5-1-1980

A Comparison and Interchangeability Study Among the Ilford, Kodak, and Unicolor Color Transparency to Print Processes

Mitzi Swenson

A COMPARISON AND INTERCHANGEABILITY STUDY AMONG THE ILFORD, KODAK, AND UNICOLOR COLOR TRANSPARENCY TO PRINT PROCESSES

by
Mitzi Swenson

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

for the degree of

Master of Science

Grand Forks, North Dakota

May
1980

This thesis submitted by Mitzi Swenson in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

(Chairman)

This thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Dean of the Graduate School

Permission

Title A Comparison and Interchangeability Study Among the Ilford, Kodak, and Unicolor Color Transparency to Print Processes.

Department Industrial Technology

Degree Master of Science

In presenting this thesis in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Library of this University shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my thesis work or, in his absence, by the Chairman of the Department or the Dean of the Graduate School. It is understood that any copying or publication or other use of this thesis or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarsly use which may be made of any material in my thesis.

Signature Mitzi Swenson

Date April 28, 1980

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Illustration | Page

LIST OF TABLES

ACKNOWLEDGMENTS

The author wishes to express her appreciation and thanks to Dr. Myron Bender, Chairperson, and Dr. Wan Lee Cheng, Department of Industrial Technology for their time, assistance and criticism during the preparation of this thesis.

The author would also like to thank Dr. Gade for his time and assistance and Marlys Kennedy for her help with typing.

The author also thanks the committee responsible for Graduate Student Research Awards, for the financial assistance with supplies.

The author further wishes to thank her husband, Sheldon, for his support and understanding, and their son, Shane, for his cooperation during the preparation of this thesis.

ABSTRACT

The purpose of this research was to investigate and experiment with three selected processes that can be used to produce color prints directly from color transparencies.

This research included: (1) a review the processes available to produce color prints directly from color transparencies, (2) identify and select three processes for producing color prints directly from color transparencies, (3) to experiment with the selected processes used to produce color prints directly from color transparencies for a comparative analysis in terms of processing time, equipment needed, cost, necessary facilities, simplicity of processing, and final results of prints, and (4) to evaluate and compare the processes for the purpose of recommending those most adaptable in a situation where limited equipment and/or funding exists.

Methods

The research design was laboratory experimentation. The Ilford, Kodak, and Unicolor color transparency to print processes were experimented with to provide comparative data. The data was recorded on tables to compare the processes so that a determination can be made as to which process is most suitable to a given situation.

An interchangeability study was completed by using chemistry and paper from the different processes together to determine the results. A contamination study was also done to determine the effects on the prints if the developer(s) were contaminated.

Conclusions

The primary conclusions obtained from this research were: (1) the Ilford processes for producing color prints directly from color transparencies would be suitable where funding would be available for materials but equipment would be limited, (2) the Kodak process produced good results with a lower material cost if a relatively large quantity of prints are processed, but required a temperature control system, (3) the Ilford processing chemistries or printing material cannot be interchanged with the Kodak or Unicolor materials, (4) the effects of contaminating the developer(s) of each process can be readily seen, and (5) although the evaluation of color saturation of the Unicolor process was rated second, the color hue result was the lowest of all three and it cost more than Kodak materials in terms of processing chemistries.

Recommendations

It is recommended that: (1) the Ilford process be used where funding is available for materials but equipment is limited and simplicity of processing is important (2) the Kodak process be used where a temperature control system is available and a large quantity of prints are to be made, and (3) further research with the Unicolor process be completed under more controlled conditions.

CHAPTER I

INTRODUCTION

Color photographic prints produced from color transparencies have been available for a number of years, but it is only recently that advancing technology has made it possible to produce them in a darkroom without sophisticated equipment. This opens many new possibilities to industry, industrial arts educators and their students, amateur and professional photographers alike.

For industry, photographic prints are used to portray industrial processes and products. Photographs can be used to improve public relations and provide for more effective advertising. Large photographic prints may be used to enhance lectures and demonstrations that are given prior to plant tours. By producing them within their own business, in a simple darkroom with a minimum amount of equipment, the cost can be greatly reduced. To have a large custom color print made commercially is quite expensive hence the great advantage of being able to do it locally. There is also an element of time. It takes only a few minutes to make the print, but to send it away may take a number of days.

Industrial arts educators can use color photography as an effective medium for teaching the color theory of light, combining principles of physics, and graphic arts. Furthermore, the instruction of photography can be advanced to the era of color processes, instead of being limited to black and white processes.

For amateur and professional photographers, having inexpensive processes they can perform themselves, requiring a minimum amount of time and equipment, are a great advantage. Most photographers have a large volume of work and can control quality and cost more effectively by performing the procedures themselves

Statement of the Problem

There are numerous processes available to produce color prints from color transparencies. Each process has certain advantages and disadvantages. The problem of this research was to investigate and experiment with three selected processes that can be used to produce color prints directly from color transparencies.

In order to fulfill the purpose, it was necessary to meet the following objectives:

1. To conduct a literature search reviewing the processes available for producing color prints directly from color transparencies.
2. To identify and select three processes for producing color prints directly from color transparencies to be used as the basis for the research, by a predetermined criteria.
3. To experiment with the selected processes used to produce color prints directly from color transparencies and to compare them in terms of time and equipment needed, cost, necessary facilities, simplicity of processing, and final results of prints.

4. To evaluate and compare the processes for the purpose of recommending those more adaptable in a situation where limited equipment and/or funding exists.

Need for the Study

The need for the study was initiated by new product availability. Cibachrome materials, produced by Ilford, Inc. were improved in 1977. Kodak Ektachrome 2203 paper and R-1000 chemistry and Unicolor RP-1000 chemistry became available in 1979. Because these materials for making color prints directly from color transparencies were new products, comparison studies that could be used as a basis for choosing a particular process for use in a given situation were unavailable.

Each of these processes has certain advantages and disadvantages that make them more or less suitable for a certain situation. This research will attempt to identify some of these characteristics.

Because the processes are relatively similar, it seemed feasible that some of the printing materials or processing chemistries could possibly be interchanged, thereby enabling a cost reduction. Also, when part of the supplies are temporarily unavailable locally, another product could be substituted. Currently, there is no data available on this concept. This research project was an attempt to provide data on the feasibility of interchanging the printing materials or processing chemistries.

When processing color prints from color transparencies, it becomes apparent that contamination of the developer could easily occur. This research also documented the effects of contaminating the developer(s). If abnormal results were obtained, the data could be used for a comparison to check for contamination.

Assumptions

The writer assumes that the reader has a basic understanding of the procedures and theory involved in making black and white photographic prints from negative.

The writer further assumed that the materials and supplies used for the experimentaion were not subjected to temperatures over $75^{\circ}F$ for an extended period of time, or frozen, prior to their arrival.

Limitations of the Study

This study was limited to:

1. The availability of laboratory equipment within the Departments of Industrial Technology, Electrical Engineering, University Relations and Academic Media, and the School of Medicine, University of North Dakota, at the time of the study.

Delimitations

Because of limited time and funds, this study was limited to:

1. The production of 4" x 5" prints
2. The three selected processes for producing color prints directly from color transparencies
3. The printing of one color separation guide and one other selected transparency.

Definition of Terms

The following is a list of definitions used throughout this research:

Additive primaries: The primary color light rays used in the additive system - red, blue, and green.

Blix: A mixture of bleach and fixer used by Unicolor.

Color hue: Refers to the trueness of a color.

Color negatives: A color photographs on film with the colors reversed to their complementary colors.

Color printing filters: Acetate filters placed between the light source and enlarger lens to alter the color of light emitted by the light source.

Color prints: An image on paper produced photographically.

Color saturation: The purity of a color.

Color separation guide: An illustration of primary and secondary photographic colors and neutral gray.

Color theory: The theory that states how light responds photographically.

Color transparency: A positive color film image, intended for projection commonly referred to as a slide.

Commercial prints: Machine-processed photographic prints by a photo-finisher.

Complementary color: The color opposite on the color wheel: magenta and green, yellow and blue, cyan and red.

Custom prints: Specially treated and/or larger size prints made by a photo-finisher.

<u>Cyan</u>: A bluish-green color, produced by equal mixtures of green and blue light.

<u>Density</u>: Refers to how light or dark a print is. A light print has low density, a dark print high density.

<u>Magenta</u>: A reddish-pink color, produced by equal mixtures of red and blue.

<u>Processing chemistry</u>: The chemical solutions used to process photographic prints.

<u>Processing tube</u>: The light- tight container used for holding the print for processing.

<u>Reversal film</u>: Film that carries a positive image after processing.

<u>Reversal paper</u>: Paper used to make color prints directly from transparencies or reversal film.

<u>Subtractive primaries</u>: Color light rays of cyan, yellow, and magenta.

<u>Yellow</u>: Produced by equal mixtures of red and green light.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Photography means many things to many people, but all recognize it as a powerful force. Phil Davis stated photography "is without any doubt at all, the most vital and significant visual force in the world today" (1:35).

Because of the large impact photography can have, a greater number of people are developing an interest in it. Photographs can be used as a medium for effective advertising and public relations for industry, and as a valuable tool for an industrial arts instructor seeking to teach the color theory of light. Amateur and professional photographers alike derive enjoyment from high quality photographs. Because of the growing interest in photography, a need for processes that could be performed within limited facilities with a small capital outlay was recognized. Producing black and white photographs could be accomplished under those restrictions, but color photographs could not be made before the appearance of Ektachrome reversal film. That film has a design allowing for processing without sophisticated equipment.

Color Reversal Film

Color reversal film consists of a base material coated with three light sensitive emulsion layers containing silver halides.

The top layer is blue sensitive, the middle layer green sensitive and the bottom layer is sensitive to red. A yellow filter layer is included between the blue and green sensitive layers to remove any excess blue light. This is necessary because the green and red sensitive layers are also sensitive to blue and that would create an excess of blue (1,2,3,4,5).

Color reversal film is available as daylight or tungsten type. In daylight type film, the red and blue sensitive layers are equally sensitive when exposed to average daylight which is a mixture of sunlight and skylight (1,2).

In the tungsten type, for use with artificial light sources, the blue layer is more sensitive than the red, because artificial light sources have a lower blue content (1,2,5).

Reversal Film and Paper Development

The development of Ektachrome transparency film is a normal reversal process, meaning the processed film is a positive transparency with the same colors as the scene that was photographed. When the film is exposed to light, a latent (invisible) image is formed in the silver halides. In processing, the film is first developed in a black and white developer. During the process of development, the silver halides are changed to metallic silver making a visible image (5).

The next step, color developer, contains a chemical fogging agent which causes the silver grains in the emulsion that were not affected by the first developer, able to be developed. The color developer then produces a positive silver image and the required dye images. The silver images are removed by bleaching, leaving positive dye images on the film. Fixing removes all remaining silver. The use of the stabilizer is to protect the dye from fading. The same principles apply to reversal paper, such as Kodak Ektachrome 2203 paper (1,2,5).

After the color transparency has been produced, it is possible to make a color photographic print from it using reversal paper, but an understanding of color theory is necessary first.

Color Theory

For purposes of photography, light is considered as waves. The length of the waves determines their hues. The spectrum humans can see ranges from reds, with a long wavelength, to greens, and then blues, with a short wavelength. Artists have known for a long time that nearly all the known colors can be reproduced by mixing a few basic colors, and photography makes use of that principle also. The three emulsion layers of film each record approximately one-third of the wavelengths of light in the spectrum. From these three impressions all the colors of the original scene can be reproduced (1,3).

The Additive Method

The colors found in nature can be produced photographically by two methods. The additive method begins with red, green and blue light. Mixed in varying proportions they give nearly all colors and the sum of all three primaries in equal amounts is white. This process was the basis for early photography, but has been replaced by the subtractive method which is more practical (1,3,4,6,7).

The Subtractive Method

In the subtractive method, the primaries absorb red, green, and blue wavelengths. These colors are cyan, magenta, and yellow respectively -- the complementary colors to the additive primaries. By combining all three subtractive primaries, all colors of light are absorbed, producing black. But, by mixing the subtractive primaries in varying proportions all the colors can be obtained (1,3,4).

Color Corrections with Reversal Paper

When making color prints from color transparencies, color printing filters are used to alter the color of light coming from the source (the enlarger lamp). That correction is necessary because of differences in each emulsion batch of paper and because each light source is different (2,3).

When judging a print with the intent of making a color correction, the color that is in excess is removed, or its complementary color is added, when dealing with reversal processes as this research does. For example, if the print appears too red, either red is removed or cyan is added. Using the subtractive primary method, it is beneficial to have the least amount of filters in the light path as possible, therefore whenever possible, filters are subtracted. If the color in excess is one of the subtractive primaries, that color of filter is removed in part. However, if the color in excess is one of the additive primaries, red, green or blue, it will be necessary to add it's complement, or to subtract equal quantities of the two subtractive primaries which are not it's complement. For example, if the print is too red, either cyan could be added, or yellow and magenta could be subtracted. If the correction made is too large the resulting print will turn the color of the complementary, i.e. a red print that is over corrected will turn cyan (1,3,4,6,7,8,9,10).

CHAPTER III

METHODOLOGY

The research was designed to experiment with the selected processes for producing color prints from color transparencies. After the literature was reviewed, three processes were chosen based upon the following criteria:

1. The processes are of a nature that a person with a limited photography background could use to produce good results.
2. The equipment needed for the processes is minimal.
3. The time involved to produce a print is minimal.
4. The cost of materials is relative low.

Description of Research

The processes for producing color prints from color transparencies were reviewed and the following three met the criteria and were chosen for the research:

1. The Cibachrome process, produced by Ilford, Inc.
2. The Kodak R-1000 chemistry and 2203 paper process.
3. The Unicolor RP-1000 chemistry and Kodak 2203 paper process.

The three processes were experimented with to provide comparative data relative to the cost of materials, necessary equipment, time, necessary facilities, simplicity, and final results.

An evaluation form (see Appendix I) was presented to two professional photographers, Mr. Jerry Olson, Instructional

Communications, University of North Dakota, and Mr. Bob Winge, Monarch Photo, Fargo, North Dakota. One amateur photographer who had experience with making color prints, Mr. Greg Carnehl, East Grand Forks, Minnesota also evaluated the prints. The prints from each process were evaluated on the basis of color saturation, color hue, and detail, as compared to the original transparency.

Each of the processes involved a chemistry and printing material or paper. An interchangeability study was done to determine if any of the materials were compatible. The developer(s) of each process were also contaminated to determine those effects on the final prints. The Cibachrome developer was contaminated with fixer, then bleach. The Unicolor First Developer and Color Developer were each contaminated with blix. The Kodak First Developer was contaminated with bleach-fix and stabilizer and the Color Developer was contaminated with bleach-fix.

Treatment of Data

The information gathered through research and experimentation provided comparative data which will guide the instructor or industry representative in choosing a particular process for producing color prints from color transparencies. The results were recorded on tables which compare the processes so that a determination can be made as to which process is more suitable to a given situation.

Introduction of Equipment

For the research, a Beseler 67C enlarger, equipped with a 75 watt bulb was used. Chromega acetate printing filters were used since a dichroic head was unavailable. A voltage regulator which emitted a constant voltage of 120 volts was used.

The prints were processed in an 8 x 10 in Unicolor processing drum with ribbed walls. The design of that drum allows the processing of four 4 x 5 in prints simultaneously. The drum was agitated on a Unicolor Motor Base which rolls the drum forwarded and then backward to ensure even processing. The prints were hung to air dry.

The chemistry was kept at a constant temperature in a water bath in a stainless steel tank with a heating coil in the bottom.

Process Constants

The following factors were kept constant for each process in order to reduce the variables between processes as much as possible.

The transparency chosen for the main evaluation was an Ektachrome ASA 64, tungsten type, supplied by the University Relations and Academic Media Center, University of North Dakota. The subject matter on it consisted of a 70 percent gray area, a grey scale, and seven color patches. The color patches were green, yellow, red, magenta, violet, cyan, and brown. An area of white was also included. The transparency chosen for evaluation of the detail was supplied by Mr. Jerry Olson, University Photographer, University Relations and Academic Media Center, University of North Dakota, and was an abstract scene with blue, tan, green, yellow, black, magenta, and red included. It was also an Ektachrome transparency, daylight type (see Appendix II).

All the chemistry was mixed using distilled water supplied by the School of Medicine, University of North Dakota. All the washes were also done with that water, except where running water was specified.

An ultra violet filter was used for all exposures to filter out the ultraviolet portion of the spectrum which could affect the color hue.

The processing tube was always cleaned and dried before the next batch of prints was loaded, except as noted in the contamination study.

When adding or subtracting filters, the exposure time must be adjusted to compensate for the change made in density. The new exposure time is calculated by multiplying the former exposure time by the factor for the filter being added, or by dividing the exposure time by the factor for the filter being subtracted. The factors are supplied by the manufacturer of the filters.

The Ilford process adds or subtracts a percentage of the time instead of using a filter factor. The change is quite similar to the other system.

For the exposure calculations in this research, the initial time will begin, followed by the appropriate mathematical symbol (+ - x ÷) and the filter factor or percent change. The adjusted time will be shown last. For example: 8 x 1.1 = 8.8.

CHAPTER IV

EXPERIMENTATION AND ANALYSIS

Experimental Procedures

The experimentation procedures for each of the three following processes were completed exactly as recommended in the information supplied with each of the chemistries and printing materials.

The Ilford Process

The process produced by Ilford, Inc. for making color prints from color transparencies is called Cibachrome. From here forth, that process will be referred to by that name.

Cibachrome consists of a P-12 processing kit of chemistry and a printing material made of triacetate support, coated with a gelatin emulsion containing azo dyes and light sensitive silver salts. The top layer is blue sensitive, then there is a yellow filter layer to filter out any remaining blue light. The next layers record green and red. The dyes act as a natural barrier to light scattering, consequently producing a sharp, detailed image with brilliant color. This material is more fade resistant and permanent than materials without azo dyes (9,11,12).

The printing material was exposed with an enlarger holding a transparency and a number of color printing filters. During the processing a black and white image is formed simultaneously in each dye layer by developing the silver. The bleach destroys the azo dyes proportional to the amount of silver which has been developed and converts the remaining silver to soluble silver halide. The yellow filter layer is also removed by the bleach. The fixer removes both the undeveloped silver and the converted silver halide, leaving the dyes to make up the image (11,12,13).

The first step was to mix the chemistry. The P-12 processing kit contains concentrated chemicals to make developer, bleach and fixer. The developer consists of Parts A and B in liquid concentrate form which were mixed with water to make working strength developer. Instructions were provided for mixing 3, 6, 12, 32 and 64 oz, in the ratio of 15 ml Part A and 15 ml Part B and 60 ml water, equaling 3 oz of developer (14).

The bleach consisted of a package of powder, bleach Part 2 A which was dissolved in 24 oz of 100-125^{o}F water. 3.4 oz of liquid bleach Part 2B was added and mixed. Water was then added to make 32 oz. The two quart kit included two packages of bleach enabling one quart to be mixed at one time. Smaller quantities cannot be mixed because the powder was premeasured. Instructions were also provided for mixing multiples of 32 oz, up to 128 oz (14).

The fixer was in liquid form which was diluted with water. Starting with 20.5 oz of Fixer Part 3, 11.5 oz of water was added to make 32 oz. Instructions were provided for mixing 32, 64, 96 and 128 oz. With the exception of the bleach, 75^{o}F water was used to mix the chemistry, as recommended (14).

The working strength developer can be stored up to four weeks in full bottles, but only two weeks in partially filled bottles. The bleach and fixer can both be stored four to six months (14).

A package of neutralizing powder was also supplied in the processing kit. After each processing step, the chemistry or wash should be poured into a polyethylene container to be neutralized. An 8 x 10 in print required two teaspoonsful of neutralizing powder (14).

To process an 8 x 10 in Cibachrome print, 3 oz of each chemistry was required. Small containers labeled developer, bleach, and fixer are included in the processing kit. Each has a mark for the level of chemistry needed (3 oz per 8 x 10 in print). All the chemistry and the water rinses should be at $75^{o}F \pm 3^{o}F$ for optimum results, however instructions for $68^{o}F$ and $85^{o}F$ are also supplied in the Cibachrome Color Print Manual (9). The $75^{o}F$ temperature was used for the prints made for this research.

The first processing step is the developer. The step is 2 min long. Rapid irregular agitation is recommended for the first 15 sec, followed by gentle uniform agitation for the remainder of the development. A 15 sec drain time is included in the 2 min development time. The developer should be discarded into the container holding the neutralizing powder.

The second step was the bleach. That step was 4 min long with the same procedure as the developer. A 15 sec rinse after the bleach is optional, to be used if there is an unpleasant odor. The rinse was employed for all the processing used for this research.

The next step was the fixer, for 3 min. No special agitation was required in the beginning and the drain time was not included in the 3 min.

The final step was a 3 min wash in rapidly running water. The total processing time was 12.5 min. All the prints were hung to air dry. The preceeding processing procedure was used for all the prints used for this research. See table 1 for processing information.

TABLE 1

CIBACHROME PROCESSING AT 75°F

Procedural Steps	Processing Time (in minutes)
1. Develop	2
2. Bleach	4
3. Rinse	0.25
4. Fix	3
5. Wash	3

To make the first exposure, the basic filter pack was found on the back label of the print material envelope. For the particular package used for this research, 30 cyan, 0 magenta, and 55 yellow was recommended. (From hereforth the filters will be abbreviated with the first letter of their name). The information supplied with the printing material recommended using a mask to make four exposures on a single sheet of paper (15). The time was kept constant and the aperture of the enlarger was changed one stop for each exposure. The exposures made were 12 seconds at f/4, 5.6, 8, and 11 in a clockwise fashion beginning in the upper left corner (see Illustration 1).

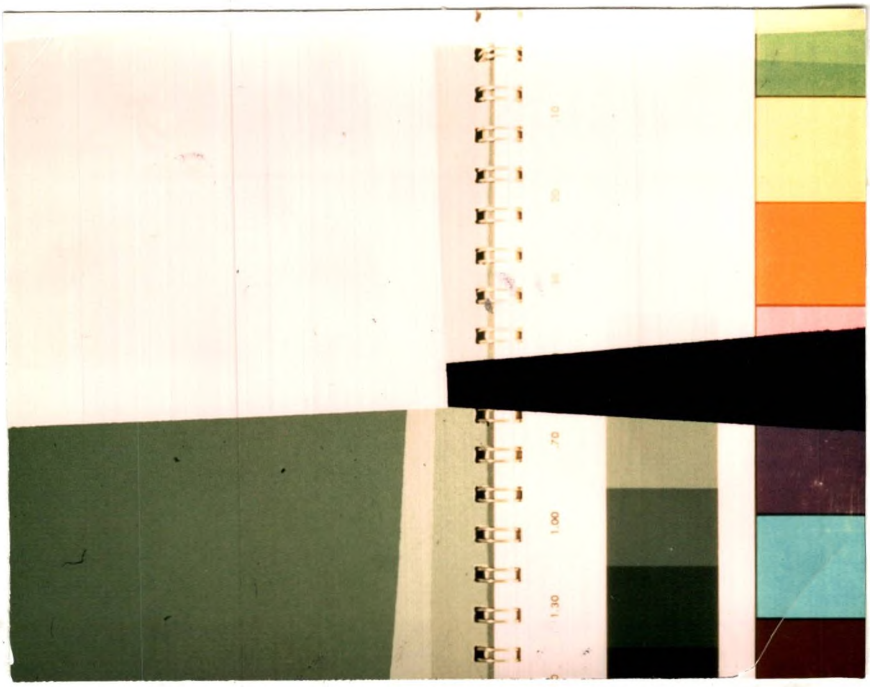

Illustration 1. Cibachrome: 30C OM 55Y, 12 seconds, f/4, 5.6, 8, 11.

After evaluation of the dry print, the correct density was chosen by evaluation of the gray area and the grey scale. By comparing the grey scale with the grey density patches on page 7 of the Kodak Color Dataguide, it could be seen that the exposure of

12 seconds at f/8 was correct. The next print was made with that exposure and the same filter pack (see Illustration 2).

The color balance was then evaluated and on the basis of the grey area it was decided the print was too yellow. The next print was made with filtration of 30C OM 40Y. By subtracting yellow filtration, according to color theory, the print would become less yellow (see Illustration 3).

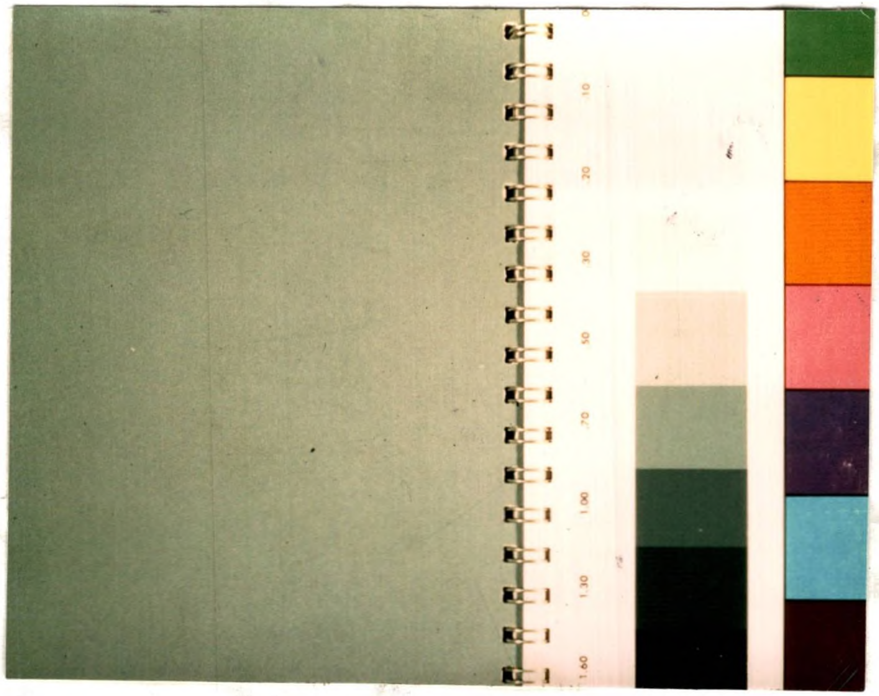

Illustration 2. Cibachrome: 30C OM 55Y, 12 seconds, f/8

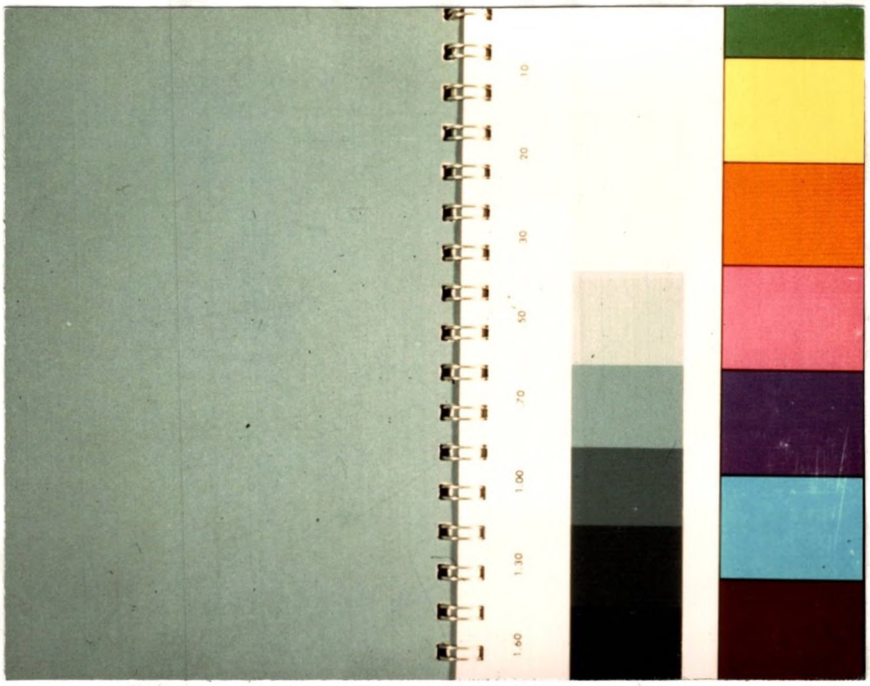

Illustration 3. Cibachrome: 30C 0M 40Y, 8.2 seconds, f/8.

After processing, the print was still too yellow so 10Y more was removed. The resulting print was made with 30C 0M 30Y and an exposure of 7.4 seconds at f/8. (8.2 - (8.2 x 10%) = 7.4). (see Illustration 4).

After processing and drying the print had the correct color balance and density, based on evaluation of the grey area and the white area.

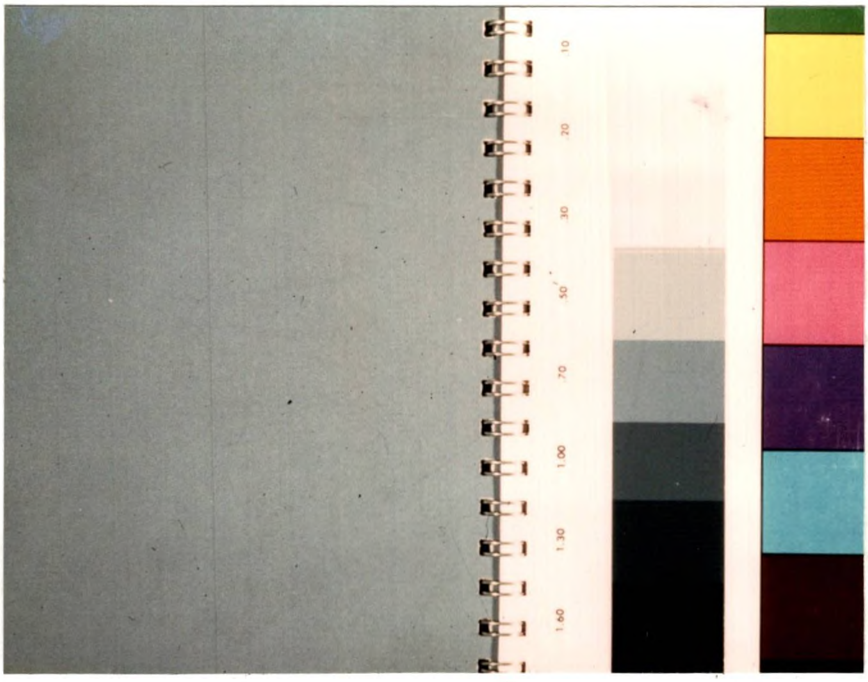

Illustration 4. Cibachrome: 30C OM 30Y, 7.4 seconds, f/8.

The next step was to print the second transparency with the same exposure and filtration. With the exception of the blue which was very light, the print was close to the original transparency in color and detail (see Illustration 5).

The Kodak Process

Kodak Ektaprint R-1000 chemistry (initially available as MX 1077-1), was designed for use with Kodak 2203 paper. The chemicals were available in separate units instead of a complete kit. Five

Illustration 5. Cibachrome: 30C OM 30Y, 7.4 seconds, f/8.

solutions were used: first developer, stop bath, color developer, bleach - fix, and stabilizer. The smallest quantity available was one gallon and partial quantities could not be mixed.

All the components were concentrated liquid, premeasured, ready to be diluted. The first developer, stop bath, and stabilizer were single concentrates that were diluted in 64 oz of water from 70 - 100^{o}F. After the concentrate was mixed in, water was added to bring the total volume to one gallon.

The color developer and the bleach-fix each consisted of three concentrated liquids that were added to 64 oz of water. The author had a problem with the first color developer that was mixed. It appeared to have a black grease film on it. Discussion with Kodak revealed that Part A must be mixed very well in order for it to be completely dissolved into a solution. This was not reflected in the mixing instructions at the time, but they have been revised and so are slightly more explicit. It was also recommended that water at 100°F be used. If the black scum still occurs, by straining the developer through cheesecloth and heating and stirring until it clears it should be suitable for use. The color developer was the most expensive component of the R-1000 process so it was important it was mixed correctly.

The recommended processing temperature was 100°F and all the instructions were directed toward that temperature. Two options for processing were given. The first was to use a processing drum in a water bath at 100°F ± 0.5°F. That required an accurate water bath which was unavailable so the second option was chosen. That method consisted of using chemistry over 100°F so the transfer of heat to the surroundings during processing would allow an average temperature of 100°F. The first developer had ± 0.5°F latitude while the other solutions and washes could be ± 2°F. For example, for a room temperature of 65°F, the starting temperature was 116°F. At 70°F room temperature the starting temperature was 114°F. For every 5°F increase in room temperature, the processing temperature was decreased 2°F. Kodak supplied data for room temperatures between

$65^{o}F$ and $90^{o}F$. For all the prints used in this research, a room temperature of $70^{o}F$ and a starting temperature of $114^{o}F$ were used. To keep the chemistry that warm, the measured quantity for each print, 2.5 oz was placed in a small stainless steel container in a water bath. Using heated water the temperature could be regulated quite easily (16).

To process a print with Kodak chemistry required 13.25 min. The drain time was included in the timing for each step. The first step was a 1 min prewet with water followed by first developer for 2 min. Stop bath was used for .5 min followed by two 1 min water washes. The color developer was also 2 min, followed by a .5 min water wash. The 3 minute bleach - fix was the longest step followed by three .5 min water washes. Stabilizer required .5 min followed by the last .25 min rinse. See Table 2 for processing times (16).

Because of the number of short steps; processing required the full attention of the person doing it. One observation was the prewet and first developer were pink when discarded. It was unknown to this researcher if that was significant.

Kodak supplied a booklet in each box containing the concentrates for mixing the color developer (16). In that booklet, the exposure and processing instructions were supplied. A starting filter pack of 20C 20M OY was recommended with trial exposures of 2, 4, and 8 sec at f/8 for an 8 x 10 in print. (In publication E-85, "Kodak Ektachrome 2203 Paper, different information was given but because that publication may not be readily available to everyone, the

TABLE 2

KODAK PROCESSING AT 100^{o}F

Procedural Steps	Processing Time (in minutes)
1. Prewet	1
2. First Developer	2
3. Stop Batch	0.5
4. Wash	1
5. Wash	1
6. Color Developer	2
7. Wash	0.5
8. Bleach-Fix	3
9. Wash	0.5
10. Wash	0.5
11. Wash	0.5
12. Stabilizer	0.5
13. Rinse	0.25

recommendations from the booklet supplied with the color developer were used). Because 4 x 5 in prints were used instead of 8 x 10 in the first trial exposures were made 2,4,8, and 16 sec at f/11. After processing, evaluation of the 70 percent grey area and the grey scale indicated 16 sec at f/11 provided the correct density. See Illustration 6. The next exposure was made with that data, (see Illustration 7).

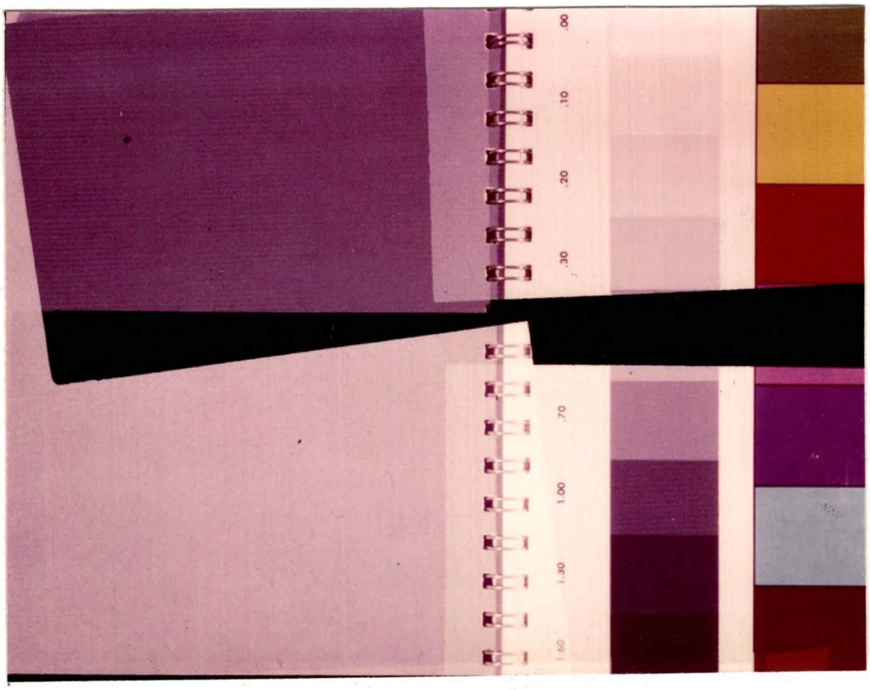

Illustration 6. Kodak: 20C 20M OY, 2, 4, 8, 16 seconds, f/11.

Upon evaluation of that print it was noted there was an excess of magenta. The next filter pack was 20C OM OY with an exposure time of 11.4 sec at f/11. (16 ÷ 1.4 = 11.4). After processing the print was evaluated and found to be correct in color balance and density, (see Illustration 8). To confirm the decision another exposure with a filtration of 40C OM 20Y and 16 sec at f/11 was made. (11.4 = 1.4 - 16). That resulted in a print with a green cast over the grey areas (see Illustration 9).

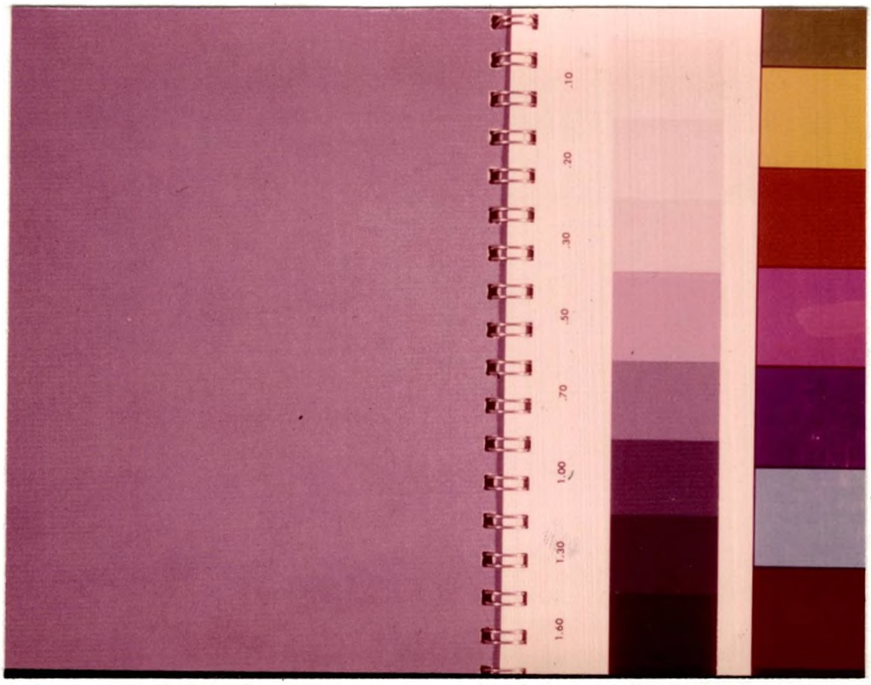

Illustration 7. Kodak: 20C 20M OY, 16 seconds, f/11

The second transparency was printed with filtration of 20C OM OY and 11.4 sec at f/11. The color tended to be slightly magenta but the detail was good, (see Illustration 10).

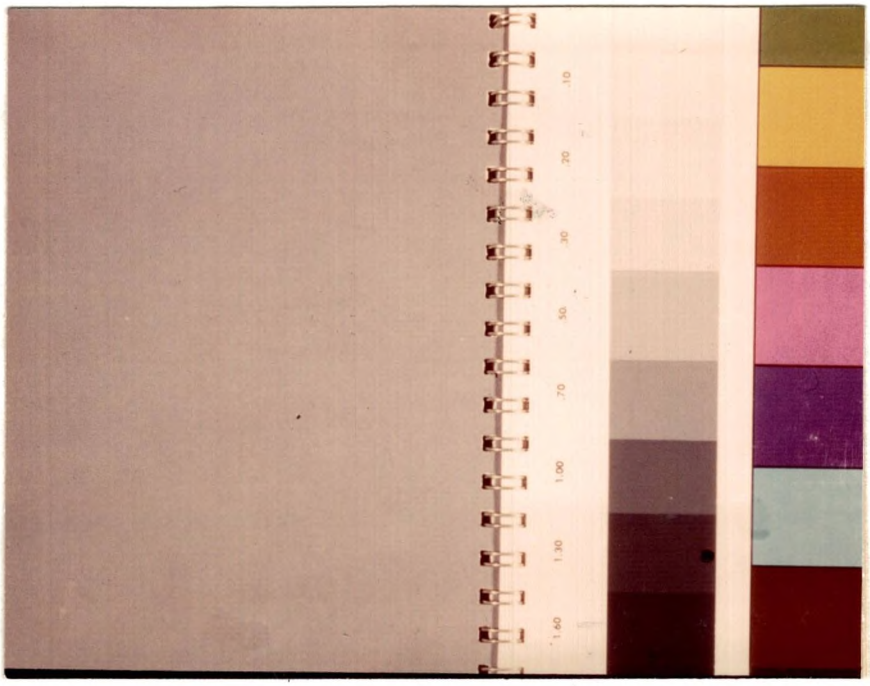

Illustration 9. Kodak: 40C OM 20Y, 16 seconds, f/11

for mixing 5, 6, 7, 8, 16, and 32 oz of working solution were also included (17).

All the working solutions were mixed using water from 70 - 80°F. The first developer consisted of one concentrate that was diluted, 12 oz of water and 4 oz of concentrate.

To mix the color developer required 1 oz of Part A, 2 oz of Part B, and 1 oz of Part C which were added to 12 oz of water and mixed, one at a time in order.

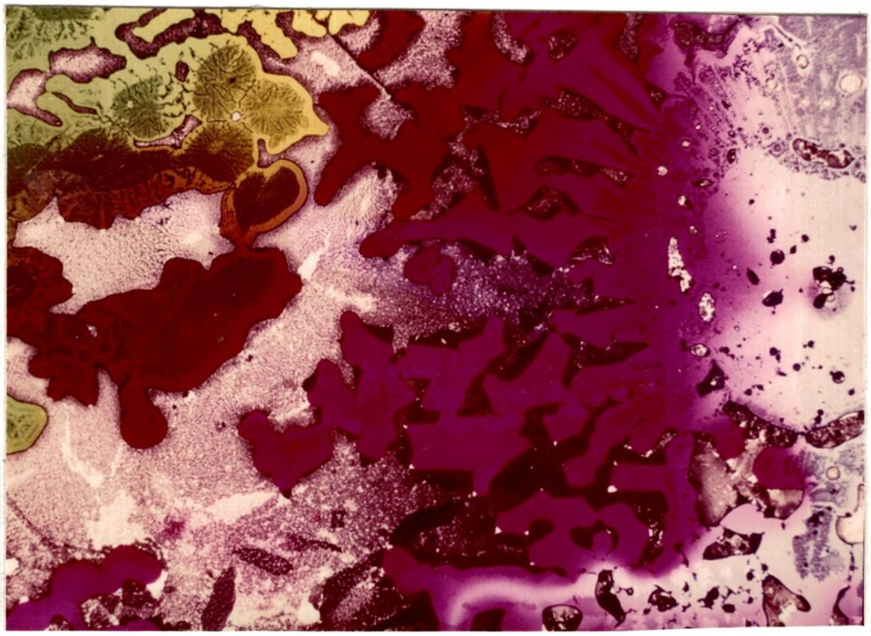

Illustration 10: Kodak: 20C OM OY, 11.4 seconds, f/11

The blix also had three parts, requiring 7 oz of water to begin, then adding 4 oz Part A, 4 oz Part B, and 1 oz Part C. Since all the components were liquid, mixing time was short.

Unicolor didn't recommend storing the working solutions but did say they could be stored up to two weeks in full glass bottles if necessary. The unopened chemistry could be kept up to two years and the opened concentrates with all the air squeezed out could be kept up to one year (17).

The instruction sheet supplied with the chemistry also included exposure and processing information, but referred the reader to the instruction sheet supplied with the paper for further information (17).

To process a print, the solutions could be at 70°F, 85°F or 100°F. At 70°F the processing time was 14 min, at 85°F, 12.5 min and at 100°F, 10.5 min. The presoak water and washes must always be at 100°F. No latitude for the temperature of the processing solutions was given. For simplicity of having all the solutions and water at the same temperature and to save time, the 100°F processing temperature was chosen for this research (17).

There were three options for the presoak step given. The processing drum could be filled with 100°F water before exposure to warm up at which time the paper is loaded, or the paper could be loaded into the dry drum and filled with water at 100°F and allowed to stand 1 min, or 16 oz or 100°F water could be poured into the loaded drum and agitated 1 min. For this research, all the water had to be heated in a water bath, so to conserve water the last option was chosen (17).

The instructions for chemistry quantities referred the reader to the instructions for the particular processing drum being used. The Unidrum instructions for the 8 x 10 in drum recommended using 2 oz of chemistry, so that quantity was used (18).

For the water washes, 16 oz of the 100°F water should be dumped into the drum, agitated 15-20 sec and discarded so as to obtain one complete rinse every 30 sec. Thus if the rinse time was 2 min, four rinses would be completed in that length of time. That procedure required a large amount of warm water. For the other steps, the draining should not be started until the time for that step had expired (17).

Table 3 shows the processing steps and their respective times for 100^{o}F.

TABLE 3

UNICOLOR PROCESSING AT 100^{o}F

Procedural Steps	Processing Time (in minutes)
1. Presoak	1
2. First Developer	1.5
3. Wash	2
4. Color Developer	3.
5. Wash	0.5
6. Blix	2
7. Wash	1.5

The presoak was 1 min, so the total time was 11.5 min, not including the 10 sec drain times for the developers and blix, which made the total processing time 12 min.

Since the instruction sheet provided with the chemistry recommended a beginning filter pack of 40C OM 40Y and an exposure to 10 sec at f/5.6 to f/8, but referred the reader to the leaflet supplied with the Kodak 2203 paper for additional information, the information on exposure was taken from the latter. A starting filter pack of 20C 20M OY for Kodakchrome transparencies was recommended. It was also stated the Ektachrome transparencies require more cyan filtration, consequently the beginning filter pack chosen was 40C 20M OY (16).

The exposure time recommended for an 8 x 10 in print was 4 sec at f/8. Since the prints produced for this research were 4 x 5 in, the first tests were made using an exposure time of 5 sec at f/4, 5.6, 8 and 1. Five sec instead of 4 sec was used because of the extra cyan filtration (16).

After processing, the density was evaluated and on the basis of the 70 percent grey area and the grey scale, 5 sec at f/4 was chosen as the correct density, (see Illustration 11).

The second print was made at that density with the same filtration. After processing the color balance was evaluated and found to be very magenta, (see Illustration 12).

The next print was made with filtration of 60C OM 20Y, which was 40M less than the previous print, and an exposure of 5.5 sec at f/4, (5.00 x 1.1 = 5.5). After processing, the print was evaluated. (see Illustration 13). Since the print was too red, 30C was added and the resulting filter pack was 90C OM 20Y. An exposure of 7.7 sec at f/4 was made. (5.5 x 1.4 = 7.7). After processing the print was evaluated. (see Illustration 13). The white areas still appeared magenta also the next print was exposed with a filter pack of 110C OM 40Y and an exposure of 11 sec at f/4 (see Illustration 15).

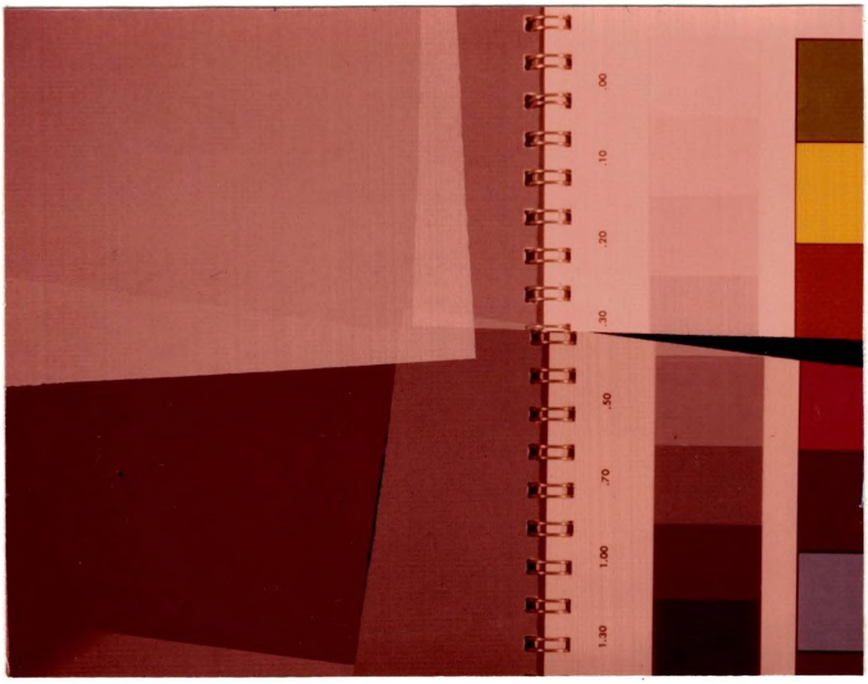

Illustration 11. Unicolor: 40C 20M OY, 5 seconds, f/4, 5.6, 8, and 11

The resulting print had a green cast on the grey areas and a magenta cast on the white areas. By referring to the color theory, it was evident that to increase the cyan and yellow filtration to remove the magenta would produce a grey area with a dark green cast. Two more exposures were made to confirm the choice of 90C OM 20Y as being the best.

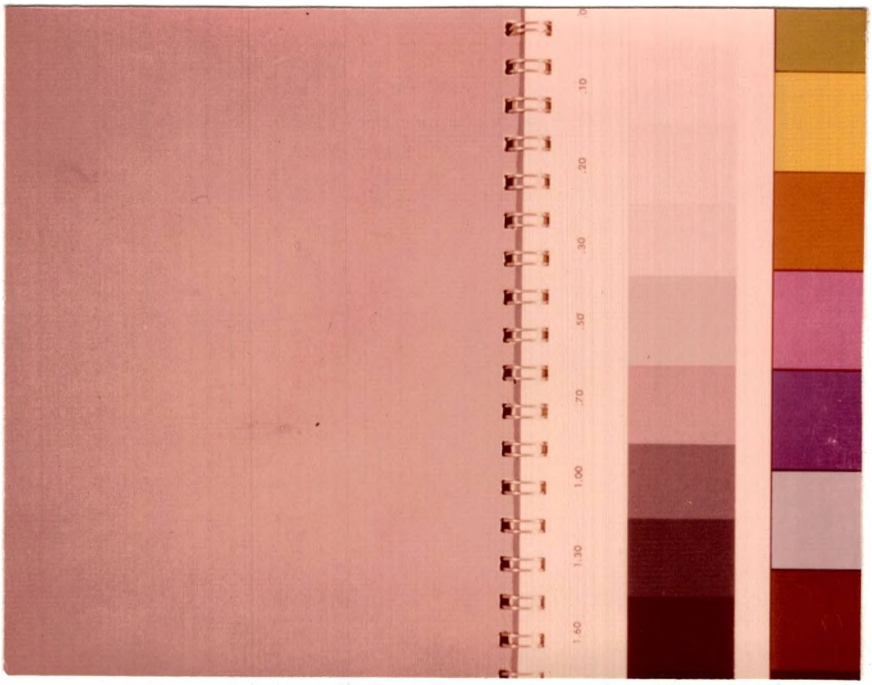

Illustration 12. Unicolor: 40C 20M OY,
5 seconds, f/4.

The next exposure was 110C OM 20Y at 10 sec at f/4. (7.7 x 1.3 = 10). The print still had a green cast on the grey and a magenta cast on the white, (see Illustration 16).

The next exposure made was 8.5 sec at f/4 with a filter pack of 90C OM 40Y. (7.7 x 1.1 = 8.5). The resulting print also had a green cast on the grey and a magenta cast on the white, (see Illustration 17).

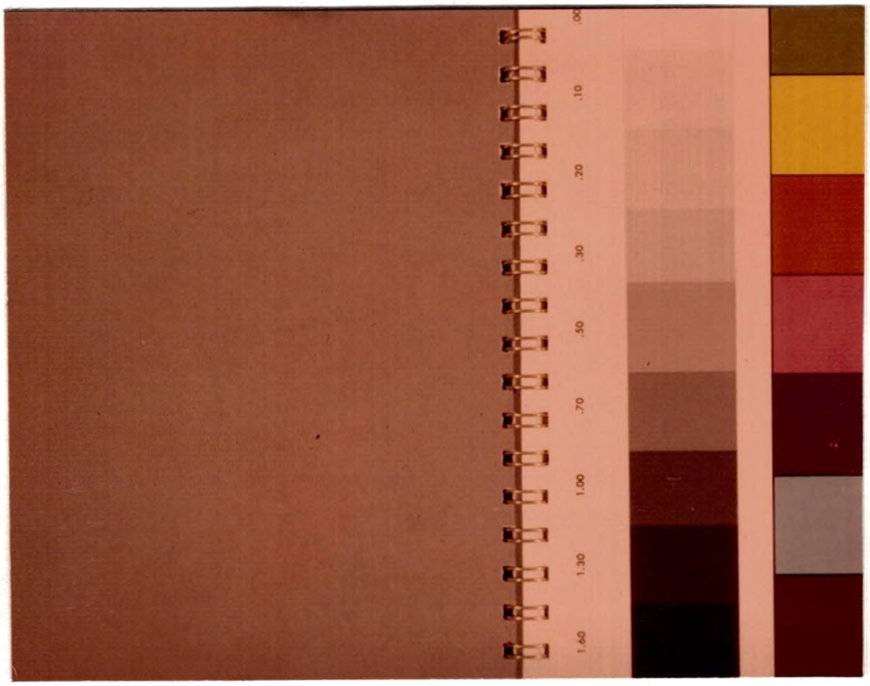

Illustration 13. Unicolor: 60C OM 20Y, 5.5 seconds, f/4.

Using the grey area as the standard, the 90C OM 20Y print was judged as being the best, and the succeeding exposures were made with that filter information. Because the results appeared undesirable, completely new chemistry and paper were purchased and used, but the results were very magenta even with the best filtration based on color theory.

Illustration 14. Unicolor: 90C OM 20Y, 7.7 seconds, f/4.

After the second transparency was printed with a filtration of 90C OM 20Y and an exposure of 7.7 sec at f/4, it was evaluated. The colors were not true although a general image of the original transparency was obtained. The tan tended toward grey, and the other colors were not as bright as the original transparency. The detail also was not very good (see Illustration 18).

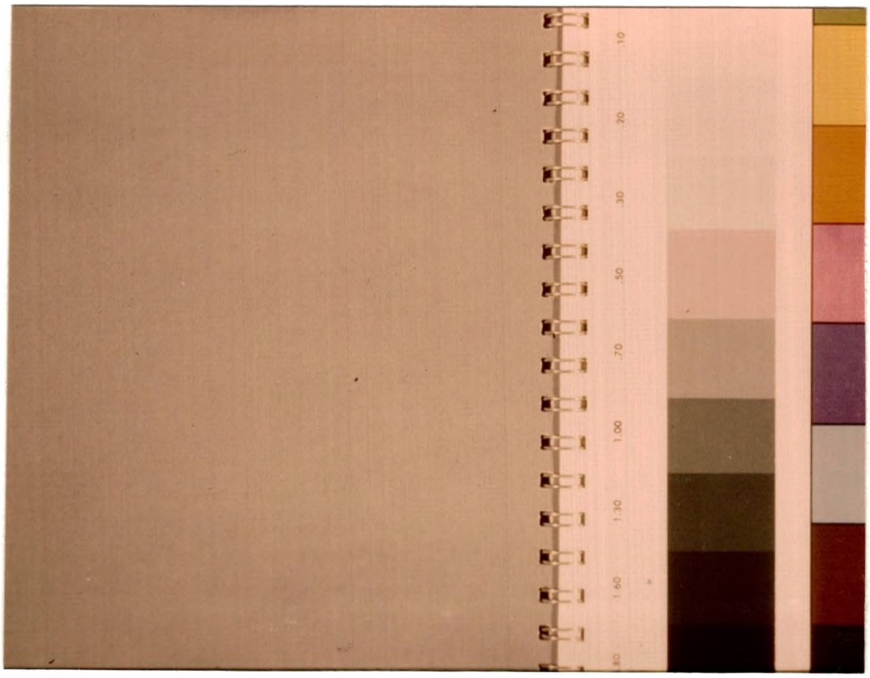

Illustration 15: Unicolor: 110C OM 40Y, 11 seconds, f/4.

<u>Interchangeability Study</u>

The possibility of interchanging the chemistry or printing materials among the three processes could allow for a reduction in cost if the materials were compatible. With the exception of the Kodak and Unicolor lines, there were no data available on the feasibility of that procedure. In an attempt to provide information an interchangeability study was done.

For the first print, Kodak paper was exposed and processed with Cibachrome chemistry. The result was a completely white print,

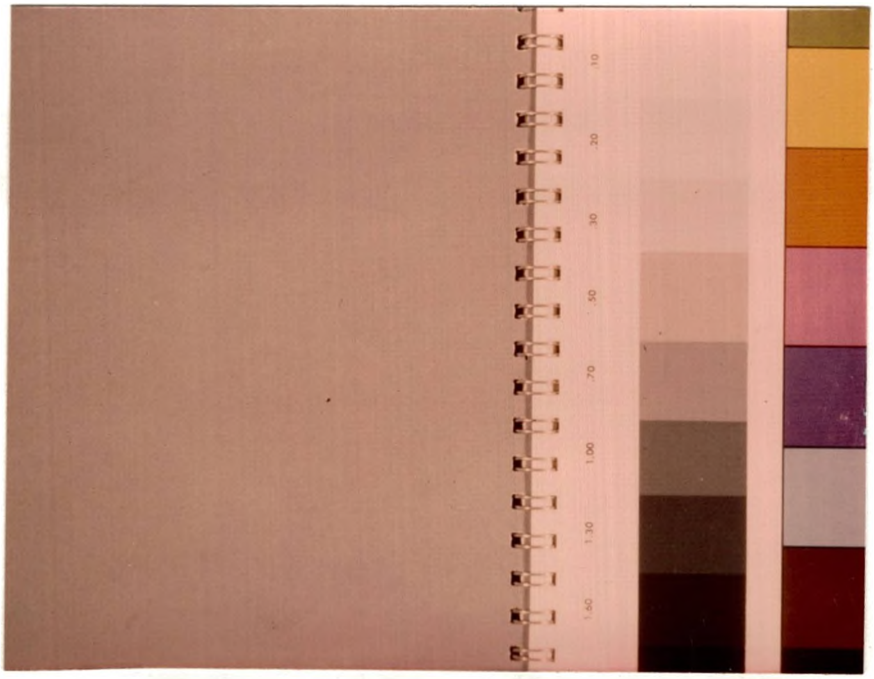

Illustration 16. Unicolor: 110C OM 20Y, 10 seconds, f/4

(see Illustration 18).

The next two prints were made using exposed Cibachrome printing material and Kodak and Unicolor chemistry respectively. The results were identical, black prints. From those results, it could be seen that it would not be feasible to use any of the Cibachrome materials with the Kodak or Unicolor processes or vice versa, (see Illustrations 20 and 21).

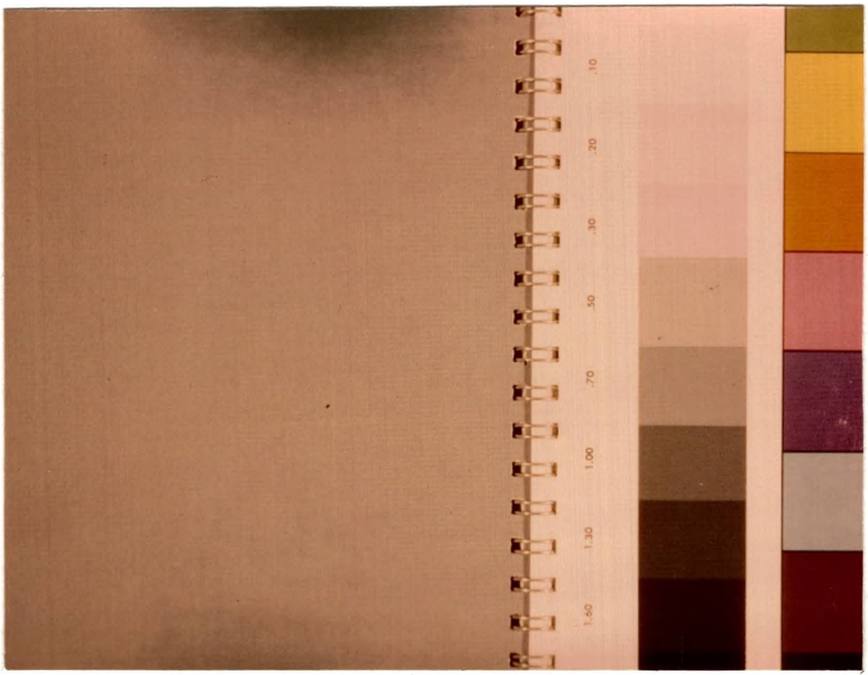

Illustration 17: Unicolor: 90C OM 40Y, 8.5 seconds, f/4

Contamination Study

Very thorough cleaning of the processing drum was necessary after each use to insure the developer of the next process would not be contaminated. But since it was a very real possibility that contamination could occur by that means or some other way, an experiment was done to determine the effects if the developer(s) were contaminated.

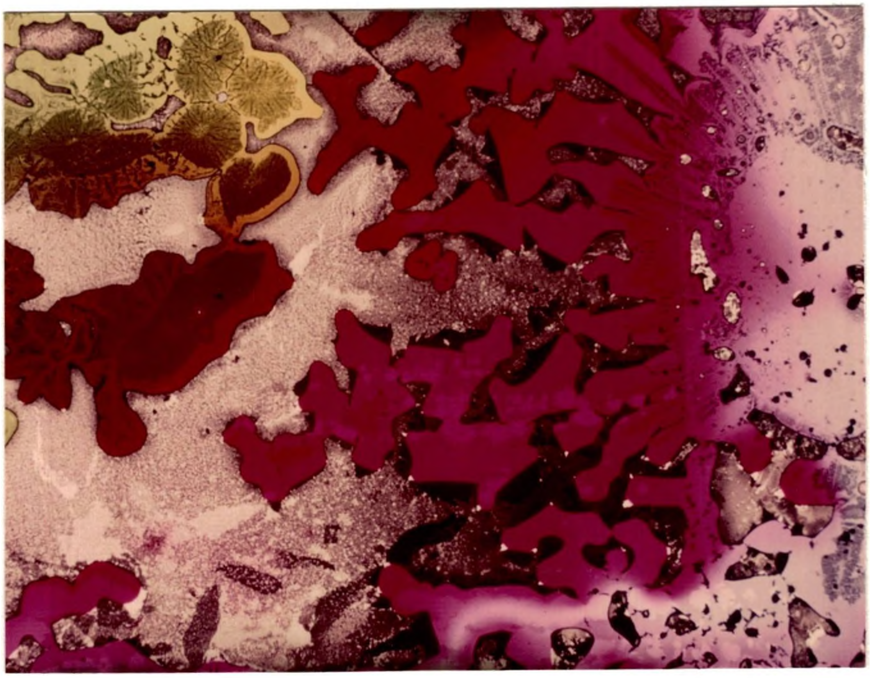

Illustration 18: Unicolor: 90C OM 20Y, 7.7 seconds, f/4

To contaminate the first developer, the processing drum was rinsed with the chemistry chosen for the experiment. The properly exposed prints were then loaded and processed as before.

When the Cibachrome developer was contaminated with bleach, it could be seen that the color balance was changed from a neutral grey to a greenish grey. The white also became slightly yellow. There wasn't any significant change in density or in the hue of the color patches. The borders of the print remained black, (see Illustration 22).

Illustration 19. Cibachrome Chemistry, Kodak Paper

When the developer was contaminated with fixer, the entire print assumed a dark magenta and the density was increased significantly. The print borders turned dark blue instead of the normal black, (see Illustration 23).

The Unicolor first developer was contaminated with blix. The result was an entirely white print, (see Illustration 24).

The color developer was contaminated by adding a small amount of blix to the color developer before it was added during the

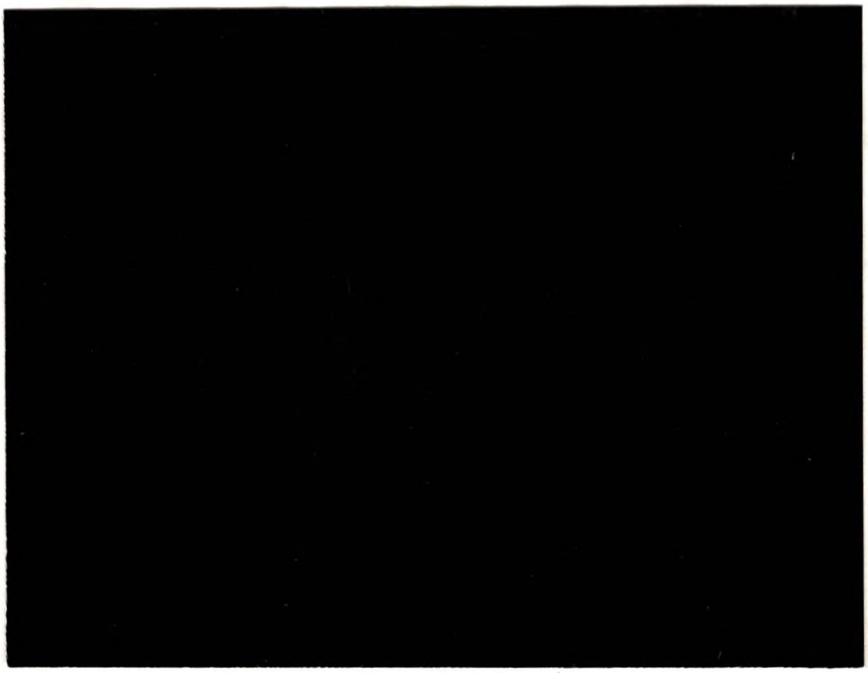

Illustration 20. Kodak Chemistry, Cibachrome printing material

processing. The result was a print with a violet cast over it entirely. The edges were dark violet and the density was noticeably reduced. All the color patches were different shades of violet, (see Illustration 25).

When the Kodak first developer was contaminated, with bleach-fix, the resulting print was pure white with light blue edges, (see Illustration 26).

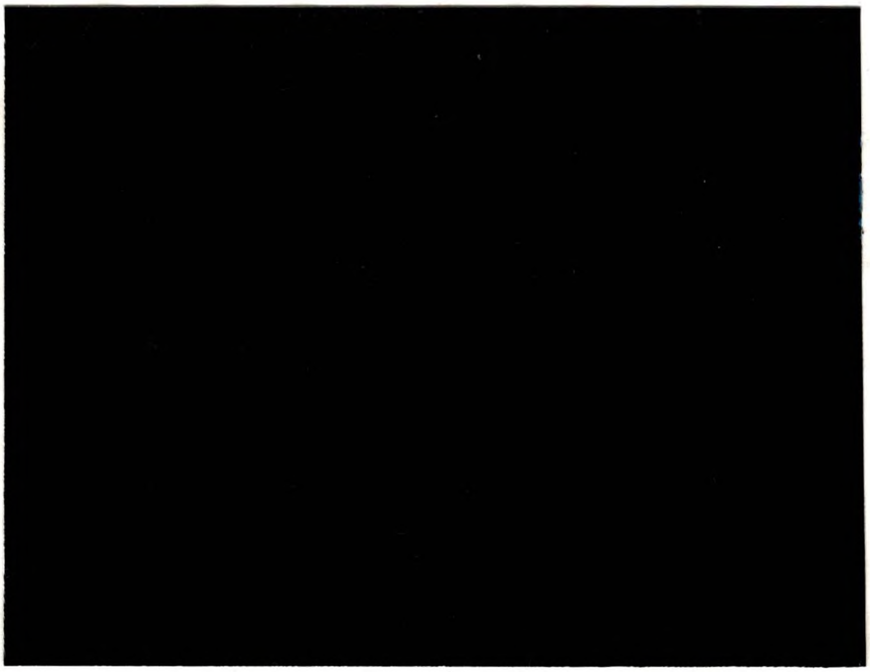

Illustration 21. Unicolor Chemistry, Cibachrome printing material

When the first developer was contaminated with stabilizer, the resulting print was normal in density, but the entire print had a light magenta overcast. The overcast was irregular, being heavier in some places than others. The color patches were normal in color, (see Illustration 27).

Illustration 22. Cibachrome Developer contaminated with bleach

When the Kodak color developer was contaminated with bleach-fix, the resulting print had a blue overcast and dark blue edges, with no change in density. All the color patches were abnormal in color, (see Illustration 28).

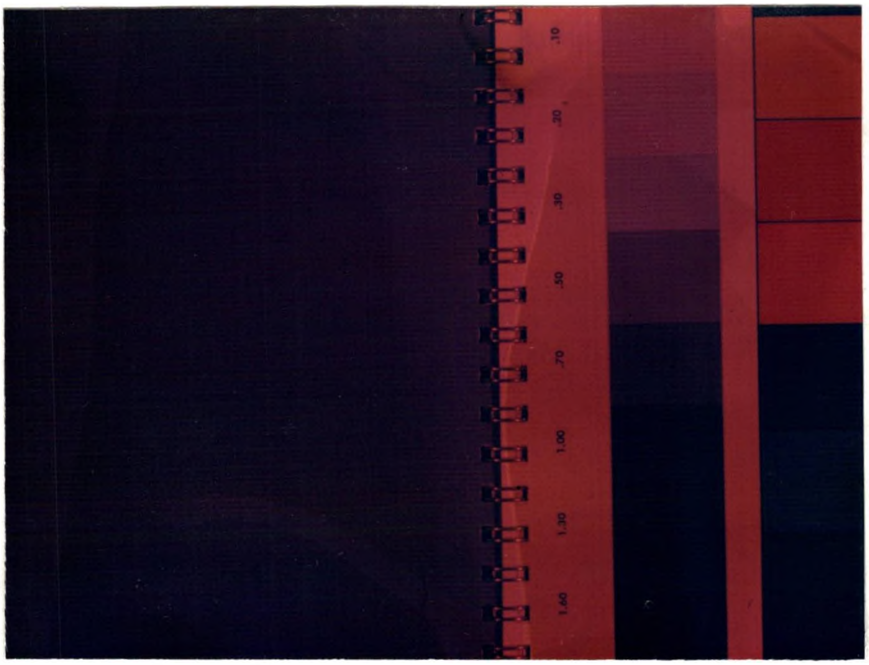

Illustration 23. Cibachrome Developer Contaminated with Fixer

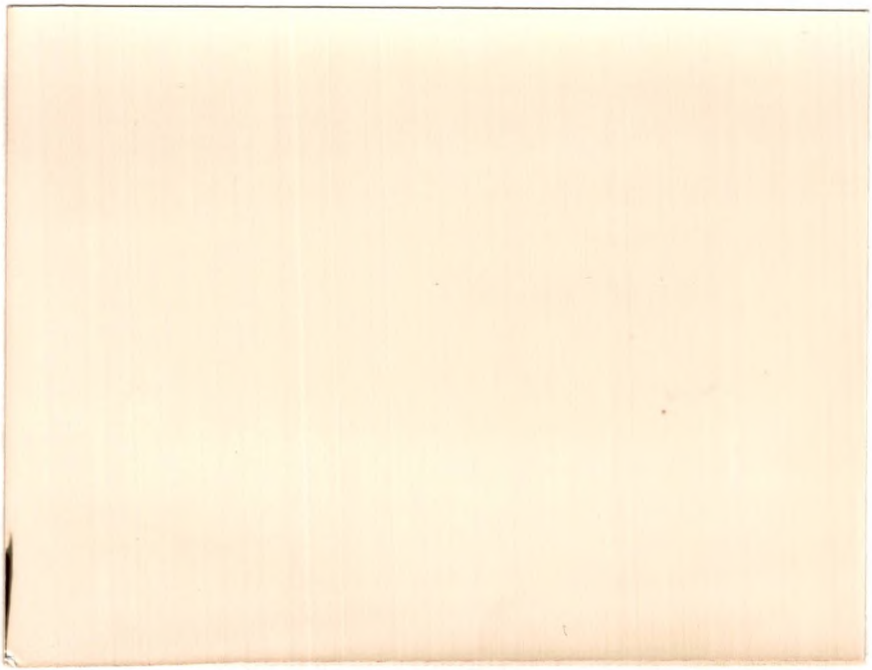

Illustration 24. Unicolor First Developer
Contaminated with Blix

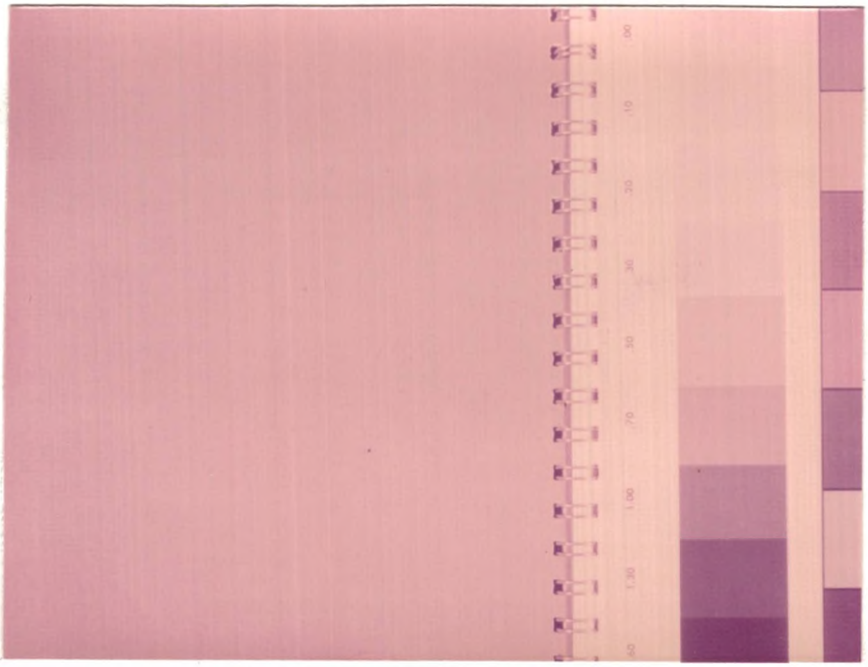

Illustration 25. Unicolor Color Developer Contaminated with Blix

Illustration 26. Kodak First Developer Contaminated with Bleach-Fix

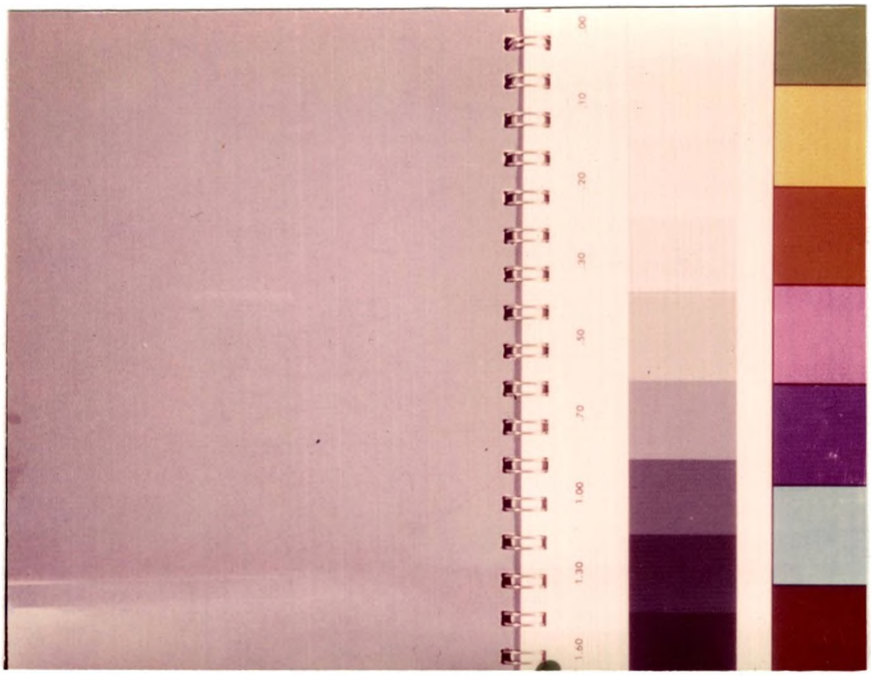

Illustration 27. Kodak First Developer Contaminated with Stabilizer

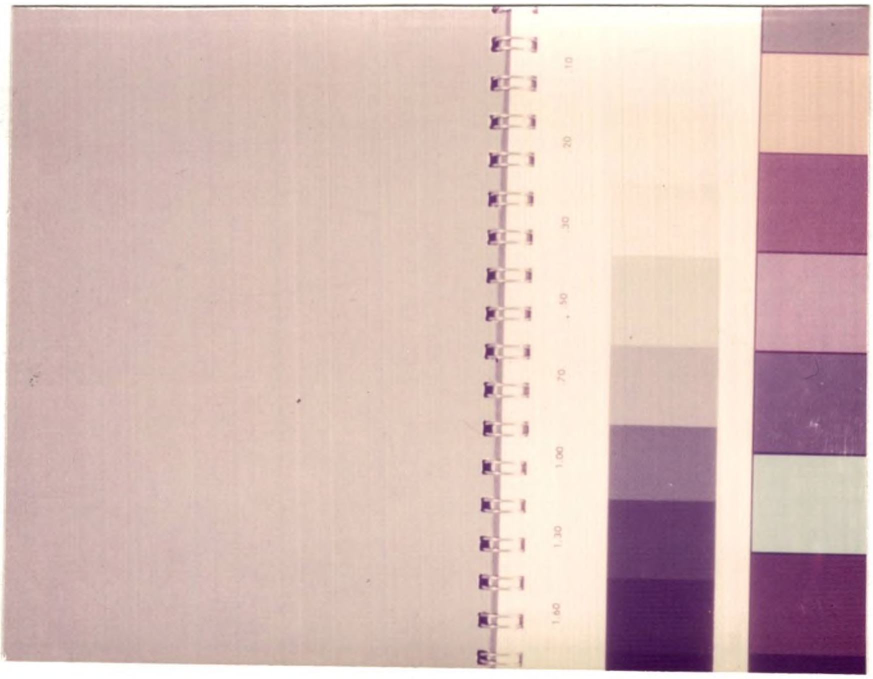

Illustration 28. Kodak Color Developer Contaminated with Bleach-Fix

Evaluation and Analysis

The evaluation form was presented to three photographers and the results were tabulated in Table 4. The best print from each process with the grey area, grey scale and color patches (See Appendix I for a copy of the evaluation instrument) on it were used.

TABLE 4

EVALUATION RESULTS OF COLOR HUE

Color Hue	Kodak			Cibachrome			Unicolor		
	Evaluator Rating		Average Rating	Evaluator Rating		Average Rating	Evaluator Rating		Average Rating
Green	4 2 1	=	2.3	3 4 1	=	2.7	3 1 1	=	1.7
Yellow	5 2 1	=	2.7	4 4 1	=	3.0	2 1 1	=	1.3
Red	2 2 1	=	1.7	4 3 1	=	2.7	2 1 1	=	1.3
Magenta	2 4 1	=	2.3	3 3 1	=	2.3	3 1 1	=	1.7
Violet	3 4 1	=	2.7	4 3 1	=	2.7	2 1 1	=	1.3
Cyan	3 4 1	=	2.7	3 3 1	=	2.3	1 1 1	=	1.0
Brown	2 3 1	=	2.0	3 4 1	=	2.7	3 1 1	=	1.7
White	4 3 3	=	3.3	4 3 1	=	2.7	3 1 1	=	1.7
Grey	3 2 5	=	3.3	3 3 1	=	2.3	3 1 1	=	1.7
AVERAGE			2.56			2.60			1.49

Print 1 was Kodak, Print 2 was Ilford and Print 3 was Unicolor. The results indicated that Ilford had the best hue, Kodak was second and Unicolor was last. The scale was a five point one, with five being excellent and one very poor.

The density evaluation was Kodak = 2, Cibachrome = 2.7, and Unicolor = 1 on a five point scale, five being the best possible. Again, Cibachrome was the highest, Kodak second, and Unicolor the lowest.

The results of the saturation evaluation can be found in Table 5.

TABLE 5

EVALUATION RESULTS OF COLOR SATURATION

Color Hue	Kodak			Cibachrome			Unicolor		
	Evaluator Rating		Average Rating	Evaluator Rating		Average Rating	Evaluator Rating		Average Rating
Green	2 1	=	1.5	3 2	=	2.5	1 3	=	2.0
Yellow	2 1	=	1.5	3 2	=	2.5	1 3	=	2.0
Red	2 1	=	1.5	2 2	=	2.0	1 3	=	2.0
Magenta	2 1	=	1.5	2 2	=	2.0	1 3	=	2.0
Violet	2 1	=	1.5	2 2	=	2.0	1 3	=	2.0
Cyan	2 1	=	1.5	2 2	=	2.0	1 3	=	2.0
Brown	1 1	=	1.0	3 2	=	2.5	1 3	=	2.0
White	2 1	=	1.5	1 2	=	1.5	1 3	=	2.0
Grey	2 1	=	1.5	2 2	=	2.0	1 3	=	2.0
AVERAGE			1.44			2.11			2.0

One of the evaluators did not answer the question pertaining to print 2 and print 3 so the average was obtained from two evaluations for all prints. Print 1 was Kodak, Print 2 was Cibachrome, and Print 3 was Unicolor. Cibachrome rated the highest, Unicolor second, and Kodak the lowest.

The averages on the color hue were Kodak = 3, Cibachrome = 3.3 and Unicolor = 1.7. Again Cibachrome rated the highest, Kodak second and Unicolor the lowest.

The averages on the detail were Kodak = 3.7, Cibachrome = 3.7, and Unicolor = 2.7. On that evaluation Kodak and Cibachrome were equal, with Unicolor the lowest.

Using the averages obtained from the three evaluations, Cibachrome rated the highest on all criteria except detail where Kodak rated equally. Unicolor rated the lowest on all evaluations except saturation where Kodak was the lowest.

Cost Analysis

The cost analysis found in Table 6 was completed on March 18, 1980 and reflects the prices on that date. The prices are based on the smallest quantity chemistry available to process 8 x 10 in paper.

TABLE 6

COST ANALYSIS

Processing Materials	Cost/unit	Cost/8 x 10 in print
Unicolor RP-1000 Kit, 1 qt.	= $13.95	= $ 0.87
Kodak 2203 paper - 25 sheets	= 14.60	= 0.58
Cibachrome P-12 processing kit 2 qt.	= 17.95	= 0.84
Cibachrome printing material 20 sheets	= 28.95	= 1.45
Kodak R-1000 chemistry - 1 gal		
first developer	= 3.70	
stop bath	= 1.30	
color developer	= 10.50	

TABLE 6--(Continued)

Processing Materials		Cost/unit		Cost/8 x 10 in print
bleach-fix	=	11.95		
stabilizer	=	1.75		
TOTAL	=	29.20	=	0.57

The Kodak process was the least expensive at $1.15 per 8 x 10 in print. The Unicolor is second at $1.45 and Cibachrome was the most expensive at $2.29. These figures were based on the recommended quantity of processing chemistry for each 8 x 10 in print.

Table 7 summarizes the advantages and disadvantages for all three processes used in this research experiment.

TABLE 7

SUMMARY OF ADVANTAGES AND DISADVANTAGES

	Ilford Cibachrome	Kodak	Unicolor
Cost/8 x 10 in	\$2.29	\$1.15	\$1.45
Processing Time	12.5 min	13.25 min	12 min
Recommended Temperature	75°F	100°F	none given*
Latitude	± 3°F	± 0.5°F	none given
Quantity of water for rinses	running water	5 oz/rinse 40 oz total	16 oz/rinse 114 oz total
Need temperature control system	no	yes	yes
Simplicity of process	Very	most complex	more complex
Possible to mix partial quantities of chemistry	yes	no	yes
Smallest quantity of chemistry available	2 qt	1 gal	1 qt
Storage life	developer - 4 wks. other - 4-6 mo.	devel. & bleach-fix- 4 weeks stab/stop 8 weeks	2 weeks
Number of chemical solutions neutralizing power	3	5	3
Quantity of chemistry/ 8 x 10 in print	3 oz	2.5 oz	depends on processing drum

*Instructions were given for 70°F, 85°F, and 100°F but no temperature was recommended as giving the best results.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The ability to produce color prints from color transparencies can be accomplished quite easily even in a darkroom with limited equipment. There are a number of processes available to do this, each with unique characteristics.

This research was concerned with: 1) identifying and selecting three processes used to produce color prints directly from color transparencies to be used as the basis for this research by a predetermined criteria, 2) experimenting with the selected processes used to produce color prints directly from color transparencies, 3) evaluating and comparing the selected processes for the purpose of identifying those more adaptable in a given situation, 4) to determine if it would be feasible to interchange the chemistry or printing material between processes, and 5) to document the results if the developer(s) for each process were contaminated.

Conclusions

By producing large color prints from color transparencies without sending them to a photo-finisher can be economical and feasible even with limited finances. Good quality can be obtained also.

The use of the processes described in this research can be a valuable tool to an instructor seeking to teach color theory. By experimenting with different filters, the theory of color can become less abstract and easier to understand.

Through the research it was noted that the Ilford (Cibachrome) process for producing color prints from color transparencies would be very suitable where funding would be available for materials but equipment would be limited. The results were good and could be obtained without the use of a temperature control system.

The Kodak process produced good results with a lower material cost, but because the chemistry can only be purchased in quantities of one gallon or greater, to be economical a large number of prints would need to be made before the developer expired (four weeks). A temperature control system was also necessary. It would be applicable where money was available for such a system.

The Unicolor process did not produce good results and is not recommended because of the material cost and final results.

The results of the interchangeability study indicated that the Ilford (Cibachrome) materials were not compatible with the Kodak or Unicolor materials.

The results of the contamination study indicated that if the developer(s) were contaminated, the results would be evident.

Table 7 compares many features of the three processes. A decision to use a process can be made by comparing the features found on that table.

Recommendations

It is the authors' recommendation that the Ilford process be used where funding is available for materials, equipment is limited and simplicity of the process is important. It is also a good choice if a small quantity of prints are to be made because the developer can be mixed in small quantities.

It is also the authors' recommendation that the Kodak process be used where a temperature control system is available and a large quantity of prints are to be made. The material costs are relatively low and the results are good.

The author does not recommend the Unicolor process at this time. The results were poor and the cost was higher for the advantages received. It is recommended that further research with the Unicolor processes be completed under more controlled conditions.

APPENDIX I

EVALUATION INSTRUMENT

Evaluation Part I

On the following page are 3 color prints labeled print 1, print 2, and print 3. Each has been made from a color transparency during the course of research for my thesis. Please evaluate them according to the following criteria. Use light reflected from the white piece of paper attached, to view the transparency.

COLOR HUE: Color hue refers to the trueness of a color. How does each of the color patches on the print compare with the color on transparency #1 in terms of hue? For example, does the blue appear the same or does it tend towards green or some other color?

1	2	3	4	5
very poor	poor	average	good	excellent

	Print 1					Print 2					Print 3				
Green	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Yellow	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Red	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Magenta	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Violet	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Cyan	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Brown	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
White	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Gray	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

DENSITY: The density on each print was judged by comparing with page 7 in the Kodak Professional Dataguide. Please compare the density of each print and circle the appropriate response. The density of the large area should be 70%.

1	2	3	4	5
very different	different	close	very close	exactly same

Print 1	Print 2	Print 3
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

COLOR SATURATION: How do the colors on the prints compare with the colors on the original transparency in terms of saturation? A saturated color is deep - not washed out or light.

1	2	3	4	5
very poor	poor	average	good	excellent

green	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
yellow	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
red	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
magenta	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
violet	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
cyan	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
brown	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
white	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
gray	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

ADDITIONAL COMMENTS (as desired).

Print 1

Print 2

Print 3

Evaluation Part II

On the following page are 3 additional prints made by the same processes from transparency #2. Please evaluate them according to the following criteria:

1	2	3	4	5
very poor	poor	average	good	excellent

OVERALL COLOR HUE: How does the print compare with transparency #2 in terms of overall color hue?

Print 1	Print 2	Print 3
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

DETAIL: In the background there are small details. Please rate the prints on the quality of the details as compared to transparency #2.

1	2	3	4	5
no detail	little detail	moderate detail	good detail	excellent detail

Print 1	Print 2	Print 3
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

ADDITIONAL COMMENTS (as desired).

Print 1

Print 2

Print 3

Appendix II

ORIGINAL TRANSPARENCIES

BIBLIOGRAPHY

1. Davis, Phil. Photography, 2nd ed. Dubuque: Wm. C. Brown Publishers, 1976.

2. Wall, E.J. and Franklin T. Jordan. Photographic Facts and Formulas, Garden City, New York: Ame-ican Photographic Book Publishing Co., Inc., 1976.

3. Color. Time-Life Series in Photography. New York: (Time Inc., 1970, revised 1975.

4. Upton, Barbara and John. Photography, Boston: Little, Brown and Co., Inc., 1976.

5. Sturge, John M. Neblette's Handbook of Photography and Reprography Materials, Processes and Systems. 7th ed. New York: Van Nostrand Reinhold Company, 1977.

6. Mitchell, Bob. Color Printing. Los Angeles: Peterson Publ. Co., 1975.

7. Eastman Kodak Company. Printing Color Negatives. Publication # E-66. Rochester, New York: Eastman Kodak Company, 1978.

8. Eastman Kodak Company. Basic Developing, Printing, Enlarging in Color. Publication # AE-13, Rochester, New York, Eastman Kodak Company, 1977.

9. Ilford, Inc. Cibachrome Color Print Manual, Paramus, New Jersey: Ilford Inc., 1978.

10. Eastman Kodak Company. Kodak Ektachrome 2203 Paper. Publication # E-85. Rochester, New York: Eastman Kodak Company, 1979.

11. Kennedy, Cora Wright. "Easiest Way Yet: Color Prints from Slides." Popular Photography, May 1975, pp. 58-60, 115, 117, 138, 178.

12. Geller, Karen Sue. "Tools of the Trade: Discovering Cibachrome." Petersen's Photographic Magazine, August 1978, p. 9.

13. Nadler, Bob. "The Color Darkroom: Update on Cibachrome Color Print Material Type A." Popular Photography, August 1977, pp. 121 and 179.

14. Ilford, Inc. Cibachrome Chemistry Kit Process P-12. Paramus, New Jersey: Ilford Inc., 1978.

15. Ilford, Inc. Cibachrome Color Print Material Type A. Paramus, New Jersey: Ilford, Inc., 1977.

16. Eastman Kodak Company. Tube- and Drum-Processing Kodak Ektachrome 2203 Paper Using Kodak Ektaprint R-1000 Chemicals. Rochester, New York: Eastman Kodak Company, 1979.

17. Unicolor Division, Photo Systems Inc. Notes, Mixing and Processing Instructions for Unicolor RP-1000 Chemistry. Dexter, Michigan: Unicolor Division, Photo Systems, Inc., 1979.

18. Unicolor Division, Photo Systems, Inc. Unidrum II Instructions, Dexter, Michigan: Unicolor Division, Photo Systems Inc., 1977.