THE MULTICOLOR PROCESS*

RUSSELL M. OTIS**

Summary.—*A brief analysis is given of the way in which colors are reproduced using a two-color negative separation method. The Multicolor process, working on this principle, is briefly described. Details are given concerning the film used, camera requirements, exposure, development, printing, and coloring.*

The Multicolor process for making colored motion pictures belongs to the class of subtractive processes employing two-color separation. This means that in photographing, the light received by the camera is separated into two parts—the blue and the red components. Each of these components acts on a separate negative emulsion. Positives are printed from these negatives and are colored, the one printed through the red-sensitive negative being colored blue and the other one red. These two colored positives are superimposed in projection so that the light which has passed through one positive is absorbed (or subtracted from) in passing through the other.

Let us briefly consider how the various colors are reproduced. Assume that a gray object illuminated by white light will reflect toward the camera such amounts of red and blue light as will produce equal densities on the two negatives. The positives will then have equal silver densities and, if the color values are properly chosen, the resulting red and blue when superimposed will absorb equal amounts of the two complementary components of the projector light, resulting in only a decreased intensity, *i. e.*, gray, on the screen.

If the object to be photographed is not gray, but contains more blue than red, the red-sensitive negative will be less exposed than the other. The density of the positive printed from this red-sensitive negative will be greater than the density of the positive printed through the blue-sensitive negative. Since the positive printed through the red-sensitive negative is colored blue it is obvious that when superimposed the two positives will transmit more blue than

* Presented in the Symposium on Color at the Spring, 1931, Meeting at Hollywood, Calif.

** Hughes Development Co., Los Angeles, Calif.

red light and the screen image will lean toward the blue. If the object to be photographed reflects more red than blue, the same analysis will show how the red tones are obtained.

It is not always appreciated that a two-color negative separation can result in many more than two colors on the screen. Most objects do not reflect a sharply defined spectral band but reflect to the camera light which affects both negatives to some degree. Hence a multitude of colors can be reproduced by making all possible combinations of red and blue densities. Thus many shades of blue, green, orange, red, and all the grays from white to black are obtained on the screen.

What has been said thus far applies to all two-color subtractive processes, but the methods by which these results are obtained in

Orthochromatic

Panchromatic

FIG. 1. Spectrograms of Dupack through No. 86 Wratten filter as used in daylight shots. Exposed in Hilger Wedge Spectrograph filtered to daylight.

practice vary greatly. The process used by Multicolor will now be described.

The separation of the two spectral regions in photographing is effected by the so-called bi-pack method. A special film with an orthochromatic emulsion and a standard panchromatic film are placed emulsion to emulsion, with the orthochromatic emulsion nearer the lens, and are run through the camera together. Blue or green light will expose the orthochromatic emulsion, but orange or red will not expose it due to the fact that this emulsion is not sensitive to orange or red. On top of the orthochromatic emulsion, on the side nearer the panchromatic film, is a layer of gelatin bearing a dye which passes only yellow, orange, and red light. By this means, the panchromatic emulsion, which is sensitive to all light, is permitted to record the yellow and red portions of the picture. Spectrograms showing the regions of the spectrum recorded on the two negatives are shown in Fig. 1.

The camera used in photographing Multicolor pictures may be any camera employed for black-and-white work provided that a Multicolor double magazine for carrying the two negatives be used and that some special machine work be done to permit the camera to accommodate the two films and secure good contact between them. On the Mitchell camera a new pressure plate with four rollers is installed to insure good contact between the films and a shim is placed in front of the ground glass to make the ground glass plane coincide with the plane of emulsions when two films are used. This camera can then be used at any time for taking black-and-white pictures by simply removing the shim in front of the ground glass. On the Bell & Howell camera the pins on the back pressure plate are increased to eleven in number to insure contact, and 0.006 inch is removed from the aperture plate to make the emulsions come in the same plane as when previously only one film was used. In photographing, a No. 86 Wratten filter is used for daylight shots but is not used when the set is illuminated by incandescent lamps.

The prime requirement for good color balance over a wide range of exposure is that the gamma of the two negatives be the same and that the toe and shoulder of the H & D curve for one negative come at substantially the same points along the exposure axis as the toe and shoulder of the curve for the other negative. If the gamma of the two negatives is not the same it is possible to get a gray of only one density on the screen. If the H & D curves for the two negatives are displaced from one another so that the positions of the toes or shoulders of the curves do not coincide along the exposure axis, the efficient exposure range is narrowed to that between the toe of one curve and the shoulder of the other. In this process two negatives can be developed in the same time and in the same solution, and the success attained in meeting these requirements is demonstrated by Fig. 2.

Rather than try to correct in the laboratory for improper exposure of the negatives, the illumination on the set is measured with a photometer. If the proper exposure is obtained it is possible to develop the negatives alike, print them with the same light, and develop the positive to a prescribed gamma, making the laboratory process nearly automatic. Generally, however, the printing lights are determined in the case of each scene by colored cinex strips. The determination of correct printing lights is one of the most critical operations in the laboratory process because it determines the relative density of the positive images, which in turn, fixes the color balance. A picture can be anything from an icy blue to a warm red, depending upon the choice of printing lights, and it is therefore essential that the man making the choice be equipped with facilities which enable him, when viewing cinex strips, to see the same thing that will afterward appear on the screen.

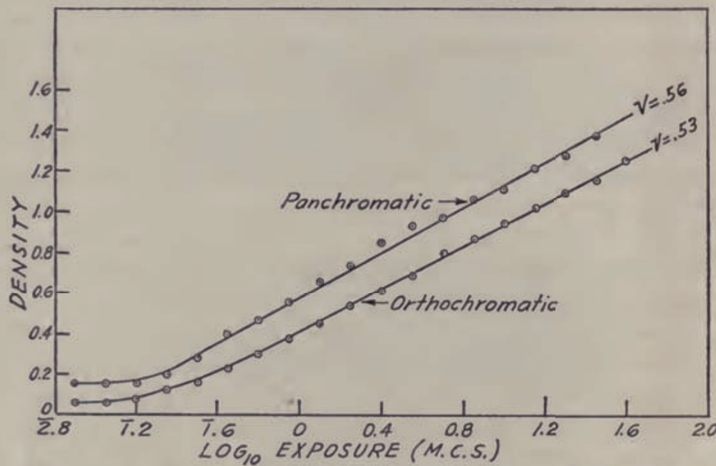

FIG. 2. H. & D. curves of Dupack exposed through Wratten filter No. 86 in E. K. Co. sensitometer filtered to daylight, and developed at multicolor by machine.

In printing, the two negatives go through the printer together, with a positive film between them. The positive film carries an emulsion on each side of the film support so that each positive emulsion is in contact with its negative emulsion. The two positive images are printed simultaneously by light coming from each side through one negative. The positive emulsions are blue-sensitive and carry a yellow dye to prevent light from one side exposing both emulsions. With the highest light used in printing, there is no exposure of the emulsion on the opposite side. The yellow dye washes out in the development process.

The main problem in printing is one of obtaining good registration, which can be obtained by using adequate mechanical devices. The shrinkage of the films, and worse yet, unequal shrinkage, is one of the greatest difficulties. Unequal shrinkage has been considerably reduced by employing negatives which are made at the same time on base from the same batch.

The positive is developed by machine to a prescribed gamma which has been determined by the condition that the contrast of grays in the picture shall be the same as that of the grays in the subject photo-

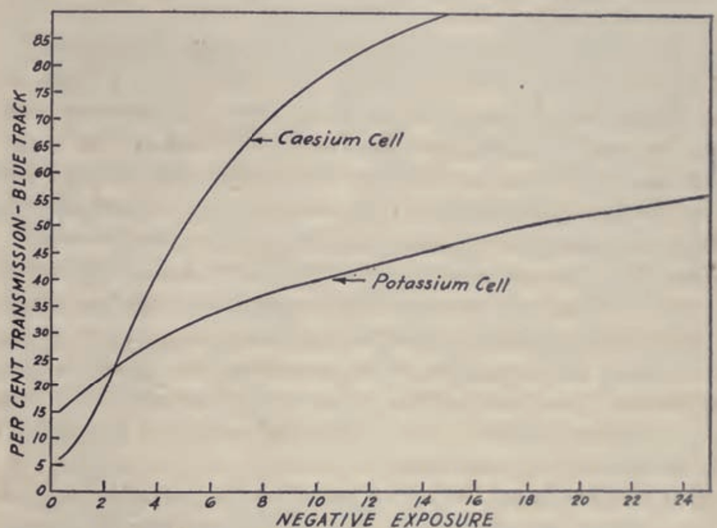

FIG. 3. Per cent transmission of blue positive sound track *vs.* negative exposure.

graphed. After fixing and drying, the film is then placed in the coloring machine.

The first operation of this machine is to apply a blue iron tone to one side of the film. Neglecting the washes, the film is then immersed in red toning solution which tones the image on the other side, leaving the blue image unaffected. This red uranium tone serves also as a mordant for a dye which next follows and which adds brilliance to the red image. The film is then passed through hypo after which it it is washed, dried, and varnished. This varnish greatly increases the life of the print, which is now ready for the projector.

The problem of the colored sound track deserves mention. There is only one sound negative, so sound is printed on only one side of the positive, resulting in a colored track. A blue track has been found far superior to a red one. In variable density recording the blue track differs from the black-and-white track in the increased contrast of the blue over the black track before toning. Moreover, the relation between the response of a photoelectric cell to the transmission of the blue track and of the black before it is toned is not linear. The situation is further complicated by the recent introduction of the caesium photoelectric cell which gives a result different from that of the potassium photoelectric cell when used to reproduce a colored sound track.

The potassium cell is sensitive only to blue light, whereas the caesium cell responds also to red light. The effect with a black-and-white sound track is simply that the caesium cell reproduces with greater volume than the potassium cell. But when used with a colored track, the relation between the blue density and the black density is entirely different for the two cells, resulting in not only a difference in volume but generally a difference in quality as well.

A study of the sensitometry of the blue track and recording tests made with it, however, have demonstrated that excellent results can be obtained with both types of cell if the sound negative is correctly exposed and if the remainder of the processing is properly done. It is particularly fortunate that the normal development of sound negative to a gamma of about 0.5 is still found to be the most suitable when the sound positive is toned blue.

The essential property of a good sound record is that there exists a linear relation between the transmission of the positive as viewed by a photoelectric cell and the exposure of the negative. Fig. 3 shows this relation for the Multicolor blue track as seen by both caesium and potassium photoelectric cells.