THE THEORY OF COLOR

All processes of color photography are based on the three-color theory of vision, orginally conceived by Thomas Young. The human eye has three sets of nerves: One of these receives the sensation of the blue and violet rays of the spectrum, another set responds to the stimulus of the green rays, while the third set of nerves responds to the orange and red rays. If we look at a lemon, some of the rays reflected from the fruit stimulate the green sensitive nerves, others the red, and the combined sensation is what we call yellow.

By means of these three sets of nerves stimulated to varying relative degrees, the eye "sees" all the different visible colors of the spectrum. It is thus easy to see how the pioneers of color photography adopted the idea of exposing three plates, one through a blue-violet filter, one through a green filter and one through a red filter. This was done by means of three successive exposures until the invention of the costly one-exposure camera. Dufaycolor, however, offers a far simpler solution of the problem in that all three primary plates are combined into one. The whole surface of the film is divided into tiny areas of blue, green and red, which act as microscopic filters. There are approximately 1,000,000 of these tiny color elements to every square inch of film surface. These tiny areas compose the "reseau" or color screen, which is the secret of the Dufaycolor process. The individual elements of the "reseau," which give the film its power to reproduce natural color, are thus quite invisible to the eye, the sensation of each color being created by confusion on the retina.

THE MANUFACTURE OF DUFAYCOLOR FILM

The preparation of the reseau is the first step in the manufacture of Dufaycolor film. It has taken many years to evolve but is now carried out as a continuous process in the following manner:

1. The clear non-inflammable film base is coated first with a single layer of blue-dyed collodion. Then with a specialized type of rotary printing press, a set of parallel ink lines is printed thereon, there being about 500 of these lines to the inch. The ink is of a specially developed type which "resists" the action of a dye or bleach.
2. The printed base then passes into a bleaching bath where the blue dye which has not been protected by the resistant ink lines is bleached out.
3. The film then passes on to a bath of green dye where the bleached areas between the ink lines are dyed green.
4. The ink line resist is then removed in a cleansing bath. This operation leaves the entire surface alternately striped blue and green. Now a new set of ink lines is printed at right angles to the blue and green stripes.
5. The film again goes through a bleaching bath. The new resistant ink lines protect the blue and green areas underneath them but in between these lines the film is again bleached clear.
6. The film then moves through a bath of red dye which colors the bleached areas red. The resist is finally removed and the color screen is thus completed. A panchromatic emulsion of extremely high sensitivity is coated over it and now Dufaycolor film is ready to be cut into whatever camera size is required.

Fig. 1

A Greatly Magnified Cross Section Of Dufaycolor Film

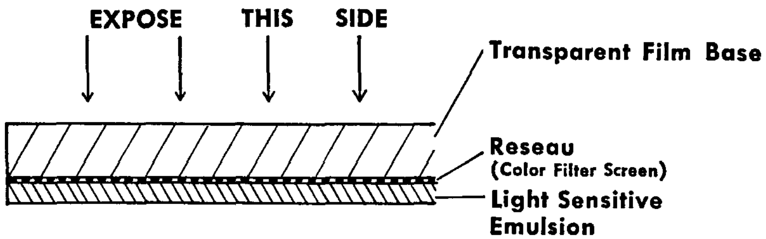
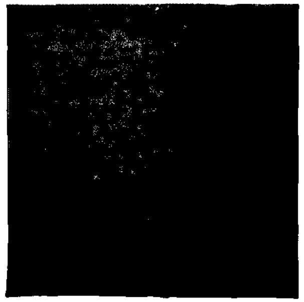
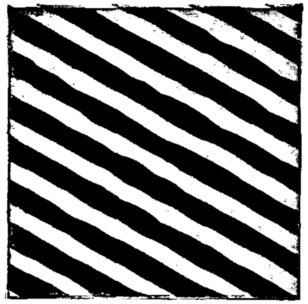


FIG. 2

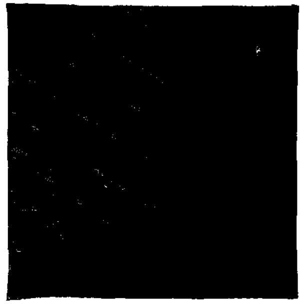
PHOTOMICROGRAPHS OF DUFAYCOLOR RESEAU

Magnification X100 Linear.

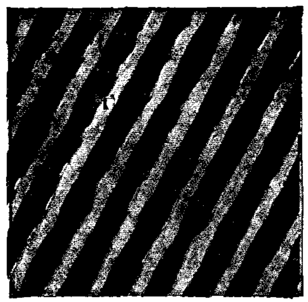

(1) Base dyed blue, then overprinted with greasy resist. in lines.


(2) Blue bleached out.


(3) Dyed green.


(4) First resist washed off and reprinted in lines at right angles to the first set.


(5) Bleached again.

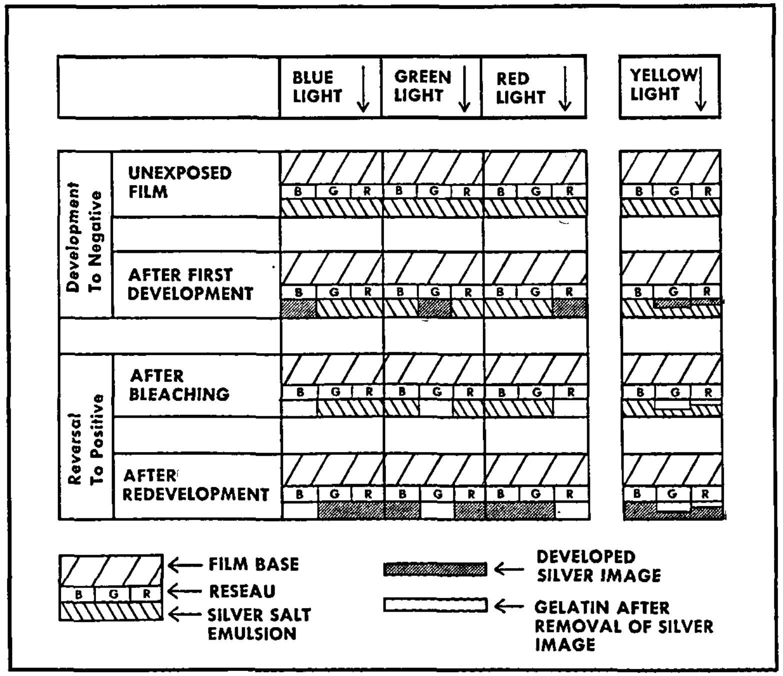

(6) Dyed red and resist removed to give final reseau.

These photomicrographs were taken on Dufaycolor Film, the reproductions being made from the transparencies.

HOW DUFAYCOLOR FILM PRODUCES COLOR

Dufaycolor film is exposed through the base so that the rays from the camera lens have to pass through the color reseau before reaching the emulsion, as shown in Figure 1. In this way, the image is broken up into three sets of minute filtered areas which represent microscopic blue, green and red components of the subject photographed. There are actually three indefinably mingled separation negatives and thus Dufaycolor film does the work of a one-shot camera in one operation, giving the three images in the form of one composite whole. The reseau really acts as a filter. A pure blue light passes only through the blue areas of the reseau

Fig. 3



and is stopped by the green and red areas. The pure green light passes through the green areas and is stopped by the blue and red areas. The pure red light passes through the red areas but is stopped by the blue and green.

Unexposed film (as shown in Fig. 3) is made of a film base, a reseau containing blue, green and red tiny filter areas, and a silver salt light-sensitive emulsion. Remember, the light from the lens must pass through the film base and reseau to reach this emulsion.

After first development we find that the blue light has passed through the blue filter areas of the reseau and has exposed the emulsion under these filter areas only. The process of first development has turned this exposed emulsion into black opaque silver. Likewise, green light has passed through the green filter areas and red light through the red filter areas, to produce developed silver under their respective filter areas. The film at this point corresponds to the customary black and white negative.

After bleaching the developed silver areas out, we have left in their place simply pure gelatin. The unexposed and undeveloped silver salt emulsion areas are still sensitive. The film is now exposed to light and these areas of light-sensitive silver salt are exposed completely.

After redevelopment, there will be black silver deposits due to the exposure made in the previous step, and the transparency is finished. This method is called "development by reversal." Notice when the transparency is held up to the light, that light passes through the blue filter areas of the reseau where the blue rays hit the original unexposed film, and thus our eye sees blue. (Likewise, in the other examples given, our eye sees green or red respectively. Bear in mind, that the individual areas are far too tiny to really "see," and we are aware of their color only as a resultant blending or confusion on the retina of the eye.)

Yellow light as seen reflected from a yellow object like a lemon, is not a pure photographic primary color, but a mixture of pure green light and pure red light. Thus we see in the last column of Fig. 3, that when yellow light hits unexposed Dufaycolor film part of it passes through the green and part through the red filter areas, but none through the blue. Again, after the first development we find developed silver areas under the green and red filter areas. Finally after bleaching and redevelopment there is some silver over the green and red areas but not enough to make these filter areas completely opaque as over the blue areas. Thus *some* light is permitted to pass through the green and red filter areas, and in the right proportion to give this final transparency the same color as the yellow originally photographed.

THE DUFAYCOLOR MANUAL

THE SOURCE OF LIGHT IN COLOR PHOTOGRAPHY

It has been seen in the foregoing, that color in photography results from the correct analysis of all the various colors inherent in white light. Normal daylight has been adopted as the standard of white light. The average person, trusting too much in the correctness of that most accommodating organ, the eye, is inclined to underestimate the wide differences in color which exist in different conditions of daylight itself. Daylight is not a constant white light, but varies widely depending on the weather conditions, altitude, climate, etc. As an example, imagine a darkened room with four windows, each looking out on identically the same landscape but that the light which illuminates the scene in each case is as follows:

1. Sunlight at 8:00 A. M. on a summer morning. Slight mist. No clouds.
2. The same at 11:30 A. M., completely overcast with high cirrus clouds. Bright even white light. No sunlight at all.
3. The same at 3:00 P. M., after a shower. Clear sky and sun shining between cumulous clouds.
4. The same at 5:30 P. M., sun setting in golden cloud. Very slight haze.

The four windows would depict the same objects, but each "window-picture" would have a different *all-over* tone or tint, and the color of the objects would not appear to be the same. The first might seem to have a slight pinkish-violet cast compared to the others. The second would seem relatively bluish and cold all over. The third "normal" or "average"—a clear sparkling day. And the fourth decidedly reddish in cast.

Thus Dufaycolor photographs taken of this same scene under the four dissimilar conditions would yield four distinguishably different results. Each result is correct, but, since the average person judges a picture by what he *thinks* the color of familiar objects should be, one may expect considerable difference of opinion as to which picture is the most faithful reproduction.

In like manner our eyes are likely to deceive us in regard to the color reflected from any familiar surface. We *know* that the surface of a tarred road is black, so our experience resists the fact that it can appear intensely blue from a reflection of the sky. We *know* what the color of skin texture should be, and cannot easily accept that it can and does reflect bright red from a red dress or hat. The user of Dufaycolor film must realize that with correct exposure, what the lens sees will be recorded. Unlike the eye, the film registers what the color *is;* not what it should be.

PRACTICAL WORKING INSTRUCTIONS

Loading

Dufaycolor film must always be exposed through the base as shown in Fig. 1. In using roll film, and with film packs, you load your camera exactly the same as with black and white. The loading of cut film is exactly similar to black and white film. In the correct position, the emulsion side is away from the lens. Care must be used in loading cut film to make sure that the film when exposed lies in a truly flat plane.

The extreme sensitivity of Dufaycolor film to light of all colors makes it essential that the loading and unloading be done in complete darkness or with the aid of a very dim green panchromatic safelight at least three feet away.

Exposure of Dufaycolor Film

It is impossible to emphasize too strongly the necessity for correct exposure for successful results in color photography. While a slight error in exposure may render a pleasing color transparency, truly accurate color reproduction can only be obtained when exposure is substantially exact for standard development.

The use of an exposure meter is strongly recommended. All makers of exposure meters publish data for their use with Dufaycolor film, and the reader is referred to these for practical working instructions. With any meter, however, it is best to take three or four readings of the light reflected from various parts of the subject and to calculate an exposure based on the average of these.

Dufaycolor film has a speed of approximately one-half that of standard panchromatic film or one-quarter of super-sensitive panchromatic film. In exposure, therefore, the lens should be opened up one stop larger than when using the standard panchromatic, and two stops larger than when using super-panchromatic, or, of course, the time of exposure can be proportionately increased. Dufaycolor, without a filter and in daylight, has a Weston factor of 8 and a Scheiner rating of 18.

COLOR PHOTOGRAPHY IN ARTIFICIAL LIGHT

Panchromatic emulsions must be standardized to some constant balance of color values, and normal daylight is customarily accepted as standard white light. If other light sources are to be employed, a compensating filter must be used to correct for the disproportionate color balance of such light compared to normal daylight.

Filters

If we strike a match in broad daylight and look at the flame, we cannot help being struck with its yellowness. Compared with daylight, Mazda is also distinctly yellow, the photoflood is much whiter than the Mazda but is still yellow, and so on.

Hence, if we take a studio portrait lit with Mazda lamps, we must use a blue "Mazda-to-Daylight" filter over the lens, which diminishes the effect of the excessive green and red rays present in artificial light.

The following series of filters is made for studio and commercial photography:

DUFAYCOLOR FILTERS AND FILM SPEEDS
IN ARTIFICIAL LIGHT

LIGHT SOURCE	FILTER	WESTON	SCHEINER
Dufaycolor Wonderlite	No Filter	12	20
Photoflood	Photoflood	3	14
High Wattage Mazdas and Projection Lamps	H. W. M.	2	12
Photoflash Bulb	Flash	—	—

NOTE: Do not mix light sources by using two types of bulbs to illuminate the same subject. For example, do not use photofloods for general illumination and a Mazda spot. No standard filter can compensate accurately for mixed lights with different degrees of color balance.

Filters are made of gelatin which may be used as such or cemented between "B" glass. The gelatin filter should not be buckled or finger-marked. It should be handled only by the edges and kept between sheets of paper when not in use. The most satisfactory way of employing a gelatin filter is to

place it between the lens components. Glass filters should preferably be placed in front of the lens.

Occasionally, results are obtained in which red appears to predominate, even using the proper filter. This may be due to voltage fluctuation. If, as sometimes happens, the supply voltage drops appreciably, incandescent lamps will emit a higher proportion of *red* rays. It may also be caused by deterioration of the filter. Gelatin filters do not last forever and in case of persistent reddish results, we recommend that the voltage of the main supply be checked and that your filters be sent to us for examination.

Lighting

It is important in studio work to have adequate lighting equipment and a sufficient number of lighting units.

It should be borne in mind that a great deal of light is reflected from drapes and even from clothing on a model. In the choice of background, drapes and dress materials require careful consideration. The light intensity on a set-up should be kept in a narrower range than is customary in black and white work. Color differences in the subject constitute *contrasts* to a great extent. Hard or underlit shadows and very hard low key lighting should be avoided. With light backgrounds, plenty of light is usually reflected from the general illumination, but where a dark background is used, it should be separately lighted as otherwise its color will be lost and it will appear unduly dark.

Make-Up for Color Photography

Panchromatic make-up is entirely unsuitable for Dufaycolor studio shots. The best make-up is such as would pass almost unnoticed on the street.

LENSES AND FOCUSING

In both studio and outdoor work, it is important to use a lens as nearly apochromatic as possible, as any marked chromatic aberration will interfere with the accuracy of color rendition. The ground glass of the focusing screen should be accurately registered with the focal plane of the film. The lens should be shielded from extraneous light with a suitable hood in order to avoid flare.

Focusing is very important since transparencies which are not sharp are usually very difficult to reproduce. With Dufaycolor, the emulsion is on the back of the film during exposure, and when using very large apertures, special care must be used to insure correct focusing. With the ordinary type of camera, with lens apertures at F 4.5 or smaller, there is no danger of the image being out of focus from this cause. It is also very important that the film should be held flat and in a correct plane.

HOW TO DEVELOP DUFAYCOLOR FILM

Roll Film

Dufaycolor film may be developed or processed to produce a positive transparency or a negative transparency. The development is quite as simple as that of black and white and with the same equipment. Usually a positive transparency is desired, namely, a transparency which when held to an even light, appears to be a positive color picture. To achieve this end, we develop *by reversal.*

Development by reversal means that after the first development, instead of fixing or dissolving out the unexposed undeveloped silver salt with "hypo," the film is transferred to a bleaching bath which dissolves out the black silver image first developed, and leaves a white positive image consisting of unexposed silver salts. This residual silver salt is still sensitive to light, and is exposed for about a minute to the light of a 60 to 100 watt Mazda lamp and is then placed in a second developer where it in turn becomes blackened, forming the silver image that creates a positive transparency. Refer to page 4 and Fig. 3.

Cut Film

Cut film offers many advantages over roll film in development, due to ease of control. Considerable errors in exposure may be corrected by increase or decrease in the time of the first development. Decreasing time will help to compensate for overexposure; increasing time, cautiously, will help underexposure and will improve shadow details. Develop with the emulsion side up and rock tray gently to insure even development.

DIRECTIONS FOR DEVELOPMENT BY REVERSAL

While a certain amount of green safelight (such as Wratten Series III) may be used in the darkroom, the film should at all times be protected from *direct* rays. After the film has had its first development and has been in the bleaching bath for two minutes, white light can be turned on in the darkroom and the succeeding operations carried out in full white light. It is quite possible to *desensitize* Dufaycolor film so that development may be made by inspection.

The first development is given in the following bath at a temperature of 68° F.

FIRST DEVELOPER

2

	Metric	Avoirdupois
Metol	1 gram	16 grains
Hydroquinone	8 grams	128 grains
Sodium Sulphite, dry	50 grams	1¾ ounces
Sodium Carbonate, dry	35 grams	1¼ ounces
Potassium Bromide	5 grams	80 grains
Potassium Thiocyanate (Sulphocyanate)	9 grams	144 grains
Water	1,000 ccs.	35 ounces

If inconvenient to use the developer at a fixed temperature, the following times for correct exposure may be given:

65° F.	5 minutes
68° F.	4¼ minutes
72° F.	4 minutes
75° F.	3 minutes

Considerable exposure errors may be corrected by increasing or decreasing these times.

After development the film should be washed one minute in running water or it may be immersed for ½ minute without washing in a stop bath:

STOP BATH

	Metric	Fluid
Acetic Acid 28%	50 ccs.	1¾ ounces
Water	1,000 ccs.	35 ounces

followed by 2 minutes washing.

BICHROMATE BLEACHING BATH

The simplest bleaching bath is made up as follows:

	Metric	Avoirdupois
Potassium Bichromate	5 grams	80 grains
Sulphuric Acid, Concentrated, Commercial, specific gravity 1.87	10 ccs.	160 minims
Water	1,000 ccs.	35 ounces

Bleach until the image is clearly visible, which will require 4 minutes and then wash for 2 minutes, after which the film should be cleared for 2 minutes in the bath given on page 13.

A permanganate bleaching bath gives rather more brilliant colors and is preferred by many. This bath, however, softens the film considerably if solution or water temperatures are above 70° F. and a hardening bath should first be used to prevent frilling before bleaching.

HARDENING BATH

	Metric	Avoirdupois
Formalin 40% solution	28.0 ccs.	1 ounce
Caustic Soda	1.5 grams	24 grains
Sodium Sulphate	150.0 grams	5¼ ounces
Water	1,000.0 ccs.	35 ounces

Use the solution only once. After washing proceed to the permanganate bleach.

PERMANGANATE BLEACHING BATH

	Metric	Avoirdupois
Water	1,000 ccs.	35 ounces
Potassium Permanganate	3 grams	48 grains
Sulphuric Acid, Concentrated Commercial, specific gravity 1.87	10 ccs.	160 minims

Mix these ingredients cautiously and *in the order given.*

The effect of the bleaching bath is to dissolve away the black silver image first developed, and will require at least four minutes. The image will then be clearly visible.

Following bleaching, the film should be immersed for two minutes in the following clearing bath, in order to remove stain:

CLEARING BATH

	Metric	Avoirdupois
Sodium Bisulphite or Potassium Metabisulphite	25 grams	400 grains
Water	1,000 ccs.	35 ounces

After clearing, the film should be washed for two minutes to eliminate clearing bath chemicals. It is now ready for the second exposure. At this stage of the processing the image should appear clearly in full color when viewed against a Mazda light. If the pictures appear to have a black deposit over any portion, the bleaching is insufficient. This may be corrected by replacing the film in the bleach bath until the black deposit is removed.

Second Exposure

All of the remaining silver salts in the emulsion should be affected by exposure to light so that on second development they will be completely reduced. An exposure of a minute at a distance of 12″ from a 100-watt globe should ordinarily be sufficient. It is better, however, to increase rather than decrease this time, as additional exposure will do no harm provided it is not unduly prolonged.

In the case of films developed in developing tanks, they must of course be removed from the reels for the second exposure. This must be done with care to prevent scratching the emulsion. A convenient method is to hang the film up by means of a clip and to give the second exposure with a lamp in a portable reflector.

For second development the first developer may also be used, but cannot then be again employed for the first development of other films. The following is recommended:

SECOND DEVELOPER

	Metric	Avoirdupois
Metol	2 grams	32 grains
Hydroquinone	9 grams	144 grains
Sodium Sulphite, dry	75 grams	2¾ ounces
Sodium Carbonate, dry	50 grams	1¾ ounces
Water	1,000 ccs.	35 ounces

Time of second development, 4 minutes at 65° F. After a short wash, the film should be fixed in any of the standard formulae, or in the following bath for five minutes to obtain full advantage of its hardening action:

FIXING BATH

	Metric	Avoirdupois
Sodium Hyposulphite	360 grams	14 ounces
Potassium Metabisulphite	12 grams	½ ounce
Water	1,000 ccs.	35 ounces
Dissolve separately and add:		
Chrome Alum	10 grams	160 grains
Water	1,000 ccs.	35 ounces

After fixing, wash thoroughly for 15 minutes.

Note: If a loss of density is noticeable after fixing, we recommend that the fixing bath be omitted, in which case proceed direct from the second development to a thorough 15-minute wash.

Alternate Reversal Procedure

In cases where second exposure may be difficult, the following chemical reversal is recommended:

CHEMICAL REVERSAL BATH

	Metric	Avoirdupois
Sodium Hydrosulphite	14 grams	½ ounce
Sodium Bisulphite	10 grams	160 grains
Water	1,000 ccs.	35 ounces

Following the bleaching bath and clearing bath, the film should be immersed completely in the above *without the necessity for re-exposure.*

Complete reversal should be effected in from 30 seconds to one minute.

This formula should be freshly prepared before using, its keeping qualities being extremely limited.

Drying

After the final washing, the film should be carefully wiped with a chamois or viscose sponge to eliminate all moisture, otherwise water marks will form.

Keeping Quality of Baths

All the baths except the chemical reversal bath keep well in tightly stoppered bottles. Two dozen 5 x 7 inch films, or their equivalent, can be developed in 1,000 ccs. or 35 ounces of solution. The permanganate solution should always be used fresh.

Hardening Bath

The various processes through which the film must be carried, are liable in very hot weather to soften the gelatin, and where the solutions or water temperature are much above 70° F. the hardening bath on page 13 should be used *before* bleaching.

AFTER-TREATMENT OF DUFAYCOLOR FILM

INTENSIFICATION

Films which have been overexposed or overdeveloped and are consequently too transparent or weak in color, may often be intensified with good results. They should first be bleached in the following bath:

BLEACHING BATH

	Metric	Avoirdupois
Ammonium Chloride........	24 grams	360 grains
Mercury Bichloride.........	30 grams	450 grains
Water	1,000 ccs.	35 ounces

The image should be bleached to completion, which takes approximately 4 minutes. It is then washed for 15 minutes, and redeveloped in either of the formulae below according to the degree of intensification needed.

FOR MODERATE INTENSIFICATION

	Metric	Avoirdupois
Sodium Sulphite, dry.......	50 grams	1¾ ounces
Water	1,000 ccs.	35 ounces

FOR CONSIDERABLE INTENSIFICATION

	Metric	Avoirdupois
Ammonia	50 ccs.	1¾ ounces
Water	1,000 ccs.	35 ounces

NOTE: Avoid putting fingers in these solutions, especially the ammonia bath, which stains badly if there is a trace of the bleach bath on the skin.

REDUCTION

Dufaycolor transparencies may also be reduced if they have been under-developed or under-exposed. Most reducers are suitable, but the following is recommended:

REDUCING SOLUTION

Solution "A"	Metric	Avoirdupois
Sodium Hyposulphite.........	50 grams	1¾ ounces
Sodium Carbonate, dry.......	15 grams	½ ounce
Water	1,000 ccs.	35 ounces
Solution "B"		
Potassium Ferricyanide	5 grams	80 grains
Water	1,000 ccs.	35 ounces

For use, mix equal parts of "A" and "B".

(The carbonate increases the life of the bath, which will keep for several hours.)

Should be used with extreme caution. Immerse film for a few seconds at a time and examine.

Great improvement is sometimes effected by intensifying pictures which have been first slightly reduced in order to increase brilliance. Having washed the reduced transparency, intensification is carried out as already outlined.

After developing, rinse thoroughly in water, then fix in a hypo bath preferably of the meta-bisulphite type rather than one containing alum.

Desensitizing Dufaycolor Film

Control in development is greatly facilitated by desensitizing the film first, when a much brighter illumination can be employed in the darkroom. It should be noted that even without desensitization, the film becomes very much less sensitive to light after it has been in the first developer for a couple of minutes so that it can be examined for a short but sufficient period by a dull green safelight. In order to take advantage of the possibilities of full desensitization, the following solution is recommended:

DESENSITIZING SOLUTION

	Metric	Avoirdupois
Phenosafranine	0.5 grams	8 grains
Water	1,000 ccs.	35 ounces

Immerse the film for two minutes in a freshly made quantity of solution.

An alternative bath which does not discolor the film at this stage to such an extent is:

DESENSITIZING SOLUTION

	Metric	Avoirdupois
Pinacryptol yellow	0.2 grams	3 grains
Water	1,000 ccs.	35 ounces

Rinse in running water and develop from 2½ to 3 minutes in the first developer, then turn on the bright green safelight, or the Wratten OA with a low wattage lamp.

The film is viewed by reflected light. The highlights should be developed until the image looks brilliant on the surface and the shadows full of detail. A little experience with this method will help to obtain the best results in stopping development at the right moment.

The usual type of cut film hangers may be used for all sizes, but we recommend the type which clips the film at each corner. Development may be carried out either by tray or tank methods. Care must always be taken to insure even and frequent agitation of the developer.

Where development is being done by inspection, we recommend placing the film for 30 seconds in the following stop bath after first development:

STOP BATH

	Metric	Avoirdupois
Acetic Acid 28%...........	50 ccs.	1¾ ounces
Water	1,000 ccs.	35 ounces

A two-minute rinse in running water should be given after the stop bath before the film is transferred to the bleaching bath. The rest of the processing then continues as described on page 12.

DIRECTIONS FOR DEVELOPMENT TO A NEGATIVE TRANSPARENCY

SPECIAL DEVELOPER FOR NEGATIVES (NOT TO BE REVERSED)

		Metric		Avoirdupois
A.	Metol	3 grams	or	48 grains
	Sodium Sulphite (dry)...........	7.5 grams	"	120 grains
	Hypo	6 grams	"	96 grains
	Potassium Bromide	2.4 grams	"	38 grains
	Water	1,000 ccs.	"	35 ounces
B.	Caustic Soda	3 grams	"	48 grains
	Water	1,000 ccs.	"	35 ounces

The development time should be from five to seven minutes at a temperature of 65° F. followed by washing and fixing as in black and white practice.

Average time of development for a *gamma** of 1 is 5 minutes at 65° F.

* See Appendix.

VIEWING DUFAYCOLOR TRANSPARENCIES

The reseau filter elements are balanced to be correct for normal daylight. The household Mazda lamp gives off a light that is more yellow and red than normal daylight and hence the transparency viewed by light from this source will have an exaggerated reddish tint or cast unless a Mazda-to-Daylight compensating filter is interposed.

Displays

Dufaycolor transparencies exhibited in suitable show-cases, make highly effective displays and advertisements. A sheet of flashed opal glass should be used behind the transparencies to insure an even diffusion in illumination. When Mazda lighting is used, a Mazda-to-Daylight compensating filter should be inserted behind the transparency.

The Brigham Gelatin Company supply a No. 25 daylight blue gelatin. The Ednol Glass Company of New York supply a blue flashed-opal glass which acts as both a light corrector and a diffusing medium. The General Electric Company and Wonderlite Lamp Company also supply incandescent lamps made of "daylight" glass. Through any of these mediums, illumination can be obtained which will give correct color value to your transparencies.

The temperature at the back of the transparency should never be more than 90° F. It is best to leave a definite space between the frame and the lamp house so that air can circulate freely. All exhibits should be designed for adequate ventilation. Overheating must be avoided if transparencies are to have a long life.

Lantern Slides from Dufaycolor Film

Colored lantern slides can be made in any quantity from Dufaycolor originals.

When processing Dufaycolor film for use as lantern slides, the time of first development should be increased by approximately an extra half minute. This will give a more transparent picture. Too great over-development must be avoided, however, as this will lead to weak and unsaturated colors on the screen. It should be noted that an original transparency, especially processed for projection, will not be suitable for duplication. No special projector is required, but incandescent light is distinctly yellow as compared with daylight and there is a tendency for the projected film to

appear too yellow or too red. This can be corrected if desired by the use of a Mazda-to-Daylight filter placed in front of the projection lens.

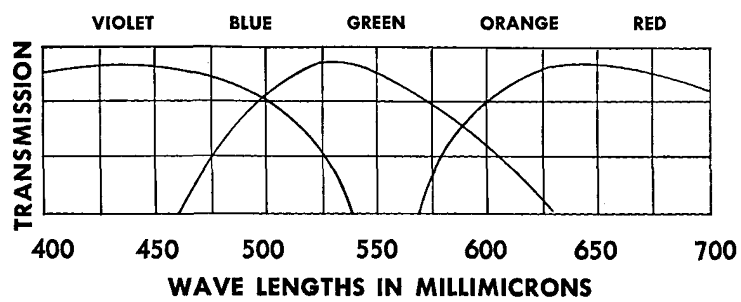
COLOR SEPARATION NEGATIVES

One of the greatest values of the Dufaycolor process is that it will yield first quality color separation negatives which are for all practical purposes as good as separation negatives taken direct from the original. Since Dufaycolor involves only one exposure and in view of the speed of its emulsion, it is possible to obtain pictures of moving objects, street scenes and other subjects that cannot be recorded satisfactorily directly on three separate negatives. The very fine mesh of the Dufaycolor reseau and the absence of any black between the color elements combined with the carefully selected color transmission of each of the color elements in the reseau accounts for the excellence of the color separation negatives obtained.

Separation Filters

The spectral transmissions of the blue, green and red reseau elements overlap to some extent as indicated in Fig. 4. The blue and red each overlap the green, while the green overlaps both blue and red. There is, however, a blue-violet portion of the spectrum which is *not* overlapped by the green; a green portion which is not overlapped by either blue or red elements; and a red portion which is not over-

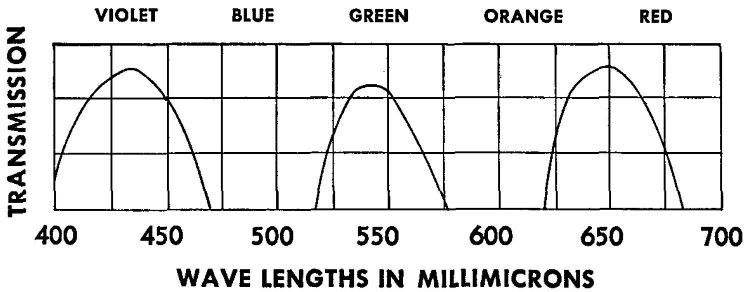
Fig. 4
Transmission Of Dufaycolor Reseau



lapped by the green. These portions, as indicated in Fig. 5, are used in the "S" series separation filters which we recommend for contact work.

Fig. 5

Transmission Of "S" Separation Filters



It has been found by practical experience that in optical separations (by camera or enlarger) the spectral transmission of the filters can be somewhat wider, and for any work other than copying by contact we particularly recommend the "P" series of filters, which are more efficient and permit considerably reduced exposures.

DUFAYCOLOR SEPARATION FILTERS

FILTER	COLOR	USE
S1	Red	For Contact Separations
S2	Green	
S3	Blue	
P1	Red	For Enlargement Separations
P2	Green	
P3	Blue	
P4	Yellow	Gray Printer

Color Separation Negatives by Contact

A single separation negative made by contact from a Dufaycolor transparency on a panchromatic film may show a very slight screen pattern, due to the reseau, because only one set of color elements records on each negative. The recombination of the three in a color print eliminates any such tendencies, however. In making contact negatives, great care is necessary to insure even pressure all over as even slight lack of contact will cause bad patchiness. For contact work, use our "S" series separation filters.

Fig. 6

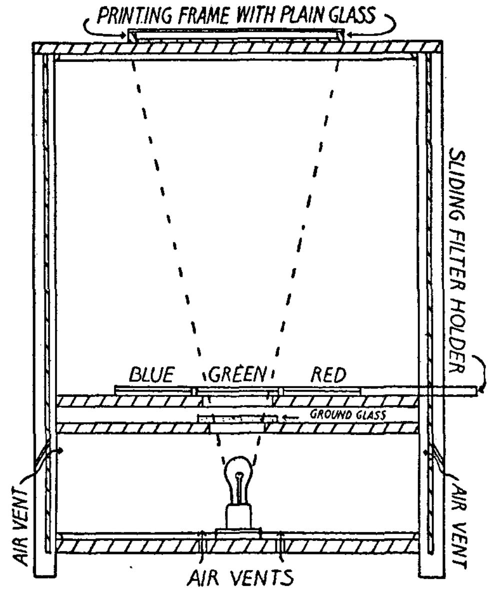


Figure 6 shows the fundamentals of a very simple contact printer. The perfect evenness of the illumination falling upon the printing frame area must be checked, otherwise unevenness may result in the final print. Some air vents are needed as shown in the construction diagram. The ground glass diffusing element is very important in achieving an even light intensity at the face of the printing frame.

Color Separation Negatives by Enlargement (or Reduction)

Enlarged (or reduced) color separation negatives can be made readily in the camera in the normal way, and here we recommend the series "P" filters. The reseau pattern can be almost completely eliminated without seriously affecting the sharpness of the image, by placing the camera the very slightest degree out of focus.

Fig. 7

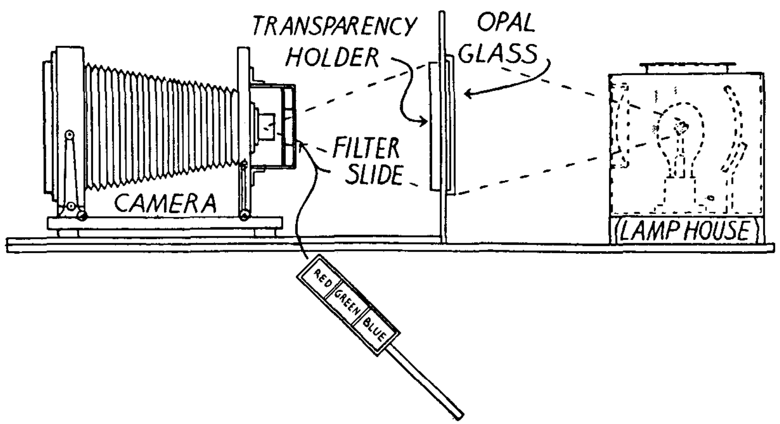


Figure 7 shows a simple set-up which can be built at comparatively little cost. In the case of optical copying, attention should be paid to the camera lens, as unless this is well corrected for chromatic aberration, some difficulty may be found in obtaining exact registration of the separated images.

EXPOSURE RATIOS FOR SEPARATION NEGATIVES WITH DUFAYCOLOR FILTERS

Photographic Material	Light Source	"S" SERIES			"P" SERIES		
		Blue	Green	Red	Blue	Green	Red
Eastman S. S. Pan.	White Flame Arc				4	2.75	1
	Mazda	7	16	1	15	6.5	1
Agfa Isopan	White Flame Arc				1.5	2	1
	Mazda	2.5	10	1	6	4	1
Defender XF Pan.	White Flame Arc				2.5	1.5	1
	Mazda	4	7.5	1	10	3.2	1
Wratten Pan. Plates	White Flame Arc				3	1.75	1
	Mazda	5	9	1	12	3.5	1
Gevaert Normal Pan. Plates	White Flame Arc				2.5	1	1
	Mazda	3.5	6	1	11	3	1
Ilford S. G. Pan. Plates	White Flame Arc				3.5	2	1
	Mazda	5	12	1	12.5	4	1

Exposure for Color Separation Negatives

It is desirable to include a neutral gray step-wedge with the Dufaycolor original in order that all three negatives may be of the same density and contrast. This wedge should appear identical in each negative. The contrast or gamma of the negatives should be equalized and the number of steps appearing in all negatives the same. As the blue sensation (yellow printer) invariably tends to be soft, from 25% to 100% extra development time must be given to it, according to the materials used.

Developing Separation Negatives

The developers recommended are those given by the makers of the respective materials in their instructions.

Generally speaking, a metol-hydroquinone developer is satisfactory for separation work, as this keeps well in tanks. A dilute solution should be used, for if development is too rapid it is difficult to insure absolutely even development, which is most necessary in order to avoid patches of false color in the prints. D-72 and DK-50 will be found excellent formulae, but they should be diluted somewhat so as to require eight or ten minutes development for the blue and red printers (red and green separations respectively), and about 50% longer for the yellow printer (blue separation). The length of time to be given for the yellow printer as compared with the others can be ascertained from tests made with the step-wedge.

Separation negatives should be transferred to an acid stop bath *without* intermediate washing and before fixing, in order that development be abruptly stopped at the correct point.

The three negatives (or four where a gray printer is made) should always be developed together in a tank, merely leaving the yellow printer in the bath for its extra time.

Recommended Development of Separation Negatives for Various Uses

	Density Range	Gamma*
Wash-off Relief	1 to 1.3	0.85
Carbro	1.2 to 1.4	0.9
Chromatone	1 to 1.2	0.9
Half-tone Letter Press	1.0 to 1.2	1.0
Photogravure	1.2 to 1.4	0.8
Offset Lithography	1.4 to 1.6	1.0

* See Appendix

The above figures, given for paper print processes, are indicated by our own experience but are not necessarily imperative. Reference to each manufacturer's instructions is emphatically recommended.

It is becoming general practice to consider density range rather than gamma in judging negatives for photomechanical reproduction, the density range being the difference between the highest and lowest densities in the negative, as measured on a density meter. In the case of photogravure, for example, where an average gamma may be taken as 0.8, the density range of an ideal negative may be taken as 1.3, the lowest density being 0.5 and the highest 0.5 plus 1.3, the highest density being thus 1.8.

DUFAYCOLOR AND THE GRAPHIC ARTS

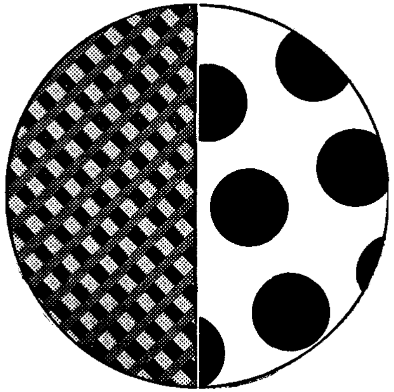
The striking success which has been achieved by Dufaycolor film in magazine, newspaper and advertising illustration, has made it the medium par excellence for the commercial photographer and the photo-engraver. The rapidity with which the transparencies lend themselves to color separation, are points of special appeal in the Graphic Arts. The Dufaycolor original not only serves as an immediate proof or record for the photographer, but it serves the printer in providing his three color separations, and later as a color guide when proving the plates.

Color Separation Negatives for Half-Tone Screens

The very small size of the Dufaycolor screen elements as compared with the dots of a 120-line half-tone engraving screen is shown in Fig. 8. It should be remembered that the Dufaycolor elements are blue, green and red, to which a good panchromatic film is almost *equally* sensitive. Hence the reseau does *not* act even as an excessively fine black and white screen.

Fig. 8

DUFAYCOLOR SCREEN 1000 lines per inch



HALF TONE SCREEN 120 lines per inch

Magnification 72 Diameters

Where half-tone screen negatives are required for the various forms of photo-mechanical reproduction, either the direct or the indirect method may be employed. Naturally, the making of the color separation screen negatives directly in the camera from the Dufaycolor transparency is quicker and more economical than the indirect method of making continuous tone separation negatives, followed by positives and subsequent screen negatives. However, both methods have their advantages.

Direct screen negatives can be made without moiré being experienced, provided that the degree of enlargement is not too great and care is given to determine the slight departure from standard angles which best eliminates interference.

The Dufaycolor transparency can be illuminated from behind, and half-tone negatives made in the camera direct at one operation, copying on to panchromatic process plates

direct through the half-tone screen; the "P" series of filters should then be used. A P4 filter is again used for the gray printer.

The best method of illuminating the Dufaycolor film is by the light of white flame arcs reflected by a sheet of white paper on the copyboard, the transparency being mounted in a black mask in front of the board.

Should it at times be necessary to give abnormal enlargement, say three to five times linear, a certain amount of interference may creep in if care is not exercised. Suppose an enlargement of 3½ times shows slight traces of cross-hatching. It will be found that by slightly lessening, or slightly increasing, the degree of enlargement, the trouble will disappear. All the engraver has to do is to use a little discretion in determining the *exact* margin of picture in an original to admit of this adjustment being exercised.

We would emphasize here the very distinct advantage offered by the fact *that Dufaycolor film can be obtained in large sizes.* The *reduction* from copy admittedly gives superior results to "blowing up" from small originals. This is an axiom accepted by all engravers. The cost of the extra size of film is negligible compared with the price of the plates, and the improvement obtained from this procedure has everything to recommend it.

Printing Inks

Separation negatives made with Dufaycolor filters from correctly exposed and processed transparencies are comparable with the finest negatives, made with standard filters and three separate exposures on panchromatic plates. It therefore follows that standard inks can be used for printing any set of plates made from a Dufaycolor original, the choice being merely that ordinarily indicated by the type of subject and kind of paper used.

Color Separation Positives from Dufaycolor Negatives

Dufaycolor cut film, if desired, may be developed and fixed as a negative instead of the usual method of reversal to a positive. The Dufaycolor negative merely transposes the "activity" from one color element to the other *two* (see first development stage in Fig. 3). Such a negative in complementary colors has, moreover, a longer scale of gradation than a positive transparency and a very pleasing photographic quality. From it, positive color separation transparencies or direct screen positives can be made, using the P filters. For direct negative development, use the special developer formula given on page 19.

COLOR PRINTS ON PAPER

There are a growing number of processes by which the photographer can make his own color prints on paper. While no print can ever reproduce the full quality and brilliance of a color transparency, the print has the advantage that it can be viewed by reflected light and can be mounted or framed.

The first step towards making a print in any of the presently known processes, is the making of the separation negatives in the manner already described. It should be noted, however, that different processes require negatives of somewhat different contrast so that the time of development of the separations must be modified somewhat according to the print process adopted.

The Carbo Process admittedly gives the best individual results as the dye pigments used in the manufacture of the tissue are consistent with theoretical requirements. A well-balanced set of separation negatives should give a perfect natural-color Carbro print. For details of the Carbro or other processes described, the reader is referred to the instructions issued by the various manufacturers.

Two other processes whereby excellent color prints can be made, are Chromatone (Defender Photo Supply Company, Rochester, N. Y.), and Eastman Wash-Off Relief

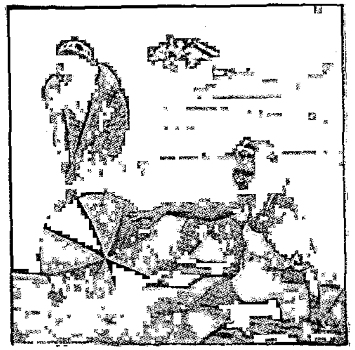
NOTE

Yellow Print from Blue Separation.

Red Print from Green Separation.

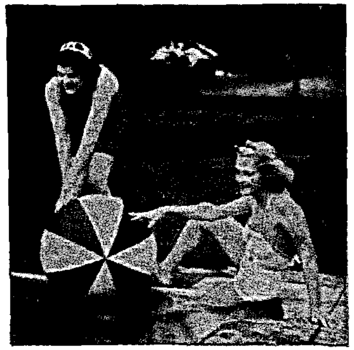
Blue Print from Red Separation.

Yellow Print



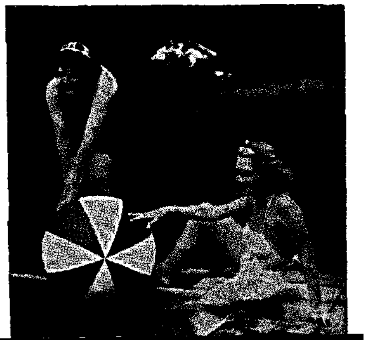
Red Print

Yellow and Red



Blue Print

Yellow, Red and Blue



(Eastman Kodak Company, Rochester, N. Y.). In the case of Chromatone, a bromide print on the specially prepared stripping paper is made from each separation, the neutral gray step-wedge being adjusted in each print. The stripping paper prints are toned in the proper subtractive colors and then assembled one over the other in register upon a prepared sheet of white support paper.

In the Wash-Off Relief Process, a print on special sensitized film is made from each separation negative, and after development and treatment in the special baths, the unexposed portions are washed away in hot water and a gelatin image in relief (matrix) remains. The matrix from the green separation negative is immersed in a pure dye bath (magenta) and is then squeegeed into contact with the support paper; the dye transfers from the matrix to the paper leaving a magenta image; on top of this is transferred a blue-green image from the matrix from the red-sensation negative in the same way, and finally a yellow image is transferred on top again, prepared from the matrix from the blue-sensation negative.

It will be noted above that the colors used for prints made by any method are yellow, magenta and blue-green (cyan). The reason for this is that a print is viewed by *reflected* light and consists of three images, one *over* the other, the light passing through these three images to the white paper base and being reflected back again through them before it reaches the eye. It follows that in any given area the combination of these images must be such as to subtract from the reflected white light all colors except that which it is desired to retain. If we subtract blue-violet, for example, from white light, we are left with the green, yellow and red of the spectrum, which together produce yellow. Hence the print from the separation negative made with the blue-violet filter is printed in yellow, yellow being termed minus-blue. Similarly the green negative is printed in minus-green, that is, magenta; and the red negative is printed in minus-red, which is cyan.

For example, a green object would be represented in a Dufaycolor transparency by an area of thousands of active green reseau elements. The separation negatives made from this transparency would consequently record this area exposed in the green record but with no exposure in the red or blue. In due course, the printing records from these negatives would therefore show exposure in the red and blue but none in the green. From the above we learn to think of these printing records in terms of their subtractive complements so, repeating the last sentence in different words: The printing record shows exposure in the minus-blue and minus-red but none in the minus-green. Combining these results, we have in the area originally occupied by our green object, a minus-blue (yellow) image and a minus-red (cyan) image on top of each other, but *no* image of the minus-green (magenta). This combination clearly subtracts from the reflected white light all color except green and we have a reproduction of the original green object.

APPENDIX

A brief account of many terms and expressions used in modern color photography is given here to facilitate the understanding of current literature.

Additive and Subtractive Color

Probably most of our readers already know the difference between the additive and subtractive systems of color mixing. For those who do not, we believe the following brief example will make clear that which would require a separate book to explain in full.

Imagine a pure white paper hung upon one wall of an absolutely dark room. At the opposite side of the room are three spotlights. One spot throws on the white paper a pure red light, the second a pure green light, and the third a pure blue-violet light. Each spot covers the whole white area and each is equipped with a shutter controlling the amount of its light permitted to fall onto the paper. With all shutters closed, the paper is of course black: there is total absence of light. With all three shutters wide open, the paper will be pure white. Between these extremes, by opening one or two or

all three of the shutters in varying combinations and degrees and thus controlling the brilliance of each light, we can produce any and all colors imaginable, from the deepest of pure color to the palest of pastel shades. Starting with no light at all we have *added* various colored lights together until in grand total we have combined (by *addition)* all the component colors which together make white light. This is an example of ADDITIVE color mixing.

Now with all our spots on full and our paper pure white, let us take three colored pigments (dyes, inks, etc.), one yellow, one magenta, and the third green-blue, and paint them in varying combinations and proportions on the paper itself. Each pigment put on will absorb some of the light that falls on it. That is to say, each color will *subtract* from the white light some component thereof. We can by various admixtures re-create all the colors formerly achieved by our spot-light addition. However, with the surface equally and completely covered by all three we shall find that we have *subtracted* from our white light all its component colors, and the paper, its power of reflection totally obstructed, will appear black. This is an example of SUBTRACTIVE color mixing.

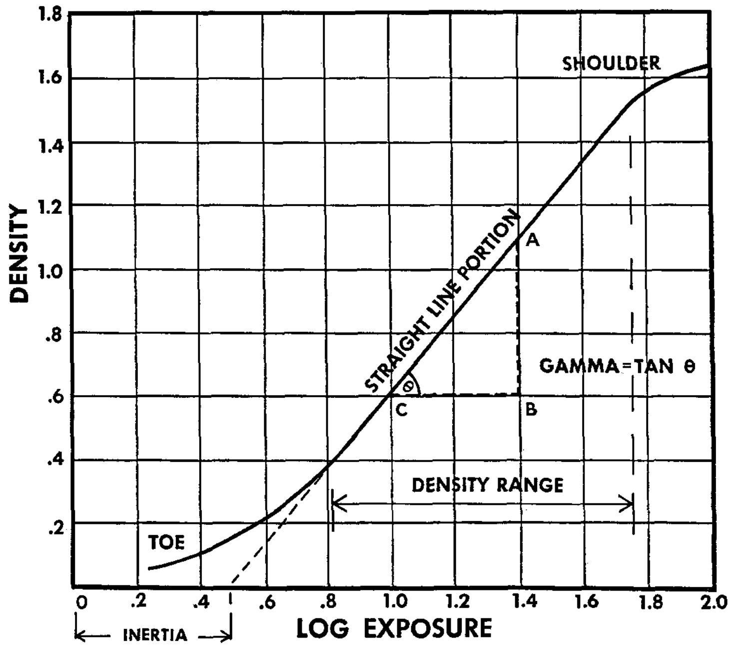
From the first example above, you can appreciate that Dufaycolor film is an ADDITIVE color process, and from the second example that all color pictures seen by reflected light (color prints, halftones, etc.) are made by SUBTRACTIVE color processes.

Characteristic Curves

Figure 9 shows a typical example of the characteristic curve of a panchromatic emulsion. This curve is plotted in the following manner: A piece of film is exposed under a step-wedge, the densities of which bear a known relation to each other. Then the densities of the developed negative under each step-wedge are measured and plotted against the logarithms of exposure.

Fig. 9

Characteristic Curve of a Typical Panchromatic Emulsion



The *Logarithm* of the exposure is plotted in this curve against the density, Density being also a logarithmic expression, since Density equals Log Opacity.

(1) D (density) = Log O (opacity)

Thus for the sake of convenience we are plotting one logarithmic function against another,—Log Opacity (density) vs Log Exposure.

A film negative has the extreme qualities of Opacity and Transparency, denoted by O and T. The relation being:

(2) O = 1/T

For example: Assume a transmission of 50% of the light which is a Transparency of one-half. Substituting in equation (2), Opacity will then be equal to 2. From equation (1) above, the Density then would be equal to Log O, or Log 2, which is .301. Referring to the characteristic curve, we find a density of .301 about half way between .2 and .4,—a density just below the straight line portion of the curve. Since the straight line portion represents the *latitude* of the film, in which we usually desire to keep our contrast range, we see that a density of .301 is an undesirably light density for this emulsion—probably representing some of the deepest shadows of the final picture.

As another example,—assume a transmission of 1/8, which is an Opacity of 8 and a density of Log 8 which equals .903. This would be found in the middle densities of the average negative.

At the "toe" of the characteristic curve, we find the rate of increase of density is not proportional to the rate of increase of log exposure. The straight line portion shows a uniform increase of density for log exposure, and at the "shoulder" the rate of increase of density again falls behind the rate of increase of log exposure. The straight line portion gives the *density range* or, in other words, the difference between the lowest and highest useful densities within which limits is confined the latitude, or correct recording ability, of the film in question. Overexposure of a picture, for example, would mean that the brighter parts of the picture and highlights are out on the "shoulder" of the characteristic curve of the film, and that the relative contrasts are not correctly recorded on this end. Thus the final print would show "burned out" whites and highlights, resulting in a "chalky" effect.

The latitude of all color film is less than that of black and white, and thus the exposure must be made more carefully to assure that the range of density lies within the straight line portion of its characteristic curve. The latitude of Dufaycolor is as great, if not greater, than any other color film now on the market. It has a range of 1 to 20 in the negative, which is reduced to 1 to 10 in the positive by the process of reversal. This means that the brightest highlight can be from 10 to 20 times as bright as the deepest shadow. Thus a Weston meter might record 200 foot candles on the bright side of a face, during a portrait, and 20 foot candles on the shadow side. This is the maximum degree of contrast that can be recorded accurately on Dufaycolor film if developed to a positive by reversal. On very brilliant sunny days the contrast is often greater than this, and it is desirable to use your meter to measure *both* the brightest highlights, and deepest shadows desired, to be assured that they will each be recorded accurately.

Referring to the characteristic curve of the example in Fig. 9, we find that the straight line portion runs from a density of .4 to a density of 1.5. If you will refer to equation (1) and look up the anti-logs of .4 and 1.5, you will find that these correspond to an Opacity of 2.57 and 31.6 which is a range of transmission of slightly more than 1 to 12.

Another characteristic that can be read from this curve, is the "inertia" of a film. This is found by extending the straight line portion to meet the log exposure scale. The inertia of the example in Fig. 9 is .47. The inertia of Dufaycolor film is about twice that of panchromatic black and white film, which accounts for its slower speed.

The slope of the straight line portion of the characteristic curve, is a measure of the flatness or contrast of a negative and is denoted by *gamma.* The angle which the straight line portion makes with the horizontal is called Θ.

(3) $$\text{Gamma} = \text{Tan}\ \Theta = AB/BC \quad \text{(Fig. 9)}$$

For example:—Should the straight line portion of a characteristic curve make an angle of 45 degrees with the base line, then gamma equals Tan 45° which is 1. A gamma of 1 is held

by many to represent the perfect negative, but for a variety of reasons we may want a higher or lower gamma in special cases.

For instance, some methods of imbibition give better results with a gamma of 1.2 or 1.3 whereas with wash-off relief we find an average gamma of 0.85 will give the most pleasing results from Dufaycolor transparencies.

In making separation negatives the *Density Range* is important—i.e., the difference between the lowest useful density and the highest. The density range gives the maximum number of tones that can be included in the subject. It does not depend on gamma, but where a long density range is wanted the gamma (or slope) should not be too high. A gamma of 0.8 to 0.9 is very usual for Carbro printing, while the density range might be as high as 1.4.

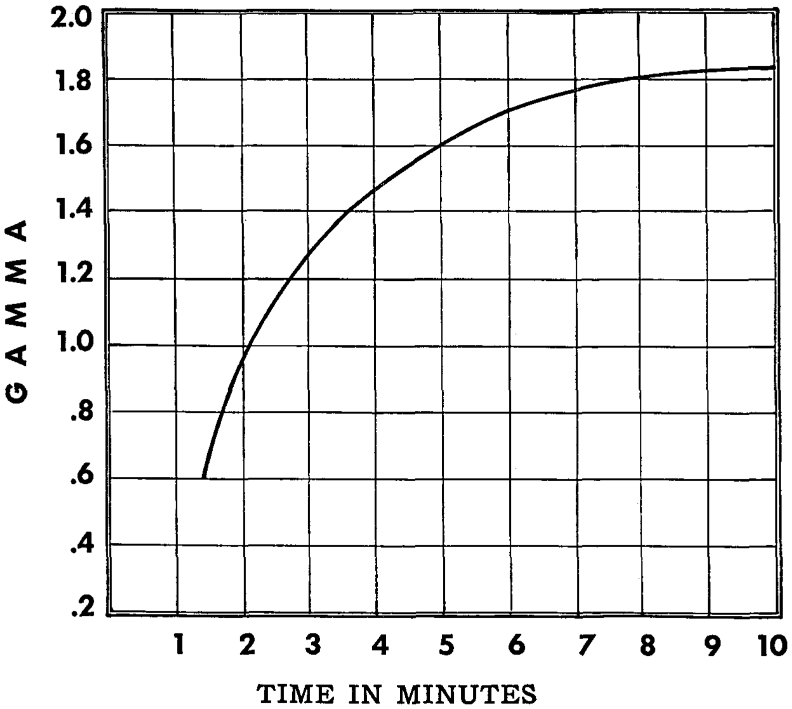
Density is measured by a density meter, and the value of this instrument cannot be over-estimated in color printing by photographic or photomechanical methods.

Gamma Time Curve

The gamma time curve shown in Fig. 10, represents the means used to find how long a development must be given at a certain temperature in order to obtain a desired gamma. Sensitometric strips are used to plot this curve for a given grade of film. These are strips of film that have been exposed, each for a fixed time, beneath a step-wedge. Then each strip is developed for a different time—say 2, 4, 6, 8 and 10 minutes. The densities of the steps in each negative strip are then measured and the characteristic curve plotted, similar to Fig. 9. From each characteristic curve the gammas are measured and these in turn are plotted against their respective times of development. The resulting curve shown in Fig. 10 indicates at a glance the required time of development of a particular material for any desired gamma—the emulsion of the film, the developer formula, and the temperature being constant.

Fig. 10

Typical Gamma / Time Curve



TIME OF DEVELOPMENT

Dufaycolor film is always developed to gamma infinity, and the gamma time curve is only of real use in connection with the making of separation negatives on the materials and with the formulae already discussed.

LOGARITHMS OF NUMBERS (TO THE BASE 10)

Numbers	0	1	2	3	4	5	6	7	8	9
1	.000	.041	.079	.114	.146	.176	.204	.230	.255	.278
2	.301	.322	.342	.362	.380	.398	.415	.431	.447	.462
3	.477	.491	.505	.518	.531	.544	.556	.568	.580	.591
4	.602	.613	.623	.633	.643	.653	.662	.672	.681	.690
5	.699	.707	.716	.724	.732	.740	.748	.756	.763	.771
6	.778	.785	.792	.799	.806	.813	.820	.826	.833	.839
7	.845	.851	.857	.863	.869	.875	.880	.886	.892	.898
8	.903	.908	.914	.919	.924	.929	.934	.940	.944	.949
9	.954	.959	.964	.968	.973	.978	.982	.987	.991	.996

To find the log of a number, look down the left vertical column for the first digit of the number and across the top column for the second digit of the number. In the center area of the table, you will find the log to the right of the first digit, and directly under the second digit.

Example: Log 3.2 = .505
Log 32 = 1.505
Log 320 = 2.505
Log 4.46 = .649

Anti-logs are merely working backward, from a logarithm to its corresponding number.

Examples:
Anti-log of .322 = the number 2.1
Anti-log of 1.322 = the number 21
Anti-log of .720 = the number 5.25

GLOSSARY

CHROMATIC ABERRATION—A defect of a lens resulting in a difference in focal length for light of different colors.

COLOR BALANCE—The adjustment of the intensities of printing or viewing colors (of a color picture) so as to reproduce properly the scale of grays.

COLOR SATURATION—The degree of freedom of a color from admixture of white.

COLOR SEPARATION—The obtaining of separate photographic records of the relative intensities of the primary colors in a subject in such a manner that a photograph in natural colors can be produced therefrom.

COMPLEMENTARY COLORS—Two colors of light, which, when added together in proper proportions, produce the sensation of white or gray. Also, two colors of dye or pigment, which when superposed in proper concentrations, produce a gray.

DENSITY—The logarithm to the base of 10 of opacity (for transparent materials). The logarithm of the reciprocal of the reflecting power (for reflecting materials).

DESENSITIZATION—Treatment of a photographic material with a solution of a suitable dye, to reduce its sensitivity to light without destroying the developability of a previous exposure.

FILTER—A light-transmitting material (characterized by its selective absorption of light of certain wavelengths).

FILTER FACTOR (Filter Ratio)—The ratio of the exposure required to produce a given photographic effect when a filter is used to that required without the filter.

FILTER OVERLAP—The spectral region in which two or more filters transmit light effectively.

GRAY KEY IMAGE—An image of neutral color occasionally printed in register with the images in tri-color inks or dyes. In the imbibition process, the gray key image is sometimes developed on the printing material by the ordinary photographic method.

MILLIMICRON—A unit of length equal to 0.000001 mm. (10^{-6} mm.). This is the unit usually used in colorimetrics in expressing the wavelength of radiant energy.

MINUS COLOR—The color which is complementary to the color that is named; for example, minus red is a color complementary to red.

MOIRÉ EFFECT—A pattern produced when two or more screens bearing a system of fine regular lines or similar pattern are superposed nearly but not exactly in register—similar to the appearance of "watered silk."

NEUTRAL COLOR—Gray; achromatic; possessing no hue.

NEUTRAL WEDGE—A wedge composed of a neutral (gray) absorbent material.

PRIMARY COLORS (ADDITIVE) — Three colors, which when mixed in the proper proportions, can be used to produce all other colors. The three colors most commonly used are red, green and blue-violet.

PRIMARY COLORS (SUBTRACTIVE)—The three printing colors used in a three-color subtractive process; usually named magenta (minus green), blue-green or cyan (minus red), and yellow (minus blue).

SPECTRAL SENSITIVITY — The sensitivity of a light-sensitive material (or instrument, such as a photo-electric cell) to radiation of various wavelengths.

SPECTRAL TRANSMISSION (of a filter)—The extent to which a filter will transmit radiation of different wavelengths. Shown graphically as transmission, opacity, or density plotted against wavelength.

STEP-WEDGE—A strip of neutral grays graduated in steps having densities increasing by a fixed amount, normally by 2 or the $\sqrt{2}$ each time.

SUBTRACTIVE PRIMARIES—The three printing colors used in a three-color subtractive process; usually named magenta (minus green), blue-green (minus red), and yellow (minus blue).

THREE-COLOR PROCESS—Any process, either additive or subtractive, for producing photographs using three primary colors.

WEDGE—A wedge-shaped piece of gray glass through which a strip of film is exposed. The resultant record grades in density from black (under the thin end) to pale gray (under the thick end)—depending, of course, on the density of the glass itself. For purposes of measurement the wedge is usually divided into steps.

WEDGE SPECTROGRAM—A spectrogram produced by photographing a spectrum through a neutral wedge (sometimes an optical wedge), placed usually over the slit of the spectrograph. Such a spectrogram shows graphically the effective photographic sensitivity vs. wavelength for the photographic material and light source used.

HINTS ON EXPOSURE OF DUFAYCOLOR FILM

It is not necessary to seek brightly colored objects to photograph. Dufaycolor should be employed in the normal way, photographing the ordinary colors met with in nature, for the most pleasing effects.

The best transparencies are usually those taken with the lens at a *wide aperture;* therefore, do not stop down much, unless it is essential to do so to obtain depth of focus.

Strong contrast in the lighting is to be avoided, as the color provides the contrast.

Brilliant sunshine gives a bright picture, but heavy shadows may result which are not always pleasing.

Large masses of color are more effective than small scattered patches.

Color pictures should, if possible, be taken with the light behind the camera, to achieve a flat lighting.

Underexposure leads to dense results, blue shadows and hard contrasts, while overexposure gives light colors and lower contrasts. Mild errors in exposure can be subsequently corrected by the development technique recommended here, but it is well to remember that the margin of permissible error in color photography is narrower than in black and white.

ADVANTAGES OF DUFAYCOLOR FILM

Considerable increase in speed, permitting snapshot exposures with ordinary inexpensive cameras under a wide range of conditions.

Greater latitude in exposure.

Finer and practically invisible screen elements.

Absence of parallax.

Simplicity of development with standard black and white equipment.

Ability to make duplicate transparencies by contact, enlargement or reduction.

The ease with which separation negatives can be made for prints on paper or for mechanical printing by any process. Monochrome negatives can be made, and from them black and white prints, either by contact or enlargement.

Dufaycolor film is available in rolls, cut films, and film packs for all popular makes of cameras.

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