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PROCESS FOR PRODUCING CONTINUOUS-TONE TRANSPARENCIES

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The present invention relates to film transparencies and to processes for producing the same.

Particularly in the commercial photography field, it has long been desired to produce monochromatic and color transparencies having continuous tones in the image, but with absolutely crystal-clear and colorless areas surrounding the image. Numerous approaches to the attainment of these ends have been tried throughout the years, but the art has had to content itself with a residual tone or hue in the so-called white areas of the transparency surrounding the image, primarily because continuous-tone film, in view of its characteristics for producing continuous-tone images, must inherently have a background tonal quality that is not completely clear and colorless. Where, indeed, absolute background clarity and colorlessness is essential, such prohibitively expensive techniques as actually cutting out the images and mounting the same on a colorless transparent surface, have been proposed.

An object of the present invention is to provide a new and improved continuous process for producing monochromatic and/or color transparencies that, while having all of the continuous-tone-film advantages with regard to producing true continuous-tone images, eliminates the previously inherent and disadvantageous tonal background in the so-called white areas of the film surrounding the continuous-tone images, and there provides, to the contrary, an absolutely crystal-clear, colorless background, free from haze and visible imperfections, transparent and optically homogenous.

A further object is to provide such a novel continuous process that obviates both the background-tone and high-cost disadvantages above described, and does so with the further advantages of faster processing and more true fine detail.

Still another object is to provide new and improved monochromatic and/or color transparencies.

Other and further objects will be explained hereinafter and will be more particularly pointed out in the appended claims. In summary, however, from one of its broad aspects, the process underlying the invention comprises the steps of exposing a high-contrast photographic film of the type normally used for line and screened negatives and positives; briefly submersing the film in a fast-acting developer until just prior to the appearance of white areas of the latent image impressed thereon by the exposure; immediately thereupon rapidly submersing the film in a high-contrast developer provided with low-density cut-off characteristics and, preferably, with means for bleaching heavily exposed areas of development; maintaining the last-named submersion until substantially crystal-clear non-tonal colorless transparency of the said white areas is attained; and thereupon short-stopping and fixing the film. Preferred details and transparencies are hereinafter discussed.

In contravention of established practice, the present invention, while concerned with the development of a continuous-tone image, does not, however, follow the convention of employing a "continuous-tone" film; but, as before

explained, employs, to the contrary, so-called "line films" that have heretofore been employed substantially exclusively for the very different purpose of copying line and screened negatives and positives. The line film is readily distinguishable from the continuous-tone film in several particulars. Line film has a steep low-to-high density characteristic sensitometric curve (i.e. density vs. exposure), which is essential to provide clean edges on lines and half-tone dots, as described, for example, on page 12 of "Films and Plates for The Graphic Arts," Kodak Graphic Arts Data Book Q–2, Eastman Kodak Company, Fourth edition, 1961. The angular slope of such almost vertical line-film sensitometric curves is of the order of about 75–85 degrees, more or less, on graphs plotting density units (ordinate) as a function of the logarithm of exposure(abscissa), with the units of density and exposure having the same scale. Typical curves of this character are presented, for example, on data sheet D–4 of the said book.

Continuous-film, on the other hand (page 10 of the said Data Book), generally has an angular slope in its sensitometric curve that is much less steep, of the order of about 30 to 45 degrees, more or less, in the initial portion thereof. Reference may be made, for example, to data page D–19 of the said book. Other well-known characteristic differences between line and continuous-tone film are the following:

Line film:	Continuous-tone film
Generally orthochromatic	Generally panchromatic.
Maximum gamma generally about 4 to 5	Maximum gamma generally about 1 to 2.
Maximum density generally about 4 to 5	Maximum density generally about 1.5 to 2.
Slow emulsion	High-speed emulsion.
Small grains of quite uniform size	Large grains of mixed sizes.
High contrast	Low contrast.

Several present-day commercial examples of line film are those sold under the trademark "Kodalith Ortho-Estar Base" (Eastman Kodak—data pages D–9 thruogh 9–17 of the said book); under the trade name "Reprolith" (Ansco); under the mark "Photolith" (Du Pont); and under the name "Process Extra Ortho" (Gevaert).

Examples of continuous-tone film include those sold under the name "Commercial Ortho" (Eastman Kodak—data pages D–41, 42 of the said book); under the name "Commercial Sheet Film" (Ansco); and under the name "Commercial" (Du Pont).

For purposes of illustration, the invention will be described in terms of producing a transparency from a photographic film negative, though the broader applications are obvious. Almost any type of film negative is useable, but "soft" or "flat" negatives seem to give the best results. The negative is placed in the normal manner in a standard enlarger, together with the line-type film to be exposed and used for the positive. As before stated, the line film is an extremely high-contrast, orthochromatic film, preferably provided with a polyester plastic base to reduce shrinkage to a minimum and with an abrasion-resistant surface, such as is embodied in the previously mentioned commercial line films.

Exposure is best accomplished with a soft, cold, fluorescent light, with the time of exposure depending upon the density of the negative and the aperture of the enlarger lens. Normally, for purposes of the present invention,

an exposure time of between about 5 to 10 seconds is satisfactory, generally constituting a deliberate underexposure of the film.

Following such exposure, the film is subjected to two critical development processes. For the initial development, the exposed film, contrary to usual practice with line film, is submersed in a fast-acting "soft" developer, as of the elon-hydroquinone type. Preferred chemical compositions for such developers follow:

Example I

Water	cc	500.0
p-Methylaminophenol sulfate	grams	3.1
Sodium sulfite (desiccated)	do	45.0
Hydroquinone	do	12.0
Sodium carbonate, monohydrated	do	80.0
Potassium bromide	do	1.9
Add water to make	liter	1.0

A similar developer is commercially available under the Eastman Kodak tradename "Dektol D–72."

Example II

Water (about 90° F. or 32° C.)	cc	500.0
Sodium sulfite, desiccated	grams	37.5
p-Methylaminophenol sulfate	do	2.5
Sodium carbonate, monohydrated	do	44.0
Hydroquinone	do	10.0
Potassium bromide	do	5.0
Add water to make	liters	1.0

This developer is commercially available under the Du Pont tradename "Professional Portrait Developer 55–D."

Example III

Water (125° F. or 52° C.)	cc	750.0
p-Methylaminophenol sulfate	grams	3.5
Sodium sulfite, desiccated	do	45.0
Hydroquinone	do	11.5
Sodium carbonate, monohydrated	do	78.0
Potassium bromide	do	1.2
Add water to make	liter	1.0

A similar developer is commercially available under the Ansco tradename "Paper Developer 103."

The emulsion of the film is completely covered by the developer in a very short time in order to prevent uneven development, and the time of development is determined by the following critical criterion, established, as by observation, under correct safe-light conditions. The exposed film must remain in the developer only until just prior to the appearance of the white areas of the latent image, impressed on the film emulsion by the exposure. This time duration, from submersion in the developer until just prior to the appearance of the white image, is determined either by making test films, or by pre-judging by an experienced technician observing the low tones on the film. The time duration has been found to range from about 5 to 30 seconds, depending upon the density of the low tones or shades desired.

While it is unnecessary to advance a theory of operation, it being sufficient to describe the precise steps necessary to attain the novel results, it is believed that this first development step above-described constitutes a very rapid, accelerated development of the surface image content which, as before explained, is generally underexposed. Through this action, it appears that a large boost to the development of the image is generated without even initiating the development of the background. It is further believed that operation is thereby had on the lower knee portion of the characteristic sensitometric curve.

Whether this theoretical analysis is or is not correct, it is the experimental fact that, when such critical initial development is correctly accomplished, there is only surface development on the film. The temperature of the developer is normally 68 degrees F., but has not been found to be very critical.

After this initial development has progressed sufficiently, as above described, the film is immediately transferred to a second developer. This step must be effected just as rapidly as possible, because the action of the first developer continues even after the film is removed from contact with the first developing bath. The second developer is a high-contrast developer with the characteristic of cutting off development very sharply in the low densities. Suitable examples of chemical composition are as follows:

Example I

Water	cc	500.0
Sodium sulfite (desiccated)	grams	30.0
Paraformaldehyde	do	7.5
Sodium bisulfate	do	2.2
Boric acid (crystals)	do	7.5
Hydroquinone	do	22.5
Potassium bromide	do	1.6
Add water to make	liter	1.0

This developer is commercially available under the Eastman Kodak tradename "Kodalith D–85." However, the commercial developer is improved by adding sufficient amounts of potassium bromide to improve restraining and bleaching action.

Example II

Water (125° F. or 52° C.)	cc	750.0
Hydroquinone	grams	35.0
Sodium sulfite, desiccated	do	55.0
Sodium carbonate, monohydrated	do	80.0
Citric acid	do	5.5
Potassium bromide	do	10.0
Add cold water to make	liter	1.0

A similar developer is commercially available under the Ansco tradename "Long-Life Reprolith Developer 81."

Example III

Water (90° F. or 32° C.)	cc	500.0
Sodium sulfite, desiccated	grams	60.0
Paraformaldehyde	do	15.0
Potassium metabisulfate	do	5.0
Boric acid, crystals	do	15.0
Hydroquinone	do	45.0
Potassium bromide	do	3.0
Add cold water to make	liters	1.0

A similar developer is commercially available under the Du Pont trade name "Paraformaldehyde Developer 7–D."

The second developer allows the continuation of contrast development that was initiated in the first developer. It also bleaches the heavily exposed areas of development so that white tones will appear on the film as absolutely colorless, providing a true, clear transparency. While this colorless, transparently clear condition is not completely apparent at this stage of development, an experienced technician can judge the correct degree of opacity on the white areas of the film that is required to obtain the desired transparent clarity in the finished product. The time of the second-stage development is not as critical as in the time of developing in the first developer. Depending upon the desired density of the image on the film, the second development time can vary from about 30 seconds to 180 seconds with a temperature of about 68 degrees F. After the second development is completed, the film is short-stopped and fixed in the usual manner.

In accordance with this process, a continuous-tone image is developed on line film, resulting in a transparency that combines the advantages of the two films (line and continuous-tone) into a single superior product without the disadvantageous background tonal color of the continuous-tone film. As before explained, the white

areas of the photographic original develop as clear and colorless areas in the line film; whereas, in continuous-tone film, the white areas are never completely colorless because the film itself has a tonal quality. By developing continuous-tone images on line film, therefore, there is no distortion of the tones of the image and there is no residual tone in the film surrounding the image. Line film dries faster than continuous-tone film, so that the use of line film offers the further advantage of quicker processing. The line film, moreover, is more sensitive to fine detail than continuous-tone film, providing a truer copy, and the line film, in addition, is less expensive than continuous-tone film.

Optical densitometer measurements comparing the colorless background produced in transparencies prepared in accordance with the process of the present invention with the so-called "transparency" of the background of conventional half-tone or continuous-tone films, show that great improvement is attained toward the goal of a truly clear background void of any detectable tonal hue:

	Density (arbitrary relative units)	
	Present invention	Continuous-tone transparency
Film base developed without exposure	0.00	0.015
Film base developed after exposure to white surface (standard "white" of the "grey scale")	0.00	0.03
Film base developed after exposure to 10% white (on "grey scale")	0.02	0.10

The last-mentioned all-important advantage of the ability to produce continuous-tone positives on a film that has no intrinsic background tones is important, also, in the development of diazo methods for reproducing multi-colored slides with a photographic image. For now, by making color-separated positives through the above-described developing method of the invention, and using the positives as "masters," individual monochrome diazo films can be made in the four basic process-colors (1 black, 1 blue, 1 magenta, 1 yellow). These are superimposed on each other with their images in registration, as is well known, producing a full color transparency that for the first time provides an absolutely colorless, clear background.

Further modifications will occur to those skilled in the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A process for producing continuous-tone images on high-contrast photographic line film, that comprises, the successive steps of exposing such high-contrast line film; briefly submersing the film in a fast-acting developer to which water has been added selected from the group consisting substantially of:

(a)

Water	cc	500.0
p-Methylaminophenol sulfate	grams	3.1
Sodium sulfite (desiccated)	do	45.0
Hydroquinone	do	12.0
Sodium carbonate, monohydrated	do	80.0
Potassium bromide	do	1.9

(b)

Water (about 90° F.)	cc	500.0
Sodium sulfite, desiccated	grams	37.5
p-Methylaminophenol sulfate	do	2.5

Sodium carbonate, monohydrated	do	44.0
Hydroquinone	do	10.0
Potassium bromide	do	5.0

(c)

Water (125° F.)	cc	750.0
p-Methylaminophenol sulfate	grams	3.5
Sodium sulfite, desiccated	do	45.0
Hydroquinone	do	11.5
Sodium carbonate, monohydrated	do	78.0
Potassium bromide	do	1.2

maintaining the said submersing only until just prior to the appearance of white areas of the latent image impressed thereon by the exposure; substantially immediately thereupon submersing the film in a high-contrast developer to which water has been added provided with low-density cut-off characteristics and selected from the group consisting substantially of:

(i)

Water	cc	500.0
Sodium sulfite (desiccated)	grams	30.0
Paraformaldehyde	do	7.5
Sodium bisulfate	do	2.2
Boric acid (crystals)	do	7.5
Hydroquinone	do	22.5
Potassium bromide	do	1.6

(ii)

Water (125° F.)	cc	750.0
Hydroquinone	grams	35.0
Sodium sulfite, desiccated	do	55.0
Sodium carbonate, monohydrated	do	80.0
Citric acid	do	5.5
Potassium bromide	do	10.0

(iii)

Water (90° F.)	cc	500.00
Sodium sulfite, desiccated	grams	60.0
Paraformaldehyde	do	15.0
Potassium metabisulfate	do	5.0
Boric acid, crystals	do	15.0
Hydroquinone	do	45.0
Potassium bromide	do	3.0

maintaining the last-named submersion until substantially colorless and clear transparency of the said white areas is attained; and short-stopping and fixing the film.

2. A process as claimed in claim 1 and in which the said exposing step is limited to a period of time up to about 10 seconds.

3. A process as claimed in claim 1 and in which the step of submersing in the fast-acting developer is limited to a period of time from about 5 to about 30 seconds.

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