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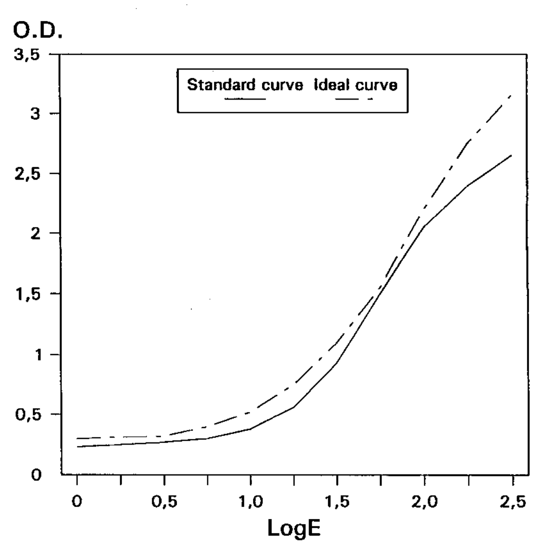
(54) **Symmetrical radiographic assembly for chest examination.**

(57) This invention relates to a double side radiographic element which comprises a support and at least two silver halide emulsion layers coated on each side of said support, wherein said at least two silver halide emulsion layers show a speed difference of at least 0.3 logE and are both sensitive to the same region of the electromagnetic spectrum, and wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40. A symmetrical radiographic assembly comprising intensifying screens and the above described radiographic element and a process for obtaining a radiographic image from the radiographic assembly are also disclosed.

FIG. 1



EP 0 661 592 A1

FIELD OF THE INVENTION

The present invention relates to a combination of photosensitive elements for use in radiography. More specifically, the present invention relates to a double-side coated silver halide radiographic element for use in medical radiography, preferably for chest diagnostic imaging, and to the combination thereof with a pair of fluorescent phosphor screens.

BACKGROUND OF THE INVENTION

It is known in the art of medical radiography to employ intensifying screens to reduce the X-ray dosage to the patient. Intensifying screens absorb the X-ray radiation and emit electromagnetic radiations which can be better absorbed by silver halide emulsion layers. Another approach to reduce the X-ray dosage to the patient is to coat two silver halide emulsion layers on the opposite sides of a support to form a duplitized radiographic element.

Accordingly, it is a common practice in medical radiography to use a radiographic assembly consisting of a duplitized radiographic element interposed between a pair of front and back screens.

One of the problems of medical radiography relates to the different X-ray absorption of the various parts of the body. For example, in chest radiography the heart area has an absorption ten times higher than the lung area. A similar effect occurs in the radiography of the stomach, where a contrast medium is used in order to enhance the image depictivity (the part of the body having no contrast medium being totally black), and of hands and legs, where bones have an X-ray absorption higher than that of soft tissues such as flesh and cartilage.

In these cases a radiographic element showing a low contrast is required for an area of high X-ray absorption and a radiographic element showing a high contrast is required for an area of low X-ray absorption. The resulting film is a compromise in an attempt to have sufficient optical density and sharpness for these different areas of the body. In the art of chest radiography, X-ray images providing visually discernible features in both the heart and lung image areas are attempted by using extended latitude radiographic elements. Extended latitude radiographic elements typically employ polydispersed silver halide emulsions to provide lower average contrasts and a wider range of exposures separating minimum and maximum density exposures. Said extended latitude radiographic elements, however, do not provide the desired sensitometric curve necessary to obtain visually useful imaging details in both heart and lung areas. The optimal sensitometric curve for obtaining good imaging information in both regions of low and high X-ray absorption is shown in Fig. 1. Various methods have been suggested to solve the problem of needing different contrast capabilities for different areas of the body. One approach relates to the use of double coated radiographic elements having a different emulsion layer coated on each side of the support. An example of this solution can be found in FR 1,103,973, wherein the use of screens having a light emission ratio of from 1:1 to 1.5:1 (back screen:front screen) in combination with a radiographic element having coated thereon a high contrast back emulsion and a low contrast front emulsion is suggested. A combination of screens having a light emission ratio higher than 1.5:1 and radiographic elements having emulsion layers with the same gradation is also suggested. Other patents disclose the use of double coated radiographic elements having emulsion layers with different contrast or sensitivity. For example, DE 1,017,464 discloses a double coated radiographic element having coated thereon a first emulsion with high sensitivity and low contrast and a second emulsion with low sensitivity and high contrast, FR 885,707 discloses a double coated radiographic element having coated thereon a first high speed emulsion and a second high contrast emulsion, and FR 875,269 discloses a radiographic assembly comprising several radiographic films or papers, each having a different sensitivity and/or contrast relative to the others, in order to obtain separate and different images of the same object with a single exposure. Nothing in the above described patents suggests the use of specific features to obtain a symmetric double-coated radiographic element showing the sensitometric curve of Fig. 1. An approach similar to that of the above described French and German patents is disclosed in US 4,994,355, claiming an unsymmetrical double coated radiographic element having emulsion layers with different contrast, in US 4,997,750, claiming an unsymmetrical double coated radiographic element having emulsion layers with different sensitivity, and in US 5,021,327 claiming an unsymmetrical radiographic assembly wherein the back screen and emulsion layer have a photicity at least twice that of the front screen and emulsion layer, the photicity being defined as the integrated product of screen emission and emulsion sensitivity. All these proposed solutions require the use of an unsymmetrical radiographic film which requires a specific orientation relative to the screens for a proper use.

The following are additional documents illustrating the state of the art.

FR 787,017 discloses a radiographic element comprising silver halide emulsion layers of different color sensitivity to be combined with intensifying screens emitting radiation to which the silver halides are sensitive. The purpose of this patent is to obtain an increased use of radiation.

EP 88,820 discloses a radiographic fluorescent screen comprising a first blue emitting phosphor layer and a second green emitting phosphor layer to be combined with a silver halide element having spectral sensitivity in the blue-green region ("ortho-type" elements).

JP 60-175000 discloses a combination of a double coated silver halide element and a screen pair wherein the fluorescent layers of the two screens have different wavelength region emissions and each screen comprises an organic dye to absorb the light emitted by the opposite screen.

EP 350,883 discloses a technique for crossover reduction in which silver halide emulsion layers having different color sensitivities are provided on the opposite sides of a transparent support, and X-ray fluorescent intensifying screens having emission spectra corresponding to the respective color sensitivities are used.

Research Disclosure, December 1973, Vol. 116, Item 11620 discloses a radiographic element which shows different contrast when observed with or without a green filter, respectively.

Finally, EP 126,644 describes a radiographic material having a characteristic curve whose gamma between optical densities of 0.50 and 1.50 is 2.7 to 3.3 and gamma between optical densities of 2.00 and 3.00 is 1.5 to 2.5, said material having a wide exposure latitude to make possible the production of images having high diagnostic ability.

SUMMARY OF THE INVENTION

This invention relates to a double side radiographic element which comprises a support and at least two silver halide emulsion layers coated on each side of said support, wherein said at least two silver halide emulsion layers show a speed difference of at least 0.3 logE and are both sensitive to the same region of the electromagnetic spectrum, and wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

In another aspect this invention relates to a symmetrical radiographic assembly comprising:

- a double side radiographic element which comprises a support and hydrophilic colloid layers coated on each side of said support, and
- an intensifying screen adjacent to each side of said radiographic element,

wherein on each side of said support are coated at least two silver halide emulsion layers having a speed difference of at least 0.3 logE, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum,

wherein said intensifying screen comprises a light emitting phosphor selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and

wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

In a further aspect, the present invention relates to a process for obtaining a radiographic image comprising the step of (a) image-wise exposing to an X-ray radiation which has passed through an object, a symmetrical radiographic assembly comprising (i) a double side radiographic element having a support and at least two silver halide emulsion layers having a speed difference of at least 0.3 logE coated on each side thereof, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum, and (ii) an intensifying screen comprising a light emitting phosphors selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and (b) developing said exposed radiographic element.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 represents the optimal sensitometric curve for obtaining good imaging information in both regions of low and high X-ray absorption, in particular in the chest area in comparison with a standard sensitometric curve.

DETAILED DESCRIPTION OF THE INVENTION

This invention relates to a double side radiographic element which comprises a support and at least two silver halide emulsion layers coated on each side of said support, wherein said at least two silver halide emulsion layers show a speed difference of at least 0.3 logE and are both sensitive to the same region of the electromagnetic spectrum, and wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

According to the present invention, the double side radiographic element comprises at least two silver halide emulsions having a difference in speed, measured at density 1.0 above minimum density, of at least 0.3 logE.

The silver halide emulsion having the higher speed and the silver halide emulsion having the lower speed will be herein defined as the "high speed emulsion" and the "low speed emulsion", respectively.

While the best choice of speed difference between the low speed emulsion and the high speed emulsion can differ widely, depending upon the application to be served, in most instances the first and the second emulsion exhibit a speed difference in the range of from 0.3 to 1.0 logE, optimally from 0.4 to 0.8 logE. It should be understood that, although in a preferred aspect of the present invention the low speed emulsion is first coated on the support, and the high speed emulsion is coated on the low speed emulsion, the order of the coating could be inverted by a man skilled in the art, without the loss of the benefits of the present invention.

As known in the photographic art, the contrast is the density difference divided by the log of the difference in exposure levels at two density reference points on the characteristic curve, where the exposure levels are meter-candle-seconds. Accordingly, the contrast γ can be measured with the following formula (I):

$$\gamma = \Delta D / \Delta \mathrm{LogE} \qquad (I)$$

wherein ΔD is the density difference and ΔLogE is the difference in speed between the density reference points. The average contrast is measured at density 0.25 and 2.00 above minimum density. The radiographic film of the present invention provides an average contrast, measured with the above mentioned formula (I), higher than 1.40, preferably higher than 1.50.

On the contrary, the toe contrast value simply represents the speed difference (i.e., ΔLogE) obtained measuring the speed at 0.25 and 1.00 above minimum density. The radiographic film of the present invention shows a toe contrast value higher than 0.45, preferably higher than 0.55. In this case, the higher the toe contrast value (which represents the ΔLogE of the two density reference points), the lower the contrast measured with the above mentioned formula (I).

In order to obtain such values of average contrast and toe contrast, the speed difference of the emulsions coated on the radiographic support should differ of at least 0.3 LogE, preferably of from 0.3 to 1.0 logE, optimally of from 0.4 to 0.8 logE. According to a preferred embodiment of the present invention the average contrast of the emulsions coated on the radiographic support should also differ from each other. The contrast of the high speed emulsion and the low speed emulsion should differ by at least 0.2, more preferably by at least 0.3. According to a more preferred embodiment of the present invention the low speed emulsion shows an average contrast in the range of from 2.4 to 3.2, more preferably from 2.6 to 3.0, and the high speed emulsion shows an average contrast in the range of from 1.8 to 2.6, more preferably from 2.0 to 2.4. Generally, the best results are obtained when the high and low speed emulsions show the lower and higher contrast, respectively.

As employed herein the term "electromagnetic spectrum" refers to radiations having a wavelength of from 300 to 1200 nm, i.e., comprising the ultraviolet, visible and infrared radiations.

The silver halide grains in the radiographic emulsion may be regular grain having a regular crystal structure such as cubic, octahedral, and tetradecahedral, or a spherical or irregular crystal structure, or those having crystal defects such as twin planes, epitaxialisation, or those having a tabular form, or combinations thereof.

The term "cubic grains" according to the present invention is intended to include substantially cubic grains, that is, silver halide grains which are regular cubic grains bounded by crystallographic faces (100), or which may have rounded edges and/or vertices or small faces (111), or may even be nearly spherical when prepared in the presence of soluble iodides or strong ripening agents, such as ammonia. The silver halide grains may be of any required composition for forming a negative silver image, such as silver chloride, silver bromide, silver chlorobromide, silver bromoiodide, silver bromochloroiodide, and the like. Particularly good results are obtained with silver bromoiodide grains, preferably silver bromoiodide grains containing about 0.1 to 15% moles of iodide ions, more preferably about 0.5 to 10% moles of iodide ions and still preferably silver bromoiodide grains having average grain sizes in the range from 0.2 to 3 µm, more preferably from 0.4 to 1.5 µm. Preparation of silver halide emulsions comprising cubic silver halide grains is described, for example, in Research Disclosure, Vol. 176, December 1978, Item 17643, Vol. 184, August 1979, Item 18431 and Vol 308, December 1989, Item 308119.

Other silver halide emulsions according to this invention having highly desirable imaging characteristics are those which employ one or more light-sensitive tabular grain emulsions as disclosed in US Patents 4,425,425 and 4,425,426. The tabular silver halide grains contained in the silver halide emulsion layers of this invention have an average diameter to thickness ratio (often referred to in the art as aspect ratio) of at least 2:1, preferably 3:1 to 20:1, more preferably 3:1 to 10:1, and most preferably 3:1 to 8:1. Average diameters of the tabular silver halide grains suitable for use in this invention range from about 0.3 µm to about 5 µm, preferably 0.5 µm to 3 µm, more preferably 0.8 µm to 1.5 µm. The tabular silver halide grains suitable for use in this invention have a thickness of less than 0.4 µm, preferably less than 0.3 µm and more preferably less than 0.2 µm.

The tabular silver halide grain characteristics described above can be readily ascertained by procedures well known to those skilled in the art. The term "diameter" is defined as the diameter of a circle having an area equal to the projected area of the grain. The term "thickness" means the distance between two substantially parallel main planes constituting the tabular silver halide grains. From the measure of diameter and thickness of each grain the diameter to thickness ratio of each grain can be calculated, and the diameter to thickness ratios of all tabular grains can be averaged to obtain their average diameter to thickness ratio. By this definition the average diameter to thickness ratio is the average of individual tabular grain diameter to thickness ratios. In practice, it is simpler to obtain an average diameter and an average thickness of the tabular grains and to calculate the average diameter to thickness ratio as the ratio of these two averages. Whatever the method used may be, the average diameter to thickness ratios obtained do not differ greatly.

In the silver halide emulsion layer containing tabular silver halide grains, at least 15%, preferably at least 25%, and, more preferably, at least 50% of the silver halide grains are tabular grains having an average diameter to thickness ratio of not less than 3:1. Each of the above proportions, "15%", "25%" and "50%" means the proportion of the total projected area of the tabular grains having an average diameter to thickness ratio of at least 3:1 and a thickness lower than 0.4 µm, as compared to the projected area of all of the silver halide grains in the layer.

As described above, commonly employed halogen compositions of the silver halide grains can be used. Typical silver halides include silver chloride, silver bromide, silver chloroiodide, silver bromoiodide, silver chlorobromoiodide and the like. However, silver bromide and silver bromoiodide are preferred silver halide compositions for tabular silver halide grains with silver bromoiodide compositions containing from 0 to 10 mol% silver iodide, preferably from 0.2 to 5 mol% silver iodide, and more preferably from 0.5 to 1.5 mol% silver iodide. The halogen composition of individual grains may be homogeneous or heterogeneous.

Silver halide emulsions containing tabular silver halide grains can be prepared by various processes known for the preparation of radiographic elements. Silver halide emulsions can be prepared by the acid process, neutral process or ammonia process, or in the presence of any other silver halide solvent. In the stage for the preparation, a soluble silver salt and a halogen salt can be reacted in accordance with the single jet process, double jet process, reverse mixing process or a combination process by adjusting the conditions in the grain formation, such as pH, pAg, temperature, form and scale of the reaction vessel, and the reaction method. A silver halide solvent, such as ammonia, thioethers, thioureas, etc., may be used, if desired, for controlling grain size, form of the grains, particle size distribution of the grains, and the grain-growth rate.

Preparation of silver halide emulsions containing tabular silver halide grains is described, for example, in de Cugnac and Chateau, "Evolution of the Morphology of Silver Bromide Crystals During Physical Ripening", Science and Industries Photographiques, Vol. 33, No.2 (1962), pp.121-125, in Gutoff, "Nucleation and Growth Rates During the Precipitation of Silver Halide Photographic Emulsions", Photographic Science and Engineering, Vol. 14, No. 4 (1970), pp. 248-257,in Berry et al., "Effects of Environment on the Growth of Silver Bromide Microcrystals", Vol.5, No.6 (1961), pp. 332-336, in US Pat. Nos. 4,063,951, 4,067,739, 4,184,878, 4,434,226, 4,414,310, 4,386,156, 4,414,306 and in EP Pat. Appln. No. 263,508.

In preparing the silver halide emulsions of the present invention, a wide variety of hydrophilic dispersing agents for the silver halides can be employed. Gelatin is preferred, although other colloidal materials such as gelatin derivatives, colloidal albumin, cellulose derivatives or synthetic hydrophilic polymers can be used as known in the art. Other hydrophilic materials useful known in the art are described, for example, in Research Disclosure, Vol. 308, Item 308119, Section IX. In a preferred aspect of the present invention highly deionized gelatin is used. The highly deionized gelatin is characterized by a higher deionization with respect to the commonly used photographic gelatins. Preferably, the gelatin for use in the present invention is almost completely deionized which is defined as meaning that it presents less than 50 ppm (parts per million) of Ca^{++} ions and is practically free (less than 5 parts per million) of other ions such as chlorides, phosphates, sulfates and nitrates, compared with commonly used photographic gelatins having up to 5,000 ppm of Ca^{++} ions and significant presence of other ions.

The highly deionized gelatin can be employed not only in the silver halide emulsion layers, but also in other component layers of the radiographic element, such as overcoat layers, interlayers and layers positioned beneath the emulsion layers. In the present invention, preferably at least 50%, more preferably at least 70% of the total hydrophilic colloid of the radiographic element comprises highly deionized gelatin. The amount of gelatin employed in the radiographic element of the present invention is such as to provide a total silver to gelatin ratio higher than 1 (expressed as grams of Ag/grams of gelatin). In particular the silver to gelatin ratio of the silver halide emulsion layers is in the range of from 1 to 1.5.

The radiographic element of the present invention can be forehardened to provide a good resistance in rapid processing conducted in automatic processing machine without the use of hardeners in processing solutions. Examples of gelatin hardeners are aldehyde hardeners, such as formaldehyde, glutaraldehyde and the like, active halogen hardeners, such as 2,4-dichloro-6-hydroxy-1,3,5-triazine, 2-chloro-4,6-hydroxy-1,3,5-triazine and the like, active vinyl hardeners, such as bis-vinylsulfonyl-methane, 1,2-vinylsulfonyl-ethane, bis-vinylsulfonyl-methyl ether, 1,2-bis-vinylsulfonylethyl ether and the like, N-methylol hardeners, such as dimethylolurea, methyloldimethyl hydantoin and the like, and bi-,tri-,or tetra-vinylsulfonyl substituted organic hydroxy compounds, such as 1,3-bis-vinylsulfonyl-2-propanol and the like. Other useful gelatin hardeners may be found in Research Disclosure, Vol. 308, December 1989, Item 308119, Paragraph X.

The above described gelatin hardeners may be incorporated in the silver halide emulsion layer or in a layer of the silver halide radiographic element having a water-permeable relationship with the silver halide emulsion layer. Preferably, the gelatin hardeners are incorporated in the silver halide emulsion layer.

The amount of the above described gelatin hardener that is used in the silver halide emulsion of the radiographic element of this invention can be widely varied. Generally, the gelatin hardener is used in amounts of from 0.5% to 10% by weight of hydrophilic dispersing agent, such as the above described highly deionized gelatin, although a range of from 1% to 5% by weight of hydrophilic dispersing agent is preferred.

The gelatin hardeners can be added to the silver halide emulsion layer or other component layers of the radiographic element utilizing any of the well-known techniques in emulsion making. For example, they can be dissolved in either water or a water-miscible solvent such as methanol, ethanol, etc. and added into the coating composition for the above mentioned silver halide emulsion layer or auxiliary layers.

The silver halide emulsions can be chemically and optically sensitized by known methods.

Spectral sensitization can be performed with a variety of spectral sensitizing dyes known in the art. An example of such spectral sensitizing dyes is the polymethine dye class, including cyanines, complex cyanines, merocyanines, complex merocyanines, oxonols, hemioxonols, styryls, merostyryls and streptocyanines.

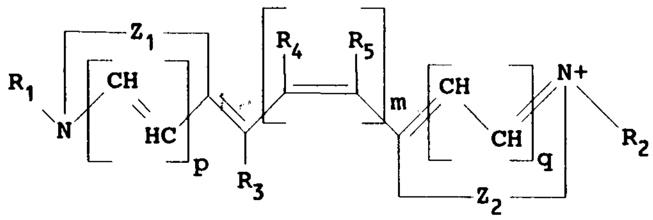
Although native UV-blue sensitivity of silver halides is usually known in the art, significant advantage can be obtained by the use of spectral sensitizing dyes, even when their principal absorption is in the spectral region to which the silver halide emulsion have their native sensitivity.

Preferably, spectral sensitizing dyes according to this invention are those which exhibit J aggregates if adsorbed on the surface of the silver halide grains and a sharp absorption band (J-band) with a bathocromic shift with respect to the absorption maximum of the free dye in aqueous solution. Spectral sensitizing dyes producing J aggregates are well known in the art, as illustrated by F. M. Hamer, ***Cyanine Dyes and Related Compounds***, John Wiley and Sons, 1964, Chapter XVII and by T. H. James, ***The Theory of the Photographic Process,*** 4th edition, Macmillan, 1977, Chapter 8. The use of J-band exhibiting dyes allows the reduction of the well-known problem of crossover.

In a preferred form, J-band exhibiting dyes are cyanine dyes. Such dyes comprise two basic heterocyclic nuclei joined by a linkage of methine groups. The heterocyclic nuclei preferably include fused benzene rings to enhance J aggregation.

The heterocyclic nuclei are preferably quinolinium, benzoxazolium, benzothiazolium, benzoselenazolium, benzimidazolium, naphthoxazolium, naphthothiazolium and naphthoselenazolium quaternary salts.

J-band type dyes preferably used in the present invention have the following general formula (I):



(I)

$(A^-)_K$ $(B^+)_l$

wherein

Z_1 and Z_2 may be the same or different and each represents the elements necessary to complete a cyclic nucleus derived from basic heterocyclic nitrogen compounds such as oxazoline, oxazole, benzoxazole, the naphthoxazoles (e.g., naphth{2,1-d}oxazole, naphth-{2,3-d}-oxazole, and naphth-{1,2-d}-oxazole), thiazoline, thiazole, benzothiazole, the naphthothiazoles (e.g., naphtho{2,1-d}thiazole), the thiazoloquinolines (e.g., thiazolo{4,5-b}quinoline), selenazoline, selenazole, benzoselenazole, the naphthoselenazoles (e.g., naphtho{1,2-d}selenazole, 3H-indole (e.g., 3,3-dimethyl3H-indole), the benzindoles (e.g., 1,1-dimethylbenzindole), imidazoline, imidazole, benzimidazole, the naphthimidazoles (e.g., naphth-{2,3-d}-imidazole), pyridine, and quinoline, which nuclei may be substituted on the ring by one or more of a wide variety of substitutes such as hydroxy, the halogens (e.g., fluoro, bromo, chloro, and iodo), alkyl groups or substituted alkyl groups (e.g., methyl, ethyl, propyl, isopropyl, butyl, octyl, dodecyl, 2-hydroxyethyl, 3-sulfopropyl, carboxymethyl, 2-cyanoethyl, and trifluoromethyl), aryl groups or substituted aryl groups (e.g., phenyl, 1-naphthyl, 2-naphthyl, 4-sulfophenyl, 3-carboxyphenyl, and 4-biphenyl), aralkyl groups (e.g., benzyl and phenethyl), alkoxy groups (e.g., methoxy, ethoxy, and isopropoxy), aryloxy groups (e.g., phenoxy and 1-naphthoxy), alkylthio groups (e.g., ethylthio and methylthio), arylthio groups (e.g., phenylthio, p-tolylthio, and 2-naphthylthio), methylenedioxy, cyano, 2-thienyl, styryl, amino or substituted amino groups (e.g., anilino, dimethylanilino, diethylanilino, and morpholino), acyl groups (e.g., acetyl and benzoyl), and sulfo groups,

R_1 and R_2 can be the same or different and represent alkyl groups, aryl groups, alkenyl groups, or aralkyl groups, with or without substitutes, (e.g., carboxymethyl, 2-hydroxyethyl, 3-sulfopropyl, 3-sulfobutyl, 4-sulfobutyl, 2-methoxyethyl, 2-sulfatoethyl, 3-thiosulfatoethyl, 2-phosphonoethyl, chlorophenyl, and bromophenyl),

R_3 represents a hydrogen atom,

R_4 and R_5 can be the same or different and represent a hydrogen atom or a lower alkyl group of from 1 to 4 carbon atoms,

p and q are 0 or 1, except that both p and q preferably are not 1,

m is 0 or 1 except that when m is 1 both p and q are 0 and at least one of Z_1 and Z_2 represents imidazoline, oxazoline, thiazoline, or selenazoline,

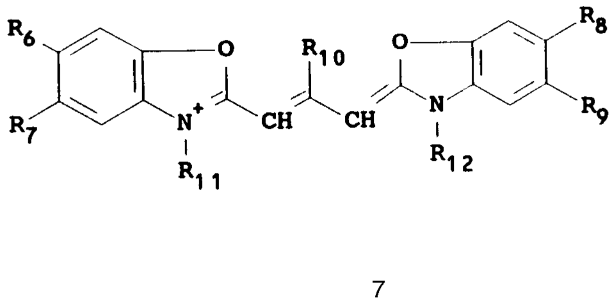
A is an anionic group,

B is a cationic group, and

k and l may be 0 or 1, depending on whether ionic substitutes are present. Variants are, of course, possible in which R_1 and R_3, R_2 and R_5, or R_1 and R_2 together represent the atoms necessary to complete an alkylene bridge.

Other references to well known spectral sensitizers can be found in Research Disclosure, Vol. 308, December 1989, Item 308119, Section IV. Research Disclosure is a publication of Kenneth Mason Publication Ltd., Emsworth, Hampshire PO10 7DD, United Kingdom.

In the most preferred form of this invention, the silver halide emulsions are spectrally sensitized to the green portion of the electromagnetic spectrum with a spectral sensitizing dye adsorbed on said silver halide grains represented by the following general formula (II):



$(X^-)_{n-1}$ (II)

wherein

R_{10} represents a hydrogen atom or a lower alkyl group of from 1 to 4 carbon atoms (e.g. methyl, and ethyl),

R_6, R_7, R_8 and R_9 each represents a hydrogen atom, a halogen atom (e.g. chloro, bromo, iodo, and fluoro), a hydroxy group, an alkoxy group (e.g. methoxy and ethoxy), an amino group (e.g. amino, methylamino, and dimethylamino), an acylamino group (e.g. acetamido and propionamido), an acyloxy group (e.g. acetoxy group), an alkoxycarbonyl group (e.g. methoxycarbonyl, ethoxycarbonyl, and butoxycarbonyl), an alkyl group (e.g. methyl, ethyl, and isopropyl), an alkoxycarbonylamino group (e.g. ethoxycarbonylamino) or an aryl group (e.g. phenyl and tolyl), or, together, R_6 and R_7 and, respectively, R_8 and R_9 can be the atoms necessary to complete a benzene ring (so that the heterocyclic nucleus results to be, for example, an a-naphthoxazole nucleus, a b-naphthoxazole or a b,b'-naphthoxazole),

R_{11} and R_{12} each represents an alkyl group (e.g. methyl, propyl, and butyl), a hydroxyalkyl group (e.g. 2-hydroxyethyl, 3-hydroxypropyl, and 4-hydroxybutyl), an acetoxyalkyl group (e.g. 2-acetoxyethyl and 4-acetoxybutyl), an alkoxyalkyl group (e.g. 2-methoxyethyl and 3-methoxypropyl), a carboxyl group containing alkyl group (e.g. carboxymethyl, 2-carboxyethyl, 4-carboxybutyl, and 2-(2-carboxyethoxy)-ethyl), a sulfo group containing alkyl group (e.g. 2-sulfoethyl, 3-sulfopropyl, 4-sulfobutyl, 2-hydroxy-3-sulfopropyl, 2-(3-sulfopropoxy)-propyl, p-sulfobenzyl, and p-sulfophenethyl), a benzyl group, a phenetyl group, a vinylmethyl group, and the like,

X^- represents an acid anion (e.g. a chloride, bromide, iodide, thiocyanate, methylsulfate, ethylsulfate, perchlorate, and p-toluensulfonate ion), and

n represents 1 or 2.

The alkyl groups included in said substitutes R_6, R_7, R_8, R_9, R_{10}, and R_{11} and, more particularly, the alkyl portions of said alkoxy, alkoxycarbonyl, alkoxycarbonylamino, hydroxyalkyl, acetoxyalkyl groups and of the alkyl groups associated with a carboxy or sulfo group each preferably contain from 1 to 12, more preferably from 1 to 4 carbon atoms, the total number of carbon atoms included in said groups preferably being no more than 20.

The aryl groups included in said substituents R_6, R_7, R_8 and R_9 each preferably contain from 6 to 18, more preferably from 6 to 10 carbon atoms, the total number of carbon atoms included in said groups arriving up to 20 carbon atoms.

The following are specific examples of J-band sensitizing dyes belonging to those represented by the general formula (II) above:

Dye	**R_{10}**	**R_6**	**R_7**	**R_8**	**R_9**	**R_{11}**	**R_{12}**	**X*** **	**n**
A*	C_2H_6	H	5-Cl	H	5'-Cl	$(CH_2)_3SO_3$	$(CH_2)_3SO_3H$	-	1
B**	C_2H_6	H	5-Cl	H	5'-C_6H_5	$(CH_2)_3SO_3$	CH_3 $(CH_2)_2CHSO_3$ H	-	1
C	CH_3	H	5-OCH_3	H	5-OCH_3	C_2H_6	$(CH_2)_3SO_3$	-	1
D	C_2H_6	6-CH_3	5-Cl	H	5'-Cl	$(CH_2)_3SO_3$	$(CH_2)_3SO_3H$	-	1
E	C_2H_6	H	5-Cl	H	5'-Cl	C_2H_6	C_2H_6	I	2

* **Triethylamine salt**
** **Sodium salt**
*** **Sign "-" means that anion is absent**

The silver halide emulsion layers can contain other constituents generally used in photographic products, such as binders, hardeners, surfactants, speed-increasing agents, stabilizers, plasticizers, gelatin extenders, optical sensitizers, dyes, ultraviolet absorbers, etc., and reference to such constituents can be found, for example, in Research Disclosure, Vol. 176, December 1978, Item 17643, Vol. 184, August 1979, Item 18431 and Vol 308, December 1989, Item 308119.

The radiographic element of this invention can be prepared by coating the light-sensitive silver halide emulsion layers and other auxiliary layers on a support. Examples of materials suitable for the preparation of the support include glass, paper, polyethylene-coated paper, metals, polymeric film such as cellulose nitrate, cellulose acetate, polystyrene, polyethylene terephthalate, polyethylene, polypropylene and other well known supports. Preferably, the silver halide emulsion layers are coated on the support at a total silver coverage of at least 1 g/m^2, preferably in the range of from 2 to 5 g/m^2.

Auxiliary layers can be represented by top-coating layers, antistatic layers, antihalo layer, protective layers, dye underlayers, and the like. Dye underlayers are particularly useful in order to reduce the cross-over of the double coated silver halide radiographic material of the present invention. Reference to well-known dye underlayer can be found in US 4,900,652, US 4,855,221, US 4,857,446, 4,803,150. According to a preferred embodiment of the present invention a dye underlayer is coated on at least one side of the support, more preferably on both sides of the support, before the coating of said at least two silver halide emulsions.

In another aspect this invention relates to a symmetrical radiographic assembly comprising:

- a double side radiographic element which comprises a support and hydrophilic colloid layers coated on each side of said support, and
- an intensifying screen adjacent to each side of said radiographic element,

wherein on each side of said support are coated at least two silver halide emulsion layers having a speed difference of at least 0.3 logE, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum,

wherein said intensifying screen comprises a light emitting phosphors selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and

wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

As employed herein the term "symmetrical radiographic assembly" refers to a radiographic assembly which comprises a silver halide double coated radiographic element comprising substantially identical silver halide emulsion layers coated on each side of the support, said radiographic element being interposed between a pair of intensifying screens.

The radiographic element according to the present invention is associated with the intensifying screens so as to be exposed to the radiations emitted by said screens. The pair of screens employed in combination with the radiographic element of the present invention is symmetrical. The screens are made of relatively thick phosphor layers which transform the x-rays into light radiation (e. g., visible light). The screens absorb a portion of x-rays much larger than the radiographic element and are used to reduce the radiation dose necessary to obtain a useful image.

The phosphors used in the intensifying screens applied in the present invention have an emission maximum wavelength in the ultraviolet, blue, green, red or infrared region of the electromagnetic spectrum according to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive. More preferably, said phosphors emit radiations in the ultraviolet, blue and green regions of the electromagnetic spectrum.

The green emitting phosphors emit radiation having more than about 80% of its spectral emission above 480 nm and its maximum of emission in the wavelength range of 530-570 nm. Green emitting phosphors which may be used in the intensifying screens of the present invention include rare earth activated rare earth oxysulfide phosphors of at least one rare earth element selected from yttrium, lanthanum, gadolinium and lutetium, rare earth activated rare earth oxyhalide phosphors of the same rare earth elements, a phosphor composed of a borate of the above rare earth elements, a phosphor composed of a phosphate of the above rare earth elements and a phosphor composed of tantalate of the above rare earth elements. These rare earth green emitting phosphors have been extensively described in the patent literature, for example in US Patents 4,225,653, 3,418,246, 3,418,247, 3,725,704, 3,617,743, 3,974,389, 3,591,516, 3,607,770, 3,666,676, 3,795,814, 4,405,691, 4,311,487 and 4,387,141. These rare earth phosphors have a high X-ray absorbing power and high efficiency of light emission when excited with X radiation and enable radiologists to use substantially lower X radiation dosage levels. Particularly suitable phosphors for use in the intensifying screens of the present invention are terbium or terbium-thulium activated rare earth oxysulfide phosphors represented by the following general formula:

$$(Ln_{1-a-b}, Tb_a, Tm_b)_2O_2S$$

wherein Ln is at least one rare earth element selected from lanthanum, gadolinium and lutetium, and a and b are numbers such as to meet the conditions $0.0005 \leqq a \leqq 0.09$ and $0 \leqq b \leqq 0.01$, respectively, and terbium or terbium-thulium activated rare earth oxysulfide phosphors represented by the following general formula:

$$(Y_{1-c-a-b}, Ln_c, Tb_a, Tm_b)_2O_2S$$

wherein Ln is at least one rare earth element selected from lanthanum, gadolinium and lutetium, and a, b and c are numbers such as to meet the conditions $0.0005 \leqq a \leqq 0.09$, $0 \leqq b \leqq 0.01$ and $0.65 \leqq c \leqq 0.95$, respectively.

The UV-blue emitting phosphors emit radiation having more than about 80% of their spectral emission below 450 nm and their maximum of emission in the wavelength range of 300-400 nm. UV-blue emitting phosphors which may be used in the intensifying screens of the present invention include UV-blue emitting phosphors known in the art such as lead or lanthanum activated barium sulfate phosphors, barium fluorohalide phosphors, lead activated barium silicate phosphors, gadolinium activated yttrium oxide phosphors, barium fluoride phosphors, alkali metal activated rare earth niobate or tantalate phosphors etc. UV-blue emitting phosphors are described for example in BE 703,998 and 757,815, in EP 202,875 and by Buchanan et al., J. Applied Physics, vol. 9, 4342-4347, 1968,and by Clapp and Ginther, J. of the Optical Soc. of America, vol. 37, 355-362,1947. Particularly suitable UV-blue emitting phosphors for use in the intensifying screens of the present invention are those represented by the following general formula:

$$(Y_{1-2/3x-1/3y}, Sr_x, Li_y)\ TaO_4$$

wherein x and y are numbers such as to meet the conditions $10^{-5} \leqq x \leqq 1$ and $10^{-4} \leqq y \leqq 0.1$ as described in EP 202,875.

References to other well known kind of light emitting phosphors can be found in Research Disclosure, Vol. 184, August 1979, Item 18431, Section IX.

The intensifying screens of this invention have a fluorescent layer comprising a binder and at least one phosphor dispersed therein. The fluorescent layer is formed by dispersing the phosphor(s) in the binder to prepare a coating dispersion having the desired phosphor weight ratio, and then applying the coating dispersion by a conventional coating method to form a uniform layer. Although the fluorescent layer itself can be an intensifying screen when the fluorescent layer is self-supporting, the fluorescent layer is generally provided on a substrate to form an intensifying screen. Further, a protective layer for physically and chemically protecting the fluorescent layer is usually provided on the surface of the fluorescent layer. Furthermore, a primer layer is sometimes provided between the fluorescent layer and the substrate to closely bond the fluorescent layer to the substrate, and a reflective layer is sometimes provided between the substrate (or the primer) and the fluorescent layer.

The binder employed in the fluorescent layer of the intensifying screens of the present invention, can be, for example, one of the binders commonly used in forming layers: gum arabic, protein such as gelatin, polysaccharides such as dextran, organic polymer binders such as polyvinylbutyral, polyvinylacetate, nitrocellulose, ethylcellulose, vinylidene-chloride-vinylchloride copolymer, polymethylmethacrylate, polybutylmethacrylate, vinylchloride-vinylacetate copolymer, polyurethane, cellulose acetate butyrate, polyvinyl alcohol, and the like.

Generally, the binder is used in an amount of 0.01 to 1 part by weight per one part by weight of the phosphor. However, from the viewpoint of the sensitivity and the sharpness of the screen obtained, the amount of the binder should preferably be small. Accordingly, in consideration of both the sensitivity and the sharpness of the screen and the easiness of application of the coating dispersion, the binder is preferably used in an amount of 0.03 to 0.2 parts by weight per one part by weight of the phosphor. The thickness of the fluorescent layer is generally within the range of 10 μm to 1 mm.

In the intensifying screens of the present invention, the fluorescent layer is generally coated on a substrate. As the substrate, various materials such as polymeric material, glass, wool, cotton, paper, metal, or the like can be used. From the viewpoint of handling the screen, the substrate should preferably be processed into a sheet or a roll having flexibility. In this connection, as the substrate is preferably either a plastic film (such as a cellulose triacetate film, polyester film, polyethylene terephthalate film, polyamide film, polycarbonate film, or the like), or ordinary paper or processed paper (such as a photographic paper, baryta paper, resin-coated paper, pigment-containing paper which contains a pigment such as titanium dioxide, or the like). The substrate may have a primer layer on one surface thereof (the surface on which the fluorescent layer is provided) for the purpose of holding the fluorescent layer tightly. As the material of the primer layer, an ordinary adhesive can be used. In providing a fluorescent layer on the substrate (or on the primer layer or on the reflective layer), a coating dispersion comprising the phosphor dispersed in a binder may be directly applied to the substrate (or to the primer layer or to the reflective layer).

Further in the intensifying screens of the present invention, a protective layer for physically and chemically protecting the fluorescent layer is generally provided on the surface of the fluorescent layer intended for exposure (on the side opposite the substrate). When, as mentioned above, the fluorescent layer is self-supporting, the protective layer may be provided on both surfaces of the fluorescent layer. The protective layer may be provided on the fluorescent layer by directly applying thereto a coating dispersion to form the protective layer thereon, or may be provided thereon by bonding thereto the protective layer formed beforehand. As the material of the protective layer, a conventional material for a protective layer such a nitrocellulose, ethylcellulose, cellulose acetate, polyester, polyethyleneterephthalate, and the like can be used.

The intensifying screens of the present invention may be colored with a dye. Further, the fluorescent layer may contain a white powder dispersed therein. By using a dye or a white powder, an intensifying screen which provides an image of high sharpness can be obtained.

In a further aspect, the present invention relates to a process for obtaining a radiographic image comprising the step of (a) image-wise exposing to an X-ray radiation which has passed through an object (particularly an animal or human body for medical radiographic imaging), a symmetrical radiographic assembly comprising (i) a double side radiographic element having a support and at least two silver halide emulsion layers having a speed difference of at least 0.3 logE coated on each side thereof, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum, and (ii) an intensifying screen comprising a light emitting phosphors selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and (b) developing said exposed radiographic element.

In addition to the features specifically described above, the radiographic elements of this invention, in the silver halide emulsion layers or in other layers, can include additional addenda of conventional nature, such as stabilizers, antifoggants, brighteners, absorbing materials, hardeners, coating aids, plasticizers, lubricants, mating agents, antikinking agents, antistatic agents, and the like, as described in Research Disclosure, Vol. 176, December 1978, Item 17643, in Research Disclosure, Vol. 184, August 1979 Item 18431, and in Research Disclosure, Vol. 308, December 1989, Item 308119.

As regards the processes for the silver halide emulsion preparation and the use of particular ingredients in the emulsion and in the light-sensitive element, reference is made to Research Disclosure 184, Item 18431, August 1979, wherein the following chapters are dealt with in deeper details:

- IA. Preparation, purification and concentration methods for silver halide emulsions.
- IB. Emulsion types.
- IC. Crystal chemical sensitization and doping.

II. Stabilizers, antifogging and antifolding agents.

- IIA. Stabilizers and/or antifoggants.
- IIB. Stabilization of emulsions chemically sensitized with gold compounds.
- IIC. Stabilization of emulsions containing polyalkylene oxides or plasticizers.
- IID. Fog caused by metal contaminants.
- IIE. Stabilization of materials comprising agents to increase the covering power.
- IIF. Antifoggants for dichroic fog.
- IIG. Antifoggants for hardeners and developers comprising hardeners.
- IIH. Additions to minimize desensitization due to folding.
- III. Antifoggants for emulsions coated on polyester bases.
- IIJ. Methods to stabilize emulsions at safety lights.
- IIK. Methods to stabilize x-ray materials used for high temperature. Rapid Access, roller processor transport processing.

III. Compounds and antistatic layers.
VI. Protective layers.
V. Direct positive materials.
VI. Materials for processing at room light.
VII. X-ray color materials.
VIII. Phosphors and intensifying screens.
IX. Spectral sensitization.
X. UV-sensitive materials
XII. Bases

The present invention will be thereafter described by reference to the following examples which are not intended to be limiting.

EXAMPLE

An octahedral silver bromochloroiodide emulsion (Em. A) containing 84.4%M bromide, 14.4%M chloride and 1.2%M iodide was sulfur and gold chemically sensitized with gold thiocyanate complex, sodium p-toluenethiosulfonate,sodium p-toluenesulfinate and benzo-thiazoleiodoethylate, spectrally sensitized with the green sensitizing dye anhydro-5,5'-dichloro-9-ethyl-3,3'-bis-(3-sulfopropyl)-oxacarbocyanine hydroxide triethylamine salt, and added with resorcylaldehyde and dimethylol urea hardeners. The silver halide grains have an average crystal diameter of 0.7μm. When coated double side on a polyester support emulsion A shows an average contrast of about 2.8.

A tabular silver bromoiodide emulsion (Em. B) containing 99.4%M bromide and 0.6%M iodide was chemically and spectrally sensitized as the above described emulsion A. The tabular silver halide grains have an average diameter of 1.35μm, an average thickness of 0.25μm and an aspect ratio of 5.4. When coated double side on a polyester support emulsion B shows an average contrast of about 2.3.

Emulsion A and B show a difference in speed of about 0.5 logE.

RADIOGRAPHIC FILM 1 (Invention)

Emulsion A was coated as first emulsion layer on both sides of a 0,18mm blue polyester film at a silver coating weight of 1.3 g/m^2 on each side. An emulsion blend was prepared by mixing equal parts (based on silver content) of emulsion A and B. This emulsion blend was coated over the first emulsion layer on both sides of the film at a silver coating weight of 1.0 g/m^2. On both emulsion layers was applied a gelatin top coat with a gelatin thickness of 0.9μm.

RADIOGRAPHIC FILM 2 (Invention)

Emulsion A was coated as first emulsion layer on both sides of a 0,18mm blue polyester film at a silver coating weight of 1.5 g/m^2 on each side. Emulsion B was coated over the first emulsion layer on both sides of the film at a silver coating weight of 1.0 g/m^2. On both emulsion layers was applied a gelatin top coat with a gelatin thickness of 0.9μm.

Both films 1 and 2 were exposed with two 3M Trimax™ T8 screens and also with a combination of 3M Trimax™ T6 and T16 screens. Trimax™ T6 screen is a medium resolution screen manufactured by 3M Company, comprising a terbium activated gadolinium oxysulfide phosphor having an average particle size of 3.5 μm coated in a hydrophobic polymer binder at a phosphor coverage of 500 g/m^2 and a thickness of 139 μm on a polyester support. Trimax™ T8 screen is a medium resolution screen manufactured by 3M Company, comprising a green emitting terbium activated gadolinium oxysulfide phosphor having an average particle size of 8.2 μm coated in a hydrophobic polymer binder at a phosphor coverage of 420 g/m^2 and a thickness of 105 μm on a polyester support. Trimax™ T16 screen is a high speed screen manufactured by 3M Company, comprising a terbium activated gadolinium oxysulfide phosphor having an average particle size of 5.5 μm coated in a hydrophobic polymer binder at a phosphor coverage of 1050 g/m^2 and a thickness of 250 μm on a polyester support. A 3M XLA™ Radiographic Film and a Kodak Insight™ Chest Film were also used as reference. 3M XLA™ Radiographic Film is a conventional radiographic film having extended latitude, Kodak Insight™ Chest Film is an unsimmetrical radiographic film having an emulsion layer with high contrast and low speed on one side and an emulsion layer with low contrast and high speed on the other side.

The exposed films were processed in a 3M Trimatic™ XP515 automatic processor at a total processing time of 90 seconds using the developer and fixer having the following composition.

DEVELOPER		
KOH (sol. 35% by weight)	g	105
Acetic acid	g	7.6
Glutaraldehyde (sol. 50% by weight)	g	7.2
Sodium metabisulfite	g	45.0
Ethylene glycol	g	10.0
Diethylene glycol	g	4.9
Morpholinomethanedifosfonic acid (sol. 40% by weight)	g	7.5
5-Methylbenzotriazole	mg	80.0
5-Nitroindazole	mg	107.0
1-Phenyl-1-H-tetrazole-5-thiole	mg	7.0
Boric acid	g	1.7
Potassium carbonate	g	13.25
Ethylenediaminotetraacetic acid. 4Na . $2H_2O$	g	1.5
1-Phenyl-3-pyrazolidone	g	1.45
Hydroquinone	g	20.0
NaBr	g	5.0
Water to make	l	1
pH		10.35

FIXER		
Ammonium thiosulfate	g	145.2
Sodium sulfite	g	8.12
Boric acid	g	7.0
Acetic acid	g	7.52
Ammonium acetate	g	19.24
Aluminum sulfate	g	7.74
Sulfuric acid	g	3.58
2-Phenoxyethanol	g	0.12
Water to make	l	1
pH		4.30

The sensitometric results are summarized in the following Tables 1 and 2.

TABLE 1

T8 + T8 SCREENS 75kV X-RAY EXPOSURE				
	SPEED	AVERAGE CONTRAST	TOE CONTRAST VALUE	Dmax
FILM 1	2.43	1.60	0.62	3.43
FILM 2	2.33	1.55	0.69	3.47
3M XLA™	2.54	2.15	0.41	3.50
KODAK INSIGHT™	2.56	2.15	0.43	4.25

TABLE 2

T6 + T16 SCREENS 75kV X-RAY EXPOSURE				
	SPEED	AVERAGE CONTRAST	TOE CONTRAST VALUE	Dmax
FILM 1	2.49	1.65	0.61	3.43
FILM 2	2.39	1.58	0.68	3.44
3M XLA™	2.58	2.15	0.41	3.50
KODAK INSIGHT™	2.56	1.92	0.51	4.20

The data of Tables 1 and 2 clearly show the improvement in terms of toe contrast value and average contrast of the films 1 and 2 of the present invention, which can provide a sensitometric curve very similar to the ideal curve of Fig.1.

It is worth noting that the Kodak Insight™ Film has an unsimmetrical structure, as described in the above mentioned US 4,994,355, and accordingly, it requires a specific orientation in order to work well. Moreover, table 1 and 2 clearly show that the Kodak Insight™ Film also provides different results with different screens in terms of average contrast and toe contrast value. On the contrary, both Films 1 and 2 maintain the same sensitometric characteristics even if the screen combination is changed or reversed. The radiographic film of the present invention does not require a specific care by the operator having regards the orientation and/or the kind of intensifying screens, and accordingly can be more easily handled than the prior art chest radiographic films.

Claims

1. A double side radiographic element which comprises a support and at least two silver halide emulsion layers coated on each side of said support, wherein said at least two silver halide emulsion layers show a speed difference of at least 0.3 logE and are both sensitive to the same region of the electromagnetic spectrum, and wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

2. The radiographic element according to claim 1 wherein said speed difference is in the range of from 0.3 to 1.0 logE.

3. The radiographic element according to claim 1 wherein said at least two silver halide emulsion layers show an average contrast difference of at least 0.2.

4. The radiographic element according to claim 1 wherein the average contrast of the silver halide emulsion layer having the lowest sensitivity is in the range of from 2.4 to 3.2, and the average contrast of the silver halide emulsion layer having the highest sensitivity is in the range of from 1.8 to 2.6.

5. The radiographic element according to claim 1 wherein said toe contrast value is higher than 0.55.

6. The radiographic element according to claim 1 wherein at least one of said two silver halide emulsion layers comprises a tabular grain emulsion having an average grain thickness lower than 0.3 μm and an average grain diameter higher than 0.5 μm.

7. The radiographic element according to claim 6 wherein said tabular grain emulsion comprises tabular grains having an average aspect ratio higher than 2:1.

8. The radiographic element according to claim 6 wherein said tabular grain emulsion comprises tabular grains having an average aspect ratio of from 5:1 to 10:1.

9. The radiographic element according to claim 1 wherein the first coated silver halide emulsion layer shows a lower speed than the second coated silver halide emulsion layer.

10. The radiographic element according to claim 1 wherein the first coated silver halide emulsion layer shows a higher speed than the second coated silver halide emulsion.

11. The radiographic element according to claim 1 wherein a dye underlayer is coated on at least one side of said support.

12. A symmetrical radiographic assembly comprising:
- a double side radiographic element which comprises a support and hydrophilic colloid layers coated on each side of said support, and
- an intensifying screen adjacent to each side of said radiographic element,

wherein on each side of said support are coated at least two silver halide emulsion layers having a speed difference of at least 0.3 logE, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum,

wherein said intensifying screen comprises a light emitting phosphors selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and

wherein said double side radiographic element shows a sensitometric curve having a toe contrast value higher than 0.45 and an average contrast higher than 1.40.

13. The radiographic assembly according to claim 12 wherein said speed difference is in the range of from 0.3 to 1.0 logE.

14. The radiographic assembly according to claim 12 wherein said first and second silver halide emulsion show a contrast difference of at least 0.2.

15. The radiographic assembly according to claim 12 wherein the average contrast of the emulsion having the lowest sensitivity is in the range of from 2.4 to 3.2, and the average contrast of the emulsion having the highest sensitivity is in the range of from 1.8 to 2.6.

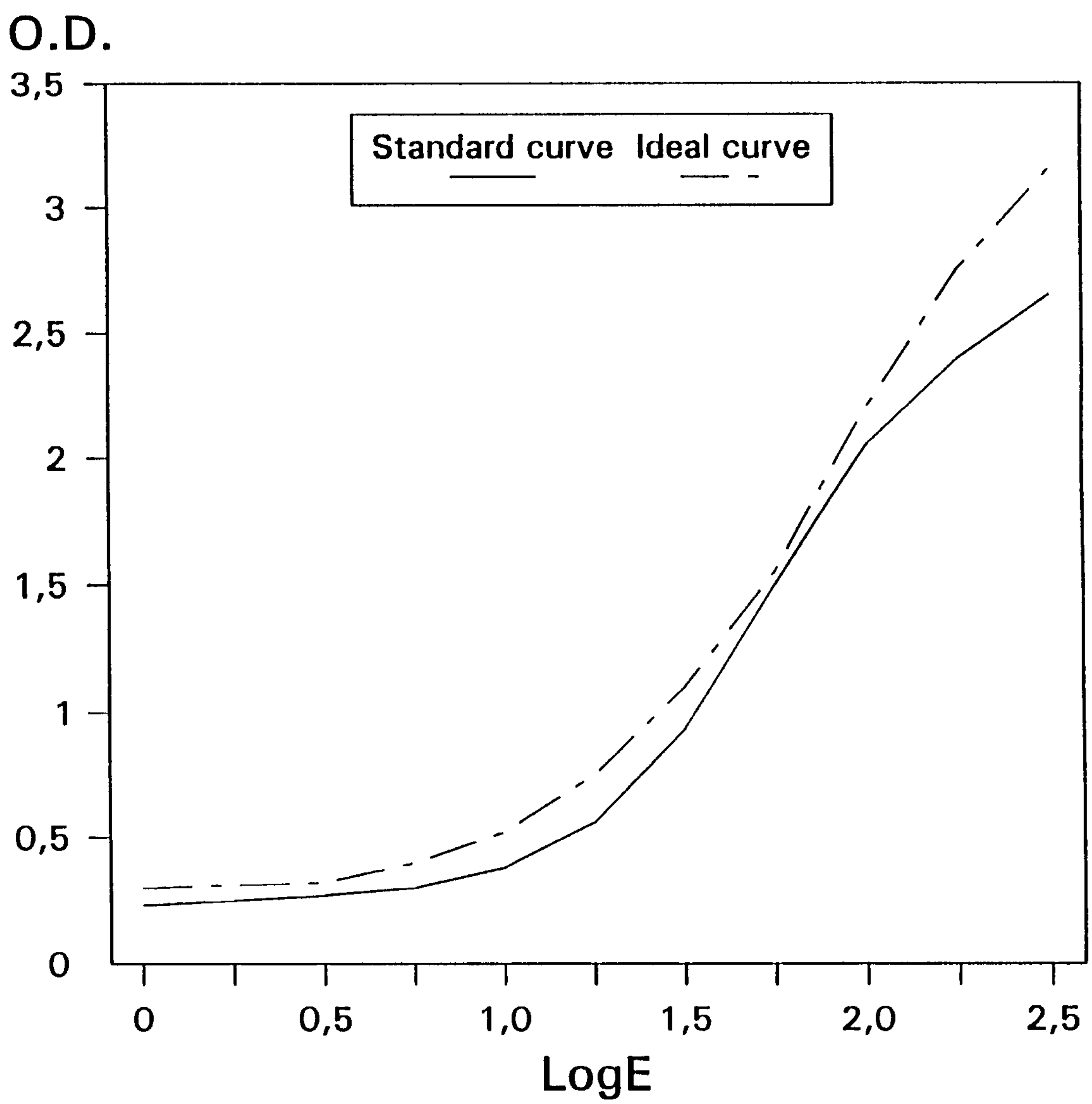
16. The radiographic assembly according to claim 12 wherein at least one of said at least two emulsion layers comprises a tabular grain emulsion having an average grain thickness lower than 0.3 μm and an average grain diameter higher than 0.5 μm.

17. The radiographic assembly according to claim 16 wherein said tabular grain emulsion comprises tabular grains having an average aspect ratio higher than 3:1.

18. The radiographic assembly according to claim 16 wherein said tabular grain emulsion comprises tabular grains having an average aspect ratio of from 5:1 to 10:1.

19. A process for obtaining a radiographic image comprising the step of (a) image-wise exposing to an X-ray radiation which has passed through an object, a symmetrical radiographic assembly comprising (i) a double side radiographic element having a support and at least two silver halide emulsion layers having a speed difference of at least 0.3 logE coated on each side thereof, said at least two silver halide emulsion layers being each sensitive to the same region of the electromagnetic spectrum, and (ii) an intensifying screen comprising a light emitting phosphors selected to have a radiation light emission having an emission maximum wavelength corresponding to the region of the electromagnetic spectrum to which said at least two silver halide emulsion layers are sensitive, and (b) developing said exposed radiographic element.

FIG. 1


O.D.
3,5
3
2,5
2
1,5
1
0,5
0
Standard curve
Ideal curve
0
0,5
1,0
1,5
2,0
2,5
LogE

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 12 1047

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)
A	EP-A-0 084 637 (FUJI) * page 1, line 17 - page 2, line 4 * * page 13, line 10 - page 14, line 11 * * page 15, line 8 - line 17 * * page 23, line 16 - line 19 * ---	1-19	G03C5/17 G03C1/46
A	US-A-5 108 881 (DICKERSON ET AL.) * column 9, line 39 - column 10, line 10 * * column 11, line 26 - line 30 * * column 14, line 20 - line 58 * * column 16, line 3 - line 5; figure 7 * ---	1-19	
A	US-A-3 923 515 (VAN STAPPEN) * column 4, line 34 - line 39; claims 1,2,10; figure * ---	1-19	
A	US-A-3 912 933 (VAN STAPPEN) * column 3, line 13 - line 15 * * column 3, line 24 - line 27; claim 7 * -----	1-19	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

G03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 May 1994	Magrizos, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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