ELECTROGRAPHICS

by

VIRGINIA RUTH HOLMES

BFA, Stanford University
(1972)

Submitted in Partial Fulfillment

of the Requirements for the

Degree of

Master of Science in Visual Studies

at the

Massachusetts Institute of Technology

September, 1980

Signature of Author.. ....
Visible Language Workshop
Department of Architecture
June, 1980

Certified by.... ....
Muriel Cooper, Professor
Visible Language Workshop
Thesis Supervisor

Accepted by...
Prof. Nicholas Negroponte, Chairman
Departmental Committee for Graduate Studies

ELECTROGRAPHICS

by

Virginia Ruth Holmes

Submitted to the Department of Architecture on June 16, 1979, in partial fulfillment of the requirements for the degree of Master of Science in Visual Studies.

ABSTRACT

The development of a variable format electrographic printer which is adaptable to standard darkroom equipment, with full color, positive and negative, imaging capabilities.

Visuals will consist of large format (16" x 20") four color prints, demonstration books, and notes on processing.

Thesis Supervisor: Muriel Cooper
Title: Associate Professor of Visual Design


ELECTROGRAPHICS

ACKNOWLEDGEMENTS

To Myron Tribus, Director, Center for Advanced Engineering Study, for allowing me to take advantage of the Student-Teacher relationship.

To Robert Gundlach and George Carr, Xerox Corporation, for all of their contributions.

To Muriel Cooper, Ron MacNeil, and all the members of the Visible Language Workshop, for listening to me, supporting me, and sometimes telling me what I could do (with it).

To Steve. Ellen, and Syl of the MIT Graphic Arts copy center, for initially supporting my habit.

To Tom Norton, for teaching me what he knows, and learning what I know.

To Donna Healy, O.T., Mt. Auburn Hospital, for bending me into shape and not letting me quit.

To Dr. Tom Cochran, Cambridge City Hospital, and Dr. Donald McKay, Mt. Auburn Hospital, for being as stubborn as my hand is. (Also for being so understanding.)

To Tom Courteau and Aztech Electronics.

To my family, especially Pat.

CONTENTS

PREFACE

What follows is intended as a study for work to be submitted in fulfillment of the requirements for the Masters of Science in Visual Studies. It is a study containing an element of ambiguity - legitimate ambiguity.

What is required of the candidate for the MSVS degree at MIT? Is it visual work? Is it research? Is it a dissertation regarding work and research? Just what happens to the artist/candidate when s/he enters the program and seeks to acheive a body of work that covers the whole scope of art/research/ verbal/visual "statement"? What becomes of the personal reasons for starting the whole process in the first place? What becomes of the artist? Are the motifs the same in the end as in the beginning?

These questions are very important for me, because I find that I no longer have a concrete answer when asked: "What is it that makes you do this? Is it because you live for the art, for the specific product which comes from this particular process? Where has this thesis study led you as one who deals with the visual?"

To this, I can only say: "I no longer know. I have spent the last year dealing with so much research that I question my approach to making images. I have had to dedicate myself to acheiving process stability to the point that the aesthetic question has been submerged. The sacrifice of personal statement as art for the development of process - a sacrifice not unwittingly made - has forced me to completely rethink my committment to the type of imagery I have, and will, produce."

The requirement that I complete a verbal statement that justifies my visuals - a statement which is restricted by institutional standards established with a different goal - adds frustration to the ambiguity. And, how will I write this? Is it to be a complete scientific support of my research, or background to my imagery? Since I involved myself in the development of a new printer, how process oriented must the write-up be? Strictly technological, or in laymen's terms?

I view this study as only a beginning.

INTRODUCTION

The first practical office machine was Thomas Edison's Mimeograph, which used specially designed stencils for printing (1887, A.B.Dick, Manufacturer). In 1910, the French introduced the Photostat, a process involving the conversion of an image to white on black through the use of silver halide coated paper. A direct positive could be made in an additional procedure, but copies were/are subject to fading and discoloration with time.

Independent inventors in the late thirties discovered the basic principles of quick copying, but Chester Carlson, a patent attorney, was the first to cohesively work the principles together with a process he called electrography (later to be called xerography - from the Greek, meaning dry writing). 1/.

The process became a commercial success primarily through the joint research efforts of the Haloid Company of New York, which is now known as Xerox Corporation, and the Batelle Memorial Institute. A variation on Carlson's process - direct electrostatic imaging - used copy paper coated with zinc oxide, which received both charge and toner. Developed by RCA, the process was marketed under the name Electrofax (electrostatic facsimile) and later under the name VQC (Variable Quality Copier) by the 3M Company. 2/.

In late 1939, Carl Miller, a graduate student in chemistry at the University of Minnesota, began experimenting with temperature sensitive coated papers, a simple process forming direct positive images with heat. Called Thermography, the process was based on the principle that the typed black characters on the page absorb heat and the white paper reflects it. By placing the treated paper in contact with the original document, dry copy is made. The process was later developed and marketed (1950) by the 3M Company under the name Thermo-Fax. In 1953, Eastman Kodak came out with the Verifax copier, a duplicating process using a master which was transferred to specially treated copy paper. 3/.

Copy capabilities were expanded in the late fifties when colored toners were first added to the RCA Electrofax process. Haloid developed color toners for xerography in order to aid animators at the Walt Disney Studios in the production of the thousands of cells needed for motion cartoons. In 1968, 3M introduced its Color-in-Color copier, a system reproducing color originals in full color. Color-in-Color formed images with a direct electrostatic process that was coupled with a thermal dye-transfer system. The only other color system to have yet reached the market (in the US) is the Xerox 6500 Color Copier, which uses existing xerox principles but employs color toners. Both systems use the subtractive color system (basic process colors: magenta, yellow, cyan) with filter separation. 4/.

Copy machines are now manufactured by numerous large and small corporations, and have evolved into highly complex systems. The popularity of copiers has spread so rapidly that the machines have become an integral part of daily life and can be found in many public establishments (in Paris, they can be found in the subways.) Brand names of copiers are now firmly established in the contemporary vocabulary and, in fact - much to the dismay of many manufacturers - have become generically used nouns and verbs...Xerox Corporation's name has become almost synonymous with the act of copying... 5/.

A more suitable name is ELECTROGRAPHY.

By the time this thesis is printed, it will be obsolete

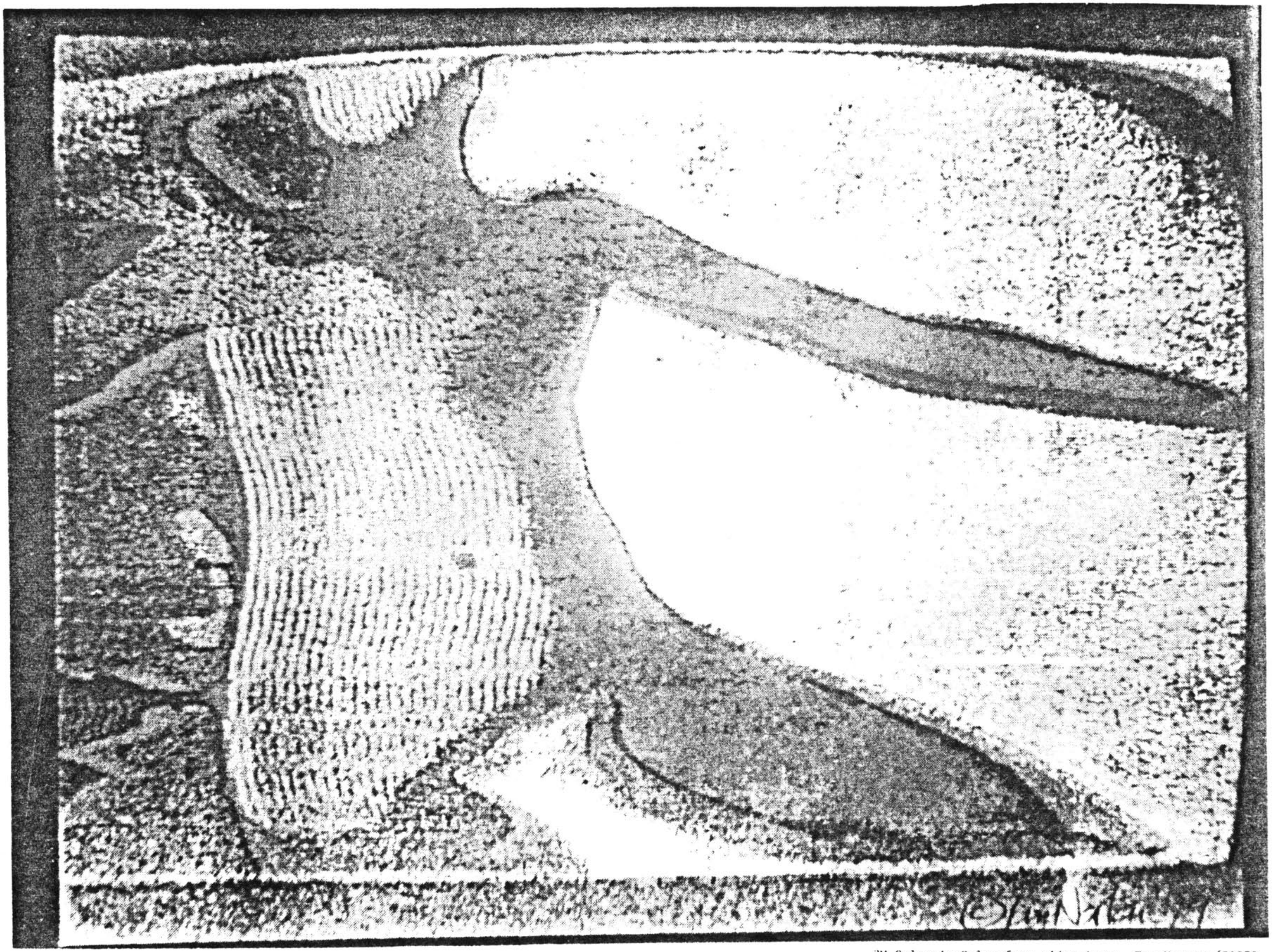
PRINT: n 1/ a mark made by pressure 2/ something stamped with an impression 3/ printed state or form 4/ printed matter 5/ a copy made by printing 6/ cloth upon which a figure is stamped.

PRINT: vb 1/ to stamp (as a mark) in or on something 2/ to produce impressions of (as from type) 3/ to write in letters life those of printer's type 4/ to make (a positive picture) from a photographic negative.

PRINTABLE: adj ...2/ worthy or fit to be published. (Merriam-Webster)

ELECTROSTATIC RECORDING: that class of processes in which electrostatic fields, forces, or charges comprise an essential part of an image recording, sensing, or reproducing system. (Dessauer-Clark)

ELECTROGRAPHY: the formation of electrostatic images by photoconductive discharge of an electrically charged surface, and the physical development of these images by electrical attraction of fine particles. (Schaffert)



3M Color-in-Color from video input. Tom Norton,©1979.
(35MM of original to Xerox 6500 to Xerox 9500)

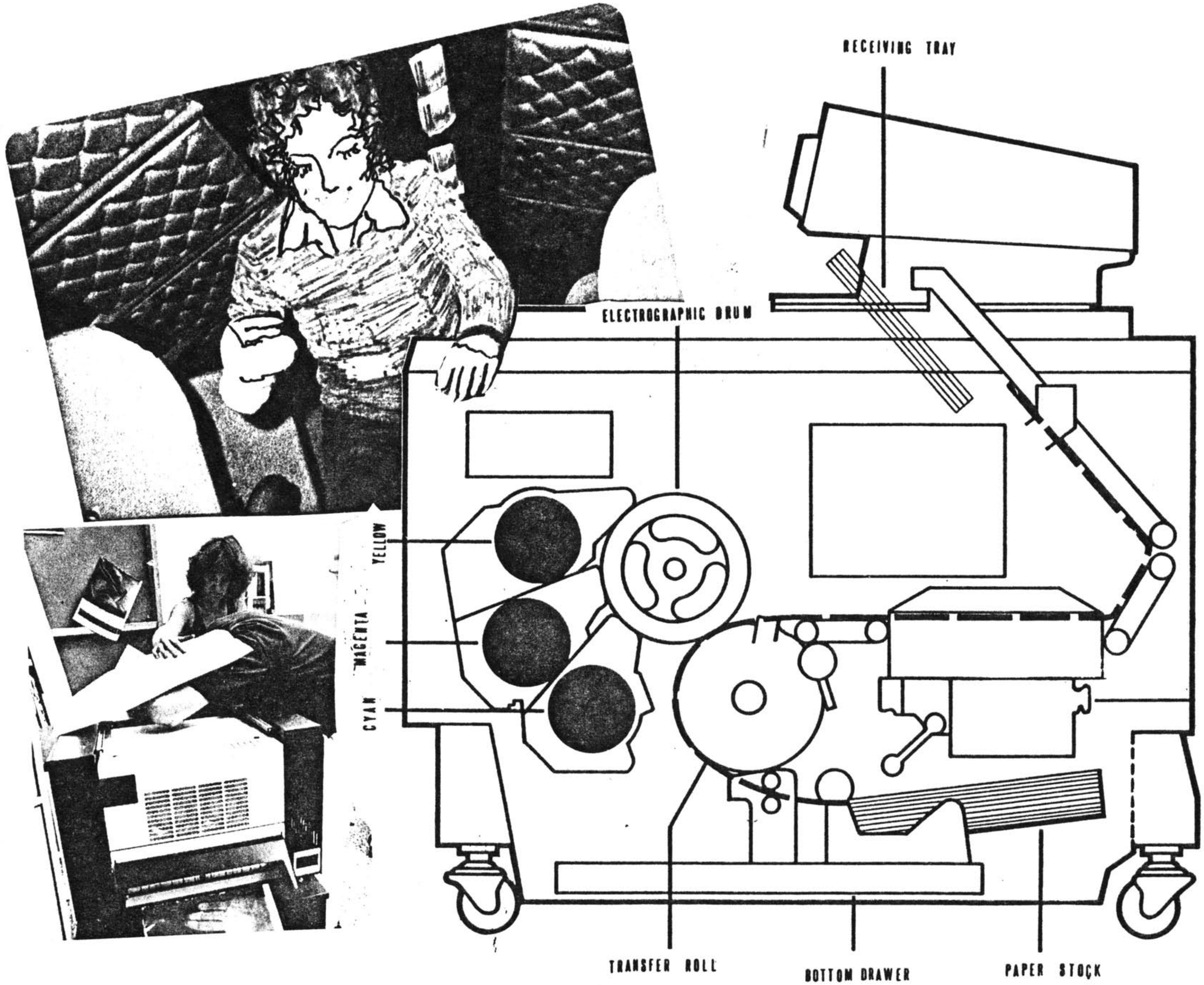
Over the years, museum curators, artists, and others with special interest in prints have met together to try and draw up once and for all some precise definition of an original print, acceptable to every one and at the same time providing the printmaker with specific rules to follow. 5/.

The following are to be regarded as original engravings, prints, and lithographs: impressions printed inblack and white or in colour, from one or more matrices, conceived and executed entirely by the artist himself, whatever the technique employed, and excluding the use of all mechanical processes...Only those prints which correspond to this definition have the right to be called original prints. 6/.

The impact of copying machines and processes on art...is an important and widespread phenomenon. Artists have adopted copying machines...to develop personal aesthetic concepts and create original works of art. Ironically, new picture-making possibilities are discovered on machines which were primarily designed to mechanically reproduce office memos. 7/.

...I should like to dwell for a moment on an attractive theory which at one time appealed to me: that prints should be seen as a democratic form of art. And so they must have been at one time, when engravings were circulated among a great many people, always at a reasonable price, the only limitations on their circulation being technical ones. But this practice, which was common up to fairly recent times, seems to be at an end now, just when the democratic ideal is perhaps most widely understood and valued. In fact, the modern print, especially if it is by a great artist, is, because of conditions imposed by the market, reserved for a relatively small and wealthy minority. 9/.

Because everyone can operate a copy machine, the technology opens lines of communication between artist and viewer...The copy machine democratizes the image-making process and makes the act of creating an image less of a specialty. 10/.


RECEIVING TRAY
ELECTROGRAPHIC DRUM
YELLOW
MAGENTA
CYAN
TRANSFER ROLL
BOTTOM DRAWER
PAPER STOCK

There are nearly 200,000 born every minute: a total of 100 billion instant copies produced each year in the United States alone...Add to this the paper clone mania of federal, state, and local bureaucracies...World consumption of instant copies had grown fivefold since 1970. Today worldwide revenues for the copier industry are close to the $8 billion mark... 11/.

The assumption that mass production is the governing factor in our civilization, or even one of them, remains to be proven. The assumption that art must express mass production by using its method of operation is certainly false. By doing this, art endangers what constitutes its essence. 12/.

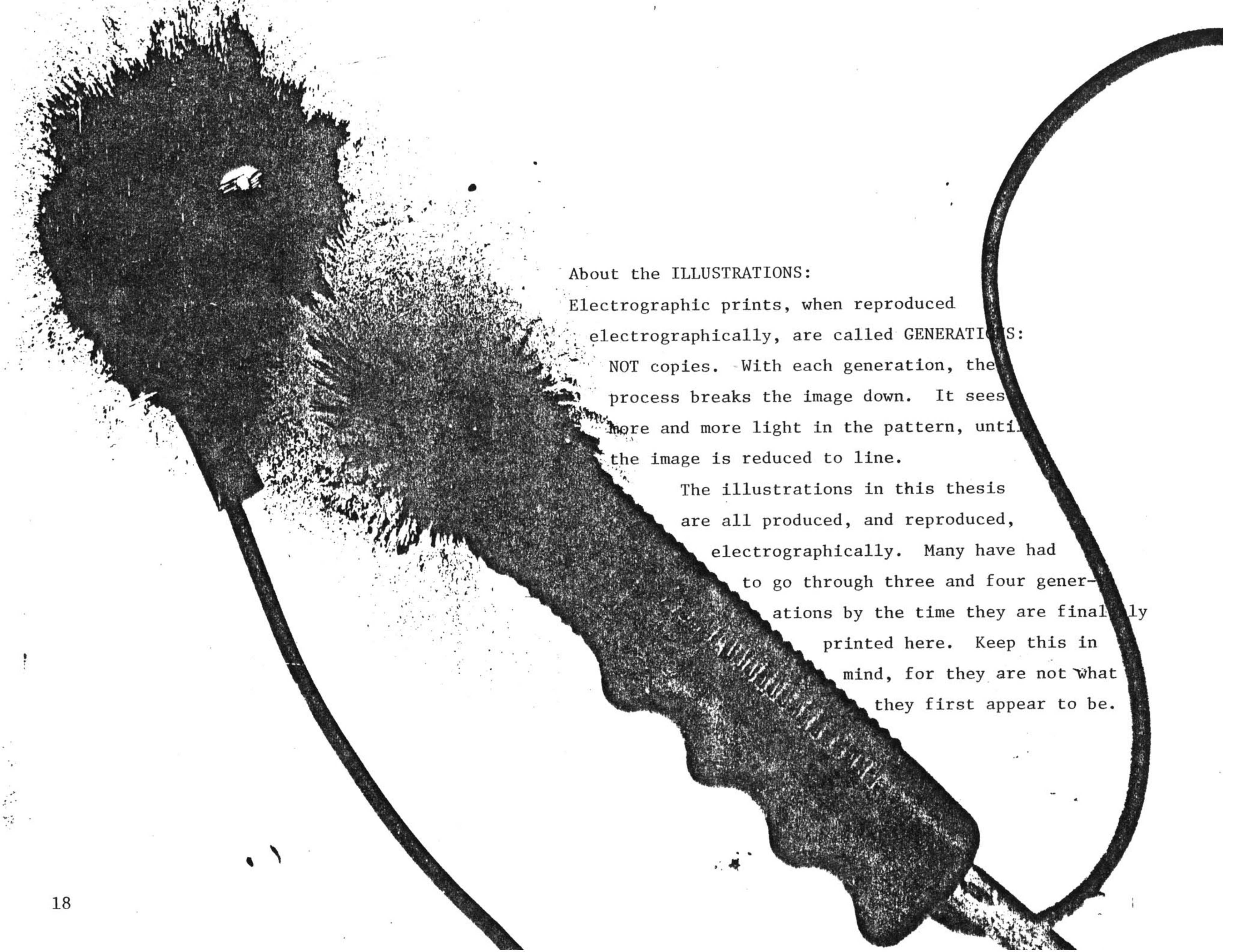
Industry, by invading the territories of art, had become art's most mortal enemy. 13/.

Living as they do, in a supertechnological society ...artists have quite naturally turned to the products, processes and imagery of science and industry. Some approach technology with traditional attitudes, others are using it to alter the very definition of art, but all who succumb to its fascination have responded with a new sense of exhilaration and discovery...To oppose technology is as much a part of man as his home or his road or his clothes...It seems we must learn again that art can incorporate any material and any process, when employed in the service of imagination. 14/.

As it becomes necessary to create new machines, to keep old ones in operating condition and to exchange information between specialties, an artist must turn to industry for technical assistance and sophisticated instruments. Artists may in turn be able to influence the directions that industry takes in the development of new machines. In this new industry-artist context an artist may hopefully acquire enough information to participate in the invention of new machines... 15/.

After immersing myself in an environment which seeks life from technology, I derive a strange pleasure from knowing that I have been able to take that which is advancing by the minute, and throw it back in time. I can't seem to rid myself of my traditional training. 16/.

The artist in the 20th century tries to extend his knowledge and continually experiments with new ways of making art. The print is being pushed to its limits and new horizons are appearing. As Kristian Sotriffer, the writer on printmaking, has remarked, "The aim of all this experimentation is to do justice to the <u>secret</u> nature of the material." 17/.



About the ILLUSTRATIONS:

Electrographic prints, when reproduced electrographically, are called GENERATIONS: NOT copies. With each generation, the process breaks the image down. It sees more and more light in the pattern, until the image is reduced to line.

The illustrations in this thesis are all produced, and reproduced, electrographically. Many have had to go through three and four generations by the time they are finally printed here. Keep this in mind, for they are not what they first appear to be.

PERSONAL INVOLVEMENT

As a printmaker trained in traditional hand-lithography, a "purist" if you will, I did not approach electrographics as a serious print medium. I saw it only as a novelty: a machine with which one could make facsimile copies of originals for the sake of record keeping. At most, it was a fun machine with which to document snapshots, copy slides, and make cards.

I began using the medium during a mini-course at the Visible Language Workshop in order to make enough copies of hand-colored Polaroids to give to the people in the course. The Polaroids, which documented the workshop, were combined in an "album" complete with golden corners, and reproduced on the Xerox 6500. I knew that the 6500 would not duplicate the colors exactly, but I was able to get close. Paper was of no concern, for I thought that only one kind could be used - the kind supplied by Xerox.

what is this?

Instamatic original to Xerox 9500

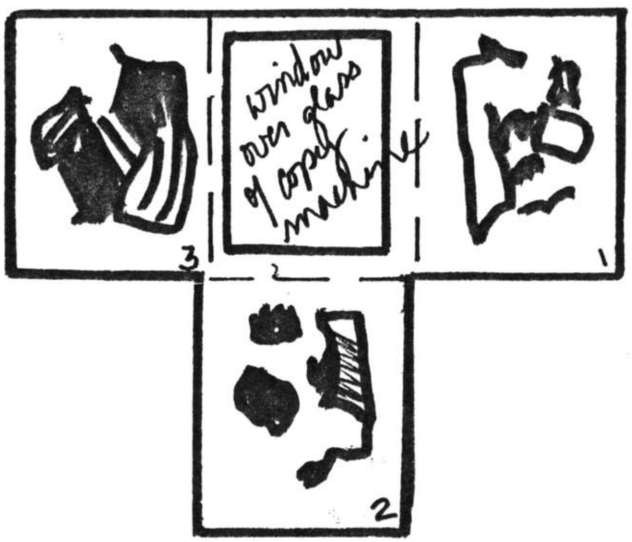
B & W Polaroid, tinted, to Xerox 6500 interpretation, Gini Holmes, © 1976. (Xerox 6500 to Xerox 9500)

Page from "Grandmother's Book," Laura Blacklow, © 1977. (slide of original to Xerox 6500 to Xerox 2000 reduction to Xerox 9500)

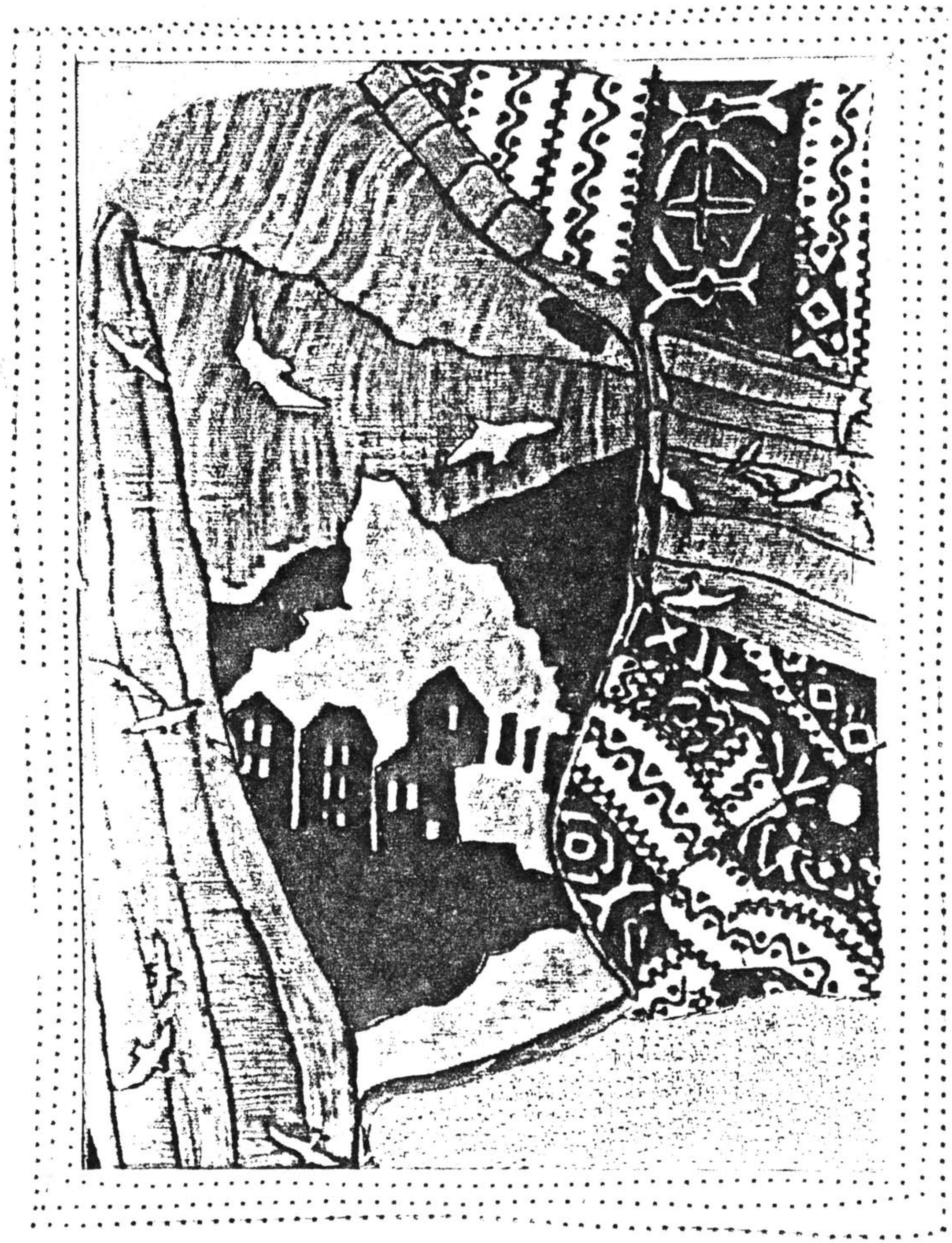
A year passed after this initial attempt at electrographic imaging. During this period, I saw how Laura Blacklow, then a graduate student with the Visual Studies Workshop in Rochester, turned to the Xerox 6500 to bring together materials she had previously been using with Kwik-Proof, a color print medium involving separate color negatives, or printers. With her electrographic book, "Grandmother's Book" (© 1977), I saw that different papers could be used in the machine. Since I was, and am, especially concerned with the relation of the paper printed on to the material making the image to the image itself, this particularly interested me. However, I still approached the Xerox 6500 as a means to retranslate snapshots, this time with different papers. While doing so, I became aware of the "fool-the-eye-of-the-beholder" style: the snapshot really isn't a snapshot, but an electrographic print.

As my interest in electrographics grew, I saw that I could use the color cycles in the Xerox 6500 as I would the color cycles in offset printing. What would happen if, using preseparated transparencies, the color sequences were shuffled, and printed using the Xerox 6500 rather than offset? Coincidentally, this problem of exploring this problem with the 6500 occurred to Tom Norton at the same time. Prior to this, he had been using the 3M Color-in-Color copier to synthesize his black and white video images, and was already a strong proponent of electrographics. (NOTE: color synthesis was not new to electrographic printing, for 3M had been using it with textile design since 1970.) Consequently, Tom and I showed up at the same Xerox 6500 at the same time with the same idea, and have been working together ever since.

The following pages illustrate projects which have come out of my involvement in the field. Many of them were made possible by Myron Tribus, Director, Center for Advanced Engineering Study, through the generous use of his Xerox 6500 color copier.



1, 2 & 3 = color separations in black/grey positives to be alternated over passes of machine.



Quilted image, Xerox 6500 color synthesis from B & W, transferred to cloth and quilted to paper. Gini Holmes, © 1978. (original to OCE 1600 to Xerox 9500)

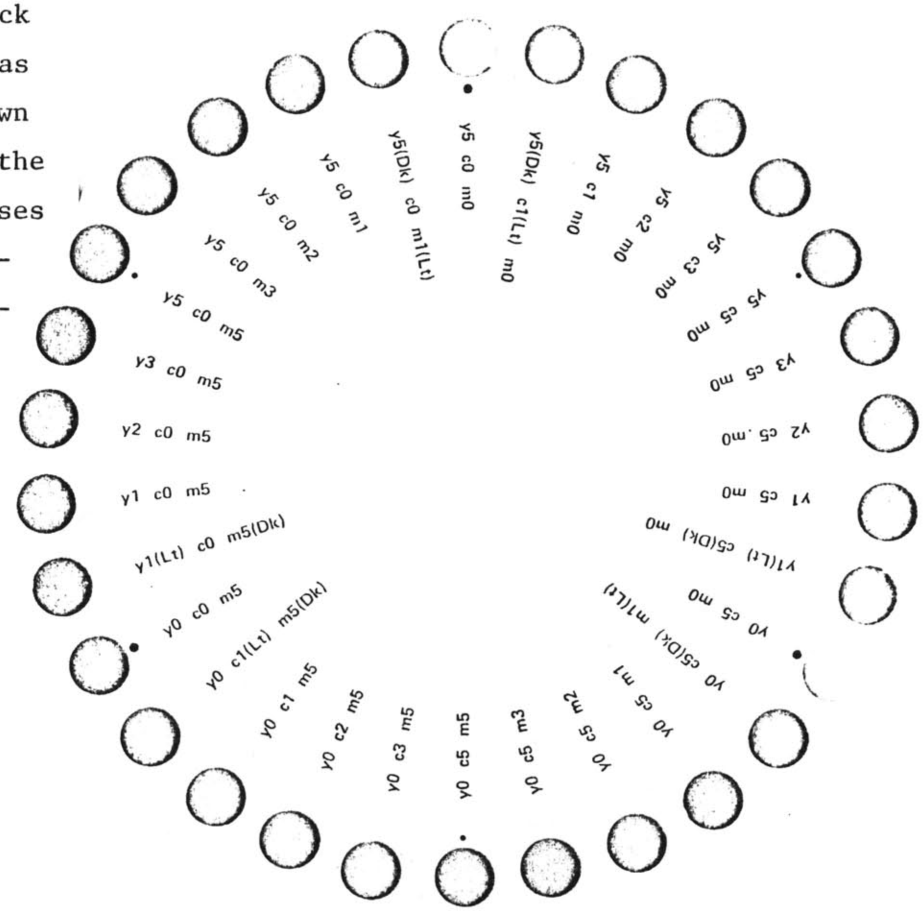
COLOR SYNTHESIS

The Xerox 6500 uses the principle of subtractive color, automatically filtering and separating for the three process colors: magenta, yellow, and cyan. If the image being "copied" has no color, just black and white, the filters will read the blacks/greys as any value of magenta, yellow, or cyan. Using my own color separations, I bypassed the color system in the machine. By rotating the separations with the passes of the machine, and using one standard for all possible combinations, I could make at least 30 combinations. Often, these variations were printed, transferred to cloth, quilted, and "framed" by stitching to handmade paper.

NOTE: The method for color synthesis on the Xerox 6500 from black and white was developed with Tom Norton. From this, we printed a color wheel which corresponds to the 6500 color system.

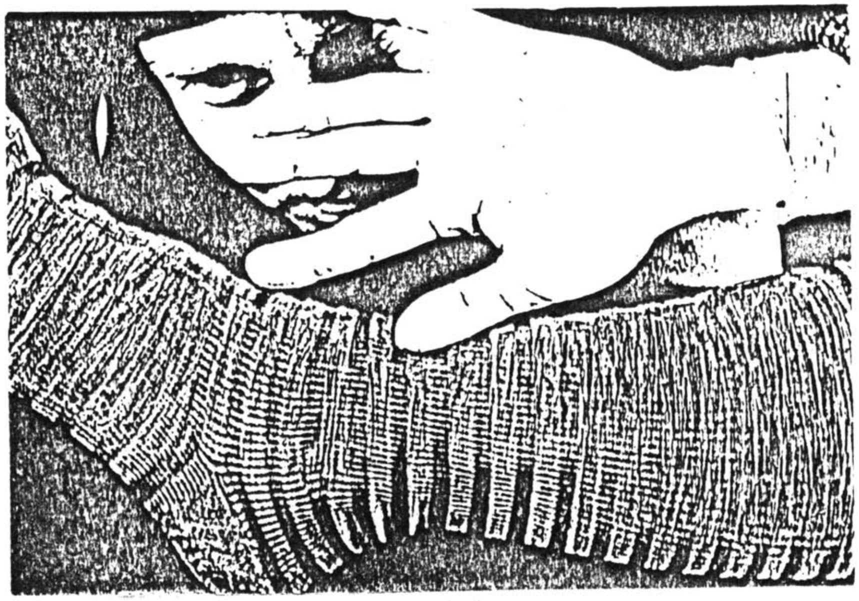
THE NORTON-HOLMES X6500 SYNTHESIZED COLOR WHEEL

Use normal contrast for all settings except where indicated as (Lt) or (Dk).
The colors on this chart were synthesized from a black original.
For pastel hues use gray originals.

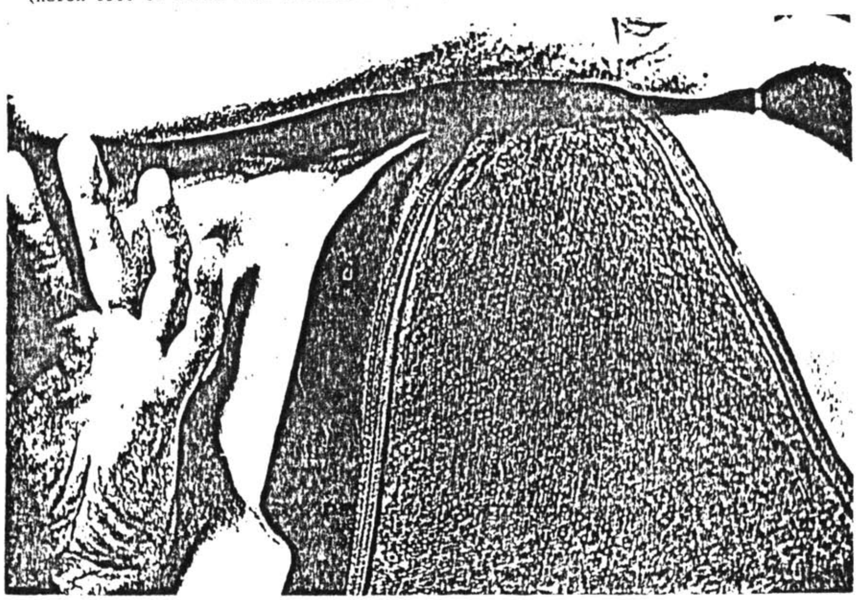


 Visible Language Workshop MIT

(Original to Xerox 2000 reduction to Xerox 9500)



Glass box images, Xerox 6500 color synthesis from B & W photographs, tinted. Gini Holmes, ©1979. (Xerox 6500 to Xerox 2000 reduction (twice) to Xerox 9500)



GLASS BOX IMAGES

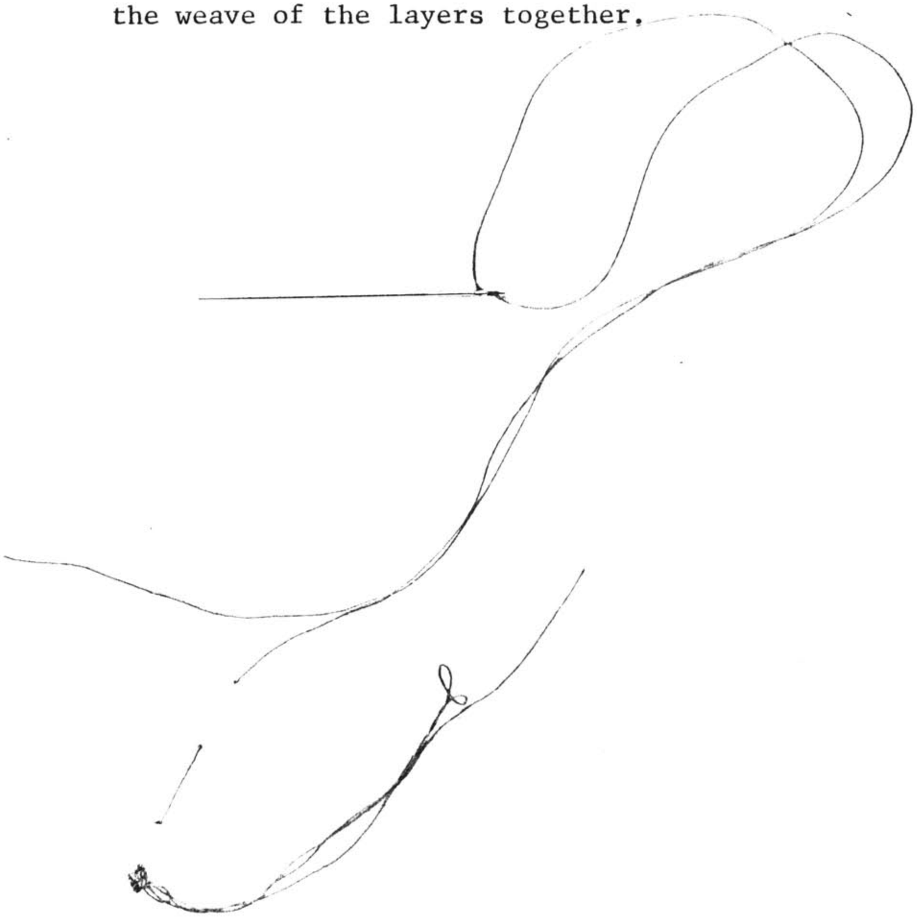
PROBLEM: When doing figurative work on standard copy machines, one cannot see the composition as the lens does. Manipulation of the color controls becomes extremely difficult.

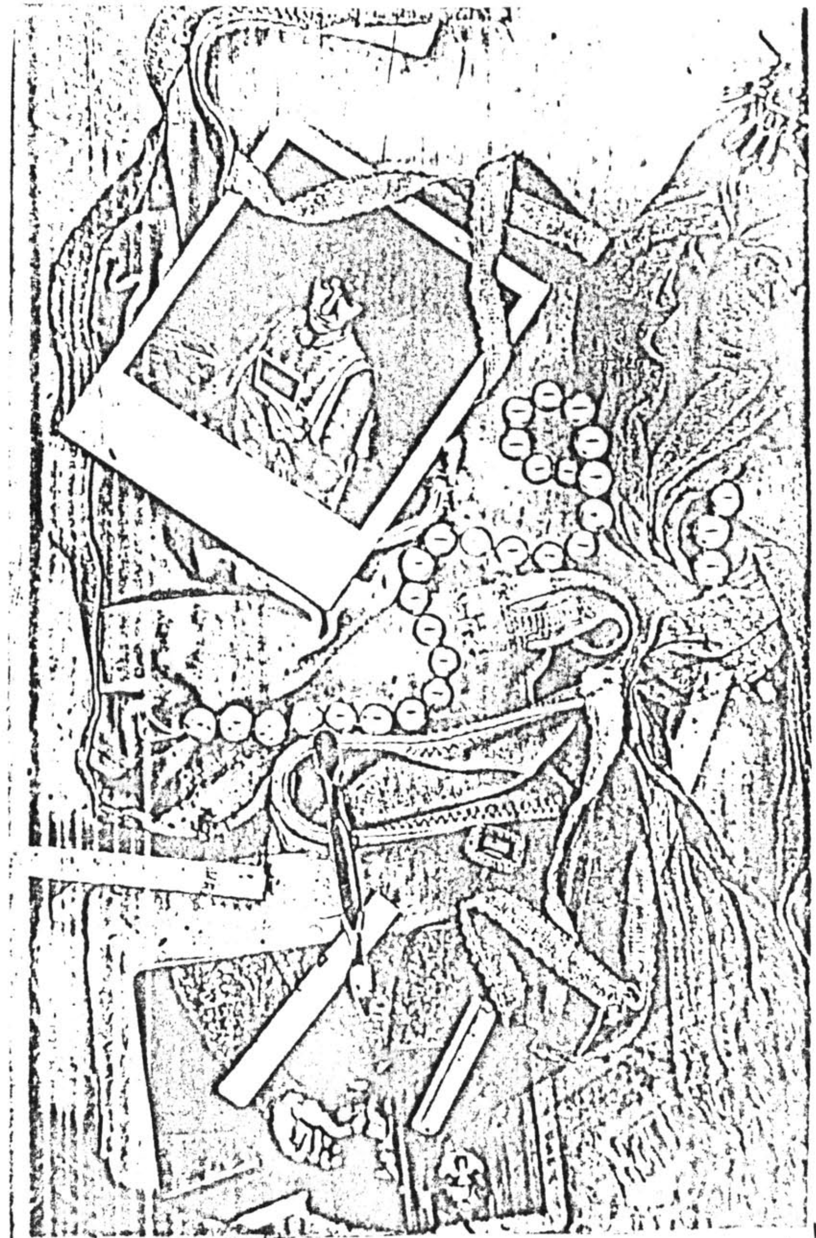
PROJECT: To create a photographic method which simulates the "pressed glass" look of copy machines. With this in mind, Tom Norton built a glass topped box affixed with 35MM camera and video monitor (for composition) for me to use. From this box generated a series of black and white photographs, which were partially colored and used as originals for color synthesis on the Xerox 6500. These prints were transferred to RIVES BFK and bound as a book.

QUILT MODULE: Images from this project were transferred to fabric and quilted.

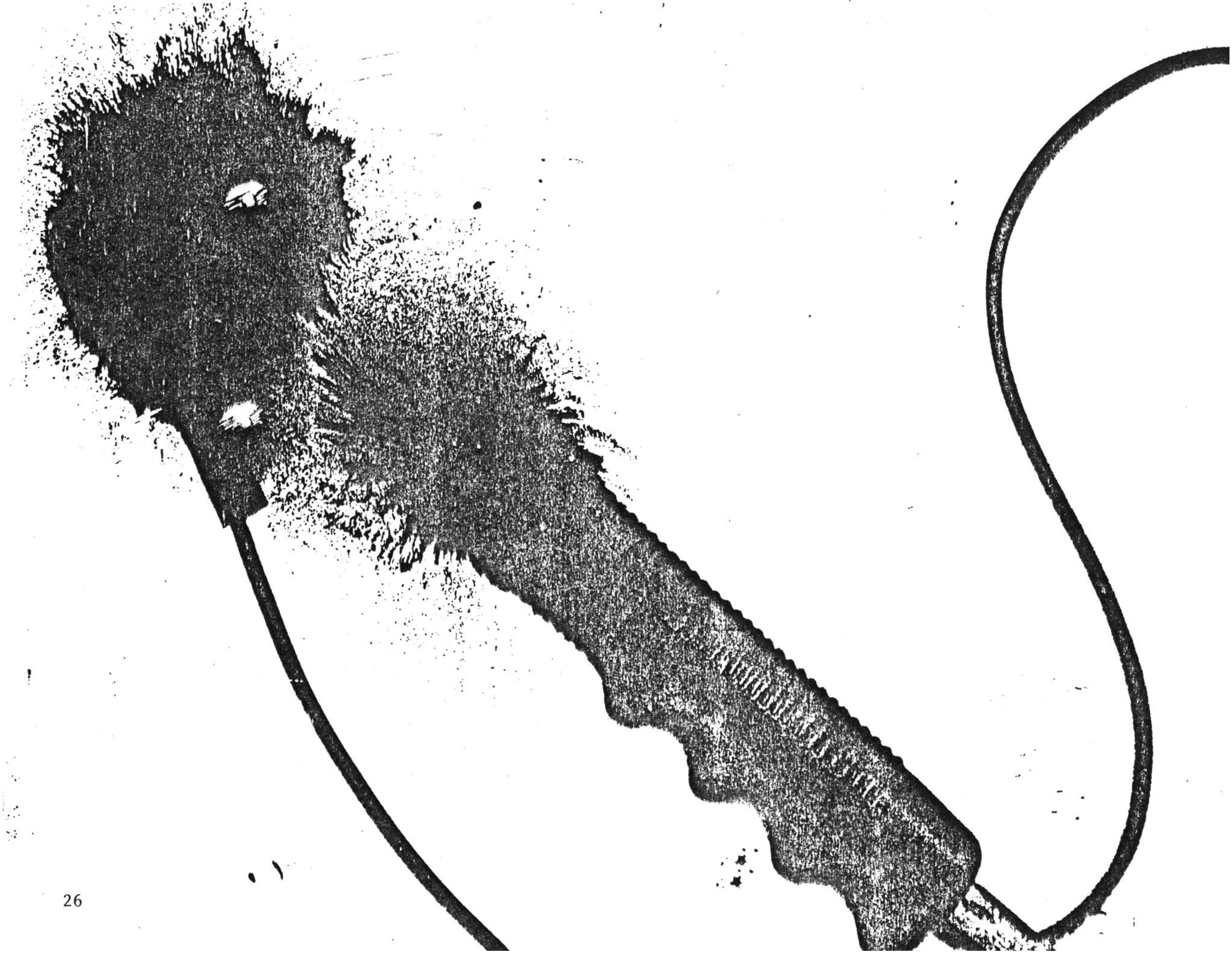
TRANSFER IMAGING ON CLOTH

PROJECT: To create a series of prints on fabric using the Xerox heat transfer process. Objects will be copied onto transfer paper, transferred to transparent cloth, which will, in turn, be manipulated into layered, laminated, cloth pieces. The lamination acts as a color enhancer, blending the weave of the layers together.



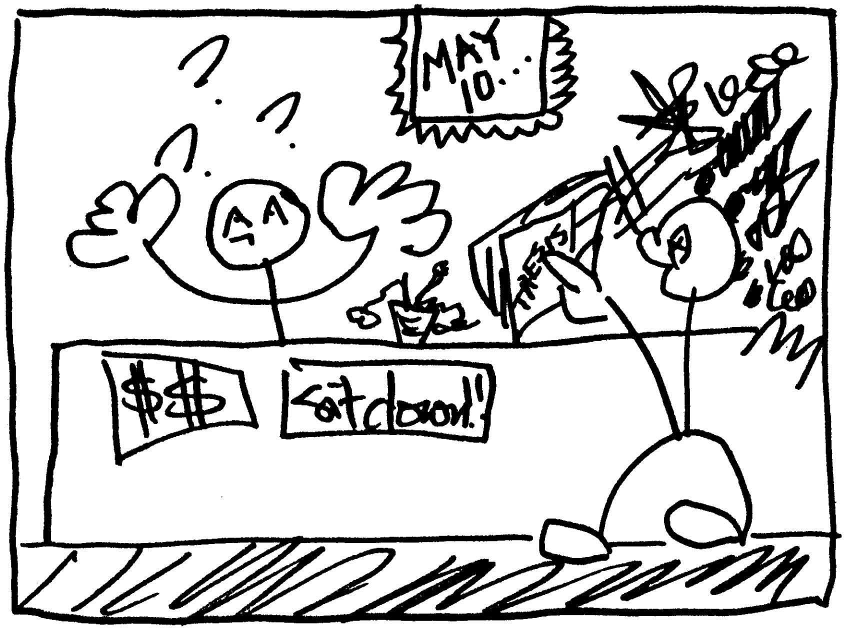


Xerox 6500 transfer images, multiple cloth layers, laminated.
Gini Holmes, © 1979.
(Laminate original to Xerox 2000 reduction to Xerox 9500)



VARIABLE FORMAT PRINTER

Since the introduction of the "copy machine," artists have been using the medium to generate images beyond its original intent. Rather than use the machines to reproduce business memoranda, artists have combined multiple copies in collage, as single fine prints, and as generative copy systems: copies of copies of copies. With the introduction of the 3M Color-in-Color machine, and the subsequent Xerox 6500 color copier, artists have had the advantage of making complex work in very short time. 18/.



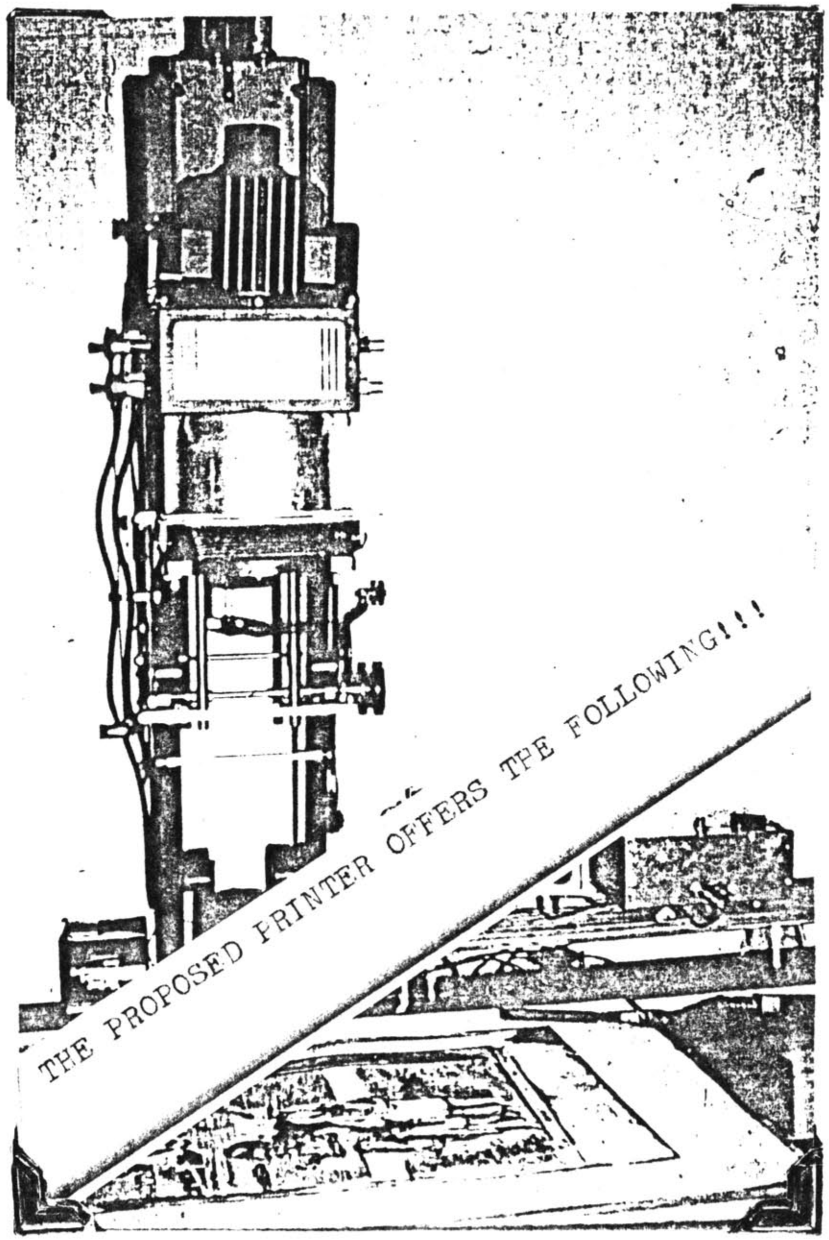
Basic copy center.

Over the past few years, the widespread use of the electrographic processes, particularly that of the Xerox 6500, has come forward as a strong print form. However, the limited availability and accumulative cost of the machines have placed understandable restrictions on the artist wishing to work. Most machines are to be found in establishments providing services for the business world. An artist may not easily acquire time to freely work.

Another problem confronted by the artist is the size limitation dictated by the machine format. The desire to make something larger than the standard 8 1/2" x 14" (sometimes 11" x 17") often presents itself after exploration of the machine's capabilities. Limited research in the large format area is being done, but not with the goal of ready accessibility to the general public.

For the past two years, through the help of Myron Tribus, I have been working with the Xerox 6500. As a consultant for the Xerox Corporation, Dr. Tribus has a great interest in electrographics as an art form. Out of this interest has grown an idea for a relatively simple, inexpensive, large format electrographic system, aimed at the educational and artistic communities. Through my interest in expanded format, I agreed to develop the idea under his direction.

NOTE: This is an adaptation of basic electrographic principles already known. It is also important to remember that this printer is not automated, and is, thereby, slower than standard copy machines. Also to be noted is the direction from which Myron and I approached the project - opposite each other. I was more interested in it as a print media, he as a photographic reproductive method. This led to many discoveries that might not have been made had I been interested in it for pure copy reasons.



ELECTROSTATICALLY INDUCED IMAGES

The question arises: "Why create these images electrostatically if it is not as fast as most other copy processes?"

There are several answers. Some are personal. Some are practical.

The personal reasons come from my involvement in the medium over the last three years, as well as my printer's affinity for surface quality and hands-on involvement. I have found this particular method of electrography to be the most chameleon: capable of adapting itself to many print effects.

Practical reasons cover: cost efficiency - ZnO paper is cheap and reusable, the power supply can be made with "off-the-shelf" materials; the process involves no harmful chemicals or equipment (there is a dust factor); the basic equipment is easily portable; and the final results are the product of a printer which allows the user a broad choice of effects.

STANDARD COLOR SEPARATION

The 3M Color-in-Color copier, and the Xerox 6500, are machines which produce, through the use of electronic and/or chemical processes, instant dry-copy prints. Each machine uses three matrices: magenta, yellow, and cyan. This equipment can either synthesize or analyze color through manipulation of each step, making the range of color possibilities nearly infinite.

The variable printer takes the matrices out of their contained environment through the use of preseparated color transparencies. A black printer is added. As in other print processes, separate plates are required for each color.

PRESEPARATED vs. DIRECT FILTER SEPARATION: The ZnO resin binder papers have peak sensitivity in the near ultra-violet end of the spectrum. Dye-sensitization of this material extends the photo-sensitivity to include various ranges of the visible spectrum. 19/. For my experiments, I used white ZnO, which could be used with standard safelight conditions - which do not effect the rate of decay of the electrical potential on the photoreceptor. This made the direct filtering with an enlarger impossible, for the paper would not respond to the light filtered through red on a standard enlarger. This left me with two possible routes to take: 1/. Expand the spectral response of the paper either through heat manipulation or chemical alteration; or 2/. Preseparate the images to black and white transparencies. I chose the second route for the following reasons:

a/. Being a beginner, I was already faced with enough problems in reaching image stability. I had no desire to compound those problems, so I chose to use a known product (industrail standard.)

b/. Knowing the way I work, I felt that I would have more flexibility with my own separations.

c/. Why make the beginning more difficult than it already is?

CHOICE OF TONER: Since the process employs toners in powder form, it is not limited to the use of special electrostatic types. In fact, this process opens possibilities in imagery by the versatility of toner choices. What about the use of powdered temperas, or pastels, or even dry pigment dye? What if fixing occurred by wetting the paper to allow the toner to seep into it? Or simply fixing it with a spray varnish? These are all possibilities for later trial. For now, I choose to use the electrostatic toners at hand: Xerox 6500 color toners, IBM black, and 3100 black. I also choose to stay with the standard color separation system used in 4-color printing: magenta, yellow, cyan, and black.

POSITIVE-TO-POSITIVE IMAGING

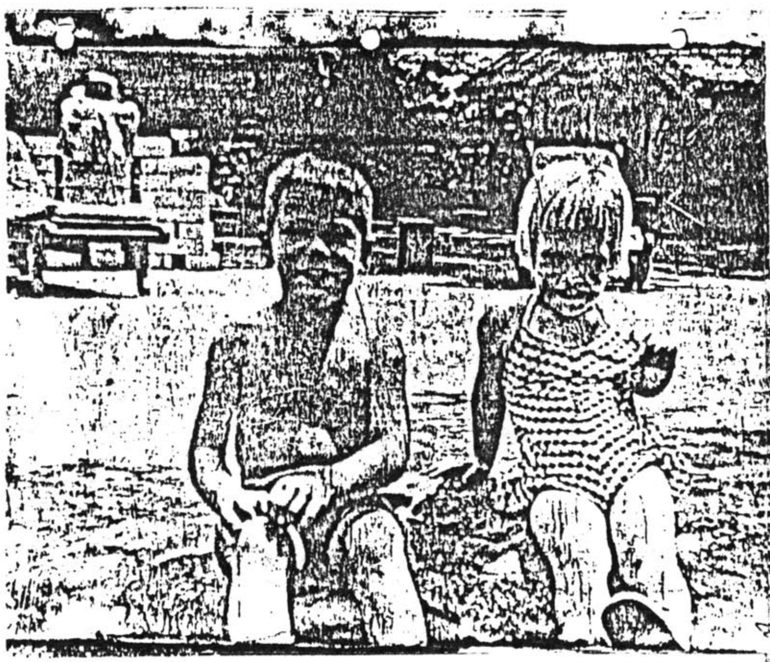
Zinc oxide-resin coatings require a negative polarity. 20/. Prior to my first tests, this was a "given." However, I found that I was capable of charging the ZnO paper positively as well as negatively, due to the fact that the voltage comes in direct contact with the photoconductor, rather than ionizing in the air around it.

Positive charging allows for direct-image development. Since the ZnO paper is more receptive to negative charging, though, the positive charge has a faster rate of decay and is not as dense. Resulting images appear more pointillist than photographic.

Positive-to-positive exposure test. Gini Holmes, © 1980.
(variable printer to Xerox 2000 to Xerox 9500)

REVERSAL IMAGING: NEGATIVE-TO-POSITIVE

Paper-backed xerographic plates, such as Electrofax papers, normally require optical reversal of the image during exposure. 21/. When ZnO paper is negatively charged, the latent image remains negative. Since the toner is also negative, it well repel from the latent image and cling to the neutral areas, causing reversal development of that which is projected. When screen intervention is involved, high resolution continuous tone images can be acheived.



Negative-to-positive exposure print. Gini Holmes,©1980.
(variable printer to Xerox 2000 reduction to Xerox 9500)

Negative-to-positive print. Gini Holmes,©1980.
(variable printer to Xerox 9500)

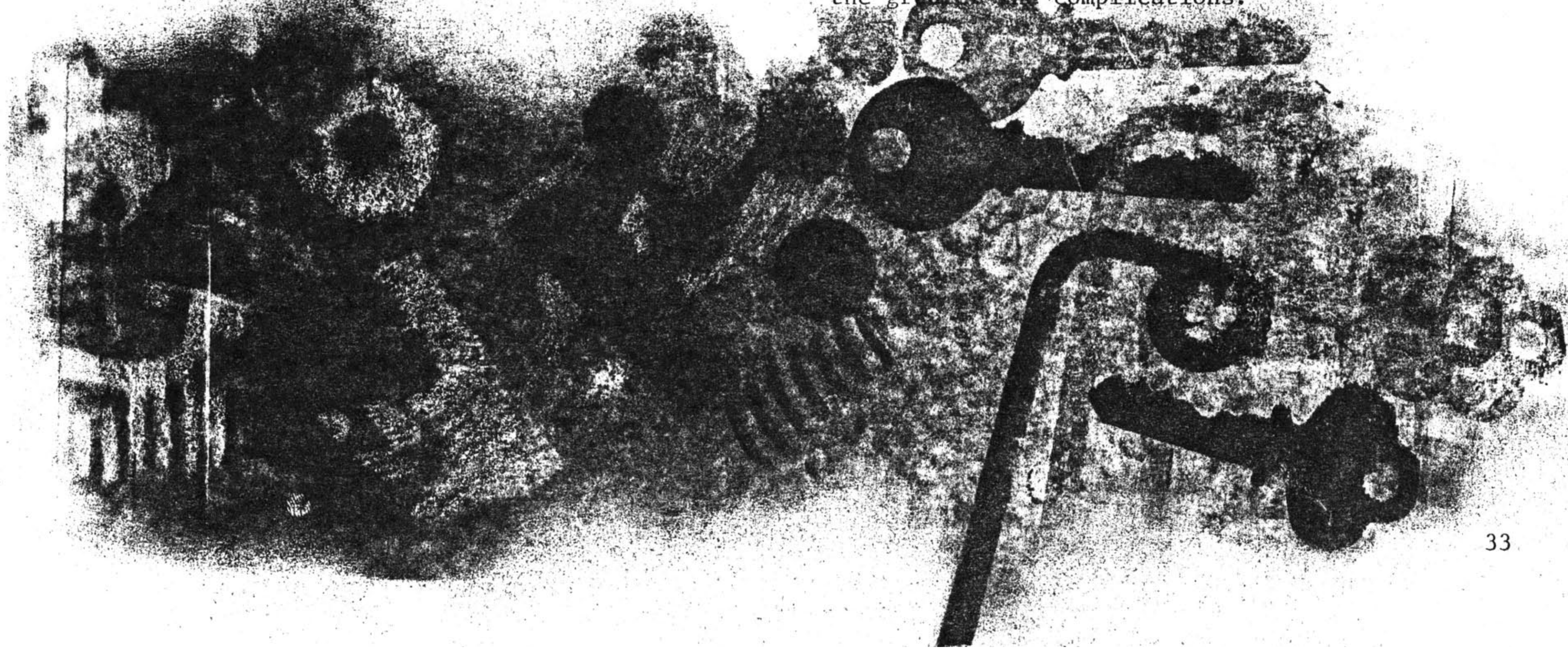
EXPANDED DEPTH-OF-FIELD

Standard copy machines (the Haloid printer excluded) employ a lens system with a depth-of-field normally no more than 1/2". With the removal of the electrostatic system from a contained environment, and adaptation to darkroom equipment, the depth-of-field is expanded. The user is not limited to one type of lens. Cameras need not even be employed. As photograms can be made on silver paper, electrograms can be made on ZnO paper. Add to this the advantage of surface layering through unlimited transfer abilities.

EXPANDED FORMAT

With the elimination of pre-determined format, as in current copy machines, the printer allows for a greater format variation. Unfortunately, the format is still somewhat limited by the standards set by the manufacturers of ZnO paper, with the paper being cut as it is milled. However, with the possibility of replacing the ZnO paper with cadmium sulfide, these restrictions may be eliminated, as well as the cost being cut.

As in any print medium, the larger the format, the greater the complications.



SURFACE MANIPULATION: CHARGING

It has already been stated that positive charging on ZnO paper will give a pointillist effect, while negative charging renders more continuous tone qualities. It must also be noted that the paper speed (dark resistivity) and the method for applying the charge will also effect the surface quality of the final image.

1/. The higher the voltage, the greater the chance of "brush" strokes left on the ZnO paper.

2/. Charging from the back of the paper often picks up the grain of the conductive base.

3/. Charging through a cover sheet creates a static intervention pattern.

4/. Contacting a transparency to the ZnO paper, and then charging through the contact gives a "solarized" effect in development.

5/. Transfer to porous papers, such as RIVES or ARCHES renders embossed effects (visually).

6/. The slower the paper, the finer the image quality.

Positive image charged through contact transparency.

Positive and negative images from one exposure, one development.
(variable printer to Xerox 9500)

SURFACE MANIPULATION: DEVELOPING

There are several types of developing methods besides the magnetic brush development. I chose the brush method for its likeness to painting and easy assembly. An advantage of magnetic brush development is that the conductivity of the ferromagnetic fibres provides the effect of a development electrode, making it possible to develop tones and solid blacks as well as line copy. If the magnetic brush is connected to ground, it further enhances the electrode effect, stretching the tone reproduction even more. If neither the brush nor the ZnO paper is grounded, the effect is higher in contrast. "Noise" development occurs when the ZnO paper is charged positively, and grounded with the brush development: static fields remain in the non-image areas, causing small deposits of toner. There is less occurrence of noise development when the brush is not grounded. By reversing the ground on the brush, direct and reversal images could be developed on the same plate. By charging the brush directly through the output, stronger images can be developed, and the polarity of the toner greatly effected.

PRE-FUSION MANIPULATION

Many copy machines allow for the fusing mechanism to be shut off, rendering images which can be erased, smudged, and altered by changing the powdered surface. In color printers, the user must wait for all of the cycles to be printed, or print one at a time, fusing each cycle, and hoping for the best in registration. With the manual printer, each color plate can be altered before transfer to the receiver, as well as after. With the process happening in front of the user, there is more creative involvement. Where other print media require elaborate steps in order to make changes, this allows for hands-on immediacy.

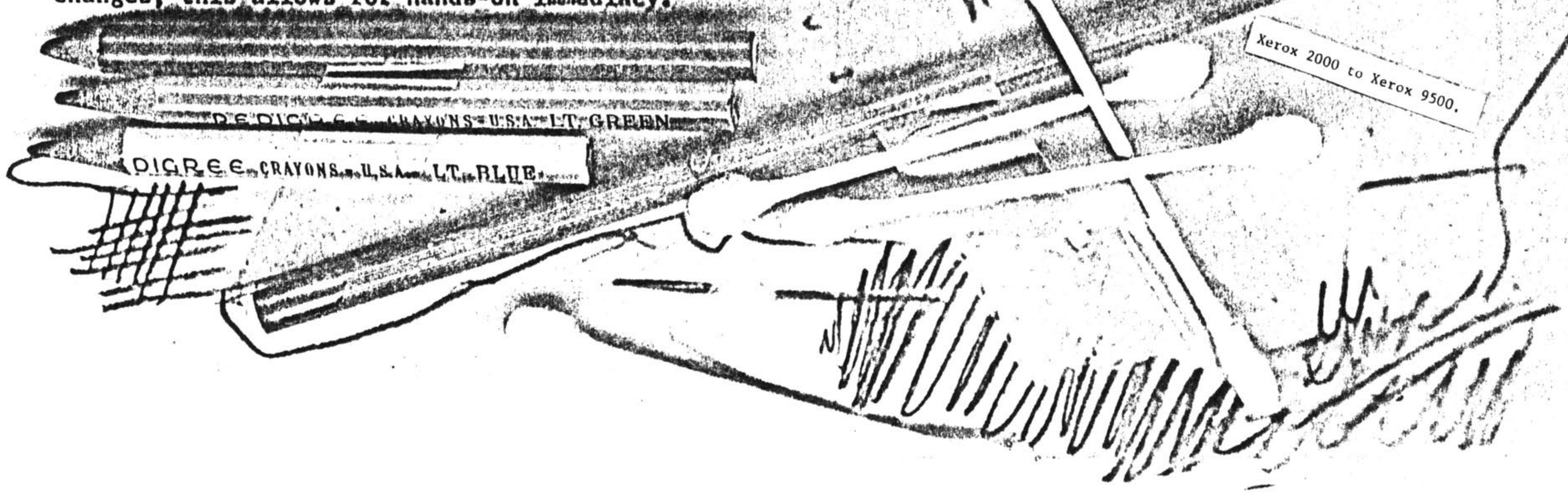
Images can be affected by:

1/. Blending of colors with brushes, cotton swabs, or fingers.

2/. addition of colors with drawing tools.

3/. erasure of images and mistakes with cotton swabs or gum erasure.

4/. enhancement of color by using two exposure plates and double printing (duo-tone).



TRANSFER CAPABILITIES

The Xerox 6500 offers transfer imaging through the use of special heat release paper. This limits the type of surface to which the transfer can be made. Since transfer with the hand printer is made prior to fusing, thereby eliminating the need for heat, the image can be transferred to many types of surfaces. This opens the possibilities for cross imaging to:

- offset
- etching
- silkscreen
- fabrics

The standard transfer method uses a charge to attract the toner to the receiver, but consider the non-charge possibilities. What if the receiver should have a sticky surface, to which the toner would adhere? Or, what if the receiver were damp, and the toner were to seep into it, as in dye processes?

Multiple transfers can be made by:

1/. Make the initial transfer, but leave the receiver in place.

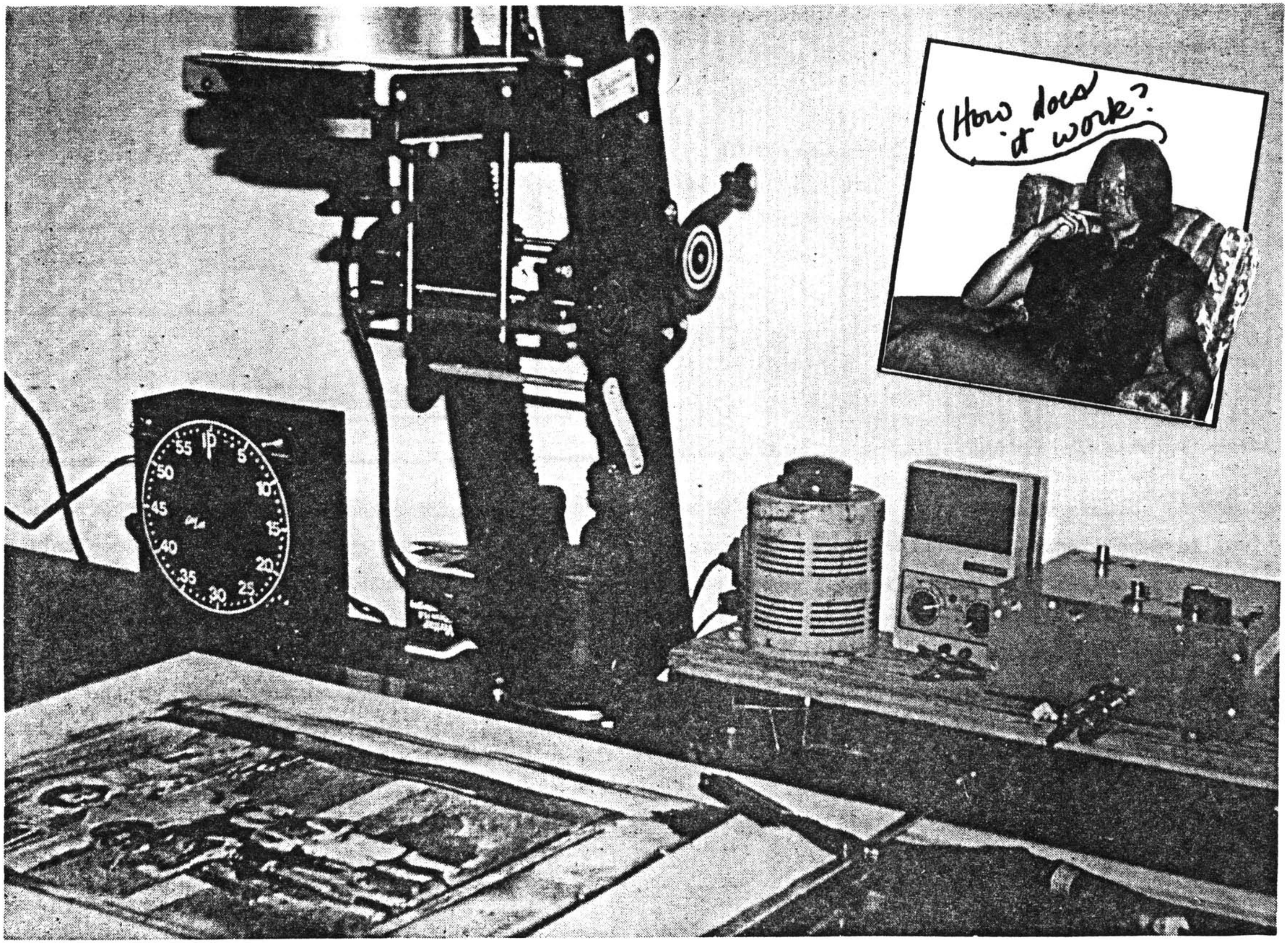
2/. Reverse the charge polarity and recharge the receiver, causing most of the toner to return to the plate.

3/. Remove the receiver and replace with another.

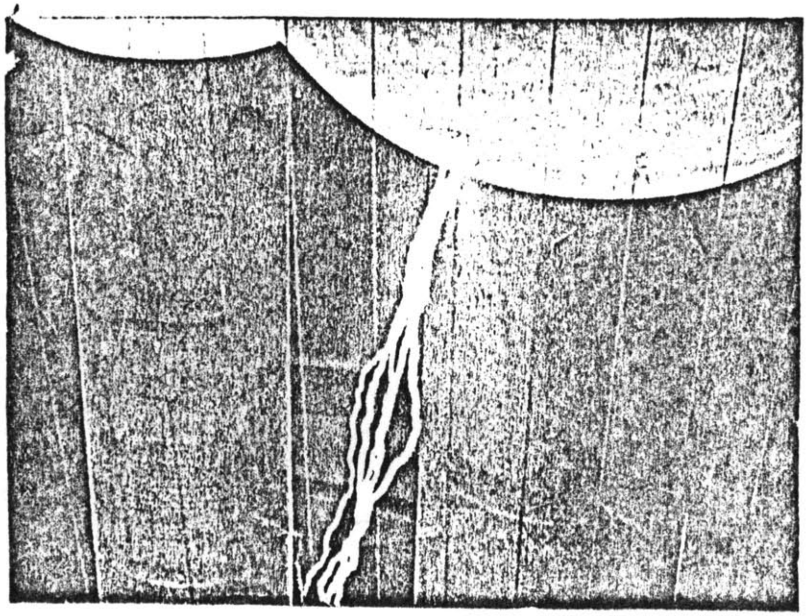
4/. Repeat the procedure.

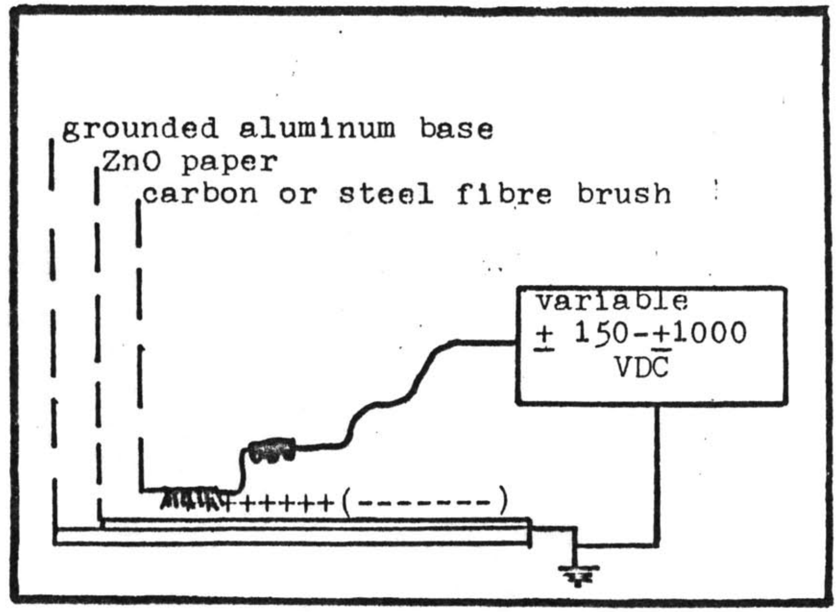
The number of images with essentially the same density can be produced by adjusting the magnitude of the charge with each cycle.

NOTE: Multiple transfers have less density than single transfers.



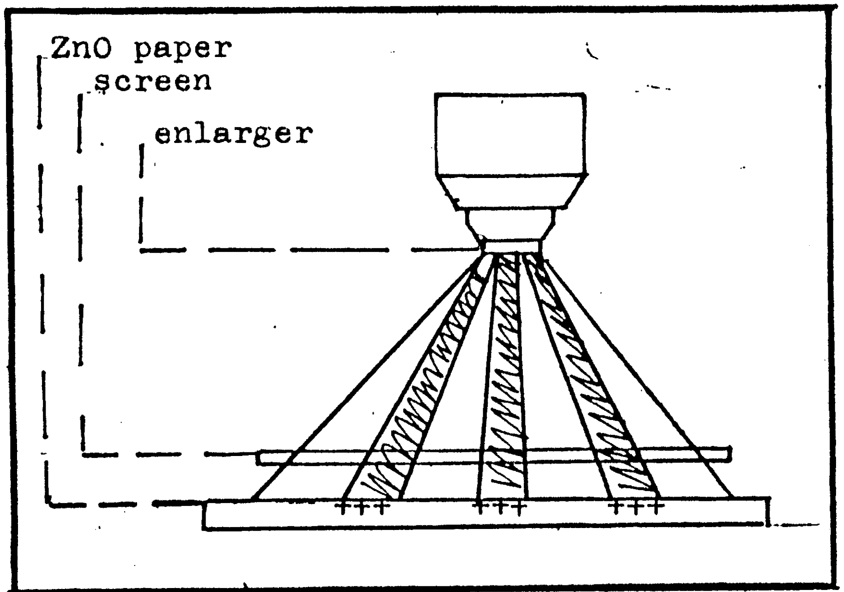
Collage, 35MM slide to Xerox 6500 + snapshot to Xerox 9500.

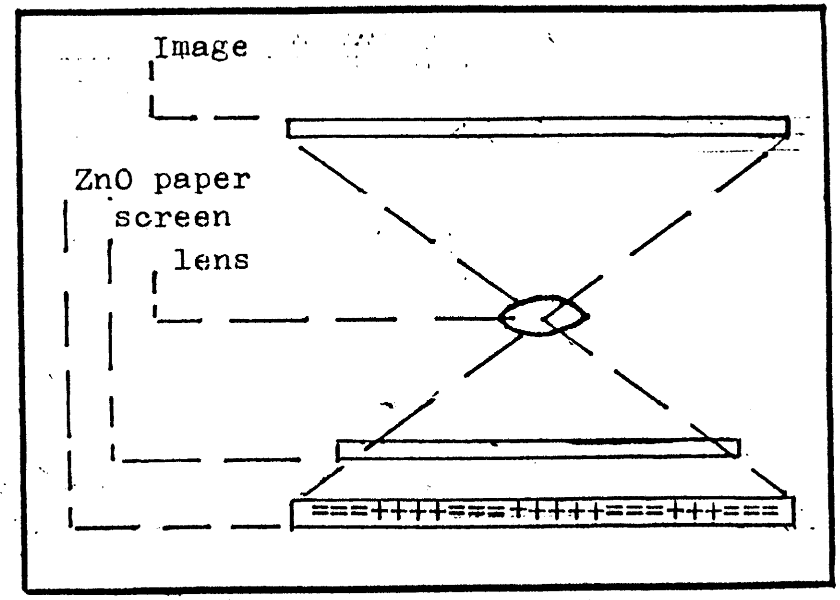




<u>CHARGING</u>: occurs when voltage (positive or negative) is deposited on a receptive surface; in this case, paper coated with zinc oxide. The ZnO paper is grounded to an aluminum charging base and brushed with a charging wand made of either carbon or steel fibres. The wand is connected to a variable power supply (±150 to ±1000VDC), controlling the amount of charge laid on the paper.

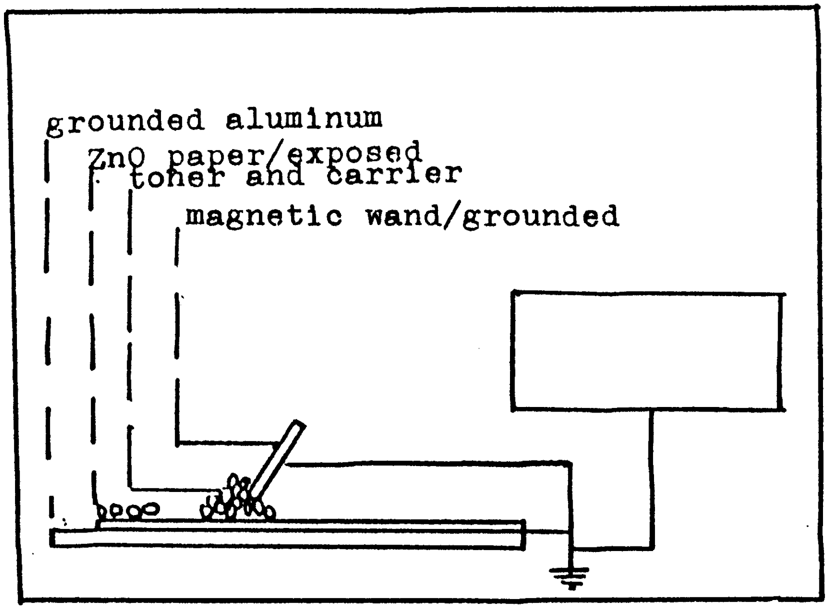
Since the wand comes in direct contact with the ZnO paper, rather than relying on the ionization of charges in the air around it, a much lower voltage may be used, and harmful ozone discharges may be avoided. One important advantage of the lower charge/direct contact method is the ability to charge the paper either positively or negatively.





<u>EXPOSURE</u>: occurs when light contacts the charged paper, forming a latent image via the intervention of some sort of imaging material: objects placed on the paper plate, transparencies contacted to it, or images projected onto it. Where light is reflected and hits the paper plate (photoconductor), the surface charge is neutralized. All other light that is reflected as grey or black becomes the latent image (not affected by red safelights).

Screen intervention (dot screen or fresnel lens) during exposure helps to break up the lights, distributing it more evenly, thus avoiding edge development and allowing for more continuous tone imaging.



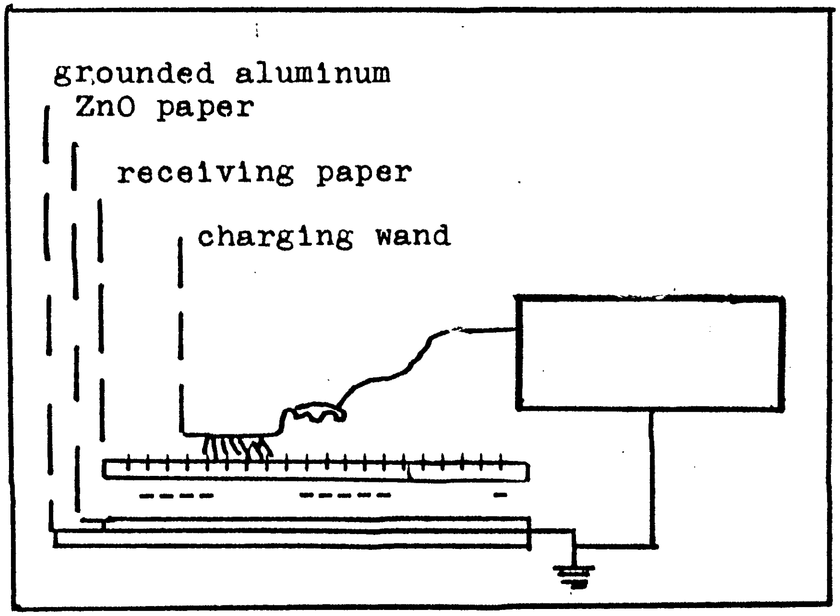
<u>DEVELOPING</u>: magnetic brush development is used for this particular method. The "brush" is created by the attraction of "fibres" (steel, nickle, metallic particles) to the magnetic pull within a "wand" made of an aluminum cigar case with a magnet inside. The "brush" is then dipped in toner, a substance which is sensitive to the charge created by the magnet, causing the toner to cling to the carrier "fibres."

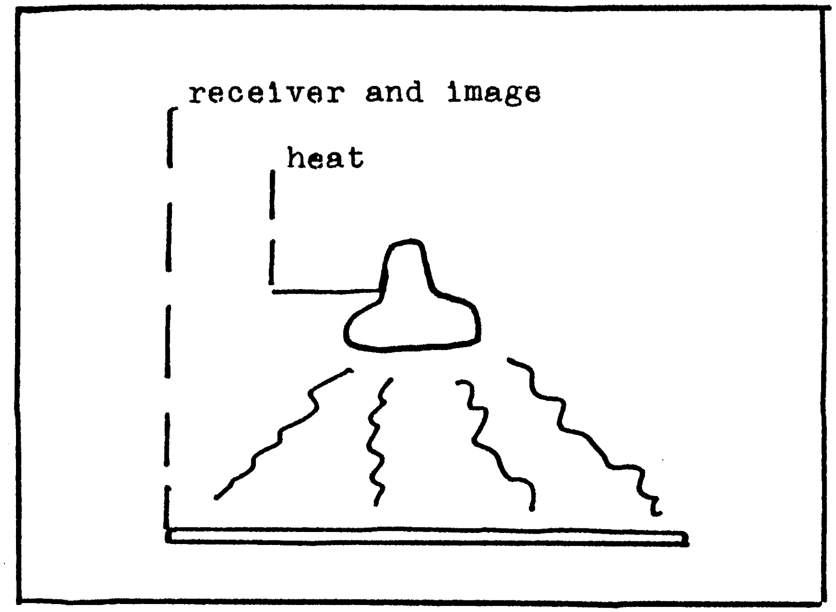
The tribo-electric field created by the toner/developer combination is greatly influenced by which type of toner is mixed with which type of developer. For most of my testing, my toner was electrostatically negative. When brushed over the latent image, it clung to the area of opposite polarity.

CHARGED AREA DEVELOPMENT: when the paper is positively charged, the latent image is also positively charged. When the negative toner is brushed over the paper, it clings to the positive charges, rendering a direct-positive image.

DISCHARGED AREA DEVELOPMENT: when the paper is charged negatively, the latent image is negatively charged. When the negative toner is brushed on the paper, it repels from the latent image and clings to the neutral areas, rendering a reversal image: negative/positive.

NOTE: all steps to this point are conducted under red safelight conditions.





TRANSFER: occurs when the grounded ZnO plate (developed) is contacted with the receiver (which is placed face down on the ZnO plate). The back of the receiver is brushed with the charging wand and charged in opposite polarity to that of the toner,. thereby attracting the toner to the receiver.

FUSING: in this case, fusing is accomplished by heating the toner for a short period, melting it to the receiver.

NOTE: these last two steps may occur under standard light conditions.

MATERIALS

Power supply

- variable voltage: ±150 - ±1000VDC
- 1 megohm impedence
- current draw less than milliamp
- discharge voltage: 150 - 1000AC RMS

Charging wand

- carbon fibre brush
- bicycle handle, rubber
- connecting wire
- insulating tape
- copper rod

Charging base

- sheet aluminum
- connecting wire, ground

Photoconductor

- ZnO paper

Charging mask

- to negate lateral drift when charging: use acetate mask to cover the edges of ZnO paper. Mask with 2" border overlay on aluminum gives maximum results, but narrower border can be used.

Developing brush

- aluminum cigar case or glass tube
- magnet
- 400 micron steel particles (magnetic developer from copy machine)
- grounding wire for electrode development

Toner

- powder toners from copy machines
- tempera
- ground pastels

Fuser

- heat source: oven, lamps
- spay fixitive, varnish

Imager

- enlarger
- contact objects
- projector
- flashlights
- etc.

Intervention

- fresnel lens
- half-tone screen

GLOSSARY

ACCEPTANCE POTENTIAL: the amount of charge the plate will accept and hold is limited by the decreased resistance of the film as the electrical field builds up to high voltage... as sinsitizing is continued, a point is reached where charges leak away as fast as they are applied due to the allowance of greater current flow through the film as a result of decreased resistance.

CONDUCTIVITY: low conductivity in the photoreceptor is essential - it permits the development step to be carried out before the electrostatic image is destroyed by electrical conduction through the plate.

DARK RESISTIVITY: the electrical resistance of photoconductive layer. The photoconductive layer must be a good insulator in the dark to retain electrical charges on the surface. When illuminated, the electrical resistance must be reduced sufficiently to permit rapid dissipation of surface charges.

DEVELOPING SPEED: The time required to produce a print is primarilty dependent upon the speed of the image development.

DEVELOPERS: generally, must be pulverizable or dispersable into fine particles, must be capable of accepting and retaining electrical charges, and should have no adverse effects on the plate.

DEVELOPMENT ELECTRODE: development without an electrode produces prints in which only the edges of blacks and continuous tones appear because of fringing fields (edge effect). Here, the brush is shorted to the backing plate. The effect is to change the field configuration of the electrostatic image and to increase the field in the space above large areas of charge. The electrode is essential to high quality continuous-tone development and the reproduction of solid blacks. Instead of shorting to the plate, it may be directed through the output to compensate for incorrect exposure or to accomplish reversal development.

ELECTROFAX: paper coated with zinc-oxide

EXPOSURE: over; light and washed out after development, under;heavy powder image. HOWEVER: with the use of lower voltage in direct contact with the photoreceptor, these properties are reversed.

FATIGUE: in binder-type photoconductive films, such as ZnO, fatigue is exhibited as a persistence of conductivity after illumination. This is found when plates are subjected to repeated cycles of charging and exposure. Fatigue is not important when the period between use is long.

FIELD INTENSITY: <u>EDGE EFFECT</u>: sharp voltage contrast at the edges of the electrostatic image. More powder is placed where the sharp voltage contrasts are present.

LATENT IMAGE: the quantity of electrical charge remaining in any particular area is inversely related to the amount of illumination. Thus, after exposure, there is a latent electrostatic image of the subject.

MAGNETIC BRUSH: advantage; the conductivity of the ferromagnetic fibres (iron, nickle, steel) provides the effect of a development electrode.

MASK: to avoid the lateral drift of charge when applied to photoconductor, an acetate mask of at least 1/4" overlay is used to cover the edge of photoconductor and the backing sheet.

PHOTOCONDUCTOR: that surface which will carry the charge and retain the latent image.

PHOTOSENSITIVITY: determined by the rate of decay of the electrical potential when the plate is illuminated.

RATE OF DECAY: the time constant for the charge to decay in illumination. In ZnO, the rate of discharge is slow at the onset of illumination and becomes faster as the discharge proceeds.

RESIDUAL POTENTIAL: the plate voltage at the point where slow decay begins after exposure to light. A low residual potential is desirable because of greater voltage contrast obtainable: of particular importance in continuous-tone development.

RETENTIVITY: the length of time that an electrostatic latent image is retained on a plate - determined by the rate of decay of the electrical potential in the dark.

SCREENING: the transformation of uniformly charged areas to an array of dots or lines which can then be developed by edge-fields.

SPECTRAL RESPONSE: normally, ZnO will respond to a light wavelength shorter than 3900 Å. ZnO has peak sensitivity in the near ultra-violet with some sensitivity into the violet end of the visible spectrum. The spectral response can be extended to longer wave-lengths by: doping with lithium; heating the zinc crystals in zinc vapor, giving yellow coloration, thereby producing exten-sion of the absorption edge.

TONE REPRODUCTION (MAGNETIC BRUSH): continuous-tone prints can be made on ZnO binder papers, but are normally somewhat contrasty due to drop-out of several tone steps on the highlight end. This is due to the tribo-electric bond between the developer powder and the magnetic carrier. The weaker charge on the ZnO surface in the highlight areas is usually not sufficient to overcome this bond. This could be corrected by applying a bias potential between the magnetic brush and the conductive base of the ZnO plate, thereby increasing the overall charge on the paper surface.

TRIBOELECTRIC: when two dissimilar materials are brought together, each material becomes electrically charged to a polarity opposite to that of the other.

ENVIRONMENTAL FACTORS (WEATHER): the charge voltage is dependent upon environmental conditions: temperature, humidity, and, particularly, barometric pressure. Humidity can have an effect on overall electrical characteristics. However, it is claimed that a wide humidity range (20% to 100%) can be tolerated. Lack of humidity, or greater concentration of static in the air, adversely effects the conductivity of the paper. To maintain constant current for barometric pressures in the normal ranges, the voltage must be reduced by 3% for each 25 torr reduction in barometric pressure, or increased 3% for each 25 torr rise.

FOOTNOTES

1/. *Electroworks*, George Eastman House, Catalogue, 1979, p.5.

2/. IBID

3/. IBID

4/. IBID, p.6.

5/. IBID, p.7

6/. Salamon, Ferdinando, *History of Prints and Printmaking*, American Heritage Press (McGraw-Hill), p.4.

7/. Comte National de la Gravure, Dec. 1964, pub. in "Nouvelles de l'Estampe," Feb. 1965.

8/. *Electroworks*, p.5.

9/. *History of Prints and Printmaking*, p.6.

10/. Sheridan, Sonia, *Breaking Barriers with Copy Machines*, 3M catalogue.

11/. Firpo, Alexander, Katayanagi, *Copyart*, Richard Marek Publishers, NY, 1978, p.13.

12/. Gottleib, Carla, *Beyond Modern Art*, E.P. Dutton, NY, 1976, p.59.

13/. Baudelaire, Charles, *The Mirror of Art; Critical Studies*, Phaidon Press, London, 1955.

14/. Davis, Douglas, "Art and Technology," *Art in America*, 1968, p.46.

15/. *Breaking Barriers with Copy Machines*, catalogue.

16/. G. Holmes.

17/. Daniels, Harvey, *Printmaking*, Viking Press, NY, 1971, p.23.

18/. Conversations with Tom Norton.

19/. Schaffert, R.M., *Electrophotography*, John Wiley and Sons, NY, 1975, p.44.

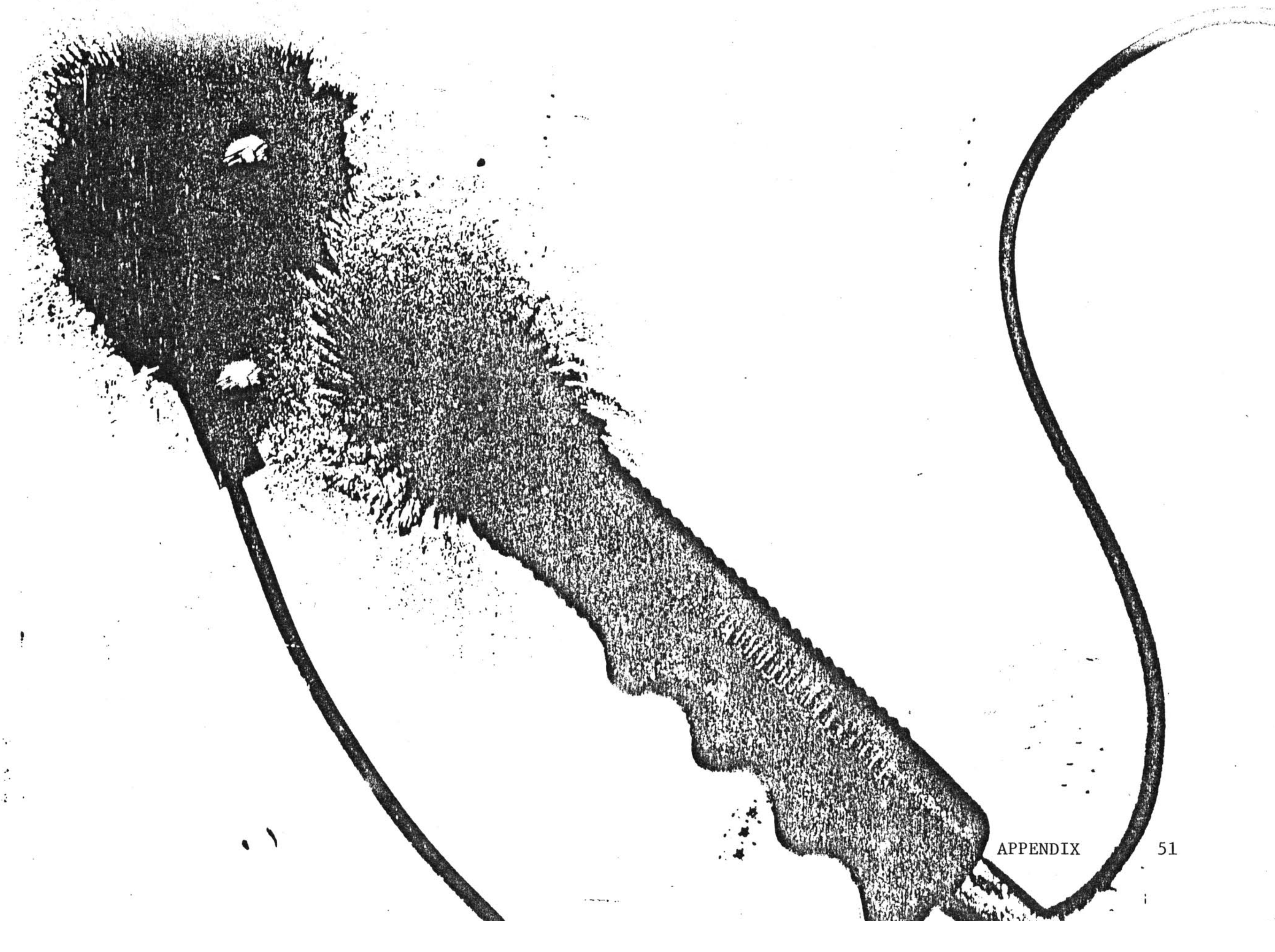
20/. IBID, p.26.

21/. IBID, p.27.

BIBLIOGRAPHY

1. Arnheim, Rudolf, ENTROPY AND ART, University of California Press, Berkeley, 1971.
2. Benjamin, Walter, ILLUMINATIONS, Schocken Books, New York, 1969.
3. Daniels, Harvey, PRINTMAKING, Viking Press, New York, 1971.
4. Davis, Douglas, ART AND THE FUTURE, Praeger, 1973.
5. "Art and Technology," ART IN AMERICA, 1968.
6. Dessauer, JH, Clark, HE, XEROGRAPHY AND RELATED PROCESSES, Focal Press, New York, 1965.
7. Firpo, Alexander, Katayanagi, COPYART, Richard Marek, New York, 1978.
8. George Eastman House, ELECTROWORKS, catalogue, 1979.
9. Gottleib, Carla, BEYOND MODERN ART, EP Dutton, New York, 1976.
10. Gorokhovski, Yu N, SPECTRAL STUDIES OF THE PHOTOGRAPHIC PROCESS, manual.
11. Green, Charles, ELECTROSTATICS HANDBOOK, Howard W. Sams & Co., Indiana, 1973.
12. Hedgecoe, John, THE PHOTOGRAPHERS HANDBOOK, Alfred Knopf, New York, 1977.
13. Jung, Carl, MAN AND HIS SYMBOLS, Doubleday, New York, 1964.
14. Kepes, Gyorgy, THE LANGUAGE OF VISION, reprint.
15. Kluver, Martin and Rose, PAVILION BY EXPERIMENTS IN ART AND TECHNOLOGY, EP Dutton, New York, 1972.
16. Kranz, Stewart, SCIENCE AND TECHNOLOGY IN THE ARTS, 1974.
17. McKim, Robert H., EXPERIENCES IN VISUAL THINKING, reprint.
18. Moholy-Nagy, Laszlo, PAINTING, PHOTOGRAPHY, FILM, MIT Press, Cambridge, 1973.
19. VISION IN MOTION, Paul Theobald and Co., 1969.
20. Needham, Joseph, SCIENCE AND CIVILIZATION IN CHINA, Cambridge University Press, 1962.
21. Norton, Tom, ELECTROGRAPHY, Visible Language Workshop, article for KUNST BEELD.
22. Rossell, Deac, "Instants East and West," AFTERIMAGE, Visual Studies Workshop, June, 1974.
23. Rhodes, Warren L., PROPOSAL FOR AN EMPIRICAL APPROACH TO COLOR REPRODUCTION; COLOR, vol.3#4, 1978.

24. Salamon, Ferdinando, HISTORY OF PRINTS AND PRINTMAKING, American Heritage Press, McGraw-Hill,
25. Samuels, Mike and Nancy, SEEING WITH THE MIND'EYE, Random House, New York, 1975.
26. Schaffert, RM, ELECTROPHOTOGRAPHY, John Wiley and Sons, New York, 1975.
27. Sheridan, Sonia, BREAKING BARRIERS WITH COPY MACHINES, 3M catalogue.
28. ENERGIZED ARTSCIENCE, School of the Art Institute of Chicago.
29. UNESCO, 700 SCIENCE EXPERIMENTS FOR EVERYONE, Doubleday, 1956.
30. Underwriters Laboratories Inc., POWER SUPPLIES.
31. Youngblood, Gene, THE MASS MEDIA AND THE FUTURE OF DESIRE, Sausolito.



AUGUST 27 2:00 Monday / Myron

Still not satisfied w/ results [illegible] need firmer base / [illegible] P & B results [illegible] ~~sk~~ scanning very [illegible]

AUGUST 28

Tom brought 1/4" alum sheet / got 1/8" sheet from mech eng dept. Tried dif method: changed to overhead lights - result: much stronger / do not need to ca[illegible] made first transfer / looks like etching

SEPTEMBER 2[illegible]

9-12	~~12:30~~ ~~3:30~~	4-7
J	D	G/N

*Masking: Problem: small [illegible] on large base - charge dr[illegible] By masking w/ acetate drift problem while hol[illegible] in place — thereby eliminating edge / air defects

[illegible] 9:30 M & M

NOV 11—1940—Coventry, England, severely damaged by Nazi bombs.
1972—Dow Jones Industrial average closes above 1,000 for first time in stock exchange history.
NOV 15—1777—Articles of Confederation and Perpetual Union adopted by the Continental Congress.
1781—John Moody was hanged as a spy, having been tried and found guilty of stealing the books and papers of Congress.
1864—General Sherman burned Atlanta.
1889—Dom Pedro II, Emperor of Brazil, driven from the throne by planters after he freed the slaves. Was the last emperor on American soil.

corrected 2 receiving

NOVEMBER 14

exposures made at 150 / 10-1 min exp image comes up, but drift factor to great to stabilize image during development / powder drops off & covers entire sheet / edge sharpness lost

discharge time → format → dev time proportional (directly) to each other i.e. / the greater the dev time / the greater the format the greater the charge

NOVEMBER 15

FIRST IMAGE

charge paper (speed-o-print, blue star)

-1000VDC

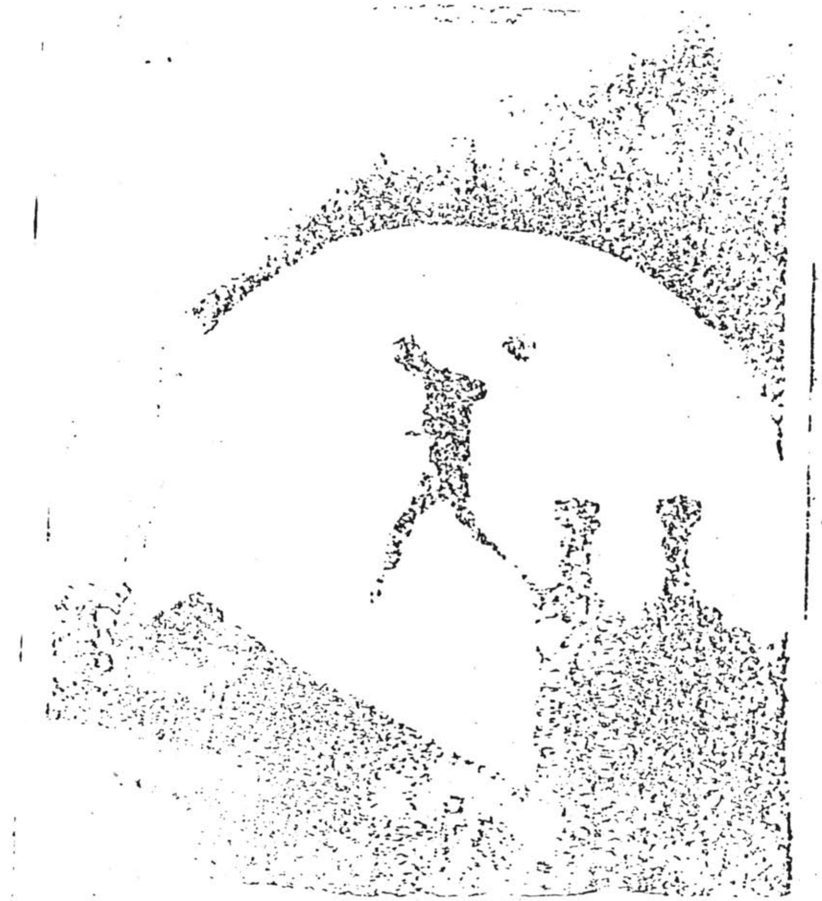
exposure: 25W bulb at 15 sec

develop: cascade wothout development electrode or ground, just poured toner over the paper, ungrounded, in plastic tray

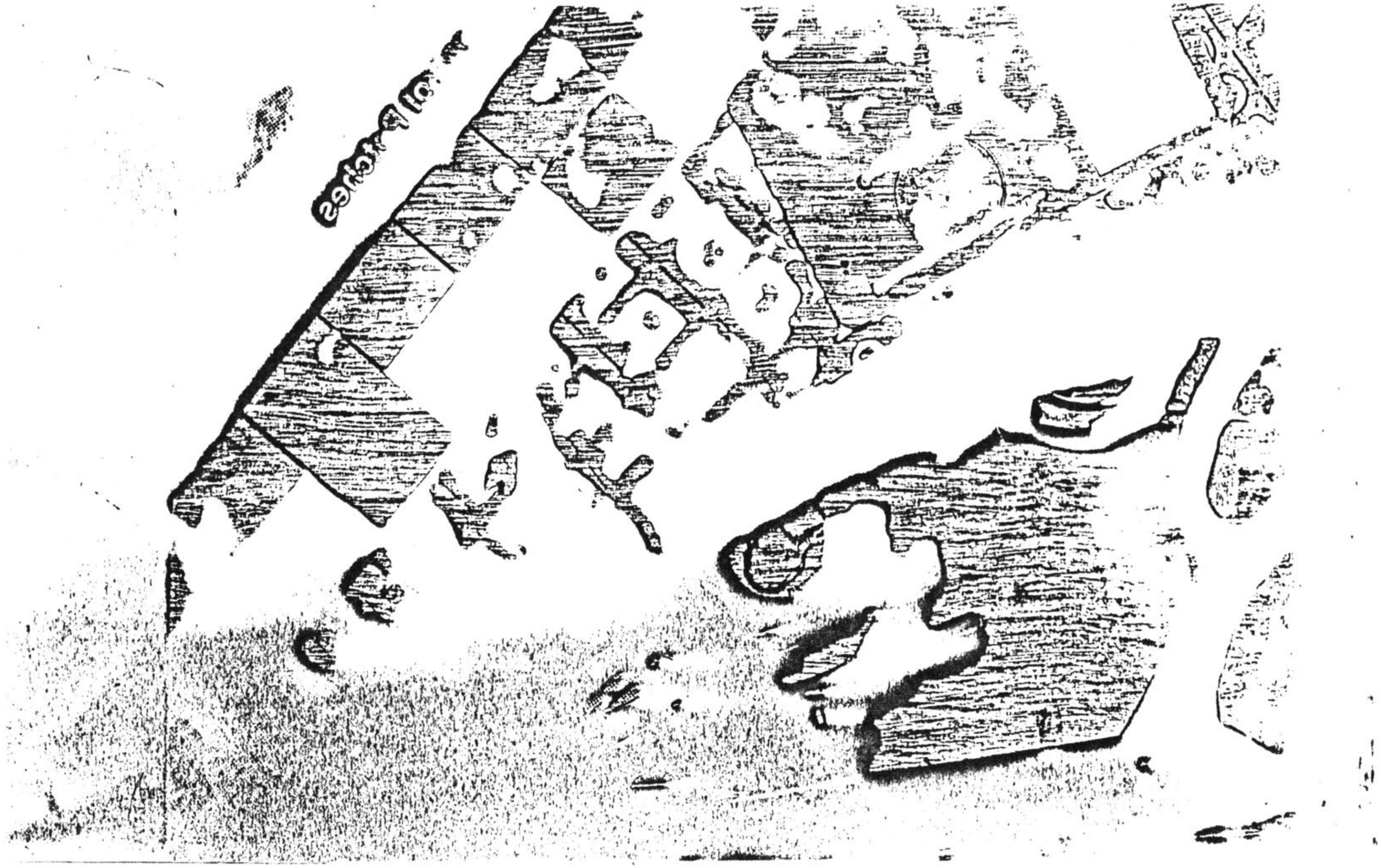
slight image, toner forming on edges, grainy

Next 4 attempts: ZILCH

too much humidity against too little equipment

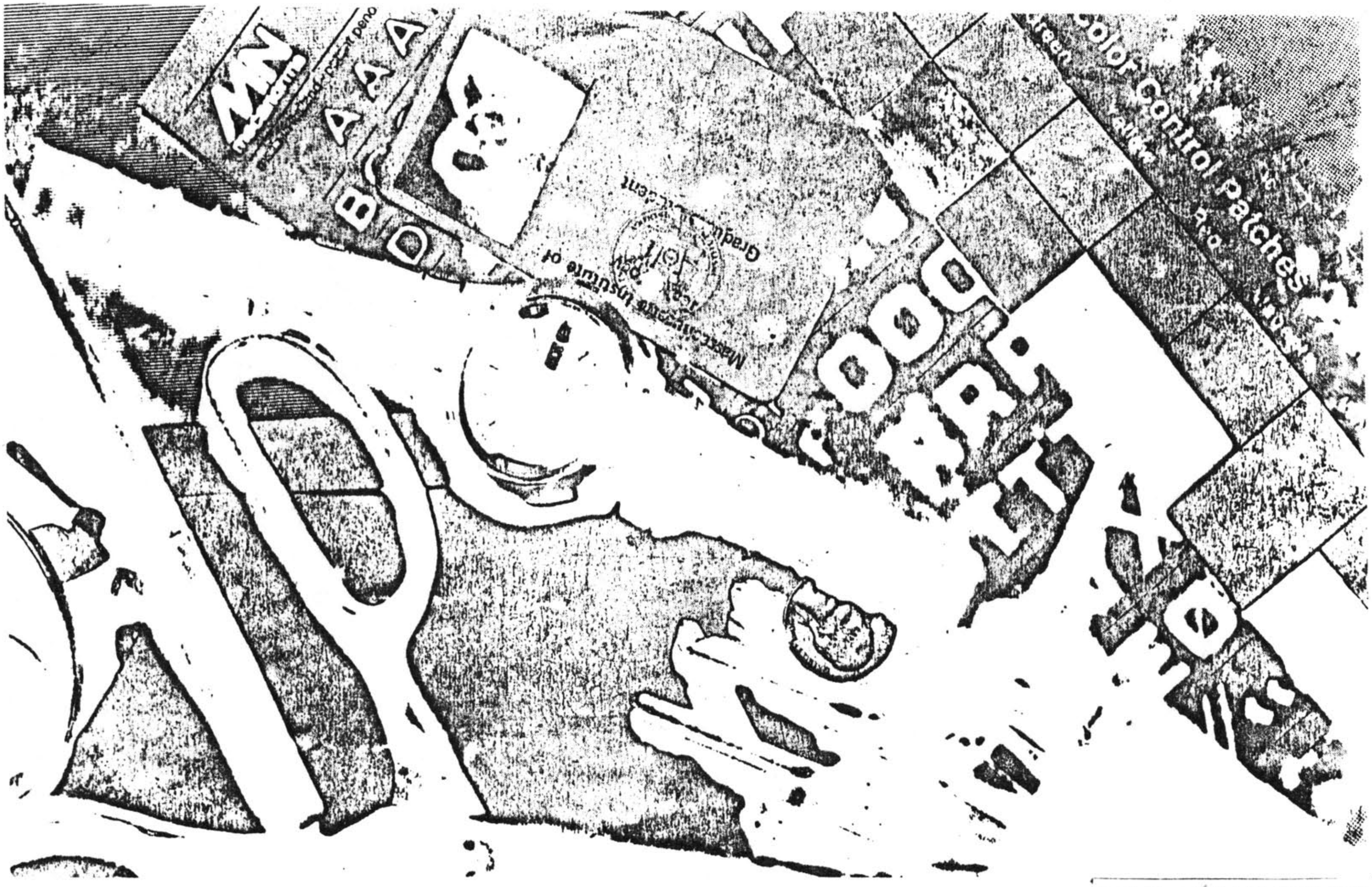


Variable printer to Xerox 2000 reduction (twice) to Xerox 9500.



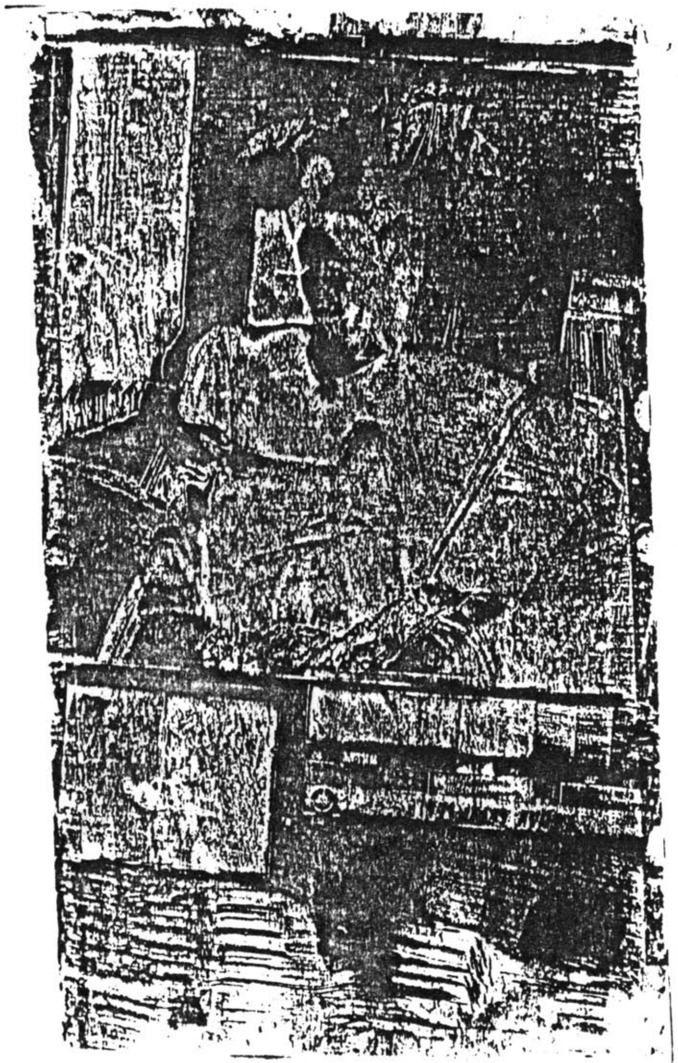
Variable printer to Xerox 9500.

-1000VDC; contact exposure 15 sec/25W bulb; cascade development IBM/ungrounded. NOTE: brush marks from the wand contacting the ZnO and the edge development on image. Still very humid, very remedial.



Variable printer to Xerox 9500.

-1000VDC; contact exposure flourescent overheads/1 sec; brush development IBM ungrounded; NOTE: edge development creates image, positive-negative working within same; transparency already half-toned, toner trapped in dot areas (did not yet realize meaning of this)



Variable printer to Xerox 2000 reduction to Xerox 9500.

Out of frustration - "what have I got to lose?" switch to positive charge on paper; contact negative transparency, get reversal image (left); negative charge gives negative image; both brush developed

CHARGING/EXPOSURE TESTS

Throughout the development of the process, tests were made to determine compatible factors in relation to the amount of charge/exposure/development times necessary to render a print yeilding desirable grey scale properties. Of all the tests made, one condition became clear: the environmental control within the workspace was erratic. Dry days, cold and high in static, would cause the charge to dissipate too quickly to hold an image during development. Humid days would cause more streaking in the paper. The rate of decay could not be adequately determined. However, a base from which to work was established, as well as certain toner/developer combinations.

Beginning tests used 150 line, eliptical dot screening for light intervention. Images with nearly complete grey scale variations were acheived (8 1/2" x 11"), but fell apart as the format was expanded. (The larger the format, the longer the development time, the greater the rate of decay.) Since intervention with a fresnel lens required less exposure time, imaging with the fresnel took over. The test image was a positive microfiche slide of the IEEE Resolution Chart.

Test factors were established as follows:

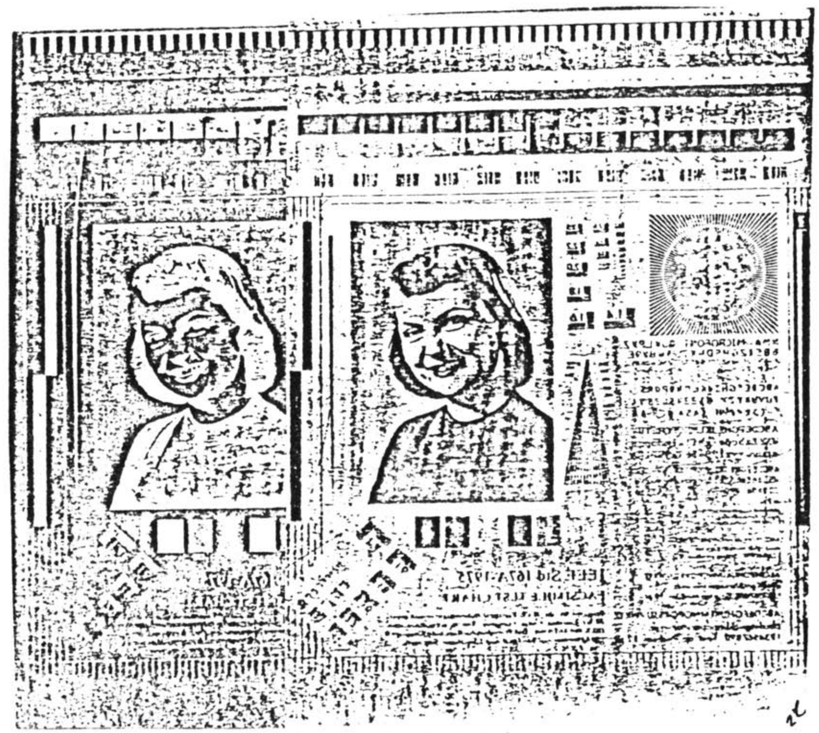
Using toners IBM black, Xerox 3100 black, and Xerox color toners in combinations with developers Xerox 4000 and Xerox FB126, the following occurred:

dev/toner	image	charge	image	transfer
FB126/3100	+	+	+	+
/3100	+	-	-	+
/mag	+	+	+	+/-
/mag	+	-	-	+/-
/yel	+	+	+	+
/yel	+	-	-	+
/cyan	+	+	+	+
/cyan	+	-	-	+
4000/mag	+	+	-	-
/mag	+	-	+	-
/yel	+	+	-	-
/yel	+	-	+	-
/cyan	+	+	+	+
/cyan	+	-	-	+

4000/IBM/3100 gave pos & neg image in one

The most stable charge for variable weather conditions (most overall stable charge whatever) was in the 700-900VDC range. Higher charging left charge marks on the paper, while lower charging decayed too rapidly. For positive charging, though, the higher the charge in the development electrode, the greater the amount of noise created by the fact that the electrode served to recharge the photoconductor, thereby distributing toner in discharge areas. For best results, the developed electrode was set at a lower charge during development (the least amount of noise occurring when no charge - relative to ground - was applied: in other words, the development electrode was not grounded.) For reversal imaging, the development electroded was grounded constant to the initial charge. Exposure time in relation to all charging was most stable at 15-20 sec.

I do not feel that I was able to properly determine the gamma response, or spectral response, under the circumstances at hand. Further research is needed, with more intervention variables (different types of screens), and better environmental controls. However, I was able to establish a good base from which to start.



Variable printer to Xerox 2000 reduction (twice) to Xerox 9500.

Pictures of Westchester, Los Angeles, California, 1950 - 1951.