Feb. 13, 1951 J. A. C. YULE 2,541,490

TONE CONTROL IN PHOTOGRAPHIC DEVELOPMENT

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FIG. 1.

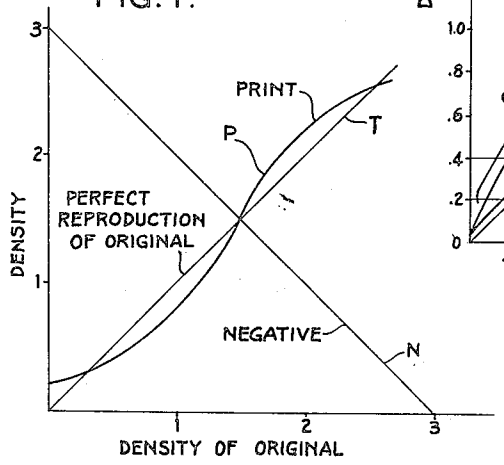
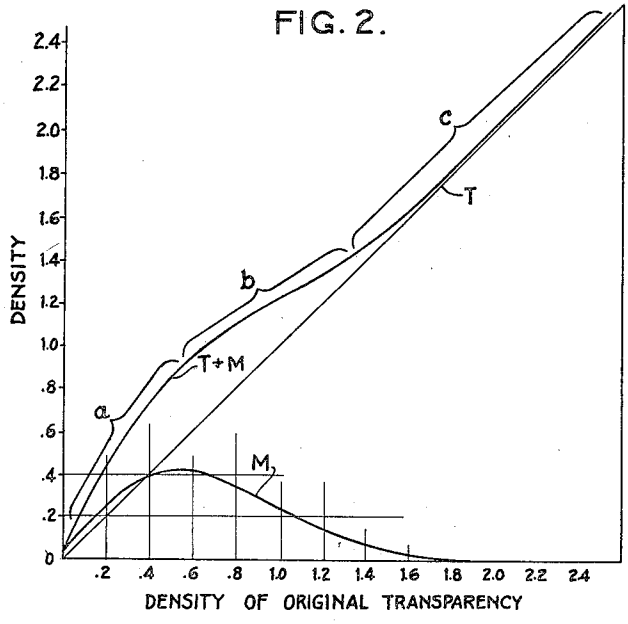


FIG. 2.



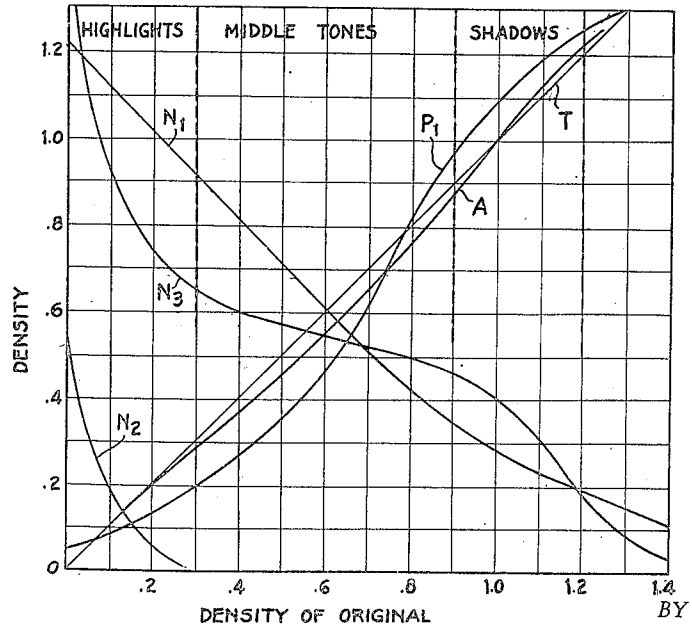


FIG. 3.

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UNITED STATES PATENT OFFICE

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TONE CONTROL IN PHOTOGRAPHIC DEVELOPMENT

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1 Claim. (Cl. 95—88)

1

This invention relates to photography and particularly to a method for controlling the tone and contrast of photographic images.

It is well known that contrast is usually lowered in the shadow and high-light portions and raised in the intermediate tones when making prints from either black and white or color transparencies. It is desirable that the contrast should not be decreased in the shadow or high-light portions nor increased in the intermediate tones. In a theoretically perfect reproduction the density at all parts of the reproduction should be the same as the density of the corresponding parts of the original subject.

It has been proposed, for example, in making masks for color transparencies to have negative contrast in the shoulder portion of the characteristic curve of the mask, that is, to have a reversed shoulder in the mask so that the contrast is raised in the low density region corresponding to the high-light of the transparency. In making a mask of this type, two separate exposure and development steps are required. A process of this type is described, for example, in Morris 2,338,661 granted January 4, 1944.

It is an object of the present invention to provide a novel method for controlling the tone of a photographic print. A further object is to provide a novel method of increasing the high-light contrast of a photographic reproduction without appreciably decreasing the shadow contrast. Other objects will appear from the following description of my invention.

These objects are accomplished by exposing to an image, an emulsion capable of giving high contrast, developing it in a high contrast, low speed developer, and without re-exposure further developing it in a high-speed developer, preferably one giving low maximum density.

In the accompanying drawing,

Fig. 1 is a graph showing the ideal density relations of a negative and print and the density relations usually obtained,

Fig. 2 is a graph showing the method of obtaining improved density according to my invention and

Fig. 3 is a graph showing another method of improving the contrast of the print.

As stated above, previous methods of achieving a lowering of the shoulder of the characteristic curve so that a reversal of the shoulder is produced have depended on a second exposure to the image after the first development has been carried out. For example, in masking color

2

transparencies, a film was laminated to the transparency, exposed, developed and the silver oxidized to silver bromide. A second exposure was then made through the transparency and the emulsion again developed. Those parts of the image which had been formed during the first development were now less sensitive so that a reversal of the shoulder was produced.

My novel method, which eliminates the second exposure, may be carried out as follows:

After exposure, the film is developed in a black-and-white developer which gives low speed and high contrast. Development is then continued in a color developer which gives a relatively high emulsion speed. The silver is then bleached to a soluble silver salt and the silver salts are removed by fixing, leaving a dye image having a reversed shoulder portion.

The mechanism of this process is as follows: During the first development, those regions which have received the greatest exposure are almost completely developed so that they will not develop further in the color developer. During the second development the regions which have received somewhat less exposure and which are unaffected by the first developer, develop to a dye and silver image. The regions which have received least exposure do not develop appreciably even in the second developer. The contrast of the reversed shoulder is controlled by the activity of the first developer and the time of development in that developer. The rest of the normal, negative part of the characteristic curve is controlled by the different emulsion speeds produced by the two developers.

The contrast relationships usually obtained may be explained by reference to Fig. 1 in which the density of the negative or reproduction is plotted against the density of the original. The curve T represents a perfect reproduction of the original which may be a transparency, a print, or the original subject. If the density of the original is compared with the density of the positive reproduction, the curve should be a straight line since at every point the density of the positive reproduction should be the same as the density of the original. In one type of negative represented by curve N, the curve is a straight line of the opposite slope. Curves for negatives obviously do not meet this requirement but depart from the straight-line relationship in varying degrees. If negative and positive materials had perfect straight line characteristics of appropriate contrasts, a perfect result might be achieved. But since photographic materials do

not meet these requirements the typical positive curve instead of being a straight line as at T is generally a curve such as P indicating that the shadow and high-light portions have lost contrast and the intermediate tones have increased in contrast. The problem therefore is to bring curve P closer to curve T.

This result is accomplished according to one modification of my invention by the provision of the dye mask made as described above. As shown in Fig. 2 the dye mask obtained by my process may have the density relationships illustrated by the curve M. The original transparency or the positive print which should theoretically be obtained from it is again indicated by the straight-line curve T. If the mask having the density relationship represented by M is registered with the original transparency such as a color transparency represented by curve T, the combination will have the density relationship represented by T + M. In this curve *a* indicating the lower portion of the curve representing the highlight portions of the original transparency, shows that increased contrast has been obtained in this region. The intermediate tones represented by the portion *b* of the curve will have decreased contrast, this region representing the intermediate tones of the transparency. In the shadow portions represented by *c* of the curve T + M, there is no change in contrast. When this combination of transparency and mask is printed, an increase in contrast in the high-light regions and a decrease in contrast in the intermediate tones will be obtained.

The masking image used according to my invention may be obtained in the following way.

A film capable of giving high contrast such as Eastman Kodalith film is exposed under a transparency and is developed for 1½ to 2 minutes at 68° F. in a developer of the following composition:

	Grams
Hydroquinone	22.5
Sodium sulfite	30
Potassium metabisulfite	2.6
Boric acid	7.5
Potassium bromide	1.6
Para-formaldehyde	7.5
Water to 1 liter	

This developer is chosen because of low emulsion speed and high contrast which it produces. If a longer reversal scale and lower reversal contrast are desired, a weakly alkaline hydroquinone developer strongly restrained by means of antifoggants may be used. A developer producing a gamma of the order of 1 to 6 is satisfactory in most cases.

The film is then rinsed in water and transferred directly to a developer having the following composition:

A. p-Diethylaminoaniline hydrochloride	g.	8.5
Sodium hexametaphosphate	g.	8.5
Sodium sulfite (desiccated)	g.	42.5
Potassium bromide	g.	3.0
Benzotriazole	g.	0.25
Water to make	liter	1
B. Sodium metaborate	g.	120
Sodium hydroxide	g.	18
1-p-Nitrophenyl-3-methyl-5-pyrazolone	g.	36
Tamol NNO (Rohm & Haas Co.)	g.	5
Water to make	liters	4

For use, take 1 part A, 4 parts B, 5 parts water.

The film is developed for one minute in the color developer and is then transferred to an alkaline potassium bromide stop bath of the following composition:

Potassium bromide	g.	20
Sodium carbonate	g.	5
Sodium sulfite	g.	5
Water to make	liter	1

After three minutes in the stop bath, the film is placed in a bleach bath of the following composition:

	Grams
Sodium sulfate	100
Sodium carbonate	8
Potassium ferricyanide	20
Water to 1 liter	20

The silver salt thus formed is removed in a fixing bath of the following composition:

Sodium thiosulfate	grams	240
Sodium sulfite	do	15
Acetic acid (28% solution)	cc.	48
Boric acid	grams	7.5
Potassium alum	do	15
Water to make	liter	1

An image made in this way is useful for masking a negative to increase shadow contrast. A badly underexposed negative may be saved by combining it with a mask of this type which will correct the tone rendering without decreasing the contrast. The process is also valuable in making a mask for a positive to increase high-light contrast. For instance, in reproducing a photographic print on paper by photomechanical methods, where high-light contrast is usually lacking, a tone correcting mask made in the camera at 1 to 1 magnification may be laid over the original print. By the use of couplers producing effectively a neutral gray image as described in Evans and Hanson U. S. Patent 2,193,023 the process may be used for masking color transparencies.

In using the process for masking, improvement in contrast of both shadows and highlights may be obtained by processing so that the normal negative part of the characteristic curve has a short scale. This is achieved by adjusting the developer composition and time of development so that less difference in emulsion speeds is produced by the two developers. The process may also be combined with that giving the Sabattier effect to give reversal of both ends of the scale. This is done by giving a further uniform exposure after the second development to light of the color most strongly absorbed by the dye and then continuing the development. Special emulsions and developers designed to give an increased Sabattier effect may be used. A mask made in this way would correct for both toe and shoulder of the image with which it is combined and it is particularly advantageous to add a small amount of a non-coupling developer such as N-benzyl-p-amino-phenol to the color developer. This gives a lower minimum density between the negative part and the Sabattier reversal part of the curve. Sabattier reversals carried out in the conventional manner have a high minimum density.

According to one modification of my invention, a negative having increased shadow and highlight contrast is made and the use of this image does not involve the use of any mask. My method produces a change in the shape of the characteristic curve of the negative material

which effects an increase in the shadow and highlight contrast of the print made from it. Previous attempts to produce emulsions which will give this type of curve have not furnished increased contrast at both ends of the scale. Moreover, such films have been found to be unstable since on age, that part of the emulsion which was responsible for the shoulder contrast lost speed at a different rate from the rest of the emulsion.

According to this modification of my invention a silver halide emulsion capable of giving high contrast is exposed to the original, which may be a transparency, a print, or original scene and is developed in a developer which gives high contrast and low speed. This develops the highlights only and the emulsion is then transferred, preferably after an intermediate wash, to a developer which gives high speed and low maximum density. A N-benzyl-p-aminophenol developer is satisfactory.

The effect of this procedure in increasing shadow and high-light contrast is illustrated by the curves of Fig. 3 of the drawing. As shown therein, the original subject or the ideal positive reproduction obtained from it is indicated by curve T. According to normal procedure a negative image represented by curve N_1 is obtained. This negative would produce a positive P_1 having low contrast in the shadow and especially the highlight portions as indicated by the slope of the curve P_1. According to my novel method, the first development in the high contrast developer produces a negative image having the characteristics indicated by the curve N_2, in which the highlights only are recorded. The second development in the high speed developer produces the curve N_3. The high contrast in the highlights and shadows of this negative compensates for the low contrast of the toe and shoulder of the positive material, so that the positive printed from this negative has the density relationships indicated by curve A. This curve approaches the ideal curve T, the contrast in the shadow and high-light portions having been increased considerably and the contrast in the intermediate tones decreased.

The procedure for obtaining a negative image having the improved characteristics referred to above may be as follows.

An exposure to the original is made on a high-contrast emulsion such as Eastman Kodalith Orthochromatic film. This exposure must be such that the highlights only will be developed in the first development while sufficient shadow detail appears during the second development. With two 35-ampere white flame arcs at a distance of 5 feet from the copy, 1:1 magnification, an exposure of about 20 seconds at f.22 will be required.

The emulsion is then developed in the high contrast developer referred to above, whose action has been retarded by the addition of 1 part of the following restrainer to 2 parts of developer:

Sodium sulfate (desiccated)	grams	180
Potassium bromide	do	10
Acetic acid (28% solution)	cc	32
Water to make	liter	1

The film is developed by inspection until the extreme highlights just go black. If the exposure was correct, this will take place in about 3¼ minutes at 68° F. The film is then rinsed for five seconds in a stop bath of the following formula:

Water	liter	1
Acetic acid (28% solution)	cc	48

The film is then washed in water at 65 to 70° F. for 25 seconds and the development continued for 3 minutes at 68° F. in a developer of the following composition:

N-benzyl p-amino-phenol hydrochloride	grams	1.25
Sodium sulfite	do	10
Sodium metaborate	do	15
Potassium bromide	do	2
Benzotriazole (1% solution)	cc	20
Water to 1 liter.		

The film is immersed in an acetic acid stop bath of the formula stated above for a few seconds and fixed in the fixing bath formula given above. It is then washed and dried.

The manner of using this image will be apparent from the above description of my invention.

Where I refer in the claim to "exposure to an image," it will be understood that I intend to include exposure to a transparency, a print, or the original subject.

It will be understood that the examples include herein are illustrative only and that my invention is to be taken as limited only by the scope of the appended claim.

I claim:

The method of producing a photographic masking image in a silver halide emulsion layer, which comprises exposing said layer to an image, developing the regions of greatest exposure of said exposed layer in a developer having the composition:

	Grams
Hydroquinone	22.5
Sodium sulfite	30
Potassium metabisulfite	2.6
Boric acid	7.5
Potassium bromide	1.6
Para-formaldehyde	7.5
Water to 1 liter	

to a contrast of the order of from 1 to 6, and immediately, without any fogging of the residual silver halide of said emulsion, further developing said emulsion in a mixture of 1 part of the following composition A with 4 parts of B and 5 parts of water:

A. p-Diethylaminoaniline hydrochloride	g	8.5
Sodium hexametaphosphate	g	8.5
Sodium sulfite (desiccated)	g	42.5
Potassium bromide	g	3.0
Benzotriazole	g	0.25
Water to make	liter	1
B. Sodium metaborate	g	120
Sodium hydroxide		18
1-p-nitrophenyl-3-methyl-5-pyrazolone	g	36
Condensation product of formaldehyde and naphthalene sulfonic acid	g	5
Water to make	liters	4

to develop silver and dye images to an extent less than required for complete development, in the regions which received less exposure, and removing developed silver and residual silver halide from said emulsion.

JOHN A. C. YULE.

(References on following page)

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,541,490 February 13, 1951

JOHN A. C. YULE

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 4, line 18, opposite "Water to 1 liter" strike out the numeral "20"; column 6, lines 26 and 27, for "include" read *included*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of May, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.