April 9, 1935. L. D. MANNES ET AL 1,997,493

COLOR PHOTOGRAPHY

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Fig. 1,

Object to be Photographed

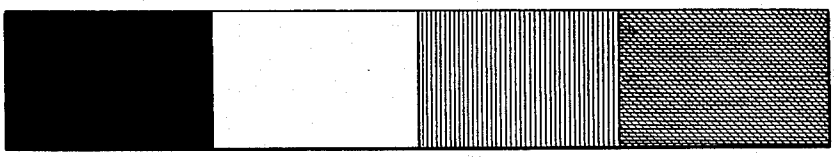


Fig. 2,

Before Exposure

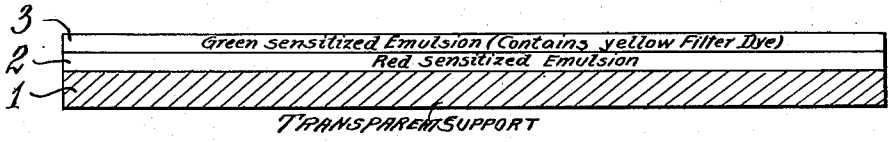


Fig. 3,

After Development of upper Image

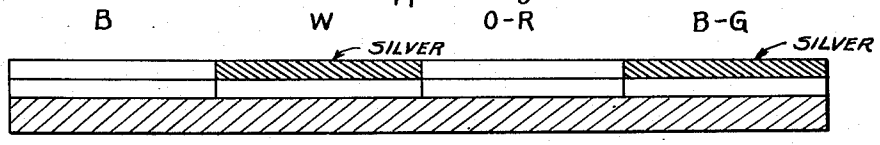
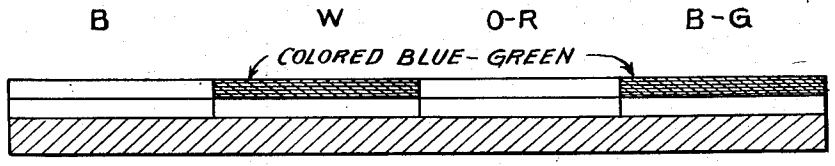


Fig. 4,

After Toning upper Image



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COLOR PHOTOGRAPHY

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Fig. 5.

After Developing lower Image

(Upper Layer Temporarily bleached by developer, restored in washing to original blue-green.)

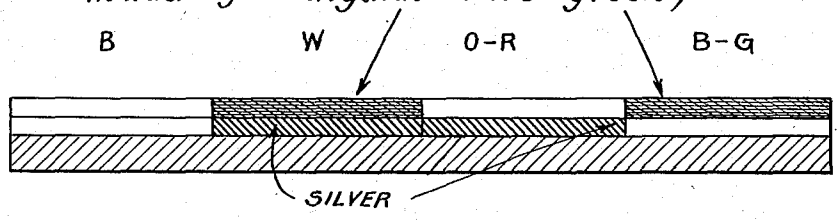


Fig. 6,

After Dyeing lower Image orange-red

(Complete Negative)

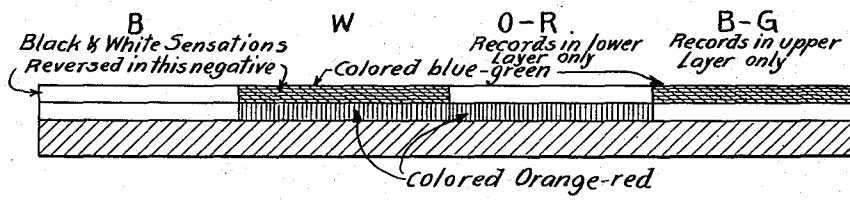
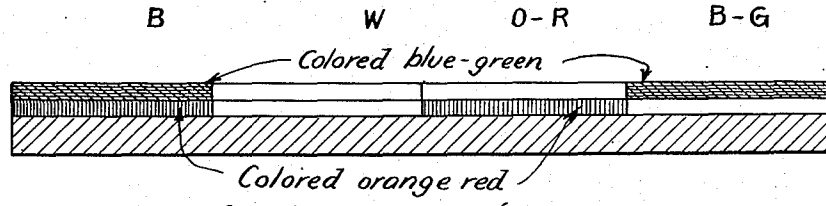


Fig. 7,

Finished Positive

(Positive repeats identical Process reversing Values light & dark back to normal & keeping Colors as they are in negative)



PRINTED FROM FINISHED NEGATIVE (FIG. 6) AND TREATED SIMILARLY

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COLOR PHOTOGRAPHY

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Fig. 8,

Alternative Method

After complete Development

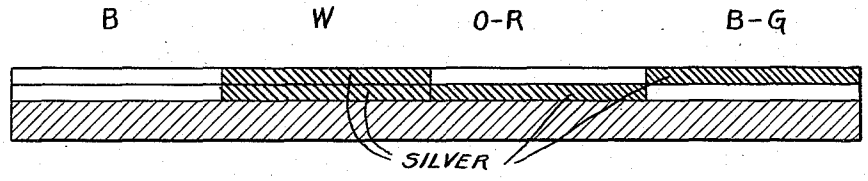


Fig. 9,

After Toning upper Image

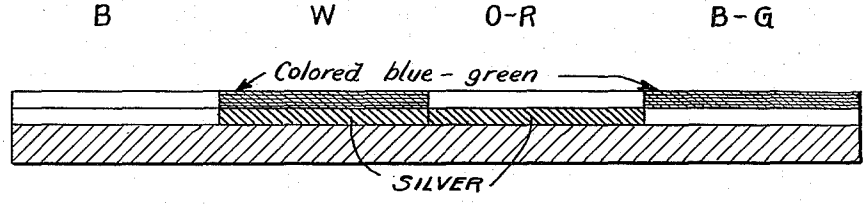


Fig. 10,

After Dye mordanting lower Image

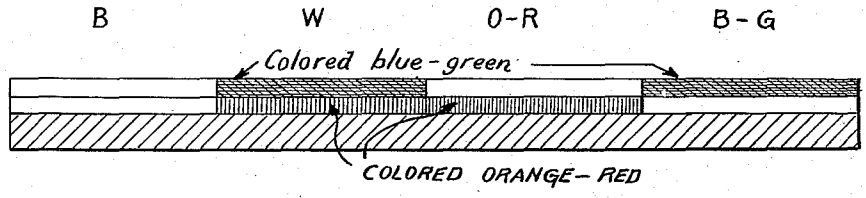
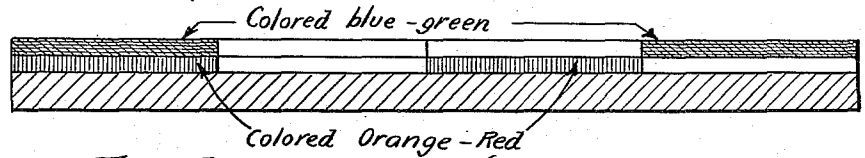


Fig. 11

Finished Positive

(Reverses light & dark values to normal)



PRINTED FROM FINISHED NEGATIVE (FIG. 10) AND TREATED SIMILARLY

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UNITED STATES PATENT OFFICE

1,997,493

COLOR PHOTOGRAPHY

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New York, N. Y.

Application January 24, 1922, Serial No. 531,356

8 Claims. (Cl. 95—2)

The present invention relates to the art of color photography, and has to do particularly with an improved process for producing photographs in substantially the natural colors of the original subject photographed. Our invention also includes the improved photographic color print resulting from our process.

Color photographs are commonly produced by a two or three color process, the colors employed in the two color process ordinarily being complementary. A picture produced by the three color process in which there is obtained an intensity of coloring on the picture of substantially the degree in which the corresponding color sensations occur in the original subject will reproduce the scene photographed naturally and effectively even to slight variations in tone and shading of the colors. Pictures obtained by the two-color process are, of course, not ordinarily as accurate in representation but have the advantage of being somewhat easier and less expensive to produce and often, particularly with relation to certain subjects, give a true representation of the scene being photographed in substantially its natural colors.

In color photography, particularly in the presentation of motion pictures, it is common to simultaneously or alternately project on the screen in superimposed position a plurality of single color pictures equal in number to the color sensations employed, the combination of the various individual pictures resulting in a composite picture containing all of the colors distributed according to their occurrence in the individual single color pictures. It has also been proposed to prepare separate simultaneously taken negatives each recording a single color sensation and to successively print them in superimposed relation on a plate or film, the prints then being colored to reproduce the proper color values occurring in the original subject. The above methods are open to the objection that it is practically impossible to exactly superimpose the various individual pictures in order that the resulting picture may be without color fringe or similar objectionable effect, and the last-mentioned method has not, as far as we are aware, been carried out successfully on a commercial scale.

It has also been proposed to provide a single plate or film sensitized on one side to record a certain color sensation and sensitized on the other side for a different color sensation, so that by a single exposure two images recording respectively the particular color sensations for which the coatings have been sensitized may be obtained. With this method, inasmuch as the two sensitized coatings are supported on the same film, one side of the film must be specially waterproofed or otherwise protected while the image on the other side is being developed and toned. This method is further limited to work in which only two exposures of different color sensations may be taken and is thus impossible of application to the three color process.

It is a principal object of this invention to provide a method for producing a finished picture in natural colors requiring but a single exposure and a single printing operation, and in which the developing process may be carried out in a single step if desired.

It is a further object to provide a process for producing a color photograph of this character which is equally applicable to the use of two or more color sensations, and in which there is no danger of producing color fringe or other imperfections such as may be occasioned by imperfect registration of the component pictures.

It is a further object to provide a process of this character in which there is no necessity of removing or otherwise protecting a portion of the plate or film during the developing process, and in which the sensitized emulsions are placed immediately adjacent so that the respective outlines of the individual color images are exactly superimposed.

It is a still further object to provide in a process of the above type an improved method of toning or dyeing which is particularly applicable to a process involving more than two colors.

A still further object is the provision of the improved photographic plate or film which is employed in carrying out our improved process.

We have illustrated the various steps of our improved process in the accompanying drawings in which Figure 1 illustrates the object photographed, this object consisting of four rectangles colored respectively black, white, orange-red and blue-green; Figure 2 illustrates the plate or film before exposure; Figure 3 illustrates the plate or film after development of the upper image; Figure 4 shows the condition of the film after toning the upper image; Figure 5 illustrates the film after the lower image is developed; Figure 6 shows the complete negative and Figure 7 illustrates the finished positive; Figures 8 to 11 illustrate the steps of an alternative process, Figure 8 showing the film after complete development, Figure 9 showing it after the toning of the upper image, Figure 10 showing the completed negative and Figure 11 the completed positive.

In carrying out our improved process we employ a film or plate of the ordinary type and provide this plate at one surface with sensitized coatings equal in number to the number of colors which are to be employed. For instance, in a two color process the transparent film or plate 1, as shown in Fig. 2, is first coated with a fast silver bromide emulsion sensitized to record the orange-red color sensations in the subject being photographed. This emulsion 2 is affected by the light entering the camera proportionally to the degree in which the corresponding color sensation is present in the subject being photographed. The silver bromide emulsion may be conveniently sensitized to record the red and orange of the spectrum by any suitable sensitizing dye.

A second coating 3 of a slower silver bromide emulsion is provided directly upon the coating 2 to form on the same side of the separating film or plate two layers united into a substantially integral body, and is sensitized for green or blue-green. The blue sensation ordinarily predominates in photographic images; that is, the blue color sensations are recorded in the picture more strongly than the other color sensations, and it is accordingly desirable not only to cut off entirely the blue-violet rays from the emulsion 2 but to at least diminish their intensity in the upper coating 3. For this purpose the upper emulsion 3 has incorporated in it a strong yellow dye distributed uniformly throughout the mass of the emulsion. With respect to the coating 2 of emulsion this yellow dye serves as a screen to effectively exclude all the blue-violet rays. With respect to the upper coating 3 the incident light acts upon the surface of the emulsion 3 with its full color value, but as the light penetrates into the emulsion the presence of the yellow dye excludes a portion of the blue light and consequently tones down the resulting blue-violet sensations which will be recorded by the material of the emulsion. If desired, the yellow dye incorporated within the upper layer of emulsion may be dispensed with and a yellow color filter placed over the camera lens. This method may be objectionable, however, in that too great an amount of the blue-violet light may be excluded.

In making an exposure the film comprising the two superimposed emulsions forming essentially a single integral coating is supported in a camera of the ordinary type and a single exposure taken in the ordinary manner. The light entering the camera first comes in contact with the emulsion 3 sensitized for the blue-green of the spectrum, that portion of the light which passes through the emulsion 3 serving to affect the lower layer of emulsion. Inasmuch as a lesser quantity of light acts upon the lower coating 2 this emulsion must be fast, and the two emulsions are so constituted that a complete exposure of each will occur in the same length of time. Thus, there is secured a single film with an essentially integral coating on one surface containing two exactly superimposed latent images of the subject photographed, each portion of the film coating having recorded that color sensation for which it has been sensitized.

In the development of the film or plate the two sensitized coatings may be developed at the same time or they may be developed successively, there being no necessity in either case of protecting one of the coatings during the development of the other. This is made possible because of the fact that a developing or toning solution acts from the surface of the emulsion down, so that the film can be left in the solution until the image occurring in the top emulsion is completed, while the lower layer remains unaffected by the solution, advantage being taken of the fact that the slow emulsion 3 will develop in a relatively short time, while the fast emulsion 2 requires a longer time. The process is further facilitated by the fact that the portion of each layer of emulsion affected by the light during the time of exposure occurs on the surfaces of the respective coatings. Thus, there is a space behind the upper image consisting of a portion of the emulsion which remains untouched. The process may be further facilitated by employing as a base for the sensitized coatings a relatively hard gelatin which is penetrated but slowly by the toning solution, and in which the action of these solutions is slow and controllable as to depth.

In this method of developing the emulsions one at a time the film is subjected to the action of a rapid surface developer, until the image formed in the upper emulsion is completely developed as shown in Figure 3. The film is then removed from the developing bath and washed in the ordinary manner, after which it may be immersed in a blue-green toning solution (such as ferric vanadium solution). Figure 4 illustrates the film or plate at this stage of the process. It will be noted that the images recorded in the upper layer of emulsion are actually colored blue-green. The black and the orange-red of the object photographed make no record which appears at this stage of the process. The film is then preferably treated in a weak sodium thiosulfate solution for the purpose of rendering the blue-green image transparent and removing the residue of ferri-cyanide which remains after the toning process. The developing and toning operations are, of course, allowed to continue until only the upper image has been developed, the lower layer of emulsion remaining unaffected. The film containing the blue-green image is now subjected to a developing solution, such as diamidophenol, containing no alkali which might injure the image already formed. The developing action is allowed to continue until the lower image is completely developed, after which the film is removed from the developing solution and fixed and washed in the ordinary manner the result being indicated in Figure 5. The film is then dye-mordanted with a suitable bath which will not bleach or otherwise injure the blue-green image occurring in the upper coating of emulsion, after which the film is immersed in an orange-red dye solution so that the lower image which has been made receptive to the action of the dye will be properly toned. We prefer to use a dye solution, such as for instance a mixture of fuchsine, auramine, and dilute acetic acid. The resulting plate is shown in Figure 6 which represents the complete negative. It will be noted that the portion of the film recording the black of the original image is transparent, the portion recording the white bears an image in both upper and lower layers, the portion recording the orange-red bears an image in the lower layer and the portion recording the blue-green bears an image in the upper layer. Thus the film carries two superimposed images one of which is toned blue-green and the other of which is colored orange red.

The resulting film after the developing process is completed is a negative, and black and white

values are accordingly reversed. Inasmuch as the two images have been toned with the proper colors, however, the colors are correct but the color values are reversed; for instance, light red appears dark and dark red appears light. This negative is then printed to form a positive, the positive being constituted entirely similar to the negative. The printing operation is accomplished in a single step in the ordinary manner, and the positive is then developed and colored in the manner just described to obtain a true picture with all the color values properly recorded. The finished positive is indicated in Figure 7. The reversal of the blacks and whites causes a reversal of the images recorded on the left-hand side of the film, namely on that portion of the film recording the black and white of the object photographed. This will be evident by comparison of Figures 6 and 7. The right half of the film, namely that portion recording the orange-red and the blue-green of the spectrum is the same in the positive as in the negative.

If desired, both coatings of emulsion may be developed and fixed at the same time. For this purpose a developer such as acid diamidophenol which penetrates well is employed. The film is left in the developing solution until both images are completely developed, whereupon the film is washed and the images fixed in the ordinary manner the result being indicated in Figure 8. The film is then immersed in a blue-green toning solution and the action of this solution is permitted to continue until the upper layer has been completely colored as indicated in Figure 9, after which the film is removed from the toning solution and immersed in a weak "hypo" solution to render the image transparent and remove the residue of ferricyanide which may have been deposited on the film. We have found that this toning process permits of minute regulation and that ample time is afforded to remove and wash the film after the coloring of the upper image has been completed before any coloring action takes place on the lower image. The film now contains a blue-green image, and may be mordanted and dyed to properly tone the lower image in the manner already described. This is the finished negative and is indicated in Figure 10. The negative is in all respects similar to the negative made from the process illustrated in Figures 1 to 7. This method may be advantageous in certain instances in that a reduction in the number of operations and a consequent saving of time is possible. The positive is likewise similar to the positive illustrated in Figure 7 resulting from the process, the steps of which are illustrated in Figures 1 to 7 inclusive.

In the foregoing description we have described our improved method as applied to a two color process. Our method is, however, equally applicable to a three color process. In a process employing more than two colors, for instance a three color process, three coatings of emulsion are employed as shown in Fig. 2. The transparent support 1 is coated with an extremely rapid red sensitized emulsion 4, a second coating 5 of a rapid orthochromatic emulsion is provided directly on top of the coating 4, and a slower emulsion 6 of the ordinary type is coated on top of the emulsion 5. It is to be understood that the various emulsions are so constituted that when subjected to the action of light they will all be exposed in the same length of time. The upper layer 6 which records the blue-violet of the spectrum is preferably constituted with a yellow dye distributed throughout its body for the purpose of toning down the action of the blue-violet rays on the material of the coating 6 and further serving as an effective screen to exclude the blue-violet rays from the other emulsions. The intermediate layer 6 records the green of the spectrum while the lower coating 4 records the red. After exposure of the film the developing process may be carried out by developing all three images at the same time as above described or by developing and toning the three images individually.

The coloring of the images may be carried out by toning the upper coating 6 blue, toning the intermediate coating 5 green, and the bottom coating 4 red. It may be difficult, however, to procure toning and dye mordanting solutions to accomplish the successive steps without damaging the images already toned and developed. To overcome this difficulty we preferably develop all three images at once and successively tone the upper coating 6 and the intermediate coating 5 as for a two color process, the image contained in the lower layer 4 being left black. The film is then immersed in a bichromate sensitizer to resensitize the upper portion of the coating on the film after which it is exposed to a powerful light with the sensitized coatings on the side of the film away from the light. The light will pass through the blackened image contained in the bottom coating 4 in proportion to the density of the black deposits over the surface of the film, which deposits represent the image corresponding to the red color sensations in the subject photographed. Since the action of the light is to harden the resensitized gelatin, the surface of the film coating will be hardened in conformity to the outlines of the black image contained in the bottom coating 4. The film is then immersed in a red dye solution, and since the surface of the film has been partially hardened it is selectively receptive to the dye and will assume a red color in proportions identical with that in which the lower layer 4 would have absorbed the dye had it been previously subjected to the action of a dye mordanting solution in the manner in which the other two images were toned. The black image is then dissolved out of the lower coating 4 and a negative in proper colors but with the color values reversed is obtained.

The negative may be printed to form a positive as described for the two color process. In printing a picture in colors, as is well known, the colors recorded on the positive are complements of the corresponding colors occurring in the negative. In the two color process complementary colors are ordinarily employed, so that although the colors in the negative are reversed the total effect is nevertheless the same since the complementary colors are merely exchanged one for the other. In the three color process the colors in the positive are complementary to the colors occurring in the negative and are different from them. For instance, in the above description it has been assumed that the negatives were sensitized to record blue-violet, green, and red sensations. Consequently, the colors appearing in the positive will be respectively yellow, magenta, and blue-green. For this reason the color sensitivities of the emulsions employed in the positive must be different from those of the emulsions employed in the negative. We preferably provide the film first with a coating of an ordinary panchromatic

emulsion, superimpose upon this a slower red sensitive emulsion containing a yellow dye, and lastly add a further orthochromatic emulsion of a still slower character. With this arrangement the top layer records the blue-green sensations. The intermediate emulsion records a magenta or blue-red sensation inasmuch as the emulsion itself is red sensitized and the blue effect, which would ordinarily predominate, is permitted to act upon the upper surface of this layer with its full value and deeper in the coating is toned down by the yellow dye, which dye serves further as a shield for the lower layer. The lower or panchromatic emulsion receives the light which remains after passage through the two upper layers and records the yellow of the spectrum. The positive is then developed and colored as above described except that the colors employed are yellow, magenta, and blue-green, respectively, instead of the colors for which the emulsions of the negative are sensitized.

It is to be understood that with our improved process there is no likelihood of a color fringe occurring in the picture inasmuch as the various images are exactly superimposed and are taken at a single exposure. A pronounced advantage results in the use of our improved process in that there is no need for protecting or separating the various images during the developing and coloring processes, and it is accordingly possible to carry out our process in a minium of time and at relatively low cost.

The terminology "substantially unitary body" of emulsion has been used throughout this specification and in the claims. It is to be understood that this expression means a body of emulsion consisting of a plurality of super-imposed layers of emulsion grouped together on one side of a single support. Our process depends for its action upon the fact that only one layer of emulsion is exposed directly to the action of the various treating solutions and that the lower layers of the emulsion are reached only by penetration of the treating fluids to these layers. The invention thus contemplates any emulsion or groups of layers of emulsion arranged in this way and not separated by any medium which will prevent the treating fluids from permeating to the lowermost layer.

While we have described preferred embodiments of our invention it is to be understood that certain modifications may be made, such as the various developing and toning solutions employed, and the like, within the full scope of the appended claims. It is further to be understood that our process may be carried out equally well by the use of a photographic plate or film such as commonly employed in the projection of motion pictures, and the expression "photographic plate" employed in the claims is understood to mean a photographic plate, film, or other equivalent structure which may consist of any suitable transparent support provided with properly sensitized emulsions.

We claim:

1. A method of producing a color photograph which comprises forming, in layers of emulsion on the same side of a common support, and sensitized respectively to record different mutually complementary color values, different color sensation records of the same object and while still joined together transforming said records into mutually complementarily colored images by a treatment involving selective action on each of said layers independently of the other layer.

2. A method of producing a positive color photograph which comprises forming, in layers of emulsion on the same side of a common support and sensitized respectively to record different mutually complementary color values, different positive color sensation records of the same object and under the control of said records producing mutually complementary color images in said layers respectively, while still joined together, by mutually independent action on said layers respectively.

3. A method of producing a color photograph which comprises forming, in layers of emulsion on the same side of a common support and sensitized respectively to record different mutually complementary color values, different color sensation records of the same object and transforming said records while said layers are still joined together into mutually complementary colored images, and then printing from said colored images upon a second photographic element having on one side a plurality of layers sensitized to record different mutually complementary color values and then transforming such records into mutually complementarily colored images.

4. A method of producing a color photograph which comprises forming, in layers of emulsion on the same side of a common support and sensitized respectively to record different mutually complementary color values, different color sensation records of the same object and transforming said records, while said layers are still joined together, into mutually complementary colored images of correct color value for the color sensation recorded therein, and then printing from said colored images upon a second photographic element having on one side a plurality of layers sensitized substantially the same as the respective layers on the first support to form records therein and then transforming such records by the same process as that first used into mutually complementarily colored images of the same color as the first named color images.

5. A method of producing a color photograph which comprises providing a suitable support having on one side a plurality of photographic layers sensitized to record different color values, forming in said layers respectively different color sensation records of the same object, developing all of said records and subsequently coloring the respective records while said layers are still joined together with mutually complementary colors, and then printing from said colored images upon a second support also having on one side a plurality of photographic layers sensitized substantially the same as the layers on the first support and processing said printed records in substantially the same way as the original records.

6. A method of producing a color photograph which comprises providing a photographic element comprising a support having on one side a plurality of photographic layers differentially sensitized to record different complementary color values, forming in said layers respectively different color sensation records of the same object, transforming said records, while said layers are still joined together into mutually complementary colors of correct color values for the color sensation recorded therein, and then printing from said colored images upon a second photographic element similar to the first and having its respective layers predominantly of the same color sensitivity as those of the first element, thereby forming images in such layers, and then transforming such images into colored

images of substantially the same color as the images formed in the first element.

7. A method of producing a color photograph which comprises providing a suitable support having on one side a plurality of photographic layers differentially sensitized to record different color values, forming in said layers respectively different color sensation records of the same object, treating said images while said layers are still joined together to produce in each layer an image which is negative as regards black and white values but of correct color for the color sensation recorded therein, and then printing from said negative upon a second support also having on one side a plurality of photographic layers differentially sensitized to substantially the same different colors as said first mentioned layers, thereby forming latent images in each layer, developing said images to produce in each layer an image which is positive as to black and white values and of correct color for the color sensation recorded therein.

8. A method of producing a color photograph which comprises providing a suitable support having on one side layers of emulsion sensitized respectively to record different color values, forming simultaneously in said layers of emulsion a plurality of latent negative images of different color sensations of the same object, treating said images while said layers are still joined together to produce in such layer an image which is negative as regards black and white values but of correct color for the color sensation recorded therein; and then printing simultaneously from said negative upon a second support having on one side layers of emulsion differentially sensitized to the same colors respectively as those of the first element, thereby forming positive latent images in each layer, developing said images to produce in each layer an image which is positive as to black and white values and of correct color for the color sensation recorded therein.

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