Interest in contact printing is further increased by the question of photographic vs. magnetic soundtracks. If equipment and films would permit four photographic soundtracks to be printed in a single-pass contact printer, considerable reduction in laboratory costs would be realized compared to the present striping and recording operation using magnetic materials. A one-pass picture and sound printer using 35/32mm film with four rows of 8mm pictures is an attractive goal for further development work. Many questions arise, however, when considering photographic sound — the kind of soundtrack, method of recording, equipment for playback, and wear characteristics. These problems, along with many others, must be solved before photographic sound for 8mm can be a practical reality.

In this paper we have discussed a number of 8mm release print systems, pointing out differences in sharpness and other qualities. We must emphasize, however, that answers arrived at here apply to this set of prints, and that similar results will be obtained only when printers and projectors are of the highest quality. Commercial 8mm prints have a great potential in reducing costs and in broadening the distribution and use of color film; this potential can only be realized through the use of the most careful printing and handling techniques.

Table I. Ratings of Prints Compared in Study.

ECN	Master Pos.	Dupe Neg.	ECP	Practicality*	Quality*	Comments
35mm	16mm	8mm	8mm	1	8	Very fuzzy print.
35mm	35mm	8mm	8mm	2	7	Only slightly better than above.
35mm	35mm	16mm	8mm	3	4	Perhaps the best compromise between practicality and quality. Grain is not as contrasty but larger than 8mm Kodachrome II.
35mm	35mm	35mm	8mm	4	3	Nearly as good as the direct print just below but requires 4 to 1 release printing.
35mm	(Direct Reduction)		8mm	6	2	Smoothest, sharpest print from ECN.
ECO	**Internegative**		**ECP**			
16mm	8mm		8mm	1	9	Worst print for definition.
16mm	16mm		8mm	3	5	Perhaps the only compromise between practicality and quality starting with ECO. Grain is not as contrasty but larger than 8mm Kodachrome II.
ECO			**ERCP**			
16mm	(Direct Reduction)		8mm	6	3	Smoothest, sharpest print from ECO, but must risk original and preclude opticals.
Kodachrome II Film						
8mm (viewed as original)				8	1	Best for definition, color and tone reproduction. Grain is contrasty but tiny.

Code: ECN — Eastman Color Negative Film, Type 5250.
ECO — Ektachrome Commercial Film, Type 7255.
ECP — Eastman Color Print Film, Type 7383.
ERCP — Eastman Reversal Color Print Film, Type 5269.
Master Positive and Duplicate Negative — Eastman Color Intermediate Film, Type 5253 (7253).
Internegative—Eastman Color Internegative Film, Type 7270.
* Practicality and Quality are rated on relative scales with number 1 as best.

Additive Exposures in Process Photography

A TUTORIAL PAPER

By JOHN H. LEWIS

Low-level fog exposures have long been used in motion-picture printing as means of decreasing contrast. An analysis of this technique defines its effectiveness and suggests extensions and controls in its use.

Introduction

The conventions in motion-picture production relegate contrast control to a department of the processing laboratory. Sensitometry thus becomes simply a means of maintaining consistency in developing film.

In motion-picture printing, print-through gamma is an important factor in determining photographic quality. Sensitometry, using production printing equipment, can serve as a useful tool in process photography and especially in effects work.

All references to sensitometry in this paper will refer to exposures made through standard motion-picture films on commercial (contact or optical) step-printing equipment. Characteristic curves and gammas are obtained by printing step-wedges on motion-picture films used in production so that the results match fairly closely the densities and contrasts obtained in production.

Reduction of Contrast

For the use of fog exposure to reduce contrast, the straight-line portion of the characteristic curve of a sensitized film may be approximated by the equation:

$$D = \gamma H, \qquad (1)$$

where $H = \log E$.

When a uniform fog exposure, K, is added to the printing exposure, assuming good reciprocity, a new characteristic curve is obtained:

$$D^* = \gamma \log (E + K), \quad H = \log E. \qquad (2)$$

This curve is asymptotic to the lines $D = \gamma H$ and $D = \gamma \log K$; its slope is

$$\frac{dD^*}{dH} = \gamma \frac{E}{E+K} = \gamma \frac{10^{D^*/\gamma} - K}{10^{D^*/\gamma}}.$$

This value, of course, varies. It has been found through experimentation that the midrange density, $D^* = 1.2$, furnishes a meaningful contrast index or gamma on duplicating negatives.

A contribution submitted May 16, 1962, by John H. Lewis, John Lewis Film Service, Inc., 619 W. 54 St., New York 19, in response to a request by the Tutorial Subcommittee of the SMPTE Papers Committee.

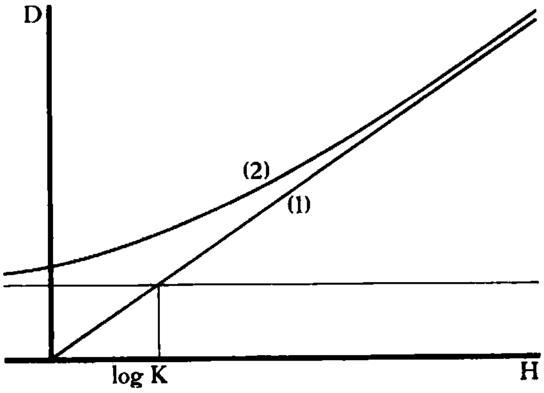

Fig. 1. The characteristic curve of sensitized film.

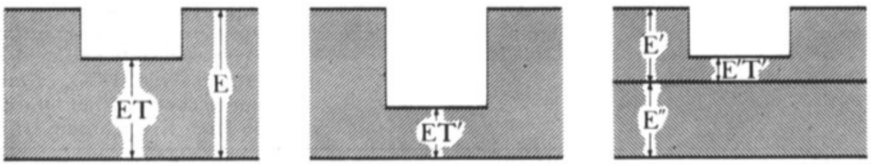

Fig. 2. Left, desired situation (to be simulated); center, available situation (to be corrected); right, corrected situation (with fog exposure).

This may be written

$$\gamma^* = \gamma \frac{10^{1.2/\gamma} - K}{10^{1.2/\gamma}}.$$

In a more useful form, this formula becomes,

$$\log K = 1.2/\gamma + \log(\gamma - \gamma^*) - \log\gamma.$$

Use of this fog exposure technique is obviously limited to values of $\gamma \log K < 0.5$ for the normal negative densities ($0.6 < D < 1.8$). This, however, reduces the effective negative gamma by as much as 0.10, which can greatly improve the appearance of scenes where only contrasty materials are available.

Increase of Exposure

Exposure can be increased from a known exposure E' to a desired exposure E by a second (additional) exposure E''.
Since

$$E = E' + E'', E'' = E - E' = E(1 - E'/E),$$

it follows that

$$\log E'' = \log E + \log(1 - E'/E),$$

where

$$E'/E = \text{antilog}(\log E' - \log E).$$

Relative Exposures

To control relative exposures in a photographically printed image, let

E = maximum exposure. Log E is log exposure used in printing (timed exposure) minus minimum density of material to be printed.

D = $-\log T$ = maximum density difference. In case of a matte this is the black minus base density. (T is the relative transmission of base to black.)

E'' = corrective fog exposure. When this exposure is to be made through the clear portion of a matte, the base density of the matte must be added to log E''.

We shall use E, D, T to denote the desired exposure relations and E', D', T' to denote exposure relations which would result from direct use of available material. Figure 2 explains that

$$E + E'' = E$$

and

$$E'T' + E'' = ET.$$

Hence

$$E' - E'T' = E - ET;$$

or,

$$E'(1 - T') = E(1 - T).$$

Thus we obtain formulas for computation:

$$\log E' = \log E + \log(1 - T) - \log(1 - T'),$$

and (from section 2),

$$\log E'' = \log E + \log(1 - E'/E).$$

As an example of the use of the above technique, in optical printing a black title would ordinarily be superimposed by running a high contrast title matte with a picture master positive. This, however, can result in titles so contrasty that they will flare when printed on release stock.

To reduce the contrast of the title without affecting the quality of the background scene, only the matte densities are to be considered in making the above computations. The master positive will then be printed once with matte; then, in the fog run, without matte.

Again, one often encounters a full-fitting matted superimposure which has only black-and-white tones. The image to be superimposed may be photographed on high-contrast film and its black-and-white tones matched to those of the background by using computed controlled exposure and fog exposure.

Multiple Exposure

For a multiple-exposure effect of two or more scenes, let the desired weighting of scenes by A, B, C, . . .; where, $A + B + C + \ldots = 1$. The exposure of each component scene will be its normal timed log exposure plus (the negative number) log A for the first, log B for the second, etc.

For such an effect to appear normal, however, the contrast reduction of multiple exposure should be considered. If the overall background of the positive picture is light, the fogging effect of this light background will adversely affect the contrast range of the companion scene and the combining should be done in a negative-to-positive process. Generally the overall fog effect of each background should be estimated. Adequate processing gammas should be used in preparing materials and in the printed material to maintain somewhere near normal contrast in all parts of the combined scene.

Summary

Print-through sensitometric data, using density step wedges made on the same materials as are employed in production, can give satisfactorily accurate predictions of expected densities in both contact and optical printing. The precision required is such that computations with the formulas presented above need only the accuracy obtained with an ordinary slide rule. The computations are relatively simple to carry through, and the reliability of the results can save many hours of making test exposures.