

## The Copying Pencil: Composition, History, and Conservation Implications<sup>1</sup>

### INTRODUCTION

Copying pencils present a significant hazard to conservators. Their markings are easily mistaken for those of standard graphite pencils, and they generally contain a dye that is water and alcohol soluble. To those unacquainted with copying pencils, their discovery might come as an unwelcome surprise during a routine wet treatment wherein copying pencil markings were mistaken for standard graphite. In order to familiarize conservators with this deceptive medium, this article describes the composition and uses of copying pencils, as well as associated conservation treatment implications. Observations resulting from tests performed on a number of copying pencil markings are described.

First introduced in the 1870's, copying pencils were developed primarily for use with the letterpress copying process. In addition, copying pencils were marketed for producing writing more indelible than that of ordinary graphite pencils. The term "copying pencil" is used here to refer generically to all copying, indelible, copying-ink, or similarly manufactured ink pencil, except where these pencil forms are specifically compared.

### COMPOSITION

Copying pencils were manufactured like standard cased pencils—a writing core composed primarily of graphite was set within a wooden sheath. (figs. 1&2) Unlike standard graphite pencils, however, copying pencils were not furnished with erasers. As with pens, a metal or plastic cap was often provided to cover the writing end when not in use. The component materials of copying pencil cores, or "leads", are graphite, clay, and a colorant. The clay typically used was kaolin, and the colorant was an aniline dye. Specific proportions of the components in copying pencil cores vary widely by manufacturer and brand. One report on the chemical analysis of 21 copying pencils suggests that the proportion of dyestuffs in copying pencil markings



Fig. 1. Assorted copying pencils

ranges from less than 25 percent to about 50 percent.<sup>2</sup> A mordant such as alumina and additional binder components such as dextrin, gum tragacanth, albumen, or wax are included in some recipes.

### Aniline Dyes

Aniline dyes are lake pigments synthetically produced from the chemical constituents of coal-tar, a product of

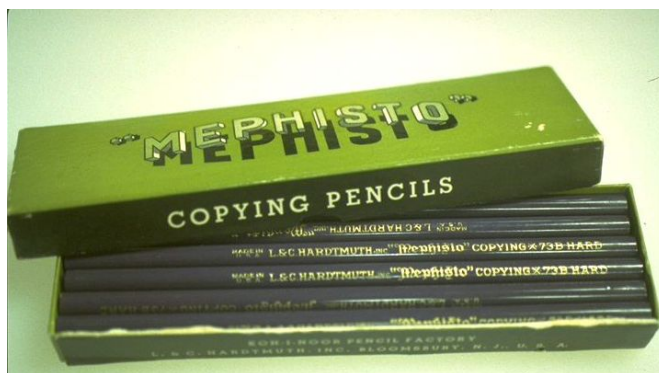


Fig. 2. Box of "Mephisto"™ copying pencils

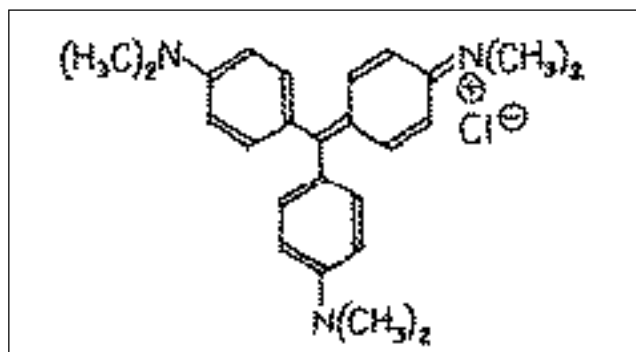


Fig. 3. Hexamethylparosaniline chloride, or crystal violet (color index no. 42555)

the distillation of soft coal. Mauvine, the first of the synthetic aniline dyes, was discovered by William Perkin in 1856. Many new aniline dyes were introduced over the next few decades, including methyl violet (1861) and methylene blue (1876), paving the way for the introduction of copying pencils in the late 1870's.<sup>3</sup> Methyl violet was the most common aniline dye used in copying pencils, though methylene blue and the other soluble blue anilines were also common.<sup>4</sup> References to other colors such as red (fuchsine), black (nigrosine), green, and a combination of dyes can also be found.<sup>5,6</sup>

Methyl violet found success as a copying ink because of its high tinctorial value and brilliant violet hue which allowed it to produce multiple strong copies. In its concentrated dry state, methyl violet appears as dark green crystals or powder and, like graphite, exhibits a metallic luster.<sup>7</sup> Methyl violet is soluble in water and alcohol. Additionally, methyl violet exhibits poor lightfastness, is vulnerable to oxidation, and is sensitive to pH shifts.



Fig. 5. Copying press

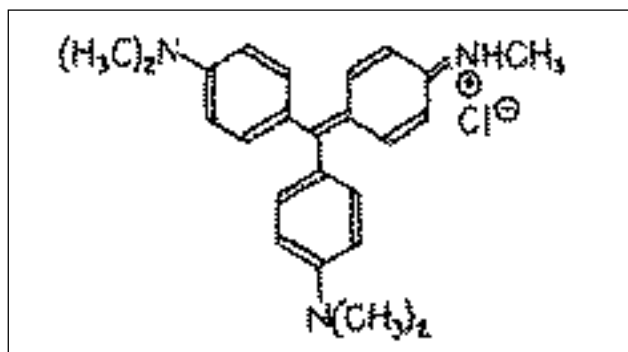


Fig. 4. Pentamethylparosaniline hydrochloride, the primary species of methyl violet 2B (color index no. 42535)

Generally speaking, methyl violet is a mixture of the tetra-, penta-, and hexamethylparosanilines.<sup>8</sup> However, the term "methyl violet" is most frequently applied to mixtures containing hexa- and pentamethylparosaniline (5 and 6 methyl groups), and often refers specifically to the hexamethyl derivative (6 methyl groups), known as *crystal violet*. Methyl violet's intensity of color is imparted by the highly conjugated organic systems which characterize its derivatives. Specific hues of methyl violet derivatives are determined by the number of methyl groups present in the molecule. The derivatives of methyl violet used as a dye include *crystal violet*, pure hexamethylparosaniline chloride, (fig. 3); *methyl violet 2B*, principally pentamethylparosaniline hydrochloride, (fig. 4); and *methyl violet 6B*, the pentamethylbenzene derivative.<sup>9</sup>

#### AS A COPYING DEVICE

The wet transfer copying process, patented in 1780 by James Watt, provided copies of documents by pressing a dampened sheet of thin tissue paper onto an original document written in special ink.<sup>10</sup> The dye component of the ink was solubilized and transferred to the moist tissue paper under pressure delivered by a copying press (fig. 5), yielding a mirror-image copy. The use of somewhat transparent

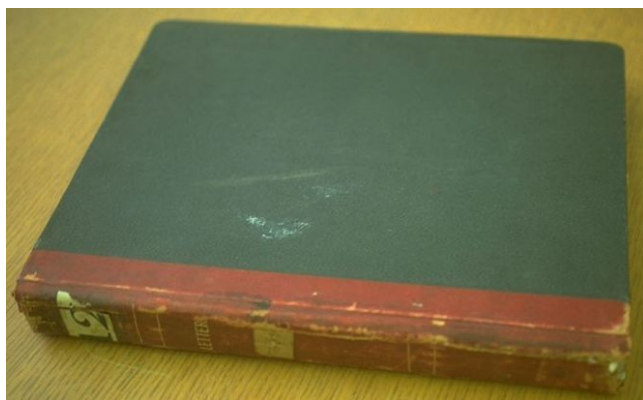


Fig. 6. Letter copying book

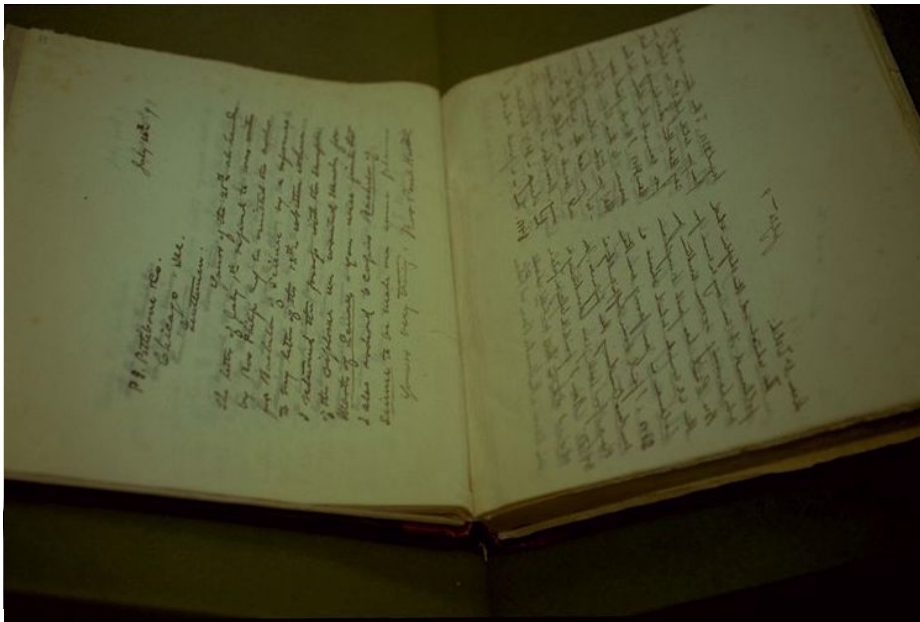


Fig. 7. Letter copying book, open

tissue paper allowed a “right-reading” copy to be viewed through the verso. By the 1870’s, letter copying books became the ubiquitous copying tool for businesses. These volumes contained hundreds of leaves of thin tissue paper, often high quality Japanese papers, bound together for the purpose of bearing copies of outgoing correspondence and other business documents. (figs. 6&7)

Copying inks employed prior to the 1870’s were traditional inks, primarily iron gallotannates and logwood inks. These were acceptable as “most inks will yield a copy if the original is pressed to a damp sheet of paper immediately after being applied, [however, traditional inks] would produce few copies before they dried and only faint images could be obtained from them after they had dried.”<sup>11</sup> The highly concentrated aniline dyes provided stronger copies than traditional inks, and “the violet coloured copy soon became characteristic of the process in its new form,”<sup>12</sup> though some letter copying books show continued use of traditional inks well into the twentieth century. Most significantly, the use of aniline dyes allowed copies to be taken long after the writing of the original document, since the writing produced from concentrate solutions of aniline dyestuffs does not undergo any material alteration on exposure to air for relatively long periods.<sup>13</sup>

Copying pencil markings which have been employed in the wet transfer process, either on the original document or the duplicate, are readily identified. (fig. 8) Because the dye has been solubilized, markings are no longer visually similar to standard graphite. These markings are characterized by feathered edges and a pronounced color, usually violet or blue. Having been made from a pencil, however, the markings are wider than those typical of pens. Markings on the original document also contain graphite in addition to the solubilized dye.

Copying pencils were also used with two other copying processes: the hectograph (developed around

1880) and the spirit duplicator (developed in 1923). This variation of copying pencils was called a “hectographic pencil” and was produced in formulations containing a fairly high proportion of dye; some had little to no graphite.<sup>14</sup>

#### AS AN INDELIBLE PENCIL

Prior to the introduction of copying pencils, the term “indelible pencil” referred to pencils with silver nitrate-based formulations introduced in the late 1850’s. Early

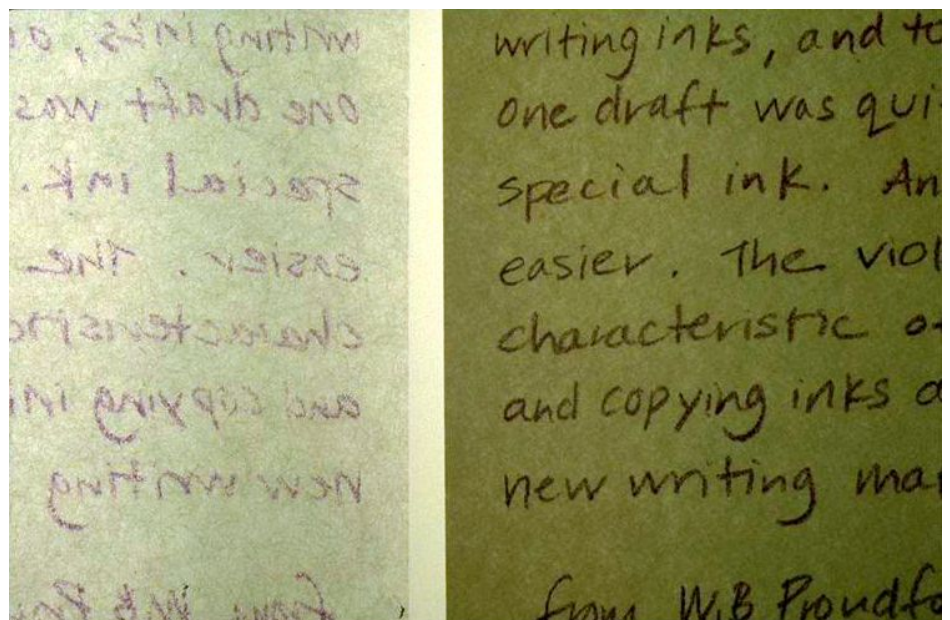


Fig. 8. Detail of an original document (right) and copy (left) produced by the author using the wet transfer method, photographed in transmitted light



Fig. 9. A copying pencil, an indelible pencil, and an indelible-copying pencil

copying pencil patents, however, indicate that they were also initially conceived for use as indelible pencils—a use which ultimately predominated. One 1877 patent for a copying pencil describes its usefulness as an “ordinary lead pencil...but more permanent, as the marks cannot be erased with rubber.”<sup>15</sup> The terminology of copying and indelible pencils is inconsistent and overlapping. Pencils with similar compositions and characteristics were marketed as copying pencils, indelible pencils, and as both copying and indelible. (fig. 9) The terms copying and indelible became largely interchangeable, and indelible seems to have become the preferred term.

The convenience of copying pencils prior to the introduction of ball-point pens was widely appreciated. In 1916, Mitchell observes that “at the present time [copying pencils] are but seldom employed for copying purposes, but are commonly used for producing writing which cannot be erased so readily as the marks of a lead pencil.”<sup>16</sup> In many ways, these pencils can be viewed as a predecessor to the ball-point pen. They were convenient (no need to continually dip one's pen into the ink well), provided firm pressure (superior to fountain pens of the time), and generated relatively permanent markings. Their usefulness is demonstrated by the wide range of applications to which they were enlisted.

Copying pencils were called to serve in WW1, when “Great Britain was buying thousands of American copying pencils per week...[It] was conjectured that the pencils were being distributed to British and Allied officers for use in completing the vast paperwork associated with the war effort and in the field, where the nonerasable qualities of indelible pencils made them much more convenient than pen and ink.”<sup>17</sup> Further confusing terminology, copying pencils appear to have been referred to, at least casually, by different names relating to particular functions. For example, copying pencils were commonly used by railroad companies as indelible pencils and have been referred to as “railroad pencils”.

Copying pencils were also widely used in conjunction with carbon papers to make duplicate copies of documents.

The first carbon paper, a double-sided variety, was introduced by Ralph Wedgewood in 1806<sup>18</sup> and the modern single-sided variety was developed in the 1820's.<sup>19</sup> When copying pencils were introduced in the 1870's, they provided a natural accompaniment to carbon papers, adding another function to the list, that of “manifolding pencil.” The term “manifold” was generally used to refer to the hard variety of copying pencils used for making copies through carbon paper.<sup>20</sup> Concurrently, carbon papers were becoming less greasy and easier to write on, and before the turn of the century there was a specific grade of paper designated as “pencil carbon” paper.<sup>21</sup> As pencils, copying pencils were more convenient and provided better pressure than the steel pens of the nineteenth century or the early fountain pens introduced in the 1880's, enabling the production of simultaneous multiple strong copies. Unlike ordinary graphite pencils, however, they provided an indelible original. Eventually ball-point pens would prove superior in this area, but not until they were successfully refined in the 1930's. Early attempts at marketing oil based ball-point pens beginning in 1888 were not successful because the inks were not fully compatible with the ball-point pen mechanism and resulted in sloppy writing. These early ball-points were described by one top executive of a writing instrument company as “the only pen that will make eight carbons and no original.”<sup>22</sup> Copying pencils could provide both adequate pressure for multiple copies and clean writing for an indelible, legible original.

#### ARTIFACTUAL EVIDENCE IN OUR COLLECTIONS

Given the variety of applications to which copying pencils were employed, it is not surprising that they have found their way into the homes and offices of many people, including business persons, writers, and artists. The author has found a number of copying pencils assimilated within piles of ordinary graphite pencils in antique and junk shops. Because of the similarity of copying pencils and their markings to standard graphite pencils, copying pencils have been employed in areas well beyond their intended uses. Their markings have been found on a wide variety of collection materials, including archival manuscripts and works of art where the conveyed “indelibility” may or may not have been deliberate. Examples include the “drawings of artists working in the first half of this century, notably Stanley Spencer, Graham Sutherland and Walter Sickert.”<sup>23</sup> Often, both copying pencil and ordinary graphite pencil markings can exist indistinguishably side-by-side on the same item, as on this bookseller's card from 1929. (fig. 10).

#### TEST PROTOCOL

Tests were performed to assess the effects of various treatments on copying pencil markings. A sample group of

copying pencil markings was created and subjected to various treatment conditions including solvent baths (water, ethanol, acetone, and toluene), humidification, and vigorous erasure.

Eight test strips of 80 lb. white Mohawk Superfine text paper were prepared, each with thirteen markings from the following copying and graphite pencils: (1) *Dixon Eldorado Indelible Copying 201 Medium*, (2) *Dixon Intenso Intense Copying 2074*, (3) *Venus Copying 171*, (4) *Mephisto Copying 73B Hard*, (5) *Mephisto Copying No. 77*, (6) *Manifold Eagle Copying 853*, (7) *Ditto Intense Purple 1002*, (8) *J.S. Staedtler "Approved" Copying No. 664*, (9) *American Pencil Co. Copying 171 no.3 Medium*, (10) *General Pencil Co. Copying No. 577 Hard*, (11) *"Friendliness is a Milwaukee Road Tradition" Indelible Medium*, (12) *Eberhard Faber Noblot Ink Pencil 705* (modern), and (13) *Faber-Castell American No. 2* (modern graphite pencil). Although most of these pencils are historic examples, the markings were newly created for the test and were not artificially aged. Test results, therefore, may not be consistent with naturally aged artifacts on which copying pencil markings have interacted over time with the substrate, moisture from the atmosphere, adjacent materials, mechanical pressure or abrasion, and other environmental factors.

Specific test conditions for the eight sample strips were as follows: (a) control, no treatment; (b) toluene bath, 5 minutes; (c) acetone bath, 5 minutes; (d) ethanol bath, 5 minutes; (e) water bath, 5 minutes; (f) humidification chamber, 1 hour; (g) Faber-Castell® no. 7092 vinyl eraser, vigorous erasing; and (h) Faber-Castell® Design ArtGum® eraser, vigorous erasing.

## OBSERVATIONS

The variety of manufacturers and brands represented in this test provided a range of results. (fig. 11) While copying pencil markings were found to vary in both their original appearance and in their reaction to treatment conditions, some identifying common features of copying pencils versus standard graphite pencils were clearly observed.

The appearances of the 13 markings, prior to treatment, were quite varied. Most of the markings on the control strip were not visually distinguishable from graphite, with two notable exceptions—Dixon's Intenso and Ditto Intense Purple (nos. 2&7), which resemble purple colored pencil

markings. Given its name and bold purple color, the Ditto Intense Purple is probably a hectographic pencil intended for use with a spirit duplicator. Of the markings resembling graphite to the naked eye, several exhibit a violet metallic sheen under magnification. This is not a recommended method of identification, however, because the sheen varies from pencil to pencil, is very subtle, and can be confused with the metallic luster of graphite, which itself varies widely among historic and modern graphite pencils.

The wet test conditions (b-f) produced varied results. As expected, the graphite sample (no.13) was not visibly affected by any of the wet test conditions. The copying pencil samples exhibited widely differing responses to the seven test conditions. Individual differences between copying pencils were ignored and the "average" response to the different wet treatment conditions were noted. The responses were ranked according to extent of visual disturbance to the media following treatment. The results, from most to least disturbance, are: water bath, humidification, toluene bath, acetone bath, and ethanol bath.

The low visual disturbance of ethanol was surprising, since methyl violet is highly soluble in ethanol. During testing, the dye component of the copying pencil markings appeared to be thoroughly solubilized and rinsed from the paper into the solvent bath, in all cases except the two markings which appeared "colored" prior to testing (nos. 2&7). Excepting these two outliers, the visual change resulting from the ethanol wash was very subtle. Following testing, the copying pencil markings appear slightly lighter and more matte in color when compared with the control group.

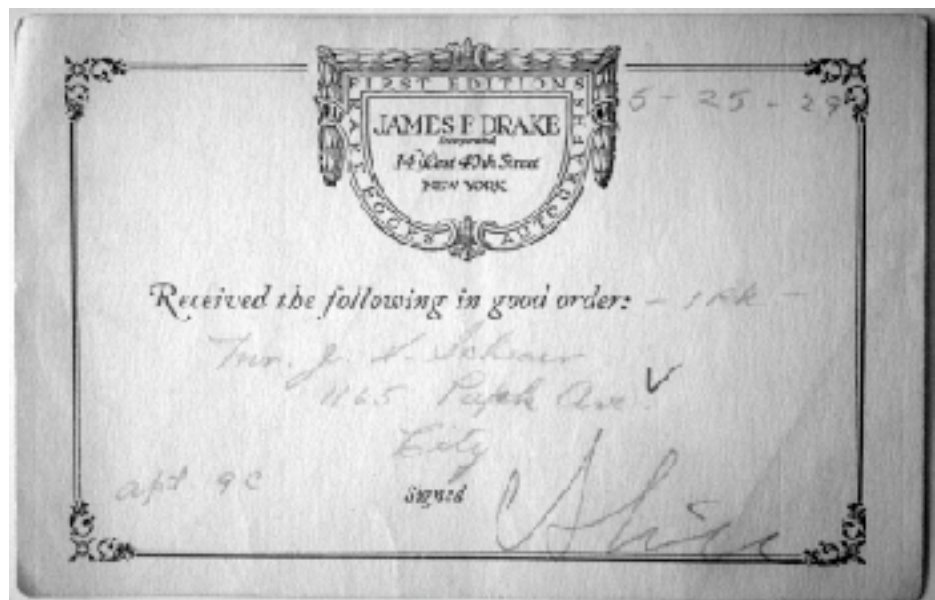


Fig. 10. Bookseller's card: signature was written with a standard graphite pencil, while the remaining "pencil" markings are copying pencil

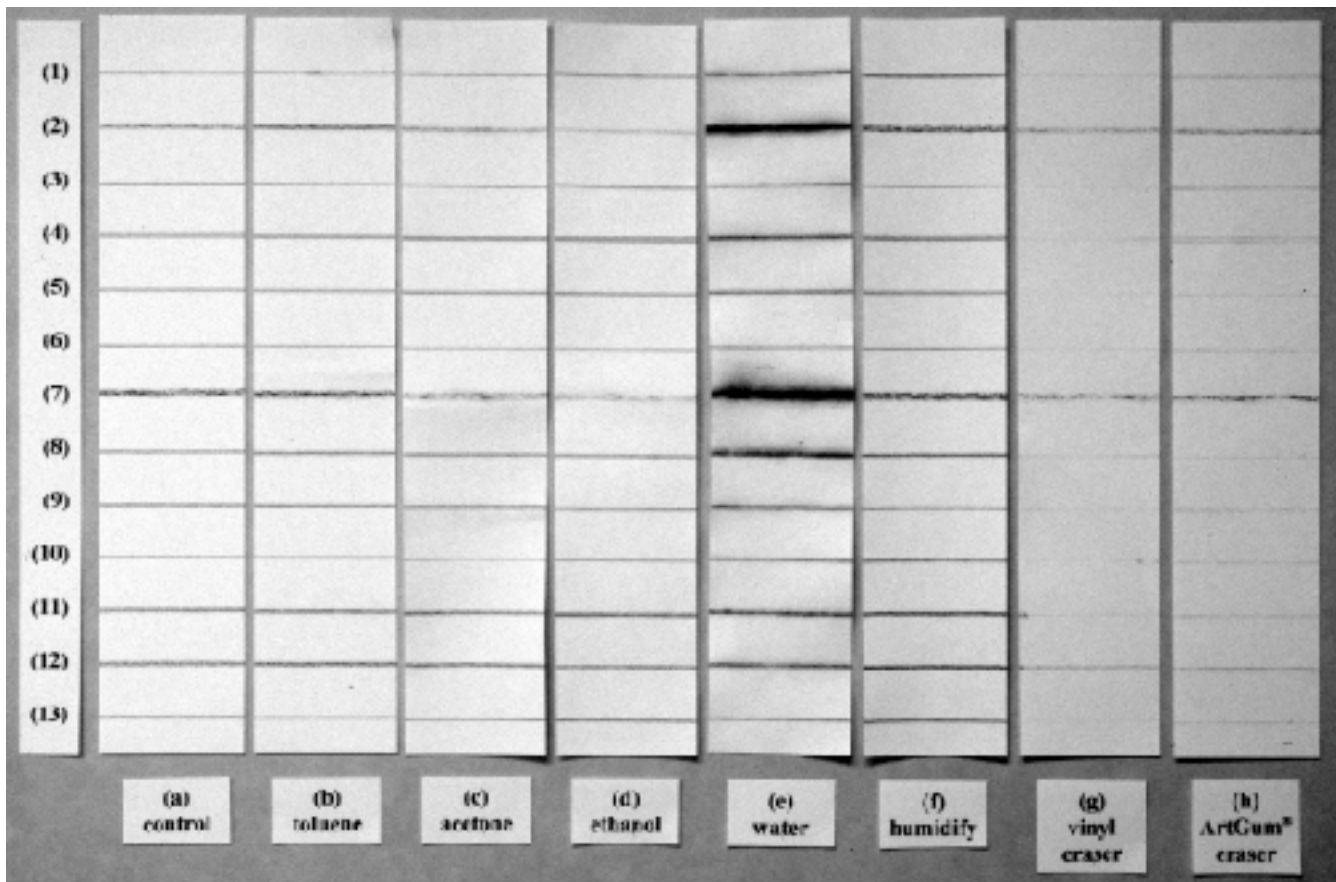


Fig. 11. Eight test strips following testing

The most dramatic visual disturbance to the copying pencil markings was created by the water bath. All of the copying pencil markings were severely disfigured when the dyestuff became soluble and spread outward from the original marking, staining the paper substrate. Some of the dyestuff rinsed out of the paper during washing, but much remained in the paper.

Surprisingly, humidification produced the second most dramatic results. The colored dyestuff was solubilized sufficiently to cause all of the twelve copying pencil markings to exhibit a pronounced purple or blue hue. Following humidification, ten of the twelve resemble colored pencil markings, while two of the twelve exhibit only slight color shifting—the hint of purple noticeable when visually compared to the control.

Results of acetone washing were similar to that of ethanol, except less of the dyestuff was completely solubilized into the solvent bath. Following testing, the copying pencil markings retained a slightly darker tone than that caused by ethanol, with half of the markings exhibiting a purple or bluish hue.

Unlike the other solvents, toluene appeared to have little effect on the markings during treatment. Upon drying, however, a strong color shift was visible. The resultant

change in the markings was comparable to that of humidification, but less intense. Though toluene appeared less damaging than ethanol and acetone during the solvent bath, the media exhibited more visual disfiguration following treatment.

#### COPYING VERSUS INDELIBLE

The relative indelibility of copying, indelible, and standard graphite pencils was also explored. Previous casual observation revealed that some copying pencil markings seem to be erased as easily as ordinary graphite pencil markings. One study of copying pencils noted that the use of the term “indelible pencil is only relatively correct.”<sup>24</sup> Because the aniline dye in dry copying pencil markings is embedded within the graphite and clay on the surface of the paper fibers, mechanical erasure is generally quite successful at reducing much of the dye along with the graphite and clay. The indelibility conveyed by dry copying pencil markings is due to the dyeing of the fibers of the paper incurred by the rubbing action of mechanical erasure. This indelibility is further intensified by dampening or exposure to humid environments.<sup>25</sup>

Two eraser tests were conducted, using a white vinyl Faber-Castell® 7092 eraser and a Faber-Castell® Design Artgum® eraser. The Artgum® eraser was chosen because it resembles historical “rubber” erasers. As anticipated, the vinyl eraser was slightly more effective at reducing the markings, but the overall results from the two erasers were very similar. The markings from the two outlier copying pencils (nos. 2&7), exhibited the least change and retained a relatively strong purple marking after erasure. The modern ink pencil (no. 12) also retained a relatively strong (blue) marking following erasure. The remainder of the copying and indelible pencil markings were very similar in their responses to erasure—they became quite faint, and at least one of the remaining markings (no.3) was no more visible than that of the very faint remaining graphite marking. Except for the modern ink pencil, there were no notable differences between the erasability of copying pencils and that of indelible pencils. In fact, at least two of the copying pencils (nos. 4&7) were harder to erase than the so-called “indelibles” (nos. 1&11).

## CONCLUSION

The markings of copying pencils are often visually indistinguishable from those of standard graphite pencils. Even for a trained conservator with acute visual perception and high-powered tools of magnification, careful visual inspection is often insufficient to detect the soluble dye component embedded within the graphite and clay. Visual detection is further confounded because the insolubilized aniline dye can actually resemble graphite—in its dry state, methyl violet exhibits a metallic luster.

This study offers general observations on the effects of various treatments on copying pencil marks. Because the majority of copying pencil markings tested produced similar results, the minor differences between individual copying pencil markings are not described. In contemplating the varying degrees of solubility of copying pencil markings, one might presume that increased solubility would be caused by a higher proportion of dyestuff in a pencil’s core. Solubility, however, appears to be connected more with the presence of a mordant in the pencil core. One study notes that when the mordant alumina (aluminum hydrate) was present in quantity, the solubility of the dyestuff was significantly reduced.<sup>26</sup>

The aniline dye component of copying pencils is visibly altered to varying degrees by a number of routine conservation treatments. Fortunately, an awareness of the possible use of copying pencils, combined with sensible testing procedures, can help prevent treatment mishaps. Specifically, rigorous testing of pencil markings on artifactually valuable materials prior to any wet treatment is critical. Since copying pencil and regular graphite can be

found together on a single item, testing should also be redundant. For training purposes, conservators may find it useful to have a copying pencil on hand. A readily available modern version of copying pencil, Eberhard Faber’s Noblot Ink Pencil 705, provides a convenient alternative to antiquing in search of a historic specimen.<sup>27</sup>

In the event that copying pencil markings unexpectedly solubilize during conservation treatment, there may be a number of alternatives for reducing the disfiguring effects. Ethanol might prove useful, since it was found to completely solubilize the dyestuff, leaving no traces of dye stains on the paper substrate. Since aniline dyes are highly fugitive, light bleaching might also be effective at reducing the visual disturbance of a dye stain. Exposure to ultraviolet radiation can oxidize the chromogenic aniline dyestuff, breaking double bonds and causing a reduction of the color-producing conjugated system. Although buffer solutions were not considered in this study, at least one conservator has noted that “since methyl violet and methylene blue are pH sensitive, the disfiguring aspects of a bleeding dye may be minimized by locally applying a buffered solution.”<sup>28</sup>

## ACKNOWLEDGMENTS

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## NOTES

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26. Mitchell, "Copying-Ink Pencils," 6.
27. Eberhard Faber's *Noblot Ink Pencil 705* is available from *Crafts Galore*, 780 Ocean Beach Hwy, Longview, WA 98632, phone: (360)501-6562, email: [craftsgalore@tdn.com](mailto:craftsgalore@tdn.com), internet: <http://www.craftsgalore.com/>. A dozen pencils, item FAB-14430, retail for \$7.29.
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