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Application of Digital Image Enhancement Software with the Macintosh Computer to Questioned Document Problems

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ABSTRACT: Computerized image enhancement has been demonstrated to be a useful tool in the examination of questioned documents. The program Digital Darkroom™ was used by the author with a Macintosh Plus™ computer, a black and white laser printer, and both hand-held and full-size scanners to enhance nearly obliterated writing. Pencil writing which had been erased and then overwritten and writing obscured by typewriter correction fluid are illustrated before and after computerized image enhancement. A photograph of a check printed from microfilm was enhanced by the author, and his results are compared with the efforts of a professional computer image service.

KEYWORDS: questioned documents, digital image processing, computers, Macintosh computer

In 1988, Silicon Beach Software of San Diego, California introduced an image enhancement program called Digital Darkroom[2] for enhancing, retouching, and composing scanned images in a Macintosh computer. In February 1989 the software was evaluated by Walden and Smith [*1*], who felt it to be "the Jaws of [image] software." They cited as disadvantages its slowness, its very memory-intensive character and tiny and imprecise controls, but believed these were overshadowed by useful features that made it a worthwhile program for anyone dealing professionally with images.

The use of this software with an optical scanner (or video camera) and laser printer opens the door to the possibilities of creating digitized images of documentary evidence and then altering or enhancing the image.

The system requires four components; a fifth is optional. A computer is necessary to process the information. In the author's system, a Macintosh Plus[3] is used.

An information storage area is necessary. When a hand-held scanner is used, one or more floppy disks containing 800 000 bytes of memory are adequate, although not optimal. For a desktop full-page scanner, a hard disk is required because of the enormous amount of memory required to retain scanned images.

A scanner or video camera converts the document into digital code, suitable for ma-

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[1]Questioned document examiner, Lake Forest, CA.

[2]Digital Darkroom is a trademark of Silicone Software, Inc.

[3]"Macintosh Plus" is a registered trademark of Apple Computer, Inc.

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nipulation, storing, and printing. Two types of scanners are used by the author: hand-held and desktop.

A program to tell the computer what to do with the data is necessary. Both the hand-held and the desktop scanners used by the author have accompanying software that is enough to complete the scan and perform some basic manipulations. An image program called Digital Darkroom is used by the author to enhance, retouch, and compose images.

While not necessary, if a permanent record of the image is desired, a printer is necessary. A dot-matrix pin printer such as the ImageWriter[4] may be used, but the resolution suffers with this type of printer. A laser or laser-type printer produces much better resolution. The author uses a LaserWriter II NT.[5] Meng [2] identifies a variety of output devices, specifically printers, phototypesetters and film recorders. She feels that the highest resolution is achieved when using a phototypesetter or film recorder.

Equipment

Two computer systems are in general use: The Macintosh[6] and the IBM (or IBM-compatible, also known as "MS-DOS"). Both systems have their advantages and disadvantages and Digital Darkroom is available for both systems. The present paper, however, deals exclusively with the Macintosh. The Macintosh Plus is used by the author. This computer comes with one megabyte of random access memory (RAM) but it was found that upgrading to 2 megabytes is advantageous and up to 4 megabytes may be accommodated.

The hand-held scanner used by the author, called "ScanMan,"[7] has a number of advantages, including price (ScanMan lists in the $350 range) and the fact that a hard disk is not required. Setup is accomplished (see Fig. 1) by connecting the component modules to each other, plugging in the power cord and connecting them to the computer via the Small Computer System Interface (SCSI) port. Appropriate software is supplied by the manufacturer.

When operational, the ScanMan can achieve a scan of up to 105 mm in width with length limited by the available memory. Resolution is 100 to 400 dots per inch in 100-dot increments. Three gray-scale settings and a "line art" setting are available. The manufacturer recommends the line art setting for scanning an image that has no shading. A sliding dial is used to set lightness and darkness.

The ScanMan is operated by depressing a start button (see Fig. 2) with the thumb and manually dragging the scanner across the face of the image. Uptake stops when the pressure on the button is lifted.

The speed at which the head may be dragged is dependent upon the degree of resolution selected—the greater (higher) the setting, the slower the head must be dragged. If the head is dragged at too great a speed, the image produced is scrambled (Fig. 3*a*). In fact, at the highest (4) setting, the author was unable to drag the head at a speed slow enough to avoid scrambling artifact.

The author was unable to note any significant improvement in resolution by selecting any of the higher numbers and suggests that a resolution of one be used, allowing maximum scanning speed and minimal risk of artifact. Note that the images in Figs. 3 are printed directly from the retained images obtained using the ScanMan.

A disadvantage of using a hand-held scanner of any brand is that unless the head is dragged in a perfectly straight line, distortion is produced. As an example, Fig. 4 is a grid of graph paper not scanned in a straight line.

[4]"ImageWriter" is a registered trademark of Apple Computer, Inc.
[5]"LaserWriter II NT" is a registered trademark of Apple Computer, Inc.
[6]"Macintosh" is a registered trademark of Apple Computer, Inc.
[7]"ScanMan" is a trademark of LOGITECH International, S.A.

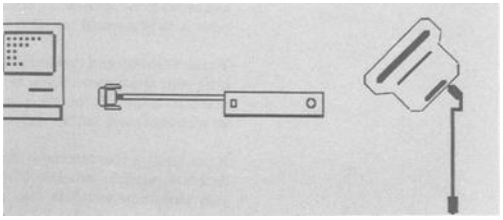


FIG. 1—*Component on the left is the scanner head, the one on the right is the SCSI box. The scanner plugs into the SCSI box, which in turn is plugged into the computer.*

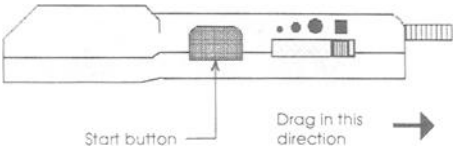


FIG. 2—*Scanner head, side view.*

Advantages of using a hand-held scanner include size and ease of storage, its relative ease of hookup and use, price, and its ability to use floppy disks for memory.

A desk-mounted scanner is larger, heavier and more expensive than a hand-held scanner and requires a hard disk for memory. On the other hand, more options are available, and the operator is not required to drag the scanning head by hand. Figure 5 has three images of the same portion of the author's signature at three different settings. In spite of the background artifact, the first two are comparable in quality to the hand-scanned images and the third is superior.

Figure 5 is the image of a black signature on a white sheet of paper. As of this writing, the author has no explanation for the background artifact seen in Fig. 5*c*.

Software

Once a document has been scanned, the software can be used to digitally change its appearance. Remember that anything on the original which is not "seen" by the scanner will not be reproduced on the image no matter how it is enhanced.

Two of the more basic ways an image may be changed are the lighten/darken and contrast settings.

Digital Darkroom will also produce a negative image. The gray-scale scan assigns each shade and color a shade of gray, with absolute white being 0 and absolute black being 256. Using the "gray map" an image full of unwanted "noise" can be cleaned up by darkening the desired parts and lightening the undesired parts. For instance, the poor quality of copies from microfilm is common knowledge; Fig. 6*a* is such a copy. The copy quality is so poor that the document boundaries have been defined by the white paper and an arrow in the lower right-hand corner. Figure 6*b* is the same image after adjusting the contrast and darkness.

Another option to try is to first assign a value of 256 to the gray shades greater than 180 and a value of 1 to those of 120 or less. This assumes that whatever writing that can be seen is visible because it is darker than the background. Figure 6*c* is the result of this manipulation. As shown, this image is not much of an improvement (if any) over changing the brightness and contrast.

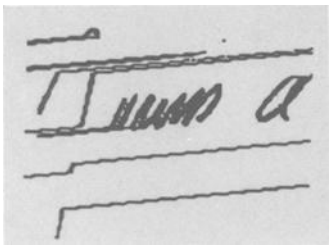


FIG. 3*a*—*First name and middle initial of the author's signature scanned at a resolution of four. Note the scrambling artifact.*

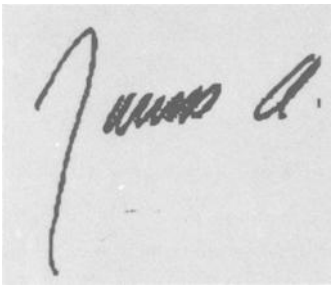


FIG. 3*b*—*Same signature at a resolution of three.*

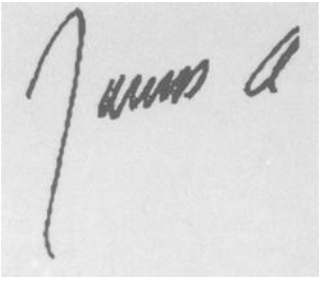


FIG. 3*c*—*Same signature at a resolution of two.*

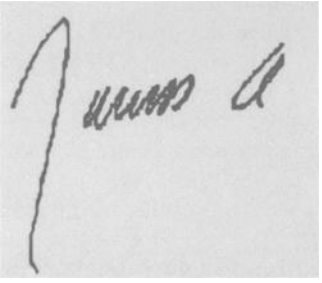


FIG. 3*d*—*Same signature scanned at a resolution of one.*

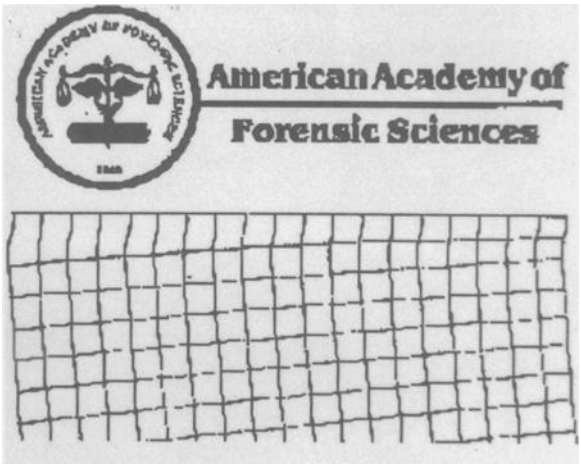


FIG. 4—*A grid hand scanned with distortion introduced by failure to drag the scanning head in a straight line.*

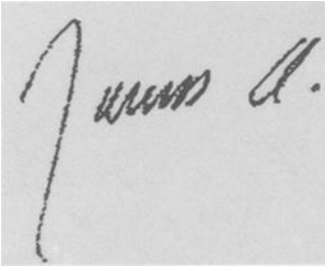


FIG. 5*a*—*Signature scanned at the linear setting.*

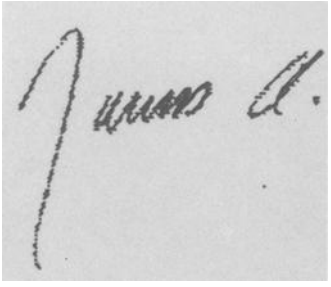


FIG. 5*b*—*Signature scanned at the halftone setting.*

FIG. 5c—*Signature scanned at the gray-scale setting.*

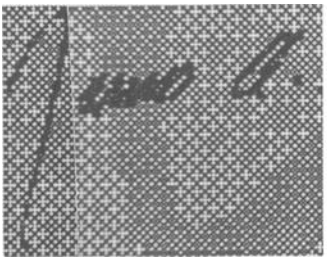


FIG. 5c—*Darkened.*

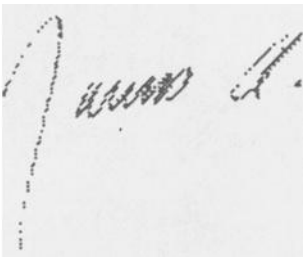
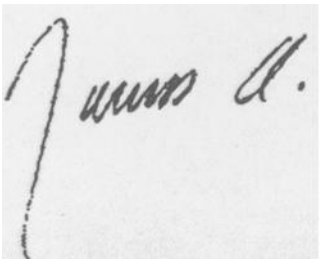


FIG. 5c— *Lightened.*



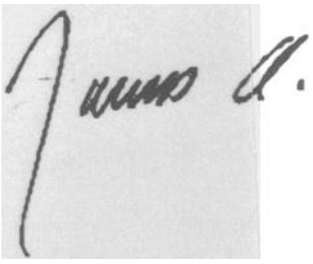


FIG. 5c—*With increased contrast.*

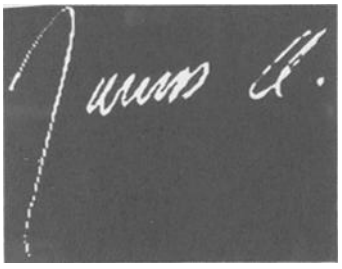


FIG. 5c—*Darkened and with increased contrast. Negative of Fig.* 5c.

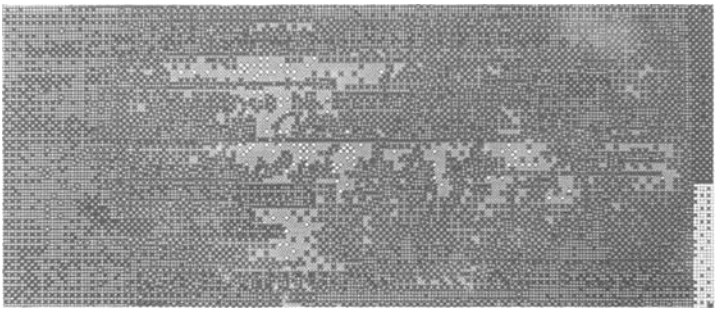


FIG. 6*a*—*Scanned image of a mirofilm copy of a check.*

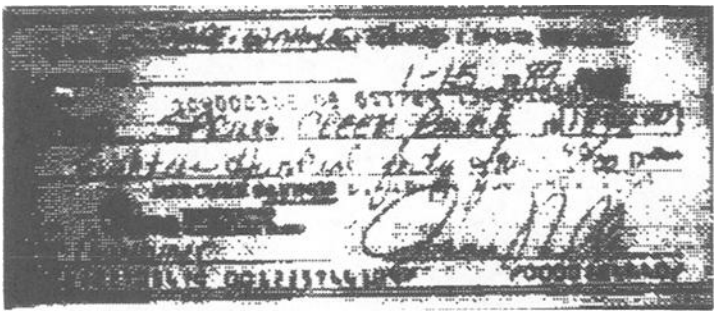


FIG. 6*b*—*Darkness and contrast adjusted.*

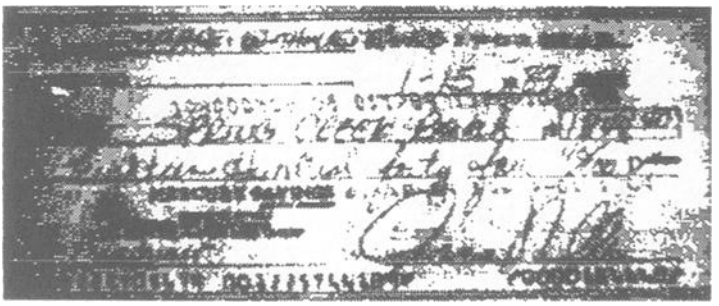


FIG. 6*c*—*Further manipulation of the gray scale after adjustment of brightness and contrast.*

The disappointing results of the author's efforts at enhancement prompted him to send the microfilm picture to a professional image enhancement expert,[8] Dr. Phillip Borden of Hidden Image Laboratories, Inc., whose results are illustrated in Fig. 7. Figure 7*a* is an image of the check without enhancement. Figure 7*b* is the entire check after being enhanced. Once again, the results are disappointing. However, Dr. Borden did not stop at this point. He went on to enhance selected portions of the check. Figures 7*c*, 7*d*, and

[8]Dr. Phillip Borden, President, Hidden Image Laboratories, Inc., P.O. Box 8847, Calabasis, CA 91372-8847, (818)222-8664.

FIG. 7a—*Unenhanced image of the microfilmed check.*

FIG. 7b—*Enhanced image of the microfilmed check.*

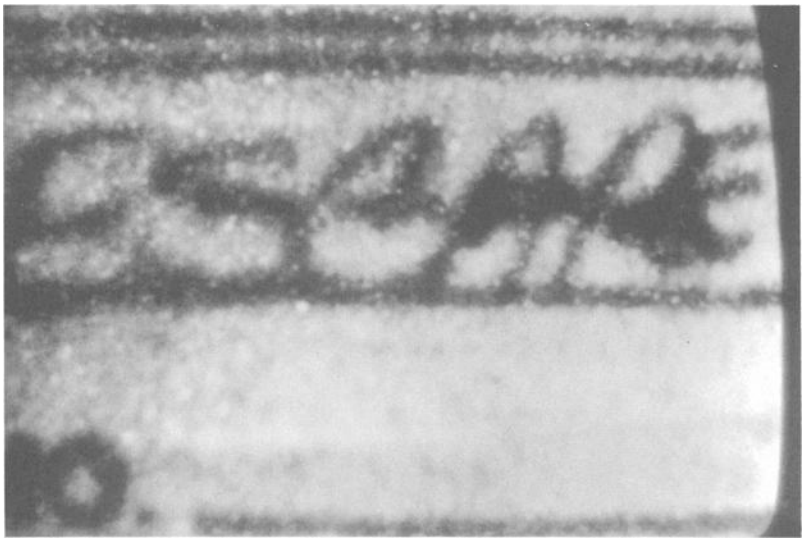


FIG. 7c—*The word "Escape" on the face of the microfilmed check enhanced by itself.*

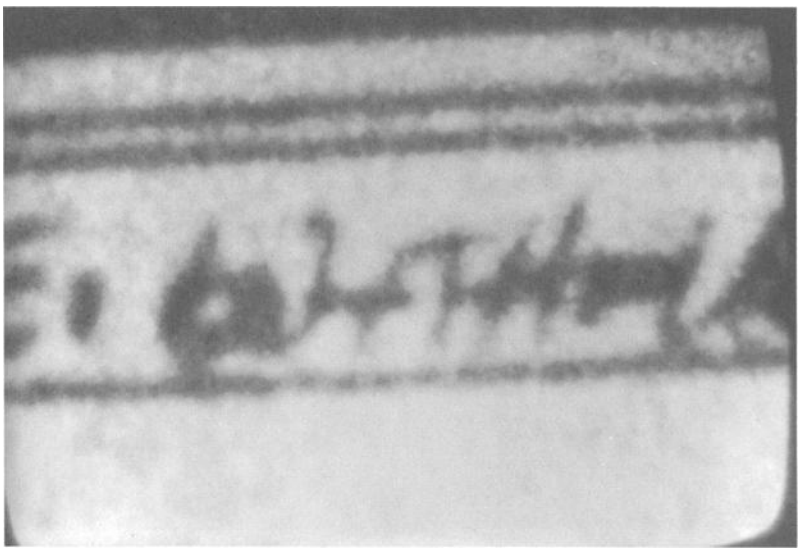


FIG. 7d—*The words "With Us" on the face of the microfilmed check enhanced by themselves.*

7e illustrate the results of enhancement on the words "Escape" and "With Us" (from the upper left corner of the check) and the signature. These results are more impressive.

In all fairness to Dr. Borden and Hidden Image Laboratories, better results will be produced if the actual film is used instead of a print from the film, as is used here.

Another application of the software is to enhance faint or obliterated images. Figure 8 is a copy of an entry on a page of a physician's appointment book. The penciled-in procedures for the noon hour had been erased and written over by the words "Brow Lift

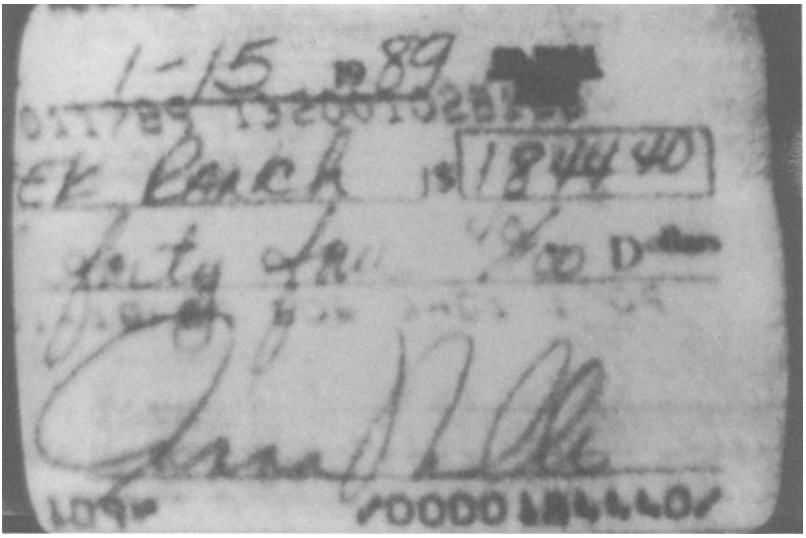


FIG. 7e—*Enhanced signature from the face on the microfilmed check.*

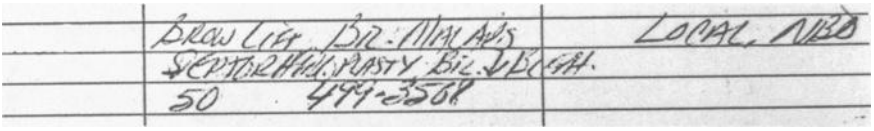


FIG. 8—*Copy of the questioned entry in the physician's appointment book.*

Bil. Malars Septorhinoplasty Bil. Bleph." The trial lawyer wanted to find out what had been erased.

The first step was to place the page in a copy machine and make a copy enlarged by 140% and darkened. Next, the entry in question was scanned; Fig. 9*a* is that image. Then the image was systematically altered until a final picture of the overwritten writing was produced; Figs. 9*b* through 9*e* illustrate that progression.

The last application to be presented herein is the enhancement of images produced by the Oleksow method[9] of visualizing writing obliterated by typewriter correction fluid. The primary image, because of the requirements of the procedure, is dark and in reverse. The word "sample" seen in Fig. 10*a* is an example of such an image. The first step is to clean up the picture without altering the image (Fig. 10*b*). Next, the image is cleaned

[9]An unpublished presentation by David L. Oleksow at the October 1990 meeting of the Southwestern Association of Forensic Document Examiners. In this presentation Mr. Oleksow described the following steps to visualize writing which has been obliterated by typewriter correction fluid:

1. Place two sheets of plastic upon the glass surface of an electrostatic copier.
2. Place down on top of the plastic the reverse side of the paper upon which the obliteration is present.
3. Set the light-dark control to very dark.
4. Run a copy.

The result will be a dark, mirror image of the writing under the correction fluid.

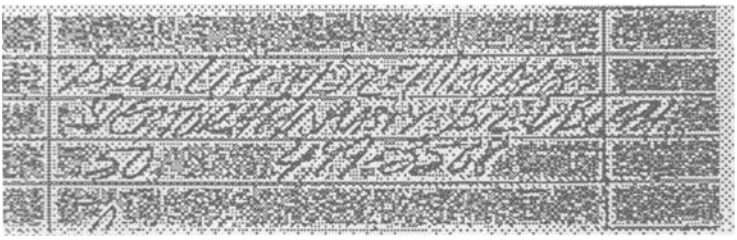


FIG. 9a—*Scanned image of the altered entry.*

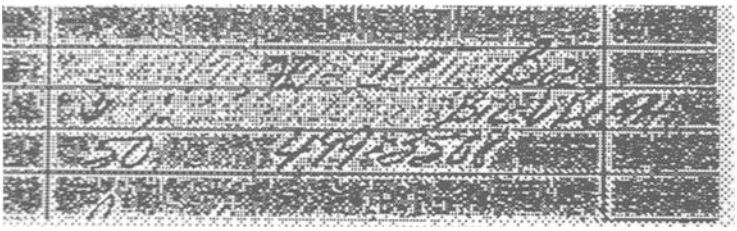


FIG. 9b—*In this step, most of the overwriting has been replaced with a shade selected to blend in with the background.*

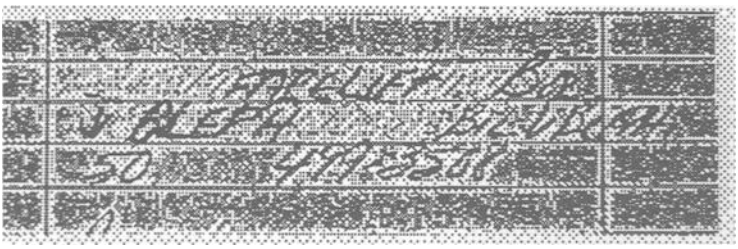


FIG. 9c—*Now the obliterated writing that can still be visualized is darkened.*

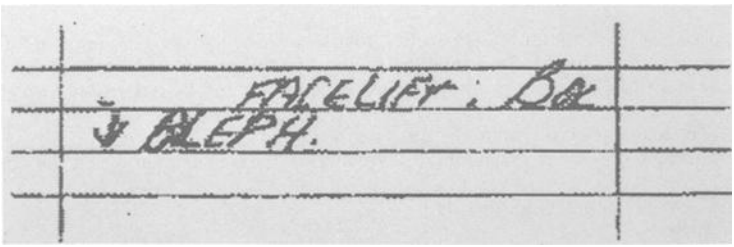


FIG. 9d—*Conclusion of this step shows the grossly cleaned-up image.*

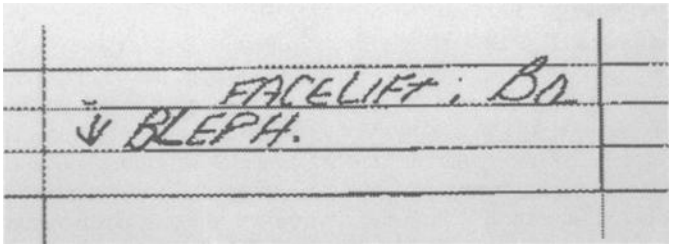


FIG. 9*e*—*Final cleaned-up image of the obliterated writing may be clearly seen.*

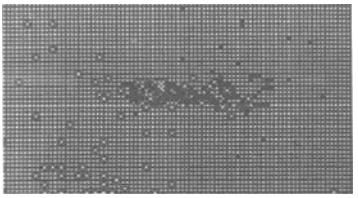


FIG. 10*a*—*The word "sample" visualized after having been obliterated by typewriter correction fluid.*

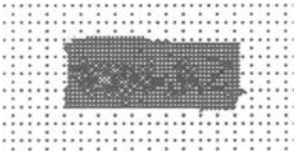


FIG. 10*b*—*Cleaned-up image.*

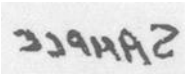


FIG. 10*c*—*Image after fine cleaning up.*

SAMPLE

FIG. 10*d*—*Image reversed.*

up finely (Fig. 10*c*). The final step is to use the "flip horizontally" transformation to reverse the image (Fig. 10*d*).

It may be seen that the software Digital Darkroom has many uses in the altering, enhancement, and manipulation of documentary images. This paper has purposely not gone into Digital Darkroom uses with electrostatic detection apparatus (ESDA). Among the disadvantages of this program are that its use is very time-consuming and requires an enormous amount of memory, necessitating a hard disk and a large amount of RAM. In the proper circumstances, however, its use will make a positive contribution to the examination of documents and presentation of the evidence.

References

[*1*] Waldon, J. and Smith, D., "An Evaluation of Digital Darkroom, Version 1.0," *Macworld*, Vol. 6, No. 2, Feb. 1989.

[*2*] Ming, B., "Reality Transformed," *Macworld*, Aug. 1988, pp. 83–87.

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