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Digital archiving and reproduction of black and white photography

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Digital Archiving and Reproduction of Black and White Photography

By

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Certificate of Approval

Master's Thesis

This is to certify that the Master's Thesis of

Susan J. Hicks

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ABSTRACT

Capturing and reproducing black and white images are common problems for high quality print reproduction. This study compared the monotone reproduction quality of the Kodak Photo CD Master technology to the standard methods currently being employed using high resolution scanners such as the Agfa Horizon Scanner and the Optronics ColorGetter II. The Kodak Photo CD Master and the Optronics ColorGetter II were used to scan the original 35mm black and white film negatives. The negatives selected represent the various tonal ranges encountered by professional photographers. High key and low key images were included in the selection since these are the extreme density range of negatives.

The same six monotone images, obtained from a professional photographer, were scanned using either the negative or the "desired print." The flatbed scanners, the midrange Agfa Horizon and the low end Agfa StudioScan, captured the "desired print" as a digital file. The Optronics ColorGetter II, a drum scanner, and the Kodak Photo CD captured the monotone negative.

This study determined whether the image captured by the Photo CD Master scanner could produce the image quality that is required by professional photographers. Currently, quality printing uses high end scanners to capture high resolutions and detail. Photo CD's are being implemented for archival storage of digital images.

Traditional methods of scanning were also investigated to determine whether it is possible to digitally reproduce a monotone desired print accurately to satisfy a professional photographer. Digital duplication of the "desired print", with its darkroom manipulation, would be a significant achievement for the photographer. In using a digital format a photographer would be able to store and recall the

information and exactly duplicate a print without spending additional time custom printing. Adobe Photoshop 2.5.1 was used to globally and locally control the negative to reproduce the photographer's intent. A comparison was made between the "desired print" and the results obtained through the digital capture, manipulation, storage and printing of the image. Each digital image captured by the four scanners was printed on four different printers.

The four printers used in this study are:

The Canon Laser Copier 500	Color Electrophotographic Laser
The Hewlett Packard	LaserJet, monochrome electrophotographic laser
The 3M Rainbow	Dye Sublimation
The Epson Stylus	InkJet

This thesis questions whether the digital darkroom can replace the professional photographer's wet darkroom through the use of scanners, computers, software and desktop printers. It determins which method is best for capturing and reproducing the professional photographer's images. An evaluation of the final digital prints is made by a professional photographer.

Chapter 1

Introduction

A vast number of black and white images have been produced since the invention of the 35mm camera. No longer is the photographer limited to a single frame format. Storage of photographic images has been and continues to be a universal problem. The United States government and organizations dealing with enormous collections of images are interested in new methods for with the archival storage of film and prints. The Photo CD is an inexpensive storage device that is gaining in popularity as a possible archival storage solution for the professional photographer. The immediate retrieval ability, affordable cost, archival quality and large storage space on a disk of the Photo CD is of interest to professional photographers. Scans need to capture the full density range of the prints and negatives when archiving photographs. The Kodak Photo CD offers an inexpensive method of storage and cataloging images. Is the Photo CD the best solution for storing negatives which have extreme density values?

This study determined whether the Kodak Photo CD Master can store and reproduce monotone 35mm negatives comparable to the standard methods currently employed using a midrange scanner. The Photo CD scanner is capable of capturing a tonal range of approximately 2.8 density. Tonal compression occurs if the images exceed this range. The professional photographer has always been aware of the reproduction limits of the photographic image. Thus it may be possible to work within the limitations of the Photo CD process and still produce acceptable results.

This project answers which digital method is the best for the capture and reproduction of the "desired print." It determined whether to scan the negative or the

"desired print" and the advantages and disadvantages of each method. It also addresses which paths from input to output are the most time intense and the limitations of the devices implemented.

Professional photographers are interested in digital reproduction and the storage capabilities available for their archives. In addition, they are concerned with the computer and its electronic darkroom capabilities and how it compares to the darkroom "desired prints." The term "desired print" refers to a print with all the global and local corrections necessary to produce an image that is the intent of the professional photographer. When creating an image a photographer captures information from the original scene with camera and film. This creation process continues in the darkroom. It often takes over an hour to make a single "desired print". Attempting to duplicate the procedure and to produce an exact replica, is extremely difficult. The amount of paper and time spent on one image can be exorbitant. This study addresses whether this procedure can be duplicated digitally to the photographer's satisfaction.

Original monotone 35mm film negatives and original finished prints were obtained from Rochester Institute of Technology's Professor of Photography Owen Butler. Professor Butler has produced photographs for over 40 years. He has achieved acclaim as a printer and photographer and master of the zone system. Professor Butler selected six of his 5 by 7 inch black and white images which capture a variety of density ranges. High key and low key images were included in the selection and represent the extreme density range of negatives.

Reason for interest in the study

Control in the hands of the photographer

Professional photographers control the creative process, from making a photograph, to the manner in which it is printed in the darkroom. If given the opportunity most professional photographers would prefer to control their images

through the entire reproduction process, including desktop publishing. Controlling the development of signature books or self promotional pieces such as postcards, press kits, resumes, even ads would eliminate a second party.

Affordable and user friendly

Technological advancements in the desktop publishing industry have led to cost reduction in high quality equipment. Equipment that was used in midrange and highend print production has become affordable and more available to the general population. There are many new desktop printers on the market that professional photographers are considering for personal work.

Technology advancements

The software and graphic user interface(GUI's) such as Windows and the Macintosh has simplified the process and made desktop publishing user friendly for the photographer. Photographers often dislike working in the traditional wet darkroom and would prefer to work in an environment free of chemicals and in the light. Digital capture and conversion of images would eliminate hours spent in the darkroom and create an image file that can contain both the global and the locally controlled manipulation of prints. The ability of a photographer to produce work digitally and print on demand is of great interest to the professional photographer. In the past five years, the creation and development of digital printers and presses, like the Xeikon and the Indigo, have made short printing runs available at affordable costs. These digital presses have eliminated the need for films and have a quick turnaround time. Capturing work digitally and printing with a fast turnaround time is something professional photographers are very interested in pursuing.

Storage and retrieval

Storage of negatives and images for many photographers is a growing concern both in longevity and in a manageable filing system. Using digital methods, i.e.

Photo CD, removable optical or tape, could solve the problem. Photo CD is the least expensive of the processes, approximately one to three dollars per scan whereas a traditional drum scan starts at $50. (The Official Photo CD Handbook, Michael Gosney, p47) With a projected longevity of 100 years the Photo CD Master could be the solution for the professional photographer.

Chapter 2

Traditional Darkroom Printing

How information is captured on film

The first step for the photographer is to capture the image on the negative. The human eye is capable of perceiving a greater tone range than is currently available on film. The visual tone range humans perceive is compressed when an image is captured on film. Negative monotone film has a density range of approximately 2.8. Color negative film has a density range of approximately 3.0. Rarely does the monotone negative reach the maximum limitation value. The majority of monochrome negatives fall in a density range of .30 to 2.40. In a negative the highlights of an image are represented by the the maximum density level and the lower number represents the shadow area. Film density differences depend on exposure and the development of the film; the greater the exposure the more silver halide particles on the films emulsion are affected. With development, the exposed silver particles are changed to metallic silver according to the amount of light received. Light areas have a greater density of exposed silver particles which are processed out with development. The highlight area becomes dense on the negative, allowing for less light to pass through the negative, resulting in a light area on the print.

Selecting the image and determining the tone value placements are decisions a professional photographer makes when taking a photograph. The photographer controls the capture of an image on film by exposure time with the aperture and shutter speed. Development of the film is another major control available for the photographer. The term "perfect negative" refers to a negative which contains the density range that have good detail in both highlight and shadow areas. The professional photographer assigns the tone values in a scene at the levels of density he desires and then develops the film accordingly. All negatives used in this study were exposed and processed conventionally.

How the darkroom print is created

Professional photographers visualize their images prior to taking photographs. They control the development and printing of their images. Once an image is captured on film and developed a photographer can create the image by controlled printing. The print either attempts to reproduce the original scene as closely as possible, or is a subjective representation of the photographer's interpretation of the original scene.

The creation of the "desired print" involves three stages of control over the process. These stages are: exposure time, contrast of the print and local control of the density in selected areas of a print by the photographer. There are two major types of darkroom printing control, global and local. Global refers to the overall treatment of a print and is easily reproducible, whereas local control refers to the treatment in specific areas and is difficult to reproduce. The first two stages in creating a desired print are global controls.

- Exposure time of the print.
- Contrast of the print.

These two global printing techniques are relatively easy to mass produce in an automated manner. (After exposure time and contrast have been established and the image can be duplicated with little effort.) A problem arises when local areas of a print require more or less exposure or contrast.

To determine the correct exposure time of the print a test print is made. In the enlarger an aperture of F 5.6 or F8 is recommended as a starting point. After placing the negative in the enlarger, a print is made using test strips. A card is held close to the print area and the print timer is started. Light is blocked from the enlarger by the card, and test strips at five second intervals are made across the image area and developed and dried. Test strips are approximately ⅙th the image area. With strips of the image exposed at different times an evaluation can be made to determine a beginning exposure. A test print of the entire image area is then made at the selected exposure time. An exposure printing time of 15 to 30

seconds and an aperture of F 5.6 or F8 is recommended. A print time of 15 to 30 seconds allows for local controlled dodging and burning. After the starting exposure has been determined, straight test prints at different time intervals such as 15, 18, 24 and 28 seconds should be made and evaluated for density. The density range of the original scene is compressed when the image is captured on film and then again when printing on photographic paper. Paper density depends on the grade and the surface characteristic of the paper. The maximum density range (D-max) of a reflective print, may reach 2.0. (*Color on the Desktop*, Miles and Donna Southworth, p32)

To produce the correct print density a full image test print is produced. The photographer assesses the highlight areas, looking to see if there is texture in the white areas. Judging pure white areas can be problematic. White appears white when the print time is less than the required exposure. If the tones in the image appear overly light or too dark another test print is produced. (*The Print*, Ansel Adams, p79-80)

After determining if the whites are accurate, the evaluation of dark tonal values for contrast is done. Contrast needs to be adjusted if the dark tones of an image are not rendering detail but are dense black with no separation of values. If the image appears too gray in the shadow areas after the correct density is achieved, the contrast needs to be increased. The contrast, or brilliance of an image is dependent on the relationship of tone values. An image which has a dark tone next to a light tone appears to have more contrast than two gray tones placed side by side. A subject can also determine the amount of contrast required in a print. Images of ethereal quality require less contrast (Figure 1, page 8).

Local control

The final stage of developing a desired print occurs after the straight print has been created with only global controls. The straight print is finished when the

Figure 1: Straight Print

Figure 2: Desired Print

correct exposure time and contrast have been established. The subjective printing of a photograph is one of the most creative tools available to a photographer. Controlling the amount of light from the enlarger on locally selected areas of the paper is called dodging and burning (Figure 2, page 9). Dodging and burning techniques emphasize or de-emphasize elements in an image. Dodging is the restriction of light on particular areas of a print. The dodging tool is placed under the enlarger creating a shadow on the paper and reducing tonal density in a print. Burning is the increased exposure of light in local areas of the print. These procedures are used to emphasize the subject in the print. A hand or a card can be used to hold back light except for areas the photographer desires to burn in. Both methods are used to either focus attention on the photographer's intended subject or to create an interpretation of the original scene. Professional photographers use their hands or a dodging tool to control the light falling on their image area. A dodging tool consists of a narrow wire handle approximately 8 inches long with a one quarter inch opaque black paper circle attached to one end. A dodging tool is used to hold back light from small areas in the print.

It requires years of practice to master the craft of darkroom printing: many hours are required in assessing images and tonal rendering before a photographer is able to print at an expert level. The print evaluation process is the same for all professional photographers creating a darkroom print. Some professional photographers dislike the hours spent in the darkroom while others enjoy the printing process. A locally controlled print can require approximately 15 minutes to an hour to produce. This process is time consuming and difficult when printing many copies of a desired print. Often professional photographers employ skilled printers to produce their work. The intent of the photographer is difficult to reproduce even when the printer is given detailed descriptions of what a photographer desires as a final print. If a professional photographer could produce the original print only once and then be able to exactly reproduce the print digitally it would eliminate hours devoted to darkroom printing or relying on others to reproduce their photographs. Appendix B contains the finished darkroom prints used in this study.

The cost of printing images is expensive; photographic paper is costly and expertise is needed. It is nearly impossible to reproduce a manipulated print exactly the same way each time, even for a master printer. The amount of time required to dodge and burn an image differs in each local area no matter how accurate a printer tries to be. The time required to place a dodging tool under the light source and the height at which the tool is placed from the light affects the size of the locally controlled print area.

Kodak Photo CD

Introduced in 1990, the Kodak Photo CD has been employed for commercial application developed into a larger market since 1992. The Photo CD (compact disk) was created as a photo viewing system for home use. However its primary use has been for commercial application. It provides easy access and an inexpensive digital lifetime storage system with many applications. The Photo CD developed by Kodak has an encoding system, PhotoYCC, which allows for viewing on PC's, Macintosh's and high definition televisions. The color encoding scheme remains proprietary to Kodak. Images are stored on the Photo CD at five resolutions. This project used the Kodak Master Photo CD's highest resolution available from the five Photo CD formats. This format has a storage capacity of approximately 120 digital images, approximately 600 megabytes total. Kodak refers to the different resolutions levels as "Base." Base resolution is comparable to a television's resolution. Base/16 is the smallest file size and is used for thumbnails or contact prints.

Base	**Resolution**	**Primary Use**
Base/16	128 lines x 192 pixels	"Thumbnails"
Base/4	256 lines x 384 pixels	Position placement
Base	512 lines x 768 pixels	Multimedia & TV
4 Base	1024 lines x 1536 pixels	Printing small image
16 Base	2048 lines x 3072 pixels	Image enlargements

Table 1: Photo CD Master Disc

Many photo labs and some service bureaus have Kodak Photo Imaging Workstations (PIW) available for capturing the image data on a 35 mm negative or transparency. A scanner, computer workstation, disc burner, color printer and a compact disc reader are the separate units of the PIW. The maximum density that Photo Imaging Workstation (PIW) can detect in film is a density of 2.8. A maximum density of 3.2 and above is possible for some color transparency films. The Photo CD implements a "visually" lossless compression scheme developed by Kodak. Cost of the entire (PIW) unit is approximately $100,000.

Kodak has developed two methods for converting Photo CD images from the Photo YCC file format to RGB. Photo CD Access was an earlier version software for the Macintosh and Microsoft Windows and is best used for screen representation. Images acquired using Access software clips highlight detail which is incapable of displaying on a standard television monitor. Kodak has since developed the Acquire software which interfaces with Photoshop as a plug in. The Acquire module produces the best results with minimum clipping of highlight values and offers control over converting from the color spacing of YCC to RGB. (*Using Photo CD for Desktop Prepress*, Frank Cost, p22) The PhotoYCC is a color encoding process developed by Kodak which interprets the color RGB scan into luminance or grayscale values (Y) and the color spaces or chrominance (CC). (*Photo CD, Quality Photos at Your Fingertips*, John Larish, p26) The PhotoYCC values are stored on the Photo CD and it is necessary to convert the files to RGB to view on the monitor. Using the correct software ensures the best results. (*Using Photo CD for Desktop Prepress*, Frank Cost, p22) The Kodak CMS plug in for Photoshop also converts YCC to the RGB mode or to CMYK. There are several other software products available for YCC to RGB and CMYK conversions. Purup's Photo-Impress, Color Extreme and Binuscan are a few of the sophisticated software programs currently available.

Kodak has produced two different Photo CD systems, the standard Photo CD which scans only 35mm file, and the Photo CD. The Master CD allows for scan-

ning of the standard 35mm and 4 x 5 inch film at a maximum resolution of 6,144 by 4,096 pixels (*The Color PC Production Techniques,* Marc D. Miller and Randy Zaucha, p73). The Pro Photo CD has two more formats than Kodak's Master Photo CD (*Using Photo CD for Desktop Prepress,* Frank Cost, p11). The CD Scanner is a CCD scanner which digitized the negative with a limited D-max density of 2.8. The scan is balanced to the scene using Kodak's Scene Balancing Algorithm (SBA) which corrects the image's color and density. This feature corrects for an underexposed or overexposed negative. The SBA attempts to replicate the "normal" scene (*Using Photo CD for Desktop Prepress,* Frank Cost, p16). Scanning using the Photo CD system is automatic with minimal selections available. A low key image can be placed at a lighter value; the results are a poor quality scan.

The darkroom paper used in this study was Ilford's non-gloss matte surface multigrade paper with a gelatin filter of 2 or less. Matte surfaced paper prevents interference of the paper surface when viewing and has a lower reflectance reading.

Chapter 3

Review of Literature

In the past few years numerous books have been published on digital scanning, imaging and printing. Most publications cover one aspect of digital production. Some books cover two aspects of digital production of image files. The information was device specific particularly with regard to the device featured by the book. There was nothing written on traditional darkroom printing compared to digital manipulation and printing on digital printers and there is a void of information on black and white Kodak Photo CD to digital output.

For a comprehensive view of digital imaging the *Color PC Professional Techniques* is terrific, clearly defining the processes and the methods used in the digital imaging from input to output. Full chapters are devoted to scanning, image rendering and tone and color adjustments.

For photo corrections and manipulations an excellent reference is *MacWorld Photoshop 2.5 Bible* by Dele McClelland. It has complete information on all Photoshop's features plus related digital topics, i.e. scanning and printing. It is the best reference for explaining the subtleties of the application program. *Photoshop in Black and White* by Jim Rich and Sandy Bozek was useful since it is devoted to Black and White reproduction using Adobe Photoshop. It also has a succinct summary on scanning. The references on input/output adjustments in Levels were valuable when first starting the project.

The Official Photo CD Handbook Published by Peachpit Press offered excellent information on the entire Photo CD processes and scanner adjustments. It contains a useful chapter on putting images on Photo CD with references to density

Chapter 4

Statement of the Problem

Can the digital method of scanning images and digital printing completely replace the traditional method of darkroom printing? Are the Adobe Photoshop 2.5 controls fine tuned enough for both the global and local manipulation (burning and dodging) for the digital "desired print?" Will this process satisfy a professional photographer, taking into consideration the limitations of the medium being used? (i.e. The papers and toners are different and will affect the reproduction.) This study investigates whether it is possible to completely eliminate the darkroom for the professional photographer by exploring the different paths of capturing and reproducing digital images.

Finally, how does the Photo CD Master scan compare to traditional methods of scanning? Can it provide a viable means for a professional photographer to store his collection of monochromatic negatives?

Chapter 5

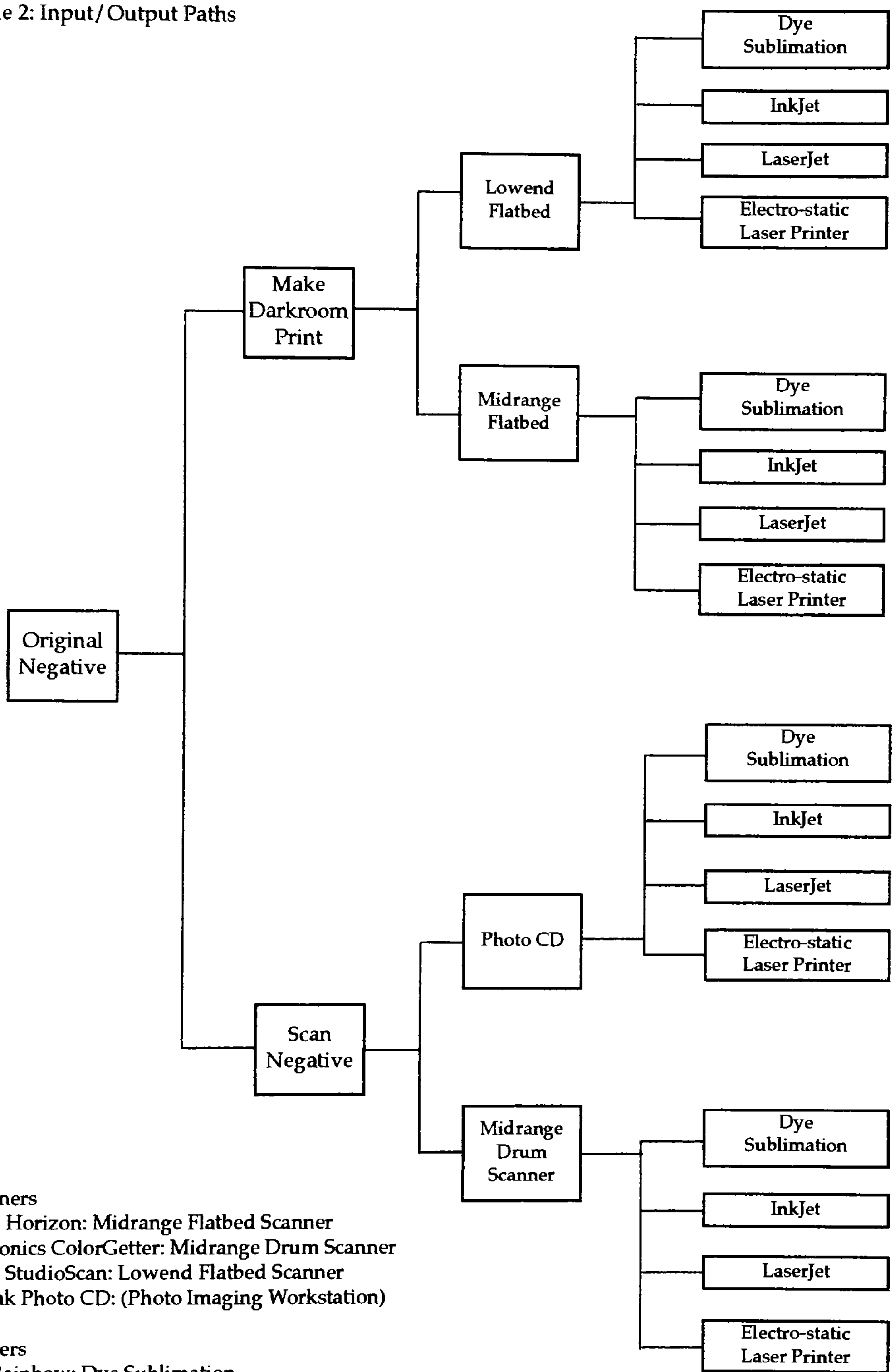
Methodology

Can the digital darkroom satisfy a professional photographer? This project made use of the currently available capturing process of four different scanners and compares them to each other by producing digital prints on four desktop printers. Table 2 on page 17 illustrates the paths followed.

The second objective was to determine whether a computer manipulated monotone image produced by a professional photographer is capable of generating a print digitally comparable to the photographer's traditional darkroom "desired print."

Two methods were implemented for capturing images; scanning the monotone negative or scanning the desired finish darkroom print. The same six monotone images were scanned using both of these methods and assessed to determine the best results. The Agfa Horizon Scanner and the Agfa Select StudioScan were the two flat bed scanners used to capture the "desired print" into digital form. The Optronics ColorGetter and Kodak Photo CD Master were used to scan the original 35mm monochrome negative. Both Tagged Image File Formats (TIFF) and Encapsulated PostScript (EPS) file formats were used. EPS files were required for applying transfer functions. Manipulation of each image was performed in Photoshop 2.5.1 to produce digital images which matched as closely as possible the "desired print." An image resolution of 300 dots per inch was used in all cases. All images were scanned first as RGB files and then converted to grayscale mode. All images were scanned at the same specifications and handled the same way, matching the Kodak Photo CD scanner which produced only RGB scans.

Table 2: Input/Output Paths



Scanners
Agfa Horizon: Midrange Flatbed Scanner
Optronics ColorGetter: Midrange Drum Scanner
Agfa StudioScan: Lowend Flatbed Scanner
Kodak Photo CD: (Photo Imaging Workstation)

Printers
3M Rainbow: Dye Sublimation
Hewlett Packard: Monochrome Electrophotographic Laser
Epson Stylus: InkJet
Canon Laser Copier: Color Electrophotographic Laser

Beginning with a good scan greatly influences the output. Without a correct digital scan it is impossible to recreate the information in the original. The first path this study follows is the scanned negative. Radically different methods of obtaining the scans from the negative were the Photo CD Master and the Optronics ColorGetter. The Photo CD is a dedicated system that is readily available while the Optronics is a midrange drum scanner traditionally used to capture quality scans. The list below shows the major differences between the two paths used when scanning negatives.

Scanner Differences in Capturing Negatives

Colorgetter	**Photo CD Master**
Wide Density Range	Limited Density Range
Controls Available	Automatic Controls
Need Expertise	Novice can Operate
Expensive Scans	Inexpensive Scans

Achieving the best scan on the drum scanner

The ColorGetter drum scanner auto scan selection finds the lightest point in the image and sets this value to white. It then calculates the darkest point in an image and assigns it a black value. This is ideal for images which have a definite black point and white point and evenly distributed density values. The placements of D-max and D-min are critical. If the black point placement is not accurate, the auto scan maps the values from the negative to a higher midtone level, resulting in a light scan. Most negatives do not have ideal characteristics. Lightening the density value in the auto scan is usually counter to the photographer's "desired print."

The Advantages of using the Auto Scan Setting:

- Density range is set automatically, ideal for perfect negatives with white point and black point and density ranges evenly distributed.
- The scan is neutralized automatically. Color shifts are eliminated from the scan.
- Can manually adjust the highlight and shadow placement

The Disadvantages of using the Auto Scan Setting:

- High compression of the density range
- Sets black point and white point incorrectly

To achieve a scan with a full density range, the image was produced using ColorGetter software on the Optronics Colorgetter. The auto scan setting was implemented first. The auto scan served two functions, it neutralized the color balance and it set an approximate density range on the scanned negative. The auto scan found the darkest point in the negative and assigned it a black value. The auto setting then found the lightest point and set that at white. After the density range of the auto scan was set, the manual scan was produced. Highlight and shadow areas were placed according to the visual appearance on the monitor after the density range of the auto scan was taken into account. Maximum density placement was extended from the auto scan setting to capture the full range of shadow detail. The other consideration was based on whether the images were to be globally and locally altered in Adobe Photoshop. Table 3 contains the scanner settings for the auto settings and the manual value adjustment.

Auto and Manual Scans

Image: Sue	**Image: Welsh**
Auto Scan .33-1.31	Auto scan .48-1.17
Manual Scan .33-1.90	Manual scan .50-2.82
Image: Muriel	**Image: Smoke**
Auto scan .30-1.69	Auto scan 1.15-2.10
Manual scan .30-2.10	Manual scan .50-2.85
Image: Hats	**Image: Atget**
Auto scan .54-1.60	Auto scan .45-1.80
Manual scan .65-2.6	Manual scan .45-2.10

Table 3: Scanner Density Differences

All the ColorGetter scans used for output in this study were obtained using the manual adjustment setting. When the manual adjustments were made to the negative the resulting files contained more highlight and shadow detail. To capture the highlight detail, the white point in the scan setup was set slightly higher and the shadow area was extended by placing the black value lower. This produced a longer density range with more tonal values.

The negative was scanned on the drum scanner using ColorRight 4.0 software to set preferences and acquire the scanned image. All files were converted to smaller grayscale files through Photoshop and the manipulations were done to correct density values for the various outputs. The software menu setup was chosen prior to scanning. The selected setting used the film type "unknown", transmissive and RGB color mode. The film typesetting for TRI X was not a choice so the film type was set to "unknown" under the separation setup menu. The preference was set and the negatives were scanned using the invert setting to create a positive image. From the file menu a new overview was selected and the ColorGetter scanner created a low resolution scan. After selecting the image by drawing a marquee around the image a new prescan was chosen from the files menu. In the separation setup the parameters were used setting Standard Web Offset Press (SWOP) at 300 and gray component replacement (GCR) set at 0. The scan was captured in RGB at a 500% magnification. A pixel sampling ratio of 2:1 is recommended. This number relates to how many pixels on the monitor screen are selected for producing the printers halftone dot. Minimum quality was set at 2.7 pixel sampling ratio to achieve the file size of approximately 18.3 megabytes. The large file size and color setting was used to match the files obtained from the Photo CD.

Scan Geometry dialog box, Figure 3, page 21, was selected from the menu to set the reproduction size, line screen, minimum quality and the scanner's aperture. Locking the scan geometry adjustments prevented settings from changing during the scan.

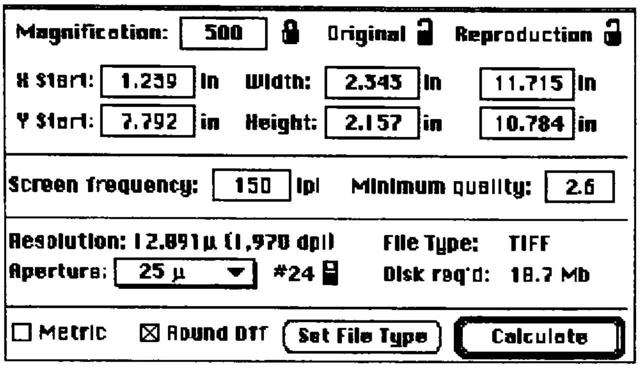


Figure 3: Scan Geometry

The settings used were 150 lines per inch and an aperture of 25 microns. A small aperture created a closer sampling of pixels and the silver grains were captured by the scan lines. A prescan was created when a frame was drawn around the image to select the area to be scanned. Care was taken when using the auto scan setting to select only the image area and not the dark unexposed area surrounding the negative. Incorrectly framing the image area resulted in inaccurate highlight and shadow points being set. The image was then neutralized automatically by using the auto scan setting. Figure 4 illustrates the Color Cast dialog box when the image was automatically neutralized. The auto setting selected the lightest pixel value in the image and gave it it a white value. It also selected the darkest value and assigned it a black value. This compressed the density range of the image.

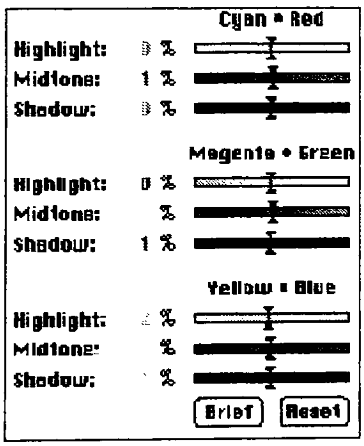


Figure 4: Color Cast Neutralized

Each scan was manually corrected, setting the density range after first implementing the auto setting feature. If the image was a low key or dark tones to begin with, the black point was set lower than the auto scan selection by extending the shadow density. Highlights were extended slightly to ensure the capture of the highlight detail in the negative. The six images selected had different density ranges so each scan was unique. Figure 4 is the dialog box for the color cast removal which is used to neutralize the scan. Overall Gradation is set using the dialog boxes represented in Figure 5-7. Figure 5 is the default setting, Figure 6 is the auto scan and Figure 7 is with the manual adjustments.

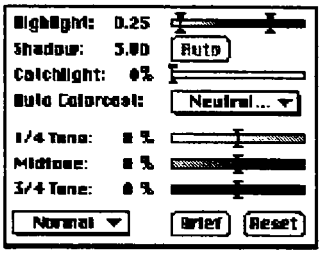


Figure 5: Default Setting

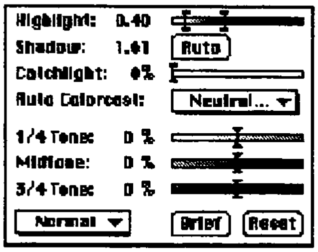


Figure 6: Auto Scan Setting

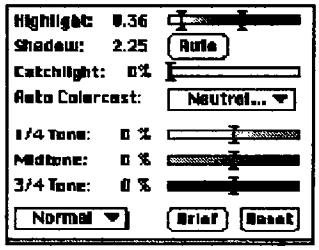


Figure 7: Manual Setting

The Photo CD image was captured and acquired through Photoshop using the Acquire v2.0.1 plug-in module. There are various ways of acquiring the Photo CD images, however, if the density values weren't obtained in the scan it doesn't matter which method is implemented to open the file.

Kodak Photo CD Scans

The Kodak Photo CD Master encodes scanned images with YCC information from the original scene and doesn't further process the image data. The variations of film characteristics were maintained, which is important to the professional photographer. The manipulation of the negative is often required to render the tonal range a photographer desires of a scene. The Photo CD will transfer the information contained on the negative film as the original scene in a digitized image format. The Photo CD image format used was with a maximum scanning resolution of 4096 by 6144 pixels. The Photo CD scans were done at a

professional service bureau on a Photo CD Imaging Workstation 4200 (PIW) and imported into Photoshop using the Acquire module.

Adobe Photoshop 2.5 methods for adjusting digital images obtained by scanning negatives.

After obtaining the digital scans, all files were adjusted in Photoshop for the specific output device used for printing. Photoshop 2.5 features, tools and characteristics were implemented to produce globally and locally altered prints. Data is sometimes sacrificed when image corrections are made in Photoshop particularly with over manipulation which can result in poor quality output. The printers used in this study had maximum quality of 600 dots per inch so this lost detail was not noticeable. Manipulation was applied to digital images to match as closely as possible the finished darkroom print and satisfy the photographer.

Histogram: A histogram is a visual representation of how the pixel values are distributed in an image. Histograms are used to analyze the value range of the pixels and to make adjustments to the image. Histograms should be evenly distributed, with no empty areas at either end of the display for a normal density range image. Figure 8: Histogram is an example of a image file that has been manipulated which has a fairly good range of values. It lacks a definite white point but it was an image with midtones to lower gray values

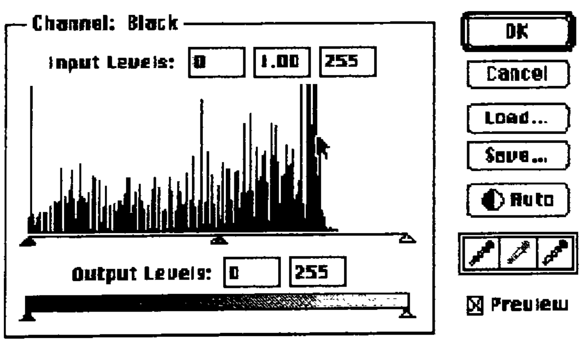


Figure 8: Histogram

Transfer functions: File> Page setup> Transfer functions. Transfer functions adjust density values for the printer without changing pixel values in the image file. The transfer function allows assigning new printer values, either darker or lighter. A screen value of 20 percent can be darkened by assigning it a value of 30 percent for printing. Figure 9, is an example of a transfer curve dialog box where an image can be further corrected. The monitor gray values in Photoshop's info palettes correspond to the output printer's value. A 10% gray on screen is a 10% gray value when printed, however, every output device renders the tone differently. Printers often print darker or lighter than the designated values. Printers made by the same company can vary in printed density values. The Canon Laser Copier in the Electronic Printing and Publishing Lab (EPPL) prints dark, therefore transfer curves were used to adjust the overall value of the prints rather than over manipulating the image. To adjust for the printer, new values were assigned to the gray levels in Photoshop's transfer function. To maintain a smoother tone curve, values were not always assigned to each dot percentage. Saving the transfer curves with the images required the images to be encapsulated postscript (EPS) files.

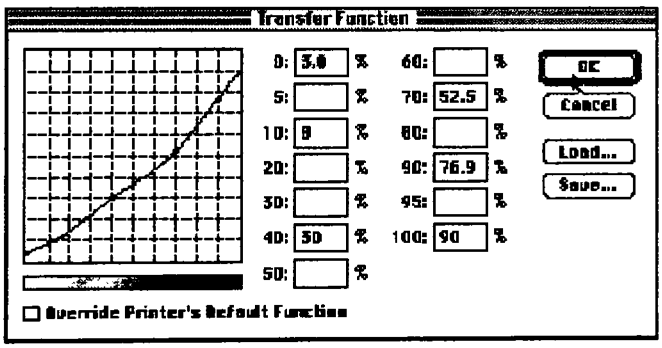


Figure 9: Transfer Curve

Global and local controls were produced in the Level and Brightness/Contrast settings. Corrections were applied locally, to areas that were specifically selected and globally, to the entire print.

Some other Photoshop features used included

•Info palette: Window>Show Info. This palette was used whenever a correction was made to an image. It provided density readings on the screen which were valuable when changing densities in an image for the particular printer.

•Levels: Adjust> Levels>This displays the Level dialog box with an active histogram which is used for a visual reference on how the pixels are distributed and for image correction. Figure 10 is an example of low key values displayed in the histogram dialog box. Pixel values range from 0 to 255. There are 256 grayscale values available in Photoshop. The pixels can be redistributed in highlight, midtone or shadow areas. All scanners capture the images differently as illustrated by the histograms in Appendix A, page 60. If the highlight detail was not contained in the scan it was very difficult or impossible to restore the information using tools Photoshop. The input Level bar was used for image adjustments. When values are entered the effect can be seen on the image without closing the Level dialog box.

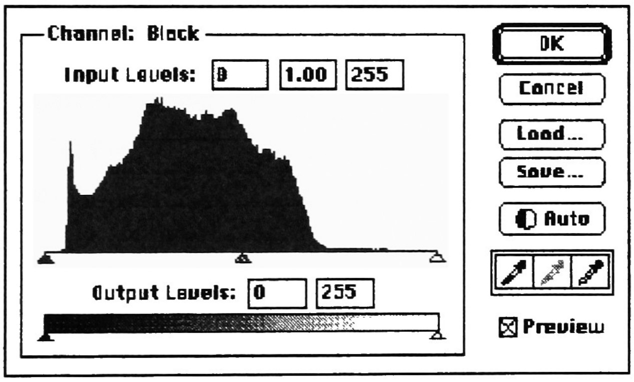


Figure 10: Levels Histogram

All images had to be corrected for the printers. In Levels there are two controls available for entering number values, either by using the dialog boxes or by using the slider triangle bar (Figure 8, page 23). There is a control slider triangle for the highlight, midtone and shadow point. If the black value is set to 30, all the values in the image of 30 or lower are assigned to black. The same follows when assigning a white point value. After selecting specific areas of an image, corrections were applied using the Level adjustment.

After selecting specific areas of an image with the magic wand or lasso tool, corrections were made using the Brightness/Contrast setting. All images for all the printers had increased contrast applied. This menu was found under Adjust> Brightness/Contrast in Photoshop.

Toolbox Features

Magic wand: Found in the toolbox, the magic wand was used to select similar pixel areas to correct the density value. Clicking on a image activates the magic wand in that area. Selected areas were either burned down or lightened for the print output. When density in the highlight area was not captured by the scan this tool was implemented. The magic wand sensitivity level can be set to percentage points and will capture areas within that range. Corrections were performed in small increments to prevent visually apparent manipulation.

Tolerance values for the magic wand range from 0 to 255 in the grayscale 8 bit data. Double clicking on the magic wand opens the dialog box. Entering a low number limits the number of values that are selected. Photoshop evaluates the brightness value of the pixel selected and extends the brightness in each direction from the number value set in the tolerance setting (*Photoshop Bible,* p 268).

Rubber stamp: This tool was used for correcting dust spots and eliminating areas which would be traditionally burned down in the darkroom.

Lasso tool: Found in the tool box and was used to select local areas to burn down in the print. The lasso is used to select an area and while the selection is active, adjustments in Photoshop's Levels, or other features, can be applied.

How a "desired print" is made digitally using Photoshop

The image Hats was a darkroom corrected print. Both the global and local controls were used to achieve the desired print. This process was repeated on the computer. The negative of the Hats image was scanned and digitally manipulat-

ed using Photoshop. The same areas were adjusted as in the desired darkroom print. The first adjustment was to compress the density range by setting the black higher in the Levels dialog box. Local corrections in Photoshop were done using the lasso tool. After selecting the head and hands with the lasso tool the area was lightened and contrast was added using the Brightness/Contrast dialog box. The highlight areas, eg the white cap in lower right, were burned down. This was accomplished using the lasso tool to make the selection and Levels. As the midpoint in levels was lowered the center figure was continually lightened. Changes were made at 3-10 increments. Adjustments were applied slowly to acquire no noticeable changes to the image. Altering an image, especially in the highlight areas is apparent if the change is greater than approximately 8 percent.

Figure11: Globally Lightened

Figure 12: Locally Corrected

Manipulation was not as noticeable either in shadow areas or in highlight areas with surrounding dark values. Figure 11 is the drum scan image with global adjustments. The density range has been raised to lighter values in Photoshop's Levels. Figure 12 is the finished digital print after global adjustments shown in Figure 11 the local adjustments were made in Photoshop. The central figure was selected with the lasso and made lighter, while the surrounding area was lowered in density using the Levels and Brightness/Contrast.

Printer density values

A 20 step grayscale was created in Adobe Illustrator 5.0 where precise values were assigned at 5% intervals (Figure 13, page 29). The grayscale was sent to each of the printers. A reflection densitometer was used to take readings of the gray levels after printing and appears in Table 4: Printer Ink Densities. Canon

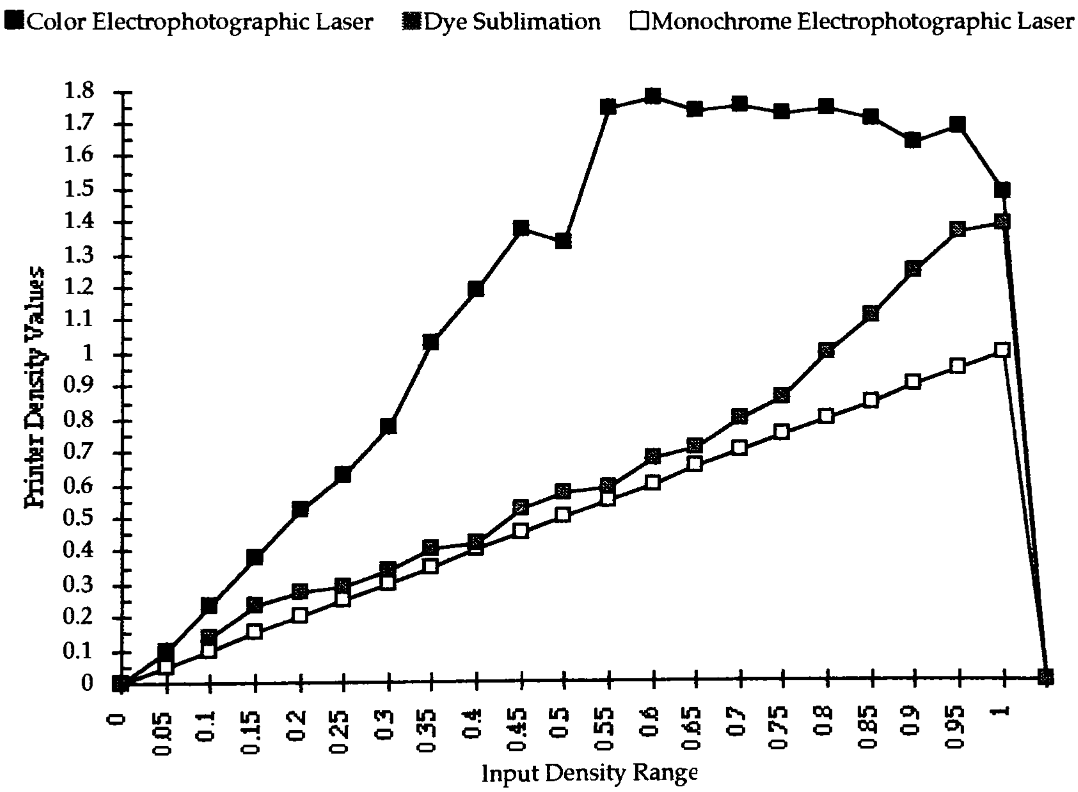


Table 4: Printer Ink Densities

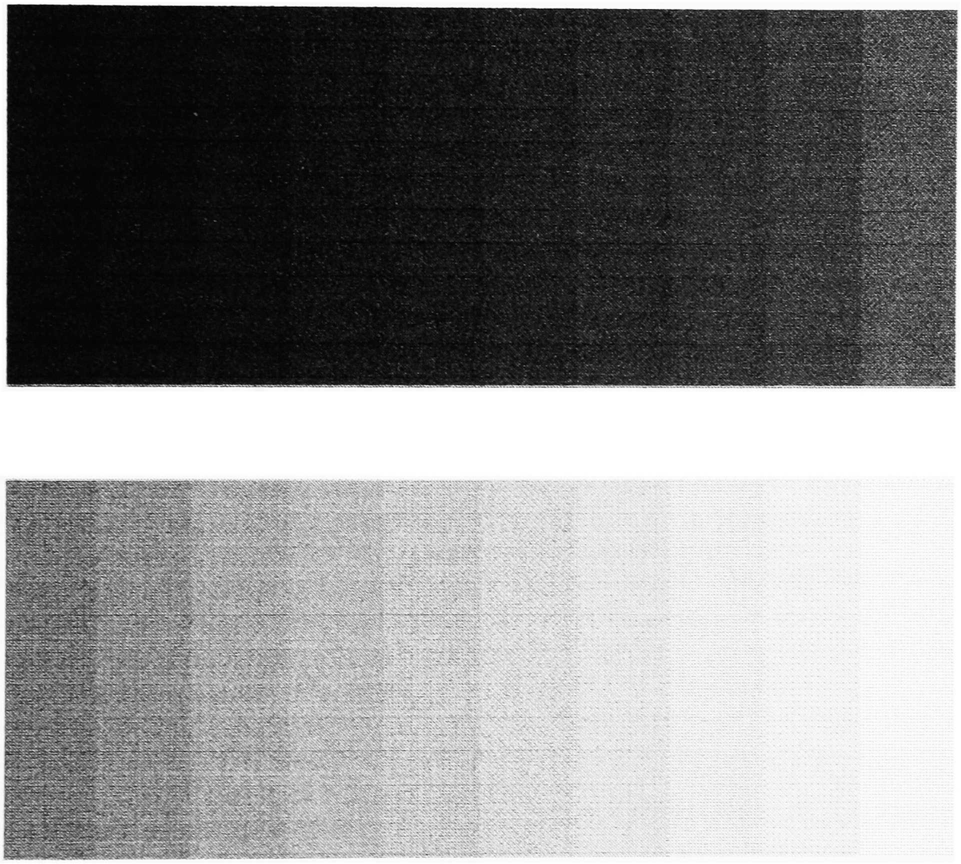


Figure 13: Grayscales

Laser Color Copier paper was used in the color electrophotographic laser printer and the monochrome electrophotographic LaserJet printer. Adjustments were made by creating transfer curves to the screen value settings in Photoshop and the grayscale was printed again. Transfer curves were developed for each of the printers after plotting the density values of the grayscale to match the monitor screen values in Photoshop. These transfer curves provide a reference as to how the printers handled grayscale density values. When correcting an image a reading was taken from the screen image using the info box. The transfer curve was consulted and a new value was assigned to the on screen image area using Adobe Photoshop. The new value was assigned the intended print density value. Using both the transfer curves and the info box densities assisted in correcting images for the designated printer (Table 4: Printer Ink Densities, page 28).

Scanning the "desired print"

Desired prints were made in the darkroom by techniques outlined in Chapter 2. Prints were made on Ilford paper which is a matte emulsion print medium. The next process used to produce a digital print began with scanning "desired print" made in the darkroom. The two flatbed scanners used in this study were the Agfa StudioScan, a lowend flatbed scanner and the Agfa Horizon, a midrange flatbed scanner. Appendix B contains the "desired prints" which were scanned on the flatbed.

The specifications of the two flatbed scanners used in this study appear in Tables 5 and 6. The major differences between the two scanners were in the resolutions, physical size of the scaners and bit depth.

Midrange verses Lowend scanners

Horizon	**StudioScan**
High resolution	Lower resolution
Larger scanner	Desktop scanner
12 bit	10 bit

Horizon Scanner Specifications

Flat-bed:	A3 size color Charge-Couple-Device
Optical resolution:	1200 dpi
Output resolution:	20 - 2400 dpi for gray scale
Accuracy:	12 bit
Output pixel depth:	8 or 10 bit for gray
Density range:	3.0D
Memory:	8Mb RAM
Lamp:	Halogen (rod type) or 400 W/80V
Demensions:	815 x 560 x 296 mm

Table 5: Horizon Scanner Specifications

StudioScan Specifications

Flat-bed:	Color Charge-Couple-Device
Optical resolution:	400 dpi horizontal x 800 dpi vertical
Output resolution:	800 x 800 dpi for gray scale & color
Accuracy:	10 bit
Output pixel depth:	8 or 10 bit for gray
Density range:	NA
Memory:	NA
Lamp:	8W Daylight fluorescent light
Demensions:	545 x 386 x 143 mm

Table 6: StudioScan II Specifications

Horizon Settings Used for Capturing "desired print":

Copy	Reflective
Mode	RGB
Pixels per inch	360
Scale	125%
Range	Automatic
Tone Curve	1.8
Descreen	None
Sharpness	None

Table 7: Horizon Settings

The "desired print" image is acquiredusing FotoLook software through Adobe Photoshop 2.5. According to the Agfa Horizon manual the recommendations for scanning reflective work was a gamma setting of 1.5. A gamma setting over 1, which is a 45 degree curve, brightens the image and compresses the tonal range. This compressed range allows for more detail to be visible in the midtone and shadow areas. After testing the images at a 1.5 setting a higher gamma setting was selected, which produced a scan with more contrast and clearly defined densities. A gamma setting of 1.8 was used when scanning the images on the Horizon flatbed scanner. Table 7 contains the settings used when scanning the "desired print" on the Horizon flatbed. The automatic range selects the optimum density range for the image. After setting the selections the preview button was clicked and the entire flatbed area was scanned. The image appears on the monitor and a marquee can be dragged to select the final image area to be scanned. When the scan is completed the scan dialog box is closed and the image appears on the monitor in Photoshop. White point and black points were not set since detail was desired in the highlights. Setting a lighter point would have deleted information. The original darkroom "desired print" was manipulated and the white point and black point had been established.

Selecting Mode in Adobe Photoshop, the Horizon red, green and blue (RGB) image files were then converted to grayscale and reduced to a lower file size. The photographer's "desired prints" on the flatbed scanner converted the images into a digitized image file. The monotone "desired print" was captured as an RGB file format and converted to grayscale using Photoshop 2.5.1. Theoretically, no electronic manipulation should be necessary since the darkroom manipulation has already been achieved by the photographer in the "desired print" and only needs to be captured by the highend flatbed Horizon Scanner for electronic output.

Table 8: Evaluation Results

Flatbed Scanner & Dye Sublimation		Flatbed Scanner & LaserJet, Electrophotographic laser		Flatbed Scanner & Color Electrophotographic laser	
Atget	unacceptable	Atget	acceptable	Atget	unacceptable
Smoke	unacceptable	Smoke	acceptable	Smoke	good
Sue	acceptable	Sue	good	Sue	good
Hats	acceptable	Hats	acceptable	Hats	acceptable
Muriel	acceptable	Muriel	good	Muriel	acceptable
Welsh	acceptable	Welsh	good	Welsh	unacceptable
Drum Scanner & Dye Sublimation		Drum Scanner & LaserJet, Electrophotographic laser		Drum Scanner & Color Electrophotographic laser	
Atget	unacceptable	Atget	acceptable	Atget	acceptable
Smoke	unacceptable	Smoke	unacceptable	Smoke	acceptable
Sue	good	Sue	unacceptable	Sue	unacceptable
Hats	acceptable	Hats	acceptable	Hats	good
Muriel	good	Muriel	good	Muriel	good
Welsh	acceptable	Welsh	good	Welsh	acceptable
Photo CD & Dye Sublimation		Photo CD & LaserJet, Electrophotographic laser		Photo CD & Color Electrophotographic laser	
Smoke	unacceptable	Atget	good	Atget	acceptable
Muriel	unacceptable	Smoke	acceptable	Smoke	acceptable
Welsh	unacceptable	Sue	unacceptable	Sue	unacceptable
		Hats	good	Hats	acceptable
		Muriel	unacceptable	Muriel	unacceptable
		Welsh	unacceptable	Welsh	unacceptable

Evaluation Results

The final evaluation of the print criteria produced from the four printers and the four scanning methods was by professional photographer Professor Owen Butler. How do the final digital prints compare in highlight and shadow density to the darkroom "desired print" and do they satisfied the photographer? The Table 8 on page 34 shows the results of the evaluation.

The best method to follow is the flatbed scanner using color management software printed on the dye sublimation printer. The flatbed scanner without color management software using the dye sublimation or the LaserJet printers also produced results that were acceptable to good. The midrange drum scanner produced fairly good results when using the LaserJet, a monochrome photographic laser printer.

Automatic settings on scanners were not able to fully capture the density range of the images. The scans produced on the Photo CD had critical highlight detail missing. This was apparent in both of the high key images (Appendix A, page 60).

Chapter 6

The Results

Each of the methods used to produce the "desired print" digitally, in this study, had its own advantages and disadvantages. The low end flatbed scanner which used color management software, was the only method that didn't required Photoshop manipulation. All the others required adjustments to produce an image which approach the darkroom "desired print" and satisfy the professional photographer. Scanning the images, whether a negative or "desired print," produced different results on each of the scanners. (Appendix A, page 60)

1. Input Method Scanning the Negative

Disadvantages of Scanning the Negative

- Takes longer to correct image density in Photoshop
- Requires more manipulation than other paths
- Requires expertise in Photoshop

Advantages of Scanning the Negative

- Starting from the original information

2. Input Method Scanning the "desired print"

Disadvantages of Scanning the "desired print"

- Necessary to make a "desired print" in darkroom
- Required some adjustment to densities in Photoshop
- Color Management Software (CMS) required color scanner/color printer
- (CMS) required printer profiles

Advantages of Scanning the "desired print"

- Less manipulation of densities in Photoshop
- Using Color Management Software required no corrections

Scans obtained from the drum scanner and the midrange flatbed were dark with density ranges which exceeded the printers. The midrange flatbed scanner created a dark and uneven scan of the desired print (Figure 14, page 37). Two meth-

Figure 14; Horizon Scan

ods were used to lighten the digital image for printing. Adjustments were made using Level's in Photoshop. This method locally altered individual pixels in the images. The other method to lighten (or darken images) was the printer transfer curves. Transfer curves were applied after corrections were made in Photoshop. The curves were global adjustments which change all the densities in the image at particular settings. Transfer curves were also applied when images were over corrected in Adobe Photoshop 2.5.

Adjustments were made in both the transfer curves and pixel values, since the transfer curves were not able to locally adjust pixel values in the image. Transfer functions corrected the printed output without remapping pixel values in the image files. This means image file remained unaltered, the transfer curve applied to the way densities would print. A 60% screen value could be assigned a print value of 30% to lighten the image.

Negatives and prints were captured differently on the scanners and the resulting digital images were varied. The types of scanners were different for obtaining the digital files which also affected the captured images. Corrections were made in Photoshop to adjust the images close to the "desired print." The following lists are the characteristics and adjustments made to the images from the various scanners.

Adjustments made to all images obtained from the Drum Scanner

1. The density range of all the files captured on the drum scanner were compressed. Using the Levels histogram in Photoshop the triangle slider in the shadow area was placed at the start of significant black information (Figure 8: Histogram). The triangle slider in the highlight area was also brought approximately half the distance from the start of the highlight information. This compressed the density range.

2. Midtones were manipulated to lighter values in the low key images by the midpoint triangle.
3. Contrast was increased by compressing the range and using the settings in the Brightness/Contrast dialog box.
4. Density values were adjusted in the images to achieve the digitally "desired print," using local burning and dodging, ie. Figure 12 page 27.
5. Transfer curves were used when "corrected" images didn't print the desired light or dark values.

Adjustments made to all images obtained from the midrange Flatbed Scanner.

1. All flatbed scans had the density range compressed using Adobe Photoshop's Levels. As with the drum scanner images the triangles were set for a shorter density range. The triangle on the left set the black point, this was placed to the right where significant pixels occurred. Contrast was increased in all files when the density range was shortened.
2. In all images midtones were adjusted in Levels to lighter values which shifted the midtone dot.
3. The midtone value was placed approximately at 42 percent rather than the 50 percent default setting.
4. Scans from the midrange flatbed were dark and uneven, even at the 1.8 gamma setting (Figure 14 page 36).

Recommendations for images placed on Photo CD

Image detail is compromised when the density range exceeds the limits of the scanner. Images which were highkey or lowkey, with detailed information in the highlights or shadows produced poor results. Images with extreme density ranges printed unacceptably. A negative which has a full tonal range will produce the best results on a Photo CD. (*The Offical Photo CD Handbook,* Ray Baggarley, p68) The images which produced the best results were those with greater densities in the midtone (Figure 11, page 27).

Adjustments made to all images obtained from Photo CD Master.

1. All scans using the Photo CD were light and contrasty. The scans were produced automatically and assigned the black and white point values. Midtone density of all images was reduced using the midpoint triangle in Photoshop's Levels. This also reduced contrast in all images. A 50 percent density value was assigned to 65 percent.
2. Highlight areas lacked detail when scanned. Tonality was added by assigning a level of gray to the pure white area using transfer curves. A value of approximately 5% was assigned to the starting white point in the transfer curves. The second method used was to add detail using the rubber stamp tool and copy areas with detail.

Printers

The Info box in Adobe Photoshop was valuable for determining density values and in how they would render when printed. Since the color electrophotographic laser printer produced dark images this tool was most useful when dealing with files that were to be printed on the CLC. When burning and dodging the screen densitometer indicated the values. These values were adjusted to the density value desired on the CLC. Scans were converted to grayscale for the electrophotographic laser process since they would not remain neutral when printing the color images. The color shifts in the midtones greatly affected the results.

Adjustments of all images files printed on the electrophotographic laser

1. Blacks printed a total black starting in the midtones. This was an unacceptable result. Manipulating the images to lighter values was one solution.
2. Scanned image files were adjusted to the electrophotographic printer by lightening the density tones. This image adjustment was described previously under the scanners.
3. Transfer functions were applied to further correct files. The transfer curve-assigned gray values to print lighter or darker.

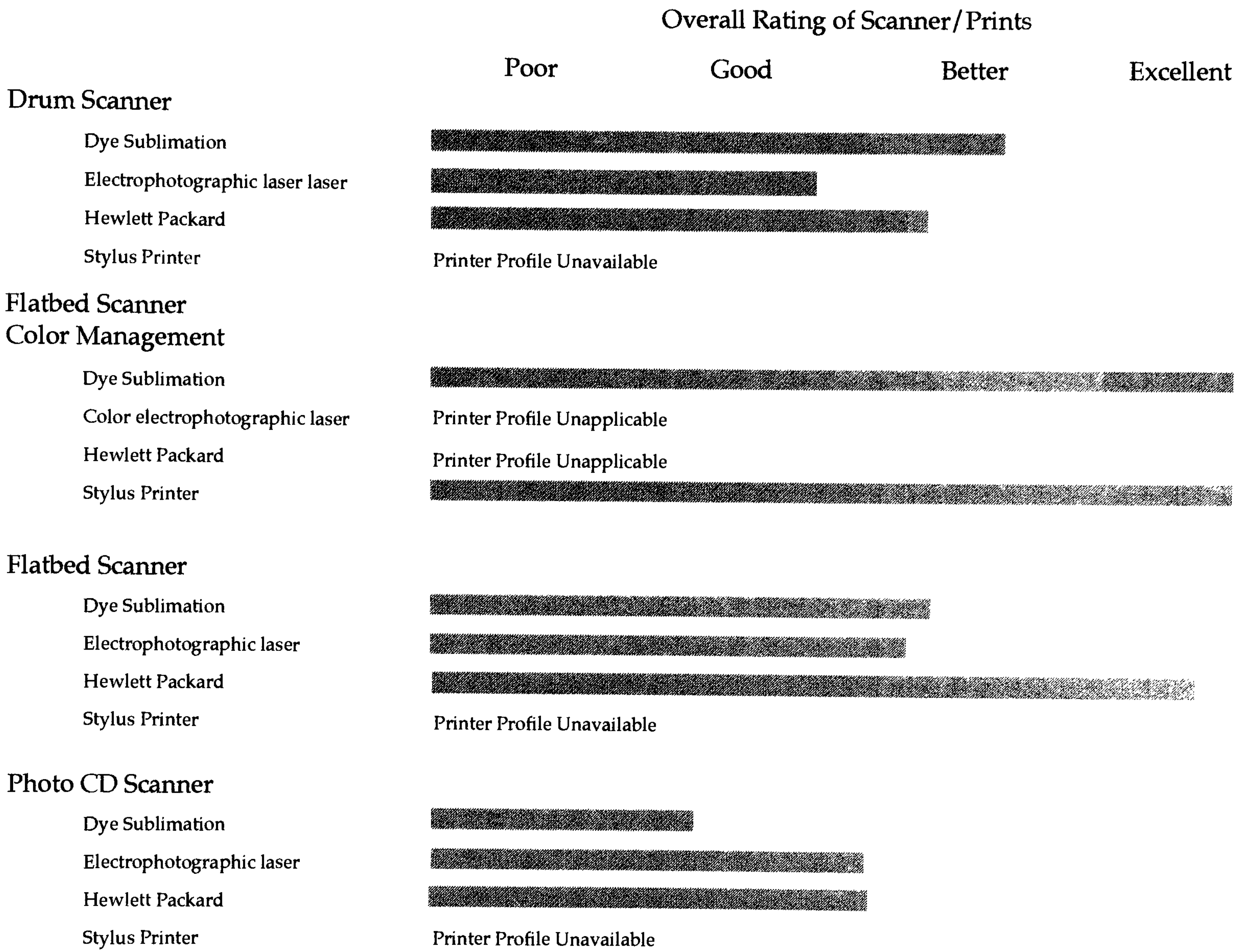


Table 9: Printer/Scanner Results

4. The electrophotographic laser printer is expensive, approximately $100,000 and usually available at service companies (i.e. Kinkos) with a resolution of 400 dots per inch (dpi).
5. It is an unstable process when printing color and had problems with the toner adhering to the paper when printing. Print densities vary daily (Figure 15, page 38).

Adjustments of all Images Files Printed on the LaserJet Printer

1. The printer produced density values closer to the screen values which were displayed in Adobe Photoshop's info box. The image printed close to the screen image, slightly darker.
2. Transfer curves were applied only when necessary. Depending on the image and scan, an image was corrected first in Photoshop. If the image was over corrected, transfer curves were applied rather than adjusting more pixels.
3. Midtones were set to lighter values in the low key images.
4. Files printed very grainy when the 150 lines per inch (lpi) was used on the 600 dpi on the monotone electrophotographic printer.
5. This printer is inexpensive approximately $2,000 with a 600 dpi.
6. Horizontal banding was often evident when printing the images.

Printers varied in the way they printed densities and in the method used in rendering the digital files. Each process had characteristics which were evaluated in choosing the best process to use for printing the "desired" image. The following lists are characteristics of the printers used in this project. Table 9, page 42 contains a comparison of the various scanners and printers used in this project.

Characteristics of the InkJet printer used with Color Management Software

1. This printer required Color Management profiles for printing. (If printer profiles were not available it was not printed on the output device)

2. RGB color scans were also essential to implement the color management software. To utilize the color management software required color printers.
3. This is an inexpensive printer but with a high dpi of 740.
4. This process required no image file manipulation or correction since the darkroom "desired print" was scanned. All corrections to density values were produced in the original "desired print."
5. Significant time was required to print the images. Color images were sent to the printer which were larger file sizes which take longer to process than the monotone files.
6. Lines appeared across the image when toner cartridge was low.
7. This printer lacks light fast dyes, they fade with time.

Characteristics of the dye sublimation printer

1. The printer was closer to screen densities. Blacks printed at a reflection density of 1.0 value. Testing showed density readings of the grayscale very close to the input values. What appeared on screen looked approximately like the print. Less image manipulation was required for printing.
2. The transfer curves were used to correct for over manipulation in Adobe Photoshop 2.5.
4. The colors of the dye sublimation process are unstable dyes. The black dye turned a pinkish hue and appeared uneven.
5. Significant time was required to print the image files since the printer has four color dyes to process even though the file was sent grayscale.
6. The printer produces 300 pixels per inch.
7. The printer is calibrated for the dye lots and for different types of output selection. Uncorrected setting produced a print closer to neutral gray than using the color corrected setting. (All files were grayscale.)
8. The color management software image files were sent to the printer using the corrected SWOP settings.
9. The printer is very expensive, approximately $25,000. In addition, the color dyes and special paper are expensive.

Capturing the image digitally and creating an output that is comprable to the "desired print" had advantages and disadvantages. The lists below show a comparison of the two processes.

Advantage of the traditional darkroom vs. Photoshop image adjustments.

Darkroom "desired print"	Digital "desired print"
•Large highlight area easier to correct	•Easy control of small areas
	•Repeatability
	•Storage/Access

Disadvantage of the traditional darkroom vs. Photoshop image adjustments.

Darkroom "desired print"	Digital "desired print"
•Requires expertise in printing	•Requires expertise in imaging
•Requires expertise in processing	•Requires expertise in scanning
	•Requires expertise in printing
	•Expertise in Photoshop

Transfer curves were used to correct rather than manipulate individual pixels in Photoshop. However using the curves developed for the printers on the images didn't work since there was density manipulation in all to achieve a "desired print" digitally. When an image with a good density range was scanned correctly and adjusted, the file was used on the same three printing devices. The image still required corrections for the printer.

Each printer had its own density characteristics. Scans were adjusted to each printer for maximum reproduction quality. Determining how images were going to print became similar to darkroom printing. Printing was customizing the images to the output device (Appendix A).

Results of the Printers and Scanner Combinations

The various paths were followed and evaluated by Professor Owen Butler. The results are recorded in Table 8 on page 34.

The electrophotographic laser copier was the least satisfactory of all the printers. It was unstable in the color mode and it couldn't maintain neutral gray values. A black value of 55% on the monitor screen, printed as solid black. The toner application was unstable on the printed images (Figure 15, page 46). Any value in Photoshop that was assigned a value greater than 55% appeared black when printed. Transfer curves were used to globally correct tones and the major image correction was done in Adobe Photoshop.

The dye sublimation printer produced acceptable to good results. It is the most expensive printer and is a continuous tone process which is comparable to the darkroom "desired print." Screen density values in the Photoshop Info box were closer to matching the actual printer values. Printing with the dye sublimation process produced the best results in combination with the flatbed scanner using color correction software when using the "desired print."

Disadvantages of printing using the dye sublimation and flatbed/CMS scan

1. Specialized paper was needed for the sublimation process used with color dyes.
2. The printer is expensive and used primarily for proofing purposes. The dyes are unstable unless they are fixed with a special coating using a 3M laminate.
3. The color management system required printer profiles.
4. The printer required significant time to print the files since the file sent was a color image with a larger file size.

Advantages of printing using the dye sublimation and flatbed/CMS scan

1. The printer had a calibrated four color process with no adjustments necessary by the operator. It was simple to operate.
2. The prints produced were continuous tone quality which were closer to the darkrooms "desired print."

The second method which produced excellent results was to scan the "desired print" on an inexpensive flatbed scanner using Color Management software in combination with an InkJet printer.

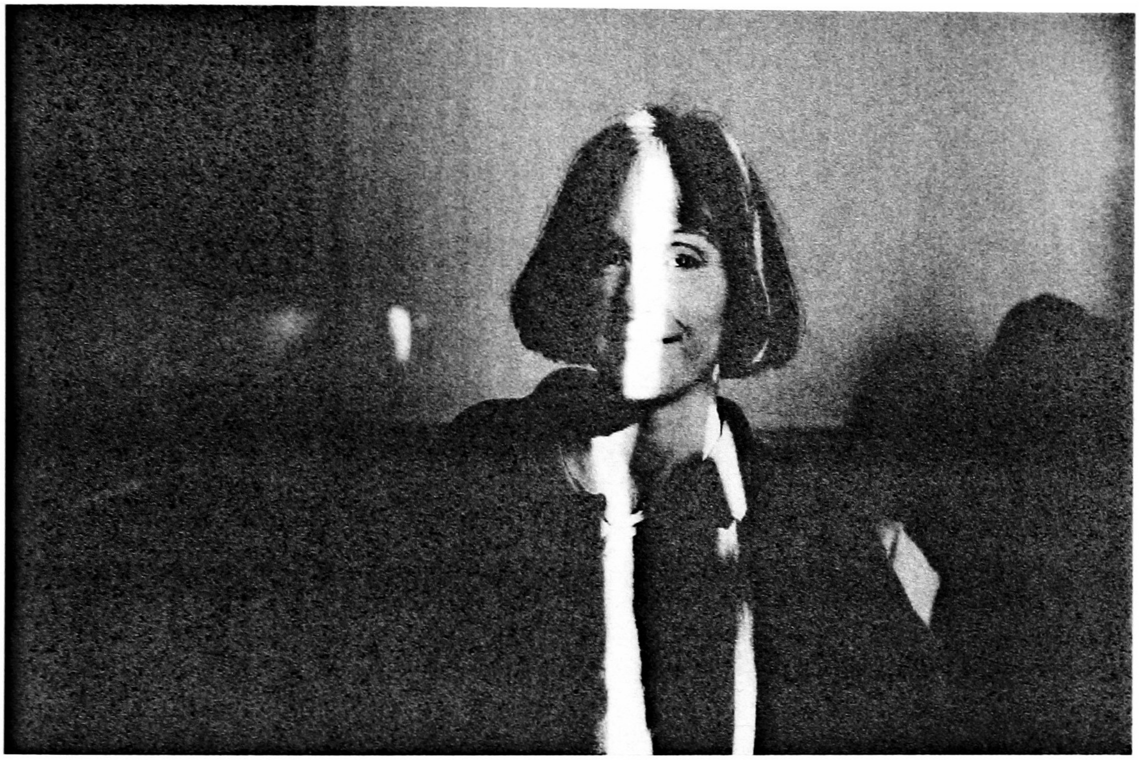


Figure 15: Unstable Color Electro-
Photographic Laser Print

Disadvantages of the flatbed scanner with CMS and the InkJet color printer.

1. The printer required RGB files when using the color management software- and printer profiles.
2. The light fastness of the toners was unstable on the prints.

Advantages of the flatbed scanner with CMS and the InkJet color printer.

1. The color printing was accomplished with a fully automatic calibrated four color process.
2. The scanner was inexpensive s,under $1,000.
3. Inexpensive printer at approximately $600.

The third method which produced good results was scanning the "desired print" on the midrange flatbed scanner and printing using the dye sublimation process.

Disadvantage of scanning the "desired print" on the highend flatbed scanner.

1. Density ranges adjustment was required in the images since the images captured from the scanner were dark.
2. The midrange flatbed scanner and printer were expensive, approximately $50,000 for the flatbed.
3. Significant time was required to print the files on the dye sublimation.

Advantage of scanning the "desired print"

1. A continuous print was produced using the dye sublimation printer.

A gamma setting of 1.8 produced the best results when scanning the "desired prints" on the Horizon flatbed scanner. A gamma setting of 1.5 produced a dark scan and the gamma setting of 2.2 produced a file that was contrasty with deteriorated shadow area. The midrange flatbed scanner was able to produce high quality scans of the "desired print," however the price range is expensive with excessive space requirement. Scanning the "desired print" achieved a closer digital file to the original "desired print." It required less manipulation than scanning a negative, particularly in images that required digital adjustments with local dodging and burning. Less time and knowledge were necessary when scanning the darkroom "desired print" than starting with a negative.

The fourth method recommended was the monotone flatbed scan of the "desired print" printed on the LaserJet.

Disadvantages of this method

1. For correction and image adjustment of the "desired print" knowledge of Photoshop was necessary.
2. The scanner was expensive, approximately $25,000.

Advantages of this method

1. Images printed close to the monitor screen's appearance. Soft proofing with the monitor screen provided a faster image correction.

The fifth method using the negative scanned on the midrange drum scanner in conjunction with the dye sublimation produced acceptable results.

Disadvantages of scanning the negative on the drum scanner

1. This method required major adjustments to most density ranges. Expert knowledge of Photoshop was needed.
2. Scanning using the drum scanner required a knowledgeable operator.
3. The scanner was expensive, approximately $45,000.
4. This was an expensive printer, approximately $25,000.
5. The dye sublimation process, as previously stated, uses unstable dyes.

Advantages of scanning the negative on the drum scanner

1. Critical highlight and shadow detail was captured when using the manual adjustments. A full density range was acquired.
2. The continuous tone print was similar to the "desired print'" produced in the darkroom.

The drum scanner was able to capture the highlight detail, needed to extend shadow area. The sensitivity level of the drum scanner was excellent in the highlight area. This scanner produced density ranges that were extended to capture more detail, however the image density exceeded the output. The highlights were captured correctly. It is better to have more information and discard the excess in Photoshop than to err on the other side with too little.

The sixth method which produced acceptable results was scanning the negative on the drum scanner and printing on the LaserJet.

Disadvantages of this method

1. This method required major adjustments to most density ranges. Expert knowledge of Photoshop was needed. The digital "desired prints" took expertise and time.
2. Scanning using the drum scanner required a knowledgeable operator.
3. The scanner was expensive, approximately $45,000.

Advantages of this method

1. Printer is inexpensive, approximately $3,500
2. Critical highlight and shadow detail was captured using the manual adjustments when scanning.

The seventh method was the flatbed scan of the "desired print" printed on the color electrophotographic laser which was generally acceptable.

Disadvantages of this method

1. Image adjustments were required for the scanned "desired prints". Knowledge of Photoshop was needed for adjustments.
2. The scanner was expensive, approximately $25,000
3. The printer was expensive, approximately $100,000
4. The printer was unstable in the toner application.

Advantage of this method

1. The scans were closer to the desired density values in the image when working from the "desired print."

Least successful of the scanner and printer combinations were those of the Photo CD scanner and the color electrophotographic laser printer. Photo CD scans were unacceptable for the extremes of high key and low key images and when the image contained critical highlight detail. The density ranges were set incorrectly. This was done automatically, setting a white point/black point. The Photo CD scanner produced poor results particularly in the critical highlight detail. The

black point was incorrectly set in a negative that had fogged blacks. Two ways to correct the image: either with plotting a transfer curve of 50% max black or correct the image to the percentage points where it is certain to print the desired tone. This appeared worse on the monitor and the histograms are lacking tones in areas, however, the CLC printer didn't have the sensitivity to print this flaw.

Disadvantages of the color electrophotographic laser printer

1. This printer required considerable image adjustment in Photoshop to lighten the images.
2. Images printed dark, a 55% and greater screen value printed solid black on the electrophotographic laser printer.
3. The printer was expensive, approximately $100,000

The eighth method is the drum scan printed on the electrophotographic laser printer

Disadvantages of this method

1. This method required major adjustments to most density ranges. Expert knowledge of Photoshop was needed. The digital "desired prints" took expertise and time.
2. The scanner was expensive, approximately $25,000
3. Transfer functions were applied to the images after adjustments in Photoshop.
4. This was an expensive unstable printer

*Scanning the Horizon and going to the Color electrophotographic laser. Both processes produced dark scans and prints.

The ninth method is the Photo CD scan printed on the dye sublimation.
The tenth method is thePhoto CD scan printed on the LaserJet.
The eleventh method is the Photo CD scan printed on the color electrophotographic laser printer.

Disadvantages of using the Photo CD for printing

1. The highlight detail was not captured in the scans. This was more noticeable in images which were high key.
2. Images were contrasty due to the automatic settings when scanned. Manipulation of files was necessary in Photoshop to add detail and reduce contrast.

Advantage of this method

1. The cost of placing scans on the Photo CD was inexpensive.

Standardization of images is difficult. When a file was manipulated to a digital "desired print" stage an attempt was made to use the corrected image on the other printers. This was easier on images with minor global adjustments with good scan detail.

Printer Densities

"desired print"	1.60
LaserJet	1.45
Color electrophotographic laser	1.75
Dye sublimation	1.00

Histograms

Screen shots of the histograms show the pixel values distributed similarly for each of the printers. The major difference is where tonal value begins and ends Histograms of the scanners can be viewed in Appendex A on page 60. Screen captures of the histogram were valuable for repeat printing and used as a reference for manipulating images with similar tonal characteristics.

Transfer functions were used primarily on the color electrophotographic laser laser printer. When images were over corrected in Photoshop, transfer curves were used. Data was sacrificed when major corrections were made in Photoshop. Rather than continuing to discard pixel levels the transfer function was implemented. Transfer curves provided a reference to how the printers handled gray

values and when used with the info box assisted in correcting images for the designated printer.

Chapter 7

Summary and Conclusion

For the professional photographer the darkroom cannot be completely replaced by digital methods, although the digital imaging process has improved significantly in the last few years. The low end printers, scanners and color management software have developed to an acceptable point for the professional photographer. Problems remain in the process, from the expense of the hardware to the expertise required. Traditional digital methods using midrange drum scanners are expensive and requires expertise in areas most professional photographers would rather avoid. Controls in Photoshop are not fine tuned enough to do major local manipulation of burning and dodging in the digital image. The tone variations and lack of density in the shadow or highlight areas was not an unacceptable result when using the Photo CD Master.

The time, testing, and analysing results for this study consumed approximately 1,000 hours. This project should eliminate the time intensive testing of digital desktop printers and scanners used to determine the best method for reproducing a "desired print," a clear benefit to the photographer. The photographer can thus determine which reproduction method is most useful by consulting Table 8: Evaluation Results on page 34 and Table 9: Printer/Scanner Results on page 41.

Of the methods used in this study, which was the best digital capturing and printing system for a professional photographer to use when printing his images? The recommendation is for the professional photographer to keep his darkroom and invest in a few tools to aid in his quest to publish. These tools would be a flatbed scanner with color management software and a color printer which has printing profiles of the scanner. After producing a "desired print" the

best method for a professional photographer is to use the color management system for the digital conversion of images. This method closely maintained the detail in critical highlight areas. It required minimal digital imaging knowledge and no additional manipulation of the "desired print."The drawback is the sepia color in the print. A photographer can mass produce his work without the darkroom. The prints aren't identical to the continuous tone prints, however, they are acceptable reproduction.

The other method recommended is to scan the negatives on a drum scanner, capturing all the critical density detail. When archiving images and highlight detail is critical, the suggestion is to use the higher quality drum scanner and store the digital files, until the output devices are developed to a higher standard to satisfy the professional photographer. Printers are constantly developing and improving, both in affordability and higher resolution.

The initial investment in a wet darkroom is still less than that of computer, scanners and printers. There is the additional cost of expertise/time for the professional photographer, either employing trained people or investing time in learning. It can take years for a photographer to gain the knowledge to be able to do the entire process digitally.

The Kodak Photo CD scan omitted critical highlight detail and extremely altered the scene in some scans. The traditional scanning methods were more successful in maintaining detailed information in difficult negatives. The Photo CD Master will not satisfy a professional photographer who has negatives that have extreme density ranges. The majority of professional photographers are concerned about the treatment of their negatives. Turning original negatives over to a service bureau and allowing a scanning operator to touch their negatives is often unacceptable. Negative originals are essential to their creative work. This is a major problem in working from a negative.

Photo CD Master is still a viable solution for converting images which have a limited tonal range with no significant highlight area, however, for a professional photographer it is not recommended unless the photographer shoots for the Photo CD. The photographic negative should be sharp with a good depth of field. The negative should have a density range that isn't beyond the capabilities of the scanner, which is 2.8. Finally, for optimizing the information recorded, the image requires a correct exposure of the central subject, with accurate highlight and shadow detail (*The Official Photo CD Handbook*, Michael Gosney, p68-69). The Photo CD produces good results using black and white film however color negative film is recommended due to its finer film grain and the film maximum density which is approximately 2.0. (*Using Photo CD for Desktop Prepress*, Frank Cost, p 15) Another recommendation when using the Photo CD is to include a white point and black point in the image to guarantee the maximum density range is used. This would prevent a clipped density range. Incorporating a grayscale on the frame when scanning would provide another method for extending the range of the scan without highlight clipping. This second suggestion would be facilitated in using the larger Photo CD format with a larger negative.

Technology continues to advance and within a few years the digital camera will probably replace the scanner for acquiring digital images. Will software continue to develop fine tune controls that are capable of replicating the photographer's darkroom techniques when creating a "desired print?"

Digital darkroom is rapidly becoming a reality, however, the professional photographer still requires a traditional darkroom. Producing the darkroom silver halide based "desired print" of high quality, scanning the print with color management software was the best method for printing. Once completed the digital print can be identically mass produced. Storage of the digital files has a longer life expectancy than traditional prints and negatives and requires less space.

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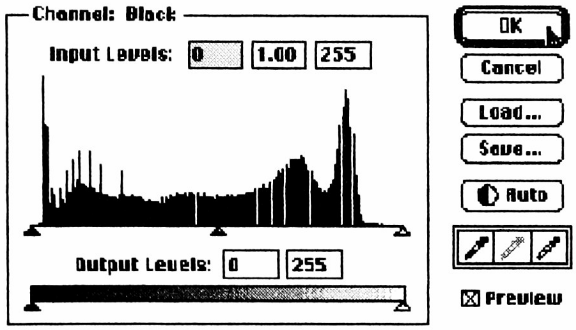
Appendix A

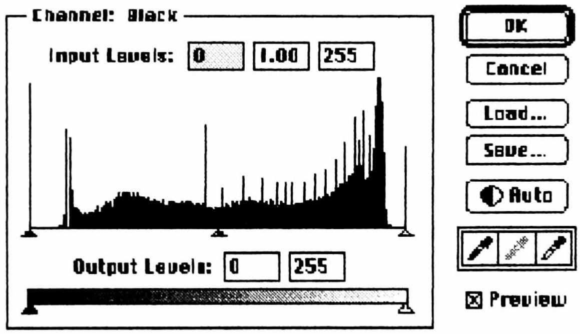
Appendix A
Images from Scanners

Scanner: Colorgetter, manual setting
Image: Atget



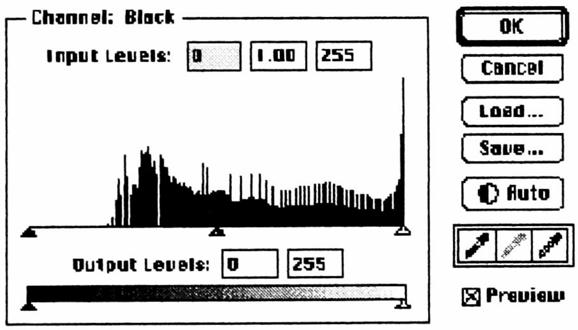
Scanner: Colorgetter manual
Image: Atget

Scanner: Colorgetter, auto scan
Image: Atget

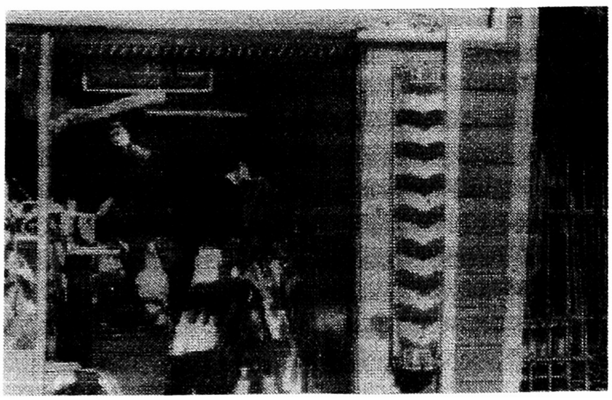


Scanner: Colorgetter auto acan
Image: Atget

Scanner: Acquire Photo CD
Image: Atget



Scanner: Acquire Photo CD
Image: Atget



Scanner: Horizon
Image: Atget

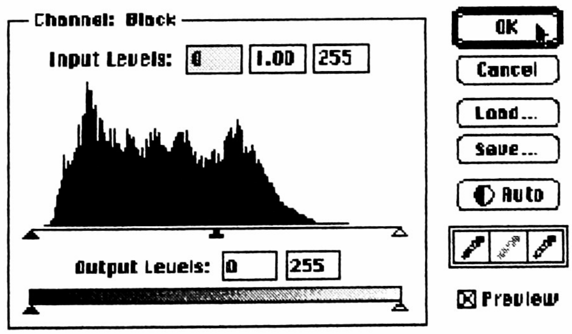


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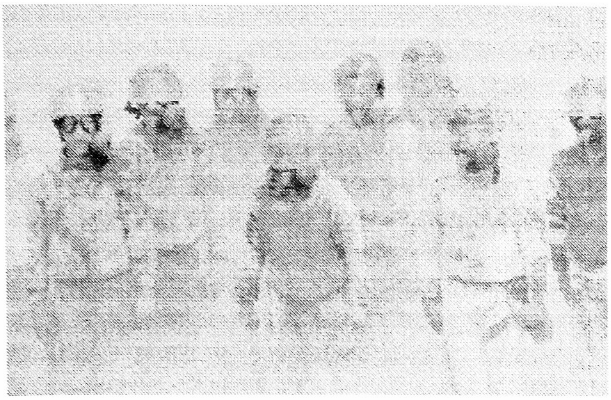
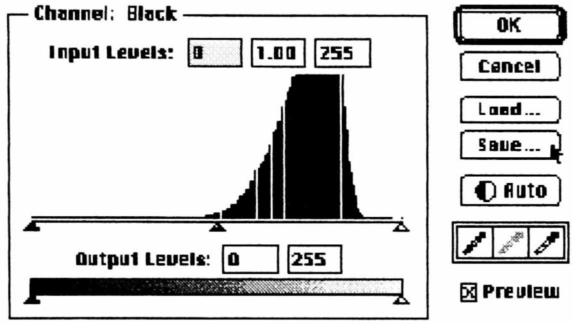
Image: Atget

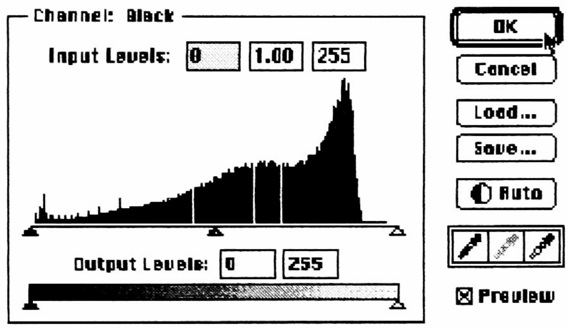


Scanner: Colorgetter, manual
Image: Smoke



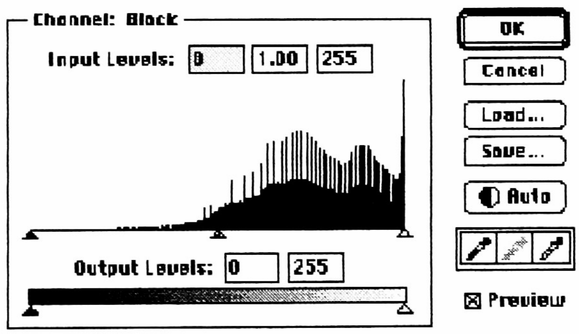
Scanner: Colorgetter, manual
Image: Smoke

Scanner: Colorgetter, auto scan
Image: Smoke



Scanner: Colorgetter auto scan
Image: Smoke

Scanner: AcquirePhoto CD
Image: Smoke



Scanner: AcquirePhoto CD
Image: Smoke

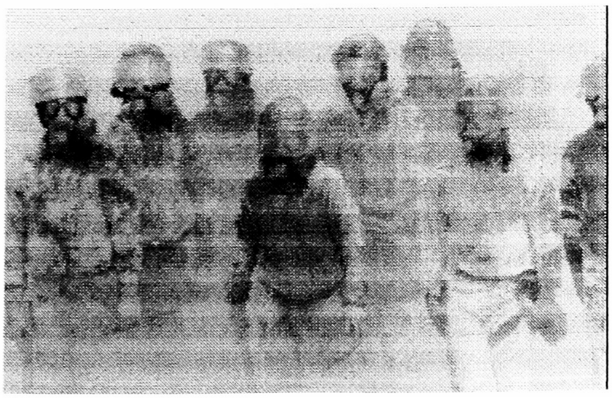


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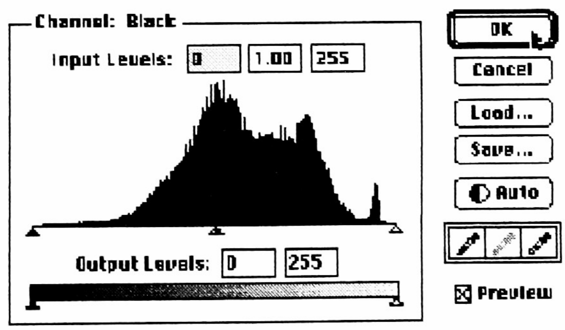
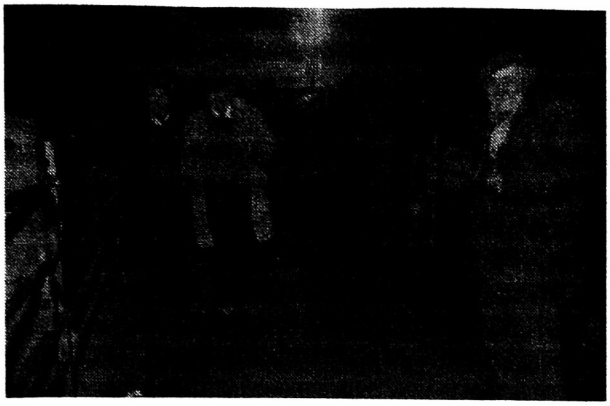
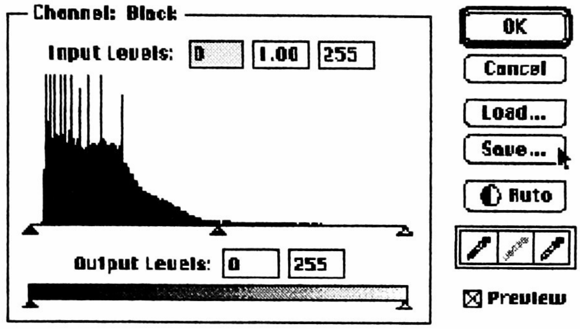
Image: Smoke



Scanner: Horizon
Image: Smoke

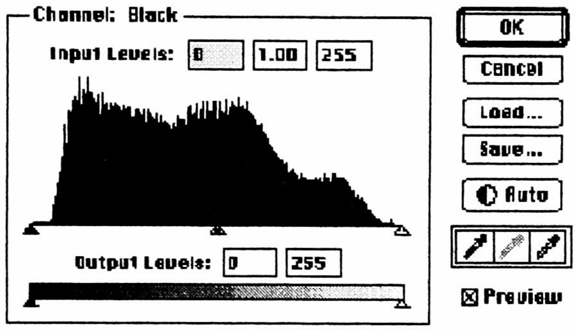


Scanner: Colorgetter, manual setting
Image: Welsh



Scanner: Colorgetter, manual
Image: Welsh

Scanner: Colorgetter, auto scan
Image: Welsh



Scanner: Colorgetter, auto scan
Image: Welsh

Scanner: AcquirePhoto CD
Image: Welsh

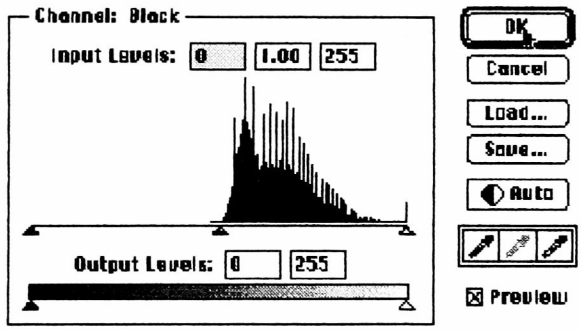


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Image: Welsh

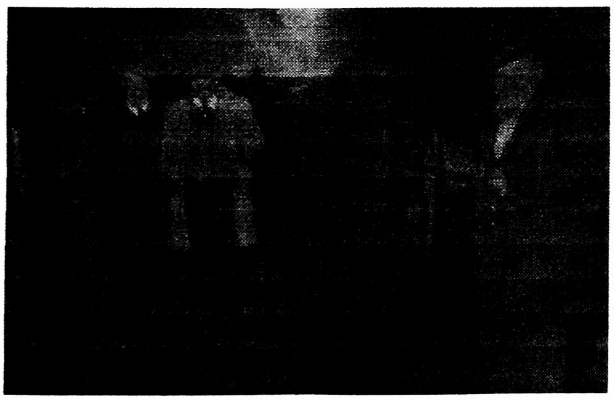

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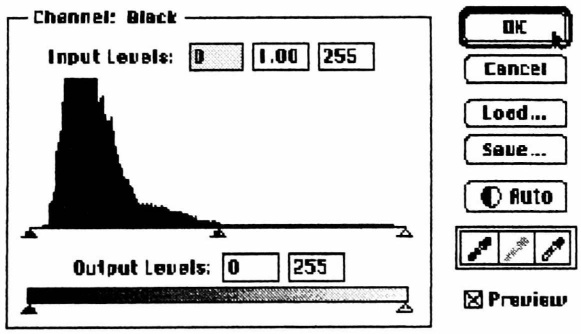
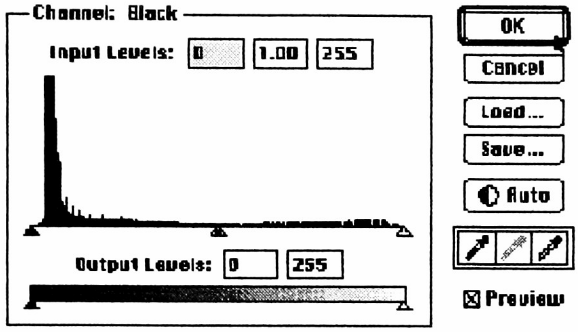
Image: Welsh

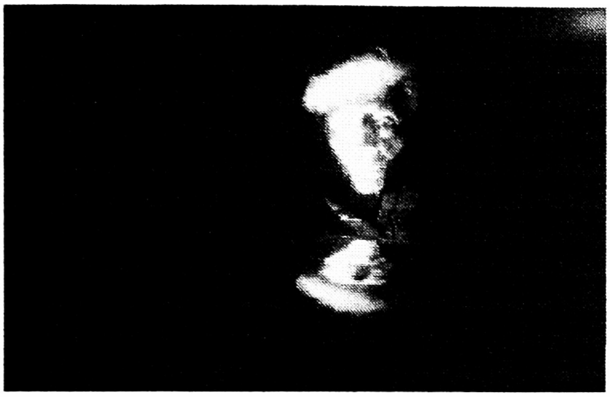


Scanner: Horizon
Image: Welsh

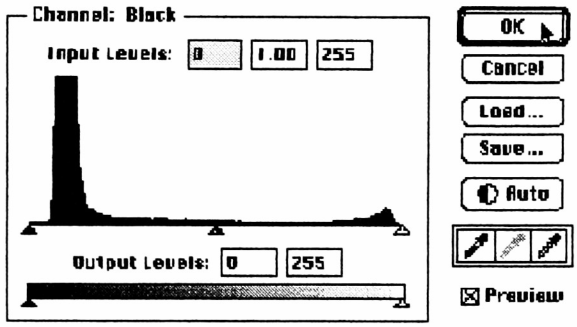
Scanner: Colorgetter, manual
Image: Muriel



Scanner: Colorgetter, manual
Image: Muriel

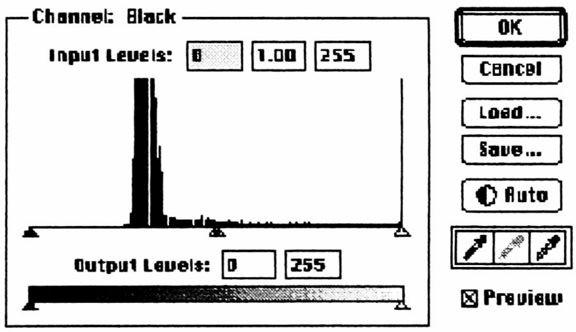


Scanner: Colorgetter, auto scan
Image:Muriel



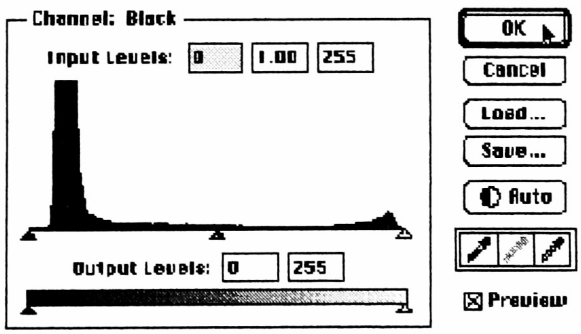
Scanner: Colorgetter, auto scan
Image: Muriel

Scanner: AcquirePhoto CD
Image: Muriel



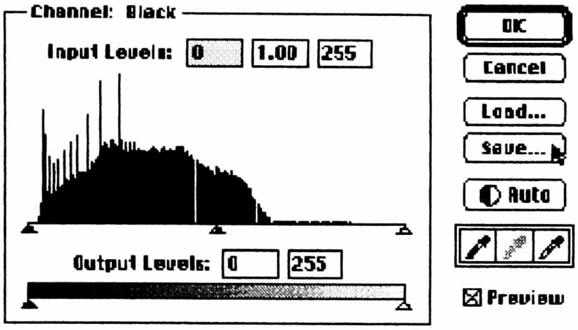
Scanner: AcquirePhoto CD
Image: Muriel

Scanner: Horizon
Image: Muriel



Scanner: Horizon
Image: Hats

Scanner: Colorgetter, manual setting
Image: Hats



Scanner: Colorgetter, manual
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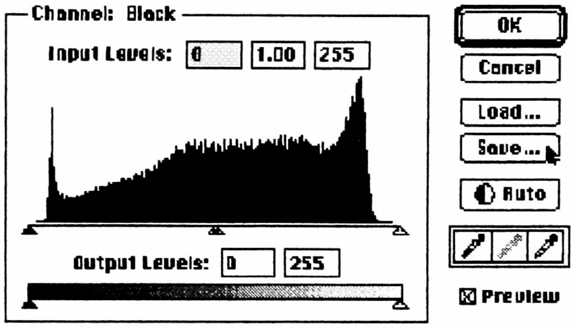

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Scanner: Acquire Photo CD
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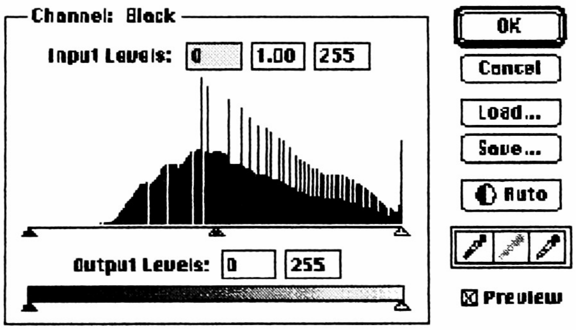
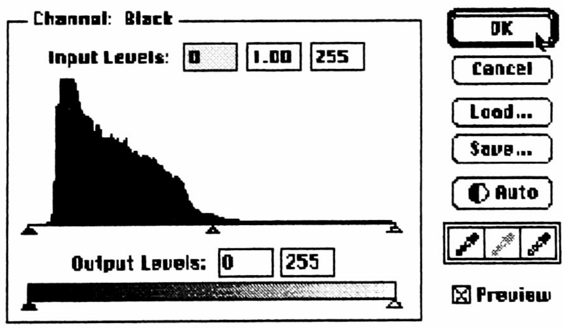


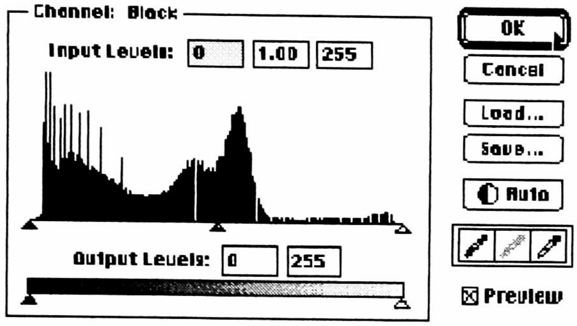
Scanner: AcquirePhoto CD
Image: Hats

Scanner: Horizon
Image:Hats



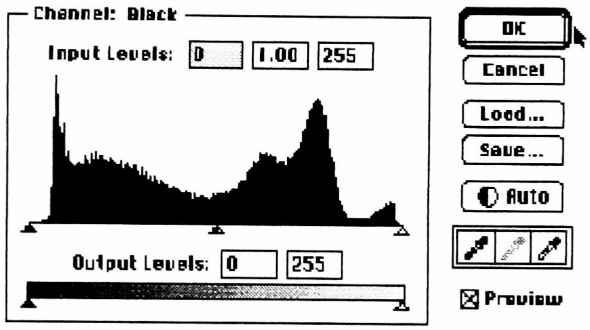
Scanner: Horizon
Image: Hats

Scanner: Colorgetter, manual setting
Image: Sue



Scanner: Colorgetter, manual
Image: Sue

Scanner: Colorgetter, auto scan
Image: Sue



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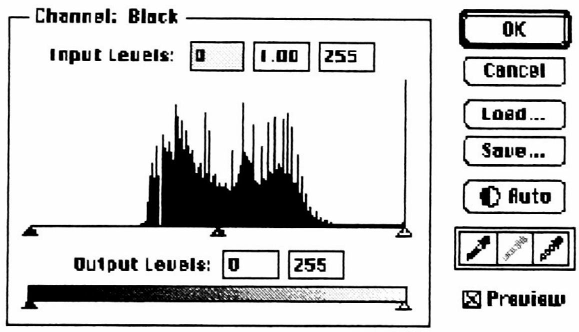
Scanner: Acquire Photo CD
Image: Sue



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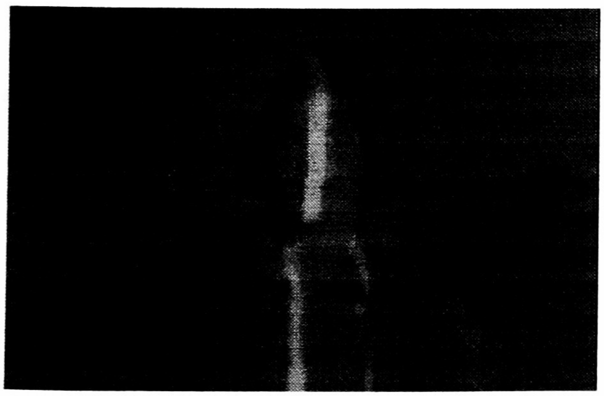

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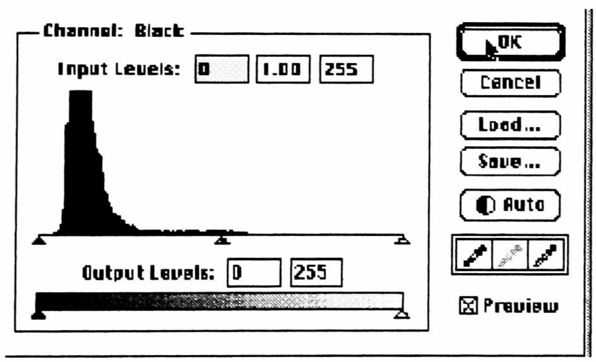
Image: Sue



Scanner: Horizon
Image: Sue

Appendix B

Appendix B
Darkroom Prints

Atget

Smoke

Muriel

Hats

Welsh

Image: Sue