March 13, 1951 J. A. C. YULE 2,544,910

TONE CONTROL IN PHOTOGRAPHY

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FIG. 1.

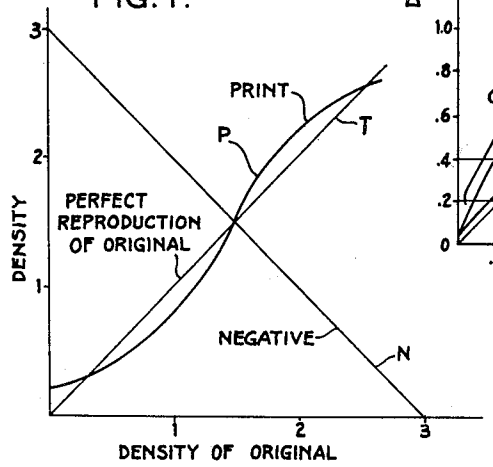
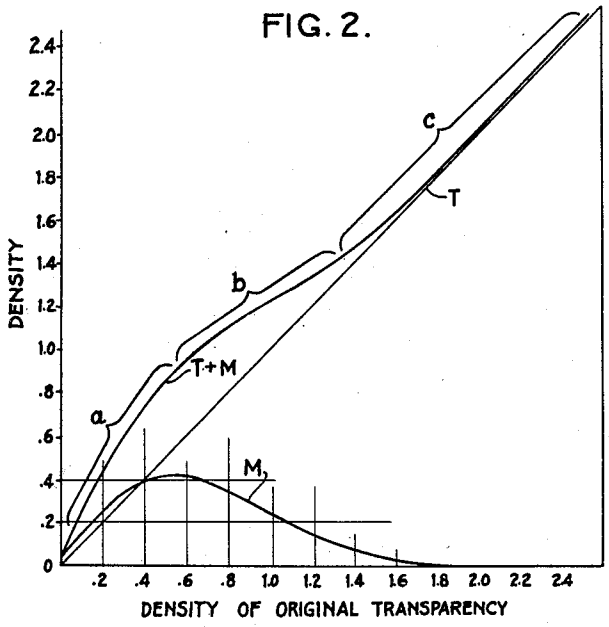


FIG. 2.



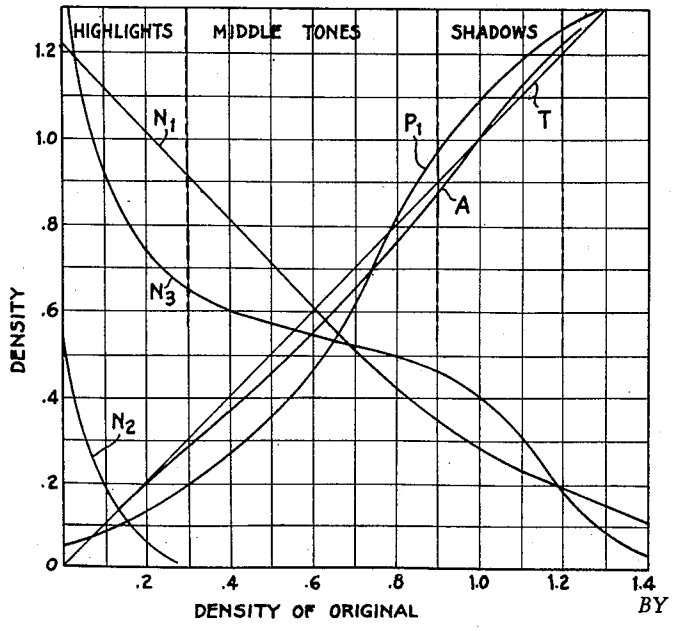


FIG. 3.

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TONE CONTROL IN PHOTOGRAPHY

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4 Claims. (Cl. 95—88)

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

This application is a continuation-in-part of Yule U. S. application Serial No. 604,351 filed July 11, 1945, now Patent No. 2,541,490, and relates particularly to that modification of the original application including making a negative having increased shadow and highlight contrast, and the use of which does not require any other mask.

It is well known that contrast is usually lowered in the shadow and highlight portions and raised in the intermediate tones when copying photographic paper prints or making prints from either black and white or color transparencies. It is desirable that the contrast should not be decreased in the shadow or highlight 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 highlight 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 highlight 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.

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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 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 de-

part 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 high-light 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 is desired, a weak 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	Grams
p-Diethylaminoaniline hydrochloride	8.5
Sodium hexametaphosphate	8.5
Sodium sulfite (desiccated)	42.5
Potassium bromide	3.0
Benzotriazole	0.25

Water to make 1 liter.

B	Grams
Sodium metaborate	120
Sodium hydroxide	18
1-p-nitrophenyl-3-methyl-5-pyrazolone	36
Tamol NNO (Rohm & Haas Co.)	5

Water to make 4 liters.

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:

	Grams
Potassium bromide	20
Sodium carbonate	5
Sodium sulfate	5

Water to make 1 liter.

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 fericyanide	20

Water to 1 liter.

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 1 liter.

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 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.

In order to correct for the characteristic curve of the printing paper used the curve of the negative should be a mirror image, rotated through 90°, of the curve of the paper, that is, substantially as shown in Fig. 3 curve N_3. This curve can be displaced horizontally or vertically by variations in exposure times and can have a shoulder. This curve is regarded as the sum of two simple curves, the first characterized by high contrast and low speed, the second by high speed and low maximum density.

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 1 liter.

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.

For perfect duplication of a print, using a given printing paper, a constant exposure and constant processing conditions are theoretically required, however, occasionally it is desirable to alter contrast in copying, for example, a flat print. This may be done by variation of the first development time keeping the second development time constant. Increase in development time in the first developer e. g. to 4–5 minutes, increases the contrast of the negative and the converse with less than about 3 minutes development.

The film emulsion used in my invention is the well-known high contrast type which is developed with, for example, a hydroquinone-formaldehyde developer, to a contrast of at least 3 when developed to less than about one-fifth of its maximum speed. That is, for the successful operation of the invention the first developed image must have a contrast of at least 3, and can be as high as 15, to compensate for the toe of the particular printing paper. It is estimated that for the useful range of the invention the desired contrast is produced when operating at somewhat less than one-fifth of the maximum speed of the film emulsion. In the drawings the maximum speed of the emulsion used would be represented by a curve to the right of Fig. 3. An emulsion satisfying these requirements is contemplated for use in my invention.

It is apparent that, depending upon the subject and the printing paper, the contrast can be above 3. In a typical case, a print to be copied, when reproduced by conventional copying methods resulted in a picture, when printed with white borders, in which the high-lights lacked con-

trast and were washed-out and lacking in detail. When attempts were made to increase printing time to get better detail in the whites the result was fog on the print borders. When the negative was made according to my invention the print had all the detail of the original subject, in fact, appeared to have better quality than the original. In case it is desired to print onto a low contrast paper of the chloride type, I may operate at a developer speed differential of as high as 15 and a contrast in the first developer of about 5 whereby an accurate copy of an original is obtained without change in contrast relative to the original subject.

As is apparent, the relative emulsion speeds produced by the two developers is important. For example, in copying a very flat or stained original, it may be desired to increase the contrast and the second developer would have a speed of about 4 to 5 times that of the first. When making a negative of a transparency of high contrast, the difference in developer speeds would be of the order of 50 to 100 times.

My process also requires that the second developer be capable of producing with the emulsion specified a maximum density of at least 1 less than is ordinarily obtainable with said emulsion. That is, the emulsion is capable of giving a density of about 5 when fully exposed and developed, but the useful range for my invention is less than 5 or preferably a "maximum density range" of 0.5 to 2.0. It is apparent that if the developer can give a density of 2, while this is operative, the tone-control image produced therewith is too dense for practicable printing, and below about 0.5 the shadow contrast is usually lacking. By "maximum density" as used herein and in the appended claims when referring to the activity of the second developer, I therefore mean the density the second developer can produce in the emulsion, if the first developer had been omitted.

In place of the second developer containing an amino phenol developing agent, I can use a p-phenylene diamine developing agent such as p-diethylamino-aniline, the formula containing the same producing an emulsion speed and maximum density in the range specified.

Where I refer in the claims 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 included herein are illustrative only and that my invention is to be taken as limited only by the scope of the appended claims.

What I claim is:

1. The method of making a negative photographic image having increased shadow and highlight contrast which comprises exposing to an image a silver halide emulsion layer giving a contrast of from 3 to 15 when developed to less than one-fifth its maximum speed 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
Paraformaldehyde	7.5

Water to 1 liter.

whose action has been retarded by the addition of one part of the following restrainer to two parts of said developer:

Sodium sulfate (dessicated)	grams	180
Potassium bromide	do	10
Acetic acid (28% solution)	cc	32

Water to 1 liter.

developing said emulsion to a contrast of from 3 to 15 at less than one-fifth the maximum speed of said emulsion, and without fogging residual silver halide developing said emulsion in a second developer giving an emulsion speed of from 5 to 100 times that of said first-mentioned developer and a maximum density between 0.5 and 2.0.

2. The method of making a negative photographic image having increased shadow and highlight contrast which comprises exposing to an image a silver halide emulsion layer giving a contrast of from 3 to 15 when developed to less than one-fifth its maximum speed 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
Paraformaldehyde	7.5

Water to 1 liter.

whose action has been retarded by the addition of one part of the following restrainer to two parts of said developer:

Sodium sulfate (dessicated)	grams	180
Potassium bromide	do	10
Acetic acid (28% solution)	cc	32

Water to 1 liter.

developing said emulsion to a contrast of from 3 to 15 at less than one-fifth the maximum speed of said emulsion, and without fogging residual silver halide developing said emulsion in a second developer giving an emulsion speed of approximately 5 times that of said first-mentioned and a maximum density between 0.5 and 2.0.

3. The method of making a negative photographic image having increased shadow and highlight contrast which comprises exposing to an image a silver halide emulsion layer giving a contrast of from 3 to 15 when developed to less than one-fifth its maximum speed 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
Paraformaldehyde	7.5

Water to 1 liter.

whose action has been retarded by the addition of one part of the following restrainer to two parts of said developer:

Sodium sulfate (dessicated)	grams	180
Potassium bromide	do	10
Acetic acid (28% solution)	cc	32

Water to 1 liter.

developing said emulsion to a contrast of from 3 to 15 at less than one-fifth the maximum speed of said emulsion, and without fogging residual silver halide developing said emulsion in a second developer giving an emulsion speed of from 50 to

100 times that of said first-mentioned developer and a maximum density between 0.5 and 2.0.

4. The method of making a negative photographic image having increased shadow and highlight contrast which comprises exposing a silver halide emulsion layer to an original, 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
Paraformaldehyde	7.5

Water to 1 liter.

whose action has been retarded by the addition of one part of the following restrainer to two parts of said developer:

Sodium sulfate (dessicated)	grams	180
Potassium bromide	do	10
Acetic acid (28% solution)	cc	32

Water to 1 liter.

until the extreme highlights just go black, rinsing said layer for about five seconds in an acetic acid stop bath, and then immediately, without fogging residual silver halide, developing said

layer for three 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.

to produce a negative image having high contrast in the highlights and shadows and lower contrast in the intermediate tones.

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