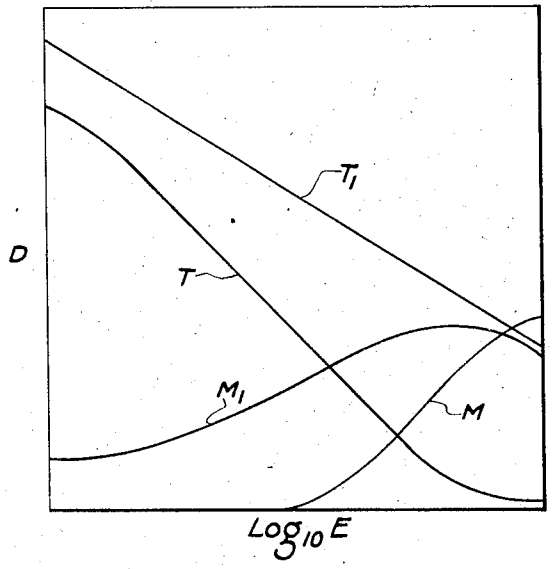
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PHOTOGRAPHIC TONE CORRECTION MASK

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PHOTOGRAPHIC TONE CORRECTION MASK

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This invention relates to a process in photography, and more particularly to a process in subtractive color photography whereby there is formed a tone correction mask which when placed in registry with a color transparency effects an improved tone reproduction curve for the transparency.

This application is a continuation-in-part of my application Serial No. 454,945, filed August 15, 1942.

In duplicating or printing transparencies, especially those obtained by the reversal process of subtractive color photography, onto a material to be processed by reversal, the low contrast in the highlight regions is exaggerated by being printed onto the low contrast highlight regions of the reversal material.

Also, in printing from multicolored originals which consist in whole or in part of dyes, the fact that the light absorption of the dyes is extended to the whole spectrum rather than to one part of the spectrum makes it impossible to obtain printed records of the individual dyes simply by restricting the color of the printing light. Since in most three-color photographic processes the three dyes are not equally bad in this respect, the final result of printing such a film is to introduce unequal parts of all three records in each image which is made, regardless of the color of light used in printing or the sensitivity of the photographic materials used.

In order to compensate for the deficiencies of the dyes used in such processes, negative color correction masks are prepared by exposing a suitably sensitive emulsion layer through the multicolor originals with a selected exposing light and forming a metallic or colored image of the exposed layer which, when placed in registry with the original during printing effects color correction. Typical methods of preparing such masks are described in Evans United States Patent No. 2,203,653, granted June 4, 1940, Hanson United States Patent No. 2,294,981, granted September 8, 1942, Evans United States patent application, Serial No. 413,442, filed October 3, 1941, and elsewhere.

In the present application I describe a method of preparing a color correction mask which not only corrects for the deficiencies of the subtractive dyes of the color process, but also has tone reproduction characteristics such that when a print is made from the combination of the mask with the original transparency of which the mask is a record, large improvement in the final tone reproduction of the transparency is achieved in the print or duplicate.

One object of the present invention is to provide a tone correction mask of use for improving tone reproduction during the printing of images having improper tone reproduction characteristics.

Another object of the present invention is to provide a tone correction mask of use in black-and-white and color photography for improving tone reproduction during printing from black-and-white or colored images having improper tone reproduction characteristics.

Another object of the present invention, and the preferred embodiment thereof, is to provide a tone and color correction mask of use in color photography for improving the tone reproduction and color during printing from colored images.

In general, the objects of my invention are accomplished by forming in a photographic emulsion layer an image of opposite sign to a transparency having improper tone reproduction characteristics, of which it is a record, the characteristic curve of the image being such that when the image is combined with the transparency an improvement in tone reproduction is achieved.

In the figure of the accompanying drawing are shown by graphical representation the characteristic curves of various photographic elements employed in my invention.

In the figure of the accompanying drawing, curve M represents the characteristic curve of an image obtained by low intensity exposure through a color transparency having a reproduction curve such as curve T. Curve M_1 represents the characteristic curve of an image obtained by exposure through the transparency onto the unexposed area of the same photographic element after removal of the image of curve M. Curve T_1 represents the corrected reproduction curve of the transparency obtained when in printing, the image having curve M_1 is used as a mask for the transparency having curve T.

My invention will now be described with particular reference to the accompanying drawing.

In a typical case to which my invention is particularly applicable, there is at hand a color transparency having a reproduction curve such as curve T of the drawing. In the normal process of reproducing this transparency, as for instance, onto a multi-color film by means of the reversal process of color photography employing color-forming development, there would be obtained a print in the toe region of which the low contrast of the toe of the curve T would be exaggerated. This is true whether or not the usual color correction mask is employed in the printing process. However, if in the manner of my invention another characteristic be imparted to the color correction mask, the errors of tone reproduction are partially or completely compensated for. A mask of these characteristics is prepared as follows: a film carrying an emulsion such as commonly used on positive motion picture film,

that is, an emulsion capable of development to a range of contrast of the order of 0.3 to 4 with different developing solutions and highly sensitive to a region of the spectrum such as red, green, or yellow (this sensitivity being chosen for the particular color correction desired) is, for instance, exposed through the transparency having the characteristics shown in curve T with blue light (Wratten No. 47 filter) so that substantially only those densities of the transparency below 0.6 are recorded. The film is then hardened in a formaldehyde hardener solution and developed to a high contrast in a developer of the following composition:

Sodium sulfite	grams	90
Hydroquinone	do	45
Sodium hydroxide	do	37.5
Potassium bromide	do	30
Water to	liter	1

Following development, the film is washed and dried without fixing. The image contained therein has substantially the characteristics shown by curve M of the drawing. For use with most color transparencies, a gamma of the range of the order of 1 to 4 is satisfactory for this image.

After development the developed image is bleached in an acid bichromate bath followed by a wash in ammonium hydroxide solution. The ammonium hydroxide solution is made by diluting 10 cc. of concentrated ammonium hydroxide to 1 liter. The bichromate solution has the following composition:

Potassium bichromate	grams	5
Sulfuric acid (concentrated)	do	5
Water to	liter	1

This treatment removes the high gamma silver image from the layer.

At this point if the sensitivity of the film, for instance, to red light has been destroyed, the film is resensitized in a suitable sensitizing bath of the following composition:

Pinacyanol	gram	0.01
Alcohol (commercial 3A)	cc	75
Pyridine	cc	1
Benzotriazole	gram	0.1
Water to	liter	1

It is apparent that in the above steps one may start with an ordinary blue-sensitive film and sensitize it, for instance, to red light at the point indicated, instead of starting with a film sensitive not only to blue light but to red, green, or yellow light.

The film is then washed and dried and following this it is given a second exposure with red light through the transparency so as to record all of the detail of the transparency. This exposure may be made to a filter such as Wratten No. 25 filter. Following this the film is developed at 70° F. for about six minutes to a gamma of about 0.5 in a developer of the following composition:

Sodium sulfite	grams	30
p-Methyl amino-phenol sulfate	do	0.16
Hydroquinone	do	5
Borax	do	2
Water to	liter	1

Finally, the film is fixed, washed and dried. This procedure gives a mask having a low gamma negative curve and a sharp reversal in the region of higher exposure as shown in curve M_1 of the drawing. Generally, a gamma of the range of the order of from 0.3 to 0.6 is satisfactory for this image, and the ratio of the gamma of this image to the gamma of the above high gamma image is, therefore, of the order of 1/0.6 to 4/0.3. The higher the ratio selected the greater the correction imparted to the transparency. The mask thus obtained has substantially the characteristics shown by curve M_1 of the drawing, wherein the straight-line portion of the curve is a low gamma image having density variations of opposite sign to the transparency having curve T, and the shoulder or high density region is a positive with respect to the transparency T. Since the mask is a positive in the shoulder region it may be said to have no density variations of opposite sign to the density variations of the transparency in that region.

An alternative procedure in obtaining the combination color correction and tone reproduction mask according to my invention is to rehalogenize the first-developed silver without removing it prior to the exposure of the residual silver halide. The first-developed silver may be bleached to silver bromide in a potassium ferricyanide-potassium bromide solution which converts the developed silver to silver bromide. The silver bromide thus formed is apparently greatly desensitized so that upon second exposure of the film using red light very little silver is formed in the rehalogenized region.

The following example illustrates the method of using my rehalogenization procedure.

After exposure of the positive film through the transparency with blue light as described above the emulsion is developed in a high contrast developer which may have the following composition:

Sodium sulphite	grams	60
Hydroquinone	do	10
Sodium carbonate	do	25
Sodium hydroxide	do	5
Potassium bromide	do	5
Water to	liter	1

The development in this solution records only the highlights in the transparency after about 6 minutes development, and the film is then washed for 4 minutes. The silver image thus formed is bleached for 4 minutes in the following solution and washed for 4 minutes:

Potassium ferricyanide	grams	50
Potassium bromide	do	20
Water to	liter	1

The emulsion is then exposed through the transparency to red light and developed for 6 minutes in the second developer described above or in the following developer:

Sodium sulphite	grams	30
Paramethyl amino phenol sulphate	do	1
Hydroquinone	do	5
Borax	do	2
Potassium bromide	do	0.25
Water to	liter	1

From 50 to 100 mg. per liter of benzotriazole may be added to this developer to inhibit development of the rehalogenized silver.

The required contrast can be obtained by varying the time of development in the second developer.

In order to print color an dtone corrected prints from the original transparency, the mask is placed in registry with the transparency, prints being made on a suitable multilayer color film in a process such as disclosed in Mannes et al. United States Patent 2,252,718, granted August 19, 1941, or if desired, color separation records may be printed and used in known color processes.

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As shown by curve T1 of the drawing, the reproduction curve of the combination of the transparency and the mask is greatly improved. Not only has the mask effected an overall decrease in contrast in the reproduction curve, but in the low density region corresponding to the highlights of the transparency, the contrast has been raised so that constant contrast is obtained throughout the length of the characteristic curve. Of course, since the exposing light for the exposure of the final mask is preferably selected so as to compensate for the errors in absorption of the dyes used in the process, color correction is also affected. The choice of wave length of exposing light depends upon whether or what correction is desired but generally a light of longer wave length than blue is satisfactory, such as red, green, yellow, especially substantially monochromatic yellow light, chosen according to the principles laid down in the prior United States Patent 2,294,981 issued September 8, 1940, above-cited.

As above-mentioned the mask of the invention having characteristics substantially as shown by curve M1, in order to compensate for low contrast in the highlight portion of a transparency, must have little or no gradation in the shoulder region with respect to the transparency. In curve M1 the mask is shown as having decreasing density, i. e. positive density gradient in the shoulder region to compensate for the low contrast in the toe of the transparency curve T.

I contemplate as within my invention tone and color correction masks of the general characteristic described, wherein the straight line portion of the characteristic curve is negative to a transparency of which it is a record, and in which in the shoulder region there is little or no gradation of opposite sign to the transparency, but including density variations of the same sign in that region. Therefore, herein and in the appended claims where I state that the mask has in the shoulder region no appreciable density variations of opposite sign to the density variations of the transparency, I mean it to be understood that this includes in the shoulder region: (1) small density variations of opposite sign to the transparency but of an order less than normally obtained with photographic emulsions, (2) no density gradation in the portion of the shoulder masking the toe of the transparency, and (3) density varying in the same direction as the density variations of the transparency.

Another use for which the mask of my invention is especially adapted, is in projecting or viewing of color transparencies. That is, in reversal processes of color photography where colored images are formed by means of color-forming development, images are obtained commonly having high contrast and the usual low contrast in the shoulder and toe regions (see curve T). A mask prepared as described is especially suitable for combining with such a transparency when it is desired to obtain the best image for viewing or projecting.

As is apparent, my invention is not limited to use in processes of color photography; however, my preferred embodiment resides therein. In processes of black-and-white photography, when printing from transparencies having improper tone reproduction characteristics, as for instance, from a black-and-white image having lower gamma in the toe and shoulder regions of the characteristic curve than in the straight-line portion, a tone correction mask may be prepared according to my invention. When this mask is used in printing in combination with the image of which it is a record of opposite sign, an improvement in tone reproduction is obtained. In the past, practically the only method of improving tone reproduction in black-and-white photography has been to print an original transparency onto a material of different contrast, thereby altering the overall contrast in the print but obtaining some compensation for errors in tone of the original.

In addition, my invention may be used in conjunction with printing from a colored negative transparency, as for example, prepared from photographic elements designed as described in Jelley and Vittum United States Patent 2,322,027, granted June 15, 1943, Mannes et al. United States Patents 2,304,939 and 2,304,940, granted December 15, 1942, that is, in conjunction with color films which after original exposure are immediately developed to subtractively colored dye images. In this case, the final mask is a negative record of the color negative but, of course, is a positive with respect to the final positive color print. In fact, my invention is applicable to the improvement of tone reproduction any process of photography wherein the image of which the mask is a record has tone reproduction errors of the order described.

Also apparent, is the fact that the masks of my invention may be designed so as to correct not only for tone reproduction errors of the transparency being printed, but also to correct for tone reproduction errors introduced by the duplicating process. This is accomplished by giving the mask a shoulder gamma compensating for tone errors of both the toe of the transparency and any toe introduced in the duplicating process.

My invention having thus been described I would have it understood that the disclosure herein is by way of example, and that I consider as included in my invention all modifications and equivalents falling within the scope of the appended claims.

What I claim is:

1. The method of forming a photographic tone correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a transparency of such intensity that only the toe densities of said transparencies are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, converting said silver image to a transparent form inactive with respect to subsequent exposure and development of unexposed silver halide in said layer, exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing all silver halide from the emulsion layer.

2. A method of forming a photographic tone correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said image from the emulsion layer, exposing the emulsion layer containing unexposed silver hal-

ide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer.

3. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a color transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emusion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer.

4. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a color transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver halide and removing any unexposed silver halide from the emulsion layer, said last-formed image having a characteristic curve which comprises in the straight-line portion density variations of opposite sign to the density variations of a transparency of which it is a record and in the shoulder portion no appreciable density variations of opposite sign to the density variations of said transparency.

5. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light sensitive silver halide emulsion layer an exposure through a positive color transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer, said last-formed image being of opposite sign to said transparency in the straight-line portion of its characteristic curve and of the same sign as said transparency in the shoulder portion of its characteristic curve.

6. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light sensitive silver halide emulsion layer an exposure through a positive transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and if higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency with light of wave lengths which will correct for the inaccuracies in absorption of light by the dyes used in the process, forming the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing unexposed silver halide from the emulsion layer, said last-formed image being of opposite sign to said transparency in the straight-line portion of its characteristic curve and of the same sign as said transparency in the shoulder portion of its characteristic curve.

7. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light sensitive silver halide emulsion layer an exposure through a positive color transparency of such intensity that only the toe densities of said transparency are recorded with blue light, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency with red light to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing only unexposed silver halide from the emulsion layer, the gamma of the first-formed silver image being of a range of the order of 1 to 4 and the gamma of said last-formed image being of a range of the order of 0.3 to 0.6.

8. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light sensitive silver halide emulsion layer an exposure through a negative transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, exposing the mulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer, said last-formed image being of opposite sign to said transparency in the straight-line portion of its characteristic curve and of the same sign as said transparency in the shoulder portion of its characteristic curve.

9. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which

comprises giving a light sensitive silver halide emulsion layer an exposure through a negative color transparency of such intensity that only the toe densities of said transparency are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency with light of wave lengths which will correct for the inaccuracies in absorption of light by the dyes used in the process, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer, said last-formed image being of opposite sign to said transparency in the straight-line portion of its characteristic curve and of the same sign as said transparency in the shoulder portion of its characteristic curve.

10. In a process of printing a color transparency in natural colors the method of forming a photographic tone and color correction mask which comprises giving a light sensitive silver halide emulsion layer an exposure through a negative color transparency of such intensity that only the toe densities of said transparency are recorded with blue light, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, removing said silver image from the emulsion layer, resensitizing the remaining silver halide and exposing the emulsion layer containing unexposed silver halide through said transparency with red light to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing any unexposed silver halide from the emulsion layer, the gamma of the first-formed silver image being of a range of the order of 1 to 4 and the gamma of said last-formed image being of a range of the order of 0.3 to 0.6.

11. The method of forming a photographic tone correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a transparency of such intensity that only the toe densities of said transparencies are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, converting the developed silver to silver bromide inactive with respect to subsequent exposure and development of unexposed silver halide in said layer, exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing all silver halide from the emulsion layer.

12. The method of forming a photographic tone correction mask which comprises giving a light-sensitive silver halide emulsion layer an exposure through a transparency of such intensity that only the toe densities of said transparencies are recorded, developing in the exposed emulsion layer a silver image of opposite sign to said transparency and of higher gamma than a second image subsequently formed therein, converging the developed silver to silver bromide in a ferricyanide-bromide bleach bath, said silver bromide being inactive with respect to subsequent exposure and development of unexposed silver halide in said layer, exposing the emulsion layer containing unexposed silver halide through said transparency to record all of the detail of said transparency, forming in the exposed emulsion layer an image of gamma lower than said first-mentioned silver image and removing all silver halide from the emulsion layer.

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