
POSTPRINTS



Presented at the 30th Annual Meeting
of the
American Institute for Conservation
Miami, Florida



JUNE 2002

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FIG. 11 A 1935 Photograph of Jean Dunand demonstrating with a blow torch the fire resistance of a lacquered table, cast from a gypsum based material containing *urushi*.

JEAN DUNAND—A FRENCH ART DÉCO ARTIST WORKING WITH ASIAN LACQUER

Mechthild Baumeister



Jean Dunand was one of the most renowned French Art Déco artists, creating lacquer furniture and decorative objects that exemplified the sophisticated taste of his time. His innovative combination of traditional Oriental lacquer techniques with contemporary forms and abstract decorative designs established his international success.

Dunand's development as a lacquer artist is remarkable, especially considering that he was one of the first western artists to work with *urushi*, which is the Japanese word for both the tree sap that is the basis of Asian lacquer and the finished product itself. Urushi is derived from sap obtained through incisions in the bark of several species of trees in the *Anacardiaceae* family, genus *Rhus*. *Rhus vernicifera* is mainly used in China, Japan, and Korea to produce raw lacquer, while *Rhus succedanea* is the source for *urushi* in Vietnam and Taiwan. Raw *urushi* is an emulsion with the main component—approximately 60–65% by weight—being urushiol, laccol or thitsiol, depending on the species. It contains also 20–30% water, 5–7% polysaccharides, 2–3% glycoproteins, and around 1% laccase. The raw *urushi* is refined by filtering and stirring, which reduces the water content and produces a more homogeneous, brownish-black lacquer. Compared to other varnishes and paint media, *urushi* is much harder and more resistant to water and organic solvents. While natural gums and resins usually set up in dry conditions, *urushi* requires a relative humidity of 65–80% to cure. The polymerization is initiated by the enzyme laccase in the presence of water.

Born on May 20, 1877 in Lancy, Switzerland, Dunand started his artistic training at the age of 14 at the École des Arts Industriels in Geneva, completing his studies in 1896 with a degree in sculpture and design.¹ The city of Geneva granted the talented young artist a stipend to continue his training in Paris, where he studied with the Art Nouveau sculptor Jean Dampé. Under the influence of Dampé, who believed that a sculptor should also be a good craftsman, Dunand spent his summer vacations working with a Geneva coppersmith as an apprentice. There he learned the traditional metalworking techniques for making household wares of hand-beaten copper and brass, known as *dinanderie*.² Although Dunand found success as a sculptor, participating in major exhibitions, such as the Exposition Universelle 1900 in Paris, commissions for carved furniture and decorative interiors on which he collaborated demonstrated to him the economic advantages of the applied arts. Consequently, he focused his energy on decorative metalwork and established himself as a *dinandier*. It was in this context that he first experimented with coatings which would inhibit corrosion. He noticed that the Japanese metal vases sent to his workshop for restoration had coatings that were not only protective but added a decorative element to the surface. Fascinated by Oriental lacquer techniques and eager to apply lacquer to his own metal wares, Dunand invited several Parisian specialists to his studio to learn from them the secret of lacquer work. He was astonished

by their lack of knowledge and considered them mere “varnishers.”³ Pursuing his keen interest in this matter, he contacted the Japanese lacquer artist Seizo Sugawara, who himself was interested in Dunand’s metalworking techniques. They agreed to exchange their workshop secrets.

Seizo Sugawara came from the small village of Johoji in the north of Japan, which is famous for its lacquerware. In 1900, he arrived in Paris as part of the Japanese national delegation to the Exposition Universelle to oversee the lacquerware sent from Japan.⁴ Sugawara decided to settle in Paris, where he became an important figure in the art scene, teaching western artists the Oriental lacquer technique. Dunand and the Irish artist Eileen Gray were his most prominent students.

The thirteen lessons Dunand received from Sugawara in 1912 are documented in Dunand’s notebook.⁵ There he recorded descriptions for preparing the lacquer, the tools and necessary materials, working procedures, and various decorative techniques, including their Japanese names. The interpretation of Dunand’s notes, especially the Japanese terminology, is made easier through consultation of extensive documentation compiled by Johannes Justus Rein and John James Quin, who independently studied traditional lacquer techniques in Japan in the late 19th century.⁶ Working on behalf of the Prussian government, Rein presented one hundred sample boards and an accompanying report to the Königliche Kunstgewerbemuseum in Berlin in 1874.⁷ Quin was commissioned by the British government to collect specimens and tools for the new Museum of Economic Botany at the Royal Botanic Gardens in Kew. By 1882 he had assembled a study collection of 170 items, including raw materials and tools, sample boards, and objects demonstrating all stages of lacquering and various decorative techniques, as well as finished lacquerware.⁸ Both reports describe in detail the cultivation of the lacquer tree *Rhus vernicifera*, the extraction of the tree’s sap, the refining of the lacquer, the lacquering procedure, and traditional techniques of decoration.⁹

Dunand’s notes and the sample boards he made during the lessons with Seizo Sugawara reflect traditional Japanese lacquer techniques. *Sessimé*, the type of *urushi* most frequently mentioned by Dunand, is a purified, filtered, evenly flowing, raw lacquer, obtained from the tree trunk.¹⁰ Dunand describes *nashizi* as a high-grade transparent lacquer and *schuaye* as a lacquer containing oil that was used for “ordinary and colored lacquerware.”¹¹ Dunand mentions the application of heat and the addition of camphor for thinning lacquer and glycerin to thicken it.

The wooden sample boards made by Dunand while he studied with Sugawara demonstrate a thirty-step process for producing a black lacquer surface (figs. 1 & 2). First, the wooden surface is sealed with *sessimé*, and then a mixture of *urushi*, rice starch, and chopped hemp or cotton fibers, known as *kokuso* and referred to by Dunand as *kekso*, is applied to even out any irregularities.¹² Another layer of *urushi* is applied and then a piece of hemp cloth, adhered with a paste of rice starch and *urushi*, called *ita* by Dunand.¹³ Seven increasingly-fine foundation layers of *kiriko*, *dzinoko*, and *sabi*, which are mixtures in varying proportions of coarsely and finely ground clays, water, and *urushi*, are then applied.¹⁴ The black surface is produced with three layers of black *louero* finished with two coatings of transparent *sessimé*. Between each application, the layer was allowed to cure and was then ground or polished with stone, charcoal, finely ground clay, or powdered, calcined deer antler, with or without a lubricant such as water or oil.¹⁵ That Sugawara must have emphasized the importance of this procedure to Dunand is indicated by a comment in the notebook: “Lacquerers who do not know very well how to polish and smooth lacquer with charcoal are called camels, because a camel has two humps, similar to badly polished lacquer.”¹⁶

Dunand describes the *louero* lacquer, called *ro-iro urushi* in Rein’s terminology, as a black lacquer of the highest quality. It is obtained through a reaction of *urushi* with iron. A solution of iron filings in vinegar is added to *sessimé* and then

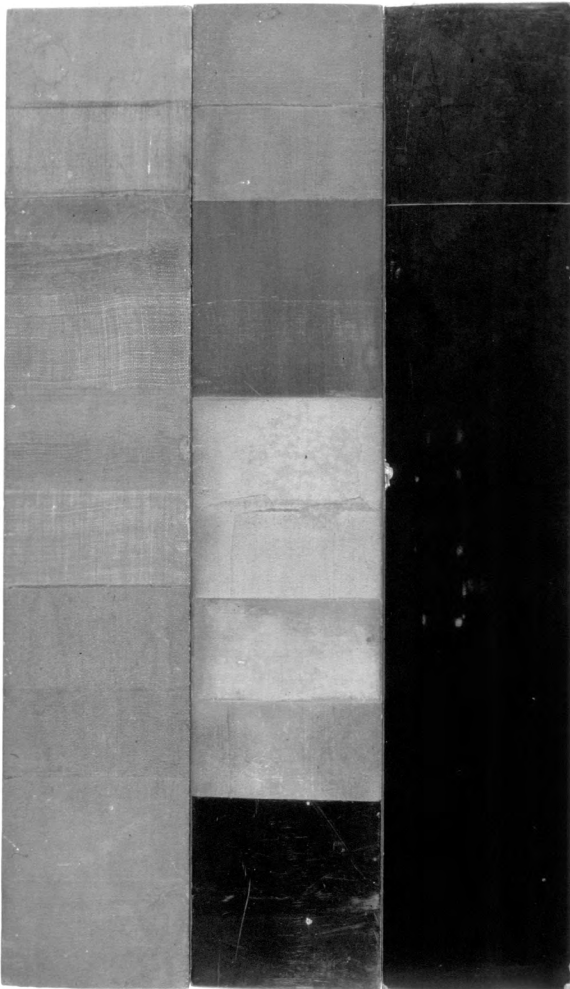


FIG. 1 Sample boards produced by Dunand during his lessons with Sugawara in 1912.

the mixture is heated and filtered.¹⁷ Additionally, Dunand mentions *yuyen*, a *nashizi* lacquer mixed with lamp black, and a lower grade *jôhana* lacquer, which contains oil and is blackened with iron powder. Dunand pointed out that lacquers containing oils, such as *schuaye* and *jôhana*, used for ordinary lacquer articles are never polished.¹⁸ For colored lacquers various pigments are added, vermilion (*schu*) and iron-oxide (*benigara*) for red lacquer, cadmium and chrome yellows for yellow lacquer, and Prussian blue for blue lacquer. Green lacquer is obtained either with a mixture of yellow and blue pigments, or with chromium oxide. Brown is achieved by mixing red *schu* and black *jôhana* lacquer. Barium sulfate, and lead and zinc whites are used as white colorants.

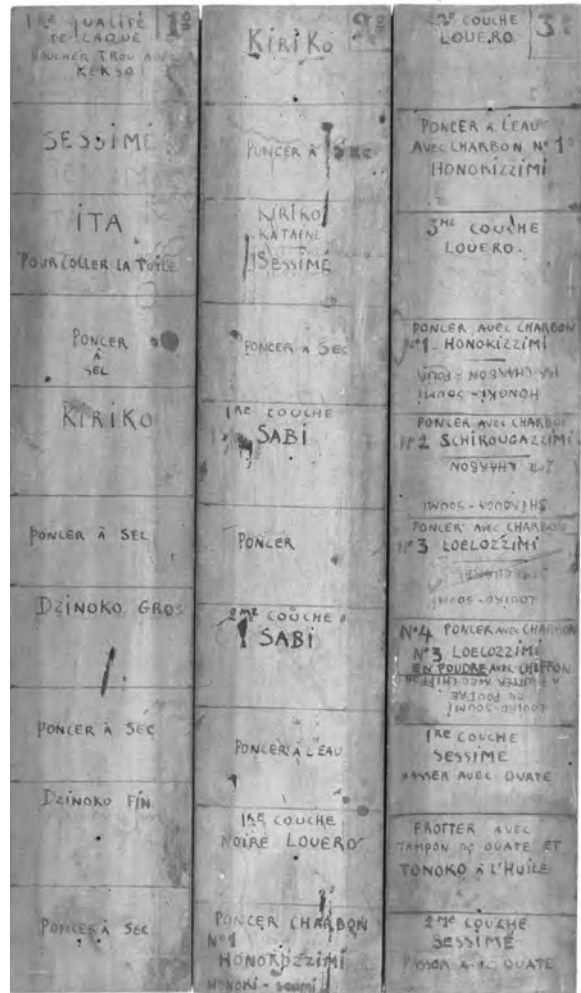


FIG. 2 Backside of sample boards listing the thirty steps for producing a black lacquer surface.

Sugawara also taught Dunand the application of gold lacquers, which incorporate metal leaf and powder, as well as other decorative techniques. Dunand noted the importance of a dust-free environment for the drying of lacquer. He also mentions that freshly lacquered objects must be placed in an “armoire,” without indicating that a high relative humidity must be maintained inside in order for the lacquer to cure. The use of *sessimé* on metal was specifically addressed and special mention was made of the fact that the lacquer applied to metal can be hardened in an oven at temperatures of 100–180°C.¹⁹

The lessons took place over a brief period of two months.²⁰ They provided Dunand with a basic

introduction to Japanese lacquer techniques, leaving this immensely talented craftsman with a new obsession. Dunand continued to experiment on his own and after World War I he installed a lacquer studio in his workshop, located in the Rue Hallé in the fourteenth *arrondissement* in Paris. He obtained *urushi* from the French colonies in Indochina, and most of the craftsmen in his studio who helped him with the lacquer work were Indochinese. In a magazine interview of the early 1920s Dunand explained that he favored Asian assistants because they were experienced in working with lacquer and not susceptible to the allergic reaction to *urushi* common among Europeans.²¹ Lacquer had become the dominant element in Dunand's artistic *oeuvre* in the 1920s and 1930s, his most successful and creative period.²² René Gimbel, a Paris-based art dealer who visited Dunand in his studio on June 8, 1920, copied into his diary Dunand's description of lacquer:

“Of course there are some art forms which are merely a matter of patience, like the lacquer which I love so much! Just look, and think how much work goes into preparing this stuff and making it. Here you have some trial attempts. On these tablets you can see the various stages of preparation. At the bottom, the first layer of lacquer, then comes the second, and at the top the twentieth. So you have to varnish or paint twenty times—or rather forty, as the job has to be repeated on the other side to keep the wood from warping; otherwise it would crack, for you wouldn't believe how easily the lacquer can twist even the hardest wood into a semicircle. Actually, not forty but as many as a hundred preparations are required, since after varnishing you have to polish and before each varnishing there have to be twenty seasonings, each lasting four days. It'll surprise you to learn that the seasonings require damp conditions, and a dark room where water flows continuously, and that success is more certain at the full moon. So you'll understand that it's positively Oriental labor!”²³

With his lacquerware, Dunand combined traditional Asian methods of manufacture with modern Art Déco designs and bold color schemes. Always searching for new applications and expanding the repertoire of his techniques, he used lacquer to embellish furniture, wall panels, paintings, metal vases, jewelry, and textiles. His extraordinary creativity and tremendous stamina led to an enormous production of lacquerware in his workshop.

Dunand participated in the important art exhibitions of his time. His work was widely shown throughout Europe and the United States, where it was acquired by major museums. In 1998, the Metropolitan Museum of Art mounted a small Jean Dunand exhibition showing works drawn mainly from its own collection.²⁴ This exhibition provided a welcome opportunity to study Dunand's lacquer techniques.

One of the most impressive interiors by Dunand was completed in 1928 for the San Francisco penthouse of Templeton Crocker, the wealthy grandson of the founder of the Union Pacific railroad company. Crocker's attention was drawn to Dunand's lacquer work by two exhibitions of contemporary French design displayed in the mid-twenties in San Francisco. He commissioned a master bedroom, a dining room, and a breakfast room, all to be decorated with lacquer.²⁵ The bedroom walls, originally decorated with lacquered panels depicting a forest landscape, are now lost, while the bedroom furniture is in the collection of the Metropolitan Museum (fig. 3).²⁶

The lacquered surfaces on the furniture mainly feature a technique favored in Dunand's workshop, *laque arrachée*, whereby the lacquer was lifted with a flat wooden spatula to create an uneven surface. In this case, the *laque arrachée* consists of a black *louero* lacquer applied to several ground layers.²⁷ After drying, the surface was lightly smoothed and a silver-gray lacquer was applied over the black layer. The color and metallic appearance of this layer were obtained by adding aluminum filings mixed with titanium-white and cadmium-yellow pigments to the lacquer.²⁸ Polishing the surface

FIG. 3 Photograph of bedroom by Dunand made for Templeton Crocker in 1928. The photograph was taken in Paris in 1928, before the room was shipped to San Francisco.



T. Bonney

revealed the raised areas of black lacquer within the silver-gray layer, resulting in a mottled effect (fig. 4). Black lacquer and silver leaf that juxtapose the colors of the mottled lacquer on a different scale accentuate the angular forms of the furniture. The analysis of samples from the black and silver-gray lacquers indicates the presence of laccol, the major component in *urushi* derived from *Rhus succedanea*, the lac tree native to Vietnam and Taiwan.²⁹ These results confirm documentary evidence that Dunand obtained *urushi* from the French colonies in Indochina.

Laque arrachée is the final surface decoration on a series of pictorial wall panels entitled “Les peuples d’Asie et d’Afrique,” which Dunand made for the 1931 Exposition Coloniale in Paris (figs. 5 & 6).³⁰ In this case, the uneven texture of the matte brown *laque arrachée* creates a striking contrast with the smooth, silver-leafed background. Instructions associated with a *laque arrachée* sample board made in Dunand’s workshop in 1931 describe the technique as follows: “On a cured lacquer with gold leaf apply a coat of *laque arrachée* mixed with clay and draw the design in the freshly applied lacquer. After drying sand lightly with fine sandpaper.”³¹

More elaborate is Dunand’s lacquer decoration on a pair of screens “Pianissimo” and “Fortissimo,” which were made for the music salon of Mr. and Mrs. Solomon R. Guggenheim’s residence in Port Washington, NY (fig. 7).³² Fabricated in 1925–26, the screens are signed by Dunand and his collaborator on this project, the sculptor Seraphin Soudbinine. The latter was most likely responsible for the overall design, as well as for carving the relief



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FIG. 4 Detail of the mottled lacquer from the bedroom furniture, showing black *laque arrachée* filled with a silver-gray lacquer juxtaposed with black lacquer.



FIG. 5 Wall panel from the series “Les peuples d’Asie et d’Afrique,” 1931, Musée des Arts d’Afrique et d’Océanie, Paris.

figures of the angels and the angular rocks. The angels are decorated with an unusual gilding technique; smooth and wrinkled sheets of gold leaf, all of the same composition, were applied side-by-side to a red vermilion lacquer.³³ The smooth leaf is shiny and appears lighter in color than the textured, matte surfaces of the wrinkled leaf. Further gradations in color were obtained through the selective application of a coating to areas of wrinkled leaf which were intended to appear even darker.³⁴ The marbling of the towering rocks was achieved through a complex layering which is vis-

ible in the cross section of a sample taken from an illuminated side of a rock (fig. 8). Black *louero* lacquer was used as the surface for the side of the rock in shadow, and also appears as the darkest color in the marbling. A brown, pigmented layer was applied unevenly to the black lacquer and covered with fragments of gold leaf. The irregularities were then filled with a transparent lacquer and the surface was polished until the marbled appearance desired was obtained. Eggshell fragments embedded in lacquer were used to produce a white surface, an effect difficult to achieve with pigments due to the inherently dark color of *urushi*. On the screens, crushed eggshells were applied to the gold lacquer surface of the angels’ draperies and also combined with mother-of-pearl particles to represent spiraling clouds within the dark blue-green background.³⁵

The use of crushed eggshells to cover large surfaces is a technique first introduced by Dunand that became a specialty of his workshop. Depending on the effect intended, shell fragments were crushed and placed on freshly applied lacquer with either their convex or concave side facing up. In the latter case, the cavities were subsequently filled with lacquer and after polishing only the white edges of the shells are exposed. In the former, the relationship between the materials is reversed, and white patches of eggshell are outlined by the contrast-



FIG. 6 Detail of wall panel from the series “Les peuples d’Asie et d’Afrique,” Musée des Arts d’Afrique et d’Océanie, Paris, showing the use of matte brown *laque arrachée* as surface decoration.



FIG. 7 “Fortissimo” screen by Jean Dunand and Seraphin Soudbinine made in 1925–26 for Mr. and Mrs. Solomon R. Guggenheim. The Metropolitan Museum of Art, Gift of Mrs. Solomon R. Guggenheim, 1950 (50.102.4).

ing lacquer. The alternating squares covering the table top, drop-leaves and shelf of a table made by Dunand around 1925, are executed with juxtaposed fields of shell fragments, with their convex or concave side facing up (figs. 9 & 10). Microscopic examination under ultraviolet light of a cross section of an eggshell particle with its concave side facing up revealed that the smoothed surface received a final coating of transparent *urushi*.³⁶ Dunand’s eggshell lacquer became so popular that he maintained a chicken coop in the courtyard of his workshop to guarantee a steady supply of eggs. In order to create different shadings and color contrasts, Dunand also incorporated into his lacquer crushed eggshells of ducks, partridges, and exotic birds.

In a similar way, Dunand experimented with embedding dried lacquer flakes in freshly applied lacquers, generally of a different color. The lacquer flakes were obtained by applying a layer of a col-

ored lacquer to a sheet of paper and heating it in an oven. After removing the paper, the dried lacquer was broken into pieces.³⁷ Sieves with different gauge meshes were used to separate different particle sizes. Dried lacquer flakes were also ground to produce a powder, which could be sprinkled onto freshly-applied lacquer surfaces.

Coromandel lacquer technique was also frequently used in the Dunand workshop. Typically the lacquered surface was engraved and the incised designs revealed ground layers, which were either left exposed or were covered with colored lacquers. This technique was mainly applied to screens and wall panels, because coromandel lacquer is a relatively simple technique which is useful for quickly decorating large surfaces.

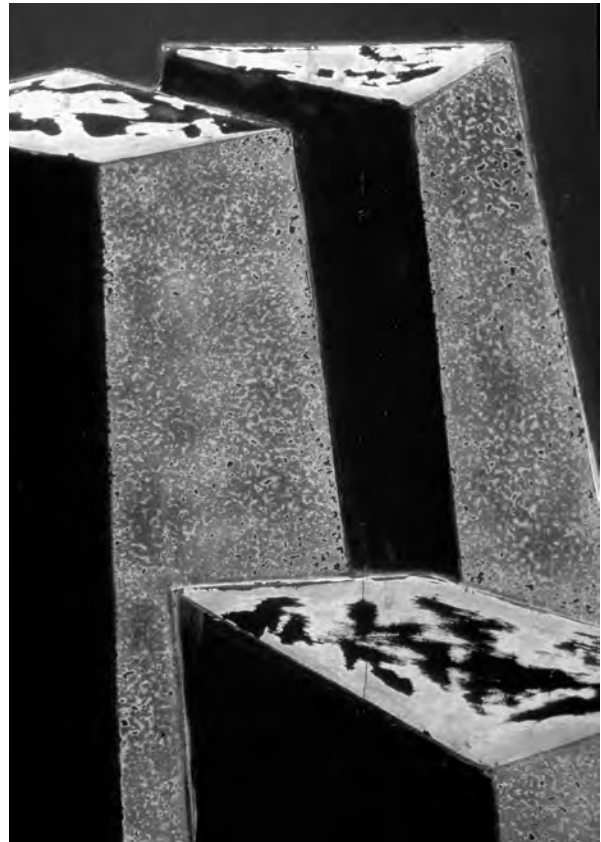


FIG. 8 Detail of “Fortissimo” screen showing the geometrically abstracted rocks.



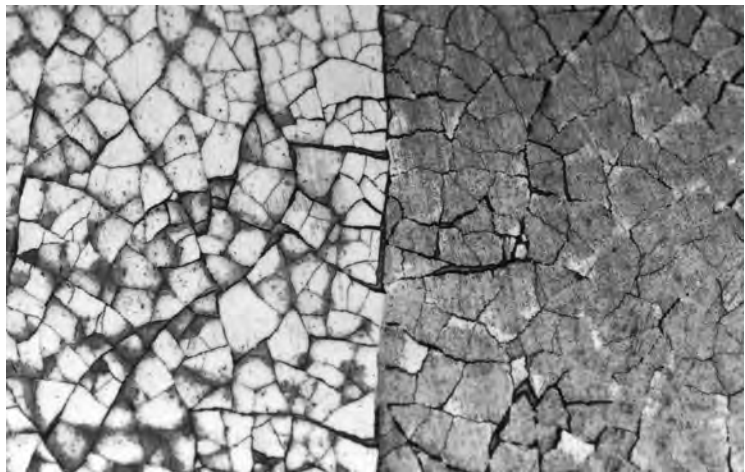
M. Baumeister

FIG. 9 Drop-leaf table by Dunand, ca. 1925. The table top, drop-leaves and shelf are decorated with crushed eggshells, arranged in a checkered pattern. The Metropolitan Museum of Art, Gift of Mr. and Mrs. Michael Chow, 1986 (1986.400).

Dunand seems to have been more interested in the technical challenges and craftsmanship involved in the application of the lacquer than in the designs per se. This is reflected in his numerous collaborations with other artists and designers, such as Jean Goulden, Paul Jouve, Seraphin Soudbinine, Jean Lambert-Rucki, Gustave Miklos, Jacques-Émile Ruhlmann, Eugène Printz, and Pierre Legrain. Dunand executed either the pictorial sketches in lacquer or decorated the surfaces of sculptures and unfinished furniture sent to his workshop. Jacques-Émile Ruhlmann, one of the most important French Art Déco furniture designers, created the “Chinoise” vanity in about 1929. This dressing table was produced with different finishes, including plain black lacquer and black lacquer with an abstract eggshell decoration,

both executed in Dunand’s studio.³⁸ Dunand’s fascination with lacquer and his identification as a lacquer artist is also illustrated by his signature: “Jean Dunand Laqueur,” with which he often signed his work.³⁹

Dunand continued to experiment with new ways of using lacquer. Among his most unusual applications were his portraits, which he based on his own photographs and sketches.⁴⁰ One of the portraits, in the collection of the Metropolitan Museum represents Madame Juliette de Saint Cyr, painted about 1925. It features an eggshell mosaic background and a *laque arrachée* border containing a floral ornament. The fabric of Mme. de Saint Cyr’s abstractly patterned dress and her jewelry originated in Dunand’s workshop as well. Mme. Agnès, an influential Parisian milliner and member of the avant-garde had introduced Dunand to the fashion world and encouraged him to experiment with lacquered fabrics and jewelry, as well as other fashion accessories.



M. Baumeister

FIG. 10 Detail of table top decorated with crushed eggshells, arranged in a checkered pattern. The eggshells that appear predominantly white were positioned convex-side up, while the adjacent eggshells were placed concave-side up and the subsequently applied grayish lacquer filled the cavities, thus creating the color contrast.

Dunand's most extensive commissions were the monumental decorative wall panels for the ocean liners *Île de France* (1927), *L'Atlantique* (1931), and *Normandie* (1935). Their luxurious interiors represented the best in contemporary French design. For the *Normandie* Dunand was required to use fire-resistant materials, which posed yet another new challenge. He developed a gypsum-based material, containing *urushi*, that could be cast, carved, and lacquered. A photograph shows Dunand with a blowtorch demonstrating the fire resistance of a lacquered table cast from his newly-invented material (fig. 11, page 2).

The enormous demand for Dunand's lacquerware and the production of large-scale projects required the constant expansion of his workshop on the Rue Hallé. A ground plan from 1935 outlines his premises, which included a show room, an office, several lacquer studios, including one for gilding, as well as designated areas for designing, model making, metalworking, cabinetmaking, casting, and sculpture. There were also several chambers, where water running down the walls produced a high-humidity environment for curing lacquer surfaces, and a large kiln for heat-resistant materials.⁴¹ The number of craftsmen and assistants working in Dunand's studio varied according to the scale of his commissions. In the twenties and thirties, Dunand had forty to sixty employees, nearly half of them lacquer workers from Indochina.⁴² During the production of the decorative wall panels for the *Normandie*, Dunand employed more than one hundred workers in order to complete this enormous project.

Considering that Dunand's lacquer oeuvre is based on a two month course in Japanese lacquer technique, his ingenuity in this field is remarkable. Dunand was an artist extremely receptive to new ideas and who was, above all, an outstanding, multi-talented craftsman, constantly looking for new inspiration, driven by his own high technical and aesthetic standards. *Urushi* presented to him a challenging medium which was difficult to master and provided endless opportunities to develop new techniques and applications. Dunand combined a

modern sensibility with a foreign material, thereby making Oriental lacquer highly fashionable in the Art Déco period. His reputation and mastery of *urushi* was such that lacquer experts from Tokyo regularly paid visits to his studio to study his innovative techniques and to acquire representative examples of his lacquer work.⁴³ His success was also based on a close collaboration with his oldest son Bernard, himself a lacquer artist, and on the help of his many Asian assistants, who produced most of the lacquerware under Dunand's supervision.⁴⁴

Dunand died at the age of 65 on June 7, 1942. Although faced with a shortage of materials during World War II, he had continued to work and to find new ways to express his creativity. A photograph, taken shortly before his death, shows Jean Dunand planing wood; the resulting shavings were lacquered and applied to hats created by the milliner Mme. Agnès.

ENDNOTES

1. Baptized Jules John, Dunand adopted Jean as his first name in 1909. Dunand became a French citizen on May 29, 1922. Marcilhac, F. 1991. *Jean Dunand—His Life and Works*. New York. 26, 37.
2. The term *dinanderie* is derived from Dinant, a Belgium town which specialized in hand-crafted domestic and ecclesiastical metal objects made of brass, copper, and bronze from the twelfth to fifteenth centuries.
3. Gauthier, M. ca. 1923. Vingt minutes avec M. Jean Dunand. *La Renaissance politique, littéraire, artistique*. I would like to thank M. Félix Marcilhac for providing a copy of this article.
4. Adam, P. 1978. Eileen Gray—Architect/Designer. New York. 49–50. Marcilhac 1991. 28–29, 170. Lorac-Gerbaud, A. 1973. *L'art du laque*. Paris. 100. Lorac-Gerbaud, A. 1996. *Les secrets du laque*. Paris. 160. According to Lorac-Gerbaud's 1996 publication, Sugawara came to Paris with a friend, the *ébéniste* Inagari, rather than with a Japanese delegation to the *Exposition Universelle*.

5. Dunand's notebook is preserved in an archive retained by Dunand's family.
6. The different phonetic transliterations from Japanese into French, German, and English must be considered. To complicate the matter, Dunand himself used more than one spelling to write the same Japanese term. I would like to thank Pascale Patris, Assistant Conservator, The Sherman Fairchild Center for Objects Conservation, The Metropolitan Museum of Art, for her help translating Dunand's notes.
7. The whereabouts of most sample boards (each 20cm x 13cm) and the report are still unknown. Investigations conducted by Hans-Werner Pape, Chief Conservator, Kunstgewerbemuseum Berlin, uncovered museum's inventory records for the transfer of 32 Japanese lacquer sample boards on April 9, 1934, most likely from Rein's collection, to the Völkerkunde Museum in Berlin. According to Birgit Kantzenbach, a conservator at the Museum für Völkerkunde, seven of those sample boards are preserved in the Museum's collection. The other samples might have been destroyed or lost during World War II. I am grateful to Hans-Werner Pape and Birgit Kantzenbach for this information. According to Rein, his report formed the basis of his later publication on Japanese lacquer work. Rein, J. J. 1886. *Japan nach Reisen und Studien im Auftrage der königlich preussischen Regierung dargestellt. Land- und Forstwirtschaft, Industrie und Handel*. 2 vols. Leipzig. II:400-448. This work was also published in English in 1889, under the title: *The Industries of Japan. Together with an Account of its Agriculture, Forestry, Arts, and Commerce, from Travels and Researches Undertaken at the Cost of the Prussian Government*. New York & London. 338-377.
8. Most of the 170 items from the Quin collection are preserved in the Economic Botany Collections, Royal Botanic Gardens Kew. Quin, J. J. 1882. *Report by Her Majesty's Acting Consul at Hakodate on the Lacquer Industry of Japan*. London. Quin, J. J. 1995 (reprint of the 1896 edition). *Urushi—The Technology of Japanese Lacquer*. Portland, OR.
9. Rein and Quin both identified the Japanese lacquer tree as *Rhus vernicifera*. The botanical name currently in use for the species is *Toxicodendron vernicifluum* (Stokes) F. Barkley; *Rhus vernicifera* D.C. and *Rhus verniciflua* Stokes are synonyms. Vogl, O., M. Qin, and J. D. Mitchell. 1995. Oriental Lacquers. 7. Botany and Chemistry of Japanese Lacquer and the Beauty of the Final Art Objects. *Cellulose Chemistry and Technology* 29:273-286. I would like to thank Dr. Dennis Stevenson, Director of the Plant Research Laboratory, The New York Botanical Garden, for his help in clarifying these terms.
10. Rein 1889, 350. Dunand also refers to *sessimé* as a transparent lacquer.
11. The name *schuaye* is spelled in various ways in Dunand's notebook: *shuai*, *schay*, *shuay*, *schuay* and *schuai*. The oil component of *schuaye* is most likely perilla oil, which Rein and Quin mention in connection with oil-containing lacquer. Rein 1889, 352. Quin 1882, 8.
12. Dunand notes that *kekso* is used to fill joints and contains equal amounts of *sessimé* and rice starch mixed with hemp or cotton fibers. Sawdust is also used traditionally as a filler in this ground layer.
13. *Ita* is made of equal amounts of *sessimé* and rice starch.
14. *Kiriko* is a mixture of 1/3 *dzinoko* (coarsely ground, baked clay), and 2/3 *tonoko* (finely ground, baked clay) with water, to which *sessimé*, in the amount of 25% of the starting mixture, is added. Coarse *dzinoko* contains *sessimé*, a little rice starch diluted with a lot of water, and coarsely ground *dzinoko*, while fine *dzinoko* has a similar composition, probably with the substitution of a

more finely ground clay, which is not explicitly mentioned. Dunand writes that *sabi* contains *tonoko*, *sessimé*, and a little water.

15. In his notebook Dunand mentions two stones by name: *arato*, which according to Quin is a rough stone for wet polishing, and *nagato*, which could refer to *nagura-to-ishi*, the finest stone for wet polishing. Quin 1882, p. 10. Three different charcoals—*honokizzimi*, *schirougazzimi*, and *loelozzimi*—are utilized, and Dunand specifies that end-grain surfaces of the charcoal pieces are used, and that the growth-rings must be perpendicular to the polishing movement. Afterwards the lacquer is polished with powdered *loelozzimi*, *tonoko* (finely ground, baked clay), and *tsinoko* (powdered, calcined deer antler) applied with oil and a cloth, cotton wool, or filter paper (*yossimo gami*, also used for filtering lacquer). The best results are achieved by final polishing with the palm or finger, and women’s fingers seem to be extremely suitable as Dunand noted: “le doigt de femme est très bon pour bien finir.”

16. “Les laqueurs qui ne savent pas bien polir et dresser une laque avec leur charbon, sont dénommés “Chameaux”, parce [sic] le chameau a 2 bosses, il est comme la laque mal dressée.” Another note from his booklet addresses the same concern: “Les laques qui ne sont pas très bien polies sont appelées laques de paresseux.”

17. “Louiro—1re qualité laque noire. Cette laque est faite avec la laque sessimé - prendre de la limaille de fer—y mettre un peu de vinaigre—ensuite le mélanger dans la laque et passer sur le feu (avec le filtre).” Quin and Rein both mention that in the preparation of black *ro-iro-urushi* / *ro-urushi haguro*, a solution produced by boiling iron filings in rice vinegar used by women to blacken their teeth is added to the lacquer. Quin 1882, 7, and Rein 1889, 352-353. Dunand mentions the use of *yossimo gami* paper for filtering lacquer.

18. With regard to *schuaye*, Dunand describes on one occasion the use of *honokizzimi* charcoal to smooth each of three layers of transparent *schuai*

after they have dried for 2 hours; no final polishing, however, is mentioned.

19. The temperature of the oven was noted as 100°C for the first five hours, then 150°C for thirty minutes and 180°C for the last ten minutes.

20. The lessons started on May 16, 1912 and continued until the end of June.

21. “Pour obtenir un laque réussi, vingt-deux opérations sont nécessaires. Et les matières premières ne sont pas seulement d’un maniement difficile; leur nocivité ne me permet d’employer, à ce genre de travaux, qu’une main-d’oeuvre elle-même importée, si l’on peut dire; mes ouvriers chinois, japonais, annamites, manipulent impunément des produits qui font, sur l’ouvrier européen, effet de poison.” Gauthier, ca. 1923.

22. At the 1921 Salon des Artistes Décorateurs in Paris, Dunand exhibited for the first time a lacquer panel depicting fishing boats seen against a mountain landscape, which was based on a sketch by his friend, the painter Henry de Waroquier. Marcilhac 1991, 35.

23. Gimbel, R. 1966. *Diary of an Art Dealer*. New York. 137–138. The diary was first published in French in 1963 as *Journal d’un collectionneur*. Paris, 165-166.

24. The exhibition, entitled Jean Dunand: Master of Art Deco (May 23–October 25, 1998), was organized by J. Stewart Johnson, Consultant for Design and Architecture, and Jared Goss, Assistant Curator, Department of Modern Art, The Metropolitan Museum of Art.

25. A 1929 article in *Vogue* magazine devoted to Crocker’s luxurious apartment, praised its modern interior, which also included rooms designed by Jean-Michel Frank, Pierre Legrain, and Mme. Lipska. Miller, M. A. 1929. A Twentieth Century Apartment. *Vogue* (August 3):30-35, 94.

26. In the above-mentioned *Vogue* article, the bedroom was described as follows: “In the adjoining bedroom, Dunand has again contrasted his own love for movement and design with Frank’s monotonous. Here again, *laque arrachée* on the walls is worked into a modern design in tones of silver and grey with overtones of tan, giving the effect of a woodland. Over the head of the bed, a life-sized deer nibbles a miraculous green bough, and on an adjacent wall, his companion sips calmly from a spring. These deer are made of thin sheets of lead, inlaid with colours. The furniture, low and square, is of black and grey lacquer, with a note of white in the ivory knobs of the commode and the goatskin that covers the chairs. The curtains are of grey chamois in three shades.” Miller 1929, 94.

The original photograph of the completed bedroom taken by Thérèse Bonney in Paris in 1928 has the following description typed on the reverse: “Lacquered bedroom by great French lacquist [sic] Jean Dunand. Done for an American pent house [sic] in soft greys and reds, chairs upholstered in white goat skin.”

Photographs of the bedroom suite in the Dunand family archive have the following comment written on the back: “Boiseries en *laque arrachée* argent, gazelle en plomb incrusté, meuble en laque chine gris et noir.”

A maquette for the wall paneling behind the bed, recently acquired by the Metropolitan Museum, has a raised surface texture imitating *laque arrachée* covered with aluminum leaf. Different shades of gray, and pale red and yellow washes, were applied to the metal surface to depict the landscape scene.

27. Elemental analyses of cross sections of lacquer samples were carried out by Mark T. Wypyski, Associate Research Scientist, The Sherman Fairchild Center for Objects Conservation, The Metropolitan Museum of Art, using an energy-dispersive X-ray spectrometer (EDS) attached to a scanning electron microscope. EDS analysis of the black lacquer detected the presence of iron in the layer, indicating the use of *louero* lacquer. Fluores-

cence microscopy of cross sections from samples of the bedroom furniture showed a maximum of eight ground layers, including cloth, applied to wood and plywood substrates. EDS analyses of the ground layers revealed large amounts of silicon, with lesser quantities of magnesium, aluminum, sulfur, potassium, calcium, and iron, apparently a mixture of silica particles and clay. The bottom ground layers also contain bast fibers and wood, the latter most likely present in the form of saw dust. I would like to thank Mark T. Wypyski for performing all EDS analyses.

28. The metal filings and pigments were identified by EDS and X-ray diffraction analysis. Silicon, phosphorus, sulfur, calcium, and barium were also detected in the silver-gray lacquer, suggesting the presence of silica, barium sulfate and calcium phosphate particles, the latter possibly in the form of bone or ivory white.

29. The lacquer was analyzed by Prof. Dr. Tetsuo Miyakoshi, Department of Industrial Chemistry, Meiji University, using pyrolysis-gas chromatography/mass spectrometry. I am very grateful to Prof. Dr. Miyakoshi for conducting the analysis of four samples from the Dunand bedroom furniture. Kamiya, Y., and T. Miyakoshi. 2000. The Analysis of *Urushi* by Pyrolysis-Gas Chromatography and Mass Spectrometry. In *Ostasiatische und europäische Lacktechniken / East Asian and European Lacquer Techniques*, ed. M. Kühnenthal. Munich: Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege 112: 107-120. *Rhus succedanea* also grows in Taiwan, but because Indochina was a French colony at the time, it is more likely that Dunand imported his lacquer from there.

30. The panels are now in the collection of the Musée des Arts d’Afrique et d’Océanie in Paris, which is housed in the Palais Permanent des Colonies, where Dunand’s panels were originally displayed. Marcilhac 1991. 119-120.

31. “Sur une laque d’or en feuilles sèche passer une couche de laque à la terre arrachée et tracer des

décors dedans pendant qu'elle est fraîche. Après séchage passer légèrement en papier de verre fin.”

32. In addition to the two screens, which are now in the collection of the Metropolitan Museum, two double doors decorated with angels sounding horns and a small panel depicting St. Michael and the Dragon were also made by Soudbinine and Dunand for the music salon. Photographs of the original interior of the music room and both screens are published by Marcilhac. Marcilhac 1991, 323, color plate 163.

33. The gilding was probably executed by a craftsman named Zuber, who was the specialist for gold lacquer in Dunand's workshop. EDS analysis was used to identify vermilion as the colorant of the red lacquer, based on the presence of mercury and sulfur. EDS analysis characterized the composition of the gold leaf as approximately 90% gold, 7% silver, and 3% copper by weight.

34. When viewed in cross section under a UV light microscope, a coating on the “darker” gold leaf displayed an orange fluorescence, which is characteristic for shellac. It is known that Dunand used shellac, and in this case he might have chosen it because of its orange coloration.

35. The examination of cross sections from the blue-green lacquer of the background revealed a mixture of coarse blue, fine blue-green, and yellow pigment particles. EDS analysis of the blue-green lacquer detected mainly chromium, aluminum, and cobalt, with traces of silicon, sulfur, calcium, and iron, which can be best correlated to the presence of cobalt blue, chromium oxide green, and an organic yellow pigment.

36. For the fluorescence microscopy the following filter set was used: excitation filter 365 nm, chromatic beam splitter 395 nm and emission filter 397 nm.

37. Records of a sample board made in Dunand's workshop in 1932 describe the technique as follows: “Sur une couche de laque noire coller des morceaux de laque à la terre rouge. Morceaux

obtenus en cassant une plaque de laque à la terre faite en passant une couche de cette laque sur du papier et en la faisant cuire au four. La laque à la terre rouge était obtenue avec de l'ocre rouge, de l'eau et moitié laque transparente, moitié laque naturelle. Après séchage passer une couche de laque noire. Après séchage poncer et polir.”

38. Camard, F. 1983. *Ruhlmann*. Paris. The dressing table with black lacquer and abstract eggshell decoration, and the matching chair, are illustrated on p. 60 and 275.

39. In addition to signing his work, Dunand also stamped pieces produced in his workshop. The heated metal stamp left the following imprint on unexposed lacquered and wooden surfaces of the Crocker bedroom furniture: “JEAN DUNAND - 72 RUE HALLE - PARIS - MADE IN FRANCE.”

40. In the 1927 October issue of the magazine *Arts & Decoration* a page was devoted to Jean Dunand's spectacular portraiture, reproducing portraits of four famous French women. Anonymous. 1927. In Paris You Must Have a Lacquer Portrait. *Arts & Decoration* (October):134.

41. A-Dayot, M. 1936. Art et technique—une visite à Jean Dunand. *L'Art et les Artistes* (November): 57-62. Marcilhac 1991, 172.

42. Dunand, B. 1982. Jean Dunand. *Club français de la médaille* 77:42-43, 49.

43. Garner, P. 1973. The Lacquer Work of Eileen Gray and Jean Dunand. *The Connoisseur* (May): 3-11. Dunand also participated in an exhibition of French decorative arts shown in Japan. Marcilhac 1991, 72.

44. From 1925, Bernard Dunand was Jean Dunand's closest collaborator. Thanks to his understanding and appreciation of his father's lacquer-work, as well as his own professional activities as a lacquer artist, many utensils, materials, documents, and sample boards from Jean Dunand's

workshop are preserved. I had the honor to meet Bernard Dunand three weeks before he died at the age of ninety. I am most grateful to Mme Dorothee Dunand-Dougoud and M. Christian Dougoud, Bernard Dunand's daughter and son-in-law, for their strong encouragement and support of my research on the lacquer techniques of Jean Dunand.

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A SECOND SET OF EXPERIMENTS USING HYDROLYZABLE POLYMERS TO PRESERVE WATERLOGGED WOOD

C. Wayne Smith

ABSTRACT

In this study, methyltrimethoxysilane (MTMS), a hydrolyzable, multi-functional alkoxy silane polymer and Q9-1315, a MTMS alkoxy silane polymer diluted with methanol, were used in conjunction with acetone dehydration to conserve waterlogged wood. Three groups of wood were used as samples for study. The Group 1 samples, waterlogged tongue depressors, were treated using acetone dehydration followed by immersion in MTMS. After using the acetone/MTMS displacement method, images of the treated wood were obtained using an environmental scanning electron microscope, and were compared to similar images of non-waterlogged samples of the same wood samples, providing data on the ability of the polymer to preserve the micro-structure of the wood. A waterlogged plank from a submerged 17th-century architectural feature, from Port Royal, Jamaica, was divided into four sections to form the Group 2 samples. Two sections of this plank were treated by using MTMS on one section and Q9-1315 on another. The remaining two sections of wood were used to calculate the water content of the wood. The Group 3 samples consisted of 18 waterlogged treenails extracted from the frames of La Salle's vessel, *La Belle*, which sank off the coast of Texas in 1686. Eight of the Group 3 treenails were treated using MTMS immersion after dehydration in acetone. Eight other Group 3 treenails were treated using acetone dehydration followed by immersion in Q9-1315. The remaining two were used as controls for comparison. The nuclear magnetic resonance spectra of the samples from these Groups indicate that when waterlogged timbers are immersed in MTMS, resins are formed through self-condensation. The hypothesis of these experiments is that alkoxy silane polymers are sufficient to preserve the diagnostic attributes of wooden artifacts.



BACKGROUND AND INTRODUCTION

In his introduction to the *Proceedings of the ICOM Waterlogged Wood Working Group Conference, Ottawa, 1981*, Colin Pearson outlined the history, structure and evolution of the ICOM Committee for Conservation Working Groups. As noted in his historical perspective of the Waterlogged Wood Working Group, he observed that at the meeting of the Working Group in Zagreb (1978) an initial list of eight areas of research were outlined (Pearson, 1981). These included the use of detergents, tetraethyl ortho silicate, freeze-drying, analysis of polyethylene glycol (PEG), organic polymers, irradiation techniques and other problems connected with the salvage of waterlogged wood. Many of these treatment strategies have proven to be less than totally reversible. However, the Zagreb list is an excellent indicator that the science of waterlogged wood conservation has advanced, and that wood conservators have been industrious in their pursuit of better treatment strategies.

In just a few years, several areas of waterlogged wood research have blossomed, due to the hard work of dedicated conservators. Cliff McCawley, David Grattan and Clifford Cook have advanced research into the effects of PEG/freeze-drying waterlogged wood (McCawley, 1981, Grattan, 1984). At the same time,

Per Hoffman conducted some invaluable studies observing that wood structures do not degrade at uniform rates, which led to his development of a highly effective, two-phase PEG-treatment strategy (Hoffmann, 1984). ARC-Nucleart has advanced studies in the preservation of waterlogged wood by impregnation with resins, which are then hardened using radiation (Ginier-Gillet, 1984). Additionally, they have worked successfully in treating larger artifacts using PEG impregnation followed by freeze-drying.

Although contributions to the discipline of waterlogged wood conservation continue, some of the long-term problems of treatments using PEG are being realized. In his address at the Ottawa ICOM Conference, Dr. Allen Bronstein, a senior chemist at Union Carbide Company, addressed the complexities of wood conservation and many factors related to the degradation of PEG (Bronstein, 1981). During the discussion, Cliff McCawley touched on the topic of the effects of metal salts on the degradation of PEG. In retrospect, this has become a topic of great concern. In recent years, the problem of PEG decomposition and the formation of chemical complexes, including aldehydes and ferrous, ferric and cupric salts, has become a pressing issue. Indeed, some of our finest examples of conserved waterlogged wood are on the verge of disintegration due to our inability to control oxidation, miscibility and chemical reactivity of PEG with oxides and compounds found naturally in waterlogged timbers.

This experiment investigates the use of trifunctional polyols to both stabilize and maintain the physical attributes of waterlogged wood samples, as suggested by Bronstein. (Bronstein, 1981) However, instead of directing research at creating "very hard and durable finishes," as he suggests, this experiment focuses on impregnating a variety of waterlogged wood samples with a self-condensing polymer, in such a way as to cause formation of resins throughout the pore structure of the wood. There are benefits to this type of resin-forming chemical reaction. Displacement of water with the self-condensing polymer methyltrimethoxysilane

(MTMS) does not appear to distress waterlogged wood. The low viscosity of MTMS allows for the thorough impregnation of waterlogged wood using either ambient or low vacuum processes. Using trace amounts of water, the alkoxy silane condenses, forming complex polymers that do not cause cell wall distortion or appreciable shrinkage. Post-treatment microscopic and NMR evaluation of the treated wood indicates that complex resins are formed throughout the wood. These resins are bound to the cell wall structures, giving the wood both strength and durability. Additionally, the wood is aesthetically pleasing without the waxy, dark coloration associated with PEG-treated wood.

Notably, the wood treatment strategies outlined in this experiment are not reversible. Considering the chemical structure of wood, however, few conservation materials used as bulking agents are truly reversible. This, in part, is due to the polymer nature of wood. Lignin, for instance, is a natural polymer composed of coniferyl alcohol and other compounds. Cellulose is a linear polymer with notably high concentrations of hydroxyl groups which form microfibrils. Even the starches found in wood consist of glucose polymers which contain amylose and amylopectin (Mills, 1994). This, in part, explains the non-reversible nature of PEG. PEG itself is a polymer composed of poly(ethylene oxides) polymerized from ethylene oxide. When introduced into wood as a bulking agent, PEG chemically bonds to cell walls, making complete reversal impossible. The polymer nature of wood also explains why alkoxy silane polymers are effective bulking and stabilizing agents. When introduced into an organic substrate, silanes form Si-OH groups that condense to form cross-links that are more stable than bonded PEG in a similar substrate. As prescribed by the ICOM activities committee in 1978, experimentation using alkoxy silane polymers and other organic polymers was, and still is, an essential phase of development in the discipline of organic artifact conservation.

CONSERVATION

Three groups of waterlogged wood samples were used for this experiment. The Group 1 wood

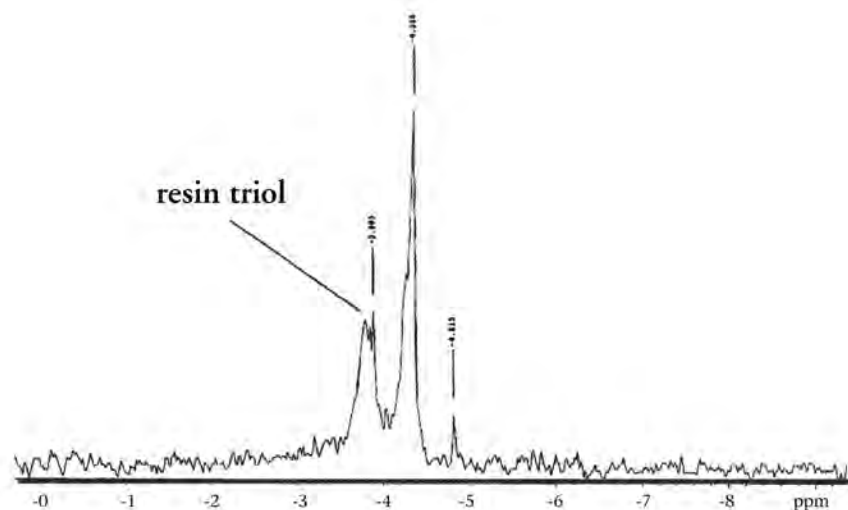


FIG. 1 ^1H spectrum of the solid polymer formed from the MTMS. It is the formation of these polymers that preserves the structure and shape of the artifact.

samples consisted of waterlogged wooden tongue depressors that had been immersed in tap water in sealed glass jars for eight years. The Group 2 waterlogged wood samples were sectioned from a large piece of archaeological wood from the marine excavations of the 1692 provenance of Port Royal, Jamaica. The Group 3 wood samples consisted of 18 treenails (hand-carved wooden dowels) that had been extracted from the frames and large timbers of the 17th-century shipwreck, *La Belle*, found off the coast of Texas. Each of these hand-carved lengths of wood were similar in circumference (26.66 mm average) and, for the most part, similar in length (128.70 mm average). Many of their surfaces bore diagnostic tool marks.

Nuclear magnetic resonance (NMR) spectra of waterlogged wood treated with alkoxy silane polymers indicate that in an aqueous environment, MTMS hydrolyzes to form a polymer triol as noted by C.V. Horie (Horie, 1999). This triol self-condenses to form a range of polymers in the ^{29}Si spectra. The primary polymer has a methyl group and three siloxy bonds (*i.e.*, Si - O - Si). The second resultant silicon has only two bonds. The third is formed to the methyl group while the fourth bond is to the hydroxy group as in the ^1H spectrum (fig. 1). One of the goals of these experiments was therefore to determine whether these polymers were sufficient to maintain the physical

attributes, cell structure and aesthetics of the Group 1, Group 2, and Group 3 wood samples.

NMR analysis was also conducted to determine whether the waterlogged tongue depressors were sufficiently degraded to provide a valid substitute for archaeological wood in such an experiment. The spectra of the Group 1, as well as the archaeological wood samples of Group 2 and 3, were nearly identical to spectra reported by Michael Wilson, *et al*, in *The Degradation of Wood in Old Indian*

Ocean Shipwreck (Wilson, 1993). To determine the physical integrity of the Group 1 wood samples, waterlogged control samples were oven-dried over a 24-hour period. In all cases, the degree of warping and shrinkage indicated that the waterlogged tongue depressors respond similarly to the air- or oven-dried waterlogged archaeological wood. Classroom conservation experiments have shown that waterlogged tongue depressors are good indicators of the effectiveness of traditional waterlogged wood treatment methods such as PEG, acetone/rosin and sucrose. This same type of waterlogged wood appears to work equally well as an indicator of the effectiveness of polymer preservation treatment strategies.

MATERIALS

Group 1 Waterlogged Tongue Depressors

Tongue depressors were chosen for use in this experiment because they are both easily obtained and relatively uniform in dimension, grain and color. To create a supply of waterlogged wood, thousands of white birch (*Betula papyrifera*) tongue depressors were placed into one-gallon glass jars filled with tap water. The jars were then sealed and stored in a cabinet. For this experiment, hundreds of tongue depressors, which had been immersed in tap water since June 2, 1992, were emptied into a plastic vat and rinsed with running tap water for two hours. Ten tongue depressors were randomly

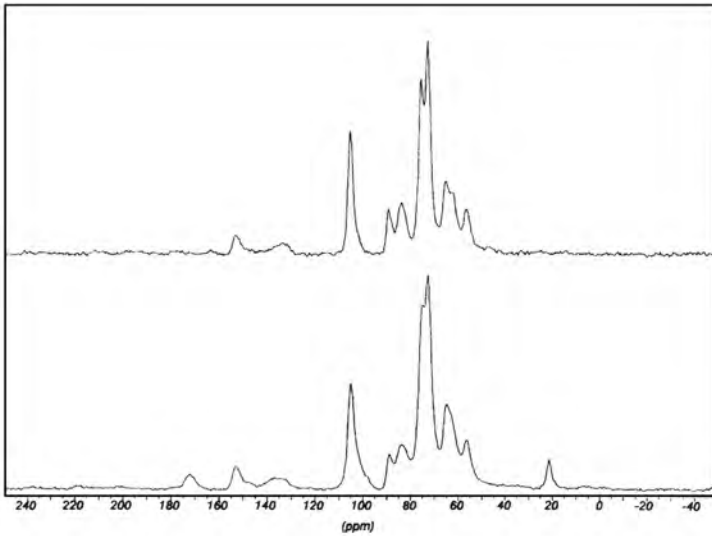


FIG. 2 ^{13}C CP/MAS spectra of an untreated, non-waterlogged control tongue depressor (bottom) and an untreated, waterlogged tongue depressor (top).

selected from the rinse vat and designated as air-dry samples, to determine the average water content of the wood of Group 1. Eighteen additional tongue depressors were randomly selected as Group 1 to undergo treatment using acetone dehydration followed by acetone/MTMS displacement.

The ^{13}C CP/MAS spectrum for a Group 1 air-dried sample is illustrated at the top of figure 2. Long-term saturation in tap water has altered the chemical structure of the wood, apparent in the loss of the acetate resonances at 22 and 174 ppm, in comparison to the spectrum of a control tongue depressor that had not been waterlogged (fig. 2). The changes in these ^{13}C spectra for birch tongue depressors are quite similar to those reported by Wilson, *et al.*, (Wilson, 1993) for oak from shipwrecks. The ^{13}C spectral signature and macroscopic observation of extensive warping and shrinkage following air-drying suggest that these samples provide a suitable model for the analysis of waterlogged wood.

Group 2 Waterlogged Archaeological Wood

A small plank of wood recovered during archaeological excavations at the submerged site of 17th-century Port Royal, Jamaica, was selected for the Group 2 wood samples. Based on cross-section microscopic analysis, the wood has been tentatively identified as *Pinus carabaea*, commonly known as slash pine or British Honduras pitch

pine. Typically, this wood has a straight fine grain which is very uniform in texture. Since excavation from the 1692 provenance at Port Royal, the plank, which measures 12.32 cm wide, 14.73 cm long and 1.87 cm thick, had been desalinated and stored in fresh tap water. For this experiment, the plank was divided into four sections. Because it was waterlogged the wood was very fragile, so sectioning was accomplished using a long scalpel blade. Figure 3 illustrates the dimensions of the Group 2 samples.

Group 3 Waterlogged Treenails

The Group 3 artifacts were treenails, which were extracted from the timbers of the 17th century shipwreck, *La Belle*. Each piece of wood was roughly carved and slightly tapered in shape. After desalinization in freshwater baths for 24 months, the 18 treenails were surface-dried with paper towels and then weighed, measured and photographed (fig. 4).

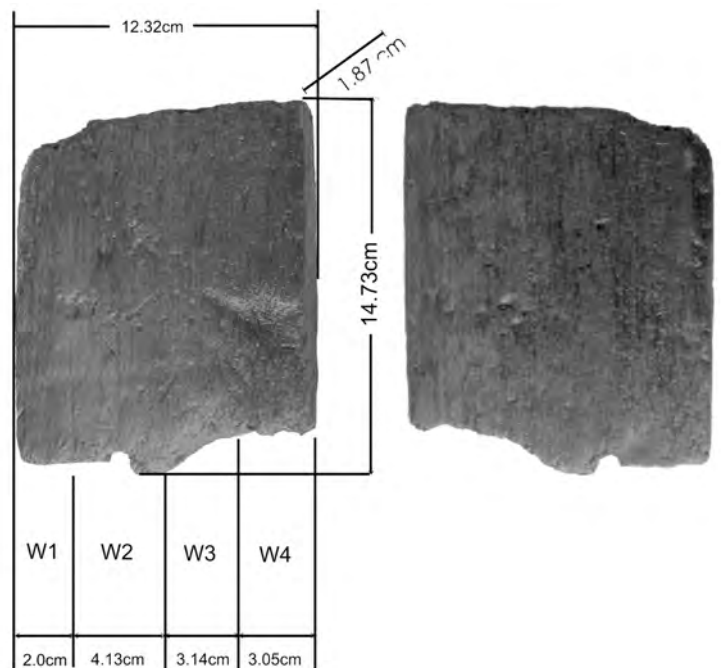


FIG. 3 Surface characteristics, sections and dimensions of the waterlogged plank used for the Group 2 waterlogged wood samples. Top surface of the plank (left); obverse surface (right).



FIG. 4 Example of a waterlogged treenail.

Group 1 Wood

Ten randomly selected waterlogged tongue depressors were placed in a ventilated warming oven for 24 hours, set at 400°C. The average water content of the Group 1 oven dried samples was determined to be 215.96%.

METHYLTRIMETHOXYSILANE AND Q9-1315

Methyltrimethoxysilane (MTMS) is a chemical monomer that reacts with water to form silane triol and methanol. The silane in turn condenses with available hydroxyl groups or other silanol monomers to form siloxane resins. The chemical formula for MTMS is $(\text{CH}_3\text{O})_3\text{SiCH}_3$. Typically, MTMS is a solution of 97% methyltrimethoxysilane with 2% methyl alcohol, and 1% dimethyldimethoxysilane added. The condensation product of MTMS is a resin with a molecular weight of 226.

Q9-1315 is a complex solution, and consists of 44% methyltrimethoxysilane (by weight), mixed with 50% methyl alcohol, 4% isopropyl alcohol, 1% ethyl alcohol, and 1% dimethyldimethoxysilane. Like MTMS, Q9-1315 is generally a clear liquid, however because of the lower percentage of methyltrimethoxysilane and a higher percentage of alcohol, evaporation during treatment is greater, and there are fewer hydroxyl groups and other silanol monomers available to form resins.

Industrial-grade ethanol (certified to be 97.62% free of water) and acetone (certified to be 99.78% free of water) were used for all dehydration processes.

WATER CONTENT OF GROUP 1, 2 AND 3 WOOD SAMPLES

Percentage water content was calculated for each group of samples using the formula illustrated in figure 5.

$$\% \text{H}_2\text{O} = \frac{\text{Weight of the wet wood} - \text{Weight of the oven-dried wood}}{\text{Weight of the oven-dried wood}} \times 100$$

FIG. 5 Formula used to calculate water content of tongue depressors and archaeological wood samples [10].

Group 2 Wood

Following 24 hours in a vented warming oven, set at 400°C, wood section W1 went from a weight of 39.10 g to 4.4 g, representing a total weight loss of 88.49%. The water content was calculated to be 788.64%. Because of the uniform thickness and condition of the wood, the water content calculation for W1 was assumed to reflect the general state of degradation of the other sections of wood.

Prior to air-drying, W4, the second air-dried archaeological wood sample, had a mass of 104.3 g. W4 was placed in a fume hood and allowed to air-dry for 36 hours at ambient pressure and a constant room temperature of 760°F (24.40°C). Following drying, the sample weighed 10.3 g, representing a weight loss of 90.13%, representing 912.62% water content.

Group 3 Wood

The two waterlogged treenails, weighing 82.1 g and 68.2 g wet, were allowed to air-dry in a ventilated warming oven for 48 hours. After air-drying, the treenails weighed 34.48 g and 34.65 g, representing an average weight loss of 58.01% (138.11% water) and 49.19% (138.62% water) respectively.

TREATMENT METHODS

Group 1 Wood

After randomly selecting 18 Group 1 waterlogged tongue depressors from the rinse vat, each was surface-dried with paper towels and labeled incre-

mentally with a felt-tip pen. Length, width, thickness and weight measurements were recorded for each sample.

Next, the wood samples were placed in a large beaker containing one liter of fresh, industrial-grade acetone. After 24 hours, they were transferred to a second beaker containing one liter of fresh acetone and dehydrated for an additional 24 hours. After 48 hours of dehydration, the Group 1 samples were transferred into a beaker containing one liter of methyltrimethoxysilane (MTMS). Then, the beaker was placed into a desiccator vacuum chamber with a reduced pressure environment of 5333.33 Pa (40 torr) for 6 hours. After 6 hours of acetone/MTMS displacement, the wood was allowed to sit in the solution at ambient pressure and room temperature for an additional 18 hours. The samples were removed from the MTMS solution and placed onto paper towels in a fume hood and air-dried for 2 hours. All of the samples were then placed into a large Ziploc bag along with an aluminum weighing dish containing 15 g of tap water. The bag was sealed, creating a closed, humid environment. After 24 hours of exposure to water vapor, the Group 1 wood was removed from the bag and allowed to air-dry in a fume hood. The treated wood was then measured in order to assess the conservation process.

Group 2 Wood

Two sections of the plank, W2 and W3, were chosen for treatment with alkoxysilanes. W2 was placed into a beaker containing one liter of industrial-grade acetone, and was dehydrated at ambient pressure and room temperature for 24 hours. The wood was then placed into fresh acetone for an additional 24 hours of dehydration. After 48 hours of dehydration, W2 was transferred to a beaker containing one liter of MTMS and placed into a desiccator vacuum chamber, where a reduced pressure of 5333.33 Pa (40 torr) was applied for 10 hours. The wood was left in the solution at ambient pressure and room temperature for an additional 12 hours. Following acetone/MTMS displacement, W2 was removed from the solution and placed into a Ziploc bag. An aluminum weighing dish containing 20 g of tap water was

placed inside the Ziploc bag, in close proximity to W2. The bag remained sealed for 18 hours. The wood was then removed from the bag and placed in a ventilated fume hood for an additional 24 hours. After air-drying, the wood was weighed and measured.

Like W2, W3 was placed in a beaker containing one liter of industrial-grade acetone and dehydrated at ambient pressure and room temperature for 24 hours, and then transferred into another fresh liter of industrial-grade acetone for an additional 24 hours. The wood was then transferred to a beaker containing one liter of Q9-1315 and placed into a desiccator vacuum chamber. A reduced pressure of 5333.33 Pa (40 torr) was applied for 10 hours. The wood was left in the solution at ambient pressure and room temperature for an additional 12 hours. After acetone/Q9-1315 displacement, W3 was removed from the solution and placed in a Ziploc bag with a rag, dampened with 20 g of tap water. The bag was sealed and the wood was allowed to sit for 18 hours. The wood was then removed from the bag and placed in a ventilated fume hood for an additional 24 hours. After air-drying, the wood was weighed and measured.

Only trace amounts of water are necessary to ensure silanol Si-OH groups that can bond with OH structures in the wood. Accordingly, W2 and W3 samples were air-dried in close proximity to a dish containing 20 g of water.

Group 3 Wood

The sixteen treenails were first dehydrated in a series of three ethanol baths, each lasting one week. Then, the dehydration was continued in a series of three acetone baths, changed at two week intervals. For the last 10 hours of dehydration, the samples were placed in a large vacuum chamber and treated at a reduced pressure of 5333.33 Pa (40 torr). During this phase of dehydration, the samples were monitored closely to ensure that they remained immersed in the acetone.

Eight of the treenails were randomly selected and carefully transferred to a large beaker containing

one liter of MTMS. The remaining treenails were transferred into a beaker containing one liter of Q9-1315. Both beakers were then placed in a vacuum chamber and treated at a reduced pressure of 5333.33 Pa (40 torr) for 24 hours. The treenails were then stored at ambient pressure in their respective polymers for an additional seven days.

All of the treenails were then removed from the solutions, surface dried with paper towels, and placed in a fume hood where they were allowed to air-dry for 24 hours.

OBSERVATIONS

Group 1 Wood

The average wet weight of the Group 1 wood was 5.62 g. After (MTMS treatment), the average weight was reduced to 2.59 g, representing a weight reduction of 53.83%. The average width of the air-dried waterlogged tongue depressors was reduced from 17.89 mm to 13.67 mm, representing a 23.58% reduction. The average length of the same samples was reduced from 152.37 mm to 151.74 mm, representing an average reduction of 0.71%. The average thickness of these samples was reduced from 0.17 cm to 0.15 cm, or -11.77%.

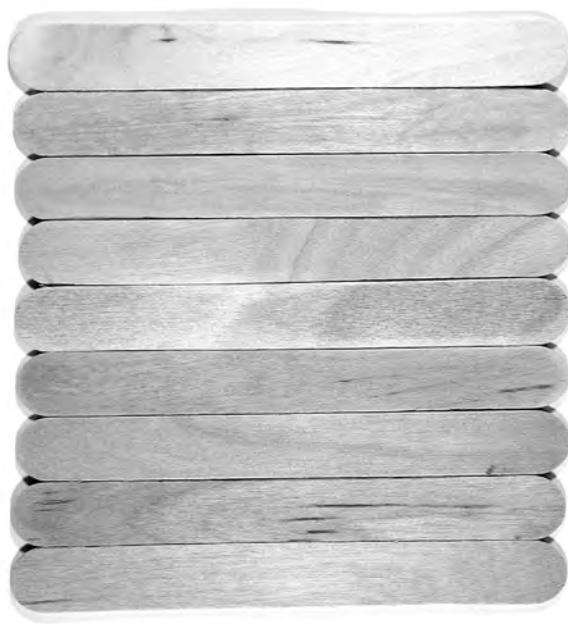


FIG. 6 Control tongue depressor (top); eight MTMS-treated, waterlogged tongue depressors (below).

The dimensions and the aesthetic attributes of the Group 1 MTMS-treated wood samples were well-maintained after treatment. Changes in length were minimal following treatment, with a reduction of only 0.41%, on average, after MTMS-treatment. Change in width of the samples was noticeably high, with an average post-treatment reduction of 11.11%. One control tongue depressor and eight MTMS-treated wood samples are illustrated in figure 6.

After air-drying, the color of the waterlogged tongue depressors had changed from a natural light yellow brown color (10 YR/8/2 Munsell), ranging from a light gray-brown (2.5Y/7/2 Munsell) to a darker brownish-gray (10 YR/6/2 Munsell).

Micro-Structure of the Group 1 Wood Samples

Cross-section samples of control, untreated wood, air-dried wood and MTMS-treated tongue depressor samples were analyzed using an environmental scanning electron microscope (ESEM). For analytical consistency, photographs of each sample were recorded at 1000-X amplification. Cell shape retention, cell wall integrity and general appearance were used to assess the effectiveness of the treatments.

In Figure 7, the left image is a 1000-X amplification of the cross-sectional surface of an untreated birch (*Betula papyrifera*) control tongue depressor showing uniformly shaped, thick-walled tracheids. In contrast, the tracheids in the waterlogged wood sample (right) are irregular in shape with the deterioration of the middle lamella. Figure 8 shows two views of the micro-structure of a Group 1, MTMS-treated sample of wood. Cell walls collapse is negligible, and there is very little distortion and structural loss of the middle lamella. In figure 9, two cross-section views indicate that after air-drying, the cellular structure of the Group 1 waterlogged wood samples collapsed, causing extreme shrinkage and distortion of the wood.

Group 2 Wood

Prior to air-drying, W1 weighed 39.10 g and measured 2.00 cm wide, 1.87 cm thick and 12.20 cm long. After 24 hours of oven-drying, the wood

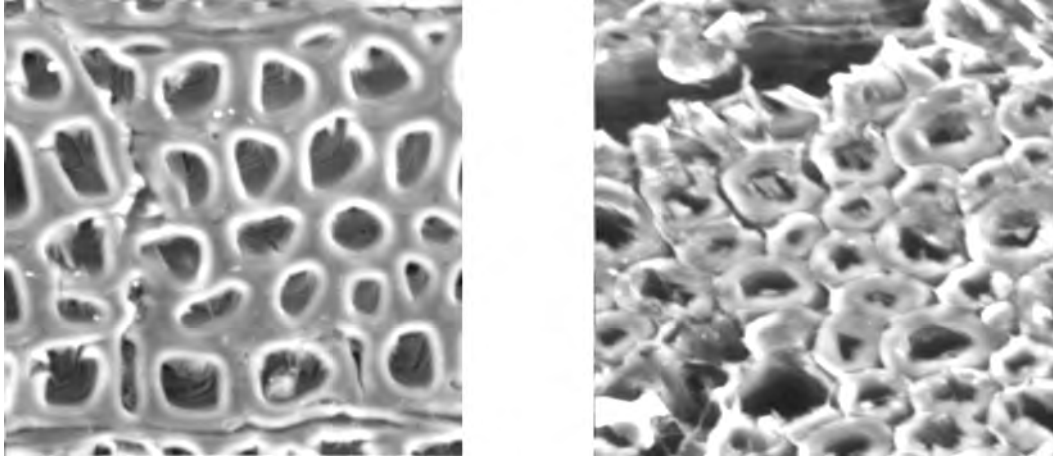


FIG. 7 Control Group 1 tongue depressor on the left and image of a waterlogged Group 1 tongue depressor on the right, viewed at 1000X.

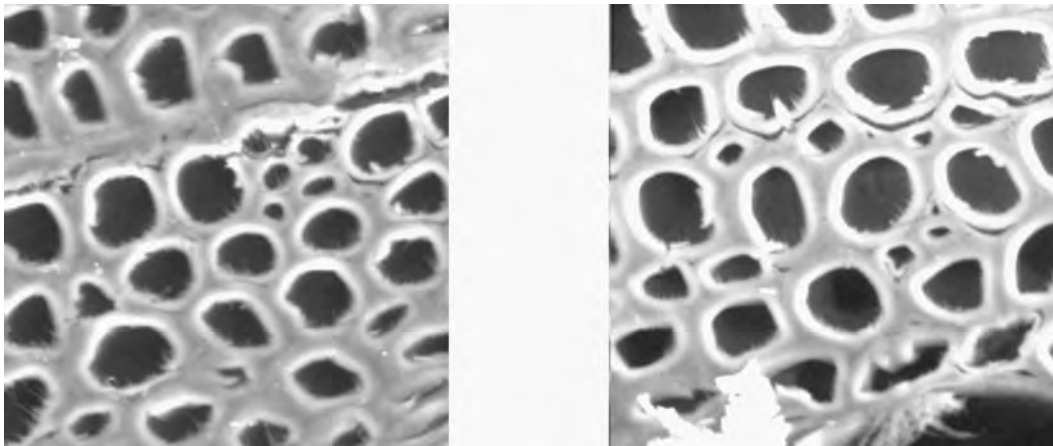


FIG. 8 Two cross-section microscopic views (1000X) of a Group 1 tongue depressor treated using MTMS.

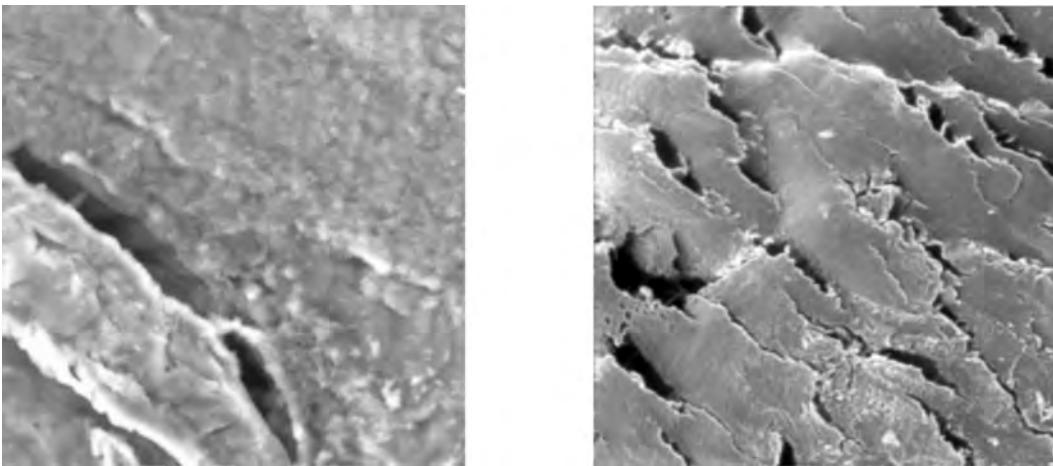


FIG. 9 Two cross-section views of Group 1, air-dried wood samples. In both images, cellular distortion and collapse is apparent, resulting in extreme warpage and distortion.

weighed 4.40 g, representing a loss of 34.70 g and an average change of -88.75%. The water content of this sample was calculated to be 788.64%. When removed from the warming oven, the wood had completely collapsed and fragmented into five sections. The final length and width of W1 was impossible to determine due to fragmentation during air-drying. Prior to treatment, the thickness of W1 was 1.87 cm thick. Average thickness of W1 wood fragments after treatment was 0.42 cm, representing a reduction in thickness of 77.54%.

W2 was sectioned from the plank adjacent to W1. This section of wood (W2) had a wet weight of 115.7 g and measured 4.13 cm wide, 1.86 cm thick and 14.68 cm long. W2 was designated for treatment in MTMS, after dehydration in acetone.

After treatment in MTMS, W2 appeared uniformly dry and light in color, and only slight dimensional changes were noted. The wet weight of sample W2 was reduced from 115.7 g to 28.7 g, representing a change of -75.20%. The width of W2 measured 4.13 cm prior to treatment, and after treatment it

measured 3.96 cm, representing a change of -4.12%. The thickness of W2 prior to treatment was 1.86 cm, and after treatment, it measured 1.85 cm thick, indicating that no significant change had occurred in thickness. After treatment, W2 measured 14.63 cm, compared to its pre-treatment length of 14.68 cm, representing a change of -0.34%.

Prior to treatment, the entire plank of wood was dark brown in color (10 YR/3/3 Munsell), while after treatment, W2 was a light, gray-brown color (10 YR/6/2 Munsell). The surfaces of the wood showed no signs of checking and the wood looked very natural. After treatment, W2 was very light in weight, and since then has withstood extensive handling with no signs of deterioration or wear.

W3 was treated with Q9-1315, after an initial dehydration in acetone. The wet weight of W3 was 91.3 g, while after treatment, W3 weighed 26 g, representing a change of -71.52%. The width of the sample was reduced from 3.14 cm to 2.98 cm, representing a change in width of -5.10%. The thickness of W3 was reduced from 1.84 cm to 1.62 cm, representing a change of -11.96%. The wet length of W3 was 14.73 cm, and after treatment, it measured 14.54 cm, representing a change in length of -1.29%.

While shrinkage was more of a problem with sample W3, the end result was more aesthetically pleasing than W2. Prior to treatment, W3 was dark brown in color (10 YR/3/3 Munsell). After treatment, the wood was slightly darker (10 YR/4/2 Munsell) than W2. Both W2 and W3 wood samples were natural in appearance and dry to the touch. The post-treatment color of W2 and W3 are illustrated in figure 10.

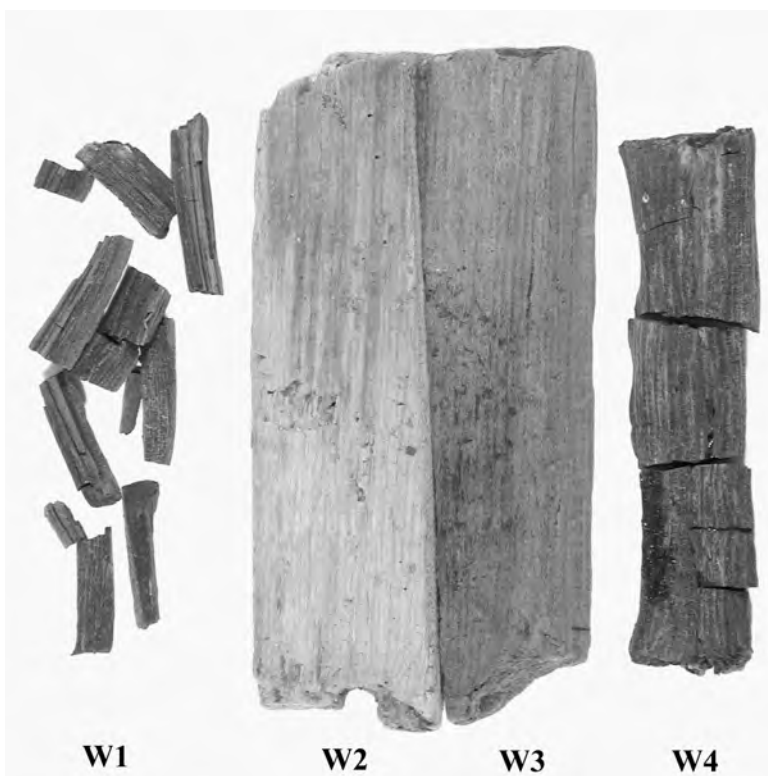


FIG. 10 Group 2 wood after treatment. W1, oven dried wood; W2, MTMS-treated wood; W3, Q9-1315-treated wood; W4, air-dried wood in vented fume hood. Note the comparatively lighter color of section W2.

The remaining section of wood, W4, was treated by air-drying. W4 was the larger of the two air-dried samples from the original plank of waterlogged wood, and in comparison to W1, W4 was more similar in size to the sections of wood treated with alkoxy silane polymers. Prior to treatment, its wet weight was 104.3 g. After treatment, it weighed 10.3 g, representing a change of -90.13%. Its width was reduced from 3.05 cm to 2.55 cm, representing a change in width of -16.39%. The thickness of the sample was reduced from 1.87 cm to 0.72 cm, a change of -61.50%. Post-treatment length of W4 was difficult to determine as the sample splintered into six large sections, each exhibiting gross distortion of its edges. Prior to air-drying, the sample measured 12.27 cm at its longest point. After treatment, W4 measured approximately 10.41 cm in length, representing a change of -15.16%. Figure 10 illustrates the post-treatment condition of samples W1, W2, W3 and W4.

The Group 2 samples were limited in number, simply because extraneous pieces of archaeological wood are in short supply for experimental purposes. The plank selected for experimentation was uniform in thickness and appeared to be uniformly soft to the touch. After drying, both samples W1 and W4 had deteriorated into a pile of splinters, making a comparison of pre- and post-treatment dimensions impossible. The wood was calculated to have the water content of 788.64%, based upon sample W1, which was considered to be more uniform than sample W4 (912.62% water content).

Group 3 Wood

Prior to treatment, the average percentage water content of the Group 3 waterlogged treenails was 321.55%, appreciably lower than the water content of 788.64% calculated for the Group 2 wood samples. During initial cleaning and desalination, the treenails were found to be less spongy than the sections of the plank (Group 2), and the wood was noticeably harder. Unfortunately, many of the ends of the treenails had either broken or been slightly splayed under the force of being removed from the ships timbers.

The Group 3 wood samples that were treated using MTMS alkoxy silane polymers experienced only slight changes in post-treatment weight and dimensions, in comparison to the Group 3 Q9-1315-treated wood. After treatment, the average weight of MTMS-treated treenails was 40.48 g, representing a percentage weight change of -45.74%. Treenails preserved using Q9-1315 polymer had an average weight of 39.32 g after treatment, representing a percentage weight change of -43.76%.

Group 3 treenails preserved using MTMS had an average change in length of -0.36%. The change in length was higher for Q9-1315-treated treenails, with an average post-treatment length of 121.76 mm, representing a percentage shrinkage of 0.49%.

Similarly, the average change in diameter for the Group 3 MTMS-treated treenails was substantially less than the average change in diameter for Q9-1315-treated treenails. The post-treatment average diameter for MTMS-treated wood was 25.74 mm, a decrease of 3.42%. Q9-1315 treenails had an average decrease in post-treatment diameter of 9.36%.

The most noticeable difference between the MTMS and Q9-1315-treated treenails was color. In all cases, the color of the MTMS-treated wood is much lighter than the Q9-1315-treated wood, which tends to be darker in color with fewer wood grain and surface features visible.

DISCUSSION

NMR spectral analysis, ESEM analysis and empirical data indicate that the structural integrity of the Group 1 tongue depressors was sufficiently degraded so that the wood samples can be used to evaluate preservation treatments for waterlogged timbers from shipwrecks. Group 1 wood samples provide a reasonably homogeneous source of wood, which allows for the quantitative and qualitative analysis of the effectiveness of consolidants being tested for use in conserving waterlogged wood. The regularity of size and species and the availability of non-waterlogged control samples makes the Group 1 wood samples invaluable

for waterlogged wood experimentation. Because of the inherent inconsistencies in waterlogged archaeological wood, similar comparative data would be very difficult to derive from archaeological samples.

MTMS-treated Group 1 wood samples were generally well-preserved. The average reduction in length was 0.41% after treatment, and the average reduction in width was 11.78%. The second figure seems high, but a comparison of the MTMS-treated samples to the untreated control tongue depressors shows that they are nearly the same, indicating that the treated wood was restored to the dimensions nearly identical to those of the control wood samples. The swelling that occurred in the tongue depressor during the waterlogging process had been greatly reduced after the wood was treated in MTMS. ESEM evaluation of these samples confirm that cell dimensions and shapes were similar to those of the control wood samples. A slight shrinkage of the middle lamella was noted after treatment.

Acetone/MTMS displacement of the Group 1 samples was conducted in a reduced pressure environment. In this environment, the boiling point of acetone is lowered, resulting in faster and more thorough evaporation of the solvent. Testing conducted in developing procedures for this experiment indicated that ambient pressure evaporation of acetone is sufficient to allow the uptake of MTMS without causing shrinkage or distortion of the wood being treated, while the use of a reduced pressure environment accelerated the displacement process.

After MTMS treatment, all of the Group 1 tongue depressors are slightly gray-brown in color (10YR 7/2 Munsell) when compared with the color of the control tongue depressors (10YR 8/4 Munsell). This shift in color is the result of changes in the wood caused by long-term immersion in water.

The Group 2 samples were highly degraded before treatment. The computed water content of the

samples was between 788.64% and 912.62%, suggesting that degradation and resultant water content was reasonably uniform throughout the plank. Oven-dried sample W1 and air-dried W4 were much darker in color than sections W2 and W3. This is the result of extreme cellular collapse and warpage that occurred as the result of drying. Both samples of wood had disintegrated so much that accurate physical measurements could not be obtained.

The conservation of samples W2 and W3 was considered successful as their physical dimensions, surface textures, and individual characteristics were accurately maintained. Lower rates of shrinkage were observed in the MTMS-treated wood sample W2. This section of wood is also lighter in color than sample W3, which is darker due to the slightly higher degree of shrinkage that occurred as the result of treatment in Q9-1315. Indeed, this degree of shrinkage suggests that the Q9-1315 solution does not contain sufficient alkoxy silane polymers to preserve badly waterlogged wood.

Because MTMS is 97% pure with a 3% addition of alcohols, this polymer has better resin-forming capabilities than Q9-1315, which contains approximately 44% MTMS mixed with organic solvents and trace amounts of dimethyldimethoxysilane. Accordingly, the resin-forming capabilities of the Q9-1315 solution are insufficient to preserve the dimensional characteristics of the wood, which is evident from the slightly higher rates of shrinkage for sample W3.

The diagnostic attributes of W2 and W3 were preserved because, as a result of condensation, sufficient resins were formed to prevent cellular collapse of the wood. Waterlogged tongue depressors and the archaeological wood samples preserved with the MTMS solution, which has a higher percentage of hydrolyzable, multi-functional alkoxy silane polymers, were the best preserved specimens of the groups. In contrast, the Q9-1315 solution, which contained a lower percentage solution of the same multi-functional alkoxy silane polymers, was insufficient to preserve the diagnostic attributes of the wood.

After treatment, the diagnostic attributes of Group 3 waterlogged treenails treated with MTMS were visibly better than the Group 3 samples treated with Q9-1315. MTMS-treated treenails did not exhibit scalloped surface features associated with cellular collapse. The shrinkage in these artifacts was minimal (0.36% average length shrinkage). The average post-treatment diameter change for MTMS-treated artifacts was -3.42%. All Group 3 MTMS-treated artifacts had shiny surfaces after treatment. This is a result of not allowing free-flowing polymers to drain sufficiently from the artifacts. As noted with Group 1 and Group 2 wood samples, the resin-forming potential of fresh MTMS is sufficient to preserve the physical appearance and cellular structure of waterlogged wooden artifacts.

In contrast, the resin-forming potential of Q9-1315 is diminished because of the addition of methyl alcohol (50%), isopropyl alcohol (4%) and ethyl alcohol (1%) (0.49% average length shrinkage). Post-treatment diameter shrinkage in these artifacts averaged 9.37%, indicating a substantial increase in shrinkage over MTMS-treated artifacts. The surfaces of the Q9-1315-treated artifacts had a matte, dry appearance after treatment, due to the fact that the less viscous polymer was able to drain more quickly than the MTMS solution

The wood that was treated using the higher percentage MTMS solution looks natural in color and texture following treatment. No surface checking was noted in either the Group 1 wood samples or the archaeological wood. Unfortunately, during the waterlogging process, the natural color of the wood was altered, resulting in a slight grayish cast to the preserved samples. The wood however, is dimensionally stable after treatment in the silane. This experiment indicates that the resins created as the result of condensation can preserve even badly waterlogged wood very well. While C.V. Horie and others have stated that conservation strategies using silicone oils are not reversible, over time the solubility of many adhesives and consolidants currently in common use in conservation are so affected, rendering these techniques also non-reversible.

Additional experiments are needed to determine whether the addition of small percentages of silicone oils might increase the bulking ability of MTMS and Q9-1315, effectively reducing shrinkage. A small percentage addition of a low viscosity silicone oil to Q9-1315 might increase its bulking ability despite its high alcohol content, making it as effective a treatment as MTMS.

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FIG. 1 “In a frame of black and gold carved by Gibbons, Sir Robert Walpole and Catherine Shorter; small whole lengths by Eckardt...,” after treatment. Overall frame measurements: 42 in. (107 cm) by 60 in. (152 cm) by 9 in. (23 cm).

TWO FURNISHINGS FROM STRAWBERRY HILL: EXPLORATION AND TREATMENT

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Williamstown Art Conservation Center*

ABSTRACT

This paper will focus on the conservation treatments of two objects that furnished Horace Walpole's Gothic Revival house, Strawberry Hill, in Twickenham, England and the information and questions that emerged in the course of the treatments. The first of these objects is a foliage-carved and gilded Baroque picture frame of circa 1700 that Horace inherited from his father, Sir Robert Walpole. In 1784 Horace attributed the carving of the frame to Grinling Gibbons. The frame's attribution is questioned here, notwithstanding its similarity to his work. The sequence of the frame's gilding preparation layers is described and may represent an experimental gilding method from the period. The treatment was prompted by an unfortunate accident, and this became an opportunity to address the historical questions, as well as the conservators' immediate concerns for surface consolidation, re-assembly, and structural support.

The second object is a neo-classic and Gothic Revival cabinet commissioned by Horace Walpole in 1784 to display a collection of drawings by Lady Diana Beauclerk. The cabinet is unique for its eclectic style and profuse decoration that includes the drawings, colorful stones and enamels, reverse-painted glass, Wedgwood ceramics, ormolu, and carved and gilded wood. The treatment required a collective conservation effort, and the close scrutiny provided information that may help in identifying period technology and the origins of decorative elements.



INTRODUCTION

The gilded Baroque picture frame (fig. 1) holds a portrait of Sir Robert Walpole (1676–1745) with his wife, Catherine Shorter, which Sir Robert commissioned John Eccardt and John Wotton to execute circa 1727. Horace Walpole's father, Sir Robert Walpole, had successful investments and a political career spanning the reigns of Queen Anne to George II. His wealth enabled him to rebuild and furnish the mansion at Houghton Hall, in Norfolk, England, seen in the background of the portrait. He assembled a considerable art collection at Houghton, and the portrait was painted to fit the foliage-carved frame that supports his painted crest. How he had acquired the frame has not been recorded, but its style and technology suggest an origin in the late 17th century, some 30 or so years earlier than the portrait.

In 1749 Horace Walpole (1717–1797) purchased Strawberry Hill, in Twickenham, and through remodeling and expansions he developed the house into the leading example of the Gothic Revival style, with an eclectic interior that was crowded with his diverse collections. In 1784 Horace placed the frame in the Blue Bedchamber at Strawberry Hill over a chimneypiece designed by Richard Bentley, and described it as “a frame of black and gold carved by Gibbons” (Walpole 1784, p. 28). Horace may have inherited the frame in 1745, or perhaps he had received it as an earlier gift, since he does not include the frame or painting in his detailed description of his father's collection at Houghton (Walpole 1743).

One of Horace Walpole's many additions at Strawberry Hill was the Beauclerk Tower, added in 1776 to pay homage to his good friend and neighbor, the artist Lady Diana Beauclerk (1735–1808). Within the



FIG. 2 The damaged frame in its packing crate on arrival at Williamstown.

small tower hung seven drawings by Lady Diana that illustrated Walpole's play, *The Mysterious Mother*. The neo-classical cabinet with Gothic Revival detailing (fig. 5) was commissioned by Walpole in 1784 to display another collection of Lady Diana's drawings, variously dated between 1775 and 1783, with subjects of a gypsy girl and children. The small cabinet was designed and made by Edward Edwards to conform to the intimate scale of the interior at Strawberry Hill, where it stood in the Great North Bedchamber (Walpole, 1784, p. 84).

Both objects were sold at the infamous Strawberry Hill sale of 1842, and they were eventually acquired in the 1930s by Wilmarth Sheldon Lewis. Lewis was a devoted scholar of Horace Walpole and is perhaps best known for having edited Horace Walpole's correspondence into 48 volumes. Lewis's extensive collection of Walpoliana, which included these two objects, was given to Yale University in 1979 and is housed at the Lewis Walpole Library, in Farmington, Connecticut.

THE FRAME

The treatment of the frame was prompted by an unfortunate accident, when the plaster that was holding the hanging nails gave out (fig. 2). The

painting was barely damaged in the fall due to the sacrificial protection of the frame. The frame's misadventure became an opportunity for the present exposure and documentation that enabled comparisons with other period survivors. Additionally, it was an opportunity to address a mass of surface consolidation that was desperately needed even before the accident occurred.

The first recorded photograph of the frame was published in 1914 (Tipping, 1914, p. 82) while it was in the collection of Lord Lansdowne, who had acquired the framed portrait at the Strawberry Hill sale. Lord Lansdowne added an inventory number, "77" in the bottom center. A second useful image was recorded in the 1930s when Lewis acquired the frame. A comparison of the photographs revealed several parts to be misaligned, loose, or missing, and the painting to be only precariously held by the rebate. The gilding and black decoration evident in the 1914 photo had deteriorated badly in the intervening years, and the smooth surfaces in the early image imply a recent restoration with over-gilding. Comparative analysis of gilding layers on Lansdowne's inventory tag with later layers on the frame (not completed during this treatment) may assist in the dating of overgilding.



FIG. 3 Detail showing the level of the glued lamination at the crest (A) and a carved corner platform (B) on which additional layers of carving were stacked.

FRAME CONSTRUCTION

The frame is constructed with four 1½-inch (29 mm) thick boards of linden (*Tilia* sp.)¹ that are joined at the corners with nailed lap joints. The wrought nails penetrate the back where they are bent over. Short miters are cut at the inside corners, and the rebate behind is carved, not planed. The choice of linden and the joinery method are consistent with the late 17th-century technology of Northern Europe (Thiel and de Bruyn Kops 1995, p. 12). Extra depth at the crest was built up with a glued lamination applied to the front before carving on a plane behind the faces of the *putti* who support the crest (fig. 3). Elements were also stacked, after being carved, in one and two layers, onto carved platforms at the corners, centers and sub-centers, and secured with glue and nails. An early use of wire armatures covered with a composition paste was noted for the modeling of the thin legs of the birds that perch in the top corners. Otherwise, the frame's ornament is achieved entirely with carved wood.

GILDING LAYERS

Cross section analysis and an instrumental analysis of particles showed an interesting sequence of gilding layers² (fig. 4). There are two early gesso

preparations; first on the wood is calcium sulfate (gypsum), which is followed by calcium carbonate (chalk). Then there is a thick protein layer, taken to be animal glue. This is followed by an orange/red bole, gold leaf, and edges of black paint, and concludes the original or early decoration. A restoration sequence follows, with more chalk gesso, bole, leaf, etc.

Evidently the cause of the extreme surface flaking is the inclusion of thick glue between the early gesso and bole, and this defies our present understanding of a successful gilding preparation. Nevertheless, thick glue without gesso has been reported as a preparation for gilding on a pair of contemporaneous Dutch frames (Bayer, 1997). Walpole's frame may show another experimental form of late 17th century gilding practice, although it is also possible that a previous intervention, yet to be identified, may have played a role in this sequence of layers.

It is an often-repeated notion today that calcium sulfate was used for gilding preparation in southern Europe, and calcium carbonate was used in the north, but our present northern example of gilding suggests an exception. Powell (1997) has

also suggested that there is no factual basis for the north-south distinction between chalk and gypsum for white gilding preparations. As we learn more about historic gilding layers through the use of analysis, we can look forward to a more detailed and coherent understanding of the regional use of white gilding preparations.

FRAME RECONSTRUCTION

Before the compromised structure of the frame could be addressed, all flaking gilding and paint was consolidated with thin gelatin size (~3%) applied by pencil brush beneath each flake, prior to pressing the flake into position.

Each splinter of wood was eventually relocated, the pieces having been carefully collected after the accident. Most wood breaks were secured using animal glue and various clamp forms, and the remnants of some old hide glue were removed in

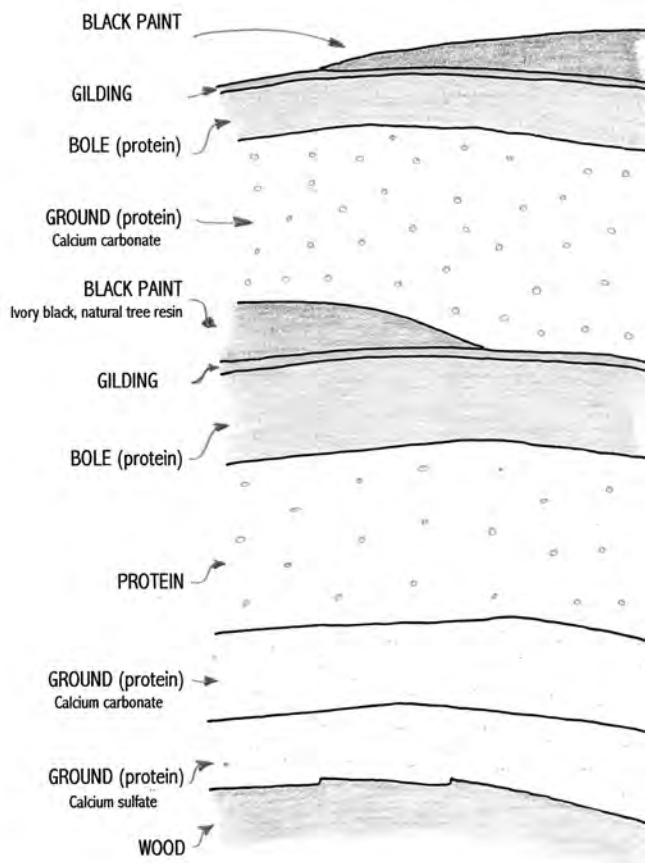


FIG. 4 Diagram of cross-section view of early and later gilding layers on the frame.

the process. Acryloid B72/acetone adhesive (1:1, by weight) was used as a more soluble alternative to secure non-structural elements, and allowing for some remnants of old hide glue to be preserved in place. The B72/acetone adhesive was also useful for securing irregular forms that defied positive clamping.

ADDING A BACK FRAME

There were significant cross-grain breaks across the width of delicate frame members compromising the structural soundness of the picture-framing device. A lightweight aluminum support frame was constructed and fitted to conform to the step of the rebate and frame back, and secured with screws using pre-existing screw holes that resulted from added metal plates on the back. The aluminum frame now supports the cross-grain breaks and houses the painting. It also usefully reduces the sight size by $\frac{3}{16}$ -inch (5mm), relieves pressure on the thin and fragmented sight edge, and supports the modern hardware that retains the painting and hangs the frame against the wall.

COMPENSATION FOR LOSS

Losses to the carved wood ornament were apparent in comparing the two photographs of 1914 and the 1930s. Older and larger losses were apparent by observing old breaks on surfaces and reading the symmetry of the surviving ornament. Any reconstruction of these old losses was beyond the scope of the treatment. Modeled and painted wax was used to continue the lines of three small stems which had suffered more recent losses and to reduce the impression of the most prominent gaps in the joinery. No new wet gesso gilding was added. Instead, areas of gilding and black paint loss were inpainted using stable colors in a soluble medium (Maimeri Restoration colors and mica pigments). These added materials are distinguishable and easy to remove, and they will not contribute to future flaking of the gilding.

ATTRIBUTION TO GIBBONS

Grinling Gibbons (1648–1721), the premier wood carver of his time, was born in Rotterdam to English parents. Sir Robert possessed a portrait

FIG. 5 The Beauclerk Cabinet, after treatment. Commissioned by Horace Walpole to display drawings by Lady Diana Beauclerk. Overall measurements: 50 ¼ in. (128 cm) by 19 ½ in. (49 cm) by 16 in. (41 cm).



of Gibbons as well as a number of his works at Houghton Hall (Walpole, 1743). Horace Walpole was so intrigued with the genius of Gibbons that he published a five-page account of the carver (Walpole, 1762–71) that has since been described as “picturesque” (Tipping, 1914, p. 46) and “far from trustworthy” (Green, 1964, p. 18). He owned the much admired point cravat carved in lime wood by Gibbons, now in the collection of the Victoria and Albert Museum and erroneously believed that an ivory relief set into his Palladian hanging cabinet was from the hand of Gibbons (Wilk, 1996).

Of 20th-century publications that address the work of Gibbons there are three that refer to Walpole’s frame (Tipping 1914; Green 1964; Beard 1989). However, the attribution they give appears to be based on the repetition of Walpole’s own attribution, rather than on a close visual inspection or direct comparison to documented examples.

During the course of the conservation treatment, the frame was examined by David Esterly, who was then preparing an exhibition of Gibbons’s work at the Victoria and Albert Museum, and an accompanying publication (Esterly, 1998). Esterly saw the frame as the work of an accomplished carver who may have had connections or training in the Low Countries. He thought familiarity with the work of Gibbons was implied by the choice of wood, overall design and construction, and the similarity of some foliage to known examples of Gibbons’s work. However, he questioned the handling of the undercutting and saw flower, leaf, cereal, and putti body and facial types that are not characteristic of Gibbon’s practice. He did not recognize the frame as the work of Gibbons or of his shop. The frame could be another example of mistaken attribution on the part of Walpole.

THE BEAUCLERK CABINET

By 1784 Horace Walpole had participated in many design collaborations with cabinet makers, architects, and artists, and he is therefore likely to have been involved in the design of the Beauclerk cabinet (fig. 5), made in that year to house a col-



FIG. 6 Interior view of drawer fronts, before treatment.

lection of drawings by Lady Diana Beauclerk. The cabinet is crafted with the best workmanship and materials of the period, and it was embellished with Walpole's collected treasures. It is small in scale, measuring 50¼ in. (128 cm) high, and encloses three equal sized oak-lined drawers that have negligible wear. A door conceals the brightly colored drawer fronts inlaid with polished stones, enamels, Wedgwood, and ormolu knobs (fig. 6). The unique design by Edwards, possibly with Walpole's input, provides an impressive neo-classic setting for Lady Diana's drawings, while the gothic additions repeat the theme of Strawberry Hill and reinforce Walpole's English heritage.

Altogether there are seventeen of Lady Diana's drawings framed under glass on outside surfaces of the cabinet, five on top, one on each side, and ten on the front. The sub-apron on three sides

holds fifteen triangular reverse-painted glass panels. Black jasper Wedgwood bas-reliefs are inlaid on each side, and a blue jasper relief is inlaid on the central drawer front. There are a total of sixty-four colorful inlaid semi-precious stones, possibly collected on Walpole's continental travels. Ten enamel roundels (origin unknown) depicting tropical birds in colorful foliage are inlaid into the top and bottom drawer fronts. Ormolu mounts (possibly) include side handles, the festoon on the front, drawer knobs, and the framing of the drawings. Water gilding on the exterior covers six round lion masks in the fluted frieze, carved leaves at the cuffs of the legs, carved pendants from the apron, blind Gothic tracery, together with carved wooden frames around stones, and architectural detailing. The woods employed include ebony veneers on secondary woods of mahogany and oak, and ebonized mahogany drawer fronts. This great variety of decorative material required the collaborative effort of a conservation team.

An engraved brass plaque was added by Walpole to the inside of the door that reads: "This cabinet was ordered by and made at the expense of Mr. Horace Walpole in 1784 to receive the drawings which were all designed and executed by the Right Honorable Lady Diana Beauclerk. The cabinet was designed by Mr. E. Edwards."

There had been some maintenance since 1784. Loose parts had been put back with glue and nails, detached parts were lost or stored inside, metals had been polished, while the gilding and varnish had been overhauled with added layers and had deteriorated a second time. The purpose of the treatment was to prepare the cabinet, after many years of quiet neglect, for the 1999 exhibition *A Treasure House in Farmington* at the Yale Center for British Art, New Haven, Connecticut.

DISMANTLING

The cabinet was dismantled down to its structural parts, all nails and screws were set out on cards and pencilled identification marks were recorded. A dovetailed oak liner within the cabinet with two drawer dividers was removed for access to screws



FIG. 7 The nine drawings removed from the door, during treatment.

into the base and cornice, and to the side drawings and handles. In order to remove the glass panels, the Gothic sub-rails were removed as well.

DRAWINGS

The drawings were executed on medium weight laid paper with gray and brown washes, some with graphite underdrawing, and details and highlights in black, red, gray, blue, and white (fig. 7). The paper had been cut to the exact size of the cover glass, backed with additional paper and sealed along the edges with goldbeater's skin. The glazed drawings were housed in brass/ormolu collar frames and backed with oak boards, and the frames fitted tightly into openings in the woodwork. The papers had become discolored due to acid migration from the oak backboards, and they had also become lightstruck to varying degrees.

The primary treatment for the drawings was their rehousing to isolate them from the acidic wood backings. It included surface cleaning with grated eraser crumbs, a dry soft brush, and a vacuum aspirator, with a focus on non-image areas and the avoidance of graphite underdrawing. Those drawings without water-soluble inscriptions could also be float washed in deionized water, after removing their stained backing papers with steam and a Teflon spatula. Edge tears on the drawings were mended with Japanese paper and wheat starch paste. They were then sealed as packages with their glass, Marvelseal® vapor seal backings, polyester tape edges, and interior backings of Artcare® and Microchamber® board and paper. The molecular traps and buffers in these products will protect the drawings from further pollution and degradation. The increased thickness of the packaged drawings, backed with their oak boards, meant that new nail holes were required in the sides of the brass-collar frames. The close tolerances for fitting the drawings into the cabinet did not allow for spacers between the drawings and the glass.

REVERSE PAINTED GLASS

The fifteen reverse painted glass panels set within the Gothic sub-rail depict the arms of Walpole (center front, fig. 8), his crest of a Saracen's head (center of sides) and strawberry leaves and berries (front and sides). The artist who painted the glass



FIG. 8 Detail of the painted glass panels in the front sub-apron, before treatment.

FIG. 9 The black jasper ceramic relief removed from the proper right side of the cabinet, after cleaning.



has not been identified, but the specificity of the panels suggests they were commissioned for the cabinet³.

It was difficult to remove the sub-rails and glass panels due to their entrapment in the cabinet's framing with added fasteners and glue, as well as the extent of flaking paint behind each glass. Fallen paint had collected in the lowest point of the framing behind the glass, and fragments that could not be put back in this treatment were collected in vials. Flaking paint was secured into place with Acryloid B72, and losses were inpainted with Acryloid B67 with dry pigments. Modifications to the rails were incorporated at the time of re-assembly, using small screws instead of glue and nails to allow for future access. Strips of polyethylene were also added to compensate for wood shrinkage, against the fixed dimension of the glass, and Mylar film was fitted between the glass and its wood backing to protect against abrasion.

WEDGWOOD

A black jasper ceramic relief is inlaid between the fluted frieze on each side and a blue jasper relief is inlaid on the center drawer front. Their porous surfaces were cleaned with an aqueous solution on cotton swabs. One cameo was removed from

its setting (fig. 9) during the re-gluing of the surrounding ebony veneer, and its reverse revealed the impressed Wedgwood mark of the period.

Walpole listed owning Wedgwood tableware and cameos with Lady Diana's designs, and he had several of her drawings and wax reliefs in frames that were decorated with Wedgwood cameos (Walpole 1784). Josiah Wedgwood included Lady Diana's drawings translated into bas-reliefs in his 1787 catalog, where he recommends their use for ornamenting furniture (Reilly, p. 607). Although there is no documentation linking Lady Diana to the design of the cabinet's ceramics, it is an intriguing idea that she might have participated in a project that was so intimately related to her work.

ENAMEL ROUNDELS

Walpole described the ten enamel roundels inlaid into the drawer fronts as "ancient enamels" (Walpole, 1784, p. 84). They are brightly painted over an all-white and modeled base, with a macaw perched in foliage within a circle of beads (fig. 10). The enamel bodies are mounted onto pierced and scored silver armatures that are attached to gold-colored back plates with wire⁴. The origin of the enamels has not been established, although they presumably came from Walpole's collection



FIG. 10 Detail of the enamel roundels, after cleaning the lower one.

and were given to Edwards for inclusion on the cabinet. Detached beads were reattached with Acryloid B72, and surfaces were cleaned with an aqueous solution on small swabs. Encrusted corrosion on the gilt metal backings was reduced mechanically.

SEMI-PRECIOUS STONES

A total of sixty-four semi-precious stones are inlaid on the cabinet's outside surfaces and on the drawer fronts. They, too, presumably came from Walpole's collection and like the roundels were also chosen for inclusion on the cabinet. The color of a lapis-lazuli stone set behind the center trefoil of the upper frieze is echoed in the blue painted backgrounds of the other trefoils in the molding. All of the stone surfaces were cleaned with an aqueous solution, and loose or detached stones

were reset with Acryloid B72/acetone adhesive. A missing stone in the top was replaced with an epoxy substitute with swirled pigmentation, cast from a mold taken from a similarly sized stone.

ORMOLU

Ormolu was the term used by Walpole in his description of the cabinet (Walpole, 1784, p.84), and we might have expected mercury-gilded ormolu produced by Matthew Boulton. However, after cleaning the mounts in an ultrasonic bath, the copper color and tarnish on the beaded top edge of the metal frames brought the presence of ormolu into question. The gold color normally associated with ormolu occurred only in the corners of the frames where the parts were soldered. Particles from one frame were analyzed for elemental surface composition using scanning electron microscopy with energy-dispersive x-ray spectrometry (SEM-EDS). Results indicated the back frame (rebate) to be copper and zinc (i.e. brass), the beaded front to be copper with minor zinc, and the gold-colored corners to be copper, zinc and iron. No gold or traces of mercury were found on the frame or in the interstices of a more discretely placed back plate of a side handle.

Boulton recognized that a high copper content (apparent on the beaded tops of the frames) was necessary to provide the best foundation for mercury gilding (Goodison, 1974, p. 70). One explanation for the absence of gilding is that it has been removed over time from cleaning with abrasive metal polishes, a point that is supported by abrasions through the varnish on adjacent wood surfaces. Alternatively, the mounts may have been originally lacquered. As to the ordering of the mounts, it is possible that the side handles and drawer knobs were a standard pattern obtained by Edwards, and that he special ordered the festoon to fit the span of the drawing below, together with the shapes and sizes of the beaded frames.

GILDED WOOD

The original water gilding on the carved, shaped and pierced wood elements had been over-gilded with gesso, bole, and leaf. A second generation of

deterioration had resulted in losses of wood and gesso, surface flaking, and accumulated grime. Gesso flakes were pressed into place and secured with gelatin size (4%), and missing tracery was filled with carved basswood inserts. An older application of varnish on the water gilding provided a means for cleaning with an aqueous solution.

Missing sections of the delicate carved wood frames around the stones at the top of the legs were cast in a bulked epoxy resin from a silicone rubber mold, trimmed to size, and after oil gilding, fitted into place with Acryloid B72/acetone adhesive. Most passages of missing gesso were replaced using gesso and red bole prepared with Acryloid B72 acrylic resin in xylene. After shaping the fills, new gold leaf was applied using traditional oil size, and these surfaces were toned with washes of pigments in an acrylic emulsion.

The origin of the six small lion mask roundels set between the fluting of the frieze is unknown, and their composition, whether cast or carved, was not determined since all of their surfaces remain covered with the gilding.

WOOD AND VARNISH

Insecurities in the structural wood joints, glue blocks and veneers were secured with hot hide glue or liquid hide glue, in conjunction with clamp pressure. In areas where water would have compromised the gilded surfaces or deteriorated varnish, Acryloid B72/acetone adhesive was used to secure decorative parts.

Varnished wood surfaces were cleaned with an aqueous solution, dried, and rinsed with mineral spirits, to remove grime and waxy accumulations. The surfaces were finished with a commercial paste wax during the final re-assembly in order to develop a reasonably even luster. No varnish was added to supplement the older varnish coatings. It was apparent that a heavier body of later varnish had been applied to the broader ebony surfaces, and only traces of an earlier varnish, possibly original, remained around the applied gilding. There is now a slightly irregular shine to the thin varnish

around the gilding and the stones, but this is hardly apparent when the whole cabinet is viewed.

A packet to be kept in one of the cabinet's drawers was constructed out of archival materials for all of the removed parts. Among the contents are the vials of paint fragments from the glass, backing papers from the drawings, together with redundant screws and nails that had been added over the years.

CONCLUSION

Conservation treatments provide the opportunity for the close scrutiny and documentation of objects. The resulting information can be useful for the identification of historic materials and techniques, and it can help the curator answer questions of provenance and attribution.

The design and execution of the black and gold frame drew on skills that were developed in the Low Countries in the second half of the 17th century. Eventually, the frame's school of woodcarving may be identified through comparison with contemporary carving. Also, the comparison of this frame's idiosyncratic gilding layers to other examples of the time will enable a more complete understanding of period gilding practices.

Just as the cabinet is the result of collaboration between Walpole and his artistic and eclectic circle, the treatment of the cabinet was a combined effort drawing on the skills of no less than seven conservators.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the collective conservation activity of colleagues at the Williamstown Art Conservation Center. With particular thanks to the participants of these two projects: Becca Johnston (paper), James Martin (analysis), Katie Holbrow (objects), Sandy Webber (paintings), Alex Carlisle (furniture), interns Antonio Mello and Adam Nesbit, together with the helpful staff of the Lewis Walpole Library, and David Esterly, woodcarver.

ENDNOTES

1. The wood sample was identified by The Center for Wood Anatomy, Forest Products Laboratory, Madison, WI. All species of *Tilia* look alike microscopically (Alden, H. 1995. *Hardwoods of North America*. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 118).

2. James Martin completed the analysis in 1997. Six randomly selected detached fragments containing multiple finish layers were examined using a stereomicroscope. Layered fragments were removed and examined using an Olympus microscope with visible light and fluorescence illumination. Particle samples were then removed from each representative layer for analysis by polarized light microscopy (PLM), Fourier transform infrared microspectroscopy (FT-IR), and scanning electron microscopy with energy-dispersive x-ray spectrometry (SEM-EDS).

3. Walpole collected painted glass and used it in the furnishing of Strawberry Hill. He had commissioned “a shield of Mr. Walpole’s arms and quarterings on painted glass, by Price” (Walpole, 1784).

4. Questions concerning method of manufacture (whether porcelain or enamel) were answered with analysis using SEM-EDS and FT-IR. The metal armature was identified as silver, with exposed areas showing silver sulfate (tarnish). SEM showed the colorful body to be fully vitrified.

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ABOUT THE AUTHOR

Hugh Glover received diplomas from the London College of Furniture (cabinetmaking, 1979), West Dean College (restoration, 1980) and City and Guilds of London Art School (conservation, 1985). After a year internship at Williamstown and an assistant conservator position at Philadelphia Museum of Art, he returned to Williamstown where he is Conservator of Furniture and Wood Objects, Department Head.

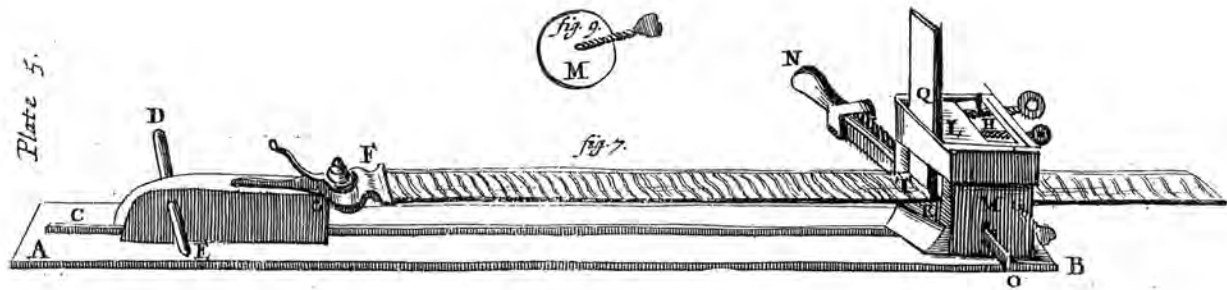


FIG. 1 "Waving Engine" from *Mechanick Exercises*, Joseph Moxon, 1678–80.

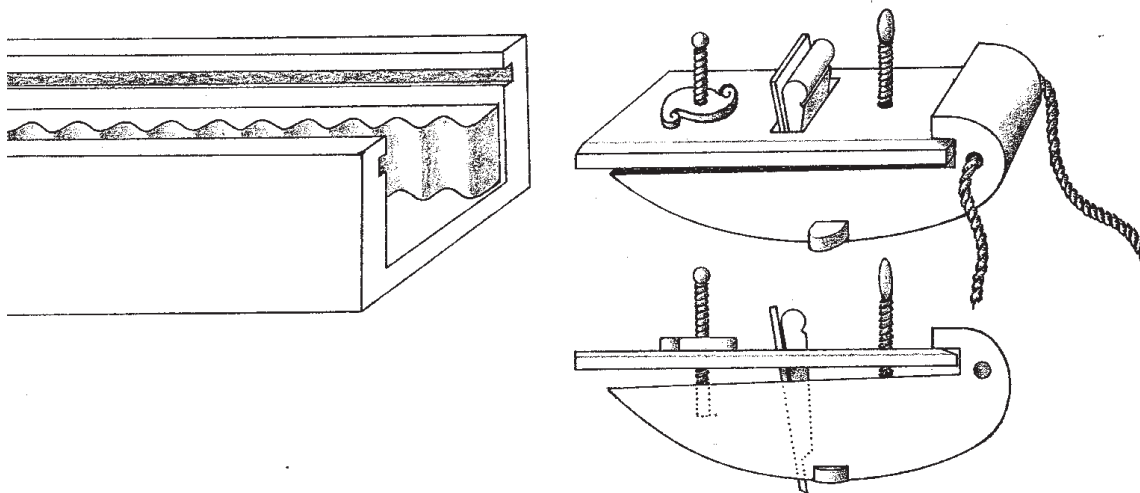


FIG. 2 Waveform molding plane and pattern-track, after an engraving in *Architectura* by Rütger Kaseman, 1630. (re-drawn by Thornton)

THE HISTORY AND TECHNOLOGY OF WAVEFORM MOLDINGS: REPRODUCING AND USING MOXON'S "WAVING ENGINE"

Jonathan Thornton

ABSTRACT

Rippled or waveform moldings (French—*moulures ondulées*), also called “flame moldings” (German—*flammeleisten* and *wellenleisten*), have been used in furniture and picture frames since the early 17th century. Reportedly invented in Germany, they rapidly spread to other European countries. They are popularly associated with Dutch baroque frames, especially when executed in ebony and ebonized fruitwoods. Devices for making these moldings all use a pattern and follower system to duplicate a waveform onto a stock piece. The device that is discussed in this article was closely based on the engraving and description in Joseph Moxon’s *Mechanick Exercises* of 1678–80. Details of construction and use of this reproduction “Waving Engine” (as Moxon called it) are given, along with examples of finished moldings and frames illustrating the tool’s versatility. Scattered published descriptions of this technology show a gradually increasing complexity of the devices from the 17th century to the present. This gradual replacement of a highly skilled operator using a simple device, by a complex machine that can be run by an unskilled operator culminating in the almost complete removal of an operator in the 20th century, illustrates larger trends in craft and woodworking over the last few centuries.



INTRODUCTION

Anyone with longstanding interests in woodworking and the history and technology of picture frames could not help but be intrigued by the complex rippled moldings that are most commonly seen surrounding paintings of the Baroque period. If that person is also a maker and collector of tools, as I am, then the construction of a device to make them is a strong temptation. It was years ago now that the temptation became almost an inevitability with my discovery of an engraving of such a device in Joseph Moxon’s seminal work on technology, *Mechanick Exercises*.¹ All I needed was the time, which was furnished by a semester sabbatical in 1994. I built a close reproduction of his device and have been exploring its capabilities as well as the literature on the subject ever since.

Moxon’s device intrigued me for several reasons: it was neglected or misunderstood in the available literature, it appeared that it would be capable of producing a variety of complex waveforms and it was the only type of such devices that to my knowledge had not been faithfully reproduced (although a somewhat modified version had been published in *Fine Woodworking* in 1986²).

The device, called the “Waving Engine” by Moxon (fig. 1), works on a relatively simple principle. A stock piece is fastened to a guide or template rod carved into a waveform, and they are pulled together through a stationary cutter. As the guide rod rises and falls over a polished feeler bar, the waveform is gradually cut into the stock piece by a fixed blade. While the principle is simple, the devil is in the details.

HISTORY

Waveform moldings can be divided into two types. The German literature makes the distinction between *wellenleisten*, or moldings that undulate up and down in the vertical direction (perpendicular to the molding length) and *flammeleisten*, which undulate from side to side (also in an axis perpendicular to the molding length). This distinction is apparently less linguistically rigid in English. Moxon for example describes the up and down form as “waved” moldings. Later literature has used the term “wave” to describe the horizontal undulation and “ripple” to describe the vertical form. This seems to be the clearest convention in modern English, and that is how I will describe them.

This type of wooden molding was probably first developed in Germany around 1600.³ There appears to be agreement in contemporaneous sources that the inventor was Johann Schwanhardt,⁴ a cabinet and gunstock maker who died in 1612, at which point the method seems to have been reasonably widespread. The makers of silver boxes may have been the first craftspeople to use the technique extensively.⁵ Such silver boxes were often combinations of silver and ebony. Ebony is one of the woods that was extensively worked into ripple moldings. Very hard tropical woods such as ebony were newly arriving in Europe, particularly as a result of the trading activities of the Dutch East India Company after the beginning of the 17th century.⁶ European craftsmen needed to develop new ways of working such timbers, and the slow scraping action of waveform molding devices would have fit the bill. Frames completely covered with rippled and waved moldings are often considered to be typically Dutch, but recent scholarship has disputed this popular opinion.⁷ Such exuberant frames were most likely made in the Catholic parts of Europe; southern Germany and Flanders, and Spain.

The earliest form of a device to make waveform moldings (fig. 2) seems to have been based on cabinet and molding planes and is illustrated in a work of 1630 by a woodworker, architect and

sculptor.⁸ The moldings are planed into a side-to-side waveform by a plane that moves in a closed track similar to a long miter box. On the sides of the box are undulating guide strips. A peg inserted through a dado on the sole of the plane and projecting slightly out of the sides engages the guide strips and causes the plane to move in a wave motion as it is pulled down the track and over the stock piece, which is fastened into the bottom of the track. The plane itself has a screw-operated device, which increases the depth of cut by advancing the entire plane downwards. This is surely the first woodworking plane to use a screw adjust of any kind, as such mechanisms were not widely used until the late 19th century.⁹

This wriggling plane of 1630 appears to be capable of only the side-to-side action, and so would have produced wavy moldings or *flammeleisten*. The method for making waveform moldings of all sorts appears to have been fundamentally rethought during the first half of the 17th century, resulting in devices in which the blade is stationary and the stock piece and template bars are the moving elements. The simplest of such devices is a frame holding both a blade and a feeler bar mounted on the end of a screw-feed pressure block. The guide bar and the stock piece are both pulled through this frame by the worker without any additional guides or adjustments. An apparatus like this, residing in an Austrian folk-life museum, was described by Hans Mayerl¹⁰ and reconstructed by him. He appears to have been unaware of Moxon’s description and illustration, which represents a more developed version of this same general method.

The technological developments did not end with the device described by Moxon. By the third quarter of the 17th century, machines to do this job had become even more sophisticated, particularly in France. Instead of the work-piece and guide templates being pulled through the cutter head by hand, they were cranked under a fixed blade by means of a cogwheel that engages a rack lying on the underside of a moving bed. The blade is spring loaded, so that it can be gradually screwed

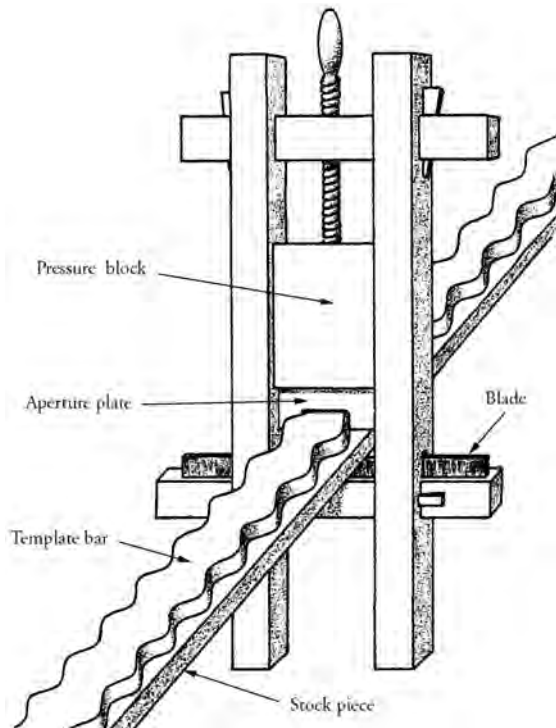


FIG. 3 An early type of device for making waveform moldings, after Hans Mayerl, 1975. (re-drawn by Thornton)

downwards to take progressively deeper cuts. The type of machine that would predominate during the 18th century was first illustrated and discussed by the French writer Andre Felibien in 1676.¹¹ The method continued in use with only minor variations for over one hundred years. Machines similar to that of Felibien are to be found in the work on cabinet making by Roubo¹² as well as in the Diderot Encyclopedia,¹³ both during roughly the same time period (second half of the 18th century). It is versions of this machine that have been reproduced and used by a few modern experimenters. I am aware of those by Cornelis Van Horne¹⁴ in this country, and van Soestbergen¹⁵ in the Netherlands. Interestingly, while Moxon certainly knew of the work by Felibien, and based his engraving of cabinet maker's tools on Felibien's illustration,¹⁶ he chose to show an earlier type of the ripple molding machine, one he probably learned of during his earlier years in Holland.

Joseph Moxon was the son of the radical Puritan printer James Moxon, who was exiled to Holland with his family from 1637–43. Joseph learned the printing trade from his father, and pursued it on his own after he returned to England. In addition to printing, he made and sold globes and instruments for mathematics and navigation. He designed and cut type, and wrote the first book on the art of printing.¹⁷ With these various activities, Moxon became of necessity something of a jack-of-all-trades. He writes as one who has seen or done all of the things he describes. It is for this reason that his works were so influential in an age when as Francis Bacon said, it was "esteemed a kinde of dishonour to descend to enquire or Meditation upon Matters Mechanicall."¹⁸ Ephraim Chambers refers to Moxon's influence in his practical Encyclopedia of 1728, and the Diderot Encyclopedia began as a translation of Chambers. It is reasonably certain that Moxon described the work methods and tools of practicing craftsmen, and this was revolutionary for his time. It is not known however, whether the "Waving Engine" that he describes and illustrates is based on memory or his own current practice.

MAKING THE MACHINE

The illustration of the device that Moxon provides (from a plate almost certainly engraved by himself) presents a few problems of interpretation, and Moxon's description, while fairly thorough omits some important information. My intent was to

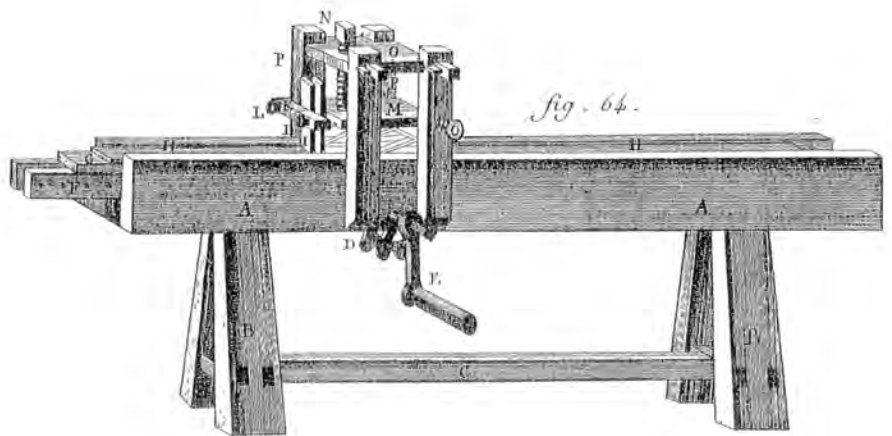


FIG. 4 Complex machine for making waveform moldings, from the *Encyclopedia* of Diderot and d'Alembert, 1751–87.

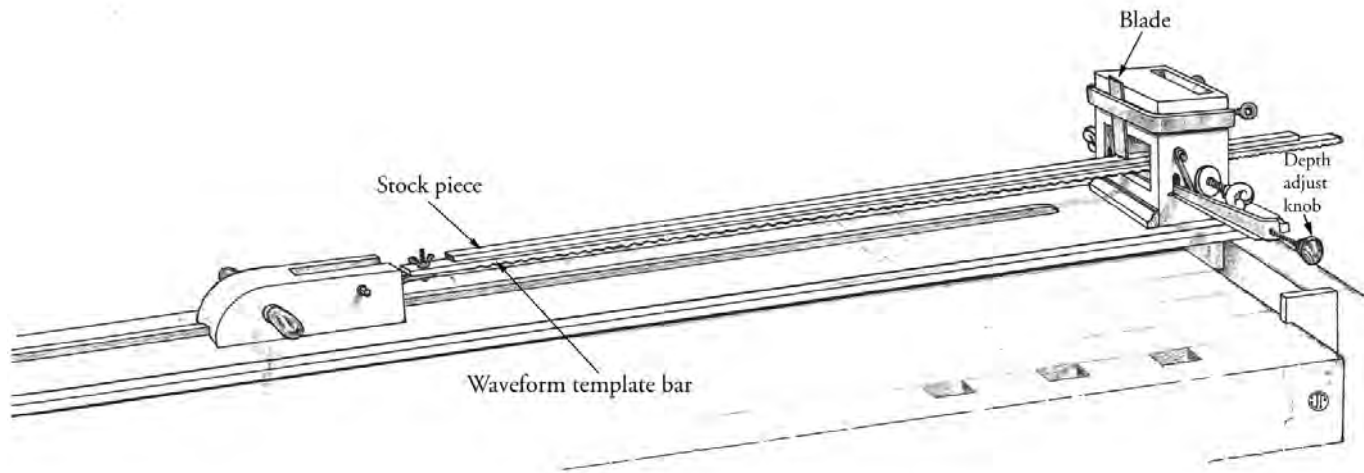


FIG. 5 Overall view of a reproduction “Waving Engine” of the Moxon type. (drawing by Thornton)

make Moxon’s “engine” to his specifications, and if modifications had to be made, the reproduction itself would tell me what to do, and not my own second-guessing.

“The Waving Engine...hath a long square Plank...All along the length of this Plank, on the middle between the two sides, runs a Rabbet...Upon this Rabbet rides a Block with a Groove in its under side...the Groove in the Block is made fit to receive the Rabbet on the Plank.” (Joseph Moxon)

I made the plank from quarter sawn sycamore (lacewood). The rabbet I made from hard sugar maple, likewise the block that rides on it. This is the block that pulls both the patterned template and the stock piece through the cutter head. Moxon attaches these elements to the block with

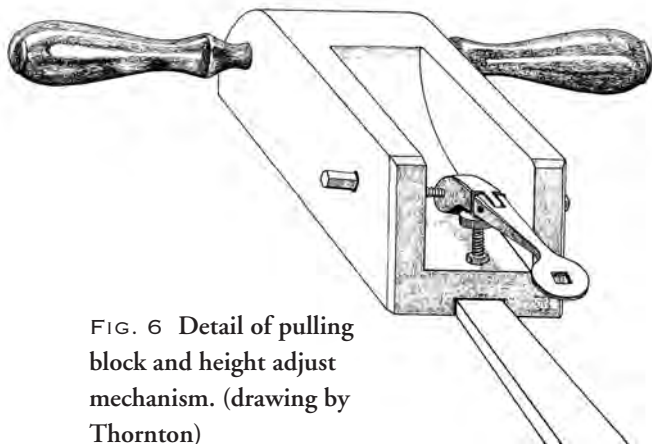


FIG. 6 Detail of pulling block and height adjust mechanism. (drawing by Thornton)

a “Vice, somewhat larger than a great Hand-vice....” In considering this, I made the only major deviation from Moxon’s machine. I didn’t see how a fixed vice could easily follow the up-and-down motion of the guide rod (“rack”) and stock (“riglet”), let alone the gradual raising of these strips as the molding was cut. I suspect that simple looseness of fit allowed Moxon’s machine to accommodate these movements. In place of the hand-vice, I forged a tongue with a hinged box-joint (mortise and tenon) much like the joint in a pair of pliers. The tongue would move to accommodate any adjustment upwards. The tongue itself was fastened into the block with a rod, which threads through it and also penetrates the block (at an angle—the purpose of which I will make clear). By means of this rod, I can adjust the attachment point to accommodate different widths of stock. In addition, I placed a support rod and knob under the end of the tongue and likewise threaded into the block, so that I could raise the attachment tongue correspondingly as the strips rose. This modification does not alter Moxon’s method in any important way, while making the machine easier to use.

“At the farther end of the Plank is erected a square strong piece of Wood...This square piece hath a square wide Mortise in it on the Top...upon the top of this is a strong square flat Iron Coller...”

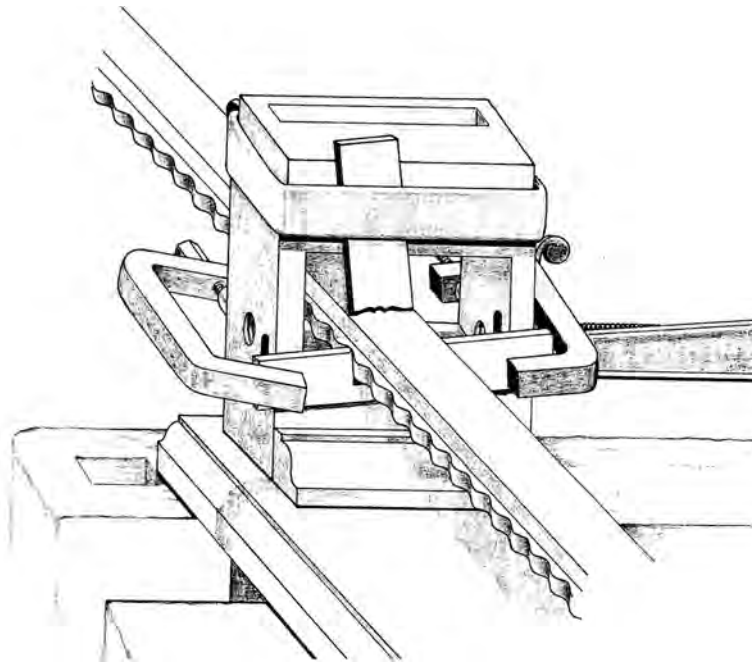


FIG. 7 Detail of cutter-head and slide-board clamped into the end-vice of a cabinet makers workbench. The device is set up to make a side-to-side (*flammeleisten*) waveform molding. (drawing by Thornton)

This is the business end of Moxon's device which I call the "cutter head." My upright block was made of a single piece of maple, with the appropriate mortises as described. I added two projecting through-tenons to fasten the block into the plank, so that they could be gripped by the end-vice of my workbench when the machine was in use, and allow me to easily disassemble the machine when it was not. The purpose of the collar is to clamp the fixed scraper-type blade perpendicular to the stock piece. My collar was forged from mild steel, as were the screws that tighten it on the block. Like Moxon, I forged perforated disks on the ends of the screws, so that a bar could be inserted to tighten them with lever action. It is important that the blade not move while in use.

Moxon is at his sketchiest when it comes to how the depth of cut is gradually increased, although the engraving seems to show what the description omits. A bar is shown penetrating the block underneath the "rack" that appears to be both tapered and furnished with a threaded rod for gradually advancing it under the work. There can be no other way to do this in a controlled way. Jutzi and Ringger in their discussion of Moxon's machine had a

different interpretation.¹⁹ They speculate that this knob, projecting out of the far side of the machine, was used manually by a helper to lift the guide rod and workpiece against the blade. Moxon however, refers to this as "a wooden screw called a Knob." He also appears to illustrate, though he does not discuss, the taper of the polished rod that is advanced by this screw-knob. It seemed clear to me what he intended: I made a steel bar with a T-shaped cross section that would slide through T-shaped slots in the block. I put the taper side up, as Moxon appears to do, and simply accounted for this cant in the rack and "riglet," by setting my attachment-tongue into the pulling block at the same angle. I captured the end of my adjusting screw-rod with a sort of clutch lever that would allow me to easily disassemble the machine, an alteration necessitated by my own tight space that again, did not alter Moxon's device in any important way. The screw-rod uses a fine thread so that I can very gradually raise the work under the cutter. In use, one or two revolutions of a rosewood knob on the end of this screw increases the depth enough for the next cutting pull. The handles on my pulling block were also made of turned and polished rosewood, press-fitted onto a steel rod, which runs through the block, again for ease of knock-down.

"But before you draw the Rack through the Engine, you must consider the Office...of the iron screw...for by these screws, and the Rabbet and Groove, your work will be evenly gaged all the way...under the edge of the iron."

Moxon shows only one screw, though he refers to them in the plural. These screws serve to keep the work "gaged" under the blade. The end of the screw shown was fitted with a flat iron disk, that appears to be a sort of wear-plate against the moving template and workpiece, called the "rack" and "riglet" respectively by Moxon. Jutzi and Ringger speculate on two screws, one from each side, that enter at an angle. Their drawings are interpretive

reconstructions as they did not build such a device. I believe that Moxon clearly shows a screw entering perpendicular to the cutter-head block. I also decided to use two screws, so that I would have greater flexibility than could be achieved with just one, though the inside surface of the cutter head could have conceivably gauged the other side of the strips. Instead of iron, I made my screws from lemon-wood (*Calycophyllum candidissimum*), a beautiful close grained relative of box-wood, and equally hard-wearing. I threaded these with the Beale® router attachment, and made decorative double volute-shaped flanges on the ends similar to the screw end shown by Moxon. I decided that locking washers were a good idea if I wanted to keep my work well “gaged.” I made these from rosewood also, and placed them on the outside of my block where they are easier to get at.

My blades were made from 01 steel, a high-carbon, oil-quenching tool-steel that has low warp characteristics in hardening, and can be tempered to create a tough and hard blade. The blade “whose lower end is cut into the form of the Molding you intend your work shall have...” has a single bevel facing towards the pulling block. I filed and ground the shapes before hardening the blades. I sharpened them once on the bevel, then subsequently only on the flat side.

“Then if you lay hold of the handles of the Block...and strongly draw upon them, the Rack and Riglet will both together slide through the Mouth of the wooden piece... and as the rounds of the Rack rid over the round edge of the flat iron...the Riglet will on its upper side receive the Form of the several Waves on the under side of the Rack, and also the Form, or Molding that is on the edge of the bottom of the iron, (blade) and so the Riglet will be both molded and waved.”

The final form of the moldings is dictated by the shape of the blade, by the form of the template or combined templates, and by the attachment point of the pulling block. The number of pos-

sible designs is multiplied by the addition of any of these elements, and quickly becomes astronomical. Even with my still limited stock of blades and templates, I will probably never produce all of the possibilities.

USING THE MACHINE

I have continued to explore the capabilities of this tool in the years since I first made it, and it has provided both mental and physical exercise. In action, I hold the tongue down with my finger as I push the strips through the machine for the return stroke, then I “draw strongly” on my handles. Depending on how deep the molding is going to be, and this is dependent on the wave amplitude of the template, I will continue to make cutting strokes until the moldings are complete. I take coarse cuts (Moxon would say “rank”) to start out with, but by the end, when the blade is bearing



FIG. 8 Making a molding on the Moxon “Waving Engine.”

more-or-less continuously, the shaving needs to be thinner than paper. I can complete some molding strips in fifteen to twenty minutes, but deep moldings in a hard wood take more time.

Any wood that is hard and relatively dense will work well for the molding strips. Cherry is excellent, as are pear and maple. Many of the period moldings are executed in either ebony, or a fruit-wood stained to look like ebony (ebonized). I have gotten by with poplar for molding with a gentle wave. It's best if the grain rises away from the pulling block so that the wood fibers are severed more obliquely. Earlier on, I mounted the molding strips to the "racks" or guide bars with a few dry-wall screws shortened so that they did not come through the surface of my moldings. I still had to make them relatively thick however, and they were only held firmly in a few places. Now I prefer to use the wood turner's trick of gluing the stock piece to the template with pieces of heavy brown paper. The finished molding is then taken off by splitting the paper interleaves, and scraping the glue and paper residue away.

The "racks" are made of hard maple. I have hand-carved some of them after stepping off the intervals with a divider, by using the same gouge across the grain both bevel side up and bevel side down. I have also used a pin-indexing jig on my table saw and router table T-slide like those jigs used to cut box-joints. I did this to create bars with tight waves that would have consumed a lot of time in carving. The mathematical accuracy of this method can be both an advantage and a disadvantage depending on your point of view. Historic ripple moldings have subtle variation and character.

No sanding is required on a properly cut molding. The blade leaves an almost polished surface in a wood like cherry. I also discovered that pushing the molding back through the cutter-head for the return stroke burnishes the molding against the polished bevel of the blade. Stain will greatly accentuate the wave appearance by selectively penetrating the severed wood fibers on the insides of the wave troughs.

WAVEFORM MOLDINGS

Moxon appears to discuss and illustrate only the up-and-down rippled moldings, and not the side-to-side type called *flammeleisten* in German. It is fairly easy however for his machine to be adapted for this purpose, and I had intended to do so from the start. It was in thinking about this function, that I chose to provide it with two "gauging" screws that would end in relatively narrow and rounded wooden ends—not the large wear plate shown by Moxon. Using these, a template with a side-to-side waveform could be guided through the cutter head on both edges. In use however, the side screws tended to loosen due to the extreme vibration. I solved this problem by making thin pieces of wood that had wide slots cut into one side exactly matching the width of my guide rods (fig. 7). These slips of wood are then clamped to the front of the cutter-head with two C-clamps. The guide rods slide through the aperture as the moldings are cut. The early type of device illustrated by Mayerl (fig. 3) solves this problem in a similar way.²⁰

The side-to-side waveform guides can be used alone, or stacked with an up-and-down guide for a complex compound effect. The sides of these template strips need to be of absolutely consistent width, so that they will pull evenly through the machine with guides bearing on both edges. There are two methods that I have used to ensure this: In the first method I start by making a thicker bar which is waved on only one (top) side and flat on the bottom. This is done on the "Waving Engine" itself. I rip this bar down the middle perpendicular to the wave surface, and book-match the pieces back together with a glue join along the flat (formerly) undersides of the strips. Since the edges started as the same surface, they can't help but be parallel. The second method uses a guide rod for a ripple molding, but this is fastened to the piece that will become my new guide rod so that the waves are perpendicular. I run the guide rod along a V-block mounted to my router table fence, so that the router blade cuts the waves on one edge of the new waveform guide rod. With the ripple guide rod removed, I rout the other edge using



FIG. 9 A selection of moldings made on the Moxon “Waving Engine.”

the first-routed edge as the reference against the V-block. This is efficient, but will work for large waves only, since the circumference of the router blade limits the tightness of the waveform.

DISCUSSION

Devices of the sort typified by Moxon’s machine did not come from nowhere. In essence, his waving engine uses a system of guides running against a “feeler” or “follower.” Such systems were on the technological cutting edge in the late Renaissance, and were to inform ever-growing complexity in tools and machine tools right up to the present. The first such systems were used for cutting screws and ornamental twisted turnings on the lathe. The earliest illustration of such a device dates from 1480.²¹ It uses a carved screw-form cranked through a follower block to impart a regular movement to the work-piece as the spiral is cut by a stationary cutter. An even more complex ornamental lathe was designed by Jacques Besson in 1579.²² Besson was Da Vinci’s successor as engineer to the French Court. His ornamental lathe uses a system of patterns and followers that either guide a moving cutter, or guide the work past a fixed cutter.

Spiral grooves were also cut into the inside of rifle barrels using similar systems. In the process

of rifling a gun barrel by hand, a carved spiral fastened to a rod with a cutter on the end is pulled through a feeler guide, imparting this spiral motion to the cutter inside the barrel. Rifling can be traced to as early as the end of the 15th century.²³ It may be significant that the purported inventor of rippled moldings, Johan Schwanhardt was among other things a gunstock maker.

The use of patterns and followers introduced a particularly productive lineage in tool making and technology. Following this line of descent, the screw-cutting lathe leads to complex ornamental lathes, to rifling of guns and ripple molding machines. Other later developments that use pattern and follower systems include the Jacquard loom, the earliest mechanical computational devices, duplicating lathes and carving machines, as well as the key-card systems, which led to computers. Historically speaking, Moxon’s device was near the beginning of a fruitful concept.

Another interesting historical point concerns the natural progression of the machines that were used to produce complex waveform moldings. The devices show a steady increase in complexity. Why should this be so if they all do essentially the same thing? The late 17th-century device of Felibien and the mid-18th century devices of both Diderot

and Roubo are more complex machines in every way, but they are still based on pattern and follower systems. In these devices, the entire table, to which the stock piece is fixed, is cranked back and forth under a fixed blade. Machines of this sort require no skill in operation as any worker could stand and crank, whereas my own and Moxon's device require relatively more effort and finesse. It may have been that the shear demand for luxury goods during this period drove the increasingly mechanized production of waveform moldings. There were also social changes at work that de-emphasized the skills of individual master-craftsmen, in the interest of manageable and efficient production changes that have continued to the present day.

What happened to the devices that created waveform moldings can be thought of as a capsule history of woodworking—as machines have grown in complexity, the necessary skills of the operator have declined. Earlier craftsmen relied on relatively simple tools, guided by hand, eye and body skills developed over a long time and with constant practice. As Moxon himself says, “The Cunning or Sleight or Craft of the Hand cannot be taught by words, but is only gained by Practice and Exercise.” A level of skill made possible by both the intellect and careful, lengthy training is replaced by reasonable care and thought, coupled with complex machines that can be set up to accomplish most tasks. Skills that are reliant on training, like those of athletes, allow complex motions to be reproduced with some degree of reliability, but they are steadily replaced by ‘skills’ that are more purely intellectual. Using the simplest tools successfully then has more in common with sports than the sort of jig and machine-based woodworking practiced widely today by both industrial and hobbyist woodworkers. Tools change as people change and vice versa.

The historian of design David Pye put forward another telling distinction.²⁴ He divides craft practices into workmanship of “chance” and of “certainty.” Workmanship of chance employs techniques that can and often do result in varia-

tion in the result. To return to the sports analogy, any fan can testify that even the best training does not produce a certain result. Moxon himself in discussing the “Barbarous sort of working which is used by the Natives of America” says that “they know neither of Rule, Square, or Compass; and what they do is done by Tedious Working, and he that has the best Eye at Guessing...” This sort of craft-work, barbarous to Moxon is typified in objects we now place a positive value on as being “handmade.” In eras when everything was handmade however, the aim of the careful worker in the European tradition was to reduce variation by skill and increasingly, by ever more complex tools. Such perfectionism was pursued into the machine age resulting ultimately in techniques that typify workmanship of certainty. The aim of industry after all is quality control, which means the absolute reproducibility of a desirable result. The history of wave-molding devices also advances along this continuum towards ever greater certainty of result, coupled with ever decreasing skill in use.

Another recent device for making ripple moldings, as described in *Fine Woodworking*²⁵ serves as a modern endpoint. It was developed with no apparent knowledge of earlier machines, and so “reinvents the wheel.” As a reinvention, it recapitulates the history of these devices by using a cutter-carriage, which rides over a fixed molding, as does the very earliest device. It is run with a motor, which powers a long threaded rod that carries the entire cutter carriage. With a reversing switch at each end it can be left unattended as it traverses doggedly up and down the molding. It combines the earliest and simplest concept with the convenience and perfection of the twentieth century, and with minimal input of labor. It is a sort of seventeenth century/machine-age Wave-O-Matic!

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AN EVALUATION OF FOUR BARRIER COATING AND EPOXY COMBINATIONS IN THE STRUCTURAL REPAIR OF WOODEN OBJECTS

Lisa Ellis and Arlen Heginbotham

ABSTRACT

This investigation was undertaken to determine the suitability of two synthetic resins for use as barrier layers in the bonding of wood with epoxy. The two materials in question, Paraloid® B-72 and Acryloid® B-67, were chosen because of their potential to be practically reversible in low polarity solvents. The two polymers were compared, as barrier materials, to two proven barrier coatings, hide glue and Butvar B-98, by measuring their strength in shear according to ASTM standard D 905-98. Investigations were also undertaken to determine the amount of time necessary for barrier layers to dry prior to application of epoxy. Finally the practical reversibility of the barrier coatings was empirically evaluated. Paraloid® B-72 was found to be a suitable barrier material in all respects, while B-67 failed both strength and reversibility tests.



INTRODUCTION

In the conservation of wooden artifacts, it is often necessary to repair broken wooden elements which serve a structural or load-bearing function. Such repairs must have high strength, yet be reversible in the future. Where the break in question is recent and the mating surfaces are clean and undisrupted, animal hide glue is widely accepted to be a suitable adhesive, though in practice, reversal of intact hide glue bonds can be problematic. In cases where the mating surfaces are dirty, damaged, or a gap filling adhesive is needed, animal hide glue may have greatly reduced strength and an alternative adhesive may be required. Bulked epoxy resins have found wide use in such instances, and some have the additional advantage that after setting they can be carved, sawn, sanded, and finished, allowing them to be used simultaneously as both adhesive and fill material. One commercially available product of this sort which is widely used by furniture conservators is Araldite 1253, a carvable paste epoxy, bulked with titanium dioxide, amorphous silica, iron oxide, and phenolic resin (Ciba, 2001). The primary disadvantage of using epoxies in conservation is that, once cured, they can be extremely difficult to reverse.

Barrier coatings are widely used in conservation to add a measure of reversibility to an otherwise irreversible adhesive bond. The barrier material is applied as a thin film to both mating surfaces prior to application of the primary (irreversible) adhesive. Subsequently, if reversal is required, the barrier layer can be softened or dissolved, releasing the bond. In the conservation of wooden artifacts, animal hide glue has been used as a barrier material for epoxy joins due to its high strength, ease of use, and its familiarity among furniture conservators. Hide glue, however, has certain disadvantages as a barrier material. First and foremost, it is not always reversible in a safe and practical manner. Reversal depends on moisture and/or heat, both of which can cause damage to wood and associated finish materials. Some promising work has been reported using microwave radiation to reverse hide glue bonds (Neher, 1997); however, the equipment necessary is quite expensive and the technique has not gained wide acceptance. In addition, hide glue is known to weaken when exposed to extremes of humidity (Buck, 1990) and may degrade over long periods of time.

Recognizing the difficulty in reversing repairs made using hide glue as a barrier, and seeking an appropriate alternative, Anderson and Podmaniczky tested the suitability of Butvar B-98 [poly(vinyl butyral)] as a barrier layer for epoxy joins in wood (Anderson and Podmaniczky 1990). B-98 is often referred to simply as a poly(vinyl butyral), but it is actually a co-polymer of poly(vinyl butyral), poly(vinyl alcohol), and poly(vinyl acetate) in a ratio of approximately 40:10:1 (Horie, 1987, 101–102; Monsanto, 1994). This polymer was recently shown experimentally to be a suitably stable material for the consolidation of dry archaeological wood (Spirydowicz, *et al.*, 2001). Reporting on the results of their testing in the 1990 article, “Preserving the Artifact: Minimally Invasive Conservation Treatment at the Winterthur Museum,” Anderson and Podmaniczky noted that while barrier coatings should help make epoxy repairs more easily reversible, they must also maintain the overall strength of the bond. The results of their work demonstrated that Butvar B-98 dissolved in ethanol is a suitably strong barrier material when used in conjunction with the bulked epoxy, Araldite 1253.

Butvar B-98, while a good alternative to hide glue as a barrier material, also has significant limitations with regard to its reversibility. B-98 is soluble in polar solvents such as alcohols and in certain mixtures of polar and non-polar solvents (Monsanto, 1994; Spirydowicz, *et al.*, 2001). Unfortunately, many varnishes and paints traditionally used to coat wooden artifacts are also sensitive to this range of solvents, making it difficult or impossible to dissolve a B-98 barrier layer without damaging an adjacent surface coating. This is particularly true because extended exposure (to liquid or vapor) may be necessary to allow the solvent to penetrate deep into the repair and dissolve the barrier. Even after Anderson and Podmaniczky’s important study, therefore, there remained a need for a well-tested barrier coating of high strength which could be reversed in low-polarity solvents.

In this study, the authors chose B-72 and B-67 for comparison with the other proven barrier adhe-

sives because they have advantageous dissolution properties, they are readily available, and they are well known and widely used by conservators. Paraloid® B-72, a copolymer of ethyl methacrylate and methylacrylate, is a Feller Class A material and is not known to become insoluble or degrade over time (Horie, 1987, p.106). It is soluble in low polarity solvents such as xylenes which will not dissolve most historic furniture finishes. Its inclusion in this study seemed obvious: it is a mainstay in the conservator’s studio, and its strength, when used in combination with epoxies in the bonding of stone, has recently been clearly established and published (Podany, *et al.*, 2001). Acryloid® B-67, poly(isobutyl methacrylate), is also considered a Feller Class A material even though it is known to cross-link over time (Horie, 1987, 108). B-67 was considered in this study because it is reversible in low-aromatic hydrocarbons which present less of a health hazard than the fully aromatic solvents necessary to reverse Paraloid® B-72.

The authors determined to conduct comparative shear strength testing with all four of the mentioned barrier coatings (hide glue, B-98, B-72, and B-67) with Araldite 1253 bulked epoxy. It was hoped that if B-72 and/or B-67 proved to be of comparable strength to the other two proven barrier materials, then the results of this work would provide conservators with more options in choosing a barrier coating when factors such as the solubility of an original finish need to be considered. In order to confirm that the adhesive bonds using barrier layers were in fact reversible as intended, the authors also conducted empirical reversibility testing.

METHODOLOGY

This study was organized into four components. First, a barrier application protocol was established and the amount of time required for barrier layers to dry was determined experimentally. Second, the shear strength of the adhesive bond made with each of the barrier materials and Araldite 1253 epoxy was determined quantitatively according to ASTM standard D 905-98. Third, the patterns of failure in the test samples were analyzed.

Both strength testing and failure analysis were conducted according to ASTM standard D 905-98. Fourth, the practical reversibility of the barrier materials was tested empirically.

Barrier application protocol

The following solutions of barrier materials were chosen for testing:

- 10% (w/v) solution of Butvar 98 in ethanol
- 17% (w/v) solution of Paraloid® B-72 weight/volume in acetone
- 17% (w/v) solution of Acryloid® B-67 in Shell Mineral Spirits 135
- Titebond Liquid Hide Glue direct from manufacturer's container

The solutions were formulated as such for two reasons; they needed to be concentrated enough to leave a significant amount of material on the surface of the wood, but also had to be able to be applied in a continuous, even coat with a brush. Anderson and Podmaniczky used a 20% (w/v) solution of Butvar B-98 in ethanol in their study. In our experience, however, this proved too viscous to brush on conveniently and a concentration of 10% in ethanol was used instead. The 17% (w/v) solution of Paraloid® B-72 in acetone was chosen because it had been used successfully in the 2001 study by Podany *et al.* and was found to be easy to apply. The 17% solution of B-67 in Shell Mineral Spirits 135 was chosen to be comparable to the B-72 solution. The Titebond hide glue was chosen because it is a widely available, reasonably standardized formulation and was found to be of comparable strength to typical hot animal hide glues in moderate humidity environments (Buck 1990). Its viscosity was found to be suitable directly from the manufacturer's bottle.

The barrier coatings were applied, as consistently as possible, to samples of hard maple similar to those called for in the ASTM shear strength testing method. For each kind of coating, a new brush was dipped into the jar containing the solution; the bristles were then brushed against the rim of the jar; the brush was flipped over and excess solution brushed away again. The sample was then

brushed once along its length and again across the grain. The coatings applied this way appeared to completely saturate the surface of the wood, leaving no bare or dry areas.

After the first application had dried, the barrier coatings were evaluated visually. While the hide glue layer appeared coherent and glossy over the entire surface, the three synthetic resin layers did not; therefore, a second coat of each synthetic resin was applied over the first. Upon drying, all three of these samples appeared to have a reasonably thin, yet coherent and glossy film over the test surface. We therefore decided that in preparing the sample blocks for shear strength testing, the hide glue barrier layer would be applied in a single layer, while the three synthetic resins would be applied in two layers.

Solvent Evaporation from the Barrier Coatings

We next tried to determine the length of time required for the barrier layers to dry, prior to the application of the epoxy adhesive. It is generally accepted that there should be little to no solvent remaining in the coating as retained solvent can act as a plasticizer within the resin and thus weaken the barrier film (Podany, *et al.*, 2001, 27).

Testing Method

A simple test was designed to establish when the solvent had evaporated from barrier layers. Small wafers of hard maple (the wood called for in the ASTM shear strength testing method) were painted with the barrier coatings and then weighed periodically until there was no more detectable weight change. The maple was cut into 20 samples measuring approximately 2" x 3" x 1/8". Five pieces of wood were set aside to be used as controls to track the changes in weight of the substrate caused by fluctuations in the ambient relative humidity. The 15 remaining samples were divided into three groups. Each group was coated with two coats of the synthetic resin barrier solutions, the second coat following the first by three days. Hide glue was not tested for solvent evaporation time because of anticipated complications due to its continual weight change with fluctuations in ambient

relative humidity. Changes in weight for all forty samples were recorded in the same order, using an Ohaus® Precision Standard scale, which is accurate to one milligram. Since the weight of solvent added in each coat was typically about 0.3 grams, the scale was effectively accurate to approximately 0.3% for measuring solvent loss. The five wafers of each group were weighed individually and their weights were then averaged. Initially, weight measurements were taken every half hour. The interval between measurements increased with time, until five days after the second application of barriers, measurements were taken twice a day. We felt that once the weight stopped changing measurably, it could be concluded that the barrier adhesives were essentially free of solvent.

In order to better understand the dynamics of solvent evaporation from wood substrates, the same test was carried out using two different substrates, Douglas fir and 4 mil Mylar® polyester film (essentially non-absorbent). These results were compared to those recorded for hard maple.

Results of Solvent Evaporation Tests

The solvent evaporation testing on maple showed that all three non-aqueous barrier coating materials would be essentially solvent free within five days of the application of the second coat. As expected, the faster evaporating solvents (acetone and ethanol) yielded dry films more quickly than the slower evaporating Shell Mineral Spirits 135. Table 1 shows the times required for 98% and 100% evaporation of solvent from the second coat of barrier solution. Based on this result, sample blocks of maple which had been coated with the barrier layers and allowed to dry for three

days, then re-coated and allowed to dry for five days were considered suitable for strength testing according to ASTM standards.

Two interesting phenomena were observed during evaporation testing. First, it became clear that the nature of the substrate played a large role in the evaporation rate of solvent from the resin layer. Figures 1 and 2 illustrate the extremely different evaporation rates for three different substrates when initially coated with resin solutions. Figure 1 shows the progress of drying for 17% (w/v) B-72 in acetone when applied to Mylar®, maple, and Douglas fir test panels. On the Mylar® substrate, which is essentially non-absorbent, over 99% of the solvent applied had evaporated within one minute. In contrast, on the test wafers of maple, a dense and even-grained wood, it took approximately 21 hours for 98% of the solvent to evaporate. With the fir substrate, which is lighter than maple and has distinct hard and soft zones in each annual ring, it took approximately 29 hours until 98% of solvent had evaporated. Figure 2 shows the progress of drying for 17% (w/v) B-67 in Shell Mineral Spirits 135 (a much slower-evaporating solvent than acetone) on the same three substrates. On the Mylar® substrate, 98% of the solvent applied had evaporated after only one hour and 40 minutes. On the test wafers of maple, it took approximately 60 hours until 98% of solvent had evaporated, and with the fir substrate, it took over 91 hours until 98% of solvent had evaporated. It is interesting to note that in the drying curves for B-67 on maple and fir substrates, the fir samples initially dried more quickly than the maple samples, but were overtaken by the maple after about a day. The cause of this phenomenon is unknown,

	98% Evaporated	Terminal Weight "100% Evaporated"
B-72 [17% (w/v) in acetone]	2.5 hours	28 hours
B-98 [10% (w/v) in ethanol]	26 hours	51 hours
B-67 [17% (w/v) in Shell 135]	75 hours	124 hours

TABLE 1 Time required for solvent evaporation from second coat of barrier material on hard maple substrate.

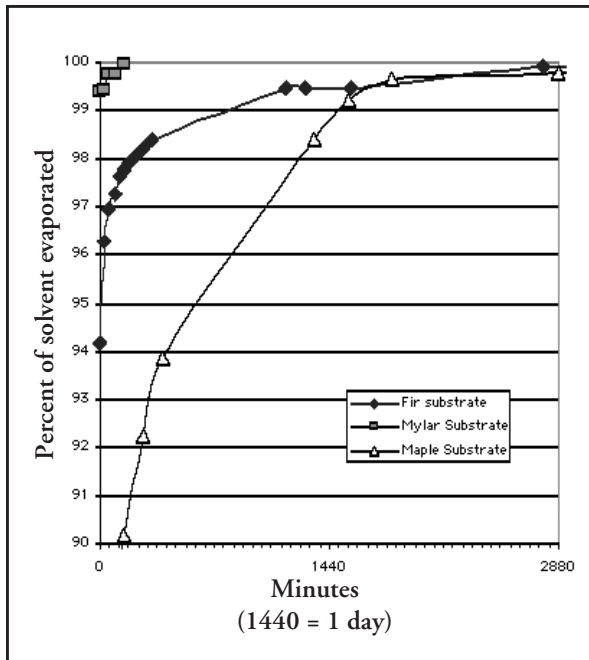


FIG. 1 Evaporation of solvent from 17% (w/v) B-72 in acetone applied to three different substrates.

but it suggests that the mechanisms of solvent evaporation from wooden substrates are complex, and may depend on a wide range of variables such as the anatomical characteristics of the wood, the condition of the wood surface, the affinity of the particular solvent for both the resin and the wood, the volatility of solvent, and the film thickness.

The second phenomenon noted during evaporation testing was that, on wooden substrates, the first and second coats of resin solutions dried at different rates. With the fast-evaporating solvents, acetone and ethanol, the second coat of barrier material clearly dried more quickly than the first. Presumably this is because the first layer of resin seals the wood so that when the second coat is applied, the solvent is not absorbed into the wood to the same degree. Figure 3 shows the percent of solvent evaporated vs. time for the first and second coats of 17% (w/v) B-72 in acetone applied to maple substrate. While the first coat does not reach 98% evaporation until 21 hours after application, the second coat is 98% dry after only 2.5 hours. In contrast to the results with fast-evaporating solvents, the second coat of barrier in slow-evaporating mineral spirits dried more slowly than the

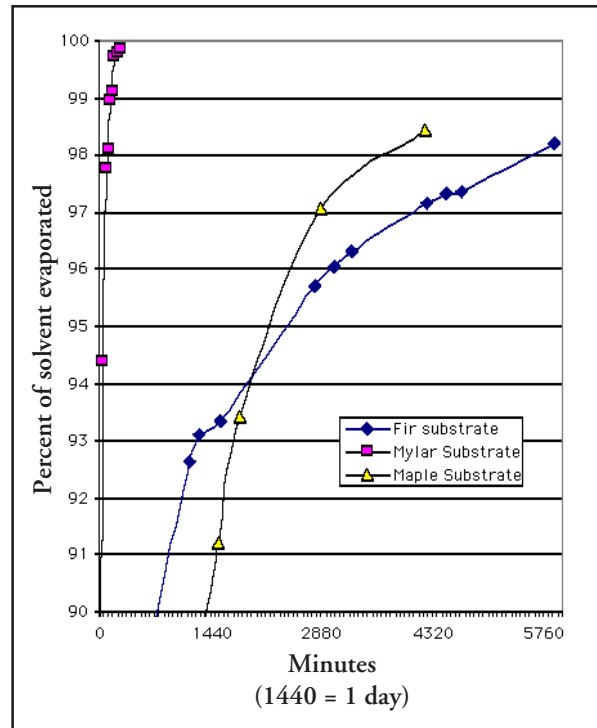


FIG. 2 Evaporation of solvent from 17% (w/v) B-67 in Shell Mineral Spirits 135 applied to three different substrates.

first. Figure 4 shows the percent of solvent evaporated vs. time for the first and second coats of 17% (w/v) B-67 in Shell Mineral Spirits 135 applied to maple substrate. While the drying rates are much more similar than with B-72 in acetone, it is clear from the graph that the first coat evaporated more quickly than the second. This presumably indicates that some of the solvent in the second coat penetrated the first coat and was absorbed into the wood. The increased overall thickness of resin after the second coat may then have contributed to an overall slower drying of the coating layer.

The degree to which barrier layers on wood should be allowed to dry before final assembly with epoxy is difficult to judge with certainty. Both for convenience and because contamination of the surface by airborne pollutants could result in a weakened bond, it is better to glue up joints soon after the surfaces are prepared. However, premature bonding when using barrier coatings could result in a joint which is initially weak due to plasticizing effects of retained solvent. It might also result in

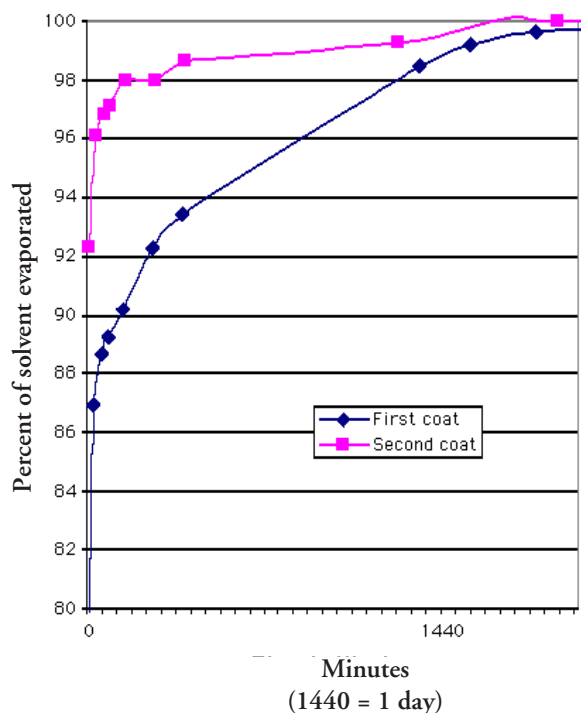


FIG. 3 Comparison of solvent evaporation rates from the first and second coats of 17%(w/v) B-72 in acetone when applied to hard maple.

a bond which is weakened even after the eventual drying of the solvent (the retained solvent could impair the bonding of the epoxy to the resin, or the shrinkage of the resin film during drying could cause internal stresses within the joint). Based on our results, it should also be considered that when applied to wood, a significant portion of the solvent may be retained, not in the resin layer, but in the wood itself. In this case, any remaining solvent would not be likely to contribute to plasticizing or weakening the barrier layer. In any event, more testing is clearly warranted to determine the relationship between solvent retention and the strength of barrier coatings on wood substrates.

Strength Testing

Unfortunately, there is no ASTM standard for determining the strength of combinations of barrier coatings and adhesives. Where possible, this study used the testing methodology as specified by ASTM Designation D 905-98 "Standard Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading" and

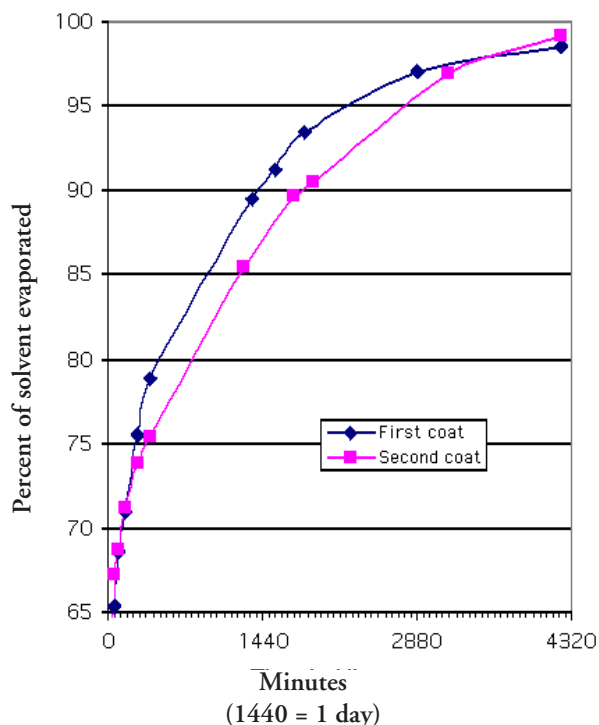


FIG. 4 Comparison of solvent evaporation from the first and second coats of 17%(w/v) B-67 in Shell Mineral Spirits 135 when applied to hard maple.

modifications were made where necessary. Modifications were in some cases based on those made by Podany *et al.* in their 2001 study and by Anderson and Podmaniczky in 1990.

Determination of specific gravity

ASTM Designation D 905-98 specifies the use of hard maple for shear strength testing of adhesives. It further stipulates that the maple used fall within a certain range of specific gravity. In order to measure the specific gravity of the maple obtained for this test, two small pieces of the wood were oven dried, according to the specifications of ASTM Designation D 143-94, "Standard Test Methods for Small Clear Specimens of Lumber." The two samples were weighed, and then placed in an oven at 103° C until their weight loss ceased changing. The moisture content of the wood was then determined by dividing the samples' loss in mass by the oven-dry mass. These results were used to calculate the specific gravity of the blocks as shown in Appendix X1 of ASTM D 905-98 (American Society for Testing and Materials 2001, 25). The

specific gravity of the hard maple stock fell in an acceptable range.

Sample Preparation

The size of the samples specified by ASTM Designation D 905-98 was too large for the Getty Conservation Institute's Instron tensile testing machine which is limited by a 10 kN load cell. Based on the ultimate strength of trial samples of different sizes prepared for this purpose, it was calculated that the machine would be able to run samples of approximately one quarter of the specified size. The final configuration of the test blocks is shown in figure 5, resulting in a bond area of one square inch.

The $\frac{3}{4}$ " x $9\frac{1}{4}$ " hard maple stock was cut into $1\frac{1}{4}$ " strips across the grain on a table saw. Surfaces to be glued were prepared by sanding lightly with 320 grit abrasive paper. The wooden strips were divided into five groups, four of which were coated on one face with each of the respective barrier materials in the manner described under barrier application protocol. The fifth group was not coated with any barrier material and served as a control. After drying, pairs of strips from each group were bonded together using Araldite 1253 in the manner described below. The two components of the epoxy were measured before mixing by weight according to the product data sheet, provided by manufacturer Vantico, which specifies the optimal resin/hardener weight ratio at 100/82.

One of the strips, already coated with the barrier, was covered with the epoxy paste and laid, face up, in a jig built for this experiment. The second strip was placed into the jig above the first, overhanging by approximately $\frac{1}{4}$ ". The upper strip was pushed down in the jig so that the adhesive layer measured 0.030 in. (30 mils) thick. This adhesive layer thickness was chosen to approximate a typical gap-filling bond as might be required in wooden artifacts conservation. The samples were removed from the jig and left to cure for eight days. Excess epoxy was removed from the edges of the strips first, using a shoulder plane.

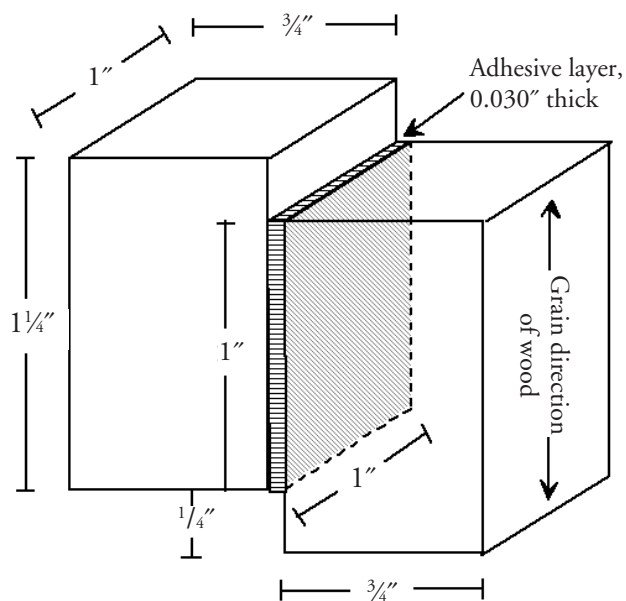


FIG. 5 Dimensions of hard maple samples prepared for shear strength testing.

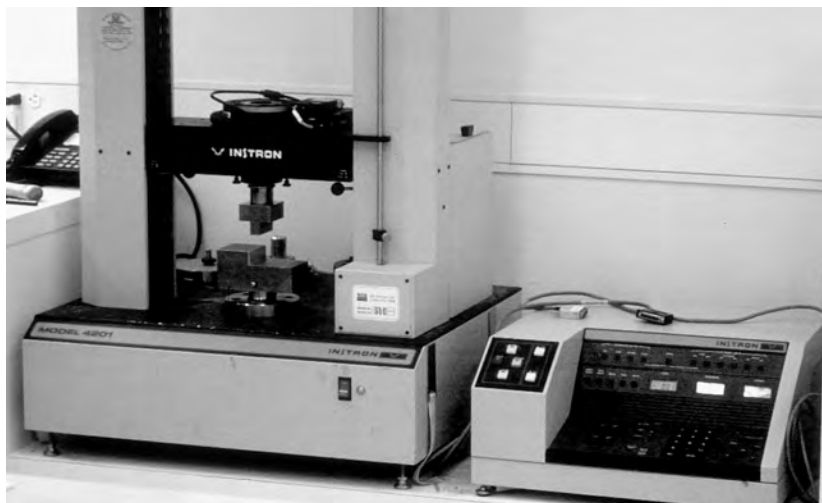
Once the samples had been cleaned of excess adhesive, the bonded wooden strips were then cut into smaller pieces, approximately 1" wide, on a table saw. Ten small test blocks were prepared and labeled for each barrier material. The bond area of each sample block was then calculated by measuring the width and length of the bonded area. This data was recorded for use in calculating the final load at failure for each test block.

Shear Strength Measurement

The samples were tested in batches according to sample type by the same operator during a four-hour run. In order to keep the samples in the same conditions, they were held in sealed polyethylene bags until just before testing. Ten samples per sample type were run. Both parts of each sample were labeled in pencil according to adhesive type and numbered in sequence, for post-testing analysis of the break edge.

A Model 4201 Instron with a 10 kN load cell, belonging to the Getty Conservation Institute, was used to test the samples (fig. 6). Instron Series IX Automated Materials Tester software, version 8.06.00, was used to run the tests and to partially analyze the data. Before each sample was run, the operator entered the width and thickness of each

sample. The Instron's moving cross-head was configured to push down on one of the two bonded sample blocks while the other was held in a fixed position creating a shear stress on the adhesive bond (fig. 7). The cross head was set to move down at a constant rate of 5 mm/min., the ASTM standard specified speed, until the sample failed.



For each sample, the Instron Series IX Automated Materials Tester software then calculated the maximum load, displacement of the cross-head at maximum load, and stress at maximum load, as well as the mean and standard deviation of the samples grouped together. The software also produced graphs showing these results.

The quantitative results of the Instron testing were then subjected, by group, to the "Q" test for outliers at the 90% confidence level. This test is part of ASTM designation 3980. The test considers the number of samples and the distribution of the results: any individual result deemed too incompatible with the spread of the others is excluded within a determined confidence level.

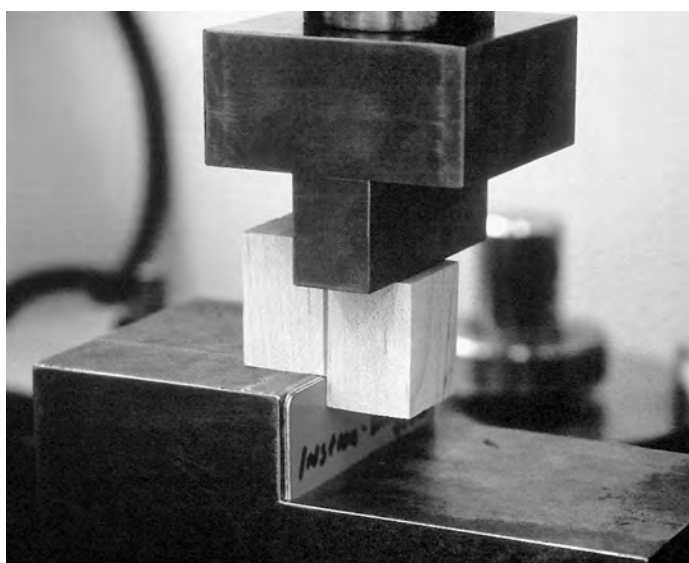


FIGURE 7

FIGURE 6

Results of Shear Strength Testing

Table 2 and Figure 8 show the results of the Instron shear strength testing. Araldite 1253 epoxy bonds prepared with B-98 and B-72 barrier layers proved to be as strong or stronger than bonds prepared with no barrier. Bonds prepared with liquid hide glue barrier layers were weaker on average, but nearly as strong as bonds with no barrier, while bonds prepared with B-67 barrier layers were much weaker than any other category. These results indicate that B-98, B-72 and liquid hide glue barrier layers yield high strength epoxy bonds and can be considered suitable barrier materials for use with wood and epoxy adhesive. Conversely, the use of B-67 was shown to result in consistently weak bonds and is clearly unsuitable for use as a barrier material. The failure of B-67 to produce a sufficiently strong bond was disappointing since it could have provided a barrier method reversible in solvents of low polarity (safe for objects) and low toxicity (safe for conservators). This failure may be directly related to the low polarity of the B-67 polymer. It may be that epoxy resin, which is a highly polar material (Down, 2001), is unable to bond satisfactorily to such a low polarity material. This hypothesis is supported by the fact that 100% of failure occurred between the B-67 and epoxy layers (see next section). If this is in fact the case, then the search for a strong barrier material soluble in low or non-aromatic solvents may be inherently unlikely to succeed.

	Mean Pressure at Failure	Standard Deviation	Samples Tested	Results Excluded
No barrier	1301 psi	±233	10	1
Butvar B-98	1403.1 psi	±134.6	9	1
Paraloid B-72	1350.4 psi	±327	10	—
Liquid Hide Glue	1153.8 psi	±366.9	9	—
Acryloid B-67	251.8 psi	±78	9	—

TABLE 2 Results of shear strength testing using epoxy adhesive alone and with four different barrier layers.

Failure Analysis—Estimated Percentage Wood Failure

ASTM Designation D 905-98 specifies that an estimated percentage wood failure be calculated. In a simple adhesive testing scenario, this serves to distinguish between areas in which the adhesive has failed and areas where the wood has failed. This study presented a more complex situation than anticipated by ASTM standards because of the use of the barrier coatings. The control samples prepared with direct epoxy bonds were analyzed according to the ASTM standard, which distinguishes only between wood failure and adhesive failure. For samples prepared with barrier adhesives, failure was divided into the following four groups:

1. Wood failure, wherein wood was removed from one of the faces of the wooden sample.
2. Barrier coating/wood failure, meaning that the barrier coating was pulled from the wooden face, sometimes, but not always taking tiny wood fibers along with it.
3. Barrier coating/epoxy failure, where the joint failed in the interface between the two.
4. Epoxy failure, where the epoxy adhesive was pulled apart and remains were found on both faces of the sample.

For all samples, the percentage failure of each type per sample was defined using a gridded, transparent plastic ruler (fig. 9). The grid, which divides square inches into 254 units, was placed on top of each bond surface after failure and examined under a stereo microscope. The number of square

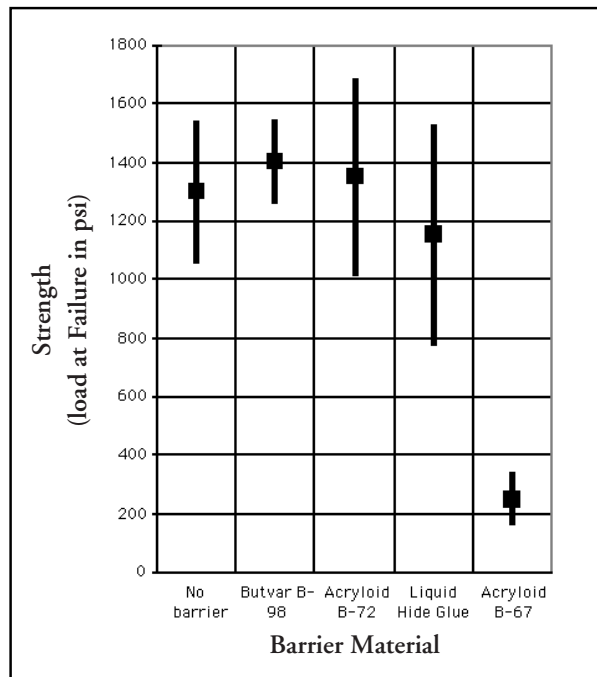


FIG. 8 Results of Instron shear strength testing of epoxy bonds with different barrier materials. The graph shows the mean strength of the ten samples tested and indicating the range of one standard deviation.

units in which each type of failure occurred were counted, and the percentage failure of each type was calculated.

In the event that an epoxy bond on a wooden artifact is stressed to the point of failure, it is preferable that the adhesive break away cleanly from the substrate without causing additional damage to the wood. The results of the failure analysis, shown in Table 3, indicate that all four barrier materials tested offer some protection to the underlying

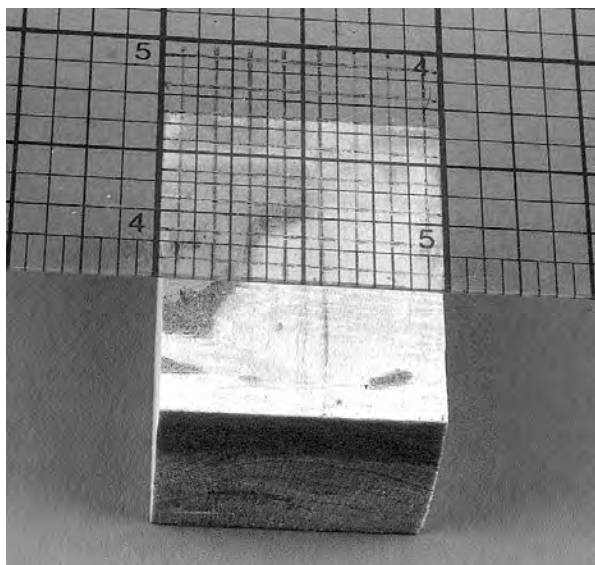


FIGURE 9

wood by reducing wood failure when the bond is broken. Wood failure, which was 6.8% for wood bonded directly with epoxy, was reduced to nil or virtually nil when any of the four barriers was used. B-98 and liquid hide glue samples tended to fail at the interface between the epoxy and the barrier layer, while B-72 tended to fail at the interface between the wood and the barrier. B-67, which failed the overall strength testing, always failed at the interface between the epoxy and the barrier, indicating that the cause of failure was poor adhesion between the B-67 and the epoxy.

Reversibility of Barrier Coatings in Solvent Vapors

In order to test the reversibility of the barrier coatings, spare sample blocks of maple, coated with the

barriers, were bonded to one another using Araldite 1253. The three barrier materials reversible in organic solvents (B-72, B-67, and B-98) were tested for reversibility in solvent vapor chambers with no direct application of liquid solvent. After the epoxy had cured, screws were inserted into the upper and lower pieces of wood. Four large steel washers were suspended from the bottom screws. The total weight of the four washers was approximately 88 grams. The samples were suspended by the upper screws on bamboo skewers laying on the rim of glass beakers, which were enclosed in a sealed, clear polyethylene bags (fig. 10). Approximately 2 ml of the appropriate solvent was placed in the bottom of the beakers. Xylene was used for the sample bonded with Paraloid® B-72; ethanol for the Butvar® B-98 sample; and Shell Mineral Spirits 135 for the Acryloid® B-67 sample.

The Butvar B-98 sample fell apart on its own in three to four days. The Paraloid® B-72 sample came apart with gentle pressure after five days in the solvent rich environment. The Acryloid® B-67 coating did not fall apart, even with gentle pressure, after five days, at which point the test was suspended. These results suggest that B-98 and B-72 barrier layers are practically reversible in ethanol and xylenes respectively, even without direct application of liquid solvent. The disadvantages of using ethanol for reversal on objects with painted or varnished surfaces have been discussed above. While xylenes should be safe to use with many painted or varnished surfaces, it will not be safe with all. Furthermore, the health hazards asso-

	Wood Failure	Barrier coating/ wood failure	Barrier coating/ epoxy failure	Epoxy failure
No barrier	6.8%	n/a	n/a	93.2%*
Butvar B-98	0.3%	16.6%	71.8%	11.3%
Paraloid B-72	nil	62.1%	37.9 %	nil
Liquid Hide Glue	nil	27.3%	64.7%	8
Acryloid B-67	nil	nil	100%	nil

* indicates non-wood failure according to ASTM D 905-98

TABLE 3 Failure analysis



FIGURE 10

ciated with xylenes makes them a less-than-ideal choice for barrier reversal. The failure of the B-67 barrier layer to be reversed by the vapor of mineral spirits (in which it had previously been dissolved) is somewhat mysterious, though it may be related to the low vapor pressure of the solvent. Had it not been for the failure of B-67 to perform adequately in strength testing, further testing of more volatile and/or more polar solvents might have been warranted.

Microwave Reversibility of Hide Glue

The possible utility of microwave technology for reversing hide glue joints has not gone unnoticed, especially by furniture conservators (Neher, 1996 and Anderson & Podmaniczky, 1990). Theoretically, microwave radiation can be used to excite the hide glue's water molecules, heating and weakening the glue line to the point that it either falls apart or comes apart with gentle pressure. In practice, consumer microwave ovens can be used to deliver the microwaves if an object is small enough; otherwise there are hand-held devices (available at considerable expense) such as the WorkRite Wood Welder, which generate radio frequencies for use in industrial applications.

A simple experiment was undertaken to separate sample blocks that had been bonded with epoxy using Titebond Liquid Hide Glue as a barrier coating. The samples were heated in a microwave oven: some had water injected into the bond line with a very fine syringe. All samples came apart

easily after 20-30 seconds. Intentional over exposure in the microwave oven resulted in scorching of the wood blocks, demonstrating that this method of reversal has some potential dangers. Microwave reversal is also not suitable for joints in close proximity to metal fasteners or ornaments. While the reversal of hide glue barrier layers with microwave radiation cannot be universally recommended, further study is called for in this area as the tech-

nology might prove to be useful.

CONCLUSION

This study demonstrates that Paraloid® B-72 is a suitable material for use as a reversible barrier layer for epoxy joints in wood. It offers strength comparable to epoxy used alone as well as to other proven and widely used barrier materials (Butvar® B-98 and hide glue). Like these other barrier materials, B-72, appears to offer some protection to underlying wood in the event that the epoxy bond is broken. Additionally, B-72 was shown in practice to be a reversible barrier material in xylene vapor. This offers significant advantages over B-98 and hide glue when making repairs near finished, painted or otherwise sensitive surfaces. This study also demonstrates that Acryloid® B-67 is not a suitable material for use as a reversible barrier layer for epoxy joints in wood. B-67 failed both strength and reversibility tests.

ACKNOWLEDGEMENTS

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Jane Down of the Canadian Conservation Institute for her helpful guidance.

MATERIALS SOURCES

Available from Conservation Support Systems, Santa Barbara, CA 93101:

- Acryloid® B-67, poly (iso-butyl methacrylate)
- Butvar® B-98, Polyvinyl Butyral Resin
- CIBA Araldite AV 1253®, Vantico Inc.
- Paraloid® B-72, copolymer of ethyl methacrylate and methyl acrylate
- Shell Mineral Spirits 135, slow evaporating, 15% aromatic content

Available from Franklin International, Columbus Ohio, 43207

- Titebond® Liquid Hide Glue

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SPECTROSCOPIC DATING AND CLASSIFICATION OF WOOD

Gottfried Matthaes

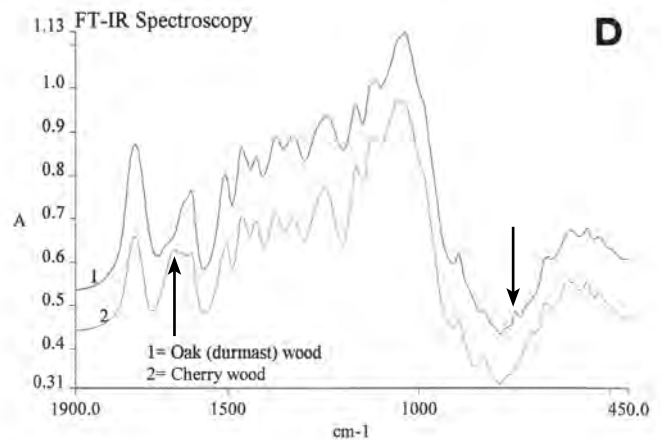
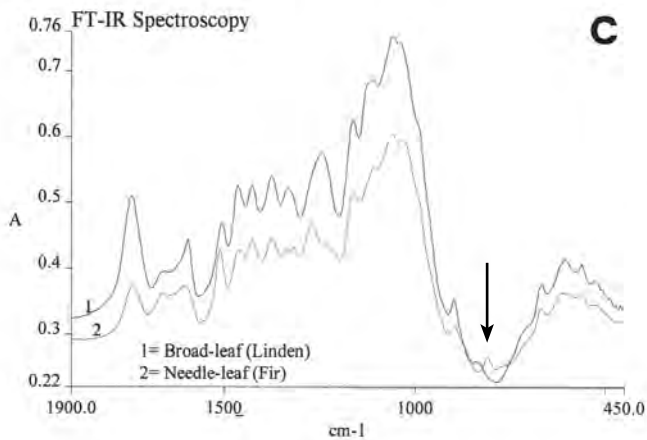
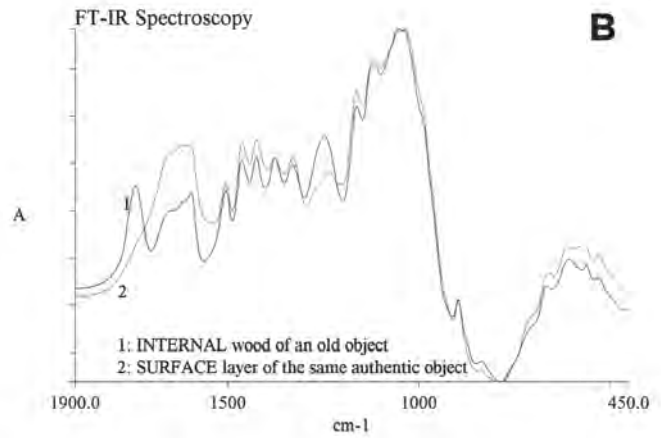
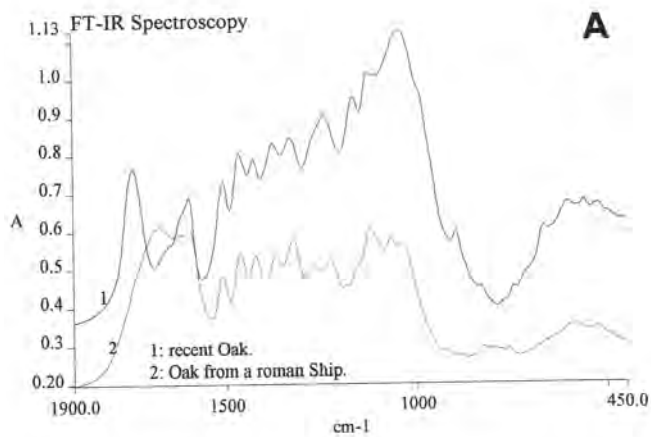


INTRODUCTION

IR spectroscopy is used on a vast scale in industry and research for chemical analyses. The novelty lies in its use for measuring the age of wood. The molecules present in wood absorb the IR rays emitted by the spectrophotometer if they oscillate at the same frequency. The spectrum showing this absorption, with its peaks and valleys, is like a fingerprint of the substance under examination. Change undergone by a molecule or group of molecules, owing for example to aging, is shown up by a displacement of the frequencies and by an alteration in the absorption intensities. The age of the wood is established by comparing these changes to spectra of certain dating.

The following problems and considerations had to be taken into account at the beginning of the research:

1. Various tree types have different chemical compositions and aging times. It is well known that faster-growing wood perishes more quickly. We also know, for instance, that pine is richer in resin than birch and that there are three main types of oak found only in Europe. Identifying these types of woods, finding objects of different ages made from them and confirming the presumed age of these objects for the creation of reference tables for spectroscopic dating has taken eight years. This research was carried out primarily in our laboratory, in collaboration with international organizations and museums.
2. A dating method based on chemical decay must consider the fact that temperature and humidity may accelerate the process. This factor of uncertainty makes it necessary to know the history of the conservation of the object because of the possibility of artificial treatments influencing the results of the measurement, and this was taken into consideration in the compilation of the spectroscopic dating tables. However, most wood molecules have an ageing process which is not influenced by temperature and humidity as demonstrated by excavated wooden objects, as well as amber, a fossilized resin which has remained under the sea and in riverbeds for millions of years. Graph A shows two spectra. Curve #1 is that of fresh oak and curve #2 is of oak from a Roman ship buried for 2,000 years under wet soil. The spectrum of the ship is still typical of the wood. Amongst these molecules are those which are used for spectroscopic dating. Extensive international studies have always confirmed the extreme resistance of wood to heat and water. In our laboratory we tested a piece of maple and a piece of pine in continuous cycles of varying temperature and humidity for two years. No measurable differences of the frequencies used for dating were observed.
3. It is important to be able to detect the use of old wood for recently-made fakes. Otherwise, no wood-dating method can be considered as definitive. The surface layer of any wooden artefact has undergone chemical changes due to UV light and other environmental agents. Since spectroscopy is a chemical analysis, it can detect these differences. Graph B shows the difference in wood from the same 300-year-old object between the surface (curve #2) and its inner part (curve #1). If an object is made of wood that is already old, both curves are nearly identical.



GRAPHS A, B, C & D

4. As frequencies and absorption intensities used for dating may differ according to the many families or types of trees, it is necessary to recognize the tree type under examination simply and quickly. Spectroscopic analysis offers this possibility. The curves of Graphs C and D illustrate this. The first test in the dating of wood is dedicated to the important distinction between needle-leaf and broad-leaf trees. The peak of Graph C, indicated by an arrow, represents the substance known as “coniferous alcohol” present in all coniferous trees examined so far. In Graph D the arrows indicate a peak formation typical of oak and cherry. Observation of a single peak or a combination of special peaks has allowed us to identify at least the tree family in approximately 90% of tests carried out to date.

5. Trees from tropical areas require special tables, but since tropical trees are subject to a similar chemical decay as trees in Europe or

North America, the compilation of specific tables was only a question of additional research work. We already have at our disposal data with a precision of ± 10 years or less for most woods used in African sculpture and approximately ± 25 years for carvings from Southeast Asia.

6. The method may be rejected, because it is seen as “destructive.” However, the damage to the object created by the taking of wood samples is very limited compared to the severe damage the wood material may have suffered in the past centuries.

The following five photos show how a sample is taken.

Figure 1: A small hole 2 mm wide is drilled into a sound part of the wooden object. The wood-powder obtained from the first millimeter can serve to discover the use of old wood. From an approximate depth of 3 mm onward for about another 3 to 5 mm the wood-powder is collected for the age test.



FIGURE 1

Figure 2: The wood particles are checked for impurities such as woodworm contamination, which could create errors.

Figure 3: After a stabilizing treatment, pressed particles are mixed with a transparent substance into discs.

Figure 4: The transparency of the disc demonstrates the tiny amount of wood required.

Figure 5: The disc is inserted into the spectrometer and then the spectrum is printed.

The following disadvantages and problems presented by the method are as yet unsolved:

- Some woods like mahogany, rosewood and chestnut are not yet datable with accuracy.
- Objects which have remained for long periods below freezing point, yield results that appear younger than the actual age because the chemical processes in the wood have been slowed. We have this problem in Europe with beams from ruins of old castles and churches in the mountains.



FIGURE 2

- Accuracy diminishes with time. The margin of error, which is around ± 10 years up to about 350–450 years of age increases to about ± 50 years for woods of 800 years or more.
- Trees from the same family may have developed subtypes in other continents. In order to elaborate a complete dating table for new subtypes, two samples of certain dating are required.

The following are some advantages of this method:

- The dating method has reached a high degree of reliability. It is simple, quick and cheap.
- In addition to age, spectroscopic analysis also provides information about the type of wood tested.
- Only the method based on spectroscopic analysis permits detection of the use of old wood in a newer object.
- Dating accuracy is bound to improve as more samples of certain date become available.
- Comparison of spectroscopic datings—which are largely independent of the place where the

tree grew or the position of the wood in large trunks—with the results of existing dating methods will reduce margins of error.

- Spectroscopic analysis is used in other fields of antique art objects. The method is gaining importance for its quick and precise classification of lacquers, glues and pigments, as well as encrustations on iron, bronze and excavated ceramics by comparing traces of such samples with existing dependable spectroscopic absorption spectra.

SPECIFIC APPLICATIONS FOR ART MUSEUMS

All museums have big problems with their inventories, in which a high percentage of furniture, wood statues and painted panels are waiting to receive a precise and definitive classification. Spectroscopy can therefore be of service in the first place to museums for their internal use.

FOR MORE INFORMATION

- www.museodelcollezionista.com
- www.SpectroscopyforArt.com



FIGURE 3

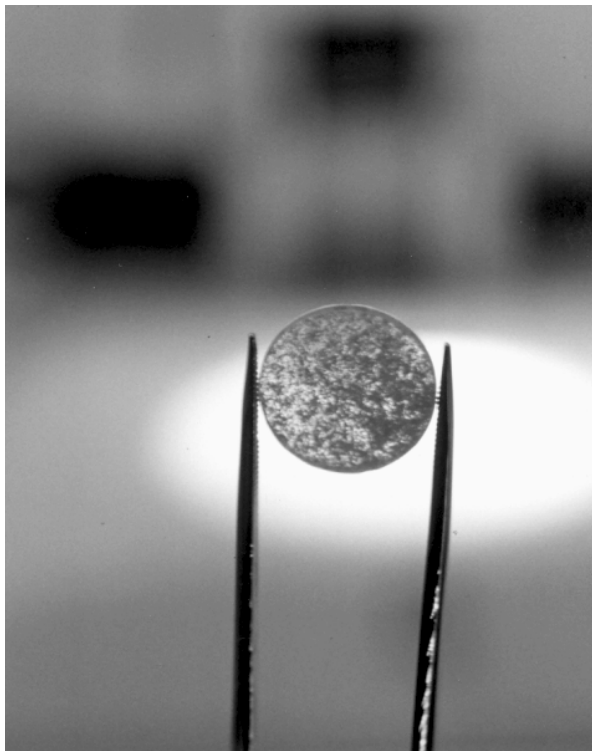


FIGURE 4



FIGURE 5

UNCOVERING HISTORY: USING PHOTOSHOP TO ENHANCE IMAGES FOR RESEARCH

Michael Smith



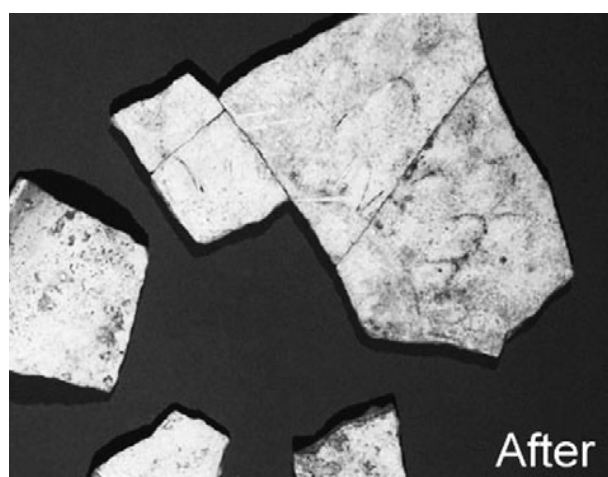
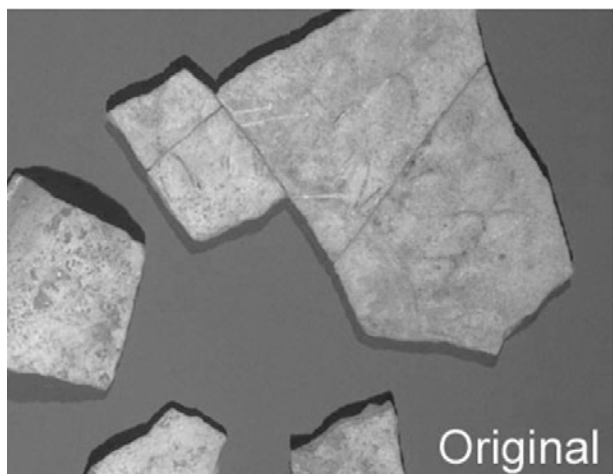
Many methods are used to study art. We are familiar with using photographic techniques like X-ray, ultraviolet and infrared photography. But with the advent of digital technologies there are many new tools that may enhance these techniques and also create new techniques. I am going to discuss the use of Adobe Photoshop both to enhance existing techniques and to create new ways to look at an image. This is not about how to use Photoshop, as there are many resources available on that subject.

When we capture or scan an image to create a digital file, it has to be put into a format we can see on screen; this format is RGB. To create this file, filters are used to divide an image into a red channel, a green channel and a blue channel.

Using these channels, we can break down an image into its parts. In these individual channels, things may become evident that we do not see when looking at the actual image. Using the RGB channels and sometimes the CMYK channels (CMYK—cyan, magenta, yellow, and black—is the common format used for most printing) is what enables us to uncover hidden parts of images. Using tools in Photoshop, we will work on these channels and the overall image to enhance the image for research purposes.

First we will talk about enhancing what we see. One of the most useful tools is the Curves tool (fig. 1); this allows you to adjust the lightness, darkness and cast of an image. With this tool, we can add contrast to an image and also accentuate any differences in tonal range. To make a good contrast move, we use what is called an “S” curve. To do this, first click on the center of the line in the Curves tool; this will be an anchor to hold the mid-tones (values below the box should read 50%) in place, then click on the 1/4 tone (values below the box should read 25%) and move the line so the output numbers decrease—the more you move it, the lighter the light areas will become. Next click on the 3/4 tone (values below the box should read 75%) and move the line so the output numbers increase; this will darken the dark areas. Using this move allows us to accentuate differences between light and dark. We can also adjust this move to a particular image by moving the points on the line, i.e., we could make a move at 15% instead of 25%, or we could move the anchor in the mid-tone to lighten or darken the 50% areas. If there is a particular area in an image that you want to work on, you can click on it with the Curves tool open; when you do this, a circle will appear in the curves window to show where this point appears on the curve—you can then adjust that particular area.

We can also use Selective Color and Hue/Saturation tools to adjust what we see (figs. 2–3). Selective Color allows us to change the hue of particular colors, i.e. you can make all the reds more orange or all the blues more blue. Using this tool, we can accentuate the differences between colors. Using Hue/Saturation we can brighten, lighten and darken one particular global color range in an image. So you can adjust all the reds in an image or all the blues, etc. Changes you make will affect all the colors in the range you select. These tools are great for enhancing differences between different color ranges, such as the differences between yellow and red or blue and green. Using these tools, we can enhance what we



see to make things more obvious and easier to look at. There are also other tools we could use and I highly recommend experimentation when using Photoshop. Just remember not to save over your original file. One thing I recommend is to do all your corrections in layers; that way you can turn them on and off. This also allows you to go back to them and re-adjust them. To do corrections in layers, open the layers window. At the bottom of the layers window is a button (a circle divided into black and white by a diagonal line); click on the button to get a pull-down window to choose your correction. Layer corrections are very important in research, because you can always see what you have done and it is repeatable. Layers are great for allowing you to document your procedure, because they show what you have done step by step. So I highly recommend you get used to working on images in layers; it will make everything you do easier to duplicate.

"S" curve

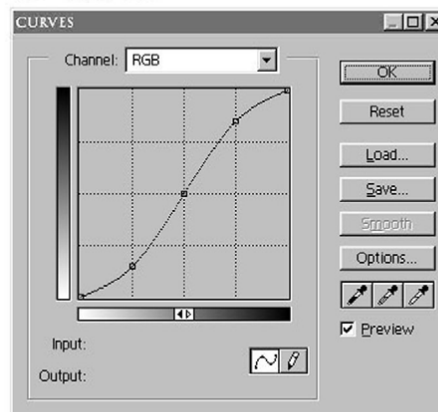
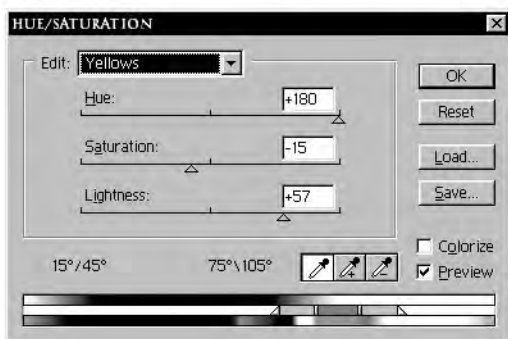
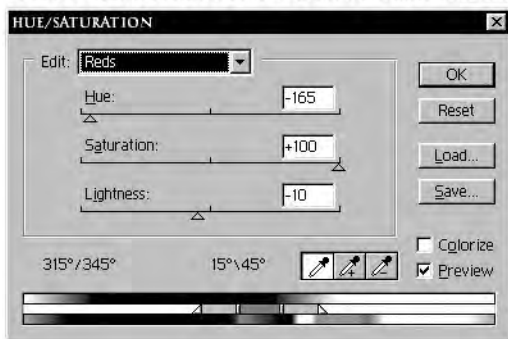


FIGURE 1

To look for hidden parts of an image, the first thing we do is look at the Channels window. This window allows us to look at individual channels or groups of selected channels. If we can find something in a particular channel, then we can use the curves tool in that channel to enhance it. Another tool we can use with channels is the channel mixer (fig. 4); here we can choose the channel we want and enhance it or turn the other channels down. This is also the best way to create a grayscale (black and white) of an image, because it allows us to choose which channel or channels will create that image. So we could create the grayscale from the channel that shows what we want.

If we do not find what we want in the individual channels, it is time for some experimentation. We can start with things that make sense, i.e. if you are trying to find something hidden in wood, work on the reds and yellows—the most prominent colors. You could work in the Hue/Saturation tool and change the hue of the reds and yellows in different directions. You could also adjust the saturation and the lightness and darkness of each. If you start to see something, adjust it until you feel it is most obvious; then go back and look at the individual channels. Now you could work on the channel where it is most prominent and enhance it more. If you are not getting good results with Hue/Saturation, then try the other tools. You could adjust Selective Color; by bringing up the amount of cyan and black in reds, you should see more detail in woods. And again to enhance differences, you could correct yellows and reds in

Hue saturation-Red and Yellow moves



different directions, i.e. you could take yellow out of red and take magenta out of yellow. Again if you do see results, adjust it to what you feel is best and work on the channels individually or in the channel mixer.

If you are not getting results with these tools working on color, the next step would be to experiment with the Curves tool. I have found by making moves with the Curves tool, you can get some very interesting results. I would start by moving the overall curve (RGB) and see if anything starts to show; try moving the curve up and down and in different areas and see what happens. Next, work on individual channels. Start with the channel that most corresponds to the area you are working on. The red channel shifts from red to light blue, the green channel shifts from green to magenta (pink), and the blue channel shifts from blue to yellow. So if you are working on a yellow area, start with the blue channel. When working with Curves, don't be afraid to make big moves—sometimes that is what it takes.

I have gotten my best results from using the tools together, so try each of the tools, and once you

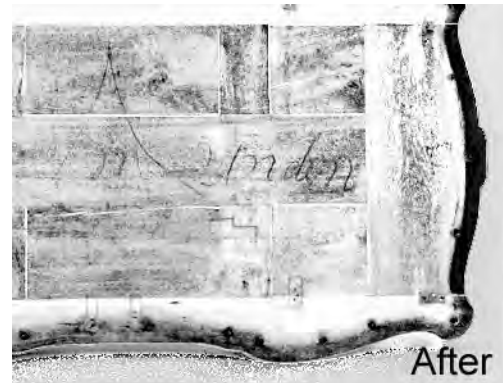


FIGURE 2

get a result in one, go back to the others and see if you can enhance it. And if you make the corrections in layers, you can go back and forth between corrections and adjust them slightly to get the best result.

Another thing I am experimenting with is the way you can apply your tools. When you do your corrections in layers, you can change the way a layer is applied. In the layers window just below where it says “layers” is a pull-down menu. It defaults to normal, but has many options. By choosing different settings, you can select how the correction is applied, i.e. by choosing Hue, your correction will only effect the hue. I have found this to be a powerful tool and highly recommend you play with it. Open an image, make a layer adjustment, and change this setting just to see what it does.

Be willing to try things—that is how you learn to use the tools better, and sometimes you will stumble upon something. It is very important to keep track of what you do, so again I highly recommend



Selective color-Reds and Neutrals moves

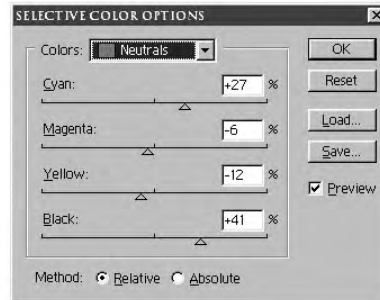
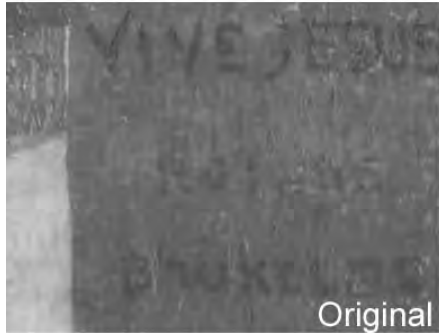
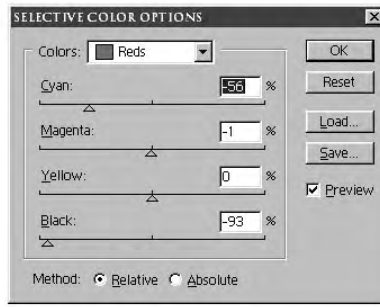
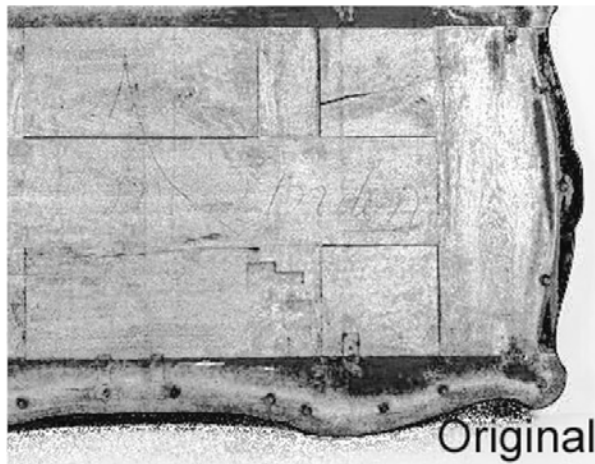


FIGURE 3

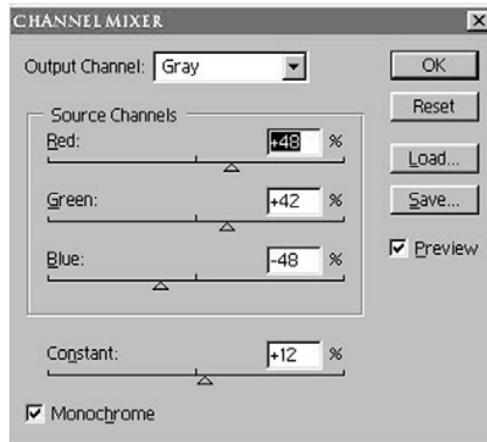
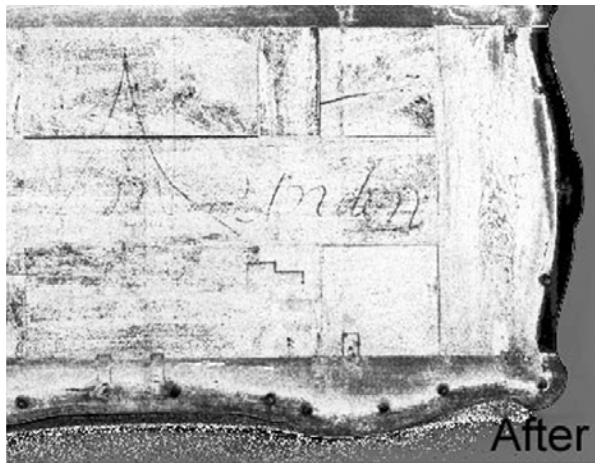
making all of your tool adjustments in layers; this will allow you to document each adjustment you make. Having your adjustments in layers will also allow you to use various adjustments together and apply them in different combinations by turning them on and off. When you are done, you should save the file as a layered Photoshop file; this will not only save the image but also all the adjustments you made. Most importantly, saving your adjustments allows anyone to see how you achieved your results and serves as documentation of the process.



One more very important factor is the quality of the images. Always work on the largest files you can, because larger files have more detail and will show more subtle differences in an image. I encourage you to experiment with Photoshop and other digital tools to see how they can enhance the way you work.

FIGURE 4

Channel mixer-changing to gra



BOTTOMS UP! (SOME SOLUTIONS FOR SUPPORTING SPRUNG SEATS IN HISTORIC UPHOLSTERED FURNITURE)

Deborah Lee Trupin

ABSTRACT

Conservators treating 19th and 20th-century upholstered furniture frequently confront seats with broken (jute) webbing and unsupported springs or seats with stretched and weakened webbing. Traditional methods of repairing sprung seats did not preserve all upholstery materials. As emphasis on the conservation of upholstered furniture developed, conservators devised alternative approaches to supporting sprung seats. In line with current conservation ethics, these newer approaches are as minimally interventive as possible. This paper focuses on methods of supporting sprung seats that have been used in the textile and furniture conservation labs at Peebles Island Resource Center (New York State Office of Parks, Recreation and Historic Preservation) for seating furniture in the collections of the New York State Historic Sites. The paper traces and credits inspirations for these methods and presents some solutions developed in other labs.



INTRODUCTION

Seats with broken webbing and springs falling out of the bottoms are the bad dreams of conservators treating 19th and 20th-century upholstered furniture. When traditional upholsterers treated historic upholstered furniture, they would typically remedy this problem by removing the webbing, replacing it with new webbing, and re-securing the springs to the new webbing. Alternatively, upholsterers would redo the entire seat—working, as for new upholstery, from the frame up. Do-it-yourself repairs often featured multiple layers of webbing and/or boards fastened to the seat rails to support springs. These methods, especially re-webbing done by skilled upholsterers, were effective, but were not without preservation problems. The most significant problems were the loss of historical evidence (caused by removal of original webbing and nails) and loss of physical stability in the seat rails (caused by removal and replacement of the large upholstery tacks used to attach the webbing).

In line with contemporary conservation practice, upholstery conservators have developed some less intrusive methods. Over the last fifteen years or so, a number of solutions for these sprung seats have been developed in many labs, but relatively few have been published.¹

Since the need for a “Bottoms Up” treatment usually becomes apparent when a conservator is faced with broken webbing and unsupported springs hanging out of the bottom of a seat, it is fairly obvious that one must usually devise a two-part treatment. In the first part, one compresses the springs, and in the second, one supports them.² For some seats, a third part, stabilizing or supporting fragile webbing, is also necessary. Since supporting webbing typically involves common textile conservation stabilization techniques, it will not be discussed in any detail here.

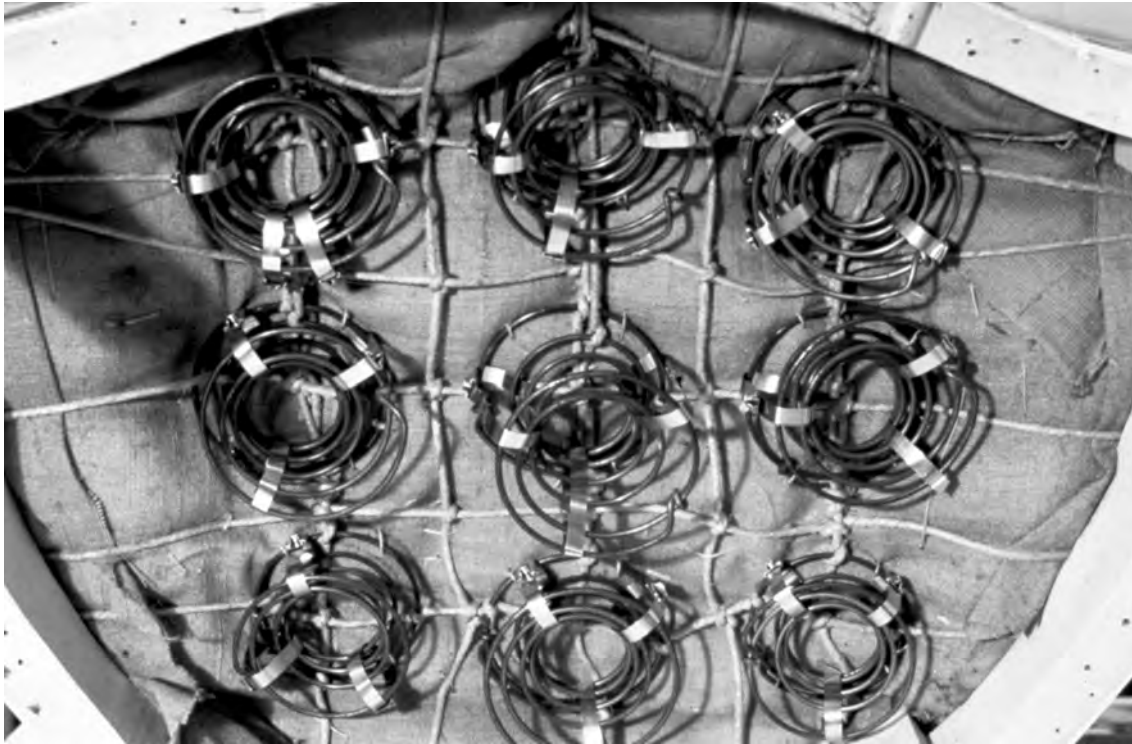


FIG. 1 Bottom view of sprung seat showing springs compressed with coated steel cable ties. Courtesy New York State Office of Parks, Recreation and Historic Preservation, Staatsburgh State Historic Site.

COMPRESSING THE SPRINGS:

MATERIALS

Compressing the springs is necessary to reduce strain on the show cover and other upholstery materials and to preserve the webbing, if it is still intact. Compressing the springs restores the profile of the seat. Most often springs that have become untied, or decompressed, create too high a profile on the seat. Compressing the springs may also be necessary to reduce stress on the seat rails, but this worry seems to be anecdotal, or theoretical. Sometimes, and this too may be a theoretical worry, conservators have chosen to remove the springs because they felt they were too heavy for the chair frame.³

Conservators want to tie the springs so as to have just the right amount of compression—enough to reduce the stress on the webbing (if it remains) and the upper layers of the upholstery, but not so much as to distort the upholstery profile. Some conservators also prefer to work with materials that are obviously not original.⁴

At Peebles Island, cable ties, a non-traditional but easy-to-use material, were used for an early spring compressing project. An intern in the furniture conservation lab first used nylon cable ties, but after speaking to a representative of the company who said that these have a short life span, he switched to using coated steel ties (fig. 1). The coated steel ties have some advantages—they are quick to use and fairly easy on the fingers. They also have some disadvantages: they are expensive, at about 90 cents each, and like most cable ties, they are only adjustable downwards. (The much less expensive nylon cable ties can be used as temporary ties, then replaced with the coated steel ties when the adjustment is right.) The coated steel ties are large and bulky and leave long tails, which must be cut off and carefully bent to avoid damaging other materials.⁵

Most significantly, the coated steel cable ties absolutely do not work if one is trying to compress springs around intact webbing. They take up too

much room and cause damage to the webbing as one works them in. For the early treatments discussed above, the dust covers and original webbing, which had largely separated from the frames, were removed, vacuumed, labeled, and placed in collections storage. Peebles Island conservators now believe that this approach is too intrusive and that the cable ties are most appropriate for a seat where the webbing is already lost, or even for one where the springs have already been separated from the seat.

To compress springs on seats with original webbing, Peebles Island conservators currently prefer to use three different colors of 20/2's linen cords together. This creates a tie that is strong, takes little space, and is clearly different from original (traditional) upholstery materials. A waxed polyester whipping cord would also work well for compressing the springs.

COMPRESSING THE SPRINGS:

METHODS

Describing the materials used to tie the springs only conveys one part of the problem. How to get those ties in place and how to adjust the springs safely to the appropriate height are the next problems one must solve. This step takes a huge amount of patience, the sort that would make one say, "yes," when a lay visitor says, "Oh, you must have tremendous patience to do this work." It helps to have a fiber optic light that can be positioned to provide light at the top, now base, of the springs and a couple of pairs of long, curved hemostats, one for each hand. One must thread a tie through the center of the spring, pass it around the top of the spring and back outside to the bottom of the seat. Typically, this is done while the seat is lying on its back or upside down, as one peers through the gaps in the webbing to find the right locations.

When working with intact but weak webbing, there is a serious risk of the webbing breaking, if one goes from uncompressed springs to compressed springs all at once. To reduce the risk, a temporary holder is required. Slip knots can work

for this, but the knots, or rather pulling the knots against fragile webbing to adjust the compression, may cut through the webbing. One can protect the webbing with wads of polyester batting placed between the webbing and the knots. One can also use small hemostats (with the batting), which work well but make a rather cluttered surface. Recently, a volunteer in the furniture lab devised a method to hold compression temporarily with heavy polyethylene sheeting cut into holders with slits. The ties can be threaded through the springs, then pulled through the slits in the plastic holders to hold the ties as the spring compression is adjusted. Once the final compression is made, the ties can be securely tied over the polyethylene holder.

It is useful to work with a support to permit the top profile of the seat to "float" above the work surface to avoid over-compression. There are several ways to judge when enough compression is enough, from measuring the finished height of the springs, to placing a straight edge across the springs (fig. 2), to eyeing the bottom of the seat (often the most successful). The furniture lab at



FIG. 2 Measuring to determine appropriate height of springs. Note support used to elevate seats to avoid over-compression or flattening of seat profile. Courtesy New York State Office of Parks, Recreation and Historic Preservation, Olana State Historic Site.



FIG. 3 It is helpful to have one person apply pressure to compress the springs while a second person ties the cords to hold the compressed height. Courtesy New York State Office of Parks, Recreation and Historic Preservation, Olana State Historic Site.

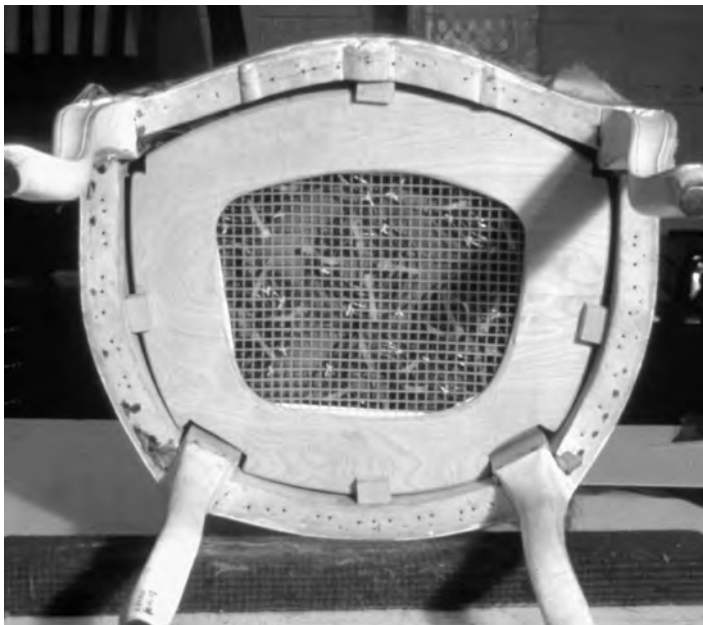


FIG. 4 Compressed springs are supported on a new inner frame stretch with polypropylene mesh. The new frame is secured to the seat rails with glue blocks. Courtesy New York State Office of Parks, Recreation and Historic Preservation, Staatsburgh State Historic Site.

Peebles Island and Kate Gill (of Textile Conservation Centre in England) have tried to make a clamp to measure the compressed springs or pre-compress them. However the clamps devised to date are either too large to fit between fragile strips

of webbing, or too delicate to stay in place and compress the springs as the ties are inserted.

Compressing the springs is sometimes most easily done by two people, one of whom is pushing to compress, while the other adjusts the ties (fig. 3). It works best to have all of the spring ties in place and looped through the plastic holders, but not yet compressed. Then, the center springs are compressed part way. This creates some slack in the webbing, so the outer springs can then be compressed to the desired height. Once these are securely tied, the center springs are compressed the rest of the way and tied.

SUPPORTING THE SPRINGS

The final step in a “Bottoms Up” treatment is to support the compressed springs. Originally, the webbing, stretched taut between the bottom of the seat rails, supported the springs. In these treatments, something must support the springs, usually above the level of the original webbing. For most of these treatments, it is necessary to compress the springs more than they would have been originally, in order to make room for this support.

An early system devised at Peebles Island involved securing the compressed springs to a polypropylene mesh that had been attached to a new inner frame. The inner frame was then held in place with glue blocks on the seat rails (fig. 4). This method works best for seats with deep and wide seat rails, or for seats where the webbing was already lost before the current treatment began.

This method requires the most “give” to the webbing—probably too much to be used with intact webbing, although it would work if webbing has broken or is released on two sides to provide sufficient give.

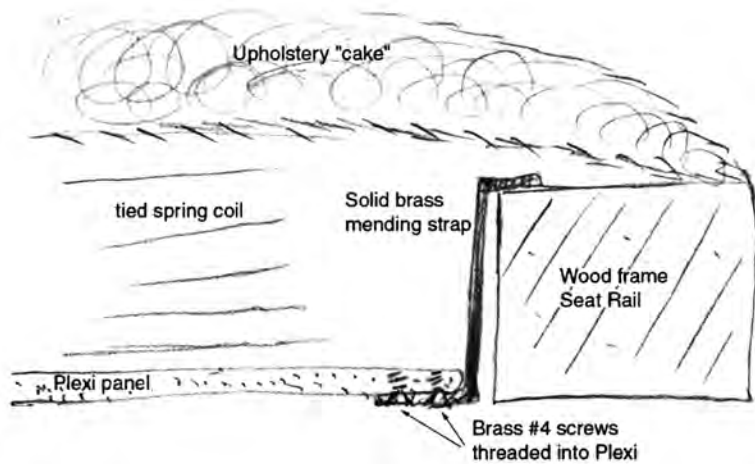


FIG. 5 Sketch showing placement of acrylic sheet and metal bracket used to support springs. Sketch by Deborah Trupin and David Bayne.



FIG. 6 Bottom view of chair showing acrylic sheet and brass brackets supporting compressed springs and plastic holders and three colored linen cords used to compress springs. Courtesy New York State Office of Parks, Recreation and Historic Preservation, Olana State Historic Site.

For seats with a narrow seat rail and a half-over the rail upholstery or with intact webbing, this method is less successful. For very narrow seat rails, one would have to compress the springs too much for safety in order to be able to fit the frame into the seat rails. For seats with intact webbing, there may not be enough clear space on the seat rails to attach the glue blocks to support the frame. On some seats it might be possible to screw support blocks into the seat rails, although most often this would be seen as too invasive.

To support the compressed springs on seats for which the frame support was not appropriate, Peebles Island conservators have successfully used acrylic sheet supports. A piece of acrylic sheet is cut to fit within the seat rails. Brackets that hang from the top of the seat rail support the acrylic sheet and thus the springs and profile of the seat. The brackets can be custom-made from stainless steel (14 gauge has been successful). If the length works, two brass mending plates can be joined with rivets and bent to the appropriate height. One can make a final adjustment of the height of the springs and profile of the seat by adjusting the length of the brackets. This system can be made more secure by pre-drilling holes in the acrylic sheet and using small screws to attach the brackets to the sheet (figs. 5 & 6).

Gwen Spicer, conservator in private practice, designed a particularly elegant solution for supporting a sprung seat. A sofa from the Doris Duke house at Rough Point in Newport had strong, modern webbing, but the springs still needed re-compression. Taking advantage of the modern webbing, Gwen and textile conservator Ann Frisina, made “buttons” out of Nomex[®] and used ties on long needles to run from the bottom of the webbing,

up the outside of the spring, through to the top of the underupholstery (the show cover had already been removed). At the top of the underupholstery, the tie went through another Nomex[®] “button,” then back down through the center of the spring. The ties were pulled and tied against the Nomex[®] “buttons” to provide the right amount of support. Pulling the buttons into place created small depressions on the top of the upholstery; these were filled with a layer of polyester batting before the new show cover was applied (figs. 7 & 8).



FIG. 7 Sofa from Rough Point, Newport Restoration Foundation, Newport, RI, before treatment. Courtesy Gwen Spicer and Rough Point.

SUPPORTING “DEAD” SEATS
(SEATS WITHOUT SPRINGS)

The methods described above to support the compressed springs are also useful in supporting seat upholstery without springs. For example, at the Victoria and Albert Museum, Derek Balfour used acrylic sheet and brackets to support the web-

bing, sack cloth and stuffing of the 17th-century Hampton Court House settee; this project was the inspiration for the use of acrylic sheet supports at Peebles Island (figs. 9 & 10). At Harper’s Ferry, Jane Merritt, Gwen Spicer and Debi Belman designed an acrylic sheet support for the seats (webbing, sack cloth and stuffing) of early

19th-century chairs from Hampton House. In this case, there was enough space between the inside edge of the rails and the tacks holding the webbing to slip the acrylic sheet onto the top of the rails, eliminating the need for brackets.

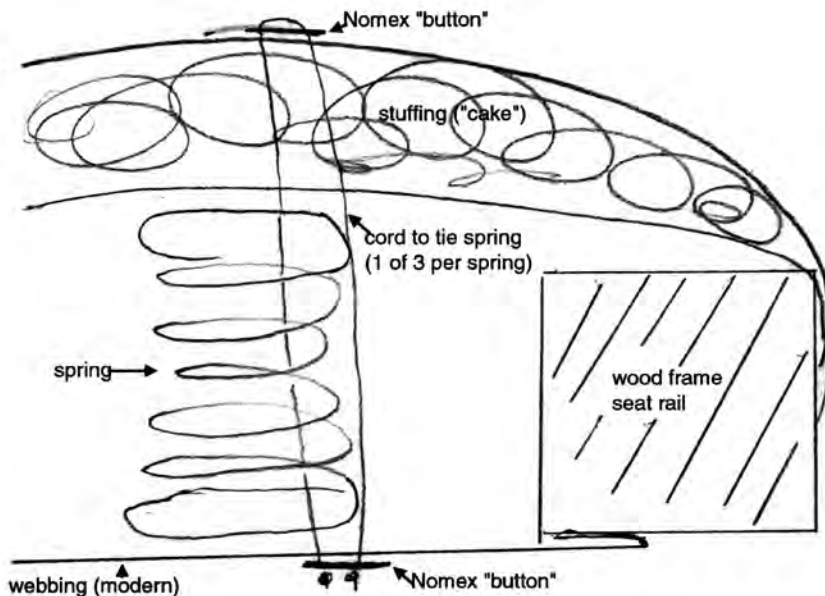


FIG. 8 Sketch showing use of Nomex® buttons and ties to compress springs on Rough Point sofa. Note that this method was feasible because of the previously installed modern webbing. Sketch by Deborah Trupin and David Bayne.

CONCLUSIONS

Successful “Bottoms Up” treatments preserve original seat frames and upholstery materials and methods. These treatments also help to restore the original appearance of seats. There are probably as many subtle variations on these “Bottoms Up” methods as there are seats needing support and



FIG. 9 Hampton Court House settee, after treatment. Courtesy Victoria and Albert Museum Picture Library.

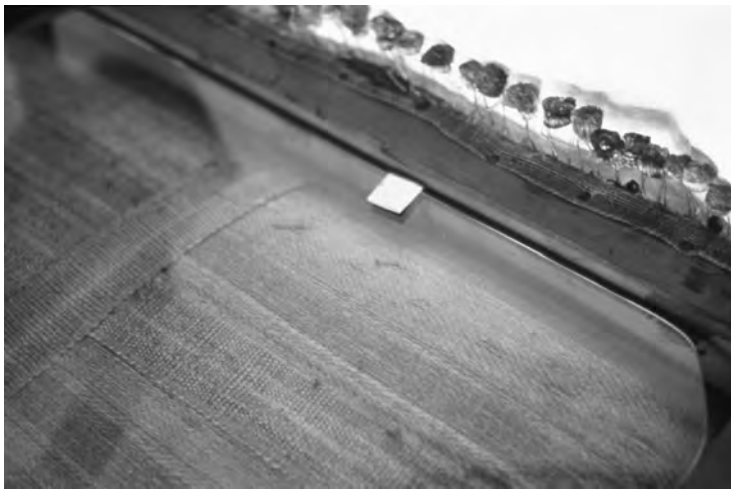


FIG. 10 Detail of bottom of Hampton Court House settee, showing acrylic sheet and stainless steel bracket to support 17th-century seat materials. Courtesy Victoria and Albert Museum Picture Library.

conservators devising treatments. It is hoped that the solutions presented here will also spur others facing these sorts of treatments to develop variations and improvements that can be shared with the rest of the field.

in good condition, the original spring ties remain secure, and/or there has not been any repair or replacement of the webbing. In these cases, it may not be necessary to compress the springs.

ACKNOWLEDGMENTS

Thanks to David Bayne, Furniture Conservator at Peebles Island for his constant collaboration in the development, execution, and evaluation of “Bottoms Up” treatments. Thanks to Derek Balfour, conservator in private practice, London, UK and Gwen Spicer, conservator in private practice, Delmar, NY for sharing details and images of their treatments.

ENDNOTES

1. In *Upholstery Conservation (Preprints of a Symposium Held at Colonial Williamsburg)* there were a few references to stabilizing springs by tying them to new (linen) webbing; K. C. Grier and R. Sherin, “Borax Jobs and Hay Balers: Understanding and Conserving Cheap Upholstery Structures of the Victorian Era;” E. Lahikainen, “Working with the Evidence: Upholstery Conservation of a Nineteenth Century Sewing Chair;” N. Britton, “Treatment of an Iron-Frame Turkish Chair, a Case Study.” The most recent publication on upholstery conservation, D. Eastop and K. Gill, *Upholstery Conservation, Principles and Practice*, did not include any sprung seat treatments.

2. In some cases, rare in the experience of Peebles Island conservators, the springs are not causing pressure upwards, distorting the profile and stressing upholstery materials. Instead, the seat has collapsed because of webbing stretching or breaking. This seems to occur when one or all of several conditions are met: the spring cover is

3. Z. A. Perkins, "Conservation of a Leon Marcotte Side Chair," in *Upholstery Conservation (Preprints of a Symposium Held at Colonial Williamsburg)*.

4. Elizabeth (Betsy) Lahikainen has preferred colored (pink) thinner linen yarns to make the difference between original, traditional upholstery materials and new conservation materials absolutely clear.

5. The author has since learned that polypropylene "releasable" (adjustable) cable ties are available. These would reduce or eliminate some of the disadvantages of the coated steel ties.

REFERENCES

Gill, K. and Eastop, D. 2000. *Upholstery Conservation, Principles and Practice*. Oxford, UK: Butterworth-Heinemann.

Williams, M. A., Lahikainen, E., Gill, K. and Gusler, W. 1990. *Upholstery Conservation. Preprints of a Symposium held at Colonial Williamsburg, February 2-4, 1990*. East Kingston, NH: American Conservation Consortium.

MATERIALS SOURCES

Cable Ties:

Coated steel—Panduit, 17301 Ridgeland Ave., Tinley Park, IL 60477. 800-777-3300. info@panduit.com.

Nylon—Ideal Industries, Inc., Becker Pl., Sycamore, IL 60178. 800-435-0705. Ideal_Industries@idealindustries.com

Reversible—Panduit, see address above. Panduit calls these "releasable" and notes that they are available in nylon and in polypropylene. They have part numbers that begin with "PRT."

Polypropylene—Panduit, see address above.

Linen cords: H. M. Nabavian & Sons, Inc., 11 West 30th St., ground floor, New York, NY 10001. 800-352-7510.

Polyethylene mesh: Internet Corp., 2730 Nevada Ave., North, Minneapolis, MN 55427. 800-328-8456

Waxed polyester cord: M. Speranza. 518-271-1054. ropesmith@aol.com.

ABOUT THE AUTHOR

Deborah Lee Trupin, Textile Conservator for New York State Office of Parks, Recreation and Historic Preservation's Bureau of Historic Sites (Peebles Island) since 1986, is responsible for the conservation of the textile and upholstery collections of the 35 state-run historic sites. She received an MA in art history and Diploma in Conservation from New York University's Institute of Fine Arts, Conservation Center and began her upholstery conservation training during an internship with Elizabeth Lahikainen at the Society for Preservation of New England Antiquities. Address: New York State Office of Parks, Recreation and Historic Preservation, Bureau of Historic Sites, Peebles Island, PO Box 219, Waterford, NY 12188.

FORMULATING GESSO FILLS FOR DISCRIMINATION BY X-RADIOGRAPHY

*Behrooz Salimnejad, Associate Conservator of Furniture and Woodwork,
Philadelphia Museum of Art*



INTRODUCTION

Like many conservators who have undertaken conservation treatments on gilded objects in recent years, we have used a gesso containing barium sulfate (BaSO_4) to fill areas of loss. The barium sulfate gesso was employed to allow detection of fill material by x-radiography, because of its higher x-ray absorbance when compared with the traditional calcium carbonate (CaCO_3) and calcium sulfate (CaSO_4) gesses that are found on cultural objects. In 1997 Arlen Heginbotham, summer intern at the Philadelphia Museum of Art (PMA), used x-radiography to examine a gilded American girandole frame that had been treated previously at the PMA with a calcium sulfate gesso containing 10% BaSO_4 . The resulting x-radiograph showed that it was not possible to discern the BaSO_4 containing fills from the original CaCO_3 gesso of the girandole. Further x-radiographic examinations of fills made with BaSO_4 concentrations as high as 20% gave similar results. Moreover, the addition of larger quantities of barium sulfate to gesso adversely affected its working properties: the barium sulfate tended to clump or settle to the bottom of the container and the gesso became gritty. This tip outlines preliminary testing undertaken to identify a non-toxic gesso fill material with a high x-ray absorbance that allows discrimination by x-radiography while retaining desirable working properties.

TEST SETUP

Two test panels were prepared to observe the effects of pigment composition and gesso thickness on the appearance of x-radiographs. The first test panel was prepared using fifteen gesses formulated with varying proportions of calcium carbonate, zinc oxide (ZnO), and bismuth oxide (Bi_2O_3). The zinc and bismuth pigments were chosen because they are widely available, inert, and better x-ray absorbers than the traditional calcium pigments.¹ The test gesses were mixed with rabbit skin glue (RSG)², brushed onto a $\frac{3}{4}$ " x 14" x 18" Medex[®] board, allowed to dry for 5 days, and sanded to a uniform thickness using a jig. The arrangement of the fifteen test gesses on the panel and their respective formulations are shown in Table 1.

The second panel was designed to measure the effect of gesso layer thickness on the appearance of x-radiographs. Eleven tapered mortises, numbered from top to bottom, shallow end on right, graduated from $\frac{1}{16}$ " to $\frac{1}{4}$ " deep were routed on a $\frac{3}{4}$ " x 14" x 18" Medex[®] board and filled with calcium carbonate gesses formulated with varying amounts of zinc oxide, bismuth oxide, and barium sulfate as shown in figure 2. Mortises #1–3 were sized prior to the application of gesso with a coat of rabbit skin glue containing 10% bismuth oxide w/v.

RESULTS AND DISCUSSION

The panels were examined using x-radiography (Picker SN262 x-ray machine/25KV, 3mA, 70 sec., at distance of 33 in.). The resulting x-radiographs for the panels described in Tables 1 and 2 are shown in figures 1 and 2, respectively. The x-radiograph shows marked variations in photographic density for the different gesses.

	0%CaCO ₃		0%ZnO			
0%	CaCO ₃	----	CaCO ₃	50	CaCO ₃	100
	Bi ₂ O ₃	----	Bi ₂ O ₃	----	Bi ₂ O ₃	----
	ZnO	100	ZnO	50	ZnO	----
5%	CaCO ₃	----	CaCO ₃	47.5	CaCO ₃	95
	Bi ₂ O ₃	5	Bi ₂ O ₃	5	Bi ₂ O ₃	5
	ZnO	95	ZnO	47.5	ZnO	----
10%	CaCO ₃	----	CaCO ₃	45	CaCO ₃	90
	Bi ₂ O ₃	10	Bi ₂ O ₃	10	Bi ₂ O ₃	10
	ZnO	90	ZnO	45	ZnO	----
15%	CaCO ₃	----	CaCO ₃	42.5	CaCO ₃	85
	Bi ₂ O ₃	15	Bi ₂ O ₃	15	Bi ₂ O ₃	15
	ZnO	85	ZnO	42.5	ZnO	----
20%	CaCO ₃	----	CaCO ₃	40	CaCO ₃	80
	Bi ₂ O ₃	20	Bi ₂ O ₃	20	Bi ₂ O ₃	20
	ZnO	80	ZnO	40	ZnO	----

TABLE 1 Arrangement of the fifteen test gesso formulations on panel #1. For each gesso, the pigments (10 g total) were mixed with 5 ml RSG. All measurements shown are in weight percentages (%).

Panel 1

In general, the opacity of the x-radiograph of panel #1 (fig. 1) increases as one moves from the upper left corner to the lower right hand corner of the panel. The greatest opacity is found in the section that contains 85% zinc oxide and 15% bismuth oxide and the least opacity in the section with 100% calcium carbonate.

Panel 2

Row 1. Mortise sized with one coat of 10% bismuth oxide/RSG and filled with 100% carbonate/RSG gesso. The increased opacity of row #1 versus row #11, which contains the same gesso but was not sized, is clearly visible in the x-radiograph.

Row 2. This row was also sized with one coat of 10% bismuth oxide/RSG and filled with 50/50 mix of calcium carbonate and zinc oxide in RSG. It exhibited very good radio-density, and sizing made a clear difference, especially on the thinner end when compared to row #10, which is also a 50/50 mix of calcium carbonate and zinc oxide in RSG. This fill material, however, cracked extensively during drying.

Row 3. The bismuth oxide/RSG sizing in this row made a clear difference compared with row #9 (no

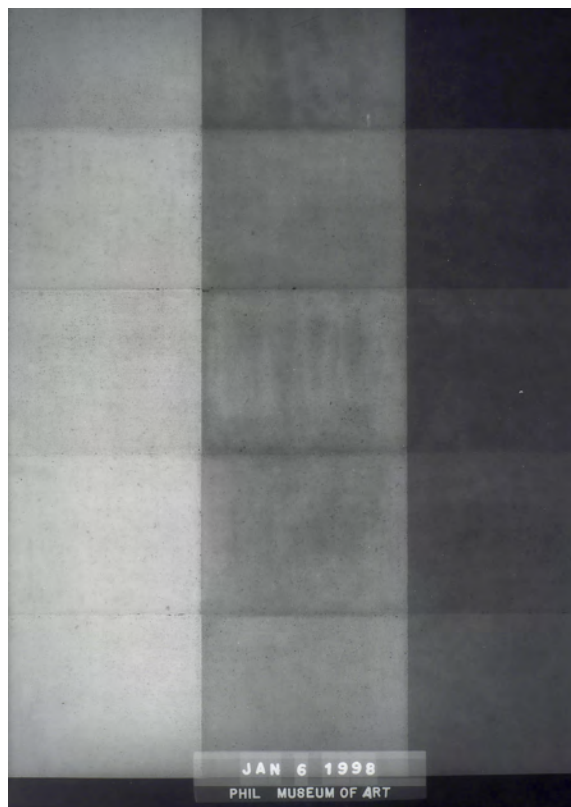


FIG. 1 The fifteen test gesso formulations in table 1.

bismuth oxide/RSG sizing) especially at the thinner end of the mortise. While Row #3 exhibited excellent opacity it cracked badly.

Row 4. The zinc oxide fill material in this row exhibited excellent x-ray absorbance but the worst cracking of all.

Row 5. The addition of 10% barium sulfate made some difference at the thicker end compared to row 11. As in our earlier tests, the barium sulfate did not stay suspended in the gesso mixture even when ground very well into the mixture.

Row 6. The gesso mixture in this row containing 20% barium sulfate was slightly more x-ray absorbing than row #5 (10% barium sulfate) but the difference is barely perceptible. The line of gritty material located in the middle of this row is residual barium sulfate, which had settled to the bottom of the container after mixing and poured unevenly into the mortise.

Row 7. This mixture exhibited excellent opacity and good drying and working properties.

Mortise #1	CaCO ₃ 100 g/over a 10% Bi ₂ O ₃ RSG size layer
Mortise #2	CaCO ₃ 50 g/ZnO 50 g / over a 10% Bi ₂ O ₃ RSG size layer
Mortise #3	CaCO ₃ 35 g/ZnO 50 g/Bi ₂ O ₃ 15 g/over a 10% Bi ₂ O ₃ RSG size
Mortise #4	ZnO 100 g/
Mortise #5	CaCO ₃ 90 g/BaSO ₄ 10 g
Mortise #6	CaCO ₃ 80 g/BaSO ₄ 20 g
Mortise #7	CaCO ₃ 50 g/ZnO 35 g/Bi ₂ O ₃ 15 g
Mortise #8	CaCO ₃ 90 g/Bi ₂ O ₃ 10 g
Mortise #9	CaCO ₃ 35 g/ZnO 50 g/Bi ₂ O ₃ 15 g
Mortise #10	CaCO ₃ 50 g/ZnO 50 g
Mortise #11	CaCO ₃ 100 g

TABLE 2 Arrangement of the eleven gesso formulations on panel #2. For each gesso, the pigments (100 g total) was mixed with 50 ml RSG.

Row 8. This mixture exhibited very good opacity and excellent drying and working properties.

Row 9. See comments above on row #3

Row 10. See comments above on row #2

Row 11. See comments above on row #1

CONCLUSIONS

A sizing treatment of a fill area with RSG containing 10% bismuth oxide provided a perceptible increase in opacity in these tests especially when thin layers of traditional calcium carbonate gesso fill were used. For thicker areas, the addition of up to 35% zinc oxide with 5% bismuth oxide to traditional gesso provided excellent x-ray density without comprising the workability of the gesso material. While concentrations of zinc oxide higher than 40% cracked badly during drying of the test panels, the cracking problems were not as severe if the gesso was applied in layers with a brush rather than poured. Pouring became especially problematic with the barium sulfate gesses because of the rapid separation (settling) of the barium sulfate from the gesso mixture.

Based on these observations, we developed a fill method using a gesso formulated with 55% calcium

carbonate, 35% zinc oxide, and 10% bismuth oxide in RSG. This fill material was used to treat the losses on an 18th-century French console table from the PMA collections after first sizing with RSG containing 10% bismuth oxide. This mixture brushed on well, dried similarly to traditional gesso, burnished well, and was easy to cut with gesso tools. Furthermore, the fills on the French console table have not shown any adverse effects such as cracking, shrinkage, or discoloration after five years in the museum environment. Additional studies would be valuable to study a wider range of formulations including calcium sulfate gesses, and to determine the effect of environmental conditions on these materials.

ENDNOTES

1. Dr. Chris Tahk, Director, Art Conservation Program, State University of New York, College at Buffalo, suggested bismuth oxide as a possible pigment for the gesso in fall of 1997.

2. The stock solution of rabbit skin glue was made by dissolving 45 g of ground rabbit skin glue in 1000 ml of distilled water.

3. Medex[®] is an engineered wood-based panel product manufactured by SierraPine, Ltd. (www.sierra-pine.com/products/mdf_medex.htm) from softwood fibers combined with formaldehyde-free synthetic resins.



FIG. 2 The eleven test gesso formulations in table 2.



FIG. 1 Ladies' fan before treatment. Black ostrich feathers and cellulose nitrate sticks.

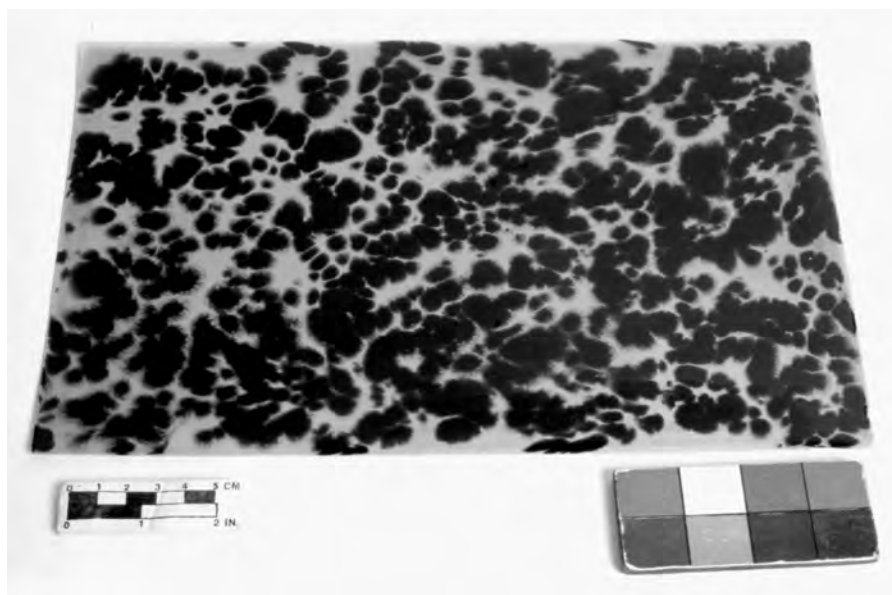



FIG. 2 A full sheet of the Tor-tis™ material, measuring 7.5 x 12 inches.

A NEW MATERIAL FOR PRODUCING FAUX TORTOISE SHELL FILLS

Thomas J. Braun



In July of 2001, during a class taught by Smithsonian furniture conservator Don Williams, a student mentioned that he had success filling losses to tortoise shell inlay on furniture using faux tortoise shell sheet stock, which he had purchased from musical instrument supply catalogs. Having never worked with tortoise shell or faux tortoise shell, it seemed like a good tip to keep in mind. In the winter of 2002, a 19th-century ladies' fan was brought to the Daniels Object Conservation Laboratory at the Minnesota Historical Society for treatment. The fan was made out of black ostrich feathers and faux-tortoise shell cellulose nitrate plastic. As seen in the photo of the fan before treatment (fig. 1), the cellulose nitrate had begun to deteriorate, shatter, and release acidic vapors. Although the feathers were still in excellent condition, until the fan came to the lab, the plastic parts were considered untreatable and a total loss, due to the extensive and irreversible damage. After consulting the appropriate curator, it was decided that if an appropriate material could be found to replace the original faux tortoise shell, it would be acceptable to replace all of the original plastic material, since there was no hope of preserving the cellulose nitrate before it completely deteriorated, and potentially caused damage to the feathers.

Several luthier supply catalogs were searched for faux tortoise shell sheet stock. Usually, there were several drawbacks: it was very expensive, often already cut into the shape of a pick or a pick-guard (which was too small for the fan), and it was frequently made out of cellulose nitrate, which was of course unacceptable. However, Luthiers Mercantile International (LMI), a supplier based in California, carried a material that was intriguing (fig. 2). It is called Tor-tis™, and LMI claimed to be the exclusive distributor. It was sold in large sheet stock (up to 7½" x 12") that came in several thicknesses between ¼" and ⅓", which tends to be rather thin for most tortoise shell inlays. However, they did not specify what it was made of, only stating that it was "highly refractive, chemically inert, untouched by all solvents, ...and backed by 25 years of industrial use." Lastly, it was not cheap, the largest sheet, sheet measuring 7½"x12", cost over \$50, though this is not a bad price if it proved to be appropriate for conservation.

Two sheets of the "light" colored grade were ordered from LMI. When the company was asked what it was made of, they provided the telephone number of the manufacturer, Colette Hanson, apparently the sole proprietor of Turtleworks, based in Bloomington, Indiana, where Tor-tis™ faux tortoise shell is made. After speaking with Colette, she indicated that she could make thicker samples (up to ⅛" thick), and that she could even imitate specific colors and patterns in original samples of tortoise shell or faux tortoise shell. Apparently, for some stringed instrument makers and restorers, it is extremely important to imitate the exact original graining in a pick guard. Colette was very helpful, and stated that her product was made from a two-part epoxy, and although she would not divulge the manufacturer, she did send some thicker samples (up to ⅓" thick) which were more consistent with the thicker tortoise shell often used in inlays.

After consulting with James Martin of Orion Analytical LLC in Williamstown, Massachusetts, a sample was analyzed with Fourier Transform Infrared analysis (FTIR) to verify if it really was epoxy, what kind of epoxy, and to see if the colorant used also could be identified (fig. 3). In figure three, the spectra for

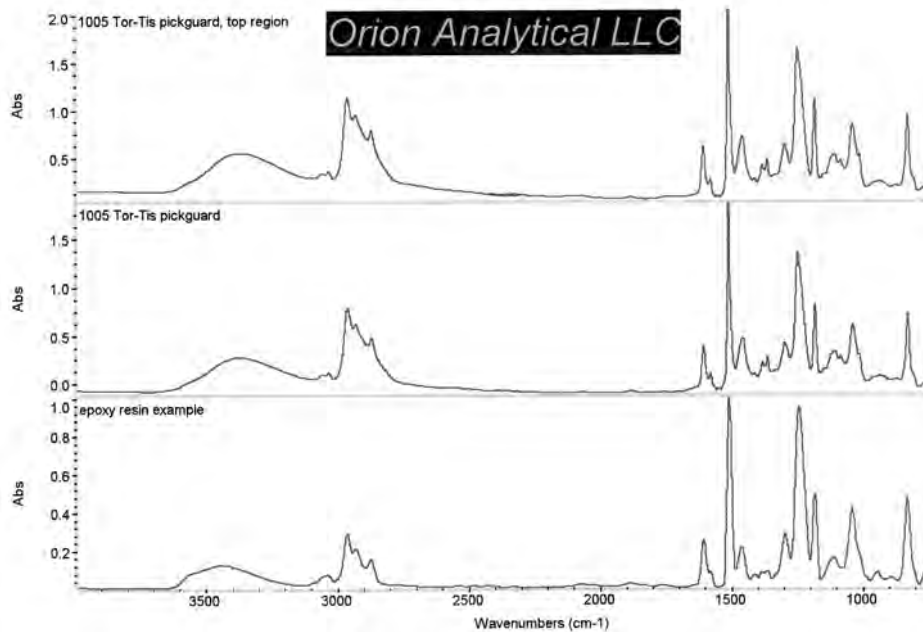


FIG. 3 Three spectra from the FTIR analysis, showing that the unknown is identical to common epoxy. Analysis and spectra provided by James Martin and Orion Analytical LLC.

a known sample of bisphenol-A epoxide is almost an exact match with the sample unknown. Mr. Martin's interpretation stated that most commercial epoxides are derived from a condensation reaction between epichlorohydrin and Bisphenol-A. Apparently, Turtleworks used a low-viscosity epoxy, because it is clear from the samples that the resin was cast out onto a non-stick surface, allowed to form a thin glass-like pool, and any air bubbles allowed to settle to the surface and burst. Using an epoxy would support the manufacturers claim that it is "highly refractive" and "untouched by all solvents." Turtleworks may use catalysts to accelerate the set, which in the long-term can also accelerate the aging and yellowing of an epoxy. Unfortunately, it was not possible to identify easily the orange or brown colorants within the epoxy, since the resin is insoluble in any known solvent, and the colorant is thinly dispersed within the epoxy.

Turtleworks recommends immersing the sheet in warm water and using a scissors to cut it, which works well (fig. 4). If the resin is cut with scissors at room temperature, it will crack and shatter unexpectedly. It does not seem to polish very well on a buffing wheel because as the resin warms, it softens and debris becomes ingrained in the epoxy.

However, Micro-mesh abrasive pads and some elbow grease work very well. Additionally, setting pieces with fine scratches on them on a clean sheet of glass in a lab oven set at about 100° Celsius will soften and conform to the surface of the glass. After cooling, the epoxy can easily be cleaved off the glass and will have a smooth glass-like finish. Where accurate bending is desired, a Leister hot air tool works very well (fig. 5).



FIG. 4 Warming the material in hot water and cutting with scissors.



FIG. 5 Bending the material with a Leister hot air tool.

After the restored pieces of the fan were cut and polished, they were attached to the feathers with Jade 403, a polyvinyl acetate emulsion adhesive. Finally, all of the parts of the fan were assembled and secured together with a brass pin, flattened on each end with a ball-peen hammer. A black thread holds all of the sticks the proper distance apart when the fan is opened (fig. 6).

In summary, this material is probably appropriate to use in conservation. It would have to be set into place with an appropriate, reversible adhesive, but few long-term problems with this material can be foreseen. One possible problem is continued yellowing or darkening with age, though this should not be significant unless the exact color of the fill is critical.

MATERIALS SOURCES

Luthiers Mercantile International, Inc.
 P.O. Box 774, 412 Moore Lane
 Healdsburg, CA 95448
 707-433-1823
 800-477-4437 (orders)
 707-433-8802 (fax)
 www.lmii.com

Micro-mesh abrasive pads
 Micro Surface Finishing Products Inc.
 1217 West Third Street, Box 818
 Wilton, Iowa 52778
 (319) 732-3240

Turtleworks, c/o Colette Hanson
 2650 N. Brummetts Creek Road
 Bloomington, IN 47408
 (812) 334-2496



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 Daniels Objects Conserva-
 tion Laboratory
 Minnesota Historical Society
 345 Kellogg Blvd West
 St. Paul, MN 55102-1906

FIG. 6 Ladies fan after treatment. Black ostrich feathers attached to restored epoxy sticks.

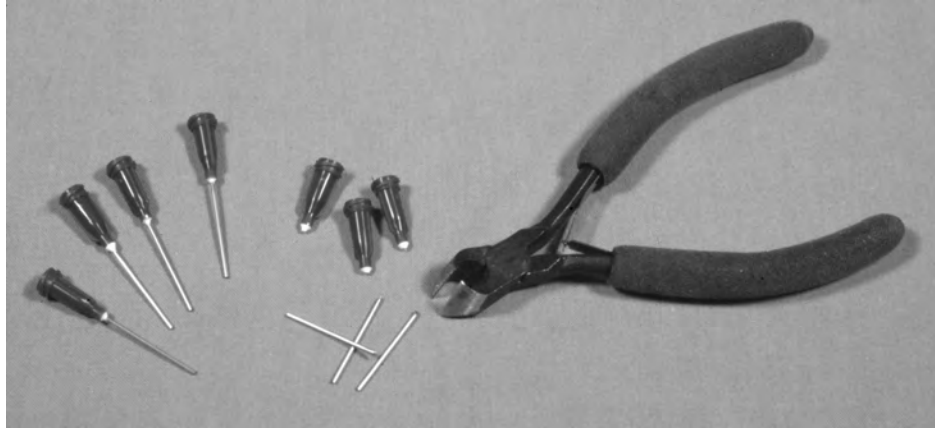


FIG. 1 Needle snipped off plastic head.

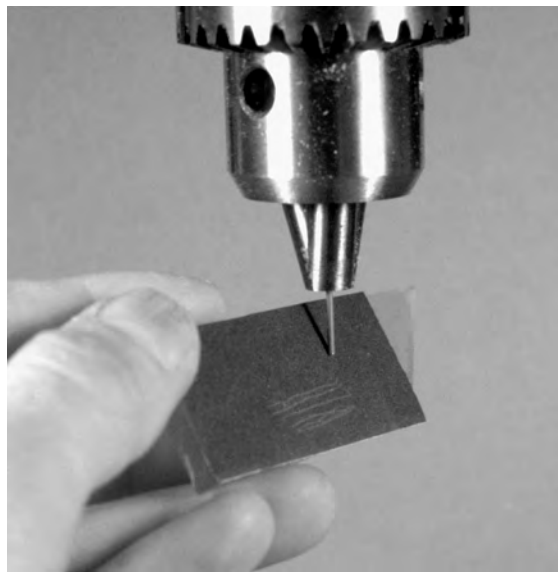


FIG. 2 Beveling tip on drill press with 400 grit paper.

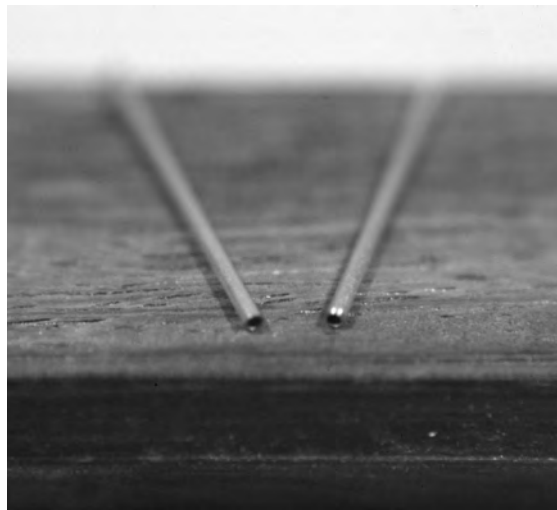


FIG. 3 Factory tip on left, beveled tip on right.

ANOTHER METHOD FOR TAKING CROSS-SECTIONS FOR MICROSCOPIC FINISH ANALYSIS

Melissa H. Carr



The problems with taking cross-sections for microscopic finish analysis are that:

- The best places aren't the easiest places from which to take the samples.
- It's difficult to protect the sample until it can be mounted and viewed.
- The client envisions something disfiguring involving large cutting tools.

The following is an alternative we worked out at Robert Mussey Associates during my tenure there. As with most approaches, it has its advantages and its drawbacks and limitations.

The basic idea is to take a core sample from the object using a sharpened hollow tube. We took some commercially available 1" hollow needles and began by snipping off the plastic end that screws onto the syringe. (fig. 1) This leaves a crimped tip at one end and the flat factory tip on the other end of the needle. Remove the crimp on a grinder. There's no need to worry about the burr—this won't be the business end.

The next step is to bevel the flat factory end (without the burr) so that it will cut sharply through the finish. We've tried using a Dremel tool held at an angle against 400x paper, but this isn't ideal because of run-out in the rotation of the Dremel that results in an uneven bevel. More recently I've been using my new drill press that has virtually no run-out. I chuck the ground-off end of the needle in the drill press, tape some 400x paper to a piece of Plexiglass, and press it gently at a 45° angle against the factory end (fig. 2). This produces the beveled tip seen on the right in figure 3, in contrast with the un-beveled tip on the left. Any grinding debris in the tube should be cleared out with a reaming wire corresponding to the interior diameter of the needle.

I've tried polishing at higher grits and even with jeweler's rouge to improve the cutting action of the tip, but haven't noticed any particular improvement in the end result. As a further disincentive, the jeweler's rouge tends to contaminate the view unless you want to spend a lot of time cleaning it out of the needles before you use them.

The next step is to punch a polyethylene plug into the needle. The plug protects the sample if you need to eject it later from the needle. Tap the needle through some sheet polyethylene set over 6# Ethafoam (fig. 4). If you don't succeed after two or three tries, that means the bevel is bad on the needle and

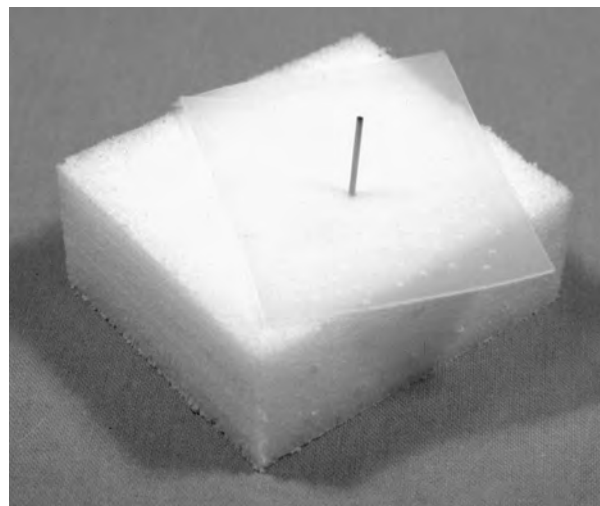


FIG. 4 Punching polyethylene plug.



FIG. 5 Taking a sample.

the needle should be discarded. Finally, wrap a “return address” size label around the non-beveled end. It gives you something to hold, and something to label. Now the needle is ready to use.

To take the sample, place the beveled tip against the surface in question and give it a firm tap with a small hammer (fig. 5). The idea is to cut through all of the finish layers and go at least a bit into the underlying substrate (wood in this case). It takes some practice to tap it just right, and of course, “just right” varies with the hardness of the substrate. Once you’ve taken the sample and labeled the paper tag, you can put it in an envelope if you’re on the road, or mount it in polyester if you’re in the lab.

There are two choices for mounting the sample; it can be mounted while still in the tube, or ejected with the same reamer used to clean out the grinding debris. Unless there’s a particular reason to remove it from the tube (*e.g.*, the metal will contaminate other analysis), I don’t recommend it. The tube is a little distracting to look at under magnification, but you’ll get used to it.

If the sample is to be left in the tube, snip off the end of the needle that contains it (being careful not to cut so close to the sample that you crimp the section holding it). Place the section on a shallow bed of cured polyester (we used the small ice cube trays), and then pour a bit more polyester on top to seal the needle in the cube. After the polyester cures, grind it back using a standing sander and Micromesh until one side of the needle is gone and the face is polished—up to 3600x usually produces a good image for viewing under the microscope.

Sometimes the sample is lost in the grinding process when the upper layer of the needle is removed—remember, it’s the needle that’s secured in the polyester, not the sample. If that’s a problem, I’ve had some success in consolidating the sample in the needle by submerging the end in a resin solution before I mount it in the polyester—it’s a good idea to test a few different solvents so that the sample isn’t dissolved into a soup.

Figure 6 shows a sample of a verte antique finish, left in the needle, viewed under UV light. The wall of the needle is visible on the left side of the sample. Figure 7 shows a finish sample from a piece with questions about whether it was originally mahoganyized. It illustrates one of the drawbacks of this technique—notice that the left side of the sample is smashed down—that’s a distortion caused by the impact of the needle in the process of taking the sample. Sometimes the impact seems to crush the entire sample, and the layers are com-

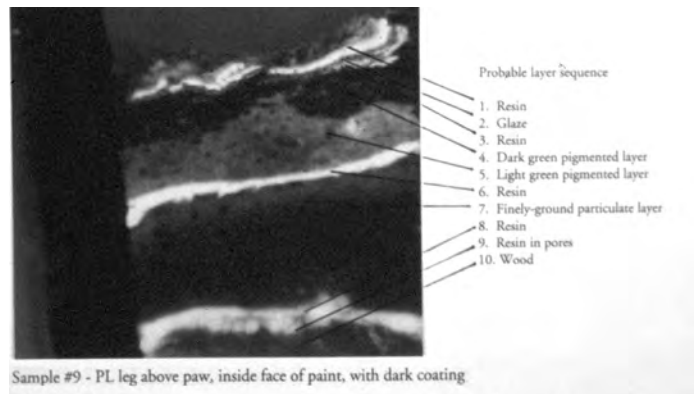
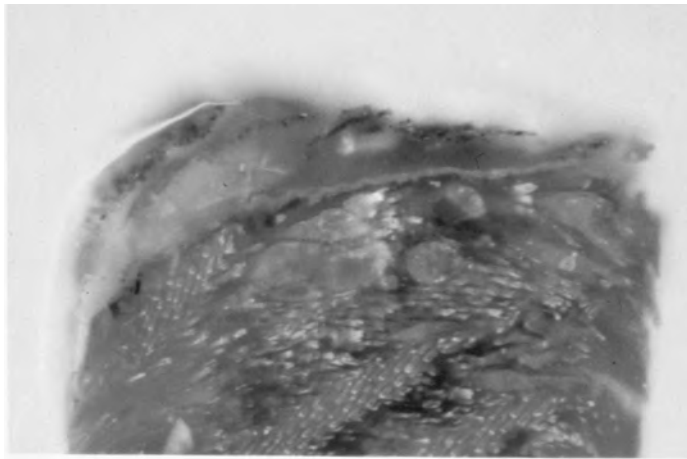


FIG. 6 Sample mounted in tube, UV light, 125X.



visible light 125X

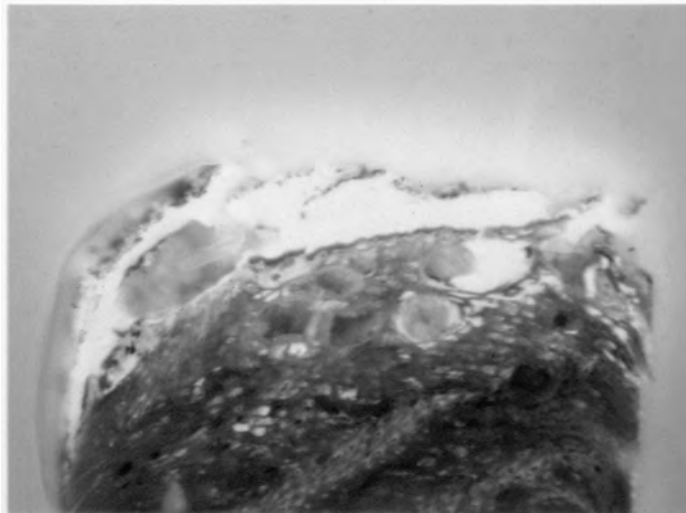


FIG. 7 Sample ejected and mounted, visible and UV light, 125X.

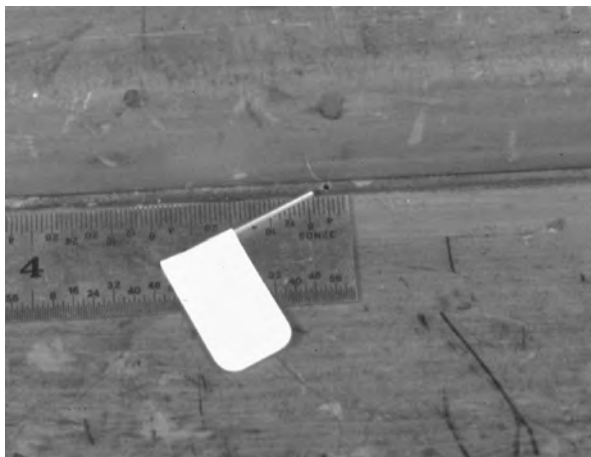


FIG. 8 Scaled illustration of sample hole in object.

pletely jumbled when you view it under the microscope.

Figure 8 illustrates the size of the sample taken. Most clients tend to relax when they see the size of the hole.

MATERIALS SOURCES

There's nothing sacred about the needle size. In my experience, anything smaller than 19 gauge won't work, but a larger needle would be just fine—it's a question of controlling the sample size for your client's anxiety level and your own conscience. Available from Technitool by special order (www.techni-tool.com, 800-832-8846. Item # 606TI189, Manuf. # KDS191P, 19g, 1").

ABOUT THE AUTHOR

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EVALUATING UPHOLSTERY LAYOUTS USING DIGITAL IMAGING

David deMuzio



Digital imaging can be used to help evaluate various layout choices when considering using reproduction fabric with long pattern repeats in re-upholstery. The example shown here is a loom proof of a wool damask (based on a design surviving at Vyne House) woven by Context Weavers in England.

A digital camera was setup on a tripod. Without moving the sofa or the camera, a series of images was taken, moving the fabric systematically across the back after each exposure. Each pattern was photographed three times in order to cover the back of the sofa. This process was repeated five times to use all of the possible patterns in the 81 inch long, 23 ½ inch wide design repeat.

The fifteen digital images taken were spliced together in Adobe Photoshop using the standard manipulation tools (marquee, move, eraser or magic wand tools).

The entire process took about 1½ hours and the resulting composite image was very useful in discussing the layout possibilities of various reproduction fabrics with the client.





FIGURE 1

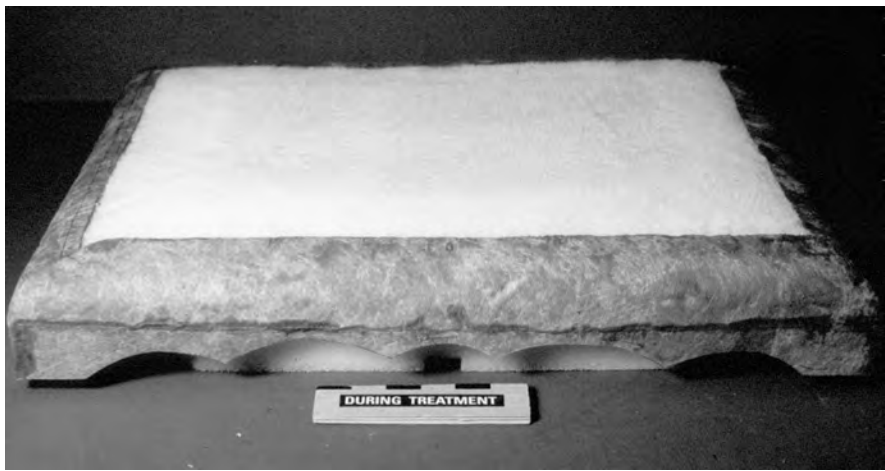


FIGURE 2

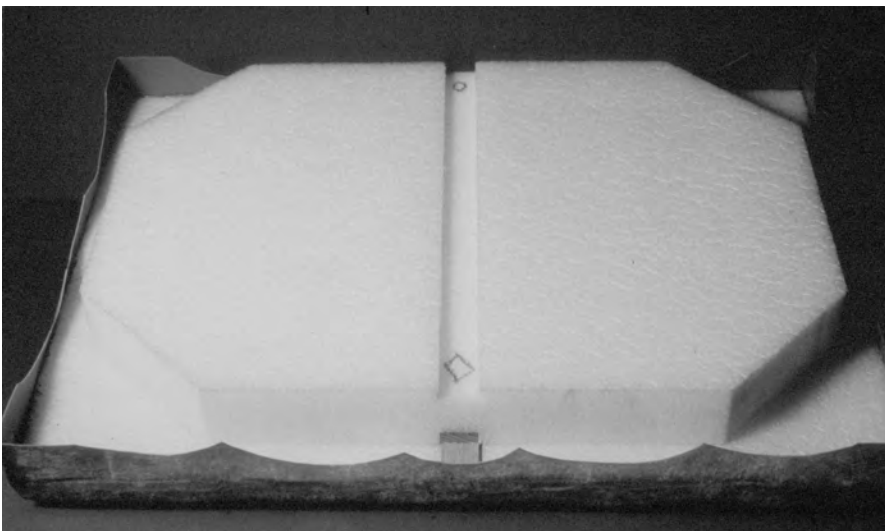


FIGURE 3

TIPS ON REMOVEABLE UPHOLSTERY CAPS & BACKING FRETTED PANELS

Mark Harpainter, furniture conservator in private practice, Berkeley, CA

A REMOVEABLE UPHOLSTERY CAP

This tip demonstrates the use of a semi-rigid material for creating a removable “cap” or armature for the tackless and non-invasive re-upholstering of seating furniture incorporating a visibly tacked, partially over-the-rail show cover.

Creating the illusion of a neat and snugly-fit show cover with a visible mid-rail tack margin without any actual attachment of new foundation or covering to the frame is a tricky and potentially vexing problem in upholstery conservation. The addition of a serpentine-shaped tack edge adds another layer of intrigue.

Many will be familiar with Mark Anderson’s encounter with just this problem on the famous Cadwalader side chairs at Winterthur. His elegant solution (written up in the 1989 WAG Postprints) used a somewhat brittle fiberglass and polyester resin, stiffened with carvable epoxy paste, to form the cap’s apron down to the tack margin. Leroy Graves at Colonial Williamsburg has used complex systems of fabricated copper caps in similar situations; others have relied on polyethylene with stitched-on linen sheaths as Joe Twitchell has described. (I don’t believe the latter can be slipped off and refit without quite a bit of re-sewing and fabrication).

The sleight of hand required is to achieve the illusion of a tight, securely tacked edge at the margin of a snug and neatly fit show cover, with no puckers, bulges or gaps to give the deception away. To achieve this with no tacks, fastenings or attachment to the original frame requires a material which is quite thin and has just the right balance of rigidity and flexibility. In addition to being minimally intrusive to the original frame, this type of simple cap allows removal for study.

To re-upholster an early 18th-century French stool for the Fine Arts Museums of San Francisco, a thermoplastic resin sheet called “Altraform,” used for theatrical masks, props and armatures, was chosen in place of the fiberglass apron used by Anderson on the Cadwalader chairs, and attached to an Ethafoam support. Altraform is available in sheet form and softens at 140–160° Fahrenheit. It also adheres to a variety of materials, including itself, if a scrim laminated to one or both sides is removed. A block of Ethafoam was shaped to fit inside and over the top of the wood



FIGURE 4



FIGURE 5

frame. An integral strut of oak was incorporated in the Ethafoam, resting on the top of the frame rails to prevent collapse if excessive downward pressure was inadvertently put on the seat (fig. 1). Pieces of the thermoplastic sheet were roughly cut to shape, softened in hot water and fused onto the perimeter of the Ethafoam (figs. 2 & 3). The thermoplastic apron was then molded to fit the frame rails and trimmed to fit the shape of the tack margin. The corners were reinforced with another thickness of the Altraform to stiffen them, and the final adjust-

ments made to the shape with a heat gun (fig. 4). The rest of the application was straightforward—polyester batting for loft and final form and show cover fabric and trim attached along the edge of the thermoplastic cap using BEVA film, set with a tacking iron (fig. 5). The result was a very convincing looking seat cover, which easily slips off and (with some care and the judicious use of a thin spatula for the pointed scallops) back in place over the frame (fig. 6). The material has great working properties and is simple to use.



FIGURE 6

This treatment was carried out 6–8 years ago and examination of off-cuts from the thermoplastic sheet now suggests potential embrittlement problems. A check with the local supplier seems to indicate that the problem may be isolated to bad batches in the manufacturing process. (The supplier has noticed the same problem with some sheets, but not others. Even though they have been on his shelf for almost the entire time since the treatment was done, some are still very flexible, some not.) Also since the treatment, other new forms of the material have become available. Some are: impregnated fabric, netting, soft felt-like material and a rigid plexiglass-like material that comes in both perforated and solid sheets (four thicknesses 1.5 to 4.5 mm), as well as pellet form. Recently the Oddy test was done on some samples at the Getty Conservation Institute and they were found suitable for exhibition purposes. Eventually, information from more comprehensive analysis would be useful. For now, given the alternatives, and the simplicity and performance of this material, it seems

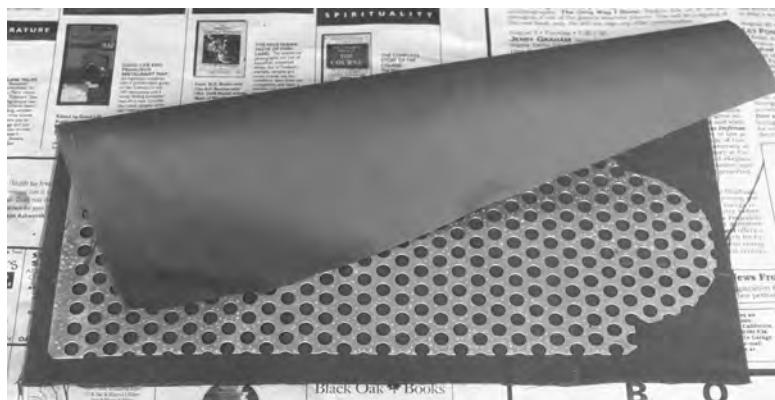


FIGURE 8

to show real promise for upholstery conservation applications.

TIP 2: BACKING FRETTED PANELS

Tip number two simply uses a thin perforated aluminum sheet to provide a backing or reinforcement for the delicate fretted wood panels, often cracked or broken, commonly found in clock cases (fig. 7). It can be hidden between silk fabric, commonly used originally to back the panels, to conceal it and provide the correct look (fig. 8) without muffling the sound of the chimes if the clock is running (fig. 9).

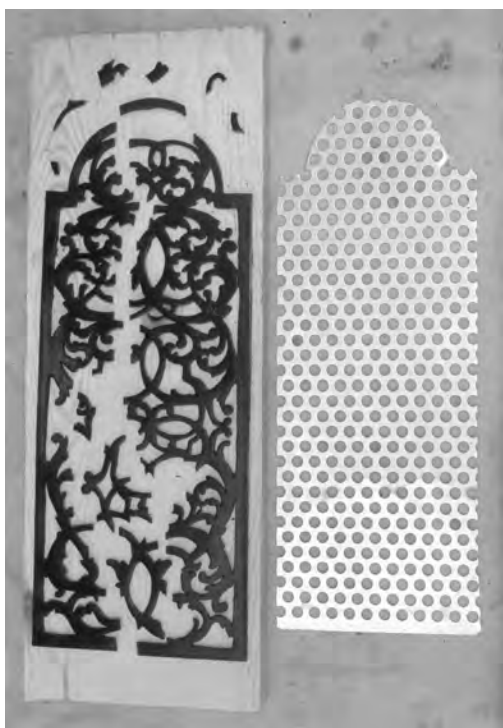


FIGURE 7



FIGURE 9