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Microfilm Documents: What Are the Boundaries in Document Examination?

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ABSTRACT: Businesses are increasingly converting document transporting and storage systems to microfilming systems that ultimately destroy the original document. Consequently, microfilmed documents are being submitted for examination either as questioned or known material. In an effort to aid the examiner in determining the boundaries of handwriting examinations of microfilmed documents, the quality of the microfilmed copies were compared to the original documents. Handwriting characteristics, pen classification, simulations, and alterations are discussed.

KEYWORDS: questioned documents, microfilm, handwriting, comparative analysis

With the high cost of transporting and storing documents, many businesses are converting their files to microfilm. In many cases, the microfilm filing system eliminates the original document soon after it is filmed. With no original, microfilmed copies will increasingly be submitted for questioned document examinations, either as questioned or known material. How does this affect scientific examination of disputed documents? To answer this, comparisons of original documents and their microfilmed counterparts were examined to determine the quality of microfilmed documents and whether or not they are useful in some types of examinations.

This study focuses primarily on the effects of microfilmed copies on handwriting. To achieve this, several tests were conducted: the Kodak Gray Scale, Kodak Color Control Patches, and the ASQDE 2.12-mm horizontal 1/6-in. vertical grid were microfilmed to determine the gradation and focusing qualities of microfilmed copies. Seven samples of checks were made with various pens to determine if class of pen could be distinguished on microfilmed copies as much as could be determined by a visual examination of the originals. Additionally, handwriting samples were collected from 28 individuals to determine what handwriting characteristics were reproduced on microfilmed copies. Several of these samples were then simulated, either by tracing or freehand, to determine if simulations could be detected in microfilmed copies. As a secondary focus, a sample of alterations to a typewritten text was made.

It is understood that a copy of any kind will reduce the clarity of some of the elements relied upon by document examiners to determine authenticity of writing. What is not understood is the specific elements that are lost and to what degree. More importantly, examiners need to know the limitations of examinations made from microfilmed copies. In some exami-

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nations, certain elements are of utmost importance and parameters are needed to aid the examiner in evaluating handwriting from these copies.

In addition to setting parameters for microfilmed document examinations, it is encumbent upon the examiner to articulate the qualifications in any examination involving microfilmed copies when called upon to do so in court. Whether the question posed to the examiner is hypothetical or directed to the evidence at issue, the broadest knowledge necessary to answer questions completely and effectively is often dependent on direct experience or research reference material. Although most examiners know the general qualities that limit an examination of a microfilmed copy, the specific qualities may be the significant issue in a given case. This study does not purport to answer all such questions, but can aid the examiner in this endeavor.

Micrographics

Two indepth papers on the background and technical aspects of micrographics have been presented to the questioned document field by Sadowsky and Hodgins [*1*] in 1965, and Masson [*2*] in 1984. These papers describe the types of cameras, various films, formats, and retrieval systems. In this study, only the cameras, films, formats. and retrieval systems commonly used for documents that are usually submitted for forensic science examinations are included. Microfiche, for example, is a system that records onto a single sheet of film. It is not a high speed process. Usually, this format is used for multipage, typed, or printed documents or for access of data in several locations, for example, library references, information records for police agencies, and insurance companies. The rotary and planetary cameras, using silver-halide roll films, and thermographic or electrostatic retrieval terminals are the systems most commonly used to produce the copies document examiners are likely to encounter. These are the systems relied upon to conduct the tests in this study.

A brief technical background is necessary, however, to understand the end product as well as the remedies needed to produce a good quality copy.

There are three parts to the microfilming system: the filmer records the image onto film, the processor develops the film, and the retrieval terminal prints the image back onto paper. The whole process can take under 10 min.

Microfilmer

The rotary filmer is the fastest and most common microfilmer. The documents can be fed into the machine at a rate of up to 700 documents a minute. The film and the lens are housed in a unit that is inserted into the mainframe of the machine. The mainframe houses the transport system, lights, sensors (which pick up the varying colors of the document and automatically adjusts the light to get proper exposure), and mirrors (that reflect the images through the lens and onto the film). The film and documents are moving at relative speed. Most banks use a modification of this camera: the camera is attached to the sorting machine that reads the microincoded numbers so that the checks are filmed during the sorting process.

The planetary filmer is set up much like a copy stand. The camera is mounted on a column and extends over the copyboard where the documents are placed. Illumination is generally at a 45° angle. The overhead camera is raised or lowered according to the reduction required. Either a fixed shutter speed with variable light intensity or constant light intensity with variable shutter speed is employed, dependent on model. Documents are positioned on the copyboard manually for each exposure, making it a longer process than that of the rotary filmers.

There are eight reduction ratios, but the most common are ×24 for single-sided documents and ×40 for two-sided documents (×50 is common on microsorting machines). The smaller the image size the more documents can be stored on a roll of film.

There are three types of film, all of which are high contrast film: silver-halide, vesicular, and diazo. Vesicular and diazo films are orthochromatic films used to duplicate the image from the original negative film [*3*]. Usually, two rolls of film are shot—one for access and the other for security. Some machines shoot two rolls of film at a time. Otherwise, a duplicate roll is recorded from the first roll.

Microimage Retrieval Terminals

Retrieval terminals follow the same principles as photocopiers: the retrieval terminal copies from film; the photocopier copies from the document. The most common processes are the thermographic and the electrostatic. The thermographic process uses coated paper imaged when heat is applied. The electrostatic process uses plain paper imaged by toner. The electrostatic process introduces an extra generation of transferring the image—the photoconducting surface.[2] This process is becoming increasingly popular because the paper costs substantially less than the coated paper and the copy is a permanent record. The thermographic paper can turn dark and lose its image when exposed to light or heat.

The document image on the film can be magnified in eight sizes for printing a hard copy: ×16, 20, 24, 30, 34, 40, 43, and 48. The retrieval machine accommodates different size lens. Therefore, a document that was reduced ×24 onto film will usually be increased ×24 onto a paper copy. However, to allow for the focusing distortions at the border of the copy, image size is slightly smaller than one to one on the paper copy. Enlargements can be made from the retrieval by changing to a larger lens.

Adjustments to the retrieval terminal may improve a poor copy. The film and the lens in the retrieval terminal must be clean or else the paper copy will have white trash marks that can obscure the image area. The intensity, focus, and alignment are usually controlled manually and can be readily adjusted. If the coated paper copy lacks intensity and has pink, brown, gray, yellow, or blue tones, or a reptile pattern in the background area surrounding the document (it should be dark and even), the paper could be old or an off brand. These suggestions do not exhaust all the remedies for a better copy, but can help.

When the examiner is satisfied that he has the best microfilm copy and it is still not good enough, then steps should be taken to photograph the document from the film, bypassing the retrieval system altogether. This can be accomplished in a number of ways: either through the microscope or the darkroom enlarger. When a negative film is photographed, a slide film will render a positive print.[3] Masson's paper [*2*] and one by Vollertsen [*4*] suggest ways to photograph the image from the film or from the reader-printer screen (a separate unit or part of the retrieval terminal).

Study

For this study, documents were microfilmed on rotary and planetary filmers and paper copies were made on electrostatic and thermographic retrieval systems (Table 1). All except the Kodak 2000 filmer and one of the Kodak 350 retrieval terminals were on-the-job machines used often and by more than one operator.

Tests

Gray Scale

The gray scale does not reproduce accurately. The Kodak Gray Scale separates 18 times between white and black. In the microfilmed copies, the light end separates from four to seven times with no separation at the dark end.

[2]Electrostatic image: original > film > photoconducting surface > paper. Thermographic image: original > film > paper.

[3]Kodak 35-mm 160 asa color slide film at ×1 to ×7 through the microscope has been successfully used in the author's laboratory.

TABLE 1—*Micrographic equipment used for collection samples.*

Filmer	Retrieval
1. Canon Rotary 800 DDs at ×24	Kodak 50 at ×30 Kodak 150 at ×24 Kodak 350 at ×24[a]
2. Canon Rotary 800 DDs at ×40	Kodak 50 at ×30 Kodak 150 at ×24 Kodak 350 at ×24[a]
3. Kodak 750 Rotary at ×40	Kodak 50 at ×30 Kodak 150 at ×30
4. Kodak 2000 Rotary at ×50	Kodak 150 at ×43 and ×48 Kodak 350 at ×43 and ×48[a]
5. Kodak 700 Rotary at ×24	Kodak 150 at ×24 Kodak 350 at ×24[a]
6. Kodak MP/230 Planetary at ×24	Kodak 150 at ×24 Kodak 350 at ×24[a]

[a]Electrostatic retrieval process.

Color Scale

The pastel colors or top band on the Kodak Color Control Patches do not separate at all.

Grid

The intersection of lines are not as clearly defined as in the original, and when either the filmer or retrieval terminal is out of focus, the intersection of lines are marked with a dot. In some samples, one or two sides were out of focus while the rest of the grid was sharp indicating poor plane focus.

Class of Pens

1. Sample checks were written by two writers with each of the pens listed in Table 2: the signatures were made by one writer and all of the other entries were made by the other writer. Each entry was executed at an increased speed, the signature being the most rapidly executed. Pens from each class were included: ballpoint, roller, fiber tip, plastic tip, and fountain. The original checks were intercompared to distinguish class characteristics. Those characteristics that were visually observed in the original samples are listed in the second column in Table 3. Although these characteristics were observed in the samples used in this study, and most of them are reported by Hilton [5] and Masson [6] in their preliminary works on distinguishing class characteristics of modern pens, they are not exclusive. As in

TABLE 2—*Pens producing sample writing.*

Ball	Bic	blue	fine
Ball	Longlife®	black	medium
Roller	Paper Mate®	blue	fine
Roller	Uni-Ball	black	medium
Plastic	Pilot Rasor	black	fine
Fiber	Flair®	blue	fine
Fountain	Schaeffer	blue	fine

TABLE 3—*Class characteristics of pens reproduced in microfilm copies.*[a]

Pens	Originals	Microfilm Copies	
		Thermographic	Electrostatic
Ball	gooping	yes	yes
	striations	breaks	breaks
	skipping	slightly	yes
Roller	opacity	yes	yes
	shading (fine tip)[b]	yes	yes
Plastic	opacity	yes	no
	shading[b]	yes	breaks
Fiber tip	opacity	yes	ragged
	heavy line	yes	yes
	paralleling striations	shaded	fuzzy
Fountain	opacity	yes	yes
	shading	yes	yes
	flowback	yes	heavier line

[a]The reproduction of these characteristics were derived from the best quality microfilmed copies collected. When the characteristic was reproduced, but in a different manner than on the original, that difference is listed.

[b]Shading here designates a combination of fine and broad strokes more attributed to the implement, rather than light and dark strokes more attributed to the writer. Shading can be a characteristic of either. But since the one-writer entries were compared between each pen and this characteristic was more pronounced with the blue roller, the plastic tip, and the fountain pens it is attributed to the pen. This does not negate the influence that the pen had on the writer in this instance, and may not always be a characteristic of the pen. Shading was not listed as a characteristic of the ballpoint pen, but suffice it to say, it was a characteristic of the writer of the signatures, but lacked the density that the aqueous ink pens produced.

any classification, a combination of characteristics are necessary to distinguish a class. The exclusion of some of the characteristics reported by Hilton and Masson, for example, grooves, tracks, compression, and indentations, are not applicable in this study because of the limitations inherent in copies.

2. The originals were then compared to their microfilmed counterparts to determine if the characteristics found in the originals were reproduced. The results of this comparison are listed in the third column in Table 3.

Skipping, striations, and shading with ballpoint are not readily distinguishable in the microfilmed copies. These elements lack the density to be fully recorded onto the film, hence, are lighter than the rest of the writing line in the thermographic copies and appear as intermittent breaks in the line in the electrostatic copies (Figs. 1 and 2).

Gooping is distinguishable most of the time, but not always in the same shape as on the original. This minute distortion is more pronounced in the thermographic copies.

Opacity is the quality of blocking out the background by an even spread of the ink, characteristic of the aqueous inks (Figs. 3, 4, 5, 6, and 7). Although in the originals aqueous ink is more grainy or coarse under microscopic examination than the nonaqueous ink, it has an overall appearance of density when examined without magnification because it spreads over the paper more evenly. However, the edges or outline of the aqueous stroke are bumpy. Under magnification the line edges have nodules or feathering of ink, producing a ragged edge. The finer point pens produce this quality less so, whereas it is more pronounced with

FIG. 1—*Ballpoint pen (blue ink). The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

FIG. 2—*Ballpoint pen (black ink). The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

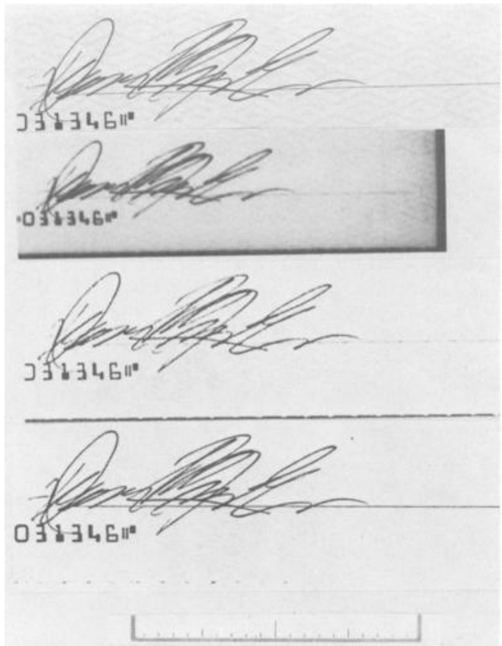

FIG. 3—*Roller pen (blue ink). The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

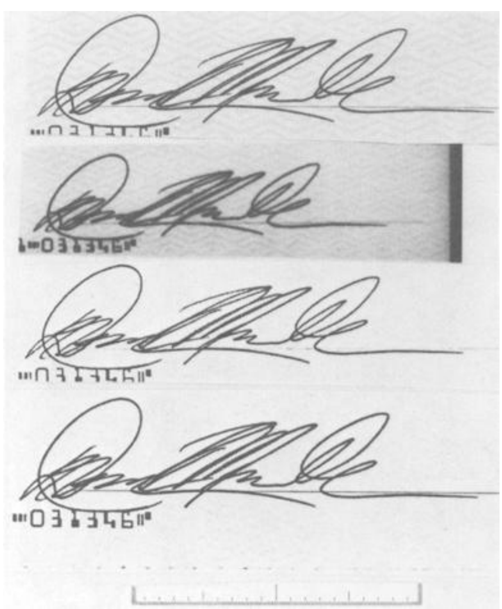

FIG. 4—*Roller pen (black ink). The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

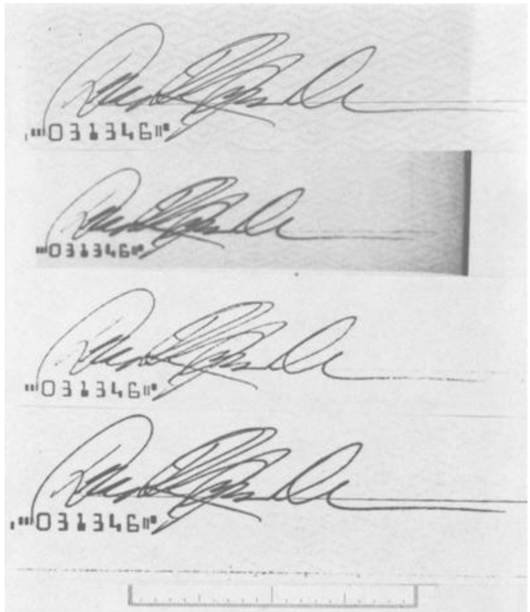

FIG. 5—*Plastic tip pen. The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

FIG. 6—*Fiber tip pen. The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

FIG. 7—*Fountain pen. The first sample is the original "Duane R. Mueller" signature, the second sample is a thermographic copy (reduced ×50 then retrieved at ×43), the third sample is an electrostatic copy, and the fourth sample is a photocopy (electrostatic process).*

the fiber tip and fountain pens. The ballpoint does not have the quality of density, nor the quality of a bumpy line edge. Instead, the edge of the ballpoint line is smooth.

In the microfilmed copies, the magnified qualities seen in the originals are not reproduced, the opacity is however. Therefore, the aqueous writing is recorded on the microfilmed copies as solid lines, with the exception of the plastic tip writing on electrostatic copies (Fig. 5), which is recorded as a broken line much like that found with the ballpoint writing in both electrostatic and thermographic copies. Further, in the microfilmed copies the edges of the aqueous writing are recorded as smooth. Whether considering the edges or the internal portion of the ballpoint strokes in the microfilmed copies the strokes are ragged.

Paralleling striations are elongated, internal, inkless tracks characteristic of the porous pens, that is, plastic and fiber tip. In the microfilm copies, the paralleling striations appear as fuzzy line edges or tapering of the line where the striation occurs (Figs. 5 and 6). Hence, one side of the line will appear sharp and the other side fuzzy on the electrostatic copy and shaded on the thermographic copy.

Flowback refers to the ink flowing back into the widest part of the stroke giving a darker appearance to the line in those areas compared to the adjacent areas losing ink. In the fountain pen sample (Fig. 7) this occurs at the bottom half of the writing stroke. Shading is recorded as wider and narrower strokes; flowback is recorded as lighter and darker strokes. Both are reproduced in the thermographic copies, and except for the plastic tip shading, are reproduced in the electrostatic copies. In the electrostatic copies, the plastic tip shading is recorded as a broken line (see footnote to Table 3).

3. Given these parameters, the microfilmed copies were then intercompared to determine if any class of pen could be recognized. In some cases, dependent on the quality of copy, the aqueous ink pens could be distinguished from the ballpoint pens. In the thermographic copies, the strokes with aqueous ink are reproduced as a solid stroke; ones with nonaqueous ink

are reproduced as textured[4] strokes. However, black ballpoint coupled with the lack of striations, skips, and shading also is recorded as a solid stroke. (The sample using black ballpoint is a case in point. Only a few strokes that are riveted with skipping and shading show the textured quality in the thermographic copy.)

In the electrostatic copies, the ballpoint and plastic tip pens have the textured strokes, whereas the other aqueous pens have the solid strokes. This distinction in electrostatic copies is crucially affected by the quality of copy. A darker copy may produce a solid line in the ballpoint and plastic tip samples; conversely, a lighter copy may produce a broken line in the aqueous samples.

Although several conditions must be met to determine the class of writing implement from a microfilmed copy, given the distinction of an aqueous or nonaqueous implement, some parameters were found, more so with the thermographic copies than with the electrostatic copies.

If the writing line is solid, has a wide range of width (shading characteristic of the fountain pen), and flowback of ink, one may deduce a fountain pen.

If the line is solid and continuously heavy or thick, one may narrow the possibilities to a fiber tip or black roller. Of course, this is relative to the resolution of any printed matter or writing produced by some other implement on the same document to determine the quality of the copy.

Combining the characteristics of gooping and textured and broken lines would strongly indicate that a ballpoint pen produced the writing.

In documents that contain both printed matter and handwriting, for example, a check, the printed matter can be a gauge to determine the resolution quality. If it is excessively soft, then this condition must be considered in evaluating the handwritten entry. Care must be taken, especially on electrostatic copies, that are excessively dark or heavy (produced by slowing the imaging process on the retrieval terminal[5]).

Handwriting Details

The microfilmed copies of all the handwritten samples (including the samples from 26 individuals whose writing ranged from legible to illegible, heavy to light pressure, simplified to complex letter forms, highly to moderately skilled) were compared to their original counterparts to determine degree of detail loss.

Compared to the originals, all microfilmed images are soft as a result of the high-contrast film and size reduction; and, with rotary filmers, the speed of filming. Comparing the two microimaging processes described in this study, the electrostatic copies are sharp and have a high contrast appearance, whereas the thermographic copies are soft and have a continuous tone appearance. These conditions are responsible for the different detail that is lost between the two processes.

Hairlines are not reproduced on electrostatic copies. They are reproduced in many thermographic copies, but not all, and are diminished to some degree. If either the filmer or retrieval is slightly out of focus, then hairlines are obscured altogether.

The line of writing in all microfilmed copies thickens a bit, therefore, tiny spaces are filled. If the space is smaller than the relative line expansion, then the area is filled solidly. Narrow loops and small eyelets are affected in this manner. This line expansion also causes a soften-

[4]Textured seems a better term to describe the quality of the line in thermographic copies, whereas broken would be more descriptive in the electrostatic copies. Textured signifies irregularities in the density of the line and not completely broken as occurs with skipping, shading, and striations. It's the reproduction of the minute spaces of paper showing through the deposits of nonaqueous ink in the solid portions of the stroke.

[5]Some retrieval terminals have controls to slow the speed of imaging, therefore, in the electrostatic copies more toner falls on the paper making a darker image.

ing of sharp turns, so sharp angles in the original appear more blunt in the microfilmed copies. However, in the electrostatic copies, slight angles and curvatures are more readily reproduced.

Penlifts are reproduced, although the space is relatively smaller than in the original because of the thickening of the line. If the writing line is resumed close to the termination of the lift, then the lift is not detectable on the microfilm copy.

Simulations

1. Various signatures were simulated with ballpoint pen and roller pen. The samples of the freehand simulations were compared to the models of the authentic signatures. Whether they were good or poor simulations the obvious elements of simulation, that is, tremor, retouching, and form sacrificed by speed, were reproduced in the microfilm copies (Fig. 8). When a simulation is relatively good and detection depends on correct interpretation of the magnified elements, then a microfilmed copy will never suffice.
2. In the traced samples, the tremor and lack of rhythm were quite obvious.

Alterations

The slight discoloration of the opaquing fluid on the original was reproduced as a smudge on the copy. In the sample, the paper had a two-tone yellow pattern (pantogram) and the

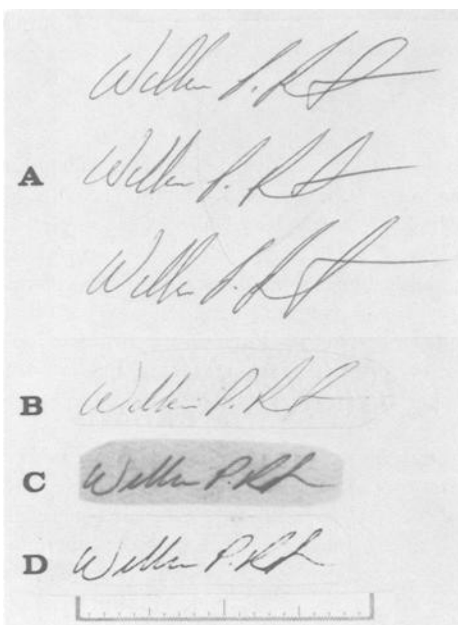

FIG. 8—(a) *Three samples of requested known signatures, "William P. Rust."* (b) *Known signature also used as the model for the simulation* c *and* d. (c) *Thermographic copy of the simulated signature.* (d) *Electrostatic copy of the simulated signature. The gross elements that indicate nongenuineness are readily recognized in the microfilmed copies: shape, alignment, and size of the second trough of the "W," lead-in stroke of the first "i," retraced "l" loops, blunt connection between second "l" and "i," curvature of "P" bulb and "t" crossing, and the height ratios.*

opaquing fluid was the same yellow color. Again, it appears that the opacity is the controlling factor, because we have already found that the pastel colors are not differentiated in microfilmed copies.

Summary

Several factors can cause a poor copy: for instance, focus of filmer or retrieval terminal, intensity setting on the retrieval, dust in the units, and bad paper in the thermographic systems—although these are not all-inclusive causes. When photographing the film is not possible to obtain a better copy, imaging the film through another retrieval unit may be all that is necessary to get a better copy. It may also help to image the film on both an electrostatic and a thermographic system, since what one system loses the other records. The image can also be enlarged by changing the lens on the retrieval unit.

The combination of elements indicating type of pen do not negate the effects of a poor copy. Still more tests need to be performed to determine the effects of the writing surface, the condition of the implement, and the color of ink. It is presumed without further study that anyone of these conditions may be misinterpreted or confused with the elements indicating class of pen.

The gross elements: alignment, spacing, letter design, size, proportions, slant, ornamentation, shading, connections, skill, and often the interruptions in the line of writing can readily be observed, even in poor copies.

Details in letter construction are slightly modified: sharpness of turns and angles is softened; the internal space of loops is diminished; retraces, penlifts closely resumed, edges of lines, and all elements dependent on magnification are obscure. In addition, color of inks, pressure, condition of the writing implement, paper and background (pantograms), and obliterations are partially or totally lost in microfilmed copies.

The differences between a photocopy and a microfilmed copy using the electrostatic process can be detected in the background surrounding the document image. It will be dark on the microfilmed copy, because it is filled with toner from the nonimage area of the film. It will also be less sharp, but of course this is relative to the same generation photocopy of the same subject matter. The bottom signature in Figs. 1 through 7 are photocopied samples.

Since microfilmed copies fail to reproduce the finer details of the originals, and these elements are often crucially important in determining a simulation, this type of examination is severely limited. However, when the grosser elements of simulation are apparent on the copies, and can be distinguished from other factors indicative of illness, disguise, and impairment, then no reservations are needed to determine a simulation on a microfilmed copy.

Conclusion

The effects microfilmed copies have on the various elements of handwriting should always be considered in making an evaluation. The examiner must understand whether the microfilmed copy or the conditions of the original writing are the cause of differences in fine detail. As in other areas of questioned documents, a collection of microfilmed samples and the original counterparts would be helpful as part of the laboratory reference file. Without such reference material, some of the qualities in this study may be difficult to interpret. With some of the distinctions reported in this study, the examiner may find some microfilmed copies adequate in some examinations, especially when a microfilm copy is included with several original samples of known material. However, more research needs to be done to account for the elements that are not fully addressed, and to confirm on a broader basis those that are addressed.

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