

tion film was shown to illustrate the capabilities of the internegative printer designed and built by the Geo. W. Colburn Laboratory. A portion of the exposition accompanying the film is abstracted below:

The film was printed on Eastman Color print stock from a color internegative. The internegative was printed from various types of color reversal

original. It was noted that valuable edited originals were protected by using the internegative for long printing runs.

The internegative printer employs both color and neutral-density filters to make instantaneous scene-to-scene color and exposure changes to correct for deficiencies in the original.

Uncorrected and corrected comparison

scenes were shown to demonstrate the improvement possible when printing intercut original scenes with dissimilar emulsions, underexposure, and "old age" dye changes.

Other scenes were shown to demonstrate quick and normal length fade and dissolve effects, incorporated in the internegative by means of a variable shutter.

## 16mm Color Intermediate Negative-Positive Printing Procedures and Controls

By JOHN R. STILLINGS

**Printing procedures and control techniques using an additive printer in the production of 16mm color positive prints from 16mm reversal color film are described. Matrix algebra is used in determining a basic exposure for each emulsion type and number used. These matrices can be used for initial printer calibration as well as for routine printer control.**

**P**RINTING PROCEDURES and control techniques using an additive printer, parallel the procedures and techniques used in subtractive printing. The same precautions and safeguards are maintained, but with modifications due to the differences in equipment. Those differences as they affect the printing of Eastman Color Internegative Film, Type 7270 and Eastman Color Print Film, Type 7382 are discussed.

The printer can derive its information from two sources. One of these is a switching panel and the other is punched tape. The function of the switching panel is to provide a wide range of intensities of blue, green and red light. This allows the printer to be balanced to print Eastman Reversal Color Print Film, Type 5269; Eastman Color Internegative Film, Type 7270; Eastman Color Print Film, Type 7382; and black-and-white duplicate negative film. For each film type, there is an available range of 1.27 log exposure in each color, in 0.01 log exposure steps. The purpose of the punched tape input is to allow for scene-to-scene deviations from a standard printing level, in 0.02 log exposure steps. The switching panel is a control operation; the punched tape, a production printing operation.

Timing of original color film for printing is probably the most time-consuming and costly of all preparatory steps. It would be of economic importance to have one timing operation suffice for all subsequent printing steps. That is, it would be valuable to use one set of

punched tapes, representing one timing, to print Type 5269 Reversal Color Print Film, Type 7270 Internegative, or black-and-white duplicate negatives. The goal is, in the case of duplicate negatives, to have a fully corrected duplicate which will print to the print film at one light.

The first step in setting up such a printer is to establish the "standard characteristic curves" for each film type. These curves are the sensitometric plots of a print-through of a silver step wedge, which yield a good visual and densitometric match to the original wedge. In the case of reversal print film, this is a one-step operation, silver wedge to print film. In the case of internegative it is silver wedge to internegative to print film.

The standard characteristic curve for Type 5269 Print Film was prepared by printing a silver step wedge onto the film at various color balances and densities, using the switching panel inputs to the printer to adjust the exposures. The exposure that gave the best visual match to the original step wedge was chosen, and the densitometric plot was made. This is our standard curve for the Type 5269 Print Film. The exposure was designated the basic exposure for that type and emulsion number. Since the goal is to achieve one timing operation to cover all possible release printing routes, this graph is also the goal plot for the overall print-through of Type 7270 Internegative to Type 7382 Color Print Film.

In printing and processing Internegative Print Film, Type 7270, it is very difficult, if not impossible to evaluate the internegative visually. There

is no original negative with which to compare it, nor is there a simple negative to view. The general overall characteristic supplied by the masking dyes, as well as all the original colors which appear as their complementaries, limits the criteria for making an exact and accurate evaluation.

In order to fix one of the variables in a two-step process, first, our Type 7382 Color Print standard characteristic was defined and the Type 7270 standard characteristic then defined by means of this Type 7382 standard.

A silver step wedge was printed through to Type 7382 Color Print Film, using a piece of unexposed but processed Type 7270 as a filter. The exposure was adjusted by means of the switching panel until a good neutral print was made. This then established the Type 7382 Color Print Film standard characteristic curve. The exposure was called basic exposure for that Type 7382 emulsion.

A similar procedure was followed in the case of the Type 7270 Internegative, but without the cleared negative filter, until a negative was produced which when printed at the basic exposure on Type 7382 Print Film, yielded a print-through characteristic which matched the Type 5269 Reversal Print Film standard characteristic. The exposure given to the negative was then defined as the basic exposure for that emulsion number of film and the plot was defined as the standard characteristic curve for Type 7270 Internegative.

For routine day-to-day control procedures, Type 7270 Internegative, is printed at the basic exposure for that particular emulsion and a densitometric plot is compared with the standard characteristic curve for Type 7270. In the case of the Type 7382 Print Film we have dispensed with the negative filter and merely print at the basic exposure for that emulsion and compare its plot with a graph of the original basic exposure, which was also printed without a filter. We do not get a neutral

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image, but since all the control procedures are densitometric, this does not matter, as long as the curves match.

Each new emulsion, and for that matter, each roll number within a given emulsion number is tested and a print is made which will match the standard characteristic for that emulsion type. This print characteristic is checked on each emulsion before production begins and is checked periodically throughout the supply of that film.

Using a test emulsion that is stored under controlled conditions, we also check out the printer each day to insure the reproducibility of the printer. This emulsion is also used for any testing of printer functions or to check the printer after any repairs or changes.

#### Control Program

The control program as outlined, necessarily consists of a large number of densitometric plots and takes considerable time in the evaluation.

With ideal film and with ideal densitometry, one would, when trying to make one set of curves match another, merely place one set of curves over the other and shift each curve for each color until it matches the desired characteristic. The displacement of the curves along the log exposure axis would be the required log exposure change to make in the printer setup. In actual practice, this results in a series of successive approximations. When the green exposure is changed by a large amount it also changes the blue and red curves by a smaller amount. When the desired change is small, the displacement of the other two curves is slight and can be estimated directly. When

the desired change is large or consists of more than one correction at a time, the effect on the other curves is sometimes difficult to evaluate.

These secondary effects were measured by printing each film type in the following manner:

- (1) basic exposure,
- (2) basic exposure plus a blue increase,
- (3) basic exposure plus a green increase.
- (4) basic exposure plus a red increase.

All four tests were than processed, read and plotted. Taking the basic exposure graph as a base, the shifts of the other curves in the accompanying tests were tabulated.

<i>Log E change from basic exposure</i>	<i>Densitometric curve shift</i>
delta Blue	$Y_b \quad M_b \quad C_b$
delta Green	$Y_g \quad M_g \quad C_g$
delta Red	$Y_r \quad M_r \quad C_r$

Where  $Y_b$  is the shift of the yellow dye layer due to the change in blue exposure,  $M_b$  is the shift of the magenta layer due to the blue exposure,  $C_b$  is the shift of the cyan layer due to the blue exposure, and so on.

If each of these changes is divided by the log exposure change, the resulting matrix describes the amount of curve shift for each color for a given exposure.

$$\begin{array}{ccc} \frac{Y_b}{\Delta B} & \frac{M_b}{\Delta B} & \frac{C_b}{\Delta B} \\ \frac{Y_g}{\Delta G} & \frac{M_g}{\Delta G} & \frac{C_g}{\Delta G} \\ \frac{Y_r}{\Delta R} & \frac{M_r}{\Delta R} & \frac{C_r}{\Delta R} \end{array} = \begin{array}{ccc} Y_b & M_b & C_b \\ Y_g & M_g & C_g \\ Y_r & M_r & C_r \end{array} = M$$

<i>Curve shift</i>	<i>Inverse matrix</i>	<i>Log exposure change</i>
$B'$	$yB \quad mB \quad cB$	$B'yB + B'mB + B'cB = \text{Blue}$
$G'$	$yG \quad mG \quad cG$	$G'yG + G'mG + G'cG = \text{Green}$
$R'$	$yR \quad mR \quad cR$	$R'yR + R'mR + R'cR = \text{Red}$

The actual information desired is not the amount of curve shift for a given exposure change, but the amount of exposure change necessary to give a known curve shift, that is, the inverse matrix. This can be found by classical matrix manipulations.

$$\begin{array}{ccc} yB & mB & cB \\ yG & mG & cG \\ yR & mR & cR \end{array} = M^{-1}$$

After a test has been run and plotted, it is compared with the desired curve. The curve shifts parallel to the log exposure axis are noted. Each of these desired curve shifts is multiplied by all the terms in the corresponding row of the matrix. The algebraic sum of all the product terms in a row is the change in exposure necessary for that color (see formula below).

#### Conclusion

The author has not attempted to describe many of the specifics of printing operations, but has chosen to emphasize some of the methods in use that are different from conventional techniques. Some of the reasons for such changes are due to the differences in film types and certain problems associated with these films. These methods were developed to help meet the goals set for the Lakeside Laboratory's 16mm program.

## 16mm Internegative and Color Positive Processing Controls

Processing control of 16mm color internegative and color positive is necessary to produce a high-quality product. This paper deals with methods of photographic and chemical processing production controls and their coordination with motion-picture printing controls.

WHEN EASTMAN Color Positive and Color Internegative films were introduced several years ago, the Calvin Company had had previous processing experience with color film. Eastman Kodachrome duplicating film had been processed in our laboratory since 1950. The experience in processing controls

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gained through the developing of Kodachrome has been applied to the internegative and color positive films. In some cases, it has been found that these two films do not require as extensive or as complicated control as does Kodachrome in its duplicate processing. In other instances, previous experience proved inadequate, and new control methods and procedures were required. This paper is intended as a report on the application of generally accepted methods of processing control and procedures found useful in our produc-

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tion for developing the internegative and color positive films.

Processing controls generally are classified into chemical, photographic, and mechanical applications. Mechanical and photographic control methods have been known and used for several decades; however, the method of chemical control through analytical procedures has been extensively utilized only within the last few years. We learned that the internegative/positive system does not require as many or as involved chemical controls as Kodachrome duplicate processing; also, we learned that by placing first emphasis on a highly accurate chemical control system, the photographic and mechanical control phases are simplified. Process variations seem