TECHNICAL NOTE

M. G. Noblett,[1] *B.S.*

The Use of a Scanning Monochromator as a Barrier Filter in Infrared Examinations of Documents

REFERENCE: Noblett, M. G., **"The Use of a Scanning Monochromator as a Barrier Filter in Infrared Examinations of Documents,"** *Journal of Forensic Sciences,* JFSCA, Vol. 27, No. 4, Oct. 1982, pp. 923-927.

ABSTRACT: This study indicates that a scanning monochromator can replace long-pass filters in examining questioned documents using infrared techniques. The use of the monochromator may increase the capability of the examiner to restore obliterated writings.

KEYWORDS: questioned documents, reflectance, monochromators

The use of infrared (IR) radiation in the examination of questioned documents for erasures, obliterations, substitutions, and so forth is routine and well documented [*1*]. In both the photographic and electronic techniques, the barrier filter in front of the receiver (photographic film or television tube) has been long-pass. This technique allows inks to be categorized by their reaction to IR radiation and has been extremely useful in such document examinations as obliterated writings. The purpose of the research reported in this paper was to increase the sensitivity and selectivity of this technique by replacing the long-pass barrier filter with a variable band-pass filter—a monochromator. To clarify the techniques and terms used, a few basic definitions and descriptions are set forth.

One of five basic reactions can occur when a document written in ink is exposed to light energy in the visible and near IR portion of the spectrum (400 to 1200 nm) [*2*]: the ink

(1) absorbs IR radiation,
(2) transmits IR radiation,
(3) reflects IR radiation,
(4) luminesces, or
(5) does not luminesce [*3*].

If the document is exposed to a broad band of visible and IR radiation such as a tungsten lamp, and a long-pass filter such as a Kodak Wratten 87 series is placed in front of the

Received for publication 8 Jan. 1982; revised manuscript received 22 Feb. 1982; accepted for publication 23 Feb. 1982.

[1]Special agent, U.S. Department of Justice, FBI, Washington, DC.

receiver, the inks can absorb IR radiation (darken), transmit IR radiation (disappear), or reflect IR radiation (lighten).

If the document is exposed to a more specific wavelength of light (typically the blue-green portion of the spectrum), and a long-pass filter such as a Kodak Wratten 89B is placed in front of the receiver, certain substances in some writing inks will absorb energy in this blue-green portion of the spectrum and emit light at a higher wavelength. This emitted light is commonly referred to as "infrared luminescence." The inks can either luminesce or not luminesce.

It is recognized that, within these five broad categories, observable variances occur from one ink to another. However, these variances must be evaluated with caution, since many are functions of the storage conditions and handling of the document prior to its examination rather than of ink composition. Most notably, some inks can be induced to luminesce by moisture, the presence of transparent tape, perspiration, and so on. Because of this, IR luminescence may not be totally reliable as a method of categorizing inks [4].

Equipment

The work was done with the following equipment (Fig. 1):

(1) a standard 525-line commercially available closed circuit television camera equipped with a Schneider-Kreuznod xenon 1:0.95 lens and an RCA 4532 silicon photoconductor vidicon camera tube (tube is sensitive to 1100 nm);

(2) a standard 525-line 23-cm (9-in.) black-and-white closed circuit monitor;

(3) a Kodak 35-mm slide projector equipped with a 300-W quartz halogen lamp with the heat-absorbing filter removed;

(4) an Oriel Model 7240 monochromator with a ruled grating blazed at 500 nm and variable entrance and exit slits; and

(5) a 2-m optical bench to allow easy optical alignment.

Procedure

A test card was prepared using eight felt-tip pens of various manufacture (Table 1).

The test card was illuminated by the lamp in the Kodak projector using a mirror system to reflect the light onto the card.

The television camera, with aperture fully open, was focused onto the exit slit of the monochromator and the variable slits were adjusted so that a clear image of the card was produced on the monitor. To produce a clear image it was necessary to adjust the slits such that the bandwidth passed varied between 5 and 10 nm.

The monochromator was manually scanned from 500 to 800 nm and the observations were recorded. The wavelength at which each of the inks began to transmit IR radiation was

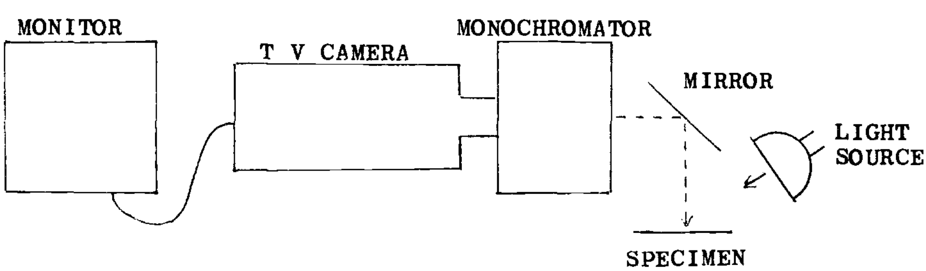

FIG. 1—*Camera, monochromator, light source, and monitor.*

TABLE 1—*The eight pens used on the test card.*

Ink	Color	Markings
1	yellow	Sanford's Sharpie®
2	blue/purple	M-Japan
3	red	Flair®
4	green	Scripto®
5	red	Skilcraft
6	green	Sanford's Vis-a-vis®
7	green	Sanford's Sharpie®
8	red	Schwan-Stabilo

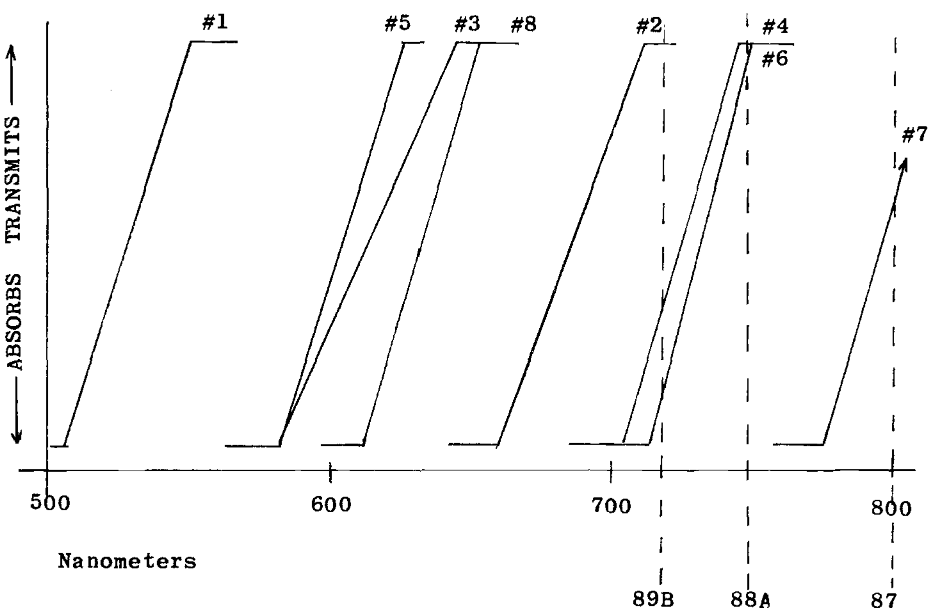

FIG. 2—*Differentiation of inks based on IR reflectance characteristics.*

recorded, as was the wavelength at which the inks were totally transmitting. The observations listed in Table 2 were made over a 64-day period.

These data were used to prepare the graph shown in Fig. 2, which demonstrates the ability of the monochromator to differentiate between inks based on their IR reflectance characteristics. All inks could be differentiated except Inks 4 and 6, which exhibited nearly the same reflectance characteristics.

Comments

The lines of Fig. 3 labeled 89B, 88A, and 87 represent the 50% transmittance wavelength for Kodak Wratten filters of those designations [5]. These filters are typically used by document examiners to differentiate inks by IR reflectance. With these filters it was possible to sort Ink 7 from the others. However, the remaining inks could not be differentiated.

TABLE 2—*Wavelengths (nm) at which each of the inks began to transmit and were totally transmitting.*

Ink	Day 1		Day 2		Day 28		Day 64	
	Begin	Total	Begin	Total	Begin	Total	Begin	Total
1	505	550	505	535	500	540	505	550
2	665	715	645	700	665	705	650	705
3	580	650	580	625	580	660	580	625
4	715	760	720	750	720	750	710	750
5	580	625	580	610	580	620	580	625
6	705	750	700	740	705	735	700	735
7	775	. . .	775	. . .	775	. . .	775	. . .
8	610	670	615	640	615	640	610	640

Results

By replacing the long-pass filter with a variable band-pass filter, it is possible to sort inks into many more categories than currently possible with only IR reflectance.

In the examination of obliterated writings, it may be possible to be selective in the IR reflectance mode, causing the obliteration to transmit while the underwriting still absorbs.

References

[1] Constain, J. E. and Lewis, G. W., "A Practical Guide to Infrared Luminscence Applied to Questioned Document Problem," *Journal of Police Science and Administration*, Vol. 1, No. 2, 1973, pp. 209-218.

[2] Richards, G. B., "The Application of Electronic Video Techniques to Infrared and Ultraviolet Examinations," *Journal of Forensic Sciences*, Vol. 22, No. 1, Jan. 1977, pp. 53-60.

[3] Hilton, O., "New Dimensions in Infrared Luminescence Photography," *Journal of Forensic Sciences*, Vol. 26, No. 2, April 1981, pp. 319-324.

[4] Sensi, C. A. and Cantu, A. A. "Infrared Luminescence: Is it a Valid Method to Differentiate Among Inks?," presented at the 33rd Annual Meeting of the American Academy of Forensic Sciences, Los Angeles, Feb. 1981.

[5] "Kodak Filters for Scientific and Technical Uses," Publication B-3, Eastman Kodak Co., Rochester, NY, 1978.

Address requests for reprints or additional information to
Michael G. Noblett
U.S. Department of Justice
FBI
Washington, DC 20535