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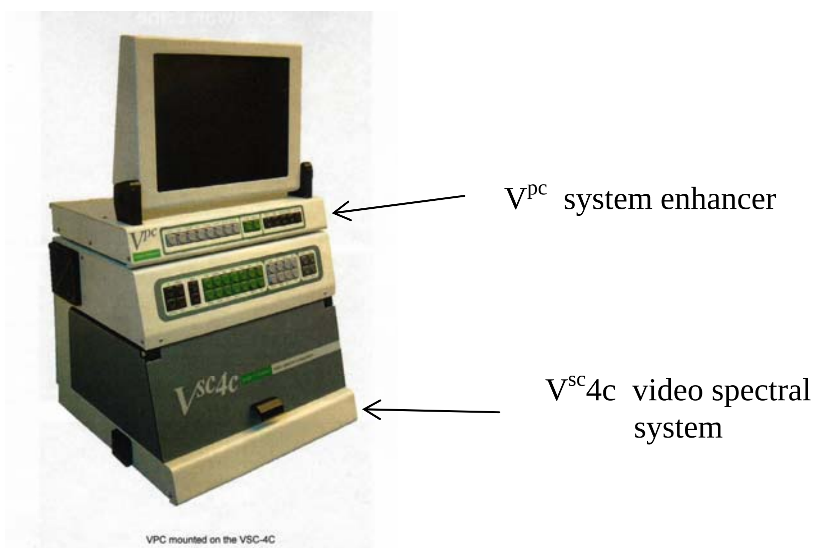
Nondestructive ink and paper examinations

When most people think of ink analysis they, think that it is a destructive examination which means my document is going to be severely damaged or destroyed. That is not completely accurate. There is a way of examining ink entries without damaging the document, and it is usually the only test necessary to resolve the issue of ink differentiation.

The examination process, known as infrared fluorescence, or luminescence, was developed by Mr. H. Gibson for use in the study of tissue samples. Forensic document examiners have used the same technique for nondestructive ink differentiation examinations for many years. Because a technical discussion of the process is beyond the scope of this paper, the reader is referred to an article on the web at http://msp.rmit.edu.au/Article_02/04.html. At the same web site there are links to other articles about the theory and equipment necessary to perform nondestructive ink examinations.

Briefly stated, when cyan light from the blue/green region of the spectrum illuminates an ink entry, components in the ink may reflect, absorb, or luminesce. The reaction of the ink to the various wavelengths of light is recorded on film, or using the Foster+Freeman, V^{sc}4c, video spectral comparator shown below. Figures 1-10, are images from this system. Foster+Freeman also market more sophisticated models of comparators, but their basic purpose is the same.



This unit enables the user to conduct incident and transmitted visible and/or infrared, short and/or long wave ultraviolet light, oblique light, and coaxial lighting for retro-reflective security feature examinations on documents. The resulting images can be imported to a computer for future use.. Most of the images in this paper are from this instrument.

Figure 1 shows original writing using five different ballpoint pens on a slip of paper. There was one Parker pen, two different Cross pens, and two pens containing no manufacturer's name. On the images imported from the V^{sc}4c, there are numerical notations in red boxes on Figure 2, denoting the wavelength characteristics of the filters used for this particular study.

The first numbers, "400-540" in Figure 2, denote the nanometer, a unit of measure, band-pass characteristics of the filter between the light source and the document. The number "610" denotes the cut-off frequency of the camera filter, also in nanometers. The camera filter is located between the document and the camera. A nanometer is equal to 1/1,000,000,000 or one billionth of a meter. The abbreviation for nanometer is "nm."

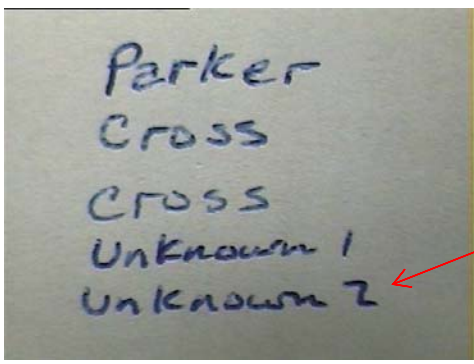


Figure 1
The original writing.

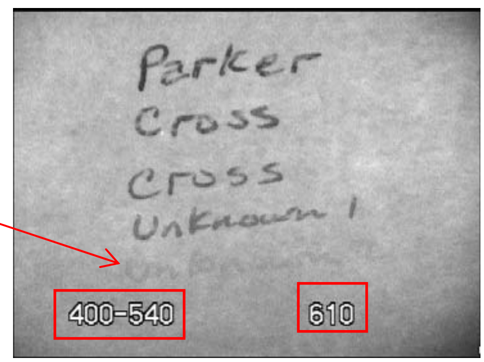


Figure 2
The ink in the last pen is beginning to "drop out" when the source light is between 400-540 nm. The reflected IR light reaching the camera passes through the filter having a cut-off frequency of 610 nm.

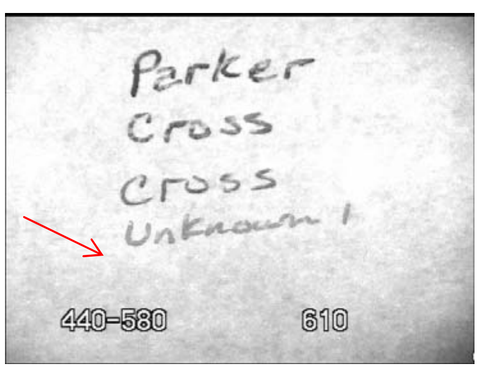


Figure 3
When the range of source light is between 440-580 nm and the camera filter remains the same, the source light is completely absorbed by the ink, and the last entry completely drops out.

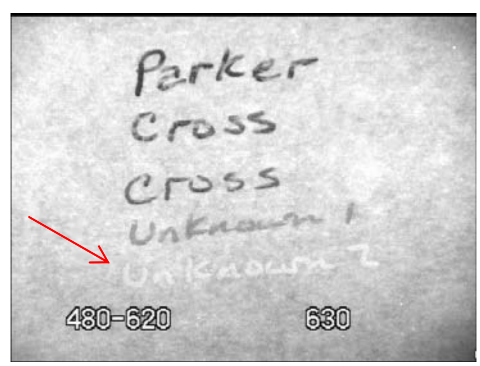


Figure 4
The reflective characteristics of the ink changes again when the source light is between 480-620 nm, and the cut-off frequency of the camera filter increases to 630 nm.

Note: The changes occurring to the ink from "Unknown 1" as the frequency of the reflected infrared light also changes. Although more subtle, the writing does appear to be lighter in Figure 4.

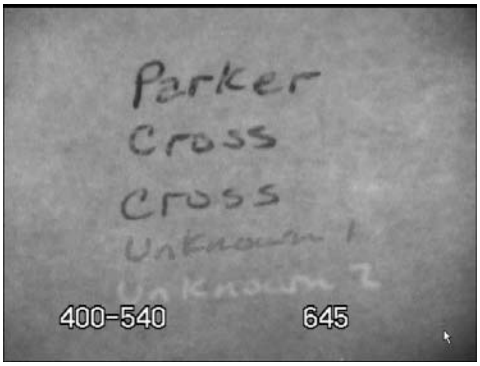


Figure 5
When the range of the source light is held between 440-580 nm, and the cut-off frequency of the camera filter is increased to 645 nm, the resulting effects for both unknown pens also changes.

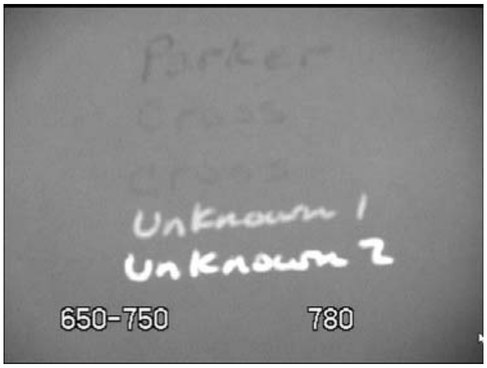


Figure 6
When the range of the source light is increased to between 650-750 nm, and the cut-off frequency of the camera filter is increased to 780 nm, there is a dramatic difference in the reflective effects of the inks in both unknown pens. The inks begin luminecesing and the other inks start absorbing the source light.

From Figures 2 through 6, it is easy to see that different inks react differently during this examination. Well, how is this affect actually used in the examination of altered entries on documents? Figure 7 shows an entry written with a single ink pen. Figure 8 shows the same entry, altered, using a pen having a different ink formulation.

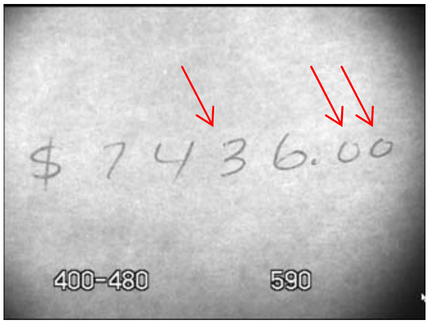


Figure 7
This figure shows an entry made with a single writing instrument. The arrows point to those numbers that are to be altered for illustration purposes.

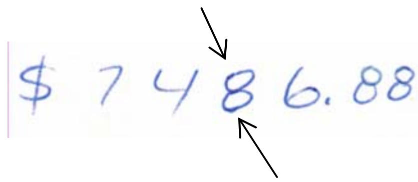


Figure 8
This figure shows a scanned image of the same entry after alteration. The "3" and both "0's" are altered to "8's" by adding a left side of the "3" and to circles above the zeros.

The alterations were not done as carefully as those typically found in actual case work. The purpose here is to illustrate the examination technique using the V^{sc}4c. The arrows in Figure 8 point to where the second pen was placed on, and removed from, the paper when altering the numeral "3." The addition of the zeros above those on the original writing is more carefully done and less easy to detect. In many instances in actual casework, it is very difficult to determine where start and stop locations are located without using this equipment.

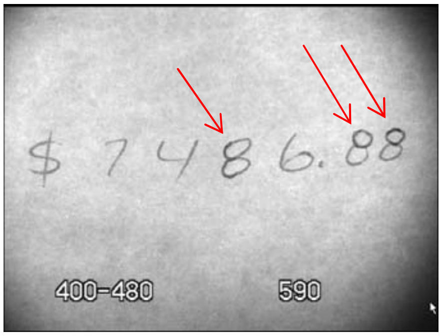


Figure 9
This figure shows the alterations when the filter settings are the same as those in Figure 7, and after the alterations were made.

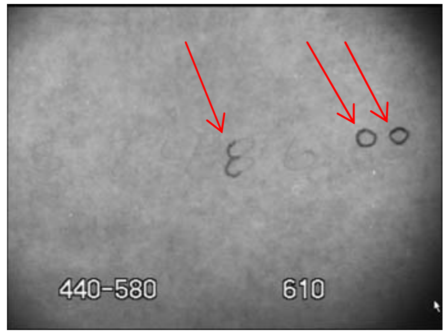


Figure 10
This figure shows the alterations made by the second pen, which are more prominent after both the source light and camera filters are changed.

Figure 11
This figure shows an attempt to obliterate a writing by over writing it using a different color ink pen.

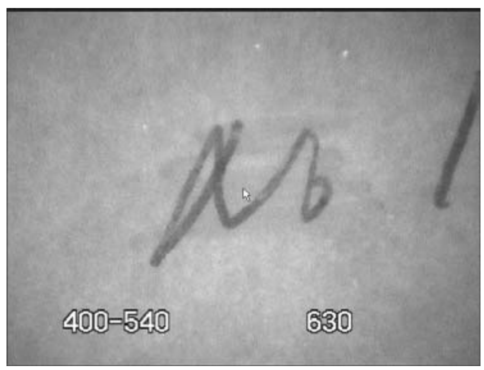


Figure 12
This figure shows how the attempted obliteration appears transparent using this technique.

PAPER

Paper is a "**thin flat material from wood pulp:** a thin material consisting of flat sheets, made from pulped wood, cloth, or fiber, used for various purposes, for example, for writing and printing on, …"
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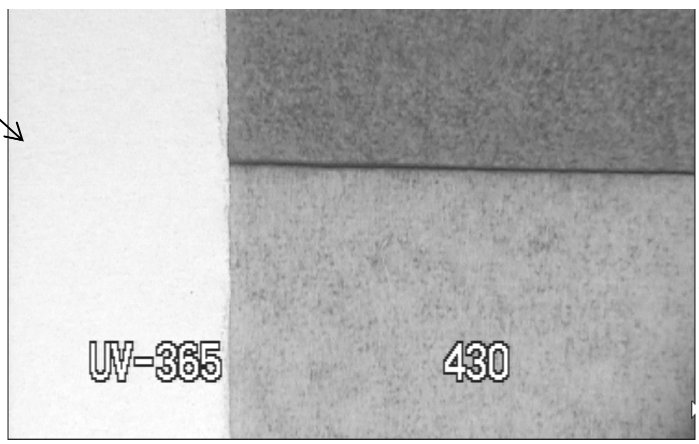
In addition to the "pulped wood, cloth, or fiber" materials, brighteners and other compounds are added to the fibrous mixture before the paper is made. The history of paper making and its manufacturing processes are very interesting, and the reader is encouraged to do further reading on the topic.

One of the characteristics of paper is its reflectance or absorption characteristics when illuminated with short and long wave ultraviolet light. Short wave ultraviolet light is usually 254 nm and long wave is 365 nm. Like the reaction to ink, when paper is exposed to ultraviolet light, the compounds in the paper react differently, and the paper has different reflective and absorption characteristics that can be photographed. Using this effect, it is frequently possible to determine that one sheet of paper is different from another without conducting a destructive examination.

Sheet No. 1

Sheet No. 2



Sheet No. 3

Figure 11
This figure shows the reaction of three sheets of paper when illuminated with long wave ultraviolet light, 365 nm. The camera filter has a cut-off frequency of 430 nm.

Figure 11 shows the ultraviolet reaction of three different sheets of paper to long wave ultraviolet light. Sheet No. 1 is a light blue color, sheet No. 2 is significantly darker, and sheet No. 3 has a color somewhere between the other two. When examining paper with ultraviolet light, it is important to use both long and short wave light as part of the examination process.

When the questioned document consists of a number of sheets of paper, and there is a suspicion that one or more sheets may have been substituted in the document, this type of examination may show that the inserted paper reacts differently to ultraviolet. This differentiation may support the possibility that the sheets were substituted. There is one caution that should always be considered—if the original document was produced using paper from different sources, then a different reaction to the ultraviolet light should be expected.

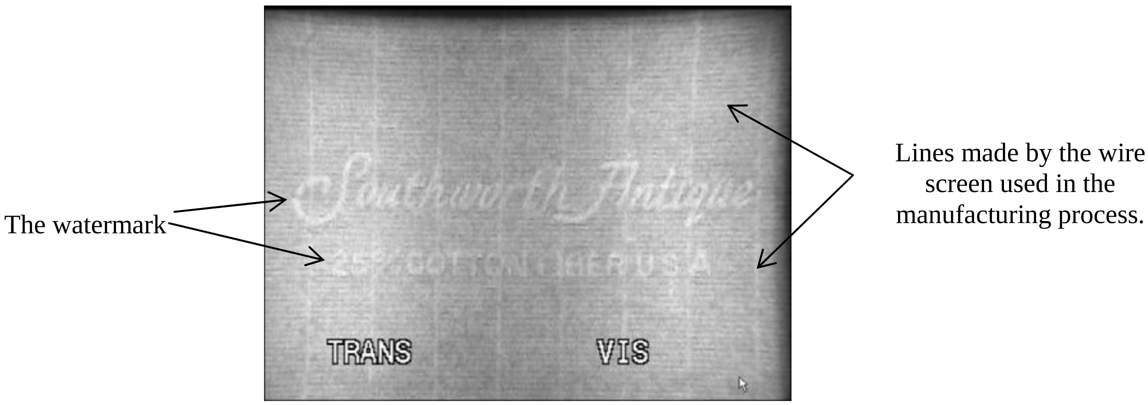


Figure 12
This figure shows a sheet of paper illuminated from the back, transmitted light, showing the watermark and other features remaining in the paper from the manufacturing process.

Many of the finer quality paper manufacturers use watermarks to identify their product. By using transmitted, or back lighting, and a camera, it is possible to read the watermark. Watermarks are also useful in establishing the date when the paper was made. Figure 12 shows a "Southworth Antique, 25% Cotton Fiber USA" sheet of paper. The light horizontal and vertical lines show the wire frame pattern used in the paper making process.

SUMMARY

The forensic examination of documents involves more than just the identification of handwriting and hand printing. Frequently, questions concerning the differentiation of inks, obliterated writings where it is important to determine what is being covered up by the overwriting, and paper examinations are necessary. To conduct these examinations, special techniques involving light of different wavelengths, cyan/green and ultraviolet, in conjunction with special filters and a digital camera, are frequently employed instead of using destructive techniques. This paper is an attempt to explain how this is accomplished.

In any type of forensic examination of documents, a conservative assessment of the observable evidence present on and in the documents is absolutely essential. The cardinal rule, the evidence in the documents may not provide the basis for a definitive answer in every case or examination. The techniques described in this paper have their limitations. The results must always be reported that include the limitations.

