June 4, 1940. D. L. MacADAM ET AL 2,203,656

COLOR CORRECTION PROCESS

Original Filed April 10, 1937 2 Sheets-Sheet 1

Fig.1.

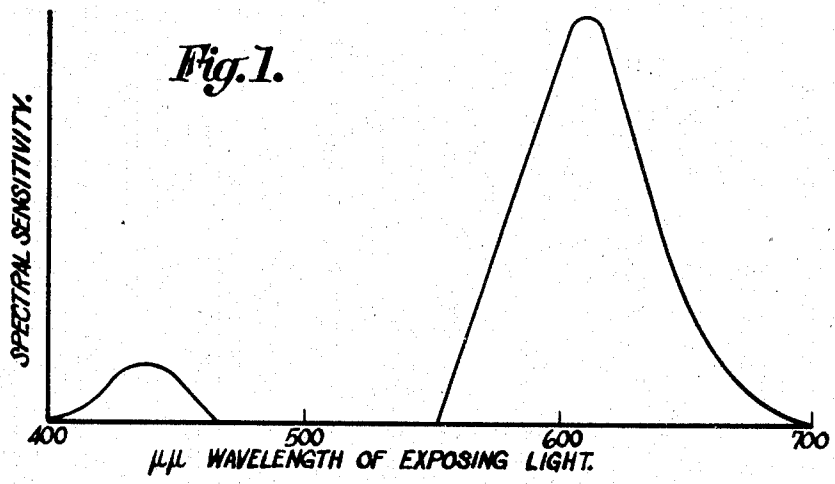


Fig.2.

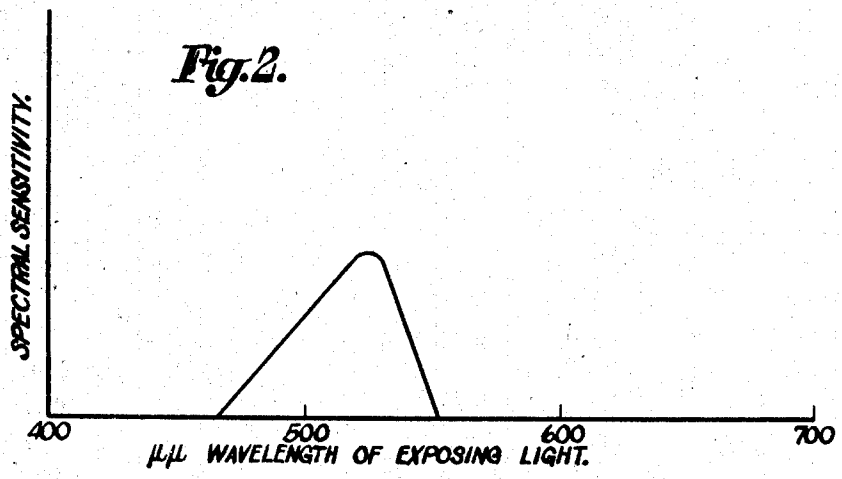
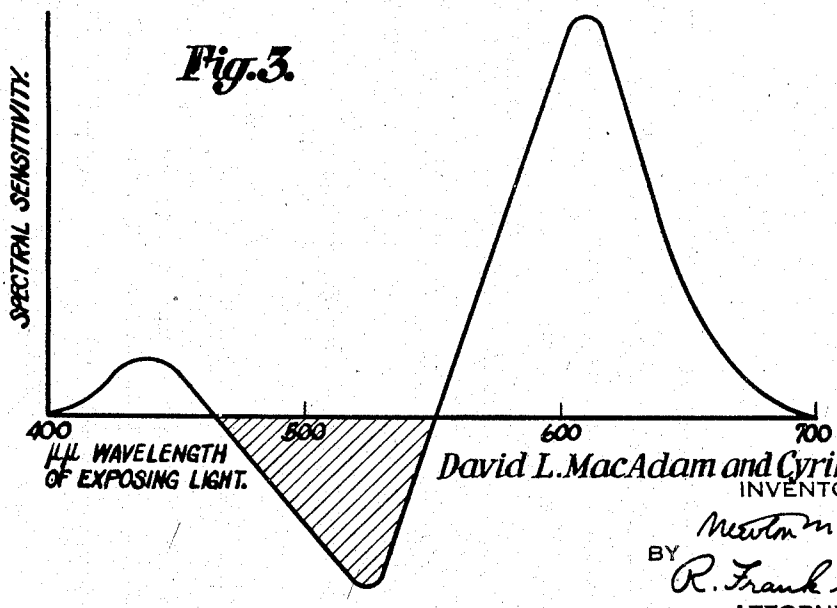


Fig.3.



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Fig.4.

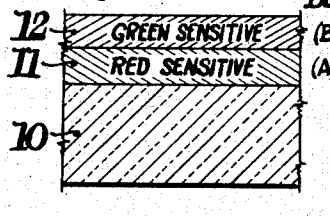


Fig.4a.

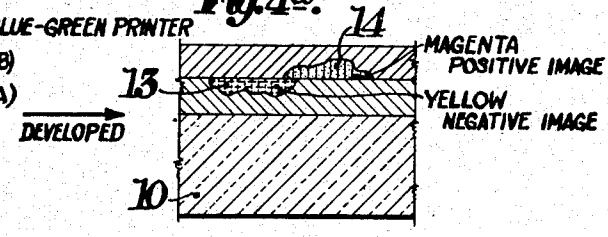


Fig.5.

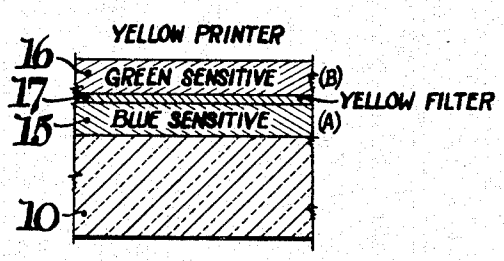


Fig.6.

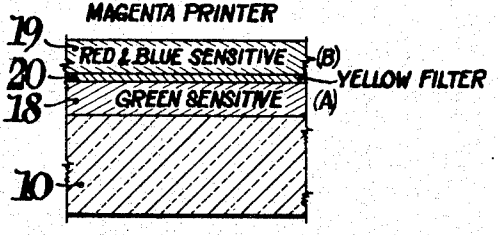


Fig.7.

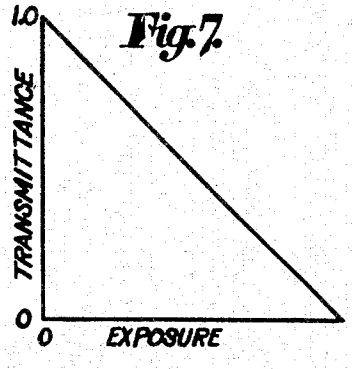
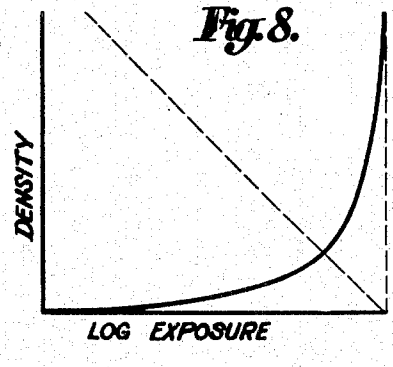


Fig.8.



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2,203,656

COLOR CORRECTION PROCESS

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Original application April 10, 1937, Serial No. 136,168. Divided and this applicaton August 11, 1939, Serial No. 289,656

4 Claims. (Cl. 95—2)

This invention relates to photographic reproduction of color and particularly to methods and materials useful in the graphic arts for reproduction of colored objects and natural-colored scenes.

This application is a division of our application Serial No. 136,168, filed April 10, 1937.

At the present time it is impossible to obtain theoretically correct color reproduction in printing processes as employed in the graphic arts and in the reproduction of colored objects and natural colored scenes by photographic methods. This defect in present reproduction methods is due to the limitations of the materials employed. The principal obstacles encountered are the inherent defects of the recording materials, such as photographic emulsions, and the deficiencies in printing inks, pigments and dyes at present available.

In order to overcome these defects two methods are in use. The older procedure is to correct the printing plates mechanically by means of hand retouching in an attempt to render the results more nearly representative of the original subject. The more recent method involves the use of correcting positive masks to print a corrected image of various of the color separation images taken through red, green, and blue filters.

The hand retouching method of color correction is obviously a cumbersome and expensive procedure and, therefore, has been supplanted to a large extent by the masking method. Masking methods now in use, as will be readily understood, involve a subtraction of photographic densities in order to arrive at a corrected color separation image. Theoretical investigations indicate that more satisfactory corrections over wider ranges of color would be obtained if transmissions were subtracted instead of densities. A method for accomplishing this result will be pointed out in the following description of our invention.

It is, therefore, an object of the present invention to provide a method for producing theoretically correct color separation images of colored objects. A further object is to provide a method for color correction involving subtraction of transmissions of photographic images. A still further object is to provide a novel photographic material for use in the graphic arts to produce corrected photomechanical printing plates. Other objects will appear from the following description of our invention.

These objects are accomplished by recording the color separation images of the object photographed on a multi-layer material having differentially sensitized layers, one of which records a negative image in a special type of emulsion and another of which records a correcting positive image in the usual type of emulsion. A corrected positive color-separation image is printed from these combined images onto a single layer of the special emulsion and may then be used for the production of colored prints or photo-mechanical printing plates. The images obtained in this way overcome the deficiency of the recording materials but do not overcome the deficiencies due to defects in the pigments, inks or dyes used to print the final reproduction.

In the accompanying drawings, Figs. 1, 2 and 3 represent spectral sensitivity curves theoretically desired for the recording material designed to record the red component of a colored object.

Fig. 4 is a sectional view of the sensitive element used to record the red components of the object and Fig. 4A is a sectional view of this film after exposure and development, according to the present invention.

Fig. 5 is a sectional view of the sensitive material used to record the blue components of the object.

Fig. 6 is a sectional view of the sensitive material used to record the green component of the object.

Fig. 7 is a diagram indicating the relation of the exposure of the special material used to record the primary components of the color object, to the transmission of the image formed in it, and

Fig. 8 is a diagram indicating the relation of the exposure to the density of the image formed in this material.

On the basis of available dyes, inks or pigments used in color reproduction or printing processes, the theoretical sensitivity of a sensitive layer which would produce a fully corrected color separation image, may be calculated. The pigments ordinarily used for color reproduction according to the subtractive process are blue-green, magenta and yellow. These are often referred to as the "blue," "red" and "yellow" pigments or inks. A theoretical spectral sensitivity curve for the blue-green printing plate, that is, the plate which prints the blue-green ink or pigments, is represented in Fig. 3 of the drawings. As shown in the shaded portion of Fig. 3 this curve includes a portion which extends below the base line. The energy in this spectral region should decrease the densities which are produced by energy in the spectral regions where the curve is above the base line. The spectral region for which the curve lies below the axis is called the region of "negative sensitivity."

Since it is impossible to obtain a negative sen-

sitivity with any known photographic materials, some means must be devised to secure the effect of negative sensitivity. One method of securing this effect is by a photo-electric scanning and recording of the color object to form color separation intelligences as described in application, Serial No. 120,964, filed January 16, 1937, by Murray and Morse. The effect of negative sensitivity may also be secured photographically by making use of special materials.

It has been found that if each color separation record of a colored object is made on a sensitive material which has such characteristics that the image produced after processing has a transmission which decreases linearly as the exposure of the image increases, the theoretical conditions can be satisfied. Such linear transmission is characterized in the terms of the more familiar H and D system by a characteristic curve which has a long toe portion with the part of the curve which rises rapidly to high densities being symmetrical with the toe when the curve is bisected by a line at 45° to the exposure axis. A sensitive material of this type has been used to record sound photographically and is described for example in the "Journal of the Society of Motion Picture Engineers" vol 17, 1931, page 172. The image in this material is processed to a negative.

When making use of the special material described above, the effect of negative sensitivity is obtained by recording the negative image on a special material of the "toe emulsion" type and having the sensitivity indicated in Fig. 1, and by recording the positive correcting image on an ordinary emulsion having the effective sensitivity indicated in Fig. 2.

The use of two separate recording layers in this way, however, involves the necessity of registration of the separate images when printing the corrected image. We have devised a method and material in which the difficulty of securing proper registration is not encountered. The separate images are recorded in two superposed emulsion layers on the same support and are processed to negative and positive images, respectively, and are colored in such a way that they may be printed separately or simultaneously to form a corrected color-separation image.

The material which we propose to use for this purpose will now be described by reference to Figs. 4, 4A, 5 and 6 of the accompanying drawings. As shown in Fig. 4 a support layer 10 is coated with a layer of a red-sensitive emulsion 11 and a green-sensitive emulsion 12. The emulsion 11 is of the "toe emulsion" type described above and the emulsion 12 is of the ordinary type in which for the straight line portion of the H and D curve $D=\gamma$ (log E—log i) where D is the photographic density, E is the exposure, i is the inertia, and γ is a constant related to the extent of development. This material is exposed to the object to be recorded through a yellow filter which absorbs any blue light which would be recorded on both of the sensitive layers 11 and 12 and permits only red and green light to pass to these sensitive layers. Both images are then processed to negative images and the image in layer 12 is then reversed to form a positive image.

The images formed in this way in layers 11 and 12 are then processed to colored images 13 and 14 as shown in Fig. 4A. Since all existing dyes and pigments show considerable overlapping of absorptions, the choice of colors for the images is somewhat restricted if optimum results are to be obtained. The visual appearance of these superimposed colored images is of no significance. We believe that the best choice of colors would be yellow for the negative image 13 and magenta for the positive image 14 although other combinations of colors are conceivable. These colored images may be formed by any suitable method. They may be formed, for example, by developing both layers in a color-forming developer, such as one of the developers described in Mannes and Godowsky U. S. Patent No. 2,059,884, and the image in the upper layer bleached differentially, reversed and processed to the second color. It is also possible to develop both images initially in an ordinary developer and then color them by any suitable method. These images constitute the blue-green printing element when used to print a corrected image.

In a similar manner the yellow printer element comprises a blue-sensitive layer 15 and a green-sensitive layer 16 carried by support 10, as shown in Fig. 5. A yellow filter layer 17 is located between the sensitive layers 15 and 16. This element is printed through the support and the blue component of the object is recorded on layer 15, while the green component is recorded on layer 16. This element is then processed to form a yellow negative image in layer 15 and a magenta positive image in layer 16. The filter dye of layer 17 is removed in this process.

The magenta printer element is shown in Fig. 6 in which the support 10 carries emulsion layers 18 and 19 having an interposed yellow filter layer 20. This element is exposed from the emulsion side to the object to be recorded and the green component of the object is recorded in layer 18 and the red and blue components in layer 19. This element is then processed as in the case of the other printer elements to a yellow negative image in layer 18 and a magenta positive image in layer 19, the filter dye 20 being removed in the processing. In the case of the magenta printer it is also possible to make the layer 19 senstive only to red or blue, in case it is desired to correct by the subtraction of one or the other of these color components.

In order to obtain a corrected positive image for each of the color separation components of the original object, the three printer elements are printed separately onto an emulsion of the "toe emulsion" type described above. The printing light is chosen so that no single wave length is present for which both of the colored images show appreciable absorption. In the case of the yellow and magenta images described, the printing light should be a mixture of the blue and green wave length bands. The use of light exhibiting single spectral lines appears to afford optimum conditions for this printing in order to obtain sharp absorption for both images. One method of obtaining such spectral lines is to pass the light from a mercury arc through an ultra-violet absorber, such as a Wratten 2-A filter and thereby use the two very narrow regions of the spectrum in which practically all of the energy of this light source is concentrated. These bands are at approximately 435 mu and 550 mu and are, therefore, suitable for independent printing of magenta and yellow images. If necessary, the yellow lines in the mercury spectrum may be removed by a didymium filter.

By printing in this way the yellow image in the emulsion layer adjacent to the support will be printed by the blue band of light without appreciable interference from the magenta image

and the magenta image in the outer emulsion layer will be printed by the green light without interference from the yellow image. This is, in effect, a double exposure method as contrasted with ordinary masking methods in which all components of the printing light are modified by both the negative and masking images.

The printing material should have the same contrast for blue and green printing bands and as stated above must also give a transmission characteristic which decreases linearly as the exposure increases.

The positive color separation images produced in this way from each of the three negative images together with their correcting images are fully corrected and the process is more satisfactory than processes previously used for this purpose. The corrected positives produced in this way may be used to print negatives on ordinary material for use in preparing photo-mechanical printing plates or they may be used for the production of color transparencies as still photographs or as motion pictures. It is to be understood that our process is not limited to the graphic arts where printing from a press is involved, but that the same materials and processes may be used for better color reproduction in the making of prints on paper or for the reproduction of color transparencies by various photographic processes.

We claim:

1. The method of producing a photographically corrected color component image of a colored object, which comprises forming in a "toe emulsion" type gelatino-silver-halide emulsion a negative image of one of the primary color components of a colored object, forming a positive image of another of the primary color components of the colored object in an ordinary gelatino-silver-halide emulsion, the images being superposed and in register, and printing both images onto a "toe emulsion" gelatino-silver-halide emulsion.

2. The method of producing a photographically corrected color component image of a colored object, which comprises forming in a "toe emulsion" type gelatino-silver-halide emulsion a negative image in one color of one of the primary color components of a colored object, forming a positive image in another color of another of the primary color components of the colored object in an ordinary gelatino-silver-halide emulsion, the images being superposed and in register, and printing both images with light having no single wave-length for which both colored images show appreciable absorption onto a "toe emulsion" gelatino-silver-halide emulsion.

3. The method of producing a photographically corrected color component image of a colored object, which comprises forming in a gelatino-silver-halide emulsion, producing an image the transmission of which decreases linearly as the exposure increases, a negative image in one color of one of the primary color components of a colored object, forming a positive image in another color of another of the primary color components of the colored object in an ordinary gelatino-silver-halide emulsion, the images being superposed and in register, and printing both images with light having no single wave-length for which both colored images show appreciable absorption onto a gelatino-silver-halide emulsion.

4. The method of producing a photographically corrected color component image of a colored object, which comprises forming in a gelatino-silver-halide emulsion, producing an image the transmission of which decreases linearly as the exposure increases, a yellow negative image of one of the primary color components of a colored object, forming a magenta positive image of another of the primary color components of the colored object in an ordinary gelatino-silver-halide emulsion, the images being superposed and in register, and printing both images with light having no single wave-length for which both colored images show appreciable absorption onto a gelatino-silver-halide emulsion producing an image the transmission of which decreases linearly as the exposure increases.

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