CONSERVATION TREATMENT OF A HUNZINGER CANTILEVERED ARMCHAIR INCLUDING THE USE OF MAGNETS TO CREATE TUFTING

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George Hunzinger (active 1860–1898) was an innovative furniture designer who inspired many with his unique manufacturing and production techniques. This paper discusses treatment of one of Hunzinger's innovations, a cantilevered seat scroll front edge armchair owned by the Munson-Williams-Proctor Arts Institute in Utica, New York. Although it no longer had its original show cover, and the profile of the seat had been dramatically altered during a previous reupholstery campaign, evidence of original materials was discovered during treatment. An identical chair, owned by the Brooklyn Museum of Art, that retained not only its original upholstery but also the true profile of the seat, provided crucial information for this treatment project. This paper presents information on the chair's construction and materials used to reupholster it as well as methods employed to re-create the original profile of the tufted seat. As part of the treatment, the ornate tufted seat with a vertical center decorative panel was re-created while original historical materials in the seat were retained. To avoid the stress of traditional tufting that creates holes in the fabric, magnets were selected as alternative securing elements. A comparison of noninvasive tufting techniques is included, along with basic information used for the selection of magnets.

KEYWORDS: *Hunzinger, tufting, upholstery, magnets, non-invasive, springs*

1. INTRODUCTION

1.1 GEORGE HUNZINGER (1835–1898)

Furniture designer George Hunzinger (1835–1898) trained as a craftsman in his father's cabinetmaking shop in Tuttingen, Germany, and immigrated to New York City in 1855. In the first 5 years after his arrival in New York, before he opened his own shop, he worked first for Auguste Pottier of Herter, Pottier & Company and later for Pottier and Stymus. Both companies produced furniture and interiors for the wealthier citizens. Once on his own, Hunzinger focused on satisfying the growing middle class in the post-Civil War years (Harwood 1997), producing furniture that was both fashionable and functional while also incorporating his interest in design and construction. He received 21 patents between 1860 and 1897, many representing his wide interest in furniture forms beyond chairs. These patents included new techniques for swivel-top and nesting tables and convertible beds, among others. His obituary mentioned that he followed no particular school in his designs (D'Ambrosio 1999).

An important Hunzinger invention was a chair design including a cantilevered seat with scroll front edge and diagonal bracing. The result is a chair that appears as if it could fold although it does not. The folding quality represented in this chair is further accentuated by the use of the sling back, reminiscent of cross-frame chairs such as the modern "director's" chair. Hunzinger's 1869 patent, No. 88,297, Mar. 30, 1869, describes a diagonal chair brace that runs from the base of the front legs to the intersection of the arms and the chair's back. This patent was the first awarded to Hunzinger for a nonfolding chair after a series of patents for folding chairs. Hunzinger made several different designs all with the same diagonal bracing, ultimately creating at least two-dozen variations on this form. Through his mastery of machine manufacturing and marketing, Hunzinger was able to offer not only design variations, but also the same chair style in several finishes and upholstery fabrics. It is one of these cantilevered seat, scroll front edge armchairs, in the collection of the Munson-Williams-Proctor Arts Institute in Utica, New York, that is the subject of this paper.

1.2 EVOLUTION OF UPHOLSTERY ELEMENTS

Developments in upholstery stem from a continuous striving for comfort. As layers of padding were added, means of fastening the layers of padding together were created. A form of quilting, to anchor the layers

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of padding together and which also had a decorative function, was first used in the 16th century (Davies and Doyal 1990; Spicer 2010b). Later, in the 18th century, individual localized points of joining together layers were used with a decorative bundle of threads, called tufts. The tufts prevented the cord used to tie or lash the springs from tearing through the show cover fabric. These wrapped bundles worked well as long as the stuffing layers remained thin. In this scenario the show cover fabric between the tufts remained smooth. As the layers of padding became thicker, buttons were used as part of the securing system. The deeper wells created by the thicker layers resulted in a folded effect in the show cover. The 1830s were a transitional period with buttons becoming the norm by the 1840s.

Another progress was the development of the spring itself. Springs and tufting were important elements of 19th-century upholstery and provided both comfort and aesthetics. The first use of spiral springs in upholstered furniture in the United States dates to the late 1840s (Cooke and Passeri 1987; Britton et al. 2009; Britton and Porter 2010). Springs were a cost- and labor-saving innovation because they efficiently filled space that would have otherwise been filled with horsehair, which required extensive time for placement and stitching. Additionally, the springs below the now thinner horsehair cake had more give, which added to the comfort. Early spring seats quickly became lumpy and uncomfortable because spring control and the natural tendency of springs to uncoil were not fully understood. Even spring creation was improved; first forming them of metals that failed less, and then mechanizing the winding of springs (Edwards 1993).

The full use of springs was accelerated not only by the numerous advances both in iron blending and spring design, but also through the method of tying or lashing springs to secure them and create an evenly comfortable seat. It was not until the 1850s that the hourglass spring design was developed, after which full integration in spring seat design and production occurred (Britton and Porter 2010). Springs were not essential for deep tufting; however, they were often found together.

The Victorian era saw the height of the deep tufting-style, generally considered an exceptionally comfortable type of seating. The period coincided with the height of the upholsterers' craft, with practitioners who were not only able to cover just about any surface or shape found on furniture, but also to execute tufting on walls. However, during the industrial age, the upholstery profession was being threatened as their trade was becoming mechanized. To ensure their positions, upholsterers began making their designs intricate and time consuming. This was their way of expressing that a purchaser was paying for an amount of work that could not be duplicated by a machine (Edwards 1993). The shapes between the tufts became quite elaborate, going beyond simple squares, rectangles, or diamonds, to "star" tufting that radiated from the center. The French adopted the style of deep tufting later, and once they did, they were enthusiastic practitioners. Grier (1988) discusses this technique as a "French novelty" in upholstery, but the evidence appears to prove that the innovation arrived in the United States through both German and French immigrants. Deep tufts could also be quite hard to sit on, but with a soft appearance. Their ability to add to the comfort of the sitter is not known, as the materials have all degraded. Enjoyment of comfort sought by the sitter was also inhibited by the social habits and dress of the time. In tufting, the tying cords and buttons are under an extreme amount of stress. The buttons or tufts are required to compress and hold all of the layers in the seat. The ties anchored on the back or underside of the seat are small cords, knotted or tied to a bundle of scrap fabric. Here, a thin cord is desired, so as not to create too large a hole in the display fabric that became finer as time went on.

As with many things, the terms used to describe tufting and buttoning are different in the United States and other countries, even other English-speaking countries. In the United States the technique that is a flat profile is described as "buttoning" and the deeper type where the show cover is folded as "tufting" or "deep tufting." In the UK, the terms are reversed to describe more the item that holds down the show cover. Therefore, the flatter profile style with a tuft is "tufting" and the deeper type secured with a button is "buttoning." In the late 19th-century United States, both terms became generic enough to describe both techniques. Another term used in the United States is "pleated tufting."

2. Hunzinger's Cantilevered Chairs

2.1 Background and History

A cantilevered seat, scroll front edge armchair owned by the Munson-Williams-Proctor Arts Institute (MWPAI) in Utica, New York (fig. 1), was treated by the author in 2008 in anticipation of the exhibition "The Fabrics of the Home," on view at the MWPAI from April to early August 2009. Although the armchair (object number 1993.21) displays Hunzinger's maker's mark—impressed into the rear leg and including the date 1869—it no longer had its original show cover. An identical armchair owned by the Brooklyn Museum of Art (BMA) that retained its original upholstery served as a model for this treatment (object number 1992.208) (fig. 2). Before MWPAI purchased the chair in 1993, it was in the collection of BMA. BMA had

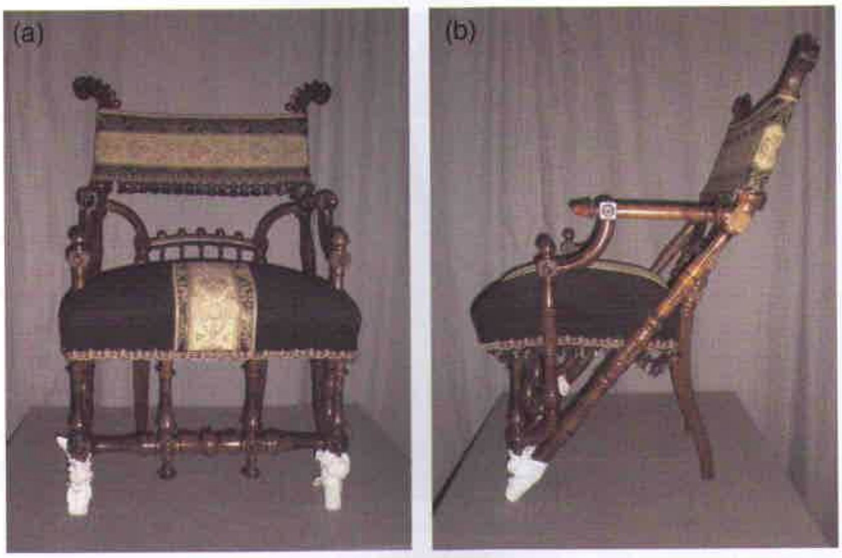

FIG. 1. Front and side views of the MWPAI's George Hunzinger cantilevered seat scroll front edge armchair before treatment (1993.21). Treatment was implemented for *The Fabrics of the Home* (April 4–August 6, 2009), an exhibition showcasing rich upholsteries and wallpapers of the Victorian Era.

FIG. 2. The BMA's cantilevered armchair with original show cover and trimmings (1992.208). The scroll front edge can be seen.

purchased that chair from Hamish Hogs Antiques (Helen Hersh) in Brooklyn, New York in 1985 and then sold it to MWPAI when it acquired an example with its original upholstery. Proceeds from the sale to MWPAI made it possible for BMA to purchase the chair with the original upholstery fabrics (D'Ambrosio 2009).

In an attempt to follow the original intent, the MWPAI chair had been reupholstered, likely in the 1920s or 1930s, with a black cotton rep fabric with a machine-woven panel insert along the center seat and sling back. This reupholstery is consistent with a date at which time a newer fabric would have been needed due to wear and tear (Harwood 2009). Many of the attached upholstery trims were also ostensibly duplicated with colors that corresponded to the panels. All of the colors of this replacement show cover were quite faded by 2008 when this treatment was undertaken. It was during this early 20th-century reupholstery campaign that the seat profile was dramatically altered and the decorative turned elements removed from both sides of the front chair rails. The seat profile changed from a scroll style to a more square profile at the front edge with straight and upright front corners; and the tufting was removed. Originally the side rails had a bit of a curve that was mirrored by the curved shape of the seat; the side rails dipped down slightly. The unique characteristic of the Hunzinger cantilevered seat scroll front edge armchair was lost in this reupholstery campaign.

3. Analysis Of The MWPAI Cantilevered Armchair

During removal of the current show cover of the MWPAI chair, original materials were revealed. Each of the layers is briefly described below and illustrated in the seat's cross-section (fig. 3).

3.1 SEAT SUPPORT EVIDENCE

Two campaigns of jute webbing were present; both webbing had stripes of brown warps. Jute was commonly used in the late 19th century, having replaced

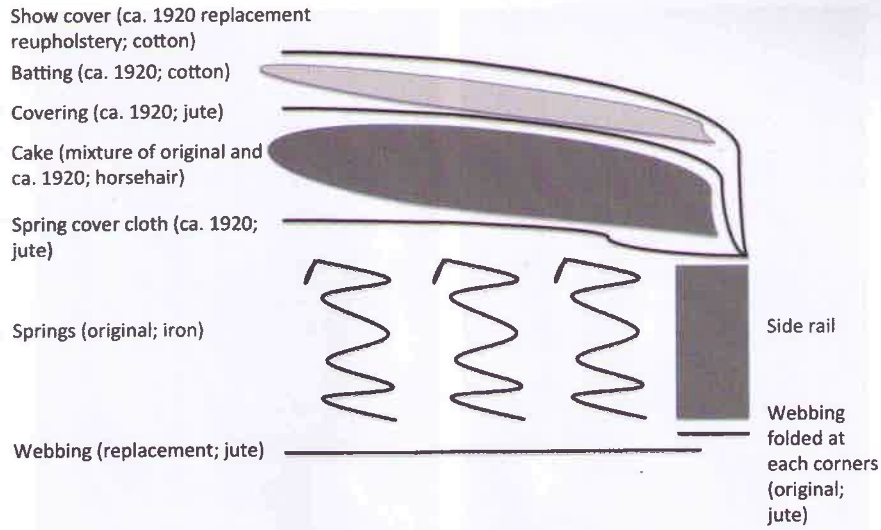

FIG. 3. Cross-section showing the upholstery layers of the MWPAI chair seat before treatment.

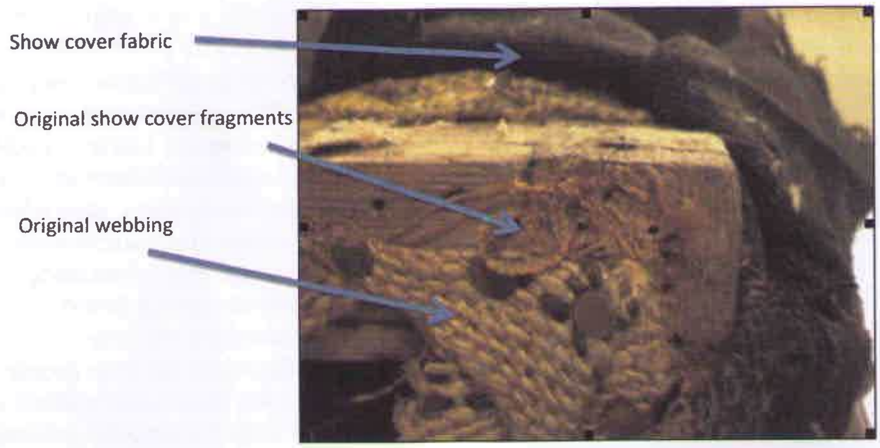

FIG. 4. Webbing evidence located at the underside corner of the seat. The webbing is folded at the corner in a method to create a diagonal orientation that continues to the opposite corner. The shallowness of the seat allows that the two "X" webbings could support all six of the hourglass-shaped springs.

linen or hemp used during the 1830s (Milnes 1983). The replacement webbing (lighter in color than the earlier, darker webbing) had three parallel strips that ran front-to-back and two side-to-side. Earlier webbing evidence of this pattern could not be located. However, at each corner folded webbing fragments were extant. Placement of these fragments indicated that the original webbing was positioned diagonally, creating an unusual "X" configuration (fig. 4). It appears that the diagonal webbing was used to support the outer four coil springs, due to the shallowness of the seat. From the examination of the BMA chair, it is possible that a similar diagonal treatment is also present but not visible or accessible due to the presence of a layer of cloth covering the webbing. This use of diagonal webbing was labor saving, requiring only two strips of webbing compared to the three that was used later. Evidence of the original method of attaching the bottom coils of the springs to the webbing also is no longer present.

3.2 SEAT SHAPING EVIDENCE

Six original hourglass-shaped springs, all of the same gauge metal, were present in the seat frame, positioned in two rows of three (fig. 5). Each spring is composed of 10 coils with the ends anchored to the coil below. Where the springs have been burnished, the metal's surface is shiny. Darkened areas of the metal are present where it came into contact with the cord used to tie the springs. All of the springs had been retied during the early 20th-century reupholstery campaign and following the original pattern, and were supported with a new base replacement layer of jute webbing

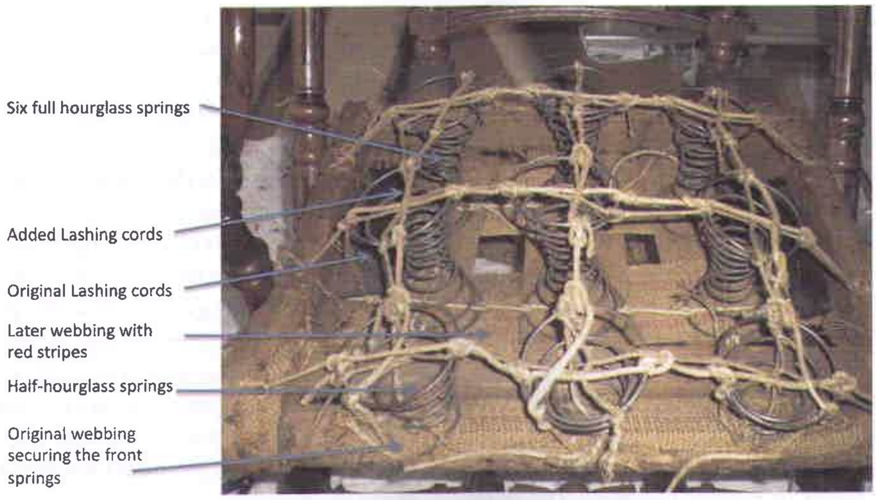

FIG. 5. The springs and lashing cords found within the chair seat. The darker, thinner cords are the original ones. The forward three springs are the shortened hourglass springs secured to the rounded front rail. They are fully extended in this image.

positioned with three webs front-to-back and two side-to-side.

Three additional half springs were attached to the front rail; each is a full-sized hourglass cut in half horizontally. The forward most edge of each spring was secured tight to the front edge of the rail (fig. 6). Because of the shape of these three springs, they actually assist in creating the round front edge scroll shape without the need of additional materials. And because this area of the seat receives the most wear and tear, without springs this area would have to be packed with filling material such as horsehair and secured with stitching, and would still be vulnerable to collapse. This alternative also would have required extensive labor and materials. A strip of original jute webbing was still present, folded in half length-wise to secure the front row of half springs to the front rail of the chair and positioned over the lowest coil of the half springs. Additional fragments of jute with brown warps were found under the newer jute.

Three types of tying or lashing cords were discovered in the chair seat. Two cords were present on all of the springs; both followed the same side-to-side and front-to-back pattern on the upper coils that held the springs in compression. No diagonal tying was present. The cord ends were anchored onto the chair rails with nails. One cord measured 0.6 cm (3/16 in.) in diameter, the other cord is slightly narrower, 0.5 cm (1/8 in.) in diameter. All three cords have the same tightness of twist. The older, thinner, cord was only present at the tops of the springs. The bottom coil of the springs was stitched to the newer replacement webbing with the thicker cord. The older cords at the front rail are short and appear to have been used to

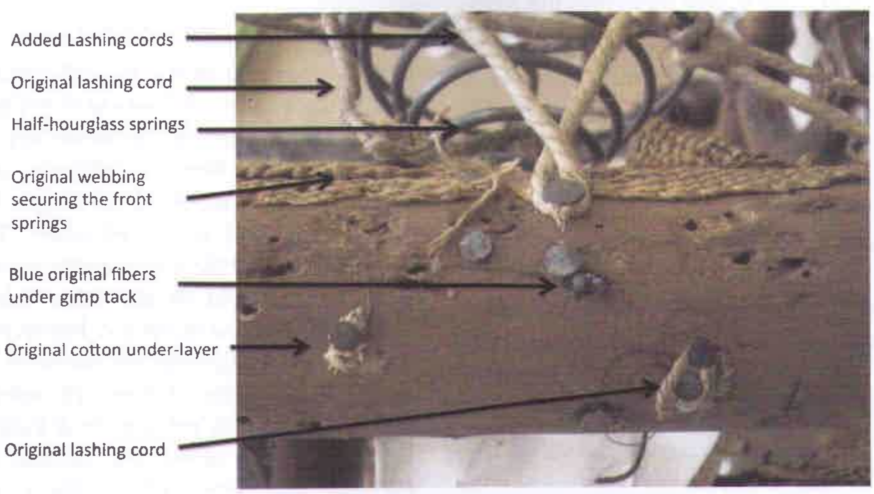

FIG. 6. Detail of a shortened spring attached to the front rail of the chair seat. Both campaigns of lashing cord and the original tufting tie can be seen.

maintain the rounded front edge profile. A third, and thinnest cord 0.2 cm (1/16 in.) thick, was located on several tacks (the longest extant piece is located at the front rail). These thin cords are from the tufting; their location on the front rail being an indication of how the tufting at the front rail was secured. The ties could not be threaded to the underside of the seat, so they had to be secured directly to the rail itself with tacks. When the upholstery of tufted furniture fails it is due to the breakage of these ties. The amount of stress and the deterioration is evident on the BMA chair where some of the buttons do appear to have been replaced at some point (now aged well to blend with the originals). However, the need for strength must also be balanced, as the fabric must be held securely in place in order to be manipulated. The combination of the use of the less stable jute tying cord and the "bound energy" of the spring was more than the chair could withstand in the long term.

The springs were covered with a plain weave jute fabric positioned parallel to the front seat rail. It appears that this was added as a means to better secure the springs to the top surfaces of the rail. Evidence of an earlier layer was found below the current jute. Small fragments of plain weave cotton fabric were also located on the vertical sides of the rails.

3.3 UNDER UPHOLSTERY LAYERS

Evidence of past tufting can often be found on upholstered furniture since upholsterers reused as much of the materials within a chair or sofa as possible. A thorough examination of all extant layers can be useful to anyone undertaking reupholstery and can reveal clues as to original intent. A ghosting pattern of dirt might be seen on the muslin cover to indicate that tufting was present; actual holes in the fabric cover may remain. Unfortunately, in the case of the MWPAI cantilevered armchair, this layer was not kept.

3.4 SEAT CAKE

With the removal of upper layers, the stitched seat cake positioned on the springs showed some of what appeared to be original horsehair embedded inside. This cake is covered with a layer of jute fabric similar to that found over the springs. Protected near the stitched edge were fragments of older, highly deteriorated jute. The extent of deterioration did not allow extensive examination for past evidence of the original profile. But hidden inside might have been the evidence of the rounded scroll front edge.

3.5 SHOW COVER AND TRIM EVIDENCE

Fragments of the original show cover, a dark rust-colored rep weave, were discovered along the side rails and buried within the horsehair cake. Although horsehair was the most popular upholstery fabric during the third quarter of the 19th century, rep gained favor among the middle classes in the 1860s due to its durability (Grier 1988). A ribbed plain-weave fabric created by a thicker thread element in either the warp or weft direction, it was woven in wool, silk, cotton, and various combinations of these, and was both piece- and yarn-dyed. Rep was widely used for upholstery, hangings, and clothing. Visual variations were created by combining different colors for the warp and weft, as well as by altering the spin of the thicker thread (Montgomery 1984). The fabric's dimensionality complemented the deep tufting and provided interest next to the highly decorative central panel seen in this chair. A complete green wool bullion element from the fringe was also found in the horsehair cake. The presence of all this original material, even after the last campaign of reupholstering, altered the original direction of the treatment.

4. Comparison Of The MWPAI And BMA Cantilevered Armchairs

It is highly unusual that the BMA cantilevered armchair survived intact with its original upholstery. These chairs were popular with the middle and upper middle classes and were functional along with being decorative. In comparison, more of the upholstered chairs created by Hunzinger's contemporaries—the Herter Brothers—survived intact as they catered to an upper class clientele where chairs were mostly decorative. The BMA chair is relatively unchanged; its show cover fabric and trimming are in remarkably good condition. When compared against protected or hidden locations under the seat, the golden ochre rep show cover shows even, minor fading.

4.1 SHOW COVER AND TUFTING

On either side of the woven decorative panel of the BMA chair is an alternating 2-1-2 front-to-back diagonal tufting pattern in wool rep. The fabric was folded forward between the tufts with the exception of the folding near the central panel, where the fabric was folded away from each other. The sides and back are vertical and the show cover is folded to match the points of the fold on the outer side of the tuft. Two tufting buttons have been completely lost but the original show cover retains its memory of the compressed tuft. No evidence of how the tufting was anchored inside the chair is present. It is assumed that the tufts were anchored above the springs instead of below (Britton and Porter 2010). The outside edges of the seat are trimmed with a z-twist cord in a contrasting color that surrounds the seat and terminates at each of the side finials. No seams in the show cover are located below the cord. The decorative panels are oriented to match their position on the chair, vertical on the seat and horizontal on the sling back. The bullion fringe at the bottom of the sling back matches in design and color the fringe found on the MWPAI chair.

4.2 SEAT CONSTRUCTION AND UNDER UPHOLSTERY

In Elizabeth Lahikainen's (1997) examination report of the BMA chair, she notes that the seat is composed of six narrow-gauge springs. She states that the ends of the springs are also bent back and looped to the coil above or below. The webbing at the bottom of the seat has been replaced with modern jute webbing. Like MWPAI's chair, fragments of the original jute are present. A thin cord possibly left from the original tying system is also present. The cake has some replacement materials that can be viewed from the bottom of the seat. One to two rows of stitching are present to shape the cake. From her report, it is clear that the construction of the scroll front could not be seen or understood due to the lack of access.

4.3 CONCLUSIONS FROM THESE CHAIRS

Even with the mass marketing and popularity of Hunzinger chairs at the time, very few examples of this type of upholstered cantilevered seat scroll front edge armchair survive. Much of the reason for this is related to the design itself—the sling back and the scroll front edge contribute to a need for upholstery layers to be replaced during the chair's life. Having a well-preserved chair such as the BMA example, which could be examined for the true profile of the seat, was indispensable to the success of this project. The scroll front edge of the seat was such an unusual design feature that it was only by seeing a surviving example that it could be fully understood. None of the surviving evidence on the MWPAI chair—the half springs and deteriorated edge of the chair pad—was in and of itself sufficient to have re-created it.

Two additional chairs of this type with incomplete original upholstery are known; both have silk show covers (Harwood 1997; Spicer 2009). One of these chairs has the same fabric design on the sling back as the BMA chair; it is possible that the MWPAI chair also originally had the same fabric on the sling back. The green bullion found embedded in the horsehair pad of the MWPAI chair matches the green bullion on the BMA chair and on another chair in a private collection examined by the author. But it is the BMA and MWPAI chairs that have the same rep show cover fabric. The variety of upholstery choices that Hunzinger provided to his clientele is evident in these surviving armchairs.

The MWPAI chair contributes to the knowledge about the BMA chair—the inner construction techniques of the seat. The use of half cut springs and their attachment to the front rail could not have been fully understood without disturbing the BMA chair seat.

5. Treatment Of The MWPAI Cantilevered Chair

Initially the author thought to re-create the seat using Ethafoam, but due to the presence of the original springs and lashing cords, this was determined not to be a viable option. The question was how to tuft the seat without damaging the historic materials present. After examination of the BMA chair, it was determined that three rows of tufting were to be located around the rail. In addition, the fact that tufting extended around the front rail where access for traditional tufting is limited would require a more invasive method for securing the tufts. A review of alternative methods in the conservation literature did not reveal any solutions.

5.1 STABILIZATION OF EXISTING WEBBING

Seat stabilization began with reinforcing the replacement jute webbing with an added layer of 10 cm- (4 in.-) wide cotton webbing. It was stapled to the underside of the rails and positioned below the earlier replacement webbing and woven in the same manner as that replacement layer. The stress on both campaigns of lashing cords tying the six full sized springs was reduced with additional lashing; the collapsing of these springs was reduced with 0.2 cm- (1/16 in.-) thick polyester cord. Full access to the springs allowed the use of this cord; limited access to springs would require a stiffer material like nylon "tie wraps" to be used. The polyester cord was threaded through the cotton webbing and up through the full height of the spring and down again through the cotton webbing before being tied off. Positioned at the top and bottom of each spring was a 3.8 cm- (1-1/2 in.-) diameter Nomex disc to spread out the pressure on both the cover cloth and webbing layers (fig. 7). This was repeated in two or three locations on each spring. The three half sized springs along the front rail were returned to their collapsed configuration with 0.6 cm- (1/4 in.-) wide cotton twill tape. The goal was to lessen the stress while maintaining the seat's unusual shape.

5.2 SEAT SHAPING AND RE-TUFTING

Due to the completeness of the first tying on the tops of the springs, the shape of the seat was easily determined. The shape and measurement of the curvature of the BMA chair was used to confirm the actual size.

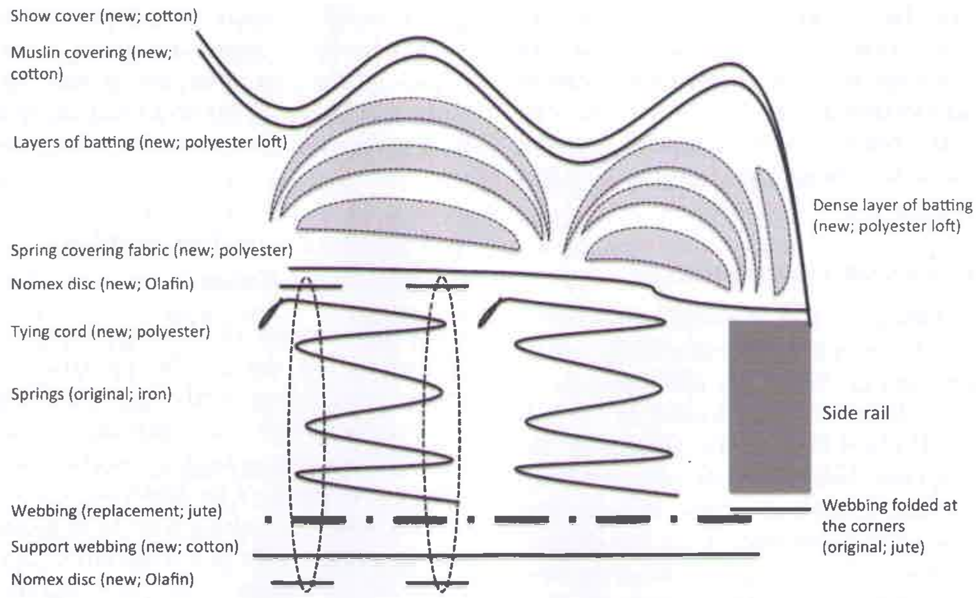

FIG. 7. Cross-section of the seat (side to side view) with the new tying cords and Nomex discs. Above the new spring cover are the layers of the batting used to create the seat's shape. Each batting layer has a hole present that is made smaller with each layer to enable the batting to conform to the intended well shape.

The positions of the front springs were estimated from the short loops of cord that had once been tacked down and were still present. These three springs are hidden in the BMA chair due to the rail being a round wooden element that blocks any access. But the construction methods can be presumed to follow the same techniques as the MWPAI.

6. Use Of Permanent Magnets

When working with magnets, two components are necessary for the attraction to occur, the magnet and the receiving side that assists in the force/draw. The use of sheet metal as a foundation material has been described in upholstery conservation literature (Graves and Howlett 1997; Balfour et al. 1999; Balfour et al. 2001). Copper (Graves and Howlett 1997), brass (Balfour et al. 1999), and stainless steel (Balfour et al. 2001) was the preferred choice of metal due to its malleability and thinness. But other metals could be used following the techniques discussed in these papers.

Due to the wide variety of strengths and versatility of magnets available it was decided that magnets could be useful in this upholstery application. As evidenced by the conservation literature, the use of permanent magnets is not unusual; they have become part of the palette of options to support artifacts in exhibitions (Maltby 1988; Potje 1988; Verberne-Khurshid et al. 2002; Derbyshire and Tallian 2005; Migdail 2009; Spicer 2010a; Holbrow and Taira 2011). Magnets are reversible and can quickly be removed from items that cannot be stitched or adhered. These features are beneficial and can be considered an elegant solution.

Neodymium ($Nb_2Fe_{14}B$) magnets are one of four permanent types of magnets available. Other permanent magnets include alnico, ferrite or ceramic (Sr-ferrite), and samarium-cobalt ($SmCo_2$). Much of the development of magnets is related to the development of metallurgy. Each new method of advancement has resulted in refinement or the development of a new permanent magnet. With the development of $Nb_2Fe_{14}B$ rare earth magnets in the 1990s, magnets became stronger relative to their size, allowing them to be easily hidden. As neodymium magnets have become cheaper, they have replaced the common ferrite magnets (developed in the 1950s) that were bulky and difficult to hide. This is evident by their increased use in the field of conservation. Table 1 offers a comparison of these four types of magnets.

The majority of use in the conservation field has been as "point fasteners" where the magnetic field of the magnet enables the metal substraight below to act as a temporary magnet in order to form a stronger attraction. If the layers between are within the gap distance, they are able to maintain the attraction.

The receiving side or metal substraight for the magnet is also a factor of the extent of pull force. The strongest fields are located at the poles of the magnet and this is where it locally magnetizes the metal that it is attracted to (Livingston 1996). Iron alloys are the most readily available, out of the three magnetized metals that also include nickel and cobalt. These materials, out of all elements, can be temporarily

TABLE 1. PERFORMANCE PROPERTIES OF VARIOUS MAGNET TYPES

Magnet type	Date of introduction	Mechanical shock tolerance	Strength of magnetic field (B_r (gauss))	Heat tolerance (T_c)	Moisture/ oxidation	Demagnetizing field (H_{ci})
Alnico (aluminum, nickel, and cobalt)	1935	Very resistant to shock.	12,500	Maximum working temperature 540°C (1004°F). Curie temperature 860°C (1580°F).	Resistant to corrosion.	Can easily be demagnetized. When repeatedly placed north-pole-to-north-pole ends together, it quickly weakens itself.
Ferrite or ceramic (Sr-ferrite)	1951	Brittle and chip or crack easily.	3900	Maximum working temperature 300°C (572°F).	Resistant to corrosion.	Keep away from rare earth magnets.
Samarium-cobalt ($SmCo_2$)	1969	Brittle and chip or crack easily. Best to separate with a cushioning material.	10,500	Maximum working temperature 300°C (572°F). Curie temperature 750°C (1382°F), very respectable for a sintered magnet.	Relatively resistant to corrosion.	Can be demagnetized by $Nd_2Fe_{14}B$ magnets. But they do not weaken others.
Neodymium ($Nd_2Fe_{14}B$)	1983	Brittle and chip or crack easily. Best to separate with a cushioning material.	12,800	Maximum working temperature 150°C (302°F). Curie temperature 310°C (590°F).	Corrodes easily and requires a coating.	Tough to demagnetize. This also means that they can easily demagnetize other classes of magnets like $SmCo_2$, Alnico, or Ferrite.

magnetized when a magnetic material is in proximity. It is the permanent or "hard" magnet, that when positioned near the temporary or "soft" magnet, creates the force or attachment. The material that is the "soft" magnet needs to have a sufficient amount of iron both in percentage and thickness to create the full attachment that is possible. A steel plate must be at least a 24-gauge thickness.

Typically in exhibition use magnets are embedded into a substrate that distributes the strength across the surface or hanging mechanism. Magnets are attached to mount supports for attachment to metal support panels. Spacing of individual magnets is determined by the specific strength of the magnet used. It is the strength and thickness of the magnet that determines the magnetic field. These systems often include a barrier layer (commonly Mylar or paper) between the magnet and the artifact.

Magnets have also been used in conservation as a treatment tool. Many of the described methods use magnets to bring a tear in-line, especially when an artifact's back cannot be reached (Dignard 1992; Barclay et al. 2004). The strong hold enables manipulation even when one cannot access the reverse. Or to hold adhesive joins, especially when not horizontal (Stone 2008). Low-strength or flexible magnets are useful for humidification in situations where less pressure is desired (Blaser and Peckham 2006). The author has used magnets to hold stretched net layers while encapsulating fragile artifacts (Spicer and Owens 2012).

6.1 RISKS OF RARE EARTH MAGNETS

Risks have been noted when magnets are used directly on artifacts where the magnet is too strong and has caused permanent indentation in the soft surface of the artifact such as skins, felt, flocked or piled structures, and thick papers or textiles (Heald 2009). This concern is less common now that more suppliers sell much wider inventories of magnets. Having a wide variety of strengths and sizes of magnets is critical to finding the most suitable one. Embedding the magnet into another support such as an iron alloy material can further distribute the magnetic field strength over a larger area. The magnet makes the iron a soft temporary magnet.

Rare earth magnets can pose some risks to the user (Spicer 2010a). The force of one magnet becomes stronger when next to others; therefore their strength of attraction can lead to pinched fingers. The use of a wooden tool with a hole that one magnet can slide into can prevent harm when trying to separate one magnet from another. Magnets can easily jump out of partitioned boxes; keeping them divided in lidded containers is recommended. Such containers can be plastic pill containers or contact lens cases where the individual compartment has a separate lid.

There are other important facts to consider when working with these high strength magnets. Magnetic fields can harm electronics such as computers, televisions, and magnetic strips on credit cards. They can chip but they cannot be tooled. They lose all magnetic strength when in contact with high temperatures; the magnetic strength cannot be restored. This was discovered by the author when hot-melt glue was applied directly to magnets to mount them onto a display. Hot-melt glue can, however, be used if allowed to cool slightly below the magnet's Curie temperature (T_c).

Because tufting of the seat extended around to the underside of the front rail, the benefit in using magnets with this upholstery project was that their strength allowed the conservator to easily create the tufting of the front seat area without altering the wood structure of the front rail or damaging any of the original materials inside the seat. Any impressions that the magnets might leave on the show cover were of less concern, as all of the added materials were new.

6.2 DETAILS OF THE MAGNET TECHNIQUE

The jute spring cover cloth was removed, re-housed, and replaced with a plain weave polyester fabric secured to the added stitching edges along the outer side edges of the seat rail. The stitching edges were created from narrow strips of Nomex cut to fit the tacking edges, tightly covered with cotton fabric, and attached to the chair seat rail with brass tacks inserted in existing holes of the chair rail. The polyester fabric protected the original materials and provided a foundation for the tufting. The complex shape of the armchair's seat precluded the use of other materials that conform less.

To determine the type and strength of magnet to be used, a three-dimensional measurement of the BMA chair was needed. This took into account both the spacing and the depth of the tufts at each location across the seat. Center-to-center measurements of each button's position were also taken. The distance of one tuft to its neighboring tuft created a lower layer that would need to be replicated on the covering fabric. Only minor adjustments of the overall pattern were found with tufts occurring between 7.6 and 8.3 cm (3 and 3-1/4 in.) apart. The variation is mostly in the location of the rounded front edge. The heights of individual tufts varied more, ranging from 10.2 to 12.1 cm (4 to 4-3/4 in.). These variations would need to be corrected in the finished product.

After testing, a 3.8 cm- (1-1/2 in.-) diameter metal fender washer was found to have a suitable pull-force for this application. The washers were placed to match the position of the deep tufts of the BMA chair and then stitched into position on the replacement spring cover cloth (fig. 8). Stitching was done around the perimeter of each washer to provide even attachment. Due to the number of tufts in the seat this step was time consuming. The washers could have been secured with hot-melt glue or another adhesive, but without a mechanical fastening there was concern that stress over time would cause the glue to release. As the washers were attached, testing was undertaken with the magnet. No apparent disturbance was witnessed between the magnets and the seat springs. The spacing between individual tufts was just beyond the individual magnets pull-force field; therefore they would not attract neighboring magnets.

The shaping of the seat was formed with layers of high loft resin-free polyester batting positioned on top of the replacement polyester spring cover cloth. The vertical sides of the seat were defined with thicker, dense batting. Holes in the batting were cut at the locations of the magnets (fig. 9). The magnets were

FIG. 8. Metal washers stitched to the replacement spring cover cloth.

FIG. 9. Batting layers applied on top of the spring cover cloth with stitched washers. The batting is cut away from the metal washers to reduce bulk and thus the gap between the magnet and the washer.

employed as layers of batting were applied, since they could easily be removed while determining the correct depth, with no harm to any fabric layer. A top layer of muslin was attached and positioned to act as a barrier between the batting and the show cover. At this point, the size and shape of the MWPAI chair foundations, as well as the position of the tufts, closely matched measurements taken from the BMA chair. The depth and position of each tuft was measured from the BMA chair (fig. 10). Making the holes for the tufting created a well for the button, thus reducing stress. The size of the hole slightly decreased with each layer of batting. This enabled the batting to conform more to the intended shape of the desired wells for the buttons. It was found that the springs inside the seat did not effect or interfere with the position of the magnets. This could be that the springs are outside of the magnetic field of the magnet.

The diameter of the selected chrome-plated magnets matched the size of the buttons used to tuft the BMA chair (1.4 cm (5/8 in.) in diameter). The surface of each magnet was first abraded slightly and degreased, then covered with fabric that was adhered with a thick solution of Acryloid-48N (40% in acetone) bulked slightly with fumed silica. A mold was created in which the covered magnet could sit to hold the layers tightly together during adhesive drying.

The selected neodymium rare earth magnet was round, with the polar direction vertically or axially oriented, grade N52 magnet with a pull force of 7.97 lb., and surface field of 3309B_r (gauss). The selection of grade N52 was made as it has the strongest pull-force for the specific size magnet. The layers between the washer and the magnet were within the gap distance to maintain the attraction. Also in magnetic terms, it more evenly distributes the magnetic field by creating a polar radiation loop. However, the higher-grade number is more brittle causing the individual magnet to break more easily than a lower grade.

6.3 SHOW COVER AND TRIMS

The show cover was applied in two sections, one on each side of the central panel (fig. 11). The direction and position of the folds, in relation to the tufts, were all determined by the measurements taken from the BMA chair. The show cover fabric could easily be

FIG. 10. The show cover fabric being manipulated and held in place with the magnets.

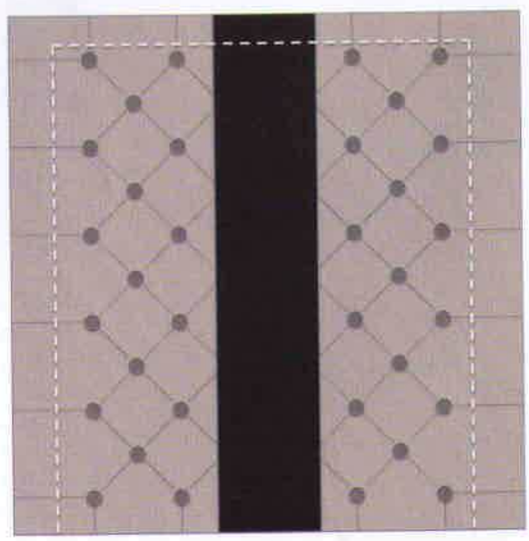

FIG. 11. 2-1-2 Tufting pattern of the Hunzinger cantilevered seat armchair. The dashed lines indicate locations of the folds.

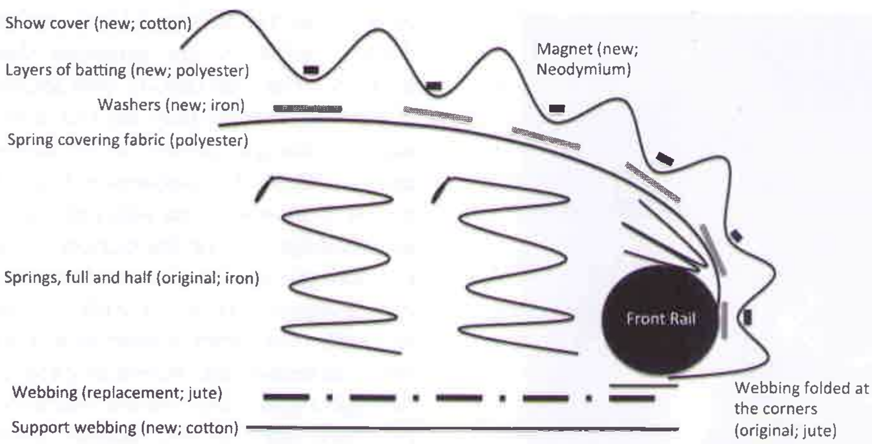

FIG. 12. Cross-section of the MWPAI chair seat after treatment showing the retained elements.

manipulated without the fear of marring it. Figure 12 details the seat layers of the MWPAI armchair after treatment. Once the tufts were determined and secured, the decorative elements were all applied with stitching. The wooden finials were reproduced and attached to the outer front corners of the front rail. The show cover fabric and trims were all custom made. The long bullion fringe was replicated in the original green color that was found in the horsehair cake. The sling back was custom needle-pointed following the design on the BMA chair. A solution for the decorative center seat panel has yet to be found. A solid black fabric was temporally placed in the location during the exhibition (fig. 13).

FIG. 13. The MWPAI Hunzinger cantilevered armchair after treatment.

7. CONCLUSIONS

As seen in its design and upholstery, the cantilevered armchair created by George Hunzinger and held by the MWPAI is an example of 19th-century invention and innovation. The armchair represents the "height of the Upholsterer's skill" (Thornton 1993). This paper briefly discusses the chair's placement within 19th-century design, the extant example at the BMA, and the conservation techniques used on the MWPAI chair. During treatment it became apparent that the MWPAI chair provided clues to the internal structure of the BMA chair. As Hunzinger was innovative, this treatment using rare earth magnets was equally innovative.

Magnets may not be appropriate for all instances. Direct stitching of the tufting could have been performed with this chair, but the large wood element prevented easy access to the underside of the seat to stitch the tufts located along the front rail. The lack of access to this location made the use of magnets critical. Aesthetically, magnets allowed for adjustments of the tufts in order to better match the original chair, while not marring the show cover fabric. The location of each tuft could be fine-tuned as necessary. In addition, not stitching ensured that the older lashing cords attached to the springs would not be pierced with the needle while tufting, potentially both weakening and further damaging historical evidence. The use of the magnets achieved the goal for the treatment. The strength of the magnets allows for any direction of tufting surfaces, whether vertical or horizontal. Due to the wide variety of available shapes and sizes magnets are made, they can be easily disguised and used with bundled tufts. Magnets also come with holes in the center that can be used for attaching decorative elements like bundled tufts if required. The magnets with Acryloid B-48N as an adhesive can be used with any type of fabric, including leather.

Acryloid B-48N was used due to it attraction to metallic surfaces.

Using magnets for other tufting upholstery projects is possible. In locations where there is no access to the reverse side of the chair or sofa, this technique would be ideal. The easiest and quickest areas of magnet use are flat and straight locations whether vertical or horizontal, where a solid sheet of metal could be placed. This would allow for the creations of any pattern or spacing of tufting. The sheet metal would eliminate the need for individual washer attachments, the most time-consuming aspect of this project.

Finding a match between the magnets and washers in order to create the necessary strength takes some adjusting. This technique might be most useful in supporting an inside back, where a solid sheet of metal could be cut and inserted into a chair frame, providing a palette on which to position the deep tufts. It is possible that further research will reveal a fabric with embedded metal that could be used to cover a three-dimensional surface, thus eliminating the time-consuming washer attachment. It might also be possible to use flexible magnet strips on the tacking edge to attach decorative nailing and therefore lowering the need for stapling or creating a sewing edge. It may also be thought that the original tacks and nails that are located at a tacking edge could be used as the magnetic receiving side. However, it appears that the layer of corrosion present, as well as their small size, is insufficient to create a significant attraction. Again as technology advances, this too might be a future treatment technique in upholstery conservation.

It is the curved upholstery areas that require more customizing. Sheet metal could still be a support for rounded straight-arms or round backs. But it is the areas like on the Hunzinger chair, with its complex curved seat, that are more challenging. Metal ring-mesh fabric that is used for protective clothing could be useful, but the cost might be prohibitive. This fabric can be formed over shapes and is somewhat thin. Other woven metal fabrics are manufactured for architectural and interior design purposes. These fabrics might have a use, but as nanotechnology progresses, other fabrics with embedded metal or magnets, are sure to become more readily available. A test using magnetic chalkboard paint on fabric did attract magnets, but was not strong enough for upholstery purposes.

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Source of Materials

Magnets
K & J Magnetics Inc.
2520 NW Boca Raton Blvd.
Boca Raton, FL 33431-6608
(561) 392-2103
www.kdsmagnets.com

Cotton webbing
TestFabrics, Inc.
415 Delaware Avenue
P.O. Box 26
West Pittston, PA 18643
(570) 603-0432
www.testfabrics.com

Nomex
Active Industries, Inc.
20 Solar Drive
Clifton Park, NY 12065
(518) 371-2020

Fender washers
These can be found at most hardware stores.

Needle punch batting
Buffalo Felt
14 Ransier Drive
West Seneca, NY 14224
(716) 674-7990, x207

High loft batting
Gaylord Brothers
P.O. Box 4901
Syracuse, NY 13221-4901
(800) 448-6160
www.gaylord.com

Decorative panel
Cass Daley Designs
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Show cover & trims
Thistle Hill Weavers
Baxter Hill Road
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Cherry Valley, NY 13320
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Résumé – George Hunzinger (actif 1860–1898) était un designer de mobilier innovateur qui fut une source d'inspiration pour beaucoup par ses techniques uniques de fabrication et de production. Cet article présente le traitement d'une innovation d'Hunzinger, un fauteuil à siège cantilever (en porte-à-faux) et traverse avant en volute, propriété du Munson-Williams-Proctor Arts Institute *à Utica, New York. Même s'il n'avait pas conservé sa tapisserie d'origine et que le profil du siège avait été fortement altéré lors d'une campagne de restauration antérieure, des matériaux originaux ont été mis en évidence durant le traitement. Un siège identique, propriété du* Brooklyn Museum of Art, *qui a conservé non seulement sa garniture d'origine mais aussi le profil original de son assise, a apporté des informations cruciales pour ce traitement. Cet article présente des informations sur la construction du siège et les matériaux utilisés pour le re-tapisser, ainsi que sur les méthodes employées pour recréer le profil original du siège capitonné. Au cours du traitement, le siège capitonné ornementé d'un panneau décoratif central vertical a été recréé, alors que des matériaux historiques originaux ont été préservés. Pour éviter les risques associés à un capitonnage traditionnel qui crée des trous dans le tissu et qui peut créer de la tension, des aimants ont été choisis comme éléments d'attache alternatifs. Une comparaison des techniques non invasives de capitonnage est inclue, accompagnée d'informations de base utilisées pour la sélection des aimants.*

Resumen – George Hunzinger (activo desde 1860 hasta 1898) fue un diseñador de muebles innovador que inspiró a muchos con sus técnicas singulares de manufactura y producción. Este artículo discute el tratamiento de una de sus innovaciones: un sillón de brazos con el asiento en ménsula, de borde redondeado que termina en forma de enrollado, propiedad del Munson-Williams-Proctor Arts Institute *(Instituto de Artes Munson-Williams-Proctor) en Utica, Nueva York. A pesar de que ya no tenía su cubierta original de exhibición y el perfil del sillón había sido dramáticamente alterado en una anterior campaña de retapizado, durante el tratamiento de conservación se encontró evidencia de los materiales originales. Un sillón idéntico, propiedad del* Brooklyn Museum of Art *(Museo de Arte de Brooklyn) que aún retenía no solo su tapizado original sino también el perfil verdadero, proporcionó información crucial para este proyecto de tratamiento de conservación. Este artículo presenta información sobre la construcción del sillón y los materiales usados para retapizarlo así como los métodos empleados para recrear el perfil original del sillón capitoneado. Como parte del tratamiento, fue recreado el asiento ornamentado capitoneado con un panel decorativo central y se mantuvieron los materiales históricos originales del sillón. Para evitar la tensión del capitoneado tradicional, que crea hoyos en la tela, se seleccionaron imanes como elementos alternativos para fijar el tapizado. Una comparación de las técnicas de capitoneado no agresivas es incluida, así como la información básica usada para la selección de los imanes.*

Resumo – George Hunzinger (activo entre 1860 e1898), foi um inovador projetista de móveis que inspirou a muitos com suas técnicas únicas de fabricação e produção. Este artigo analisa o tratamento de uma das inovações de Hunzinger, uma poltrona reta na parte frontal de propriedade do Munson-Williams-Proctor Arts Institute *(Instituto de Arte Munson-Williams-Proctor) em Utica, New York. Apesar de já não conservar seu revestimento original, e o* *perfil do assento ter sido drasticamente alterado durante o último trabalho de re-estofamento, restos dos materiais originais foram descobertos durante o tratamento. Uma cadeira idêntica, possuída pelo* Brooklyn Museum of Art, *que mantem além da tapeçaria original, também o perfil verdadeiro do assento, serviu de informação fundamental para este projeto de tratamento. Este artigo apresenta informações sobre a construção da cadeira e dos materiais usados para o re-estofamento, assim como os métodos empregados para recriar o perfil original do assento estofado com enchimento. Como parte do tratamento, o assento estofado ornamentado com um painel decorativo central foi recriado retendo os materiais históricos originais. Para evitar a tensão do acolchoamento tradicional que cria perfurações no tecido, foram selecionados imãs como alternativa para os elementos de fixação. Uma comparação de técnicas não-invasivas de enchimento, com informação básica usada para a seleção dos imãs.*