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(54) An x-ray recording element comprising a stimulable phosphor and a prompt emitting phosphor

(57) An X-ray recording element is disclosed comprising an image storage phosphor (photostimulable phosphor) and at least one prompt emitting phosphor, said prompt emitting phosphor emitting light with a peak emission wavelength between 400 and 850 nm. In a preferred embodiment the emission spectrum of the prompt emitting phosphor overlaps with the stimulation spectrum of the image storage phosphor.

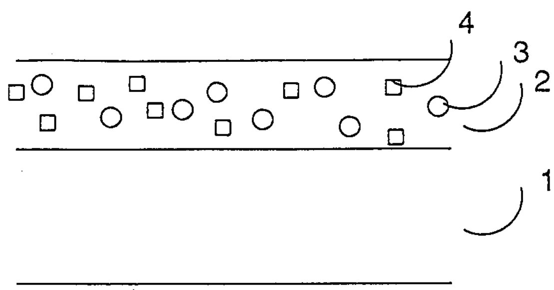

FIG. 1

EP 0 688 021 A1

1. Field of the Invention.

This invention relates to an element absorbing electromagnetic radiation having a wavelenght A and capable of converting absorbed radiation energy into an electromagnetic radiation with wavelength B, wherein A < B. More specifically this invention relates to an X-ray absorbing element capable of converting absorbed X-ray energy into visible light.

2. Background of the Invention.

Computed radiography is described in, e.g., US-P 3,859,527, where an X-ray recording system is disclosed wherein photostimulable (storage) phosphors are used having in addition to their immediate light emission (prompt emission) on X-ray irradiation the property to store temporarily a large part of the absorbed X-ray energy. Said energy is set free by photostimulation in the form of fluorescent light different in wavelength from the light used in the photostimulation. In said X-ray recording system the light emitted on photostimulation is detected photoelectronically and transformed into sequential electrical signals. This recording method gives an X-ray image in digital form.

In computed radiography, the sensor (i.e. the image storage phosphor) used to absorb X-ray energy has a good signal to noise ratio over a large dynamic range, up to 12 bit (4096:1).

While the diagnosis is performed by a human observer, the digital image as obtained, containing diagnostically important information within a wide amplitude range, has to be represented in a human readable (analog) form. This is done by representing the image on a film hardcopy (to be viewed on a lightbox) or on a display screen. In both case the contrast of anatomic detail, as present in the digital image, must always be traded off against dynamic range of the medium on which said digital image is represented. Given the limited dynamic range of the image output medium (smaller than 500:1 in case of a transparent film, and smaller than 100:1 in case of a CRT screen under normal viewing conditions) then the tradeoff can be stated extremely as follows:

i) if the entire dynamic range of the diagnostically meaningful signal levels is mapped onto the available output medium dynamic range, then overall contrast will be very low, and for many subtle, diagnostically important details, the image contrast will be below the perceptual threshold level, hence these will be missed by the observer.

ii) if at the other hand only a part of the original dynamic range is mapped onto the output medium dynamic range then all signal levels below this range will all be mapped onto the same (low) output level, and all original levels exceeding this range will be mapped onto the same (high) output level.

In that case only those image pixels having a level within the selected dynamic range will be presented with acceptable contrast, while the other pixels will have uniform brightness, and will show up with no contrast at all.

In image workstations connected to a computed radiography or computed tomography system the desired compromise between both extreme mappings is interactively selectable, a feature which is commonly referred to as window/level setting. This problem is largely recognized in the field of digital radiology, see: Maack I., Neitzel U., "Optimized Image Processing for Routine Digital Radiography", Proceedings International Symposium CAR '91, p. 109, Springer Verlag. A possible solution to this problem is described in e.g. EP-A 527 525.

These image manipulations require the use of sofisticated electronics and algorithms in order to reduce the dynamic range of the image as captured from 12 bit (4096:1) to 10 (1024:1) or even 8 bit (256:1).

When it were possible to reduce the dynamic range already during the recording of the X-rays, the electronics and algorithms needed to provide a human readable image out of the digital information could be simplified, and hence the apparatuses to perform said digital to analog conversion could be made less expensive.

3. Objects and Summary of the Invention.

It is an object of the present invention to provide a recording element, comprising an image storage phosphor, with controlled dynamic range.

It is another object of the invention to use a recording element, comprising an image storage phosphor, with controlled dynamic range.

It is still a further object of the invention to provide a recording element, comprising an image storage phosphor, with controlled dynamic range for use in medical diagnosis in order to simplify the image processing necessary to provide a human readable image from the digital data gathered during read-out of the image storage phosphor panel.

It is an other object of the invention to provide a recording element, comprising an image storage phosphor, with controlled dynamic range in which the energy absorbed in said image storage phosphor due to radiation falling beside the patient is erased during exposure.

It is also an object of the invention to provide a recording element, comprising an image storage phosphor, that makes it possible to have a simiplified dual energy recording system.

Other objects and advantages of the invention will become clear from the description hereinafter.

The objects of the invention are realized by providing an X-ray recording element characterised in that said element comprises an image storage phosphor (photostimulable phosphor) and at least one prompt emitting phosphor, said prompt emitting phosphor emitting light with a peak emission wavelength between 400 and 850 nm.

In a preferred embodiment the emission spectrum of the light emitted by said prompt emitting phosphor upon X-ray irradiation overlaps with the stimulation spectrum of said image storage phosphor.

In a further preferred embodiment an X-ray element is provided, comprising a support and said image storage phosphor and said prompt emitting phosphor are mixed together and coated together onto said support.

4. Brief Description of the Drawings.

Figures 1 to 5 represent cross-sections (not on scale) of specific embodiments of an X-ray recording element according to the present invention.

5. Detailled Description of the Invention.

In this document the term "X-ray" has to be understood as all penetrating radiation and includes i.a. radiation originating from a radioisotope (e.g. a Co60 source), radiation created by an X-ray generator of any type, radiation created by a high energy radiation generator (e.g. Betatron), radiation from a sample labeled with a radioisotope as is the case in e.g. autoradiography.

It is known that the X-ray energy absorbed in an image storage phosphor can be released by irradiating said image storage phosphor with electromagnetic radiation with a given wavelenght (i.e. stimulate said image storage phosphor by stimulation light) to make said phosphor to release the absorbed X-ray energy as light (stimulated light). The stimulable phosphor can release said absorbed energy not only by irradiation with a single wavelenght, but also with a set of wavelengths around a peak wavelength, at which the stimulation is most effective. Said set of wavelengths is called "the stimulation spectrum" of the stimulable phosphor. The peak wavelenght of the stimulation spectrum is longer than the peak wavelenght of the "stimulated spectrum". By "stimulated spectrum" is meant a set of wavelengths around a peak stimulated wavelength released by the stimulable phosphor after irradiation with the stimulation spectrum. Both wavelenghts depend on the composition (chemical and crystallographic) of the image storage phosphor.

After stimulation not all energy is released from the image storage phosphor and before using the image storage phosphor to record again X-ray enrgy, the image storage phosphor has to be erased. This erasure can proceed by visible radiation (light) having a particular "erasing spectrum", i.e. a set of wavelengths that are capable of erase all energy from an image storage phosphor.

A prompt emitting phosphor is a substance that upon irradiation with X-ray directly converts said X-ray energy into light : the "emission spectrum" of said prompt emitting phosphor.

It has now been found that it is possible to stimulate an image storage phosphor by using emission light of a prompt emitting phosphor and also to erase the remaining X-ray energy by the emission light of a prompt emitting phosphor.

According to the present invention an X-ray recording element is provided comprising a prompt emitting phosphor and an image storage phosphor (photostimulable phosphor), that are combined. The prompt emitting phosphor, for use in an X-ray recording element according to the present invention, emits, upon X-ray absorption, light with a peak emission wavelenght between 400 and 850 nm, preferably between 500 and 700 nm and with an emission spectrum that either overlaps with the erasing spectrum or with the stimulation spectrum of the image storage phosphor that has been combined with said prompt emitting phosphor. The absorption of erasing or stimulating light by the image storage phosphor lowers the dynamic range of the X-ray energy, absorbed and stored in the image storage phosphor.

The emission spectrum of the prompt emitting phosphor, used in combination with an image storage phosphor, overlaps preferably with the stimulation spectrum of the image storage phosphor in order to give an X-ray recording element according to the present invention. E.g. an image storage phosphor having a stimulation spectrum around 633 nm has to be combined with a prompt emitting phosphor, having an emission spectrum that overlaps with said stimulation spectrum. This means that the peak emission wavelength of the prompt emitting phosphor is as close as possible to 633 nm.

The prompt emitting phosphor and the image storage phosphor can be combined in several ways to provide an X-ray recording element according to the present invention. In Fig. 1 to 5 specific example are described.

As illustrated in Fig. 1, it is possible to mix both phosphors and to form a panel, supported or self supporting, comprising the mixture of both phosphors. In Fig. 1, 1 represents an optional support, 2 represents a phosphor layer comprising an image storage phosphor 3, mixed with a prompt emitting phosphor 4. In this way it is possible that the X-ray recording element according to the present invention, comprises a support and an image storage phosphor and a prompt emitting phosphor are mixed together and coated together onto said support, forming at least one phosphor layer.

Fig. 2 illustrates another embodiment of the invention, the panel comprises separate layers, one comprising an image storage phosphor and the other comprising a prompt emitting phosphor coated on top of each other. In fig. 2, 1 represents an optional support, 5 represents a phosphor layer comprising an image storage phosphor 3 and 6 a phosphor layer comprising a prompt emitting phosphor 4. In a preferred design of this embodiment said recording element comprises a support and said image storage phosphor and said prompt emitting phosphor are coated in separate layers onto said support. When this embodiment is realized with a supported panel, it is unimportant which phosphor layer is coated closest to the support. When using a recording element according to this particular embodiment of the present invention, the element is preferably placed such as to have the layer comprising the prompt emitting phosphor farthest away from the X-ray source.

Fig. 3 illustrates a further embodiment of said recording element comprising two self supporting or supported panels, one panel comprising a prompt emitting phosphor, an other comprising an image storage phosphor and the two phosphor layers are brought into close contact. In Fig. 3, 1 and 1' represent optional supports, that can be the same or different, 5 represents a phosphor layer comprising an image storage phosphor 3 and 6 a phosphor layer comprising a prompt emitting phosphor 4.

In the recording element according to this specific embodiment of the present invention it is preferred that the panel comprising the prompt emitting phosphor is localised farest away from the source of X-rays.

In Fig. 4 still a further embodiment the recording element according to the invention is shown. It is an X-ray recording element comprising (i) a first supported panel or screen comprising a phosphor layer comprising a first prompt emitting phosphor and an image storage phosphor mixed together (this is an recording element as illustrated in Fig. 1).

(ii) a second supported panel comprising a second prompt emitting phosphor, that can be the same as or different from said first prompt emitting phosphor.

The phosphor layer of said panel or screen comprising said second prompt emitting phosphor is brought in contact with the phosphor layer of the panel according to the embodiment illustrated in Fig 1.

In Fig. 4, 1 and 1' represent optional supports, that can be the same or different, 2 represents a phosphor layer comprising an image storage phosphor 3, mixed with a prompt emitting phosphor 4, 7 represents a phosphor layer comprising a second prompt emitting phosphor 8, that can be the same as or different from prompt emitting phosphor 4.

In this case it is preferred that the said second prompt emitting phosphor 8 emits light of a wavelenght different of the wavelength emitted by the first prompt emitting phosphor 4 and/or said second prompt emitting phosphor 8 shows a different K-edge from said first prompt emitting phosphor 4.

Fig. 5 show schematically a further embodiment of a recording medium according. It is an X-ray recording element comprising

(i) a first panel or screen comprising a transparent support and at least two phosphor layers, one comprising an image storage phosphor closest to the support and one comprising a first prompt emitting phosphor farthest away from said support and

(ii) a second supported or self supporting panel or screen comprising a phosphor layer comprising a second prompt emitting phosphor, equal to or different from said first prompt emitting phosphor, that is positioned such as to have its phosphor layer in close contact with said support of said first panel or screen.

In Fig 5, 1 represents an optional transparent support, 5 represents a phosphor layer comprising an image storage phosphor 3 and 6 a phosphor layer comprising a prompt emitting phosphor 4, 7 represents a phosphor layer comprising a second prompt emitting phosphor 8, that can be the same as or different from prompt emitting phosphor 4 and 1' represents an optional support that can be either transparent or opaque.

In this combination the phosphor layer comprising the second prompt emitting phosphor is brought into close contact with the transparent support of the screen or panel according as described in Fig. 2. In this case it is preferred that the said second prompt emitting phosphor emitts light of a wavelenght different of the wavelength emitted by the first prompt emitting phosphor and/or said second prompt emitting phosphor shows a different K-edge from said first prompt emitting phosphor.

The embodiments shown in the figures 1 to 5 are only meant as illustrations of the present invention, but by no means as limiting the present invention thereto.

The amount of lowering of the dynamic range depends on the amount of light emitted by the prompt emitting phosphor. This amount can be increased by choosing a prompt emitting phosphor with high conversion efficiency, or by using relatively more prompt emitting phosphor than image storage phosphor.

All image storage phosphors, known in the art can advsntageously be used in a recording element according to the present invention. Examples of stimulable (image storage) phosphors are e.g. :

SrS:Ce, Sm, SrS:Eu, Sm, ThO_2:Er, and La_2O_2S:Eu, Sm, as described in U.S. Patent N°.3,859,527;

ZnS:Cu,Pb, $BaO.xAl_2O_3$:Eu, in which x is a number satisfying the condition of $0.8 \leqq x \leqq 10$, and $M^{2+}O.xSiO_2$:A, in which M^{2+} is at least one divalent metal selected from the group consisting of Mg, Ca, Sr, Zn, Cd and Ba, A is at least one element selected from the group consisting of Ce, Tb, Eu, Tm, Pb, Tl, Bi and Mn, and x is a number satisfying the condition of $0.5 \leqq x \leqq 2.5$, as described in U.S. Patent N°. 4,326,078;

$M^{III}OX$:xCe, in which M^{III} is at least one trivalent metal selected from the group consisting of Pr, Nd, Pm, Sm, Eu, Tb, Dy, Ho, Er, Tm, Yb and Bi; X is at least one element selected from the group consisting of Cl and Br; and x is a number satisfying the condition of $0 < x < 0.1$, as described in Japanese Patent Provisional Publication N°. 58(1983)-69281;

LnOX:xA, in which Ln is at least one element selected from the group consisting of La, Y, Gd and Lu, X is at least one element selected from the group consisting of Cl and Br, A is at least one element selected from the group consisting of Ce and Tb, and x is a number satisfying the condition of $0 < x < 0.1$, as described in the above-mentioned U.S. Patent N°. 4,236,078;

$(Ba_{1-x},M^{II}_{x})FX$:yA, in which M^{II} is at least one divalent metal selected from the group consisting of Mg, Ca, Sr, Zn and Cd, X is at least one element selected from the group consisting of Cl, Br and I, A is at least one element selected from the group consisting of Eu, Tb, Ce, Tm, Dy, Pr, Ho, Nd, Yb and Er, and x and y are numbers satisfying the conditions of $0 \leqq x \leqq 0.6$ and $0 \leqq y \leqq 0.2$ respectively, as described in US-P 4,239,968.

Bariumfluorohalide phosphors as disclosed in, e.g., US P 4.239.968, DE OS 2 928 245, US-P 4 261 854, US-P 4 539 138, US P 4.512.911, EP 0 029 963, US-P 4 336 154, US-P 5 077 144, US-P 4 948 696, Japanese Patent Provisional Publication N°. 55(1980)-12143, Japanese Patent Provisional Publication N°. 56(1981)-116777, Japanese Patent Provisional Publication N°. 57(1982)-23675, US-P 5 089 170, US-P 4 532 071, DE OS 3 304 216, EP 0 142 734, EP 0 144 772, US-P 4 587 036, US-P 4 608 190, and EP 0 295 522.

$Ba_{1-x}Sr_xF_{2-a-b}X_b$:zA, wherein X is at least one member selected from the group consisting of Cl and I; x is in the range $0.10 \leqq x \leqq 0.55$; a is in the range $0.70 \leqq a \leqq 0.96$; b is in the range $0 \leqq b < 0.15$; z is in the range $10^{-7} < z \leqq 0.15$, and A is Eu^{2+} or Eu^{2+} together with one or more of the co-dopants selected from the group consisting of Eu^{3+}, Y, Tb, Ce, Tm, Dy, Pr, Ho, Nd, Yb, Er, La, Gd and Lu, and wherein fluorine is present stoichiometrically in said phosphor in a larger atom % than bromine taken alone or bromine combined with chlorine and/or iodine, as disclosed in EP 345 903.

Alkali metal phosphors comprising earth alkali metals as disclosed in e.g. US-P 5,028,509 and EP 0 252 991.

Halosilicate phosphors as disclosed in, e.g.,EP 304 121, EP 382 295 and EP 522 619.

The above-described stimulable phosphors are given by no means to restrict the stimulable phosphor employable in the present invention. Any other phosphor can be also employed, provided that the phosphor gives stimulated emission when excited with stimulating rays after exposure to a high energy radiation.

Prompt emitting phosphors for use in a recording element according to the present invention can be chosen from any phosphor, having a light emission with peak emission wavelength between 400 and 850 nm, known in the art, provided that the largest portion of the emission light of said prompt emitting phosphor overlaps with the stimulation spectrum of the image storage phosphor used together with said said prompt emitting phosphor. Examples of useful prompt emitting phosphors are those disclosed in e.g. US-P 4,362,944; EP-A 0435 241; EP-A 0088820; EP-A 0350 883 and US-P 5,138,167. Useful prompt emitting phosphors are e.g. $CaWO_4$, $YTaO_4$:Nb, $YTaO_4$:Eu, $YTaO_4$:Tb, Y_2O_2S:Eu, Y_2O_2S:Tb, $GdTaO_4$:Tb, Gd_2O_2S:Tb, Gd_2O_2S:Eu, LaObr:Tb, etc.

The amount of overlap between the stimulation spectrum of the stimumlable phosphor and the emission spectrum of the prompt emitting phosphor can be controlled by changing the dopant in said prompt emitting phosphor. E.g. Gd_2O_2S:Tb has a peak emission wavelength at 627 nm, Gd_2O_2S:Eu has a peak emission wavelength at 545 nm ; Y_2O_2S:Eu has a peak emission wavelength at 627 nm, Y_2O_2S:Tb has a peak emission wavelength at 545 nm. Also the differently doped Yttriumtantalates, Lantanumoxibromides, etc, show different peak emission wavelengths.

The amount of overlap between the stimulation spectrum of the stimumlable phosphor and the emission spectrum of the prompt emitting phosphor can also be controlled by mixing different prompt emitting phosphors.

The above-described prompt emitting phosphors are given by no means to restrict the prompt emitting phosphor employable in the present invention.

The panel or panels comprising the stimulable phosphor and the prompt emitting phosphor can be self supporting or supported. When supported any support known in the art can be used. The support can be paper, cardbord, a polymeric film, an opaque black pigmented polymeric film, an opaque reflecting polymeric film (e.g. a polymeric film comprising white pigments, or void inducing non compatible polymers as disclosed in, e.g., US-P 4,780,402, EP-B 182 253, or US-P 4,187,113. The thickness of the support can vary widely from 50 µm to 1 mm.

The panel or screen according to the present invention can comprise, apart from one or more phosphor containing layers, subbing layers (hardened or unhardened), reflecting layers, protective layers, edge reinforcing ingredients, antistatic layers or antistatic agents incorporated in at least one of the layers constituting the panel, as known in the art of screen manufacturing. The panel or screen may also comprise sliding agents, spacing agents (polymeric beads as well as inorganic particles) to enhance the transportability of the panel in the apparatus to record the X-ray energy and in the apparatus to stimulate the panel. The phosphors, both stimulable and prompt emitting, can be mixed with a binder before coating. Useful binders are e.g. those disclosed in US-P 2,502,529, US-P 2,887,379, US-P 3,617,285, US-P 3,300,310, US-P 3,300,311, US-P 3,743,833, WO 93/01552 and WO 94/00530.

A mixture of two or more of these binders may be used, e.g., a mixture of polyethyl acrylate and cellulose acetobutyrate.

The weight ratio of phosphor to binder is generally within the range of from 50:50 to 99:1, preferably from 80:20 to 99:1.

A recording element, according to the present invention, can be construed such a to give a recording element that makes it possible to have a method for dual energy subtraction.

Dual energy subtraction is a technique in medical diagnosis to provide an image of differences in the object. One image of the object is made with with high energy (E1), in a human body this energy is more absorbed in bony structures, than in soft tissue. Therefore this image shows mainly the bony structures, while the soft tissue is less well or not imaged. Another image is made with low energy (E2), in a human body the bony structures stop this energy more or less completely while the soft tissue absorbes part of it. Therefore this image shows mainly the soft tissue, while the bony structures are less well or not imaged. By subtracting the two images (one generated by E1 and one generated by E2) a third image, showing only the differences between the first two images is made, making it possible to make a diagnosis of a specific structure in the body without being distracted by other information in the image. In digital radiography several methods for dual energy radiography have been disclosed, e.g. in EP-B 089 665 and EP-B 112 469.

It is however necessary to read the two images made with X-rays of different energy (E1 and E2), digitize the information content of both images and subtracting both image contents. This procedure is time consuming and requires a sofisticated, expensive computer and software.

When in a recording element, according to the present invention, an image storage phosphor and a prompt emitting phosphor, having different K-edges and thus showing a different relative absorption coefficient for low and high energy X-rays, are used, the energy subtraction is performed in the recording element during the exposure. When, e.g. the prompt emitting phosphor emits more light by absorbing X-ray energy E1 than by absorbing X-ray energy E2, the energy stored in the image storage phosphor due to the absorption of E1 in said image storage phosphor, will be erased more during exposure than the energy stored in the image storage phosphor due to the absorption of E2, leaving a subtraction image into the image storage phosphor comprised in the recording element.

EXAMPLES

COMPARATIVE EXAMPLE

A panel comrising a stimulable phosphor ($Ba_{0.87}Sr_{0.17}F_{1.11}Br_{0.89}:Eu_{0.02}$) was irradiated trough an aluminium stepwedge with X-ray of 70 kVp and 20 mAs at a distance of 125 cm from the X-ray source.

After irradiation the stimulable phosphor on the panel was stimulated with a He-Ne laser (632.3 nm) and the emitted light collected in a photomultiplier. The dynamic range of the stimulable phosphor panel was determined by dividing the reading of the photomultiplier at the step of the stepwedge having minimal thickness by the reading of the photomultiplier at the step of the stepwedge having maximal thickness and by squaring the quotient. This gave a value of 7.18.

EXAMPLE 1

The panel comrising a stimulable phosphor from the comparative example was combined with a panel comprising a prompt emitting phosphor. The prompt emitting phosphor was $Gd_2O_2:Eu$, with average particle size of 10 µm, coated at 110

mg/cm^2 on a polyester support comprising $BaSO_4$ as a withener, the prompt emission spectrum of this phosphor has a peak emission wavelength of 627 nm.
Both phosphor layer weres facing each other and the panel comprsing the prompt emitting phosphor was placed farthest away from the X-ray source.

The assembly was was irradiated trough an aluminum stepwedge with X-ray of 70 kVp and 20 mAs at a distance of 125 cm from the X-ray source.

After irradiation the stimulable phosphor on the panel was stimulated with a He-Ne laser (632.3 nm) and the emitted light collected in a photomultiplier. The dynamic range of the stimulable phosphor panel was determined by dividing the reading of the photomultiplier at the step of the stepwedge having minimal thickness by the reading of the photomultiplier at the step of the stepwedge having maximal thickness and by squaring the quotient. This gave a value of 2.25.

This means that in the assembly according to the present invention, the dynamic range was lowered by a factor 2.87.

Claims

1. An X-ray recording element characterised in that said element comprises an image storage phosphor (photostimulable phosphor) and at least one prompt emitting phosphor, said prompt emitting phosphor emitting light with a peak emission wavelength between 400 and 850 nm.

2. An X-ray recording element according to claim 1, wherein said prompt emitting phosphor emits light with a peak emission wavelength between 500 and 700 nm.

3. An X-ray recording element according to claim 1 or 2, wherein the emission spectrum of said prompt emitting phosphor overlaps with the stimulation spectrum of said image storage phosphor.

4. An X-ray recording element according to any of the claims 1 to 3, wherein said image storage phosphor and said prompt emitting phosphor have a different K-edge.

5. An X-ray recording element according to any of the claims 1 to 4, wherein said recording element comprises a support and said image storage phosphor and said prompt emitting phosphor are mixed together and coated together onto said support.

6. An X-ray recording element according to any of the claims 1 to 4, wherein said recording element comprises a support and said image storage phosphor and said prompt emitting phosphor are coated in separate layers onto said support.

7. An X-ray recording element according to any of the claims 1 to 4, wherein said recording element comprises two self supporting or supported panels, one panel comprising a prompt emitting phosphor, an other comprising an image storage phosphor and the two phosphor layers are brought into close contact.

8. An X-ray recording element comprising
(i) a first supported panel or screen comprising a phosphor layer comprising a first prompt emitting phosphor and an image storage phosphor mixed together
(ii) a second supported panel comprising a second prompt emitting phosphor, that can be the same as or different from said first prompt emitting phosphor.

9. An X-ray recording element comprising
(i) a first panel or screen comprising a transparent support and at least two phosphor layers, one comprising an image storage phosphor closest to the support and one comprising a first prompt emitting phosphor farthest away from said support and
(ii) a second supported or self supporting panel or screen comprising a phosphor layer comprising a second prompt emitting phosphor, the same as or different from said first prompt emitting phosphor, that is positioned such as to have its phosphor layer in close contact with said support of said first panel or screen.

10. Use of a recording element according to any of the preceding claims in a "dual energy" subtraction diagnosis.

11. A method for recording and reproducing an X-ray image comprising the steps of :
i. irradiating a recording element with X-rays
ii; storing the absorbed X-ray energy in said recording element
iii. stimulating said recording element with stimulating radiation to yield a stimulated light output
iv. reading said light output
characterised in that said element comprises an image storage phosphor (photostimulable phosphor) and at least one prompt emitting

phosphor, said prompt emitting phosphor emitting light with a peak emission wavelength between 400 and 850 nm.

12. A method according to claim 11 wherein the emission spectrum of said prompt emitting phosphor overlaps with the stimulation spectrum of said image storage phosphor.

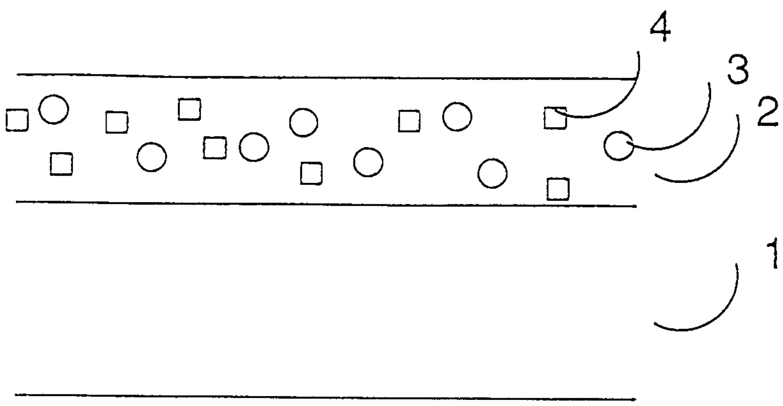

FIG. 1

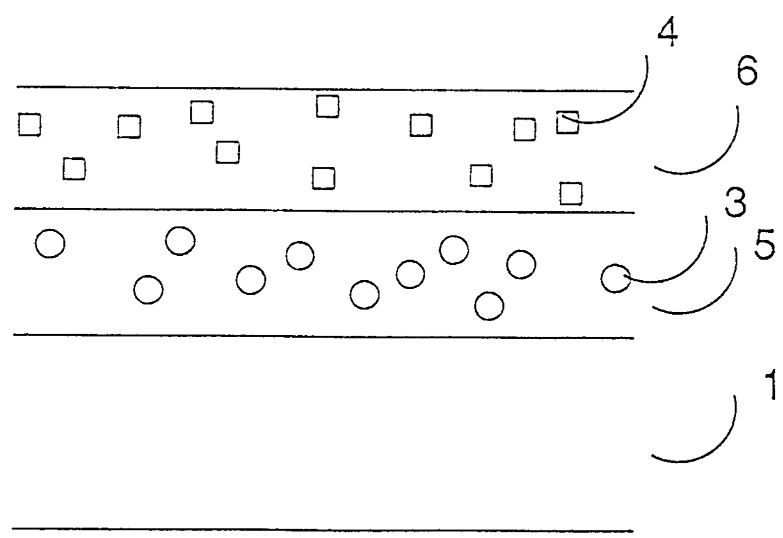

FIG. 2

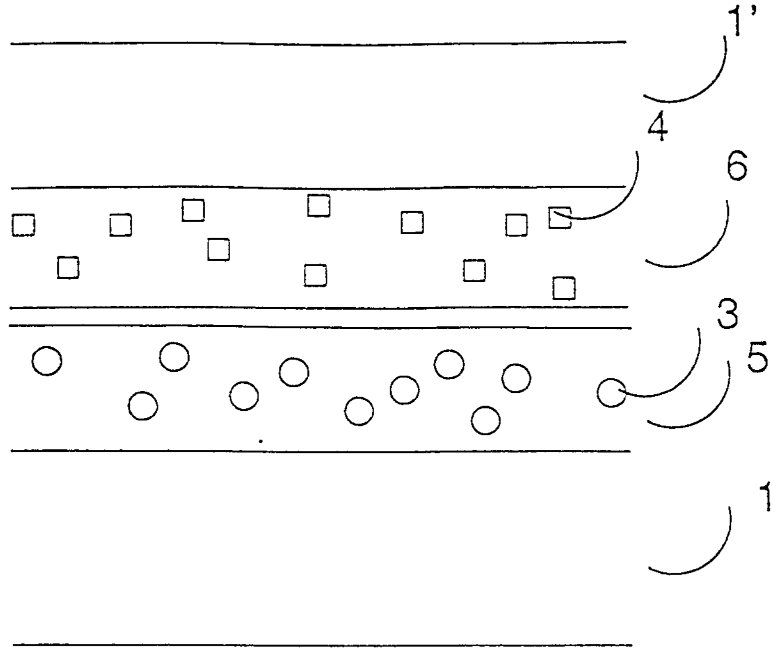

FIG. 3

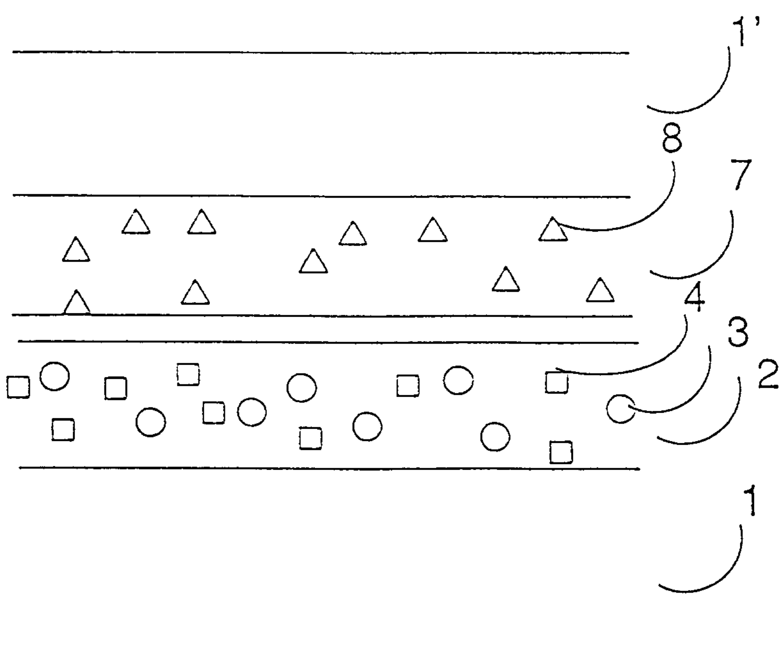

FIG. 4

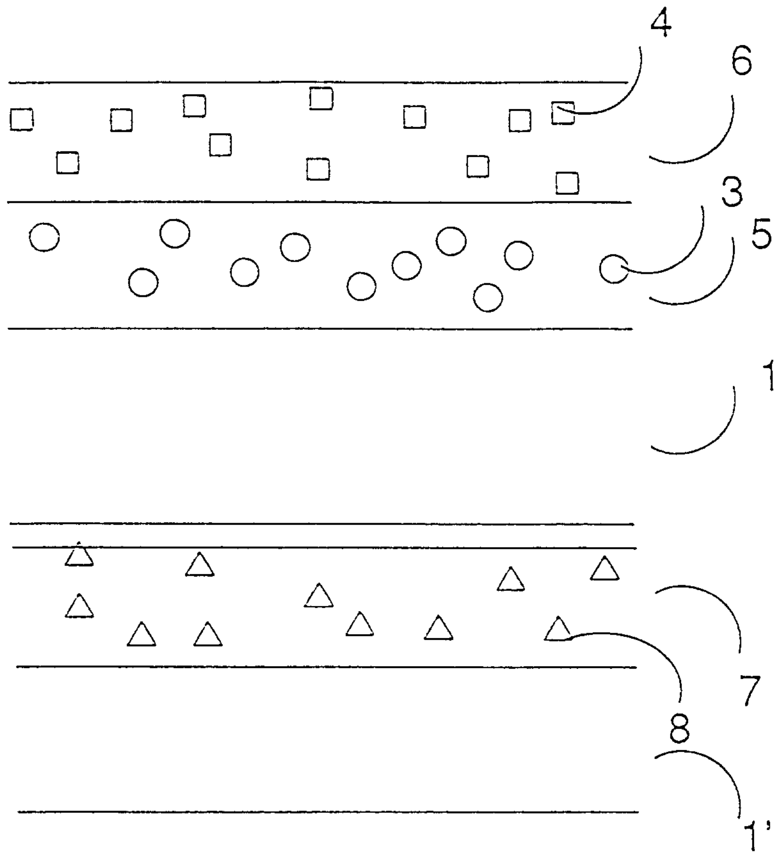

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 1736

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 165 340 (SIEMENS) * claims 1-6 * ---	1,5,11	G21K4/00
X	US-A-5 036 207 (T.NAKAMURA & AL) * claims 1-8 * -----	1,5,11	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G21K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 November 1994	Drouot, M-C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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