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PHOTOGRAPHIC PRODUCT HAVING X-RAY INTENSIFIER SCREEN AS AN INTEGRAL COMPONENT OF THE IMAGE RECEIVING SHEET

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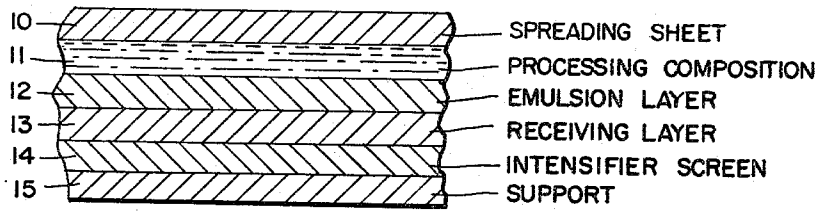

FIG. 1

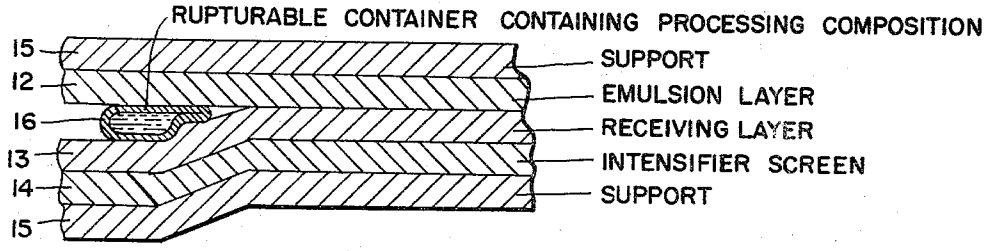

FIG. 2

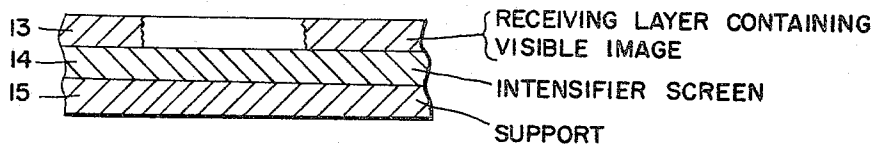

FIG. 3

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PHOTOGRAPHIC PRODUCT HAVING X-RAY INTENSIFIER SCREEN AS AN INTEGRAL COMPONENT OF THE IMAGE RECEIVING SHEET

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This application relates to photography and more particularly to novel radiographic products and processes.

It is therefore one object of this invention to provide novel products and processes particularly useful in X-ray photography.

Another object is to provide improved products and processes for obtaining positive X-ray images by diffusion transfer techniques.

A further object is to provide positive X-ray transfer images having an X-ray intensifier screen as an integral component of the image-receiving sheet.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the products possessing the features, properties and the relation of components, and the processes involving the several steps and the relation and order of one or more of such steps with respect to each of the others which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing wherein:

FIGURE 1 is a diagrammatic enlarged cross-sectional view showing the novel product of this invention during one stage of development, the thicknesses of the various materials being greatly exaggerated for purposes of illustration;

FIG. 2 is a similar view of another embodiment of this invention prior to application of the processing fluid; and

FIG. 3 is a diagrammatic enlarged cross-sectional view of the visible image obtained by separating, at some time subsequent to development, the receiving layer containing the radiograph from the emulsion layer of the film assembly shown in FIGURE 1 or 2.

It is known to prepare radiographs by diffusion transfer processes. U.S. Patent No. 2,565,378, issued to Edwin H. Land on August 21, 1951, discloses such a diffusion transfer process for preparing X-ray images. U.S. Patent No. 2,887,379, issued to Blake et al. on May 19, 1959, discloses a film structure containing an intensifier screen, which may be utilized in diffusion transfer processes for obtaining X-ray images.

The present invention relates to improvements over the disclosures of the above-mentioned Land and Blake et al. patents, and more specifically to a novel film structure wherein the intensifier screen is associated with the image-receiving layer and, consequently, is an integral part of the positive image, as distinguished from the film structure of the Blake et al. patent, wherein the intensifier screen or phosphor layer is discarded along with the emulsion layer.

The use of intensifier screens in radiography is well known. As is understood in the art, such screens are employed primarily to reduce the amount of exposure to X-ray or other radioactive waves necessary to form a latent image. Use of such screens also gives a more desirable, i.e., longer, contrast range curve. The advantages obtained by subjecting a living being, for example, to lesser amounts of radiation are obvious, and it has accordingly become quite common to employ such screens in radiography.

Generally, as is well known in the art, an intensifier screen comprises a support or carrier containing a layer of a material which is fluorescent, e.g., contains phosphors which fluoresce and emit light upon being activated by exposure to radioactive waves, e.g., X-rays. The light emitted by the activated phosphors strikes the photosensitive emulsion, thereby forming a latent image much more quickly than would the radioactive waves alone. The net result when employing an intensifier screen is a lowering in the exposure time and/or the amount of radiation necessary to form the latent image.

The utilization of such an intensifier screen in accordance with the present invention may best be understood by referring to the drawing.

FIGURE 1 depicts a preferred embodiment of this invention during one stage of processing. As shown in FIGURE 1, there is provided a film structure comprising, in order, a support 15, an intensifier screen 14, a receiving layer 13, and an emulsion layer 12. In the integral assembly shown in FIGURE 1, the intensifier screen 14 is preferably laminated to receiving layer 13, and receiving layer 13 is, in turn, laminated to emulsion layer 12.

Support 15 is either opaque to actinic radiation and transparent to X-rays and other radioactive rays, or, as in the preferred embodiment, support 15 comprises a transparent base material, preferably a plastic, for example, a cellulosic ester such as cellulose acetate, or a synthetic superpolymer of the nylon type. Where support 15 is transparent, it should be apparent that it must be provided with a light-opaque backing, such as black paper, or the film unit must otherwise be encased in a light-opaque material to prevent exposure to actinic light.

Intensifier screen 14 may comprise any of the conventional intensifier screens heretofore known in the art. Particularly satisfactory results have been obtained by employing the intensifier screens described in the aforementioned U.S. Patent No. 2,887,379. Where intensifier screen 14 is of sufficient strength and resiliency, it should be apparent that support 15 would not be necessary and may be dispensed with. In such a case, a light-opaque backing or other means should be provided to protect the film from actinic light.

The image-receiving layer 13 may be any of those heretofore used in photographic diffusion transfer processes. In a preferred embodiment, image-receiving layer 13 comprises an image-receiving layer containing deacetylated chitin, which is described and claimed in the copending U.S. application of Ryan et al., Serial No. 808,123, filed April 22, 1959, now U.S. Patent No. 3,087,815.

Emulsion layer 12 may be any suitable photosensitive emulsion, such as the silver halide emulsions described in the aforementioned U.S. Patents Nos. 2,565,378 and 2,887,379.

Where desired, a stripping layer may be positioned between the photosensitive emulsion layer 12 and the image-receiving layer 13 to facilitate separation of these layers. Materials suitable for use as stripping layers are well-known in the art.

The film structure described above is employed in a diffusion transfer process similar to that described in the aforementioned U.S. Patent No. 2,565,378, in order to obtain a positive radiograph.

As will be appreciated by those skilled in the art, X-rays or other radioactive radiations pass through support 15, thereby exciting the phosphors in intensifier screen 13, thus producing a latent image in emulsion layer 12.

At some time subsequent to exposure, emulsion layer 12 containing the latent image is contacted with a processing composition 11, preferably as a relatively viscous

layer. To insure uniform application of the processing composition, a spreading sheet 10 may be provided.

The layer of liquid processing composition 11 may be obtained, for example, by spreading in the manner disclosed in U.S. Patent No. 2,698,244, issued December 28, 1954 to Edwin H. Land. As disclosed in that patent, the liquid processing composition may be disposed in a rupturable container so positioned with respect to the emulsion, that, upon compression by passing between a pair of suitably gapped rollers, a substantially uniform layer 11 of processing composition is distributed between the surfaces of emulsion 12 and spreading sheet 10. While the above-mentioned means of application is particularly useful in a continuous processing operation, the liquid processing composition may be applied in other manners, such as by immersing, spraying, flowing, etc. in the dark.

The processing composition may be a film-forming processing composition such as those disclosed in the aforementioned U.S. Patents Nos. 2,543,181 and 2,565,-378. It may comprise, for example, a developing agent such as hydroquinone, an alkali such as sodium hydroxide, a silver halide complexing agent such as sodium thiosulfate, and a high molecular weight film-forming thickening agent such as hydroxyethyl cellulose or sodium carboxymethyl cellulose. Various other additives such as accelerating developing agents, preservatives, antifogging agents, and the like may also be employed. All of these materials are preferably in aqueous solution. These photographic agents are preferably contained in solution in the processing liquid prior to the spreading thereof as layer 11, but they may be in part or wholly dissolved into the processing composition as it is spread upon emulsion layer 12.

As a substantially uniform distribution of processing composition 11 is distributed on the external surface of silver halide emulsion layer 12, the reagents of the composition permeate the photo-sensitive emulsion, thereby developing the latent image contained therein according to the point-to-point degree of exposure of the emulsion. Substantially contemporaneously with the development of the latent image, an imagewise distribution of soluble silver complex is formed from the unexposed silver halide within the emulsion. At least part of this soluble silver complex is transferred, by imbibition, to the image-receiving layer 13. The transferred silver complex is reacted to provide a positive, reversed image of the latent image according to known diffusion-transfer reversal techniques.

At some time subsequent to the formation of the positive image, the image-receiving layer may be stripped from the emulsion to reveal the positive image.

FIG. 2 illustrates another embodiment of the invention. As shown in FIG. 2, a rupturable container of processing solution, such as that disclosed in U.S. Patent No. 2,565,-378, is provided between emulsion layer 12 and receiving layer 13. A suitable support 15, such as that heretofore described, is provided for both the emulsion layer 12 and the intensifier screen 14. The radiographic product illustrated in FIG. 2 is utilized in a diffusion transfer process very similar to that previously described. Subsequent to exposure, rupturable container 16 is broken, as by passage through a pair of rollers, and the processing composition is thereby spread in a uniform layer between the emulsion layer containing the latent image and the receiving layer. As will be appreciated by those skilled in the art, a positive image is thus obtained by the transfer, by imbibition, of an imagewise distribution of soluble silver complex formed from unexposed silver halide within the emulsion. This positive image may also be revealed by stripping the image-receiving layer from the emulsion.

In a variation of the film structure illustrated in FIG. 2, emulsion layer 12 and receiving layer 13 are laminated together, as by a stripping layer, and rupturable container 16 is located exterior to the two laminated layers at one edge thereof, rather than between them such as shown in FIG. 2. By eliminating the air space between the emulsion layer and the image-receiving layer, substantial increases in image resolution are obtained. In such an arrangement, the rupturable container is provided with a discharge mouth connected to the elements in a fluid-tight manner so that hydraulic pressure generated upon compression of the container tends to force the fluid between laminae of the film assemblage and to force the laminae apart, rupturing the bond therebetween. Photographic products of this nature are disclosed in the copending U.S. application of Edwin H. Land, Serial No. 734,613, filed May 12, 1958, now U.S. Patent No. 3,053,659. In a particularly useful variation of this embodiment, a white reflecting layer, e.g., baryta, is coated between the support 15 and the emulsion layer 12. This white layer contributes to the total film speed by its reflecting action. The support for the image-receiving layer 13 and intensifier screen is preferably a transparent plastic, e.g., cellulose triacetate, and the support for the emulsion layer 12 is paper.

FIG. 3 illustrates the structure of the visible positive radiograph after it is stripped from the emulsion layer. It should be apparent from FIG. 3 that the radiograph differs significantly from those heretofore made. In all prior art processes, including the diffusion transfer process described in the aforementioned Blake et al. patent, the intensifier screen is not a component part of the finished radiograph. In the Blake et al. patent, the intensifier screen is not retained along with the positive image, as shown in FIG. 3, but is destroyed along with the emulsion layer.

Quite surprisingly, particularly in view of the above-mentioned prior art practices, unique and highly significant advantages are afforded the practitioner employing the novel film structure illustrated in the drawing.

As was mentioned previously, in the preferred embodiment support 15 is a transparent base material such as cellulose acetate. When employing such a transparent support, the intensifier screen associated therewith renders the support sufficiently opaque that the radiograph may be viewed as a reflection print. The intensifier screen may be part of the transparent support or it may be a separate stratum carried by the transparent support. Quite surprisingly, however, the intensifier screen acts as a "built-in" diffusing device, whereby the transparent support has properties of an opalescent sheet, so that the radiograph may also be viewed as a transparency with any bright light, thereby avoiding the necessity of using a light box such as is customarily utilized to view transparencies. In other words, the novel film structure of this invention may be employed to produce a single positive image which may be viewed, in a matter of seconds from the time of exposure, as either a reflection print or a transparency. This enables practitioners, such as surgeons, radiologists and the like, to obtain quickly a radiograph which they may view at their option either as a reflection print or as a transparency.

It has also been found that, when employing the novel film structure of this invention, it is possible to obtain a sharper image than was normally available by previous processes. This is due to the fact that the intensifier screen is uniformly optically closer to the emulsion layer in the film structure illustrated in FIGURE 1 than in prior art processes. In a preferred embodiment of this invention, the intensifier screen is laminated to the receiving layer which, in turn, is laminated to the emulsion layer. This lamination permits a proximity of elements which does not permit of any bending or crinkling of the intensifier screen such as may occur if there is an air space between the elements. As should be apparent, any such bending whereby the intensifier screen is not uniformly in association with the emulsion layer, i.e., where the distance between the intensifier screen and the emulsion layer varies from point-to-point, will cause a

distortion and/or a lack of sharpness or fineness of detail in the finished radiograph.

The last-mentioned advantage of sharpness of image will be afforded regardless of whether support 15 is transparent or opaque.

In addition to the above advantages, where the intensifier screen is also activated by ultraviolet radiation whereby ultraviolet light striking the screen is converted to visible light, whether the support material be normally transparent or opaque, the resulting reflection print may be viewed under ultraviolet light as if it were a transparency, in accordance with the viewing procedures described and claimed in copending U.S. application Serial No. 113,102, filed May 29, 1961, now U.S. Patent No. 3,115,977.

As is described in that copending application, when viewing such a reflection print under ultraviolet light, there is obtained a brilliance and contrast ordinarily obtainable only with a transparency.

The following example serves to show, by way of illustration and not by way of limitation, the novel film structure of this invention.

Example I

A conventional cellulose acetate transparent base was coated with a layer of barium sulfate/lead sulfate mixed phosphor dispersed in a chlorosulfonated polyethylene prepared in the manner described in U.S. Patent No. 2,887,379, thereby forming an intensifier screen on the transparent base material. After the phosphor layer had dried, a receiving layer containing deacetylated chitin and prepared in the manner described in U.S. application Serial No. 808,123, now U.S. Patent No. 3,087,815, was coated over the phosphor layer and dried. An X-ray type gelatino-silver bromoiodide emulsion containing 1.5 mol percent silver iodide and 98.5 mol percent silver bromide was then coated over the receiving layer.

The following example shows, by way of illustration and not by way of limitation, the novel X-ray process of this invention.

Example II

A sheet of the photographic film prepared in Example I was given an 0.8 second unscreened X-ray exposure at 60 k.v.p., 10 ma. and 36-inch distance through a 1¾ inch thick aluminum machine part. A positive image was then obtained, in accordance with conventional diffusion-transfer procedure, by imbibing the X-ray exposed film for one minute with the developing solution described in U.S. Patent No. 2,565,278. The positive image was revealed by stripping the receiving layer from the silver halide emulsion layer.

For convenience, the expression "X-ray" has been used in the specification and in the claims and is intended to cover all photographically useful radioactive rays, such as those emanating from an X-ray tube, radium, or radioactive isotopes.

It should be noted that where both supports are opaque to actinic light but transparent to the desired radioactive rays, e.g., the supports are black, exposure may be made without opening the film unit. The film units of this invention also are flexible and thus are adaptable to conform more closely to the shape of the subject matter being X-rayed.

This application is a continuation-in-part of application Serial No. 734,613, filed May 12, 1958 and now Patent No. 3,053,659.

Since certain changes may be made in the above product and process without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An integral photographic product comprising a photosensitive emulsion layer, an X-ray intensifier screen, and an image-receiving layer laminated between said emulsion layer and said intensifier screen.

2. An integral photographic product comprising a support having thereon, in sequence, an X-ray intensifier screen adjacent said support, an image-receiving layer above said intensifier screen, and a photosensitive silver halide emulsion layer above said image-receiving layer.

3. A photographic product as defined in claim 2 further including a photographic processing composition comprising an aqueous alkaline solution containing a silver halide developing agent.

4. A photographic product as defined in claim 3 wherein at least the solvent for said solution is confined in a rupturable container.

5. A photographic product as defined in claim 3 further including a spreading sheet for said processing composition.

6. A photographic product as defined in claim 2 wherein said support is opaque to actinic light but transparent to radioactive rays.

7. A photographic product as defined in claim 2 wherein said support is transparent to actinic light.

8. A photographic product as defined in claim 7 including means for preventing actinic light from striking said support.

9. A photographic product as defined in claim 8 wherein said means comprises a sheet material opaque to actinic light but transparent to radioactive rays.

10. A photographic product for receiving and viewing radiographs which comprises, in combination, a support, an image-receiving layer, and an X-ray intensifier screen between said support and said image-receiving layer.

11. A photographic product as defined in claim 10 wherein said support comprises a base material opaque to actinic light.

12. A photographic product as defined in claim 10 wherein said support comprises a base material transparent to actinic light.

13. A photographic product as defined in claim 10 wherein said intensifier screen is also sensitive to ultraviolet radiations, whereby ultraviolet light striking said screen is converted into visible light.

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