

*Jeannine Zimmerman,¹ M.S.; Paige Doherty,² B.S.; and
Dennis Mooney,² B.A.*

Erasable Felt Tip Writing Instrument Detection

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ABSTRACT: This project was undertaken to determine if erasable felt tip writing instruments and their chemical erasers were susceptible to nondestructive examination techniques which are accepted in the field of questioned documents. Through the application of seven different examinations, class characteristics of the inks and erasers were observed and found to be distinguishable.

KEYWORDS: questioned documents, inks, erasures, class characteristics

Modern society revolves around paperwork. To compete, the manufacturers of writing instruments constantly seek to develop new products for this perpetual market. To the questioned documents examiner, the nearly infinite variety of modern inks available is an uncontrollable and troublesome variable. Recently, a new type of felt tip ink was added to this profusion.

This new ink is not a particularly exciting development or cause for alarm, unless the claims of a manufacturer are taken literally. One producer claims that by using a special felt tip eraser, supplied with the marker(s), the ink "erases like magic." If true, this could cause difficulties with document examinations.

Consequently, this project was undertaken to determine if erasures of this type were susceptible to common, nondestructive examination techniques. Another consideration of this study was to determine the characteristics displayed by the inks when subjected to the same procedures.

Method

Felt tip inks and liquid felt tip erasers from two different manufacturers, a total of ten different inks and four different erasers, were used (Fig. 1). Each marker was only tested with its respective eraser. The first was "Erasable Line Markers," produced in Japan by Adger. These markers are double-ended instruments, the ink tip being at one end and the felt tip eraser at the other. Three different colors of Adger markers were used in the examinations; green, orange, and purple (Fig. 2).

The other markers used were "Erasables" produced by the Italian firm Pentech (Fig. 2).

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¹Questioned documents examiner, Aurora Police Department, Aurora, CO.

²Questioned documents trainee and questioned documents examiner, respectively, Colorado Bureau of Investigation, Denver, CO.



FIG. 1—Felt tip inks and liquid felt tip erasers from Pentech (center) and Adger (right and left).

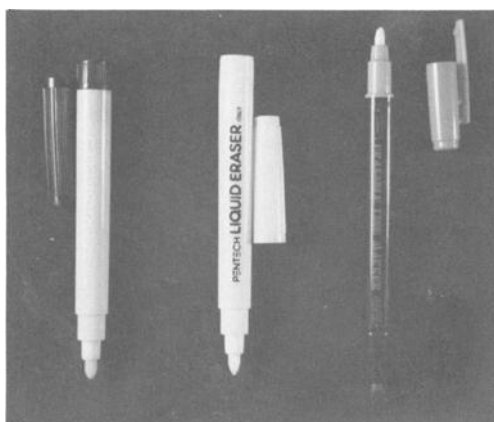


FIG. 2—Double-ended Adger felt tip marker and eraser (right), Pentech liquid eraser (center), and Pentech erasable felt tip marker (left).

The Pentech markers are packaged as a set of seven colored markers and a separate eraser felt tip marker. The Pentech colors include: black, blue, green, orange, pink, red, and yellow.

The examinations were performed using writing and erasures on two different papers, Cascade® Xerographic white bond paper and Dixon Paper Company Blue Basket Weave Lamonte Safety Paper.

Seven different examinations were performed using standard equipment at the Colorado Bureau of Investigation's laboratory, with the exception of laser examinations which were performed with equipment made available by the Aurora Police Department. The seven examinations included: heat exposure, infrared reflectance, infrared luminescence, shortwave

ultraviolet, longwave ultraviolet, neodymium:yttrium aluminum garnet (Nd:YAG) laser, and pH determination [1]. In addition to the above examinations, it was discovered that the erasures became visible (to the unassisted eye) after a period of approximately two weeks [2].

The heat exposure examination was conducted using a standard laboratory oven heated to 120°C. A sample of writing and erasures on white bond paper was exposed to this temperature for a period of about 2 h.

Infrared reflectance examinations were performed with a Pulnix Silicone Chip video camera with a Tiffin 7-87 glass filter equipped with an RCA black-and-white video monitor.

Infrared luminescence testing was accomplished by using the above infrared reflectance equipment with the addition of a 12% copper sulfate filter [3].

Short- and long-wave ultraviolet examinations were performed with a Model UVGL 54 mineral light, operating at 254 to 366 nm.

The laser used in these examinations was a solid state frequency doubled Nd:YAG laser. This is a pulsing laser of amount 7 mJ which operates at 532 nm. It has a pulse duration of about 10 ns and its frequency is approximately 20 Hz. The emission pulses are a very intense bright green color with an average power around 140 mW [4].

The pH tests were achieved by using Em Reagents Color-Phast indicator sticks. To prevent potentially distorting ink transfers to the indicator sticks, they were first soaked in neutral distilled water, and then the edge was touched to the ink and erasures under scrutiny. Control tests of the papers used were also performed [5].

Results

Both paper background and pen color radically affected most tests; however, it was determined that all of these pens and their erasures could be detected by some method.

After a period of approximately two weeks, the visibility of the pen erasures was examined. The results, identical for both types of paper, are illustrated in Table 1.

The heat exposure examination obtained some interesting results among the Adger markers. The visualized erasures of the Adger markers appeared quite different from those obtained by the passage of time. The Pentech markers did not respond favorably to this examination. Table 2 compiles the results of the heat exposure examination. These results were identical for both types of paper.

The Adger markers (Nos. 1, 2, and 3) showed a dramatic response to this examination. Eraser markings resulted in a strong brown color. Underlying ink became visible as a pale yellow color for erased green ink, or a light purple color for the orange and purple inks. Of

TABLE 1—*Visibility of pen erasures.*^a

Pen	Description	Erasure
1	Adger green	WV
2	Adger orange	SV
3	Adger purple	SV
4	Pentech black	WV
5	Pentech blue	MV
6	Pentech green	WV
7	Pentech orange	WV
8	Pentech pink	NR
9	Pentech red	WV
10	Pentech yellow	WV

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image. NR = no response/no visible image.

TABLE 2—Heat exposure results.^a

Pen	Description	Ink	Erasure
1	Adger green	SV	MV
1a	Adger green eraser	SV	...
2	Adger orange	SV	MV
2a	Adger orange eraser	SV	...
3	Adger purple	SV	MV
3a	Adger purple eraser	SV	...
4	Pentech black	SV	WV ^b
5	Pentech blue	SV	WV ^b
6	Pentech green	SV	WV ^b
7	Pentech orange	SV	WV ^b
8	Pentech pink	SV	NR
9	Pentech red	SV	WV ^b
10	Pentech yellow	SV	WV ^b
11	Pentech eraser	NR	...

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image. NR = no response/no visible image.

^bNote that the Pentech results obtained may not be attributed completely to the application of heat. These pens will demonstrate a similar response if allowed to sit for an extended period of time.

the Pentech pens, the erased blue ink resulted in a faint brown color while all other erased colors that responded became a faint, nearly illegible, yellow color. The Pentech pink ink and eraser did not respond to this examination.

The infrared reflectance examination was disappointing; not a single ink, erased ink, or solitary eraser mark could be seen by this method. In Tables 3 and 4 the results of this examination are compiled.

Infrared luminescence results were substantially better than those of infrared reflectance. The outcome of the infrared luminescence examination is affected by both the brand and color of ink and the type of paper used. Tables 5 and 6 show the results of the infrared luminescence examination.

The shortwave ultraviolet examination also produced good results. Tables 7 and 8 show these results.

The longwave ultraviolet light also produced beneficial results. These results are compiled in Tables 9 and 10.

The results of the Nd:YAG laser examination are compiled in Tables 11 and 12.

The results of the pH testing were identical for both types of papers. These results are shown in Table 13.

Conclusion

Based on this study, the erasable felt tip markers and their respective erasers were found to be susceptible to nondestructive examination techniques. The results of these tests disclose only the class characteristics of the markers/erasers. However, familiarizing the questioned documents examiner with these class characteristics only increases his/her awareness of yet another variable which may be encountered in the realm of written communication.

Acknowledgment

Appreciation is extended to Janis S. Tweedy, St. Paul, Minnesota, for assistance in locating the Pentech writing instruments.

TABLE 3—*White bond paper—Infrared reflectance results.*

Pen	Description	Ink	Erasure
1	Adger green	NR ^a	NR
1a	Adger green eraser	NR	...
2	Adger orange	NR	NR
2a	Adger orange eraser	NR	...
3	Adger purple	NR	NR
3a	Adger purple eraser	NR	...
4	Pentech black	NR	NR
5	Pentech blue	NR	NR
6	Pentech green	NR	NR
7	Pentech orange	NR	NR
8	Pentech pink	NR	NR
9	Pentech red	NR	NR
10	Pentech yellow	NR	NR
11	Pentech eraser	NR	...

^aNR = no response/no visible image.

TABLE 4—*Blue safety paper—Infrared reflectance results.*

Pen	Description	Ink	Erasure
1	Adger green	NR ^a	NR
1a	Adger green eraser	NR	...
2	Adger orange	NR	NR
2a	Adger orange eraser	NR	...
3	Adger purple	NR	NR
3a	Adger purple eraser	NR	...
4	Pentech black	NR	NR
5	Pentech blue	NR	NR
6	Pentech green	NR	NR
7	Pentech orange	NR	NR
8	Pentech pink	NR	NR
9	Pentech red	NR	NR
10	Pentech yellow	NR	NR
11	Pentech eraser	NR	...

^aNR = no response/no visible image.

TABLE 5—*White bond paper—Infrared luminescence results.^a*

Pen	Description	Ink	Erasure
1	Adger green	SL	WL
1a	Adger green eraser	NR	...
2	Adger orange	ML	WL
2a	Adger orange eraser	NR	...
3	Adger purple	ML	WL
4	Pentech black	ML	NR
5	Pentech blue	ML	ML
6	Pentech green	ML	NR
7	Pentech orange	SL	NR
8	Pentech pink	SL	WL
9	Pentech red	SL	NR
10	Pentech yellow	WV	NR

^aSL = strong luminescent image. NR = no response/no visible image. ML = moderate luminescent image. WV = weak visible image. WL = weak luminescent image.

TABLE 6—Blue safety paper—*infrared luminescence results.*

Pen	Description	Ink	Erasure
1	Adger green	SL	WL
1a	Adger green eraser	ML	...
2	Adger orange	ML	ML
2a	Adger orange eraser	ML	...
3	Adger purple	ML	ML
3a	Adger purple eraser	ML	...
4	Pentech black	SL	WL
5	Pentech blue	ML	ML
6	Pentech green	ML	WL
7	Pentech orange	SL	WL
8	Pentech pink	SL	WL
9	Pentech red	SL	WL
10	Pentech yellow	WV ^b	ML
11	Pentech eraser	SL	...

^aWV = weak visible image. SL = strong luminescent image. ML = moderate luminescent image. WL = weak luminescent image.

^bThe Pentech yellow ink was nonluminescent and, consequently, was visible as being darker than the background paper.

TABLE 7—White bond paper—*shortwave ultraviolet results.*^a

Pen	Description	Ink	Erasure
1	Adger green	SL (green) ^b	ML (purple)
1a	Adger green eraser	WV (purple)	...
2	Adger orange	SL (orange)	ML (lt. blue)
2a	Adger orange eraser	WV (purple)	...
3	Adger purple	SV (pink)	WV (purple)
3a	Adger purple eraser	WV (purple)	...
4	Pentech black	SV (black)	MV (purple)
5	Pentech blue	SV (dk. blue)	SV (purple/pink)
6	Pentech green	SV (dk. green)	WV (purple)
7	Pentech orange	SV (dk. red)	MV (purple)
8	Pentech pink	SV (red/pink)	WV (lt. blue)
9	Pentech red	SV (brown/red)	MV (purple)
10	Pentech yellow	SV (green)	MV (purple)
11	Pentech eraser	WV (purple)	...

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image. SL = strong luminescent image. ML = moderate luminescent image.

^bThe colors in parentheses are the colors that appeared under the shortwave ultraviolet light.

TABLE 8—Blue safety paper—shortwave ultraviolet results.^a

Pen	Description	Ink	Erasure
1	Adger green	SL (lt. green) ^b	ML (purple)
1a	Adger green eraser	WL (blue)	...
2	Adger orange	SL (lt. green)	SL (blue)
2a	Adger orange eraser	ML (blue)	...
3	Adger purple	ML (yellow/red)	NR
3a	Adger purple eraser	WV (blue)	...
4	Pentech black	SV (black)	WV (purple)
5	Pentech blue	SV (dk. blue)	ML (lt. blue)
6	Pentech green	SV (green)	WV (gray)
7	Pentech orange	ML (red/orange)	WV (purple)
8	Pentech pink	ML (lt. red)	WV (gray)
9	Pentech red	ML (red/orange)	NR
10	Pentech yellow	SV (red/orange)	WV (purple)
11	Pentech eraser	WV (purple)	...

^aSV = strong visible image. WV = weak visible image. SL = strong luminescent image. ML = moderate luminescent image. WL = weak luminescent image. NR = no response/no visible image.

^bThe colors in parentheses are the colors that appeared under the shortwave ultraviolet light.

TABLE 9—White bond paper—longwave ultraviolet results.^a

Pen	Description	Ink	Erasure
1	Adger green	SL (orange)	ML (yellow/blue)
1a	Adger green eraser	WV (purple)	...
2	Adger orange	SL (yellow/orange)	SL (lt. blue)
2a	Adger orange eraser	WV (purple)	...
3	Adger purple	SV (purple)	WV (lt. purple)
3a	Adger purple eraser	WV (purple)	...
4	Pentech black	SV (black)	MV (purple)
5	Pentech blue	SV (blue)	SV (dk. purple)
6	Pentech green	SV (dk. green)	MV (lt. purple)
7	Pentech orange	SV (red/brown)	SV (gray/purple)
8	Pentech pink	SV (red/pink)	WV (lt. blue)
9	Pentech red	SV (red/brown)	MV (purple)
10	Pentech yellow	SV (green)	MV (gray/purple)
11	Pentech eraser	NR	...

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image. SL = strong luminescent image. ML = moderate luminescent image. NR = no response/no visible image.

TABLE 10—Blue safety paper—longwave ultraviolet results.^a

Pen	Description	Ink	Erasure
1	Adger green	SL (yellow/green)	SL (blue)
1a	Adger green eraser	WL (blue)	...
2	Adger orange	SL (yellow/green)	SL (blue)
2a	Adger orange eraser	SL (blue)	...
3	Adger purple	ML (red/orange)	NR
3a	Adger purple eraser	WV (purple)	...
4	Pentech black	SV (black)	MV (gray)
5	Pentech blue	SV (dk. blue)	SL (lt. blue)
6	Pentech green	SV (green)	MV (gray/purple)
7	Pentech orange	SL (orange)	MV (gray)
8	Pentech pink	SL (yellow/orange)	WV (gray)
9	Pentech red	SL (orange)	MV (gray)
10	Pentech yellow	SV (red)	MV (gray/purple)
11	Pentech eraser	NR	...

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image. SL = strong luminescent image. ML = moderate luminescent image. WL = weak luminescent image. NR = no response/no visible image.

TABLE 11—White bond paper—laser results.^a

Pen	Description	Ink	Erasure
1	Adger green	MV	WV
2	Adger orange	SV	MV
3	Adger purple	SV	SV
4	Pentech black	MV	MV
5	Pentech blue	MV	MV
6	Pentech green	NR	WV
7	Pentech orange	SV	WV
8	Pentech pink	SV	MV
9	Pentech red	SV	MV
10	Pentech yellow	WV	WV

^aMV = moderate visible image. SV = strong visible image. WV = weak visible image. NR = no response/no visible image.

TABLE 12—Blue safety paper—laser results.^a

Pen	Description	Ink	Erasure
1	Adger green	WV	WV
2	Adger orange	SV	WV
3	Adger purple	SV	WV
4	Pentech black	MV	WV
5	Pentech blue	MV	MV
6	Pentech green	MV	WV
7	Pentech orange	SV	WV
8	Pentech pink	SV	MV
9	Pentech red	SV	WV
10	Pentech yellow	WV	WV

^aSV = strong visible image. MV = moderate visible image. WV = weak visible image.

TABLE 13—*pH* results.

Pen	Description	Approximate Ink pH	Approximate Erasure pH
1	Adger green	9	2
2	Adger orange	9	2
3	Adger purple	9	2
4	Pentech black	5	9
5	Pentech blue	5	9
6	Pentech green	5	9
7	Pentech orange	5	9
8	Pentech pink	5	9
9	Pentech red	5	9
10	Pentech yellow	5	9

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Address requests for reprints or additional information to
 Jeannine Zimmerman
 Aurora Police Department
 15001 E. Alameda Dr.
 Aurora, CO 80012