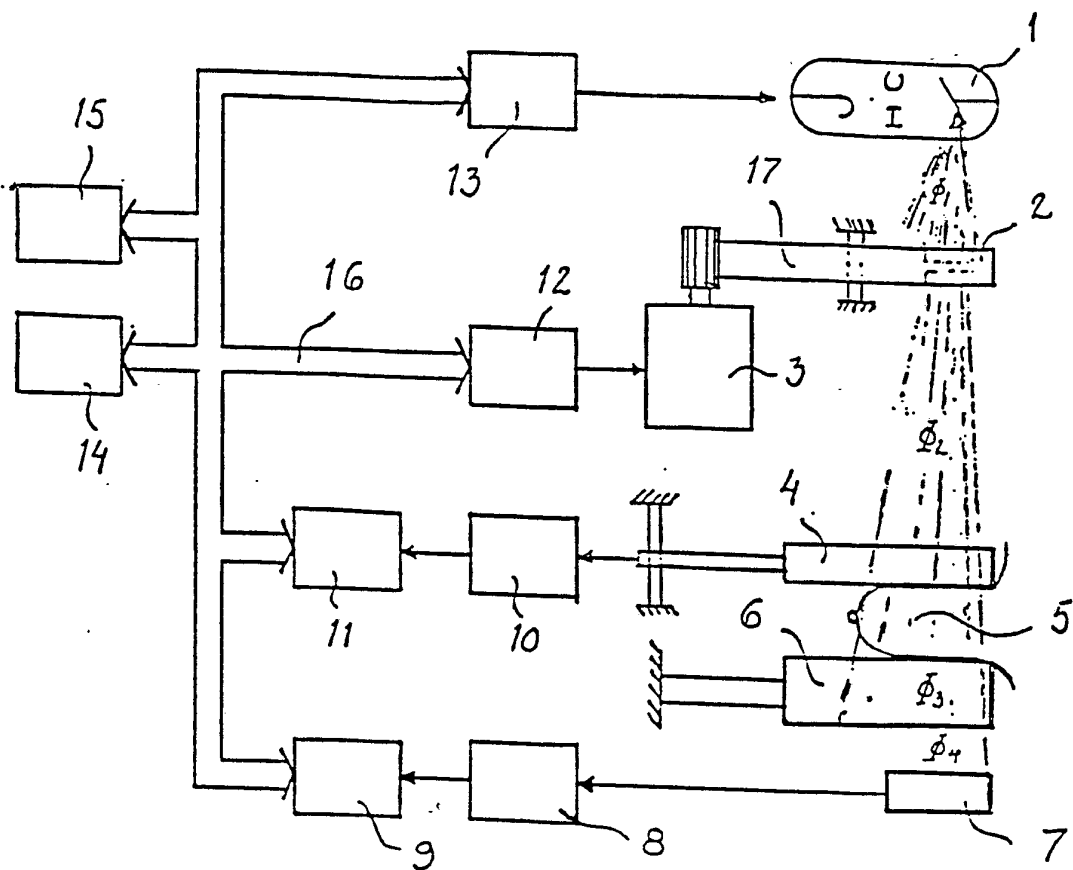
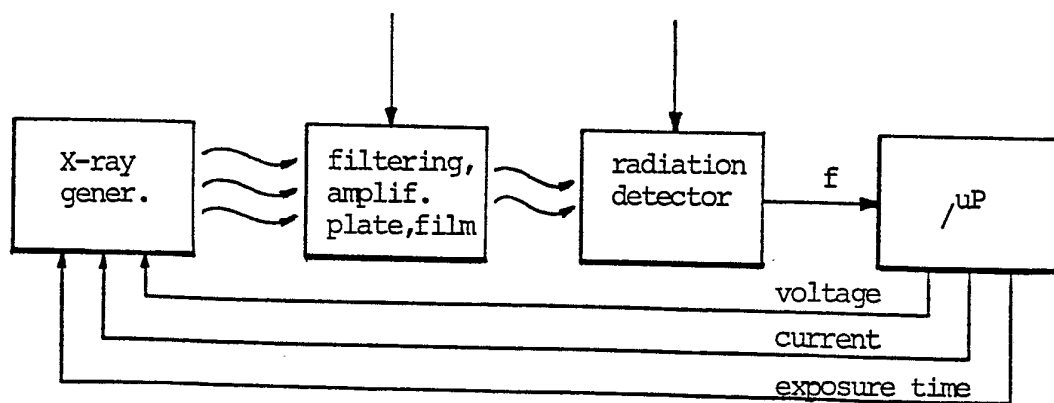
7. A device for adjusting the X-radiation of an X-ray apparatus, in particular that of a mammographic apparatus, which mammographic apparatus is constituted of an X-ray tube (1), an adjustable X-ray tube generator (13), a radiation filter (2) and a photographing device (6) sensitive to X-rays, characterized in that it comprises a detector (7) detecting the effect of the radiation having penetrated the photographed object (5), as well as a regenerative coupling (8,9,14,15) starting from the detector for adjusting the voltage of the X-ray tube (1) or the filter (2), or for adjusting the focus point in the anode of a nonhomogenous material, on the basis of the radiation detected in the beginning of the radiation sequence.

8. A device according to claim 7, characterized in that it comprises additionally a thickness gauge (10) for the photographed object, of which the output signal is used for selecting the initial value of the parameter to be adjusted.

9. A device according to claim 7, characterized in that the filtering unit comprises essentially a circular disc (17), in which various radiation filters (2) have been disposed, and that the selection of the filter (2) is performed by rotating the disc with the aid of the guided motor (3).

10. A device according to claim 7, characterized in that the filtering unit is composed of superposed filters (2), of which each one is separately or together with the others transferable into the radiation path e.g. by the associated solenoid.

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**Fig. 1****Fig. 2**

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI86/00092

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC 4 H 05 G 1/30		
II. FIELDS SEARCHED		
Minimum Documentation Searched 7		
Classification System IPC 4 US C1	Classification Symbols H 05 G 1/26, /30, /32, /46, /52 250:393-409, 416, 505, 510-513, 520, 521; 378:37, 101, 108, 156-159	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8		
SE, NO, DK, FI classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT 9		
Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No. 13
A	US, A, 4 486 896 (RICHTER ET AL) 4 December 1984	1, 5, 7
A	US, A, 3 974 385 (GRIM) 10 August 1976	2, 5
A	US, A, 2 747 104 (JACOBS) 22 May 1956	5
A	US, A, 4 189 645 (CHANEY ET AL) 19 February 1980	3, 9, 10
A	"Derwent's abstract No. 84-181289/29, SU 1 053 334-A. (CHARON ET AL) 7 November 1983".	3, 9
A	US, A 3 857 039 (FRANKE ET AL) 24 December 1974	4
A	SE, B, 420 459 (LUNDGREN) 12 October 1981	
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IV. CERTIFICATION		
Date of the Actual Completion of the International Search 1986-11-21		Date of Mailing of this International Search Report 1986-11-25
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