May 22, 1962 E. HELLMIG 3,035,913

PHOTOGRAPHIC TONE CORRECTION

Filed Sept. 18, 1957

FIG. 1a

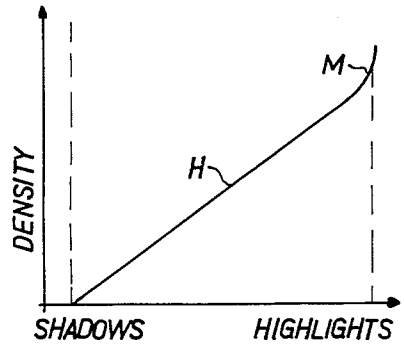
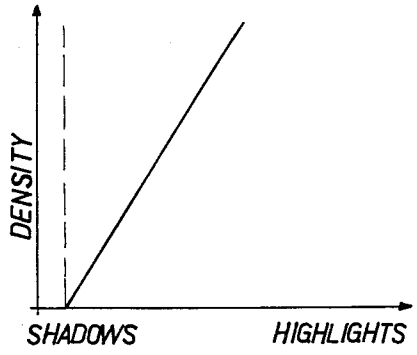


FIG. 1b



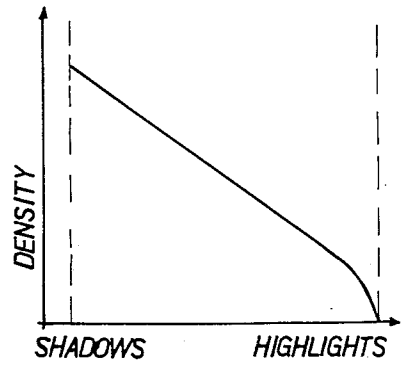


FIG. 2a

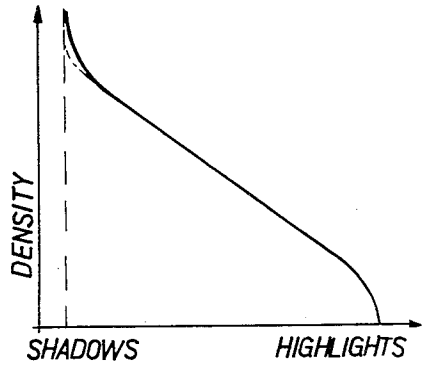


FIG. 2b

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PHOTOGRAPHIC TONE CORRECTION

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10 Claims. (Cl. 96—27)

The present invention relates to photography and particularly to a process for correcting the tone of photographic images.

It is well known that photographic images produced on normal silver halide emulsion layers have a decreased contrast in the shadow and highlight portions as compared with contrast of the original subject. This holds true especially for prints which are either made from photographic black-and-white or from color transparencies. These tone defects are due to the characteristic curves of the silver halide emulsion layers which have a lower contrast or gamma in the highlights and shadows as compared with the contrast in the intermediate tones.

Photographic processes for correcting these defective tone values are already known. They generally involve copying a photographic image of "normal tone value," and containing the aforementioned tone value defects, in correct register with a second photographic image or copy of the same original (mask) onto a silver halide emulsion layer. The combination of the two images then constitutes an image corrected for tone value. To increase for instance the highlight contrast of a negative image this image is combined with a highlight mask which is an underexposed negative image representing only the highlights of the original, whereas the shadow mask for a positive image is a positive image representing only the deepest shadows. These masking images are usually prepared on less sensitive photographic material or with a shorter exposure time than the image which has a normal tone value.

The two-light-sensitive layers for the normal tone value image and the tone value separation record or masking image can be arranged on the same support ("continuous tone layer" and "masking layer"), it being possible for their spectral sensitivity to be either in the same or in different ranges of the spectrum.

A material of this known type, when exposed to give a negative, only leads to improved definition of highlights, and the definition of shadows is still insufficient.

It has now been found that this disadvantage can be avoided if the photographic material used for the exposure is one having one or several silver halide emulsion layers and having a steeper gradation or higher gamma in the highlights (higher densities) than in the densities representing the intermediate tone values and the shadow parts, either a color image or a combined silver and color image being produced after the exposure in said material, these images being such that they absorb actinic light of different wavelengths to different degrees and thus produce, in the copying process, images having different gradation which depend on the copying light which is used, whereupon said color image or said combined silver and color image is so copied with both types of light, simultaneously or successively, onto a material sensitive to both types of light that the printed image produced with one type of actinic light is an image corrected as regards shadow definition while a correction of the highlight definition is produced with the other type of actinic light, whereby the resultant image is an image corrected as regards shadow and highlight definition.

The process will hereinafter be more fully explained by reference to an exposure material of the aforementioned type which contains a yellow-coupling color coupler for the color forming development.

After exposure, color development and fixing in a neutral fixing bath, a silver image combined with a yellow dyestuff image is obtained. The relation between the quantity of silver and the quantity of the color component of the silver halide emulsions is such that the image, when observed through a green filter, shows increased highlight contrast. It corresponds in this respect to a black-and-white image which is obtained on a double layer material containing a continuous tone silver halide emulsion layer and a masking layer, the silver halide emulsion of which is of lower speed than said continuous tone layer as it is for instance disclosed in copending application Serial No. 666,343, filed June 18, 1957. By printing said image with green light on an orthochromatic silver halide layer an image is formed which is only masked in the highlights, while by subsequent exposure with blue light an image is formed which is additionally masked in the shadows. This result can be obtained with a single exposure, by using a cyan copying light. The shadow masking is particularly effective when the copying material used is a double layer material of the aforementioned type, comprising a continuous tone and a masking layer, said masking layer being sensitive to the blue region of the visible spectrum (that is to say a region of the spectrum which corresponds to the region of the spectrum in which the color image absorbs) said continuous tone layer being sensitive to the green part or to the green and red part of the visible spectrum.

Schematic sensitometric curves of the materials referred to in the preceding paragraph are shown in the accompanying drawing.

FIG. 1*a* represents in diagrammatic form the sensitometric curve H of the negative image measured through a green filter. The sensitometric curve behind a strictly blue filter is shown in FIG. 1*b*, since the negative silver image is combined with a yellow color image, i.e. strongly absorbs the blue light, it now has a substantially steeper gradation than in FIG. 1*a*.

If the negative image is then copied with green light on a corresponding light-sensitive material, a copy is produced which is only masked in the highlights (as shown at M in FIG. 1*a*) and which has the density curve shown in FIG. 2*a*. If, before development, an exposure with blue light is subsequently made through the same negative on to the same copying material, only those areas of maximum transparency in the negative are copied on account of the great steepness of the negative gradation (FIG. 1*b*). These are the shadows, and an emphasis of the shadow definition is obtained in the copy in addition to the masking of the highlights. There is thus obtained the sensitometric curve which is represented in FIG. 2*b*, which clearly shows the shadow correction produced at the upper end of the density curve in addition to the highlight correction, this curve represents the known tone-separation curve according to Person.

The invention is not restricted to the example which has been described. The photographic materials can be modified in very many different ways as regards the spectral sensitivity, the color of the dyestuff image and the method of processing.

In case that the exposure material is panchromatic it can be used for the production of color separation records from multi-color images. The exposure material can be transformed into a pure dyestuff image by bleaching and fixing the exposed material after color forming development. To obtain the same effect as with the aforementioned combined silver and yellow dyestuff image the material should be transformed into a combined yellow and magenta dyestuff image. The present invention may also

find application for the two layer materials disclosed in my copending applications Serial Nos. 571,793, filed on March 15, 1956, and 613,221 filed October 1, 1956 (now abandoned), in which the images of the masking layer have a color different from that of the image of the continuous tone layer.

As regards the color of the pure dyestuff image or of the combined silver and dyestuff image, it may also be magenta, cyan, red, blue or green, whereby the sensitivity of the printing material must be adapted to the color of the dyestuff image. In such cases in which the dyestuffs of the color images have a main adsorption in one region of the visible spectrum and a smaller side absorption in another region of the visible spectrum, it may be of advantage to use printing materials which are sensitive to both of these regions. If for instance in the aforementioned process a combined magenta dyestuff and silver image is produced in the exposure material, the first exposure in the printing process is made with blue and the second exposure (shadow correction) with green or yellow light (the main absorption of the magenta image lying in the green and the side absorption in the blue region of the spectrum), the printing material being either an orthochromatic single layer material or a double layer material of the types disclosed above, in which the continuous tone layer is blue sensitive and the masking layer orthochromatic or green sensitive.

Generally speaking it is preferred to use as a printing material the same material as the exposure material, whereby the printing material in contradistinction to the exposure material is developed in a non-color-forming black-and-white developer solution.

The dyestuff images in the exposure materials are produced by methods well known in the art, such as by the process of color forming development, the silver dye-bleach process, the imbibition process, the toning of silver images by means of uranium and lead toning solutions (compare Eder:Rezepte und Tabellen, 1948, page 771), the processes making use of wash out reliefs, and mordanting processes. Furthermore, developer solutions may find application which form a dyestuff image besides a silver image in the absence of a color coupler, such as solutions of pyrogallol, pyrocatechol, chlorohydroquinone.

The process of the present invention can also be carried through by producing in an exposure material a black-and-white silver image which has an increased gradation in the highlights, printing said silver image onto a layer containing components for the production of an azo-dyestuff image which layer is coated on a transparent support and developing said layer by means of ammonia into a negative dyestuff image of the original. If these two images are brought into printing relation and printed onto a light sensitive material according to the process described above, there is obtained a print which is corrected in the highlights and shadows.

Example 1

A silver halide emulsion is coated on a transparent support of acetyl cellulose to produce a layer having a gamma which in the densities above 1.5 is twice as high as the gamma in the lower densities. The emulsion is produced in known manner by mixing a low sensitive silver halide emulsion of high gamma and a silver halide emulsion of high speed and low gamma. The emulsion is optically sensitized to the green part of the visible spectrum and contains per kilogram, 15 g. of a coupler for the production of the yellow dyestuff image by the process of color forming development such as 3-[p-stearoylaminobenzoyl-acetimido]-isophthalic acid in the form of the sodium salt.

A gelatine protective layer provided with hardening agents is coated on said silver halide emulsion layer so as to protect the light sensitive layer from mechanical damage. After exposure, for which purpose a black-and white image is used as original, the film is developed for 5 minutes in one of the known color forming developing solutions, thereafter rinsed for 1 minute and then fixed for 10 minutes in a neutral fixing bath, rinsed for 10 minutes and dried. The resulting image is composed of a silver image and a yellow dyestuff image. The choice of the emulsion for the light sensitive layer was such that the resulting image, when measured behind a strictly green filter (Agfa Filter No. 54), shows a gradation of 1.0 in the densities below 1.5, and a gradation of 2.0 in the densities above 1.5. The quantity of the color forming couplers was so chosen that the gradation behind a strictly blue filter (Agfa Filter No. 552) is 3.0.

The aforementioned negative silver image is then printed with green light from the wavelength range 500–600 mμ (Agfa Filter No. 54) and thereafter with blue light from the wave length range 400–500 mμ (Agfa Filter 552) onto a two-layer material which comprises in superimposed relationship an orthochromatic highly sensitive silver halide emulsion layer having a gradation of 1.3 and a blue sensitive silver halide emulsion layer as top-layer having a gradation of 1.5 and a sensitivity which is 40 times lower than that of the orthochromatic silver halide layer. In this case, the exposure with blue light is such that only the shadow portions of the image are copied. The print is then developed in known manner in a black-and-white developer (metol-hydroquinone) for 5 minutes, rinsed, fixed, rinsed again and dried.

Example 2

The composition of the exposure material is as in Example 1, but the silver halide emulsion contains per kilogram 10 g. of the yellow coupler and 10 g. of a magenta coupler. After exposure the silver halide emulsion layer is processed to produce a dyestuff image by color forming development, bleaching of the silver image and fixing. The printing process is the same as disclosed in Example 1. As magenta coupler there may be used 1-(4'-phenoxy-3'-sulfophenyl)-3-heptadecyl-5-pyrazolone.

Example 3

A silver bromide-gelatine emulsion is cast on a transparent support consisting of acetyl cellulose, the said emulsion having been made sensitive to green light by one or more of the known sensitizers. In addition, this emulsion contains one of the known colorless, yellow-coupling color components for color development. There is cast above this layer a second light-sensitive layer, which is not sensitized and is therefore only blue-sensitive. Its sensitivity is lower by a factor of 40 than that of the first-mentioned layer. A gelatine protective layer provided with hardening agents is also situated above the top layer so as to protect the light-sensitive layers from mechanical damage.

After exposure, for which purpose a black-and-white image is used as original, the film is developed for 5 minutes in one of the known color developers, thereafter rinsed for one minute and then fixed for 10 minutes in a neutral fixing bath, rinsed for 10 minutes and dried. The resulting image contains in the lowermost layer an image consisting of silver and yellow dye, while the upper layer contains an image of pure silver (highlight mask) disposed only at the brightest areas of the original. The choice of the emulsion for the two light-sensitive layers was such that the lower layer, when measured behind a strictly green filter (Filter No. 54) shows a gradation of 1.0 while the upper layer (masking layer) has a gradation of 1.5. The quantity of components in the lower layer was so chosen that the gradation behind a strictly blue filter (Filter No. 52) is 2.4.

The negative record was then coplied with green light from the wavelength range 500–600 mμ (Agfa Filter 54), and thereafter with blue light from the wavelength range 400–500 mμ (Agfa Filter 522) onto a two-layer material which is of similar structure but which does not contain any color component. In this case, the exposure with blue light is such that only the densest areas of the

image (the shadow portions) are copied. The copy is then developed in known manner in a black-and-white developer (metol-hydroquinone) for 5 minutes, rinsed, fixed, rinsed again and dried.

Example 4

The formation of the two-layer film is as in Example 3, but the masking layer contains a magenta component for the purpose of intensifying the mask in green light to a gamma of 3.5. The processing of the exposed layers and the copying of the color image is the same as above.

Example 5

Formation of the two-layer film is as in Example 3, but the continuous tone layer contains a yellow-orange coupling component instead of the yellow component or a magenta component in addition to the yellow component as disclosed in Example 2 and the green absorption is of the same value as the absorption of the purely silver image of the continuous tone layer in the two previous examples. The material is processed to provide a purely dye image, this being done after the color development in known manner by bleaching the image silver and fixing.

Example 6

The negative silver image having an increased gradation is produced on a photographic material as disclosed in Example 3, but containing no color coupler in the green sensitive emulsion layer. Such a material is on the market under the trade name "Agfa LM Film." The aforementioned image is printed by means of arc light onto a diazo material which is developed by means of ammonia to a yellow negative image of the original. This yellow image is brought in printing relation with a silver image, whereafter the combined images are printed onto a silver halide emulsion material as disclosed in Example 1.

Example 7

A black-and-white silver image is produced on the exposure material disclosed in Example 1 by developing the exposed material in a black-and-white developer and thereafter fixing the developed material. The silver image obtained is treated in a common intensifier of the following composition:

500 g. of potassium ferricyanide are dissolved in 10 litres of water. To the solution there is added 50 cc. of a 1% potassium bichromate solution. The solution thus obtained is added to a solution of 550 g. of uranium nitrate and 500 g. of oxalic acid in 40 litres of water. The silver image is treated in said bath for 5 minutes and thereafter rinsed. The tone image obtained is printed as disclosed in Example 1.

The double layer material used for carrying out the process of the present invention is preferably one in which the lower silver halide emulsion layer has a gamma value of at least 0.5 and less than 2 (continuous tone layer) whereas the upper silver halide emulsion layer (masking layer) has a gradation which is at least one and a half times that of the continuous tone layer and a speed which is within the range of about $\frac{1}{10}$ to about $\frac{1}{100}$, preferably $\frac{1}{20}$ to $\frac{1}{80}$ of that of the continuous tone layer when developed in a black-and-white developer of the type disclosed below. It is furthermore possible to use a material in which the masking layer is coated on the masking tone layer or in which the two layers are arranged on different sides of the support.

When the double layer material is used as an exposure material either a color image or a combined silver and color image may be produced in the continuous tone layer and a color image, a silver image or a combined silver and color image may be produced in the masking layer, provided that the continuous tone image is such that it absorbs actinic light of different wavelengths to different degrees and that the masking image absorbs at least in that wave-length range of the copying light in which the continuous tone image produces an image with a flatter gradation.

Suitable for the production of dyestuff images by the process of color forming development are disclosed for instance in U.S. Patent specifications 2,179,238; 2,186,733; 2,224,329; 2,178,612. These couplers are incorporated in the silver halide emulsions in amounts of about 5–20 g. per kilogram of emulsion.

A suitable developing solution for color developing the exposure materials has for instance the following composition:

p-Diethylaminoaniline hydrochloride	g	2.75
Hydroxylamine hydrochloride	g	1.2
Sodium sulfite (anhydrous)	g	2.0
Sodium carbonate (monohydrate)	g	66.0
Potassium bromide	g	2.5
Water	cc	950

As a developing solution for the black-and-white development of the materials of the present invention there may be used a bath of the following composition:

Water	cc	1000
p-Methylaminophenolsulfate	g	7.5
Sodium sulfite (anhydrous)	g	40.0
Hydroquinone	g	3.5
Sodium carbonate (anhydrous)	g	30.0
Potassium bromide	g	3.0

One part of this solution is diluted for use with two parts of water.

What I claim is:

1. Process for the production of photographic silver prints corrected for tone value in both the highlights and shadows which comprises (1) exposing to the object to be reproduced a photographic film having two superimposed silver halide emulsion layers of different sensitivities, the lower layer having a higher speed and lower gamma than the upper masking layer after development in a black-and-white developer, (2) developing said exposed film to produce an upper layer image which is selected from the group consisting of a silver image, a dyestuff image, and a combined silver and dyestuff image, and to produce in the lower layer an image selected from the group consisting of a dyestuff image and a combined silver and dyestuff image, the lower image absorbing light of two different wave lengths to a greater extent than the masking layer, the combined image having a steeper gradation in the highlights than in the other parts of the reproduction curve, (3) printing said images with light containing both of said different wave lengths on to a printing material comprising a silver halide emulsion layer which is sensitive to both of said wave lengths of light, thus producing a print corrected on the one hand as regards shadow definition and also corrected as to highlight definition, and (4) thereafter developing the printed image in a silver halide developer to form the desired print.

2. Process of claim 1 wherein the lower emulsion layer of the photographic film has a gamma of at least 0.5 and less than 2 after being exposed and developed in a black-and-white developer; whereas, the upper layer, after exposure and development in a black-and-white developer, has a gamma which is at least 1½ times that of the lower layer and a speed within the range of about $\frac{1}{10}$ to $\frac{1}{100}$ as compared with that of the lower layer.

3. Process of claim 1 wherein the lower layer image is a combined silver and dyestuff image, and the upper layer image is a silver image.

4. Process of claim 1 wherein each image is a combined silver and dyestuff image.

5. Process of claim 1 wherein both images are dyestuff images.

6. Process of claim 1 wherein the dyestuff image com-

ponent is selected from the group consisting of a yellow and a magenta dyestuff image.

7. Process of claim 1 wherein said photographic film is developed in a color-forming developer in the presence of a color-coupler to produce a combined silver and dyestuff image.

8. A process for the production of photographic prints corrected for tone value in both the highlights and shadows which comprises exposing to an original to be reproduced a photographic film having two superimposed silver halide emulsion layers of different sensitivities, the lower layer emulsion having a higher speed and lower gamma than the upper layer, and thereby obtaining a combined image consisting of a lower layer negative continuous tone image of the original and a highlight tone-correcting masking image which is also a negative of said original, said combined image having a steeper gamma in the highlights than in the lower densities when measured with light in both of said spectrum portions, said masking image and said continuous tone image absorbing light in a first portion of the spectrum, said continuous tone image also absorbing light in a second part of the visible spectrum where said masking image does not absorb light, printing said combined image by means of printing light from both of said spectrum portions onto a silver halide printing material sensitized to both of said portions, the amount of printing light from said second portion of the visible spectrum beig adjusted so that substantially only the shadow portions of said combined image are printed, and thereafter developing the printed image in a silver halide developer to form a silver image corrected for tone value in both the highlights and the shadows.

9. The process of claim 8 wherein the printing material has a steeper response to the printing light in said second spectrum portion.

10. The process of claim 8 wherein said printing material has two silver halide emulsion layers, one of said layers having a smaller speed and a steeper gradation than the other layer and being sensitive to light in said second spectrum portion.

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