DOUBLE TONING OF MOTION PICTURE FILMS*

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Summary.—*A motion picture image with green shadows and blue halftones can be prepared by toning the image blue in the usual toning solution, fixing in hypo, washing, and then re-toning followed by immersion in a solution of a basic dye. In this way the first toning bath converts the silver image to a mixture of Prussian blue and silver ferrocyanide, the reaction going to completion in the halftones but incompletely in the shadows so that some of the silver is unaffected. The silver ferrocyanide is removed in the hypo solution leaving an image consisting of pure Prussian blue in the halftones and a mixture of this substance and silver in the shadows. On re-immersion in the blue toning bath, the silver in the shadows is again converted to a mixture of Prussian blue and silver ferrocyanide which latter substance is a mordant for basic dyes, so that on immersion in a dye solution the dye is absorbed only to the shadows.*

Commencing with a black and white image on positive motion picture film, it is possible to color this differentially by purely chemical means so that the hue of the shadows is different from that of the halftones while the highlights remain perfectly clear.

One method of accomplishing this worked out by one of the authors and described previously[1] consists in toning the positive image in the usual single solution iron toning bath from which the potassium alum has been omitted, washing, and then immersing in a solution of a basic dye. The omission of the potassium alum from the formula causes the bath to convert the halftones to white silver ferrocyanide while only the shadows are toned blue. On immersing the film in a basic dye, the halftones assume the color of the dye while the color of the shadows is a combination of blue and that of the dye employed. For example, safranine gives pink halftones and purple shadows while auramine gives yellow halftones and green shadows.

A new method of double toning recently devised produces blue halftones and differently colored shadows. The procedure consists of four operations as follows:

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(1) Tone the positive print of normal quality in the following:

	Avoirdupois	*Metric*
Ammonium persulfate	3¼ ounces	100 grams
Ferric alum (ferric ammonium sulfate)	8¼ ounces	250 grams
Oxalic acid	1¼ pounds	600 grams
Potassium ferricyanide	8¼ ounces	250 grams
Ammonium alum	1 pound 10 ounces	800 grams
Hydrochloric acid (10%)	6½ ounces	200 cc.
Water to make	50 gallons	200 liters

The method of compounding this bath is very important. Each of the solid chemicals should be dissolved separately in a small quantity of warm water, the solutions allowed to cool, filtered into the tank strictly in the order given, and the whole diluted to the required volume. If these instructions are followed, the bath will be a pale yellow color and perfectly clear.

Time of Toning.—Tone fully at 70°F. (21°C.). The color of the toned image varies from a light bluish gray for short time toning (about 3 minutes) to a deep blue for long time toning (10 minutes).

Time of Washing.—Wash for 10 to 15 minutes until the highlights are clear. A very slight permanent yellow coloration of the clear gelatin will usually occur, but should be only just perceptible. If the highlights are stained blue, then either the film was fogged during development or the bath was not compounded correctly. Washing should not be carried out for too long a period, especially with water inclined to be alkaline, because the toned image is soluble in alkali.

Life of Bath.—If the acid is renewed to the extent of the original amount after toning each 5000 feet, the bath is capable of toning 15,000 feet per 50 gallons of solution.

If even after revival the tone remains flat, the bath is exhausted and should be thrown away.

After continued use, a slight bluish sludge will collect in the bath, but this is not harmful. Should this form, to any appreciable extent, it is a result of incorrect mixing, the action of light, contact with metallic surfaces, or the presence of hypo in the bath.

(2) Immerse in a 10 per cent solution of hypo for 2 to 3 minutes and wash for 5 to 10 minutes.

(3) Re-immerse in the above iron toning bath for 5 minutes and wash for 10 to 15 minutes.

(4) Immerse in the solution of the basic dye for 5 to 15 minutes

until the desired depth of color in the halftones is obtained. The formula for the dye solution is as follows:

Dye	3.2 grams
Acetic acid (glacial)	2 cc.
Water to make	4 liters

Dissolve the dye thoroughly in hot water, filter, add the acid, and dilute with cold water. After toning, wash the film in water until the highlights are clear or the halftones are blue.

Suitable dyes are Safranine A (pink), Chrysoidine 3R (yellowish brown), and Auramine (yellow) supplied by the National Aniline & Chemical Company, New York, N. Y. They produce purple, dark green, and green shadows, respectively.

Theory of Process.—(*a*) The iron toning bath consists essentially of a solution of ferric ferricyanide in oxalic acid. This reacts with the silver image forming silver ferrocyanide and ferric ferrocyanide according to the following equation:

$$4Fe_3(FeCN_6)_3 + 12Ag = 3Ag_4FeCN_6 + 3Fe_4(FeCN_6)_3$$

Ferric Ferricyanide — Silver — Silver Ferrocyanide — Ferric Ferrocyanide (Prussian blue)

The reaction goes to completion in the highlights but not in the shadows so that after toning the composition of the shadows and halftones may be represented as follows:

Halftones—Silver Ferrocyanide + Prussian blue
Shadows —Silver + silver ferrocyanide + Prussian blue

(*b*) Treatment with hypo removes the silver ferrocyanide from the halftones and shadows leaving Prussian blue in the halftones and a mixture of silver and Prussian blue in the shadows.

(*c*) Further treatment in the blue toning bath does not affect the halftones but the silver in the shadows is converted to a mixture of silver ferrocyanide and Prussian blue as explained above. The composition of the shadows and halftones is now as follows:

Halftones—Prussian blue
Shadows —Silver Ferrocyanide + Prussian blue

(*d*) Silver ferrocyanide is a mordant for basic dyes and on immersion in the dye bath the blue color of the shadows is therefore modified by virtue of the addition of the dye.

Effect of Toning on Sound Track.—Tests with both the variable area and variable density types of sound records indicated that toning by the above method had little or no effect on sound quality. It is therefore possible to apply this method to sound prints.

Equipment.—Suitable materials for the construction of processing apparatus have been described.[2] Allegheny metal is fairly resistant to toning baths but hard rubber is the most satisfactory material for constructing sprockets or moving parts which come into contact with the toning solution.

REFERENCES

[1] "Toning and Tinting of Eastman Positive Motion Picture Film," published by Eastman Kodak Co., Rochester, New York.

[2] CRABTREE, J. I., MATTHEWS, G. E., AND ROSS, J. F.: "Materials for the Construction of Photographic Processing Apparatus," published by the Eastman Kodak Company, Rochester, New York.

DISCUSSION

MR. TEITEL: I would like to point out, in regard to multi-toning, that these colors have been successfully produced in the laboratories of the Multicolor Improving Co., Inc., as far back as 1914. When projected, the colors will show up properly only when the subjects portrayed are still objects. If the subject were in motion, as a moving person, vehicle or fast moving clouds, the effect would be that of a mass of uneven color spots, quite unpleasant to view.

MR. CRABTREE: I agree, of course. The applications of the process are limited.