PART THREE

History of the Structural Conservation of Panel Paintings

Critical History of Panel Painting Restoration in Italy

Andrea Rothe

Modern italian panel conservation techniques are directly related to a long history of panel construction that dates to antiquity and flourished from the Middle Ages to the Renaissance (see Uzielli, "Historical Overview," herein). The ingenuity and intuition of the woodworkers of the past compensated for their lack of scientific understanding of this complex and widely diverse material. Central Italy, in particular, produced a large quantity of paintings on panel. Many of them—such as the Cimabue Crucifix in the Church of Santa Croce in Florence—were constructed to the highest standards of craftsmanship. The early woodworkers often used techniques or methods similar to those applied by modern-day restorers in treating panels—techniques such as movable crossbars (Figs. 1, 2) and coats of gesso, paint, or red lead to seal the backs of panels (Fig. 3). These sealants were probably applied as humidity barriers and protection against wood-boring insects, and panels treated in this manner have often survived better than untreated panels.

The large number of panel paintings in Italian churches and museums created the need for appropriate conservation work, particularly in modern times. The state-run centers of Florence and Rome have become the largest and most advanced in Italy and have generated a group of highly qualified experts in this field. The volume of panel work that has been executed in Florence far surpasses that of any other conservation center in the world.

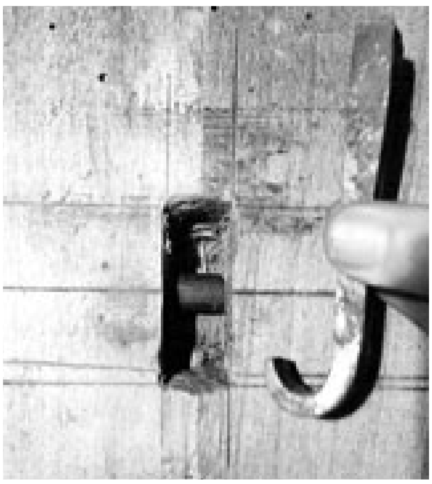


Figure 1, right
Fra Angelico, *Annunciation,* ca. 1440. Reverse. Tempera and gold leaf on panel, 95 x 158 cm. Convent of Montecarlo, San Giovanni Valdarno. The original metal pin inserted from the front of the panel, along with the hook that latches onto it, is shown.

Figure 2, far right
Fra Angelico, *Annunciation,* reverse. This detail of the original crossbar shows the metal hook inserted into it and the metal wedge that holds it in place (see Fig. 1 for the hook-and-pin mechanism). This mechanism ensures free lateral movement of the panel.

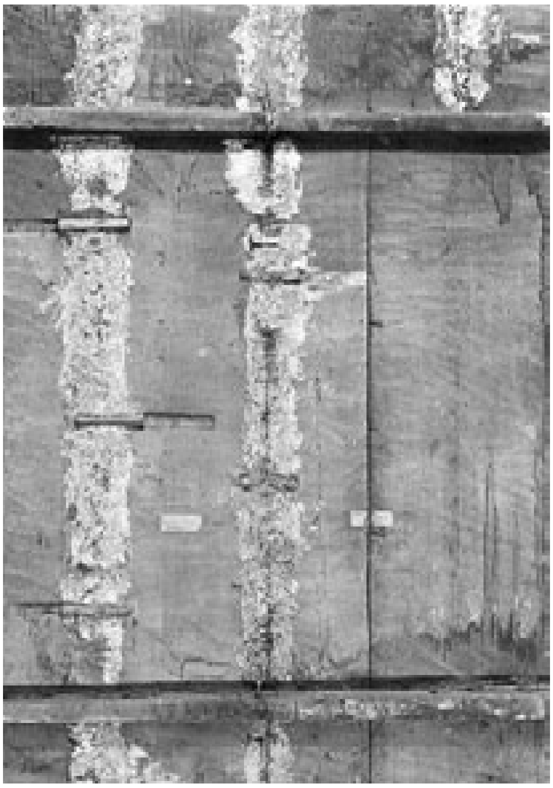
Figure 3
Riminese, *Crucifixion,* fourteenth century. Reverse. Tempera on panel. Galleria Nazionale delle Marche, Urbino. Back of the panel showing a gesso ground covered with a red tempera layer (possibly red lead) and an ornate decoration.

More conservative methods have replaced the radical ones of the past. Up to the late 1950s, it was common practice in Italy to transfer onto a new support those panel paintings that had severe woodworm damage, flaking paint, or warping. Such interventions date to Napoleonic times, when many of the paintings that had been plundered from Italian churches and collections were transferred onto new supports because of severe flaking problems, caused particularly by the stress suffered during the long trip to Paris. One such example is Raphael's *Saint Cecilia* (now in the Pinacoteca in Bologna), which was taken to Paris in 1798 and subsequently transferred from panel to canvas. Because of this drastic intervention and the additional effects of aging, it has adopted the surface characteristics of a canvas painting. Fortunately, as methods of wood conservation became more effective and less radical, transfers have become nearly obsolete.

Splits in the wood and failure of original joins are caused by various factors, such as rigid restraints, defects in the original construction, and excessive fluctuations of humidity and temperature. Until the dawn of synthetic adhesives such as polyvinyl acetate (PVA) emulsions and epoxies, panels were rejoined with animal glue and casein. Panels that had completely separated were planed on both sides of the split to level the surface for a butt join, but this was often achieved with a considerable loss of original color. In other cases—such as the large panel by Fra Filippo Lippi, *The Coronation of the Virgin* in the Uffizi—the splits were rejoined, but no care was taken to realign the planks, and the paint layer was simply planed down and repainted. The insertion of dovetails straddling splits was common until the late 1950s. The V-shaped wedges, which are still used today, are mentioned in a book by Secco-Suardo, although he recommends adding the dovetails as a precaution (Secco-Suardo 1866:68–70). The use of dovetails to repair split panels dates to at least the sixteenth century. They can, for instance, be made of walnut, such as in the original construction of the back of the panel for Lorenzo Lotto's Martinengo Altarpiece in San Bartolomeo in Bergamo, dated 1516 (Brambilla Barcilon 1978:60–63). There are original dovetails found in the front of some paintings, such as Luca Signorelli's *Adoration of the Shepherds* (Fig. 4). Cross-grain wedgelike

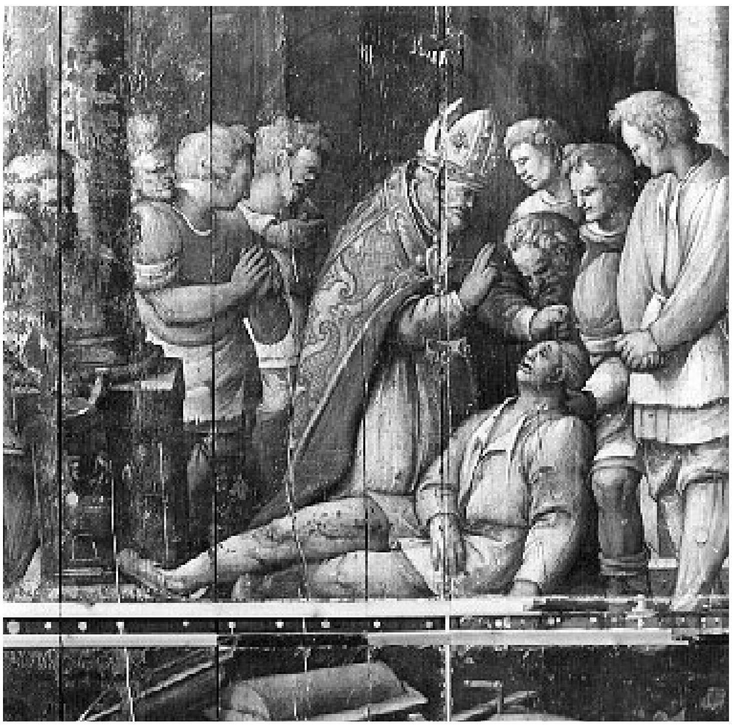
Figure 4
Luca Signorelli, *Adoration of the Shepherds,* 1496. Oil (?) on panel, 215 × 170.2 cm. National Gallery, London. Detail. The dovetail set into the front of the panel is original.

Figure 5
Domenico Puligo, *Virgin and Child with Saints,* ca. 1522. Reverse. Oil (?) on panel, 195 × 289 cm. Cathedral, Laterina, Italy. Repairs, dated 1634 on the crossbar, with applications of flax fibers and gesso over the cracks, which have also been reinforced with wedgelike insertions placed into carved-out channels.



insertions are present on a panel, Domenico Puligo's *Virgin and Child with Saints,* from the cathedral in Laterina, with the inscription "RESTA[urat]a 1634" on the crossbar (Fig. 5). On some occasions one finds dovetails set into the front, a method that destroys the paint layer locally, as in the organ shutters by Amico Aspertini, *The Miracle of the Workman,* in San Petronio in Bologna (Fig. 6).

Figure 6
Amico Aspertini, *The Miracle of the Workman* (organ shutter), 1531. Oil or mixed technique (?) on panel, 500 × 202 cm. San Petronio, Bologna. Old repairs were made with dovetails set into the front of the panel.



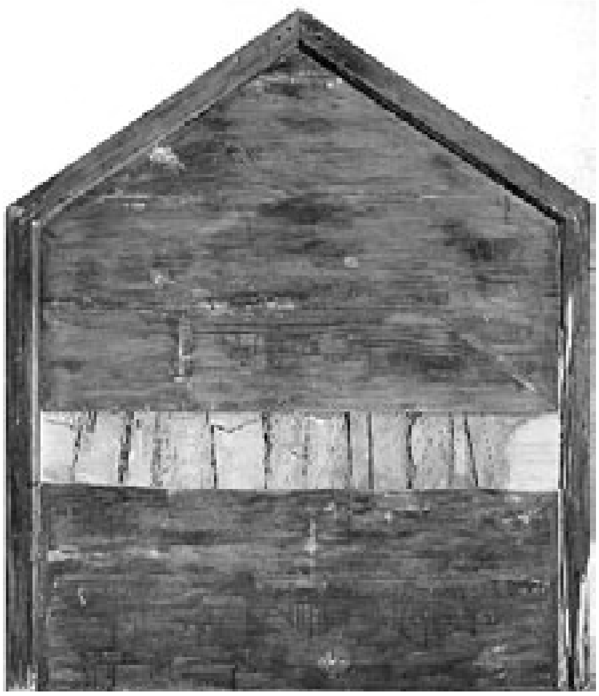


Figure 7
Parri di Spinello, *Madonna della misericordia,* 1437. Reverse. Tempera on panel, 199 × 174 cm. Museo Statale di Arte Medievale e Moderna, Arezzo. Exposed by the removal of a fake fir backing, inserts of fir with animal glue can be seen; they were inserted into lost areas of the severely worm-eaten original poplar panel.

In other cases, such as the dated restoration from 1634, futile attempts were made to reinforce the splits by gluing strips of wood and hemp fibers over them. On some panel backs, however, one can find hemp fibers in very good condition that date from the time the panel was made. In two cases that were probably nineteenth-century interventions, severely worm-eaten and hollowed-out panels were filled with many different pieces of wood and abundant animal glue. These had caused extreme contractions and cleavage effects on the front, as on the painting by Parri di Spinello, *Madonna della misericordia,* from the Museo Medievale Moderno in Arezzo (Figs. 7, 8).

Figure 8
Parri di Spinello, *Madonna della misericordia*. This close-up of the ground and paint layer shows extreme distortions caused by the contraction of the glue on the back and by the imperfect fit of the fir insets shown in Figure 7.

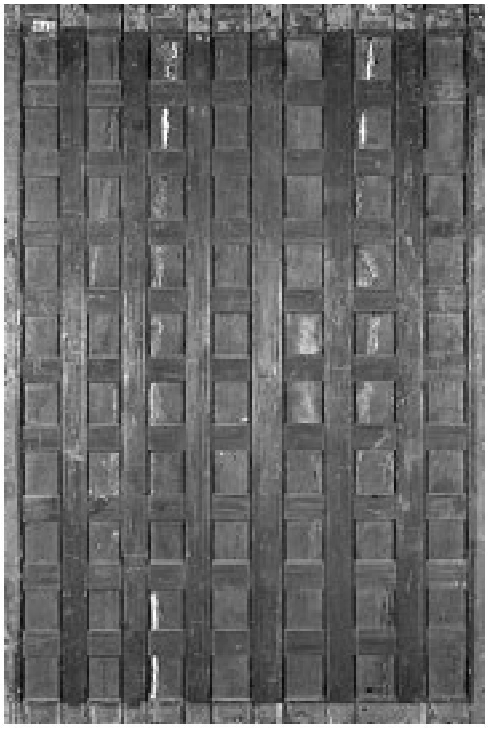


Figure 9, above
Giulio Romano, *The Birth of Bacchus,* ca. 1533. Oil on panel, 127.3 × 79 cm. The J. Paul Getty Museum, Los Angeles. Splits and surface deformations, creating what is often called the "washboard" effect, have been caused by a nineteenth-century thinning of the panel and application of a heavy cradle.

Figure 10, above right
Giulio Romano, *The Birth of Bacchus,* reverse. The cradle was applied to the back when the panel was thinned. Rigid and heavy, it has contributed to the splits and deformations on the front (Fig. 9).

In nineteenth-century Italy, as in the rest of Europe, more in-depth interventions treating warpage problems became common practice. The brutality with which deformed panels were straightened generates respect for the malleable and resilient nature of wood. Panels were planed down to a fraction of their original thicknesses and often humidified to relax the warp. Then, invariably, a heavy cradle would be applied. Often the thinning process and application of the rigid cradle later caused severe deformations of the surface (Figs. 9, 10). Some of the methods described by Secco-Suardo include the application of hot cinders and sand, as well as the addition of hot bricks, if necessary, to prolong the process. If the panels were severely deformed, he recommended cutting longitudinal grooves at intervals of 1–2 cm before applying the above-mentioned hot cinders. After the panel had been straightened, strips of wood were glued into the grooves (Secco-Suardo 1866:55–65). Unfortunately, cutting grooves to straighten panels is still practiced today by some restorers and accounts for the dreaded "washboard" effect.

For partially deformed panels, Secco-Suardo also mentioned a method developed by a certain Déon, a Frenchman. In this method, tapered longitudinal V-shaped channels are sawn into the panel at intervals of 1–2 cm; V-shaped wooden strips are wedged into these with the aid of animal glue and humidity. Next the panel is placed face down on a bench and clamped tight with crossbars and wedges for an extended period (Secco-Suardo 1866:75–88). Unfortunately, all of these drastic interventions can lead to the formation of a new series of cracks and splits.

Today the disastrous effects of most of these radical interventions are apparent, and the general tendency is to leave distortions alone so as not to cause other problems (Stout et al. 1954). Cradles that pose no danger are best left on; and if the battens stick, they are removed and sanded. Paraffin is then applied to make them slide more easily. Many cradles, though, have had to be removed because of the excessive restraint they

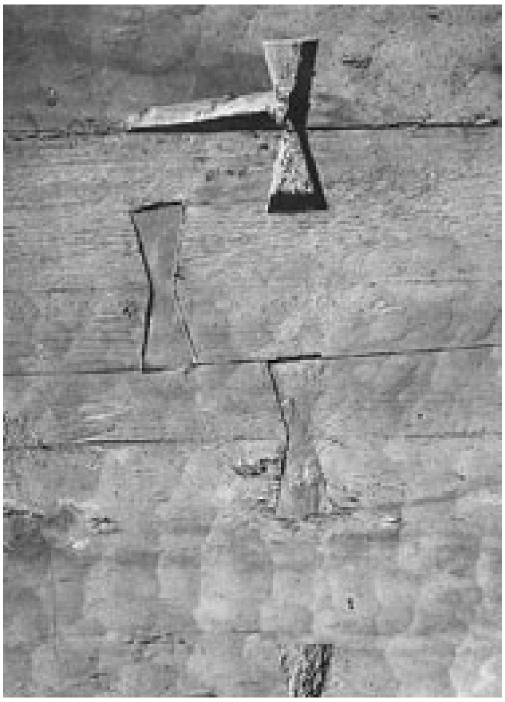


Figure 11
Simone de Magistris, *Deposition,* 1576. Reverse. Tempera (?) on panel, 265 × 182 cm. Convento dei Cappuccini, Potenza Picena, Italy. These old dovetails have caused a new series of splits in the panel.

exerted on the original panel and have been replaced with others of different designs and varying degrees of effectiveness. In this context it is interesting to note the shrinkage that has occurred on many panels that were thinned and cradled in the nineteenth century. The shrinkage can be measured by how far the battens extend beyond the sides of the panel (Buck 1978)—sometimes as much as 0.5 cm on a panel only 90 cm wide.

In postwar Italy, methods of panel painting conservation became more sophisticated. Splits were rejoined with wedges, in the method mentioned by Secco-Suardo in 1866, but the wedges were tightly fitted into carefully cut V-shaped grooves and glued with PVA emulsion glues.[1] Dovetails were no longer used because it was observed that they did not properly secure breaks and splits and, in fact, created new ones (Fig. 11). Opinions have differed on how deep the V cuts should go into the panel. Ultimately a general consensus was reached that they be cut as close as possible to the original gesso from the back and that the wedges be carefully fitted into these to ensure a lasting hold. Deformations and cracking have been observed in those cases where the incisions have gone only halfway into the panel, such as in a sample made in 1961 (Fig. 12).

Figure 12
Two grooves cut into a poplar panel at different depths contain the same poplar wedges glued with a PVA emulsion glue. There is a marked cracking of the ground opposite the top groove, which is cut only halfway into the panel; opposite the bottom groove, which is cut into the whole thickness of the panel, there is no cracking of the gesso.

Modern restraints or cross braces are made to be as unobtrusive as possible, and original battens are often readapted if they still exist. Otherwise new ones are made that require the least intervention to the original panel. It is interesting to observe how new battens have become progressively lighter since the early 1950s, thus reducing to a minimum the amount of reworking required on the back of the panel. Many different constructions were designed by the various conservation centers. Metal T bars were used, as well as brass tubes that slide inside wooden braces or cleats attached to the panel with or without metal sleeves. These sometimes have the drawback that they behave more like clamps and actually block the movement of the panel if there is a tendency for it to warp. Other crossbars—such as the wooden ones constructed at the various

Figure 13, above
Duccio di Buoninsegna, *Maestà,* 1311. Tempera and gold leaf on panel, 214 × 412 cm. Museo dell'Opera del Duomo, Siena. This detail of the left section before the restoration in the 1950s clearly shows two of the six vertical cuts made in 1771.

Figure 14, above right
Duccio di Buoninsegna, *Scenes from the Life of Christ,* 1311. Tempera and gold leaf on panel, 214 × 412 cm. Museo dell'Opera del Duomo, Siena. The left section of the former reverse side of the *Maestà* before the restoration of the 1950s, showing the horizontal cracks (marked with tape) that formed after the separation from the *Maestà*.

restoration departments in Florence—have proved to be very effective. The present-day interventions at the Fortezza da Basso in Florence are described by Castelli (see "Restoration of Panel Painting Supports," herein).

In the 1950s the Istituto Centrale per il Restauro in Rome carried out some of the most complex interventions that had ever been attempted on panels. One of them is the *Maestà* by Duccio di Buoninsegna in the Opera del Duomo in Siena (Fig. 13). The large altarpiece was originally painted on both sides. It was constructed with two layers of poplar running perpendicular to each other, but in 1771 the altarpiece was divided into seven panels; subsequently, the scenes depicting the life of Christ (Fig. 14) were separated from the sections of the large frontal scene (Fig. 15). During this process the blade slipped twice, cutting through the front of the central and widest panel and causing severe damage to the Virgin's face and her blue robe (Istituto Centrale per il Restauro 1959:17–19) (Fig. 16). After the front was separated from the back, the panels of the *Maestà* were rejoined.

For nearly two centuries the newly exposed wood was subjected to atmospheric fluctuations that caused new tensions that resulted in a series of large splits, cracks, and severe cupping of the paint layer (Istituto Centrale per il Restauro 1959:20–26). During the last restoration, these cracks were stabilized with the insertion of wedges, and the irregularly cut areas of the back were filled and reconstructed with seasoned poplar insets to create an even surface (Fig. 17).

Given the size, weight, and proportionately extreme thinness of the front panels, a system had to be developed to sustain the large *Maestà* altarpiece. For this purpose a steel support system was devised consisting of fifteen flat steel braces about 0.5 cm thick and 2.5 cm wide. The braces

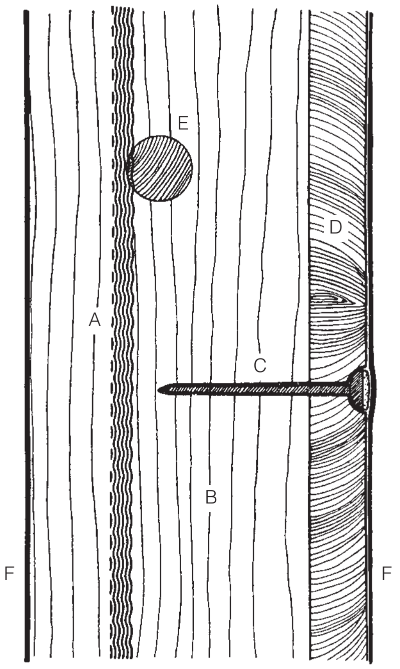
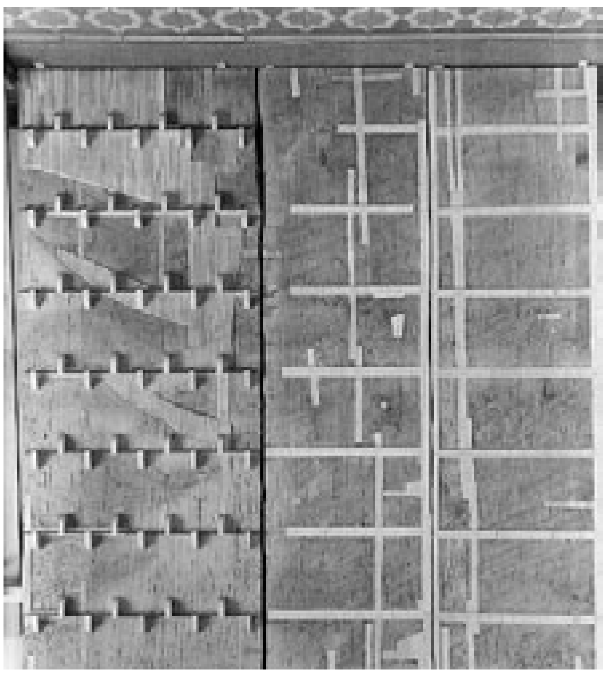


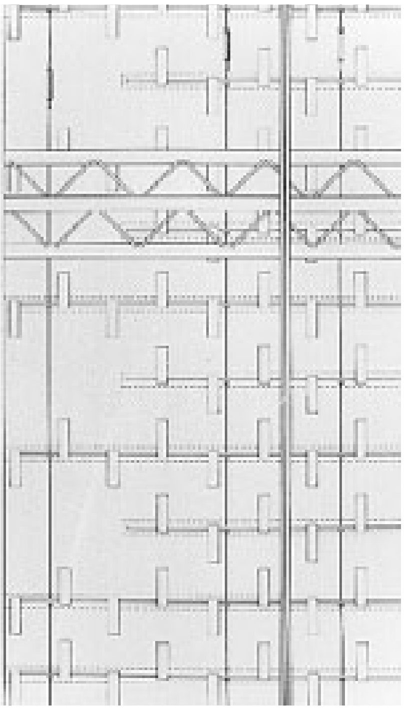
Figure 15, above
Duccio di Buoninsegna, *Maestà* and *Scenes from the Life of Christ*. Drawing showing the cut (A) that separated the front from the back. The portion remaining attached to the *Scenes from the Life of Christ* (Fig. 14) consisted of a horizontal layer (D) and a vertical layer (B). The thickness of the vertical layer, which is the part that is missing from the back of the *Maestà,* was dictated by the depth of the nails (C). One of the original dowels (E) is shown. In this manner, the two painted surfaces (F) were divided.

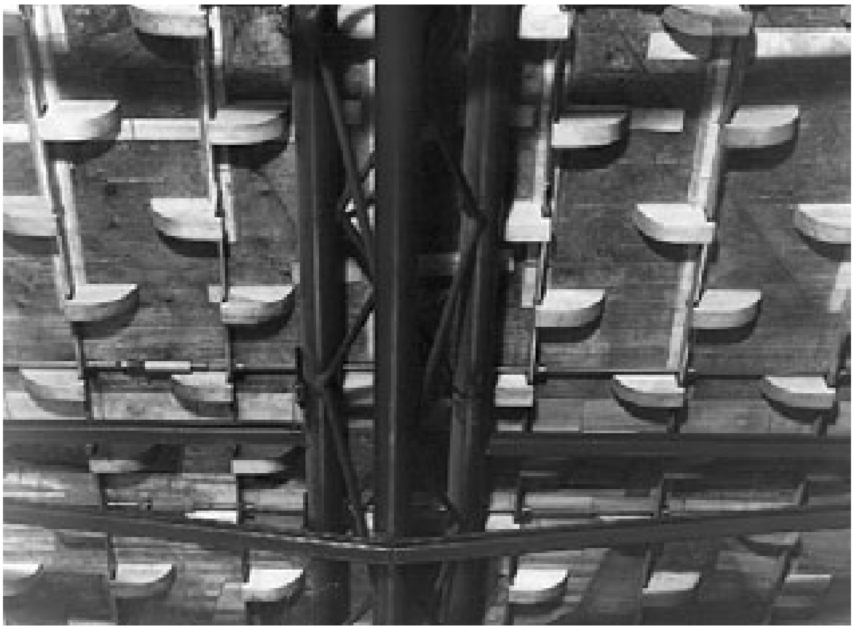
Figure 16, above right
Duccio di Buoninsegna, *Maestà*. This scene of the Virgin with the Christ Child before restoration, photographed in raking light, clearly shows one of the cuts caused by a blade that slipped during the separation process of 1771.

Figure 17, right
Duccio di Buoninsegna, *Maestà,* reverse. On the left, the irregularly cut areas on the back of the central panel have been filled, and the cradle has been attached. On the right, the splits have been repaired, and the panel is ready for cradling.

run across the width of each of the seven panels, perpendicular to the grain of the wood (Fig. 18). The braces were attached on edge with a series of wooden pegs with metal reinforcements (Fig. 19). About sixteen thin, vertical steel rods were inserted through these steel braces. Each steel rod had a series of small clamps placed below each brace. The clamps were later individually calibrated. The vertical rods were attached to a steel frame that was constructed on a principle similar to that of an airplane wing (Fig. 20). With this sturdy support, an even distribution of the weight of the panel was ensured (Istituto Centrale per il Restauro







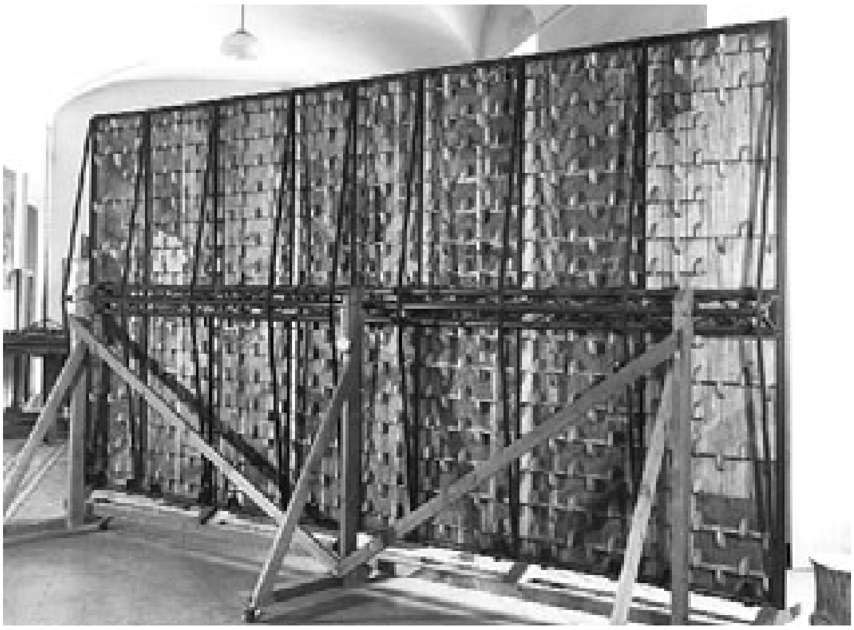


Figure 18, above
Duccio di Buoninsegna, *Maestà*. Drawing of the metal support attached to the horizontal cradle on the back of the panel.

Figure 19, above right
Duccio di Buoninsegna, *Maestà,* reverse. Detail of the support mechanism.

Figure 20, right
Duccio di Buoninsegna, *Maestà,* reverse. The completed support mechanism on the back of the panel.

1959:35–47). Although the room in which the painting is exhibited was the first in Italy to have a climate-controlled environment, damage to the installed equipment by lightning and general neglect (such as wide-open windows) have severely tested the support of the *Maestà,* which, nevertheless, is holding up very well.

The back panels, with the scenes from the life of Christ that had not been thinned in the separation, still had the original nails that had held the two panel layers together. A slice of the wood belonging to the back of the *Maestà* also remained, but it had to be removed. The nail heads that were under the paint layer had to be removed because of the damage from the progressive accretion of rust (Istituto Centrale per il Restauro 1959:29–34). After the nail heads were removed from the back with a hole saw, the holes were filled with poplar plugs inserted parallel to the wood grain. The cross braces were constructed in the same way as those of the *Maestà* (Carità 1956).

Another example of even weight distribution is found on Raphael's large altarpiece, *The Transfiguration,* in the Vatican Museums. The panel is constructed with planks that have been glued together vertically. The Vatican restoration team devised a system similar to that used on the Duccio altarpiece by hanging the painting on horizontal steel crossbars. These steel crossbars are fitted into slots cut into the vertical sections of a large metal frame. Clamp screws attached to the vertical frame sections sustain each of the crossbars. They are calibrated and tightened individually in order to distribute the weight evenly over the whole height of the panel. This gives the heavy panel greatly improved support; fortunately, it has not been thinned and still has the original crossbars.

As mentioned above, many different systems were invented for building crossbars or braces out of materials such as steel and brass. Many of these systems were proposed by the Istituto Centrale per il Restauro (Carità 1953). Today most of them seem rather cumbersome and incompatible with the artworks (Carità 1956). The *Maestà* metal support system still seems to be the most functional. One proposal, however, seems promising: it uses plastic pegs and thin steel rods to hold a panel suspended inside a metal frame (Carità 1956:124–31).

Del Zotto and Tonini (1993) developed some interesting proposals for extremely flexible battens. Their system makes use of ball-knuckle joints attached to the panel with hardwood plugs and inserted into a flexible sleeve that acts as the crossbar. The spring action of the sleeve combined with the free movement of the joint gives the panel maximum freedom to move laterally and permits limited movement perpendicular to the crossbar.

The great flood of 4 November 1966 caused enormous damage to artwork in Florence and Venice. The tragedy helped promote an increased understanding of the behavior of wood and the effectiveness of some of the past interventions on panels. Wooden crossbars with pegs made out of *mansonia*[2] proved to be very effective in holding together the waterlogged panels that expanded with absorption and then, upon drying, contracted drastically. Of all the woods that were tried, none has been as stable as mansonia, which shows practically no deformation or splitting, even under severe conditions, yet has the necessary flexibility and give. PVA emulsion glues proved to be very suitable for poplar panels because of the elasticity of the adhesive, which kept new splits from forming next to the old ones. The glue had sufficient strength to keep these panels well bonded, even after having been immersed in the floodwaters for up to eighteen hours. PVA emulsions have been found to be less effective on hardwoods such as oak or walnut, so epoxy glues are used instead (see Rothe and Marussich, "Florentine Structural Stabilization Techniques," herein).

Wax infusions and applications of balsa wood have never been popular in Italy. While this is principally an aesthetic decision, it may also stem from the knowledge that once a panel has been impregnated with wax, it is practically impossible to remove all traces of it. Attempts to reglue the splits that might form afterward when this method has not been effective (as with the *Resurrection* by Girolamo da Santacroce in the Blaffer Foundation, Houston, Texas) can be frustrating (Figs. 21, 22). Animal

Figure 21
Girolamo da Santacroce, *The Resurrection,* ca. 1525. Oil on panel, 54.6 × 82.5 cm. Sarah Campbell Blaffer Foundation, Houston, Texas. This detail shows the severe formation of cracks after the painting delaminated from a support constructed with wax-resin and balsa wood.

Figure 22
Girolamo da Santacroce, *The Resurrection*. Side view, detail. The edge shows the delamination of the panel from the balsa and wax-resin support.

glues, PVA emulsion glues, and epoxy do not adhere well when there are even minimal traces of wax.

One of the main problems facing Italian conservators today is the certainty that many of these objects are destined to return to environments with severe fluctuations in their ambient humidity and temperature. Many Italian museums have little or no climate control, and it is not unusual to see a great masterpiece—such as a polyptych by Giotto in the Pinacoteca in Bologna—close to a wide-open window. Panel paintings housed under such unsympathetic conditions will eventually blister, deform, or split. To offset some of these effects, attempts have been made to create microchambers that attach to and seal the backs of panel paintings to reduce drastic exchanges of humidity (Del Zotto and Tonini 1993:684–85). Most Italian restorers are faced with the daunting task of finding a solution to establishing an equilibrium among unsuitable environments, minimal intervention, and the natural tendency of wood to constantly react to changes in humidity and temperature.

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Notes

1 Vinavil NPC, Stella Bianca, is a nonionic dispersion of a medium plasticized polyvinyl acetate emulsion in water (see Materials and Suppliers).

2 *Mansonia altissima;* the tree comes from the rain forests of Ghana, Ivory Coast, and Nigeria. The sapwood has characteristics similar to those of the heartwood; the heartwood, which is slightly toxic, is most often used.

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History of Structural Panel Painting Conservation in Austria, Germany, and Switzerland

Ulrich Schiessl

This article presents a survey of the history of structural panel painting treatments in Austria, Germany, and Switzerland. Since much historical research remains to be done on this subject, the present discussion must be somewhat schematic.

Critical Survey of the Historical Sources

Beginning in the late eighteenth century, some literature about restoration appears in the German language. Contemporary journals in technology and fine arts published news about art techniques and gave information about recent restoration treatments of famous works of art. Articles published in French or English were usually translated into German, very often within the same year. For example, a translated extract from the important English book *The Handmaid to the Arts* appeared immediately in 1758 (*Bibliothek* 1758). Names of prominent eighteenth-century restorers, such as Robert Picault, were well known among the educated German classes. The first German report about Picault appeared in 1759 (*Bibliothek* 1759:830). From 1816 to 1849 the historian Ludwig Schorn edited the *Kunstblatt* (Dahn 1953), which presented, among other subjects, much information about current restoration treatments and discussions about critical conservation situations in museums, such as the circumstances in the Dresden Painting Gallery during the early nineteenth century. Recent research about the activities of Italian restorer Pietro Palmaroli in Dresden proves that these journals received much public attention (Schölzel 1994:1–24).

All of the eighteenth- and early-nineteenth-century literature shows a lack of precise technical information about restoration. Due to the zeitgeist, only a change in the aesthetic quality of a painting was considered worthy of description. Except for some small restoration books, not one word concerning treatments of wooden painting supports appears in the literature.

Three of the earliest important German-language books on restoration appeared between 1827 and 1828 (Wagner 1988:11–30). The first small work, *Über Restauration alter Oelgemälde* by the painter-restorer Christian Köster (1784–1851) came out in 1827 in Heidelberg. It was followed by two more booklets, in 1828 and 1830 (Köster 1827, 1828, 1830). In the third booklet we find an appendix by Jacob Schlesinger entitled "Über Tempera-Bilder und deren Restauration" (Köster 1830:35–47). Together Köster and Schlesinger, who belonged to the group of so-called romantic painter-restorers, carried out some restoration for the Boisserée brothers in

Heidelberg. In 1824 Schlesinger was the first paintings restorer of the Royal Museums in Berlin (Schiessl 1990:97–117). Köster's small booklet with Schlesinger's appendix emphasized the ethical basis of restoration work. The 1828 German translation of the noteworthy book about oil painting by M. B. L. Bouvier (1828:465–96), a painter from Geneva, contains an appendix about paintings restoration written by the translator Christoph Friedrich Prange. In 1832 the famous restorer's book by Friedrich Lucanus, connoisseur and pharmacist in Halberstadt, appeared (Lucanus 1832). The restoration books by the painter and restorer Welsch (Kurer 1988:2), published in 1834, and by Hampel, published in 1846, are also important. Born in 1796 in Breslau, Hampel studied architecture and learned restoration work at the Academy of Vienna (Kurer 1988:1). One may presume that Hampel's descriptions are most representative of Austrian methods. A translation by Hertel of Horsin Déon's book, *De la conservation et de la restauration des tableaux* (1851) appeared in 1853. Completing the list of German books on paintings conservation are a booklet by Voss published in 1899 and one by Goetz (1916). An Austrian book about paintings restoration was written by Kainzbauer in 1922.

The establishment of the journal *Technische Mitteilungen für Malerei* in 1884 provided an important new platform for the exchange of experiences and techniques in the field of fine arts, conservation, and restoration.

Finally, in the early twentieth century, publications in conservation and restoration began to include more details of particular methods and treatments. Since that time, good information about treatments for the supports of panel paintings has been available.

How was German conservation literature linked with the literature of other countries in earlier times? As mentioned, the literature on conservation and restoration shows international references dating from the eighteenth century, including translations from English, French, and Italian. In the twentieth century, translations from other languages appear frequently until the 1930s, and then again after the Second World War. Today international exchange of conservation publications is common, although many conservator-restorers are not acquainted with the publications from other countries, as they are limited in their knowledge of foreign languages.

It is quite evident that the circumstances of international exchange in the past were limited to the professional "upper classes" among the academically trained painter-restorers of the nineteenth century and later. For example, some Italian restorers worked in Germany, and some German restorers worked in Italy. This international exchange may have been the consequence of the relationships between governments and of the contacts between the collectors and connoisseurs, as clearly seen in the example of the Boisserée brothers, the most important collectors of medieval painting in German-speaking countries in the nineteenth century. The German restorer Andres worked at the end of the eighteenth century in Naples, and restorers named Metzger and Roeser worked at the same time in Paris. The Italian restorer Palmaroli worked in Dresden at the beginning of the nineteenth century. The restorer Andreas Eigner was conservator and inspector at the Gallery in Augsburg beginning in 1830, after which he worked for museums in Bavaria, including the Alte Pinakothek, and, in the 1860s, for the Öffentliche Kunstsammlung Basel and the Kunstverein Solothurn in Switzerland. Contemporary literature is filled with critical commentaries citing differences among national methodologies and attitudes in restoration, such as the case of Palmaroli. Köster's booklet is full of insinuations regarding the "Italian methods."

Beyond this international level in conservation and restoration exists a level of national and regional tradition—and perhaps even an additional level, defined by particular museums or individuals. These different levels are reflected in the various traditions of cradling panel paintings.

Other, more accurate historical sources are the unpublished and published reports about particular restoration treatments, as well as the larger reports about collections management. In earlier times, such references were usually very short and lacked detail, but in certain archives there are documents with more complete information. The well-known official report of the transfer of Raphael's *Madonna di Foligno* in Paris by Louis Hacquin in 1799–1800 was finally translated into German (Hertel 1853:14; see also Schaible 1983:122). Archival documents also provide some useful information about the 1867 conservation treatment of the *Solothurn Madonna* by Hans Holbein the Younger (Brachert 1972:6–22; Griener 1993:104–20). Some museum catalogues also provide useful information about previous treatments of objects (Zehnder 1990).

Recent studies of restorers and their activities are also helpful; these include research on Christian Friedrich Köster (Rudi 1996), Jacob Schlesinger (Schiessl 1990), Andreas Eigner (Vogelsang 1985), and J. A. Ramboux (Vey 1966; Mandt 1987–88), as well on Alois Hauser Jr., former restorer in Munich (Mandt 1995).

Field research, including a consistent collection of data about previous treatments, rarely exists. An exception is the unpublished diploma thesis of Werner Koch on the support treatments of panel paintings at the Kunsthalle Karlsruhe (Koch 1981).

The development of technological literature concerning panel paintings and their materials has an interesting history. Almost all books on painting techniques address the qualities of wooden supports and their preparation (Schiessl 1989:9–10). Theodor von Frimmel, an art historian in Vienna, addressed the character, wood species, and conservation treatment of wooden supports for panel paintings in *Gemäldekunde* (von Frimmel 1894). The scientist Franz von Frimmel published a study about examinations of wood species of painting supports (von Frimmel 1913–15). Alexander Eibner, professor of chemistry at the Institute for Technology of Painting at the Technical University of Munich and corresponding member of the Royal Academy of Arts in London, wrote many important texts about the development and materials of painting, among them a 1928 publication that described the history of wooden supports and the influence of some supports on the degradation of the paint layer. Many publications on types and qualities of wooden supports for artists may be found in the *Technische Mitteilungen für Malerei*. New boards such as Masonite, plywood (Laue 1891; Hengst 1940), and particleboard were first recommended as new supports for use by artists but were soon used as backings for wooden panels.

Historical Evolution of the Profession

Within the context of this article, there is no place to describe the situation in private collections and museums in the eighteenth and the nineteenth centuries. The heads of the galleries were usually painters and often professors from fine arts academies—simultaneously connoisseurs and conservators. These gallery inspectors usually executed restoration work by themselves and supervised restoration work done by others (Koller 1991:81). Sometimes these inspectors were supervised by a commission, as was done at the Alte Pinakothek in Munich. This Commission for Restoration Affairs was assigned to the Royal Bavarian Board of Directors of the Public Galleries until the end of the First World War.

In German regions in Austria and in the German-speaking regions of Switzerland, the classic distinction between the reliner (in French, *rentoileur;* in Italian, *foderatore*), who was responsible for relining paintings, and the painter-restorer, who was responsible for aesthetic retouching, did not exist as it did in other countries—where the person who treated the wooden support was normally a joiner or a cabinetmaker, and the restoration of the painting itself was the task of the artist painter-restorer.

Köster did not wish to do repair work on wooden supports without the help of a joiner (Köster 1827:14). Almost all the larger museums had specialized joiners for cradling. Most of the authors of restoration books advised leaving all practical work—such as planing, sawing, removing wood, gluing, and cradling—on the wooden support to an experienced cabinetmaker (Welsch 1834:66). Theodor von Frimmel wrote, "The repair work on wooden panels is the work of the joiner, it has to be done under control and on the instructions of the restorer" (von Frimmel 1904:140).[1] Hertel noticed that even the best cabinetmaker should not work immediately on the wooden support but should gain experience in working with panels first, after which the cabinetmaker may become a specialized *parqueteur* (Hertel 1853:16–19). The tasks of a parqueteur consisted of flattening and joining broken panels, paneling paintings, joining wooden strips, reinforcing panels, and cradling (Hertel 1853:16–19). Thus, for all daily needs in the house, every larger museum had its own cabinetmaker who could also, if necessary, assume the duties of a parqueteur. Sometimes, as is reported in an 1828 report from a museum in Cologne, joiners also worked as museum attendants and guards. An instance of a joiner who worked as a museum attendant and was also responsible for restoration work was cited by Vey (1966:46).

Martin wrote that a paintings conservator should possess all the knowledge a joiner requires to cradle panels or else hire a joiner (Martin 1921:168–69). In the same year, the German restorer Victor Bauer-Bolton noted that even the facing of the paint layer with paper before treatment of the reverse was usually executed by a joiner (Bauer-Bolton 1921:39–40). Voss, however, wrote that the panel painting should first be faced on the front side by the restorer before it comes into the joiner's hands, and that the restorer should instruct the joiner not to subject the panel to too much heat. In general, a restorer should leave a panel to a joiner only in the most challenging cases (Voss 1899:70).

Remarks critical of the work of the cabinetmaker first appear in 1952 in a summary of a survey on the treatments of panel painting supports conducted in twenty-eight conservation laboratories in West German museums and monument conservation offices. The analysis of this survey, based on detailed interviews of restorers, was performed by Christian Wolters and will henceforth be referred to as the Wolters Report. This report discusses the joiner's position in panel painting conservation from a new point of view: "Cradling work should not be done by the joiner.

Craftsmanship is not enough. . . . Only a well trained conservator is in the position to judge all conditions of the paint layer and its ground, of humidity, temperature and the tension of the wood" (Wolters 1952:11).

Surely, however, some cabinetmakers of the time must still have worked on the backs of panel paintings.

History of Conservation of Supports of Panel Paintings

The history of the conservation of panel painting supports in earlier times is a history of mistreatments, rather than of treatments. Most were executed not to satisfy conservation-related requirements but to render the panel painting into a particular aesthetic form in accordance with contemporary taste. Most of the early treatment methods for panel paintings, and for canvas paintings as well, had to render the surface smooth and clean. The support was not accepted as an integral and authentic part of the painting, which was considered to consist only of the thin paint layer; the rest could be altered.

Sawing double-sided panels

The earliest known examples of this horrifying procedure date from the eighteenth century. This drastic treatment was applied to the large altarpiece dating from 1539 by Lucas Cranach the Younger in Saint Wolfgang's Church in Schneeberg, Saxonia (Figs. 1–4). In 1712 the altarpiece was altered to the Baroque style. Whereas the central painting was integrated into the new altar, the two wings were left separated and sawn into four paintings that were mounted on the walls in the choir at either side of the new altar. The full history of these pieces cannot be described here, but in recent years they were finally mounted together again. When the restoration work is complete, they will finally return to the church in Schneeberg (Magirius et al. 1994).

Another very important altarpiece, the main altar by Hans Holbein the Elder dating from 1502, was originally mounted in the church of the monastery of Kaisheim. The altarpiece remained in its original place until 1673, when the church was changed during Baroque renovations. The wings were separated into eight component parts. In 1715 they were sawn through and put separately into splendid frames that were mounted in the church on both sides of the main entry. By the secularization movement in 1803, the paintings became possessions of the Bavarian authorities and are presented today in the Alte Pinakothek in Munich, where the paintings are reassembled in their original arrangement as wings (Bayerische Staatsgemäldesammlungen 1986:247–50).

An Austrian example from an important 1440 altar work of the Albrechtsmeister, initially made and mounted in the Kirche am Hof in Vienna, may mark the end of the history of the splitting of panels in the eighteenth century. The Gothic altarpiece was removed around 1700 to allow the construction of a new Baroque altar. Sometime before 1799 they were sawn through "with much deftness" by a joiner (Koller 1972:144).

Secularizations at the end of the eighteenth century in Austria and from 1798 on in Germany spurred the dismantling of many Gothic wing altarpieces. The secularization in Germany and Austria transferred a considerable amount of movable church artifacts, including many Gothic altarpieces, into public collections or private hands. Many paintings also were

Figure 1
Lucas Cranach the Younger, high altar of Saint Wolfgang's Church, Schneeberg, Saxony, 1539. Oil on panel, 285 × 99 cm. Left rigid wing with Lot and his daughters (reverse of the formerly double-sided wing) during restoration treatment and before retouching. The vertical cut in the center of the panel was made to delineate two parts for splitting, a procedure probably performed in 1712.

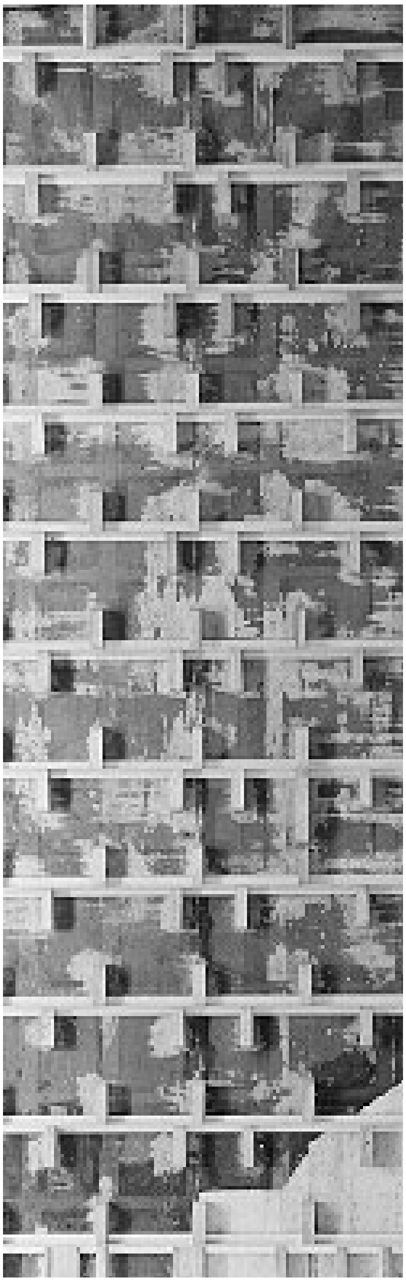


Figure 2
Lucas Cranach the Younger, high altar of Saint Wolfgang's Church. Split wing with Crucifixion (reverse of the formerly double-sided wing). The condition of the reverse since 1970 and before conservation treatment is seen. A cradle with aluminum edges of the Italian type was mounted (see Fig. 3).

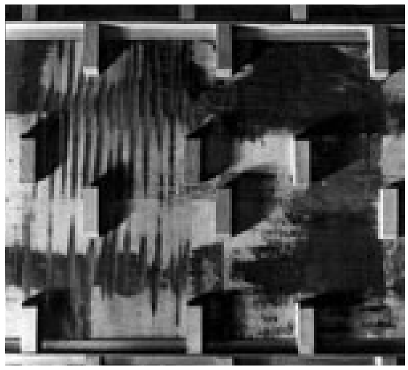


Figure 3
Lucas Cranach the Younger, high altar of Saint Wolfgang's Church. Split wing with the Fall of Adam and Eve. Reverse, showing traces of treatment since the splitting, a procedure probably performed in 1712; traces of the saw blade and the plane, a dark paint layer, and traces of rasping done in 1970 to prepare the Italian cradle can be seen (photograph taken after conservation treatment of 1991).

put on sale. Collectors at that time did not want the complete altar work (including its shrine architecture, ornamental carving, and sculpture); only the primitive medieval paintings were of interest. For aesthetic reasons and ease of presentation, hundreds of double-sided paintings were separated, a

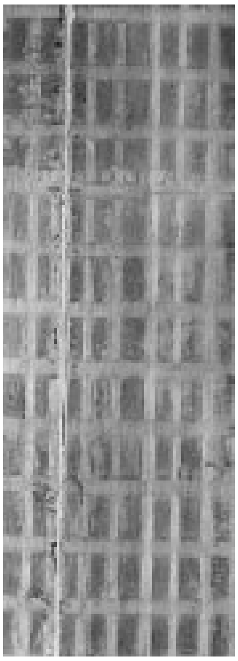


Figure 4
Lucas Cranach the Younger, high altar of Saint Wolfgang's Church. Split wing with Adam's expulsion into hell. Reverse. The panel wing, probably split in 1712, received a wooden cradle in 1886 with flat and broad strips; the condition after removal of the cradle is seen.

practice that became relatively common in all museums and continued into the twentieth century. Hans Thoma, director of the Kunsthalle in Karlsruhe between 1899 and 1919, noted: "Many of the old altar paintings had painted back sides. These are at least of the same interest as the front sides. That's why I gave the order to split them. Thus some fine paintings are added to the Gallery's collection" (Fig. 5) (Busse 1942:280).

Few, if any, gallery reports record by whom, when, and how often splitting occurred. Thus, the date of splitting remains unknown for a huge number of paintings. Written notes by conservator J. A. Ramboux in the Museum of Cologne record that about thirteen paintings were split after their acquisitions in 1846–47 and 1854 (Mandt 1987–88:316).

Because joiners and, above all, cabinetmakers were expert in the use of veneer frame saws, they—as well as some parqueteurs—were well-trained "masters" in splitting paintings. To make splitting easier, a painting was frequently cut into two parts vertically before splitting, with the placement of the cut chosen to avoid important parts of the painting. The preparatory vertical cutting happened to the wings of the Schneeberg Altar of Cranach mentioned previously. There are also early examples in Switzerland (von Imhoff 1973:90–91). Typically, larger panel paintings were cut into more "handsome" parts for easier splitting, as was the case for the double-sided *Crucifixion* (front) and *Saint Drusiana Raised from the Dead* (back), of around 1440, now in the Bayerisches Nationalmuseum (inv. MA 2343, 2358), Munich (Figs. 6, 7). The artwork was cut through vertically along the beam of the cross (Christ's head was avoided) using a 5 mm thick saw blade. After the separation into halves, splitting was easier. According to Dorothea Preyss of the Bayerisches Nationalmuseum, the date of splitting is unknown (Preyss 1994). Adelheid Wiesmann-Emmerling of the

Figure 5
Late Gothic altar wing, Swabian school (probably Ulm). Painting on panel, 147 × 100 cm. Kunstmuseum Saint Gall, Switzerland. This formerly double-sided painting was split and then combined into a composite one-sided painting. After the splitting, which was done in the nineteenth century, Saint Anne and Saint James the Great were brought together and repainted for continuity. The drapery and the floor on the left side were copied from the right, and the whole background is overpainted. Condition before the 1978 conservation treatment at the Schweizerisches Institut für Kunstwissenschaft, Zurich.

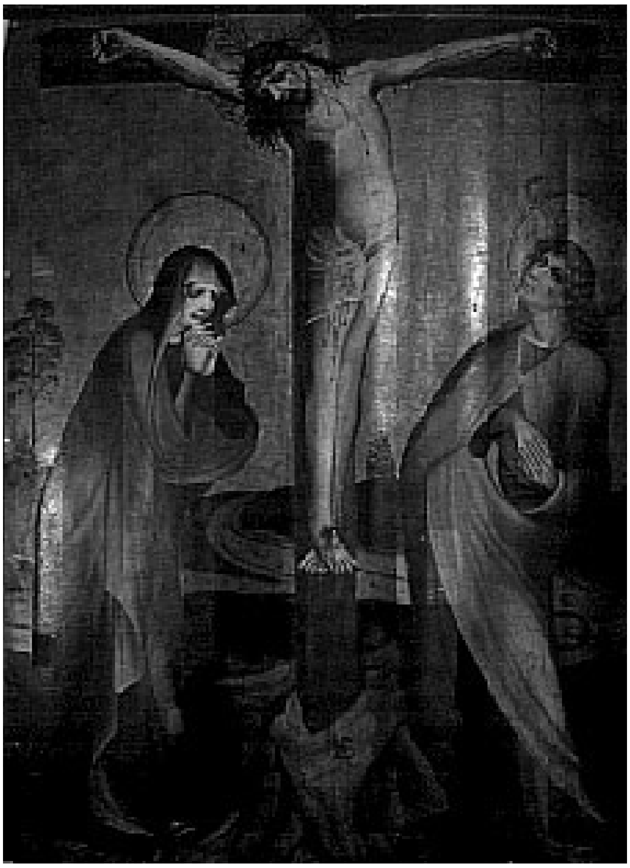


Figure 6, above
Bavarian master, *Crucifixion,* ca. 1440. Altar wing. Painting on panel, 179.5 × 138.5 cm. Bayerisches Nationalmuseum (inv. 2343), Munich. This formerly double-sided painting was split about 1804, around the time it came into the Royal Bavarian Collections. An earlier flat wooden cradle caused a very strong washboard effect. The painting is unrestored.

Figure 7, above right
Bavarian master, *Saint Drusiana Raised from the Dead,* ca. 1440. Painting on panel, 179.5 × 138.5 cm. Bayerisches Nationalmuseum (inv. 2358), Munich. This painting was split away from the painting in Figure 6. The panel, shown during conservation treatment and before retouching, shows the vertical cut that divided the panel into two parts before splitting (white line). To avoid sawing through the head of the Christ on the other side, the the sawyer took a small detour at the top of the panel.

Hessisches Landesmuseum Darmstadt cites other examples of paintings as large as 203 × 106 cm that were split without being first divided vertically (Wiesmann-Emmerling 1994).

No statistics about the disasters of splitting have been collected, and it is clear that there was not sufficient interest to make accidents public knowledge. Few reports on splitting problems exist, but enough traces remain on the original objects themselves to provide relevant information. In 1874 the sawing of a painting of Lucas van Leyden in the Alte Pinakothek in Munich by a gallery attendant and joiner named Nüsslein resulted in an unfortunate failure. The order to split the painting was given by a retired director of the gallery who wanted to hang both sides of the panel side by side on a museum wall. The front side of the painting sustained some damage, and a third of the painting on the reverse was lost. This accident is well documented in reports at the gallery (Kok, Eickemeier, and van Asperen de Boer 1976:252–54).

Another dramatic accident happened in 1943 to a painting by Niklaus Manuel at the Schweizerisches Landesmuseum, Zurich (Figs. 8, 9). The painting was put between zinc plates and held firmly so that the joiner could saw through the panel. The saw drifted to one side of the panel and destroyed huge sections of the paint layer (Kersten and Trembley 1994:159–78).

Little discussion of the splitting of double-sided panels appears in the conservation literature. A very rare comment can be found in the 1912 conservation report by the conservator Kinkelin about the damages to paintings in public possession in Bavaria and their restoration. Kinkelin describes how double-sided paintings were split and discusses the

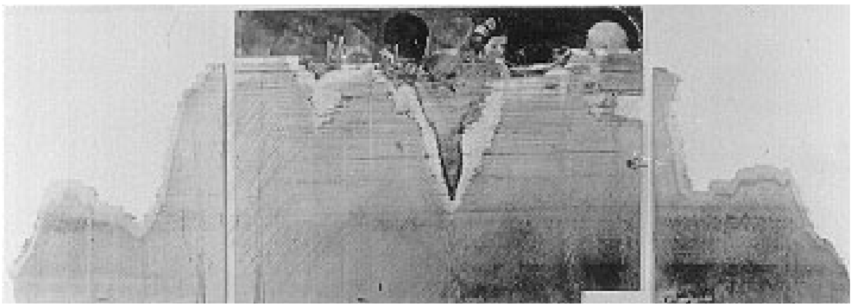


Figure 8
Niklaus Manuel, *Adoration of the Kings,* ca. 1518. Oil on panel, 899 × 149 cm. Kunstmuseum Bern. Disastrous mishaps that occurred during the splitting of panels were not publicized; even so, these procedures destroyed many panel paintings. Heavy damage was caused by the 1947 splitting in Zurich of Niklaus Manuel's double-sided painting *Adoration of the Kings* and *Sending of the Apostles*. The damage to the front of the *Adoration of the Kings* is shown.

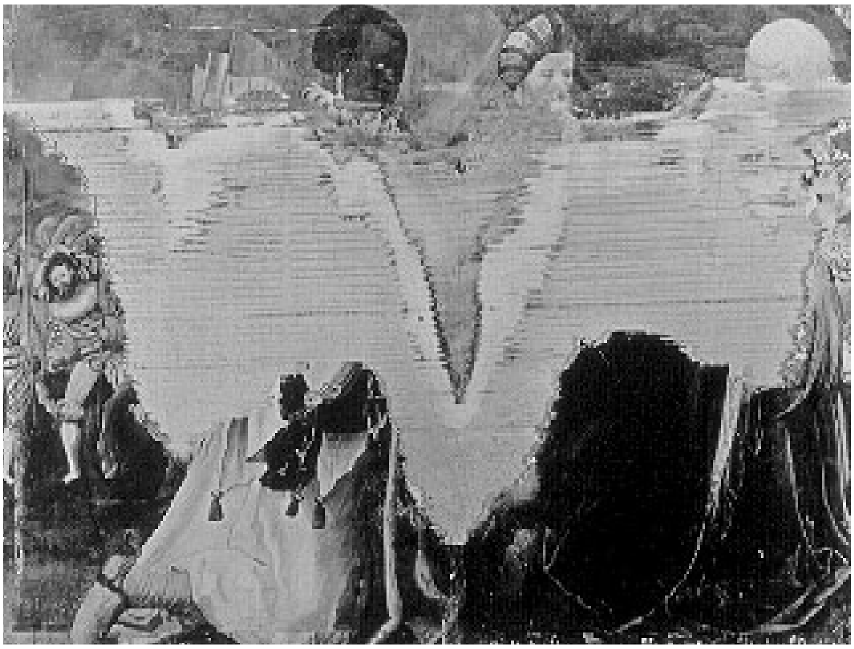


Figure 9
Niklaus Manuel, *Adoration of the Kings*. Results of the first repair in 1955, after the partial destruction of 1947 (see Fig. 8).

subsequent damage resulting from this treatment: "Until dividing, this type of panel was healthy. Humidity and heat could not react with the wood because it was covered on both sides with priming and paint layer. Now the situation of both split paintings was changed. Each painting was open at the back. Sawing diminished their stability. From now on, the backs could react to heat and moisture. The effect was shrinking by the influence of heat on the sawn side and warped back. Thus, many cracks developed in the paint layer, and in the worst case, cracks in the wood were the consequence. In cases of high humidity, the wood swells from the back; therefore, the support warps forward, [resulting in the] loosening and loss of the paint layer" (Kinkelin 1912:fol. 4).

Finally, the Wolters Report describes the negative effects and the possible ways to correct and control the damages provoked by splitting. The thickness of the paintings is often reduced to 2 mm. Due to the very thin supports after separation, treatments were necessary to reinforce the panels and to keep the supports flat. Usually the supports were cradled with various systems, or they were glued onto auxiliary supports such as wooden panels, and later to plywood or Masonite boards. Only very small panel paintings remained untreated after splitting.

Thus, it seems evident that splitting of double-sided panel paintings was done less frequently after the beginning of the twentieth century.

But splitting was still recommended when a damaged support required a partial transfer. In such instances, it was noted that the separated back side should always be preserved (particularly if there were inscriptions, seals, and marks) and that after the transfer of the painting with its split, thinned support to a new rigid support, this original back side should be glued onto the reverse of the new support (Goldkuhle 1932:15).

Finally, splitting of double-sided panel paintings has been done for conservation reasons. Thomas Brachert discussed the method again in 1955 (Brachert 1955b). He pointed out that splitting a double-sided panel painting spells the destruction of an original, organic work of art, although it can sometimes be the indicated treatment when blistering panel paintings cannot otherwise be preserved. There are occasional examples of this. In 1957 Schmidt-Thomsen published a well-documented case study about the partial transfer of a double-sided panel painting (Fig. 10a–f) (Schmidt-Thomsen 1957:6–11), and an unpublished treatment was executed by the conservator-restorer Adolf Jobst in 1969 at the Hessisches Landesmuseum in Darmstadt.

Thinning of the support

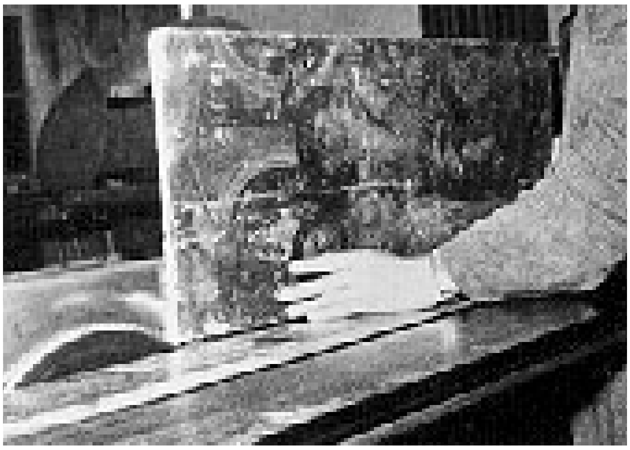
Split double-sided panel paintings were sometimes left without any other treatment on the newly exposed surface, so that the saw marks remained visible (Fig. 11). But frequently, auxiliary supports or auxiliary constructions such as cradle systems were added to the reverses, and then the sawn surfaces were treated to obtain an even surface or smooth thickness. To accomplish this, the saw marks and the drifts of sawing were usually smoothed with a tooth plane or smooth plane. If the thinning and planing were done well, it may be impossible—except for the extant corresponding side of the painting—to determine if the painting had been double-sided and was split or if it had originally been one-sided. Through such treatment, even the supports of some larger-sized paintings have been thinned to 2–5 mm thick.

In southern Germany, Austria, and parts of Switzerland, supports were mostly of coniferous wood, but oak supports were also thinned to a minimum of 2 mm (Zehnder 1990:passim; Goldberg and Scheffler 1971:passim). Italian wooden panel paintings, consisting mostly of poplar, were also thinned to 0.5–1.2 cm (Boskovits 1988:18–19, 27, 85, 136–37). The sawn surfaces often retain evidence of dowel holes.

In general, all panels required cradle and auxiliary supports after thinning. It is easier to flatten very thin panels than thick ones. The reverses of one-sided panel paintings have also been thinned by planing to expose the tunnels of burrowing wood insects for better impregnation treatment. Thus, not only split panels but also numerous (originally) one-sided paintings appear today with only a small portion of their original support.

Pest control

Many methods have been used to attack insects and fungi in wood, especially in painted panel supports. Solutions of salts were used for impregnation (Schiessl 1984:10–11). Treatments against insects were used against fungi in anticipation of good results, but to no avail. The opposite approach, using known fungicides as insecticides, was also unsuccessful. Mercury chloride was often used in the eighteenth century and recommended in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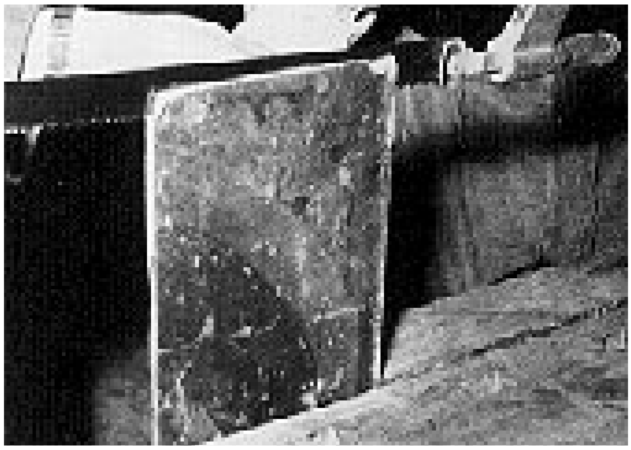
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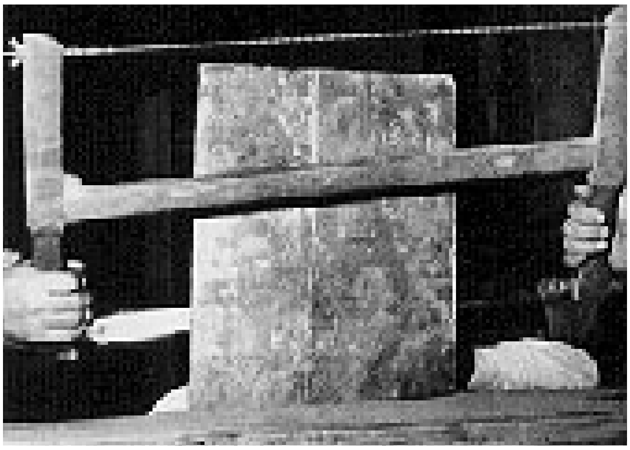
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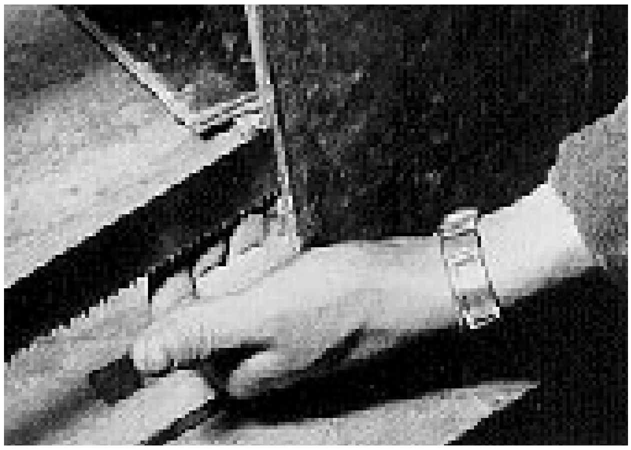
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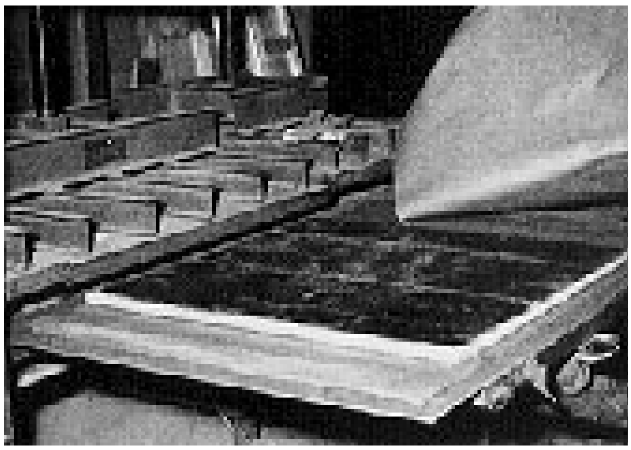
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Figure 10a–f
Splitting of panels for conservation reasons, done in 1957 (Schmidt-Thomsen 1957). The very degraded support of a double-sided painting urged partial transfer of the paintings, as follows: (a) first, slits were made with a circular saw; (b–d) the phases of splitting followed; (e, f) then the two thinned panel parts were mounted on new auxiliary supports of chipboard.

the nineteenth century. In 1867 Andreas Eigner treated Holbein's *Solothurn Madonna* with mercury chloride (Brachert 1972:6). In Austria in 1911, many altarpieces were totally impregnated with mercury chloride, a strong poison that was recommended until the 1950s (Aberle and Koller 1966:7). Many soluble salts were tested in combination with arsenic. Acids were thought to be effective mainly against fungi (Schiessl 1984:12; Unger 1988:48), as were some alkaloid mediums. Concoctions of tobacco leaves, blackthorn, pepper, bay leaves, aloe, myrrh, and garlic were believed to kill woodworms (Schiessl 1984:13).

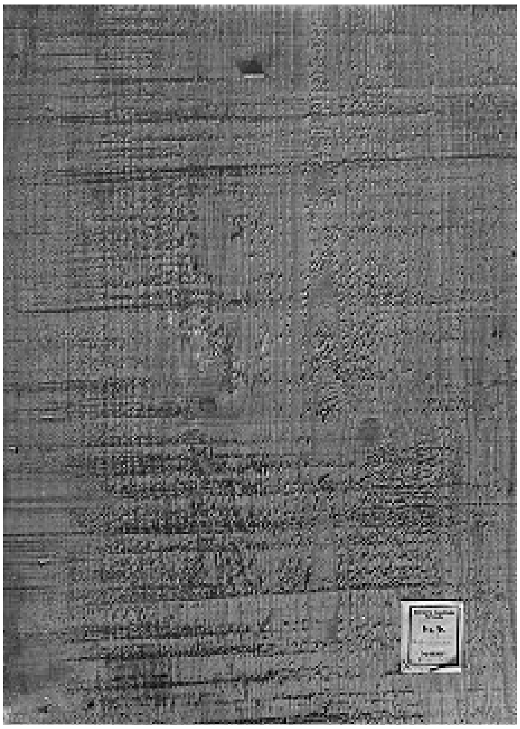

Figure 11
Master of Rottweil, *God the Father with the Body of Christ,* ca. 1440. Reverse. Painting on pinewood panel, 590 × 435 cm. Kunsthalle Karlsruhe (inv. 1135; in the collection since 1858). The panel is one half of a double-sided split panel; traces of the saw blade are visible. All edges have been cut and reduced.

In 1910 the conservation chemist Friedrich Rathgen cited an old recipe, a concoction of 1.5 l vinegar, 12.5 g garlic, 25 g onions, 11.5 g salt, 80 g vermouth leaves, and 2.25 g ground pepper (Rathgen 1910:23–27; Trillich 1924:23–27; Rasser 1925:42–43).

Beginning in the nineteenth century, oils from turpentine, juniper, birch, clove, lemon, thyme, and lavender were recommended (Schiessl 1984:13). According to one source, boiling turpentine oil provides superior penetration (Fernbach 1834:6). First mentioned in a conservation context as "stone oil" (in Old German, *Steinöl*), petroleum and all its derivatives have been used widely as conservation materials since the mid–nineteenth century (Schiessl 1984:14). Similar to wax, petroleum derivatives imparted the dark, heavy, metallic character of bronze color to the unpainted wooden surface, especially to oak (Schiessl 1984:14). The same effects are caused by tar oil. The new taste for special surfaces and structures (the so-called *Materialgerechtigkeit*) in the early twentieth century is perfectly put into words by Haupt, who stated that if the reverse of a panel painting were impregnated with tar oil, the wood grain would be beautifully intensified (Haupt 1908:559). The demand for noncoloring, nondarkening conservation materials did not arise in the wood conservation field until the 1950s. The trade names of "classic" mediums include Arbezol, Basileum, Creolin, Carbolineum, Jakutin, Mobe R, and Xylamon (Brachert 1955b:27). At the time, all these materials consisted in part of mineral oils that cause irreversible darkening of wood. Materials with the same trade names are today formulated differently.

Industrial pest control products containing naphthalene chloride, dichlorodiphenyltrichloride (DDT), pentachlorphenole, or lindane have also been used, the latter in the former German Democratic Republic. Most of these toxic agents continue to effloresce today from the treated wood. Grave concern about these highly toxic chemicals undoubtedly contributed to the development of preventive conservation.

Pest fumigation of wood has also gone through fundamental changes. Having been practiced since antiquity, fumigation may be one of the oldest methods of impregnation of wood (Unger 1988). In the eighteenth century sulfur dioxide was used for fumigation. Prussic acid, first used around 1880, is no longer used. Today new experiments with nitrogen and carbonic acid have shown promising results.

Consolidation of panels damaged by insects and fungi

Until the 1950s the diagnosis of extensive damage by insects or fungi on a wooden panel painting support always led to drastic treatment measures: total or partial transfer of the support. Less pronounced damage provoked responses that would be considered aggressive today. One such "light" operation was planing the whole reverse to open the burrowing passages of wood insects to enable better impregnation.

Exhaustive studies about wood consolidation and especially about wooden painting supports have been written in the German language; only a few are mentioned here. R. E. Straub wrote the first systematic critical introduction to both pest control and wood consolidation (Straub 1963:128–40). The general study published by Brigitte Aberle and Manfred Koller in 1966 on wooden sculptures is also valuable for panels (Aberle and Koller 1966). Achim Unger's important book about wood conservation contains a very complete bibliography, material descriptions, and recipes used for treatment materials (Unger 1988).

There is insufficient room in this article to describe all the materials used for wood consolidation during the history of conservation. Today scientific identification of old consolidation materials remaining in the objects and the study of the degradation of such materials has become a new, highly problematic topic in conservation research. Thus, exploring old restoration texts may be of value. In 1834 Welsch recommended an impregnation mixture of copal varnish, turpentine oil, and boiled linseed oil (Welsch 1834:65). An early method for the consolidatation of degraded wood was impregnation with animal glue mixed with alum as a hardener. A mixture of casein glue and alum is also mentioned (Wolters 1952). Attempts to reinforce wood include the application of shellac, followed by a putty of hardwood sawdust, chalk, dextrin, and carbolic acid (Kainzbauer 1922:38).

The advice to remove all of the wood possible, however, as well as to cradle, appeared frequently in early literature (Lucanus 1832:77). In some instances, wooden supports have been so weakened by degradation that they have required consolidation before they could be thinned with a plane.

The Wolters Report of 1952 provided a good overview of the consolidation materials used for panel paintings until the 1950s. It noted discussions both for and against cellulosic acetate and cellulosic nitrate. Some laboratories preferred solutions of natural resins such as colophony in turpentine oil, shellac in alcohol, and mixtures of wax-resin solutions. Compositions of resin, wax, and linseed oil or Chinese wood oil, and casein glue with alum were also described. All restorers interviewed for this report rejected bone glue and hide glue. The use of combined conservation materials for the dual purposes of pest management and wood reinforcement was remarkable (Wolters 1952).

In the 1960s Straub described a preference for consolidation materials that hardened without solvent action (e.g., some types of wax, mixtures of wax with resins, epoxy resins, and polyester resins) (Straub 1963). An immersion method is also described. Melting a wax-resin mixture in a flat tub on the hot table is recommended (Straub 1963:138–40). In 1957 Peter J. Hermesdorf modified such a type of wax bath on the hot table for impregnation (Hermesdorf 1963). Synthetic resins, especially acrylic resins, have been in use since the 1970s (Unger 1988). Many experiments and conservation techniques used for other types of wooden works of art have not been executed on wooden panel painting supports (e.g., application of the conservation material under vacuum, or polymerization of monomers in the degraded object itself). Current methods are, for the most part, restricted to local treatments.

Flattening of warped panels without cradling or other auxiliary constructions

Flattening methods used in the past could—at best—be considered restoration efforts rather than conservation treatments. Many such treatment types of the past are also classified today as impractical and inconvenient for our standards of practice.

Flattening panels with a plane was also preparatory in nature, inasmuch as flattening was a necessary antecedent to the thinning or removal of the wooden substance of the support. It was almost impossible to mount thinned panels on an auxiliary support without prior flattening. Thus, the flattening of panels was considered a preliminary step to mounting thinned panels on an auxiliary support.

Flattening of panels with water

The easiest way to straighten a split or one-sided warped panel is to bring the reverse into contact with water to swell the wood. When this side is swollen, the panel is flat. After drying, the panel returns to its original orientation, perhaps becoming even a little more warped than it was before. Considerable measures must be taken to keep the swollen panels straight.

Lucanus recommended moistening the reverse of the panel once or twice (Lucanus 1832:114). Welsch recommended moistening every half hour with warm water until the painting is straight (Welsch 1834). Hertel recommended spreading moistened fabric sheets over the reverse of the panel painting (Hertel 1853). Following advice given in a 1912 report at the Alte Pinakothek in Munich, moistened sawdust was spread over the reverse of panels to straighten them (Kinkelin 1912:fol. 4; Wolters 1952:8). In 1952 most of the public conservation laboratories in West Germany rejected flattening methods for panels that involved direct contact of water with the wooden surface (Wolters 1952:8).

Wet cloths, wet sawdust, wet sand, and wet split bricks were also used to allow the water vapor to affect panels in climate chambers or similar constructions (Wehlte 1958:106). Climate chambers or tents for flattening panel paintings were more frequently used after 1950 (Wolters 1952:8).

Before the use of climate chambers became more frequent, simple moistening methods were practiced to prevent the direct contact of water with the panel's surface: the warped panels were exposed only to water vapor. Hampel described how small warped panels can be positioned on a pot filled with water, remaining there for about twenty-four hours until flat (Hampel 1846:8). Traditionally, the water was heated. Another humidification method, possibly a very old one, involves placing the warped painting on a slightly humid support such as a stone or brick floor, sometimes with a load on the warped panel to straighten it (Wolters 1952:8).

Flattening of panels with polar solvents

Polar solvents such as ethanol mixed with water or pure ethanol may have been used to moisten panels for the purpose of flattening. It may have been observed that the flattening of a warped wooden panel could be effected by ethanol when mercuric chloride was used in an alcoholic solution for pest control in wood. The use of organic solvents to straighten panels is rarely documented. Spraying ethanol on the reverse of a warped panel to moisten it has been reported (Wolters 1952:9). In two cases, when the so-called shellac method was performed without efficacy, swelling of the panel reverse was initiated with Cellosolve. Such treatments were carried out in 1957 and 1959 in the Schweizerisches Institut für Kunstwissenschaft laboratories in Zurich (SIK 1957, 1959).

Cutting the backs of panels

During the nineteenth century and in the first half of the twentieth century, the reverses of panel paintings were treated on the surface to assist in humidification. Typically, such treatments drastically altered the original surface of the reverse. The most aggressive method consisted of planing the whole surface of the reverse to obtain pure and fresh wooden material for moistening. From the 1950s this opening of the wooden structure was done with a scraping tool to reduce loss of the original substance (SIK 1957, 1959). Another "classic" method was to make cuttings, notches, and slits with a knife along the grain of the panel to promote penetration of water into the wood structure (Lucanus 1832:115; Welsch 1834:63–64). Such cuttings were also carried out in the same way as the Italian *sverzatura* by sawing along the grain. Around 1950 a modified paring chisel was used to make slits in panel reverses (Wolters 1952:9; Brachert 1955b:14).

Shellac, or Munich, method

A technique to flatten warped panels was developed at the Doerner Institute in Munich by Christian Wolters (1952:10). Initially, water-insoluble binding media were postulated for use, particularly those that contain water in their liquid phase, such as watery dispersions of synthetic polymers, urea resins, cellulosic esters, and high-molecular alcohols (Wolters 1952:10). Repeated applications of such binding media on the reverse of warped panels were intended to flatten and reinforce the support simultaneously. Solutions of shellac in ethanol and Cellosolve were applied as a type of solvent compress on the wooden surface. The polar solvent vapors penetrate the wooden structure and cause swelling, while the shellac film serves as a solvent-retention barrier. This so-called shellac method, or Munich method, was described by Christian Wolters at the 1961 conference in Rome of the International Institute for the Conservation of Artistic and Historic Works (IIC) (Wolters 1963:163–64).

Today the Munich method is understood to have rather negative effects, as the shellac film has a very strong gloss that covers the entire reverse (Fig. 12). Typically, conservators no longer apply materials directly to the support. However, at that time shellac was not the only coating applied to panel reverses—wax layers were also used. That technique may have the advantage of not requiring the removal of original material (Straub 1965).

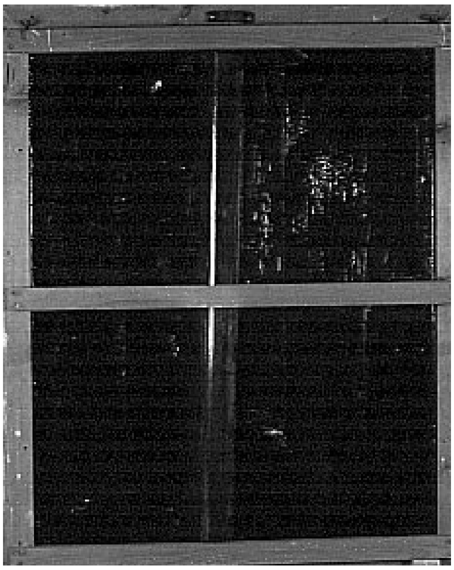

Figure 12
Frankonian master, *Epitaph for the Nun Gerhäuser,* 1443. Reverse. Tempera on panel, 114 × 875 × 2.2 cm thick. Bayerisches Nationalmuseum (inv. MA 2586), Munich. The painting was treated in 1960–61 with the shellac method to flatten it. This photograph of the reverse, from 1994, before conservation, shows a rigid cross slat that contributed to the enormous crack in the middle of the support. The thick and glossy shellac layer is remarkable.

The shellac method for flattening wooden panel paintings may be beneficial in that, unlike other systems, it does not require pressure. The method aims to make corrections of warping only as far as it is allowed by the condition of the individual support.

Pressure for flattening

Lucanus and Welsch were the first to write about the application of pressure. The warped panel painting may be positioned on small wooden slats and covered with a cloth. Then, after every moistening, the load on the top of the panel is made increasingly heavy (Lucanus 1832:116; Welsch 1834:62). The Austrian Ludwig Kainzbauer recommended an even easier straightening method—laying a moistened panel (painted side up) on the floor and toploading it (Kainzbauer 1922:36). Although in the German literature there is little technical information about the application of pressure to panels, there is one good example from Secco-Suardo (Zillich 1991:40–45). All tools of the joiner, such as screw clamps, were used to set pressure to flatten. Most of the panels, however, may have been thinned and cradled, or glued to an auxiliary support. Later case studies on flattening and cradling mention the affixing of screw clamps after flattening and up to the moment of cradling (Wehlte 1958:106).

Drying under tension was another method to flatten panels. Small and thin panels were first moistened and flattened by swelling of the reverse. They were then immediately nailed into their frames to keep them straight (Welsch 1834:63; Kainzbauer 1922:36). According to the Wolters Report, one conservation laboratory applied slight pressure on the panels, working with a veneer press and many cauls of wood and rubber (Wolters 1952:10).

Slots and wedges

Another practice was cutting along the grain in the reverse of a warped panel to facilitate effective penetration of water into the wood structure. Water was dripped into the cuttings and slots. When the painting was flat, it remained under pressure. These slots were then filled. After drying and hardening, pressure was removed from the panel. The fillers kept the panel straight (Wolters 1952:9). Wider slots, made with saws, were normally filled with small strips or wedges of wood to keep the panel straight (Zillich 1991:46–50).

Flattening by cradling

Many panel paintings are cradled from earlier conservation treatments. Cradling was the normal procedure after double-sided paintings were split; it was also the classic system used to reinforce thinned panel painting supports. Cradle systems are well known and widely published; therefore, the technical details of particular cradling systems will not be described.

Cross cleats or lattice systems of the eighteenth and nineteenth centuries

In Germany, Austria, and Switzerland, cradle systems were not used until the eighteenth century. An early method to maintain the flatness of panels involved setting cross cleats into the support (Fig. 13). Lucanus did not adhere to the method of gluing or screwing slats to the panel reverse, as he stated that slats or cross cleats are not necessary for small panels and are ineffective for huge panels (Fig. 14) (Lucanus 1832:116). Köster recommended a movable system of two slats laid across the grain (Köster 1828:13). Hampel described movable cross cleats, left loose without adhesive joins in a dovetail halved joint (Hampel 1846:22). A 1912 restoration report from the Alte Pinakothek in Munich summarized all problems with rigid slats fixed across the grain of the panels. Such slats were removed from many Gothic and Renaissance panel paintings to set the wood of the panels free (Kinkelin 1912:fol. 8). Brachert discussed cross-cleat systems and their disadvantages, as did Straub (Brachert 1955b:15; Straub 1963:153).

Starting in the eighteenth century, rigid wooden frameworks and lattices were mounted on the reverses of panels to reinforce them (Zillich 1991:59). There were many early treatments that preceded movable cradles. Many such rigid frameworks and lattices mounted on panel paintings were well documented in the Kunsthalle Karlsruhe before they were removed during this century (Koch 1981:passim). These simple but potentially

Figure 13, right
Lucas Cranach the Elder, *Mary with the Child,* ca. 1518. Reverse (photographed during the 1950s). Oil on limewood panel, 345 × 226 cm. Kunsthalle Karlsruhe (inv. 108). The very small and thin panel was probably glued in the eighteenth century onto a rigid cradle that was obviously originally a canvas stretcher with crossed reinforcements. Traces and drops of glue can be clearly seen.

Figure 14, far right
Master of the Bamberg Altar, *Legend of Saint Wolfgang,* ca. 1490. Reverse. Oil on panel, 675 × 375 cm. Kunsthalle Karlsruhe (inv. 54). This photograph from the 1950s shows the conservation treatment of the nineteenth century. All the edges were cut, and four strong cross braces of oak were adhered to keep the painting flat.

harmful rigid lattices and frameworks were still made during the nineteenth century by joiners and restorers.

Evidently, Hacquin's movable system of cradling became known in Germany and Austria through his articles in art journals. Lucanus and Köster were the first to describe a movable cradle system (Lucanus 1832:117; Köster 1828:14).

The quality of the wood species used for the slats along and across the grain may be significant. Even in the Wolters Report, however, there was no consensus. Some laboratories used softwood cradles, while others preferred cradle slats of the same wood species as the original support. It was proposed that the slats glued along the wood grain should show growth-ring structure in a perpendicular position with respect to the support (Wolters 1952:12–13).

In some collections, all or most of the panel paintings were systematically cradled. According to H. Dietrich of the Hochschule für Angewandte Kunst in Vienna, oral legend reports that between 1825 and 1835, most of the panel paintings in the Kunsthistorisches Museum in Vienna were treated, thinned, flattened, and cradled (Dietrich 1994). Apparently, during the nineteenth century there was no discussion about the quality of cradling; it was a common and unquestioned practice.

Cradling in the late nineteenth and early twentieth centuries

A positive attitude toward cradling was so pervasive that the treatment was even recommended by the painter and restorer Aloys Hauser as a preventive measure for new wooden panel supports used by contemporary painters (Hauser 1885:6). At the beginning of the twentieth century, cradling still had not been discussed in a negative light. If paintings were damaged, the cause was usually attributed to a technically incorrect cradle. Until the middle of the twentieth century, flat cradles were still in use (Figs. 15, 16). In the 1930s cradle systems with huge slats positioned on their sides were preferred (Zillich 1991:63). At that time the first discussions about cradling can be found in the literature. Painter-restorers like Doerner had no doubt about the necessity of cradling (Doerner

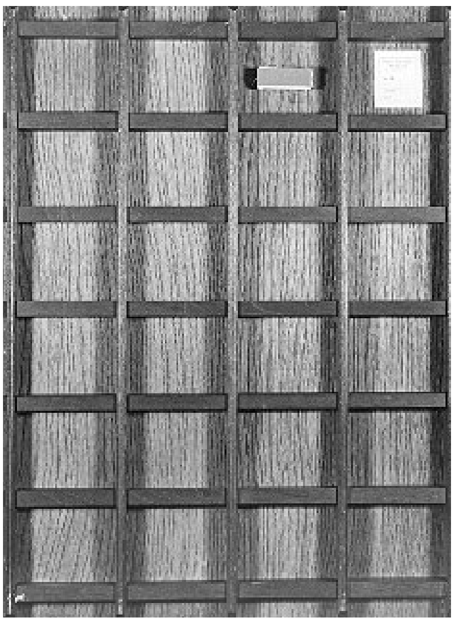

Figure 15
Hans Müelich, *Portrait of Pankraz von Freyberg,* 1545. Reverse. Oil on panel. Kunsthalle Karlsruhe (inv. 2477; in the collection since 1961). A rather delicate treatment that must have been done before 1961 is shown. The panel was thinned to 1 mm, then glued onto a particleboard as an auxiliary support. To hide the particleboard, a counterveneer was glued over it. Finally, a very fine wooden cradle was mounted.

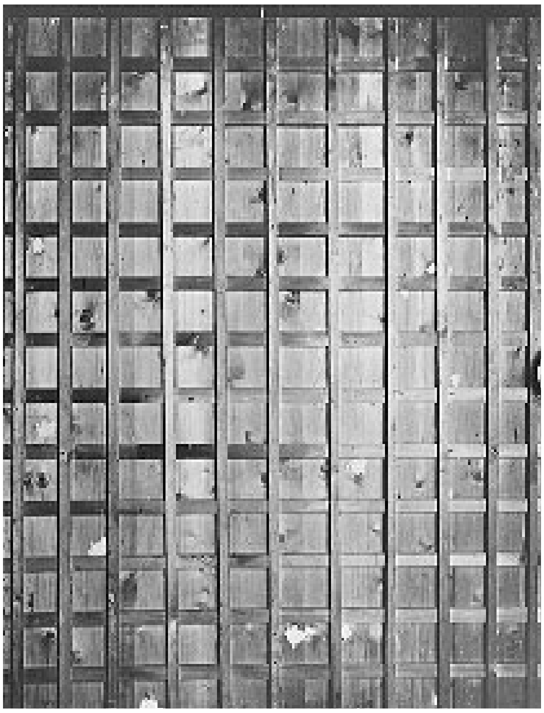

Figure 16
Matthias Grünewald, *Our Christ Carrying the Cross,* 1520–24. Reverse. Tempera on pinewood panel, 195.5 × 142.5 cm. Kunsthalle Karlsruhe (inv. 994; in the collection since 1900). The painting is one part of a formerly double-sided painting. In 1883 the restorer A. Hauser split, cradled, and cleaned the paintings. This photograph from the 1950s shows the old, flat wooden cradle.

1921:294). Other restorers who voted against cradling pointed out the disadvantages—but their criticisms were directed toward a recommendation that thin panels be mounted on plywood instead of being cradled (Bauer-Bolton 1933:99–100).

International exchange facilitates communication about other methods—even methods that were first proposed seventy or eighty years ago. Secco-Suardo's method of a reduced cradle system without slats along the grain of the panel seems to have become known in Germany during the middle of the twentieth century (Zillich 1991:63). In Germany this cradle system was called the Italian cradle. It was described in detail in 1949 by Toni Roth in Doerner's ninth edition (Doerner 1949:418). The Italian cradle system was apparently invented a second time by Kurt Wehlte (1958:110). But here the old conservation master adopted a system that had been described as the Italian system three years earlier by Thomas Brachert, who briefly summarized all cradling systems (Brachert 1955b:8). The only differences between the methods were broader slats across the grain.

Discussions about cradling in the 1950s and 1960s

Cradling was discussed more in detail in the 1950s and the 1960s. The 1952 Wolters Report summarized all positive and negative aspects of cradling. It emphasized that cradling with flat slats should be avoided and that cradling with slats positioned on their sides, or with the Italian system, would be more convenient. It is evident that the Wolters Report supplied much fundamental material for the important article "The Care of Wood Panels" by the International Council of Museums (ICOM) Commission for the Care of Paintings (1955:139–94).

In 1960 Keyselitz presented an article on the so-called Vienna method of cradling in the journal *Maltechnik*. It was a call to reestablish traditional artisans' techniques, which were in danger of disappearing in a theoretical world of new conservation attitudes. Under the guidance of the chief restorer, Professor Haysinek, and Mr. Sochor, the head of the technical department, who had practiced that special method of cradling since 1930, the reinforcement of wooden supports was accomplished in a quite traditional way with the use of flat cradle systems. It is quite remarkable that partial transfers were executed on some Rubens's panel paintings: paintings situated on portions of the panels whose grain orientation was not parallel to the rest of the support were transferred to new supports of the same wood species with parallel grain; they were then inserted back into the overall ensemble (Keyselitz 1960:73–75). The Vienna method is also known as the Sochor method.

A very concise summary about all the problems of cradling and the reasons to avoid it was written by Straub (1963:139–64).

Balsa-block systems

Straub made a major contribution by bringing to the German conservation scene the discussion about structural panel painting conservation raised by Richard Buck in the United States (Straub 1963:154). Several years later Roettger published a case study about an application of the new balsa-block system (Roettger 1967:13–17). During the following fifteen years, this method was frequently used in cases where formerly thinned panels were reinforced after the removal of rigid lattices or cradles. Some interesting case studies are in the archives of the Schweizerisches Institut für Kunstwissenschaft, among them Holbein's *Solothurn Madonna* (the treatment of which will be described in detail below). Normally the balsa blocks, cut longitudinally into little bricks, were applied as an initial layer along the grain of the panel. Then a second layer of blocks was set across the grain, or again along the grain. The glue was usually wax cement with filler. Christoph von Imhoff proposed the application of quadratic balsa blocks affixed diagonally in relation to the grain of the support with the use of Master Model Paste (a putty of sawdust and epoxy resin, also marketed under the trade name Araldite) as glue; the blocks also served as an equalizer for the support's surface (von Imhoff 1973:94).

Transfer to a new support

Wooden panel paintings have been transferred to new supports for many years. The significance of such a treatment in relation to the original substance of a panel painting, comprising a support and its paint layer, was not yet recognized at the beginning of this century (Krattner 1910:150).

Total transfer

In comparison to partial transfers of thinned wooden supports, total transfers were not frequently done in Germany. Total transfer was often described in early restoration texts. The most extensive coverage of the subject can be found in Hertel's 1853 translation of Hacquin's work on the *Madonna di Foligno*. Köster clearly stated that the paint layer should be controlled and that blisters should be consolidated before the joiner's work begins (Köster 1827:16). Welsch described how the joiner is involved in the transfer work (Welsch 1834:66).

Transfer from wood to wood. Until the end of the nineteenth century, wooden panels were used as new supports for the transferred paintings. Since the only technical possibility was to transfer the painting to another wooden panel, the transfer of paintings did not occur often

(Hertel 1853:24). In 1904 von Frimmel described wood-to-wood transfer as an impractical method no longer in use (von Frimmel 1904:136).

There is no mention of this topic in earlier German literature, but oral traditions regarding the quality and species of wood for new supports seem to be summarized in the Wolters Report. The use of the same wood as that of the panel—from trees cut in winter, growing on the west side of mountains or in the forest—is recommended. Wood from higher mountain regions was considered preferable. The cut trunk was stored vertically during the winter in a protected place. In spring, the bark was removed and the trunk dried in a place protected from sun and wind. If the trunk were floated or boiled for a long time in water, the quality of the wood improved. Only the heartwood board could be used for the new support (Wolters 1952:20). Sometimes restorers were secretive about their new supports; one of these "secrets" was plywood (Goldkuhle 1932). (New types of rigid supports are described below in the context of auxiliary supports.)

Transfer from wood to canvas. Hacquin's work on the *Madonna di Foligno* is one of the most famous transfers of a wooden panel painting to canvas in the history of conservation and restoration. Canvas was preferred as a new support for panel paintings during the nineteenth century. The arguments against this method, however, started early. In 1834 this treatment was thought to be very difficult and dangerous (Welsch 1834:66). In 1873 the transfer of paintings from wooden panels to new canvas supports was officially rejected by museum custodians, conservators of monuments, and restorers (Koller 1991:78). In the first half of the twentieth century, negative opinion about total transfer increased very quickly. Painters voted against it—among them Doerner (1921:290). The loss of the genuine character of a panel painting and its transformation into a canvas painting was decried. It was noted that the painting so treated would then have two types of craquelure at once (Bauer-Bolton 1933:110). The survey of public conservation laboratories revealed that, on the whole, transfer of paintings from wooden panels to canvas was no longer accepted. Transfer in general was now classified as a treatment that could be carried out only as a last resort (Wolters 1952:19). Straub's important paper on the conservation of panel paintings does not address that subject, as he considered the technique unnecessary (Straub 1963:108). Today many old transfers on canvas require additional conservation treatment, particularly if the transfer was not done properly. According to A. Schulze, at the conservation laboratories of the Saxonian Institute for the Care of Monuments and Sites in Dresden, a painting transferred improperly from wood at the beginning of the twentieth century was heavily damaged, with wooden particles left on the back of the paint layer (Figs. 17, 18) (Schulze 1994).

Auxiliary supports since about 1865

The history of total and partial transfer has been related to the history of new rigid auxiliary supports since about 1865, when plywood was first produced industrially in the United States. Around 1900 the first plywood mills were founded in Germany; they appeared in Austria in 1903 and in Switzerland in 1920. The history of wooden fiberboards began in the early nineteenth century. Production started in Germany in 1932 (Schiessl 1983:72–77). Masonite and Sundeala boards were often used in Germany. Particleboards were invented in 1943 in Switzerland; industrial production began in 1950 (Schiessl 1983:72–77).

Figure 17
Gothic altarpiece, late fifteenth century. Tempera on panel. Chapel of Kriebstein Castle, Saxonia. In 1913 two wings were split and transferred to canvas, resulting in four paintings. This detail of Christ before conservation treatment shows the very irregular surface, caused by wooden particles left on the paint layer. Climatic influence caused further damage.

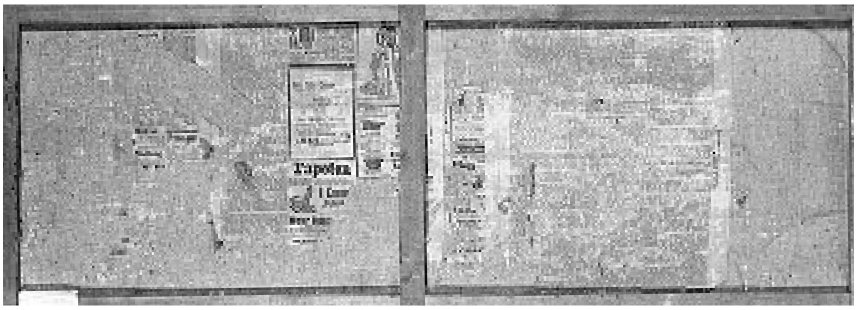

Figure 18
Reverse of one of the four paintings transferred to canvas from the Gothic altarpiece from the chapel of Kriebstein Castle, Saxonia (see Fig. 17). The newpaper backing enabled the precise dating of the transfer.

Chipboards have a more extensive history, as they have long been produced for the furniture industry (Schiessl 1983:72–77). They were highly recommended in the conservation literature of the 1920s and 1930s (Bauer-Bolton 1933:111).

Aluminum sheets and aluminum honeycomb-wave supports were introduced as auxiliary supports in the 1950s. Most of the restorers interviewed for the Wolters Report considered aluminum sheets unsuitable as new supports for transfers (Wolters 1952:21).

Insufficient information is available about the use of these new types of boards for the transfer of paintings to new rigid supports. The Wallraf-Richartz-Museum in Cologne owns eleven surviving paintings from an altar work of the Master of Saint Laurent, dating from 1425–30. These paintings were split in the early nineteenth century. All subsequent treatment (mostly reinforcements of the reverses) caused such heavy damage that in 1964–70, part of these paintings was transferred from wood to chipboard. The other part of this altar consists of very thin panels mounted on chipboard as auxiliary supports (Zehnder 1990:500–509). Another early example of the transfer of a painting from wood to chipboard (19 mm thick) with a canvas interlayer was published by Fritz Reimold in 1972. The transfer of the painting, *The Annunciation* by Konrad

Witz, was considered necessary to treat drastic problems caused by climate changes in the new wing of the Germanisches Nationalmuseum in Nuremberg. The particular character of the support was determined by the wooden panel, which consisted of boards of different wood types (Reimold 1972:825–27). In general, it seems that chipboards were the preferred type of all the new rigid supports after 1950.

Partial transfer to auxiliary supports

In the German-speaking countries, partial transfer was practiced much more often than total transfer of wooden panel paintings. Partial transfer began no later than the middle of the nineteenth century. In this technique the thinned original panel was reinforced by being glued to another wooden panel. Welsch recommended gluing the original panel, whenever it had become too thin, to a very old oak board (Welsch 1834:66). The original panel should not be thicker than 3–6 mm (Hampel 1846:23).

Although the treatment dates are unknown for most of the paintings that received partial transfers, the technique seems to be one of the early ones. To repair the *Last Supper* of Hans Holbein the Younger in the Kunstmuseum Basel, the restorer Andreas Eigner removed a spruce board about 3 cm thick (Vogelsang 1985:142). The Wallraf-Richartz-Museum owns large panel paintings (inv. 137, 143 × 46.8 cm; inv. 146, 93 × 68 cm) reinforced by adhered oak boards (Zehnder 1990:347, 476). In one case it is possible to date the treatment to before 1925. Other treatments of this type were presumably done in the same museum in the nineteenth century (Zehnder 1990:124). The same treatments can be found in other galleries, such as the Alte Pinakothek (Goldberg and Scheffler 1971). It is possible that some of these paintings with adhered auxiliary wooden panels were cradled later on. But the auxiliary wooden panel support was also cradled at the same time. This treatment is documented on Gothic panel paintings in the Alte Pinakothek (Goldberg and Scheffler 1971:88–89). Other examples were performed at the Schweizerisches Institut für Kunstwissenschaft on a Gothic panel painting (101 × 92 cm) (SIK 1961). In 1989 the same situation was seen in a painting measuring 48 × 64 cm. The original, 5 mm thick support was glued to a wooden sheet 2–3 mm thick that had been cradled (SIK 1989).

Partial transfer of wooden panels was sometimes done with the grain of the reinforcement positioned across the original support and sometimes with an adhered counterveneer sheet on the reverse. This type of treatment has probably not been performed since the middle of the nineteenth century, but the technique itself is an old one and is still used in furniture manufacturing. The painting, with its thinned original wooden board, was understood as a veneer sheet. The new auxiliary panel was glued across the grain of the original support, having the effect of a crossbanding. A third, thinner wooden sheet (of the same thickness as the original support) was glued across the grain of the auxiliary panel. Thus, this layer's grain was parallel to that of the original support, so that the effect of a counterveneer was created.

This technique for reinforcing diminished wooden supports has been mentioned only once, but it was frequently used (von Frimmel 1904:140). Many panel painting support treatments executed by the restorer Andreas Eigner (1801–70) were executed with this reinforcing technique, which seemed to be a specialty of Eigner or, rather, of the joiner who worked for him, as seen in some Holbein paintings Eigner treated. In 1865 Eigner restored the so-called *Madonna in the Strawberry Field* (Kunstmuseum Solothurn in Switzerland); he planed the back of the panel to 2 mm thick and mounted it to a wooden reinforcing system, as described above. This support is still in good condition (Vogelsang 1985:145).

From 1865 to 1867 Eigner restored the *Solothurn Madonna* from the same museum (Fig. 19) in his studio in Augsburg; the reinforcing work was done by his joiner E. Huber (Brachert 1972:8). In documents, Eigner reports a total transfer of the painting, but he actually left 2–3 mm of the original support; thus, he performed only a partial transfer. In 1960 the support was still in good condition (Vogelsang 1985:147). The painting was treated in 1971–72 at the Schweizerisches Institut für Kunstwissenschaft in Zurich by Thomas Brachert (1972:6–21). Eigner's auxiliary support was removed, and a new balsa-block reinforcement was applied.

Eigner's typical reinforcing system can also be found on Hans Holbein the Younger's *The Last Supper* in the Kunstmuseum Basel (Vogelsang 1985:142). The panel painting *Saint Christopher and Saint Peter* (Bernese School, about 1480) in the Kunstmuseum Berne was treated in Augsburg by the joiner E. Huber after Eigner's death. Huber continued to use the same system of reinforcement (Wagner 1977:22, 28).

The archives of the Schweizerisches Institut für Kunstwissenschaft contain many reports of plywood as an auxiliary support to reinforce thin, reduced wooden painting supports. Plywood reverses are often described, but in most cases, treatment dates are not available. All plywood types, such as three-, five-, and seven-ply boards, with thicknesses of 3–10 mm, were reported.

In the early twentieth century, reinforcing reduced panel supports with plywood was highly recommended as a good alternative to cradling. Victor Bauer-Bolton rejected cradling, arguing that plywood is an absolutely rigid material that does not respond to climatic changes (Bauer-Bolton 1933:110–12; Goldkuhle 1932). In the Wolters Report it was noted that German plywood products were insufficient for reinforcing panel

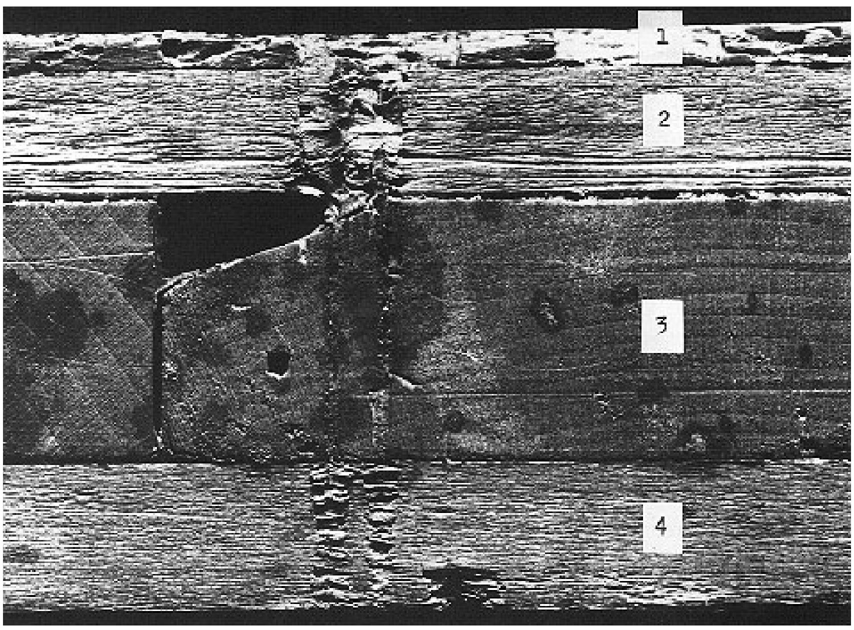

Figure 19
Hans Holbein the Younger, *Solothurn Madonna*. Side view, detail. The German restorer A. Eigner treated, among many other masterpieces, a great number of paintings by Hans Holbein the Younger. Eigner, who worked in the latter half of the nineteenth century, was probably the first to use partial-transfer techniques in panel treatment. In 1866 and 1867, he transferred this painting onto his auxiliary system, composed of the following: (1) the thinned original support and paint layer; (2) limewood boards of 8 mm thickness glued onto the original support following its grain orientation; (3) limewood boards of 12 mm thickness glued across the grain of the first layer of limewood; and (4) limewood boards of 8 mm thickness glued following the grain of the original support.

paintings, that quality U.S. products were preferable, and that only high-quality chipboards should be used for reinforcement (Wolters 1952:20). Thinner plywood auxiliary backings for weak wooden supports were also sometimes cradled to maintain an even configuration (SIK 1990).

Fiberboards were rarely used as auxiliary supports in panel painting conservation. Sundeala boards were used in 1958 as auxiliary supports for thinned Gothic paintings.

Partial transfer to particleboard has been possible since about 1950. An example is the portrait of Johann Caspar von Laubenberg by Bernhard Strigel, acquired by the Kunsthalle Karlsruhe in 1955 (inv. 2375; Lauts 1966:286). The thinned wooden panel is glued to particleboard, and the back of this auxiliary support is covered with an oak veneer. In addition, a cradle is mounted (Koch 1981).

In the Wolters Report, particleboard is not recommended for use as an auxiliary support because of its uneven surface (Wolters 1952:21). According to Wiesmann-Emmerling, a treatment of the epitaph painting of about 1420 for Count Dietrich von Wernigerode is documented in the Hessisches Landesmuseum Darmstadt. The central painting was thinned and reinforced with particleboard in the 1960s (Wiesmann-Emmerling 1994).

Other modern types of auxiliary supports in use since the 1960s are frequently identical to those used for the conservation of transferred wall paintings. These include aluminum honeycombed panels covered by a fiberglass tissue and laminated with epoxy resin.

Materials for gluing auxiliary supports to original supports include wax-resin mixtures or hide glue; wax-resin was preferred because of its reversibility.

Installations and tools used to mount the thinned original panels on the auxiliary supports with the use of pressure are part of the joiner's technical equipment. The use of veneer presses or similar constructions also used for canvas painting relining seems to have been understood as a great "improvement." Since about 1968, the vacuum table has also been used.

Rejoining broken and cracked panels

Traditionally, rejoining broken and cracked wooden panel paintings was considered the task of the joiner, perhaps working under the supervision of a painter-restorer (Hertel 1853:33). Welsch recommended flattening the damaged portions of the painting before gluing (Welsch 1834:65). The bonding medium was probably bone glue, hide glue, or casein glue. The addition of natural resin such as colophony made these glues somewhat water-resistant.

Numerous new types of glues became available in the early twentieth century. Synthetic adhesives for cold application were attractive for gluing wood. *Kauritleim,* a watery dispersion of urea resins, was used with a hardener (Gerngross and Goebel 1933:477).

Around 1950 environmental climatic conditions for the paintings became the determining factor in the choice of glue. Normally most German public conservation studios use neutral bone and hide glue, sometimes with added chalk or zinc oxide. In the process of gluing with hide glue, the butt-joint surfaces of the panel were warmed slightly with infrared spotlights. Casein glue is still frequently in use. The new synthetic glue types were mentioned in the Wolters Report (1952:14–15). But Brachert shows that animal glues are still in use (Brachert 1955b:19).

Straub prefers an adhesive type that is water- and mold-resistant. He emphasizes casein glue over animal glues and discusses all new synthetic glue types, among them epoxy resins, following the outlines of Anthony Werner (Straub 1963:141, 145, 171).

To support the bend of a warped panel during the gluing process, auxiliary constructions should be made. Sometimes butt joints are damaged by insects, reducing the quality of adhesion. Cuts can be made, and a small slat of the same dimensions can be inserted and glued (Wolters 1952:14–15). Brachert also describes this early technique, noting the use of the *Keillade,* an old joiner's tool (Brachert 1955b:19, 21). Wehlte also refers to this tool and illustrates its advantages in a case study (Wehlte 1965:37–41).

This apparatus proves helpful for rejoining smaller panel paintings. Broken panels can be warped nearly spherically, making it necessary to hold the parts of the panel in complicated positions to get the joints into perfect three-dimensional contact. Straub presented a modified apparatus for rejoining thick, heavy Catalan panel paintings, the basic mechanism of which had been developed by Hermesdorf (Straub 1956:192–94; Hermesdorf 1953:87–91). Some years later Straub presented a construction in steel and iron that was very similar to his first construction of wood (Straub 1961:44). In the international conservation scene in the 1960s, more technical constructions were described that permitted better rejoining of panels. Niedermann presented another simple apparatus (Niedermann 1979:51–54).

Early and modern auxiliary methods to reinforce glued joints

An examination of the original backs of medieval and later panel paintings reveals the numerous methods that have been used to reinforce the joints of a panel (Straub 1984:139–42). Oakum, calf hair, or horsehair was glued along the butt joint. In other cases, canvas strips cover the joints (Zehnder 1990:471, Wallraf-Richartz-Museum, Cologne, inv. 128). Sometimes butterfly inserts, as well as original cross cleats, keep the panel together. All these techniques have been used by restorers in the eighteenth and nineteenth centuries to reinforce glued joints (Bünsche 1984:70–74).

Early examples of butterly insert treatments can be found on panels in the Wallraff-Richartz-Museum in Cologne (Zehnder 1990:198, inv. 653.223, 67.422, 179). This method was in use around 1900 at the Alte Pinakothek in Munich. Annual reports describe how butterfly inserts were taken out of the structure and the remaining holes filled with putties or pieces of wood whose grain was parallel to the grain of the original support (Kinkelin 1912:fol. 9). Around 1950 setting of butterfly inserts to reinforce joints was totally rejected (Wolters 1952:15; Straub 1963:147).

Brachert recommended reinforcing open joints with wooden strips inserted along the joint; mortises should be made along the joint to set and glue the strips (Brachert 1955b:21). This method of treatment is very old and no longer used today.

Around 1950 veneer strips glued across the flow of the grain across the joints were described. An older technique is to mount very small wooden blocks over the joints. In the early twentieth century, the annual reports of the Alte Pinakothek in Munich described how small wooden blocks could be glued to reinforce joints, to replace the old butterfly inserts and cross cleats (Kinkelin 1912:fols. 8–10). Some conservators glued these blocks across the grain, others along the grain (Wolters 1952:15). Straub pointed out that in both directions of the wood grain, tensions in the wood caused by these wooden blocks had the same deleterious effect. The new, high-quality modern adhesives were to make reinforcement with blocks unnecessary (Straub 1963:147). Nevertheless, the setting of small wooden blocks is a reinforcing system that remains in use (Fig. 20). Fine wooden veneer strips are also used instead of these wooden blocks.

Repair of partially damaged supports

Repair of such damages to panels as cracks, holes, broken corners, and edges has always been made with wood or filling materials. Cracks normally are filled with wooden splints. Wormholes were filled with crushed paper (Köster 1827:13) or with small sticks of oak wood (Welsch 1834:64). Holes in the support could be filled with very old oak wood (Welsch 1834:64).

The gluing of wooden splints into holes is still in use today. This type of reintegration of damaged parts of the support was in recent years executed during the very difficult and delicate conservation and restoration of the Grünewald painting at the back of the Lindenhart Altarpiece; the conservation was conducted in the laboratories of the Bavarian Office for the Care of Cultural Heritage (Bachmann 1978:7–19). It is still debated whether it is beneficial to fill with the same wood as that of the original support; some believe that the wood of reintegrated parts in the support should be softer than the support, in which case balsa wood is convenient.

Many recipes exist for filling materials to be applied on the wooden support. Köster worked with a traditional chalk or gesso ground (Köster 1827:13). Welsch also preferred typical priming materials, such as animal glue and chalk, or oily putty (Welsch 1834:64). Kainzbauer utilized a mixture of sawdust, chalk, dextrin glue, and carbolic acid (*Karbolsäure*). Wax-colophony mixtures also served as preferable filling compounds (Brachert 1955b:30). Such compositions are well known in cabinetmakers' traditions. In the early 1950s the first filling compounds bound with synthetic resins became available. For example, polyvinyl acetate (PVA),

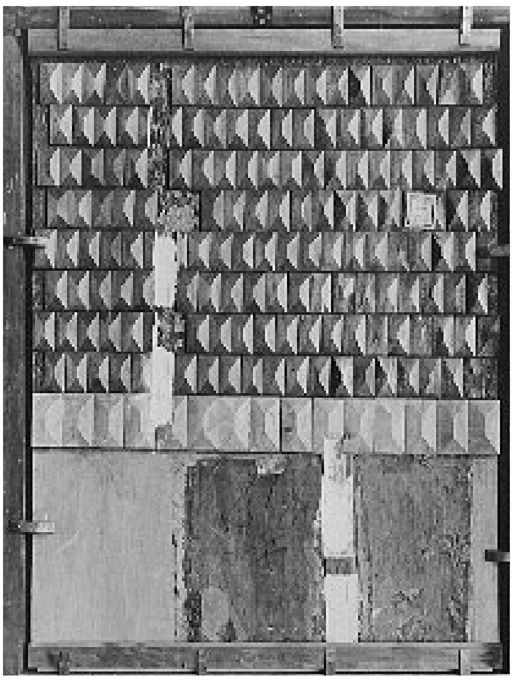

Figure 20
Hans Baldung, *Birth of Christ,* 1539. Reverse. Oil on pinewood panel, 103 × 775 cm. Kunsthalle Karlsruhe (inv. 90). The upper part of the painting came into the collection as a fragment in 1878; then in 1895 Friedläner found another part. Both fragments were combined in 1937, and the area where one part is still lacking has been completed. The photograph of the reverse from the late 1950s, before conservation, shows a reinforcement of small faceted blocks, which were removed in the subsequent conservation treatment.

toluene, chalk, and sawdust were combined to make a filling material (Brachert 1955b:30), or sawdust was mixed with cellulosic nitrate or acetate. Mixtures of epoxy resins with filling pigments, such as Master Model Paste, were also used. Not all these fill materials containing modern adhesives are reversible.

Protection of unpainted backs of panels

Authors of early restoration books complained that the old masters had often failed to apply a protective barrier to the backs of one-sided painted panels to protect against warping (Köster 1828:16). An application of linseed oil with red pigments, typically red ochre, was recommended (Köster 1828:14–15). Old brownish, reddish, or yellowish paint layers on the original backs of paintings can be found in the Alte Pinakothek in Munich and in the Wallraf-Richartz-Museum in Cologne (Goldberg and Scheffler 1971:passim; Achternkamp 1991:18; Zehnder 1990:passim). Other authors were convinced that oil paint layers on the back would help suffocate woodworms (Hampel 1846:21). Panel backs were sometimes painted with red lead (Wolters 1952:6). In Munich around 1900, hot linseed oil was used to impregnate the wooden back, after which an oily pigmented paint layer bulked with chalk or mixed with shellac was applied (Kinkelin 1912:5). At the end of the nineteenth century, some new binding media such as cellulose nitrate were recommended.

Linseed oil impregnation was sometimes done before cradling. Köster recommended covering the entire reverse, including all cradle slats (Köster 1828:14–15). Application of shellac is often reported (Zehnder 1990:422, Wallraf-Richartz-Museum, Cologne, inv. 179.59, 208). Sometimes marks or labels are helpful for dating the application of the paint layers (Zehnder 1990:335). Application of shellac after cradling was an important part of the Vienna method of cradling (Keyselitz 1960:73–75). Since the 1950s wax-resin mixtures have been used for impregnation.

Wolters summarizes a wide range of binding media that can be used to protect the reverses of panel paintings: beeswax; beeswax mixed with natural resins; beeswax mixed with colophony and linseed oil; wax combined with AW2 resin (cyclohexanone resin); pigmented oil paints; hot unpigmented linseed oil with subsequent layers of shellac; shellac mixed with Manila copal; cellulose nitrate; cellulose acetate; latex emulsions combined with paraffin, sodium silicate, and water; PVA dissolved in toluene; and an emulsion of animal glue and linseed oil pigmented with chalk or gesso, sometimes followed by a pigmented oil paint layer (Wolters 1952:6).

Concerning the effectiveness of paint layers applied to protect the backs of painted panels against humidity, Wolters presented the results of important experiments (Wolters 1963). Mühlethaler tested the effectiveness of Saran coatings, recommended by Buck (Mühlethaler 1975).

Paper, foils, and metal sheets were also used to protect the backs of panel paintings. Large paper sheets, probably applied in the nineteenth century, have been documented on some panel backs in the Kunsthalle Karlsruhe, sometimes as a type of counterveneer on sawn panels (Fig. 21) (Koch 1981; Achternkamp 1991:23). The use of paper to flatten thin panels before partial transfer is also reported (Wolters 1952:10). Apparently, foils of synthetic materials such as polyethylene are not used as frequently outside the United States (Achternkamp 1991:23), but there are some examples with cellophane foil (Wolters 1952:5). Tin and aluminum foils were first

Figure 21
Hans Brosamer, *Portrait of Wolfgang Eisen,* 1523. Reverse. Oil on limewood panel, 479 × 305 cm. Kunsthalle Karlsruhe (inv. 128). Sometimes paper sheets were glued on split or thinned panels to reinforce them. The treatment shown dates from the nineteenth century.

recommended about 1920 but were rejected in the 1950s (Basch-Bordone 1921:10; Wolters 1952:5).

Loose wooden boards, glass plates, and metal sheets were some options explored since the 1920s (Achternkamp 1991:25). Hygroscopic materials such as wooden boards, compressed fiberboards, and plywood are still used today.

Conclusion

The very young history of the conservation of wooden panel supports has a very long prehistory. The period of the joiner working under the supervision of the painter-restorer is concurrent with this long prehistory and ends in the early twentieth century. In summary, this period can be considered a period of neglect and suppression of the inherent nature of wood.

During that prehistory, pure aesthetic opinions and preferences for even, smooth panel paintings heavily influenced treatment methods. There was no understanding of the wooden support as an integral part of the picture itself; at that time, only the paint layer was considered to compose the picture—all the rest could be changed. This attitude is most clearly demonstrated by the practice of transferring paintings from wooden to textile supports. There is no doubt that total transfer of a painting was, for a long time, a technically difficult but ethically accepted procedure.

The practice of sawing a double-sided painting into halves was, therefore, not uncommon. In the nineteenth century, the concept of the gallery picture on the museum wall was dominant. It is obvious that other possible presentation methods for double-sided paintings were not considered, nor was there any discussion about this method of transforming altar wings into gallery paintings.

Finally, the dubious effects of cradling methods were never discussed. If there were damages, it was assumed that the individual cradle system was incorrect, the thinning of the original support was not extensive enough, or the remaining wood from the original support was too "lively." The next treatment to be adopted was total transfer.

The same disrespectful attitudes toward the original and integral character of the painting support appear also in the early techniques of removing wood from the support for purposes of pest control and wood consolidation.

In the nineteenth century, the difficulty of totally transferring paintings from wood without respect for the original support may have been the determining factor when it became more common to retain a thin portion of the wooden panel in partial transfer. New, rigid, wooden auxiliary supports have been advocated since the beginning of the twentieth century; partial transfer was easy to accomplish with these new types of supports.

The "prehistory" period of panel paintings conservation ended during the 1920s and 1930s. The history of the conservation of wooden panels began with a new understanding of wood's natural material characteristics and their influence on supports of works of art.

At the time of the 1930 conference in Rome, organized by the International Office of Museums, restorers started to explain the relationships between humidity and wood (Bauer-Bolton 1933). The Second World War barred further development until a new period of activity and exchange was possible, a period documented in the 1952 Wolters Report. The substantial impact of this report as a symbol of new international activity and cooperation in conservation cannot be emphasized enough (Wolters 1952). An important subsequent development in the field was the 1961 conference in Rome of the IIC. The late 1950s and the early 1960s were, in fact, the years when—under the great influence of the research of Richard Buck—the care of wooden panels definitively changed, and the knowledge that formed the basis for the choice of treatment evolved from empirical to scientific. For German-speaking conservators, Straub's published work was much more than a dissemination of that new thinking: Straub also heavily influenced ethical and technical thinking about the conservation of panel paintings.

In Germany, as elsewhere in the conservation world, research about the conservation of panel paintings diminished significantly after the 1960s. At that time, research on wooden panels was no longer a trend; it became more of a special interest. The conservation of wood in general became a more common concern—particularly the areas of wood consolidation, pest control, and climate control (including climatic boxes for panel paintings). The main subjects in international conservation research in the 1970s and 1980s were the conservation of canvas paintings and of stone. It is now time to return to the questions concerning the conservation of wooden panel paintings.

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Note

1 Unless otherwise indicated, all translations are by the author.

Materials and Suppliers

Cellosolve, Fisher Scientific Co., P.O. Box 12405, St. Louis, MO 63132.

Master Model Paste, Ciba-Geigy Corporation, 4917 Dawn Avenue, East Lansing, MI 48823.

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History of Structural Conservation of Panel Paintings in Great Britain

Ian McClure

This article is an attempt to describe the techniques used to conserve panel paintings in Britain from the seventeenth century to the first quarter of the twentieth century. It is probably impossible to write a continuous history of painting conservation practice in Britain. Restorers before the middle of the twentieth century rarely kept detailed records. Such records as survive often note only invoices and payments and offer, at best, insight into the provenance of particular paintings. While references to full-time restorers exist from the seventeenth century, artists also worked regularly as restorers, and on occasion artists would direct the work of restorers. Structural conservation of paintings on both canvas and panel was increasingly carried out by artisans and was considered so routine as to be unworthy of detailed discussion. In the literature on paintings conservation, a tendency to emphasize restoration—that is, the cleaning and retouching of paintings—undergoes steady development. Through the nineteenth century, improving their status became a matter of increasing concern to restorers. It was only in the 1930s that the beginnings of the museum conservation profession as we know it began in Britain, with treatments proposed, reported, and discussed. This development coincided with increasing awareness of practices elsewhere in Europe as well as in the United States.

Some idea of the development of structural conservation techniques before the 1930s can be gained first by the study of the backs of paintings, where the marks of previous treatments can sometimes be seen. Notes and other entries in inventories of collections can also provide clues. Second, it is fortunate that the Royal Collection has a series of inventories and papers with many references to restoration of the collection, starting with the inventory made by Abraham van der Doort, who was appointed the first surveyor of paintings by Charles I in 1625. From these sources, at times informative and at times tantalizingly obscure, comes the most complete picture of the treatment of paintings in Britain from the first quarter of the seventeenth century.[1] Third, information can be found in other documentary sources, such as artists' manuals, works devoted to conversation written by conservators, reports of commissions set up to inquire into aspects of conservation, and the occasional published record of a conservation treatment.

Unlike in the rest of Europe, relatively few early British panel paintings have survived in Britain. The destruction of church furnishings during the Reformation has resulted in only a few chance survivals where an altarpiece or a devotional painting was hidden or lost. Such a circumstance had the added benefit of delaying the painting's entry into the conservation cycle, leaving the support virtually untouched. Religious paintings that are now found in churches are most likely to have been installed much later (Grössinger 1992). There were, therefore, very few indigenous painted panels to enlist particular conservation techniques, good or bad—such as the splitting of altar panels, as was a common practice in Germany in the nineteenth century, as mentioned by Ulrich Schiessl (see "History of Structural Panel Painting Conservation," herein). The Thornham Parva Retable, found in 1924[2] and generally accepted to have been made and painted in about 1340 in an East Anglian abbey, possibly Thetford, has undergone little structural alteration, although parts were crudely overpainted in the eighteenth century (Figs. 1, 2). The Westminster Abbey Retable, painted around 1275, was first noticed by George Vertue about 1725; it formed the top of a large press built to house several effigies (Wormald 1949:166–74). Until the beginning of the nineteenth century, the painted surface was damaged by neglect and deliberate vandalism, but the complex wooden support is largely untouched.

The majority of English panel paintings that have survived are portraits painted up to the beginning of the seventeenth century. Many of these were painted by itinerant Italian, German, or Flemish artists who, like Zuccaro, Holbein, and Stretes, might have made several extended visits to the Tudor court. These painters competed with British painters such as Robert Peake. Some larger panels also survive from the sixteenth century, a notable example being *The Family of Henry VIII: An Allegory of the Tudor Succession* by Lucas de Heere (Royal Collection, Hampton Court Palace), who escaped religious persecution in the Netherlands and worked in England from 1566 to 1576. The painting,

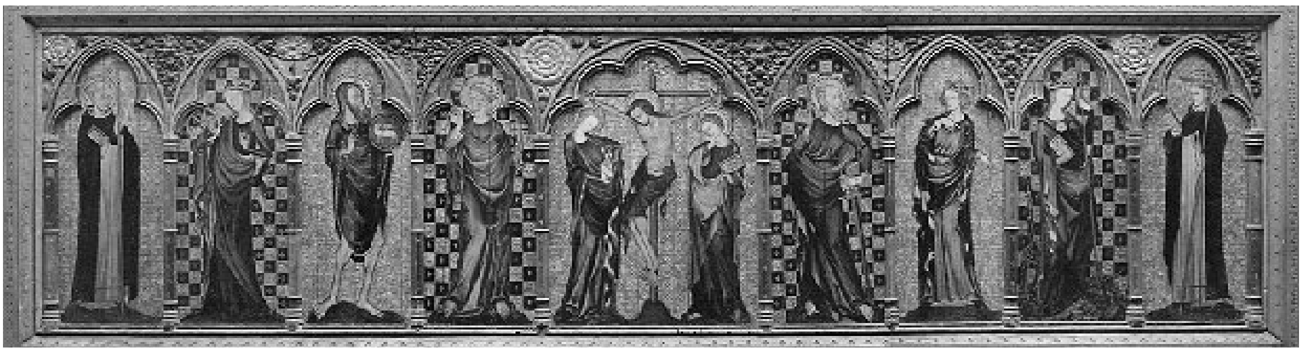

Figure 1
British school, Thornham Parva Retable, ca. 1340. Oil on panel, 381 × 94 cm. Church of Saint Mary, Thornham Parva.

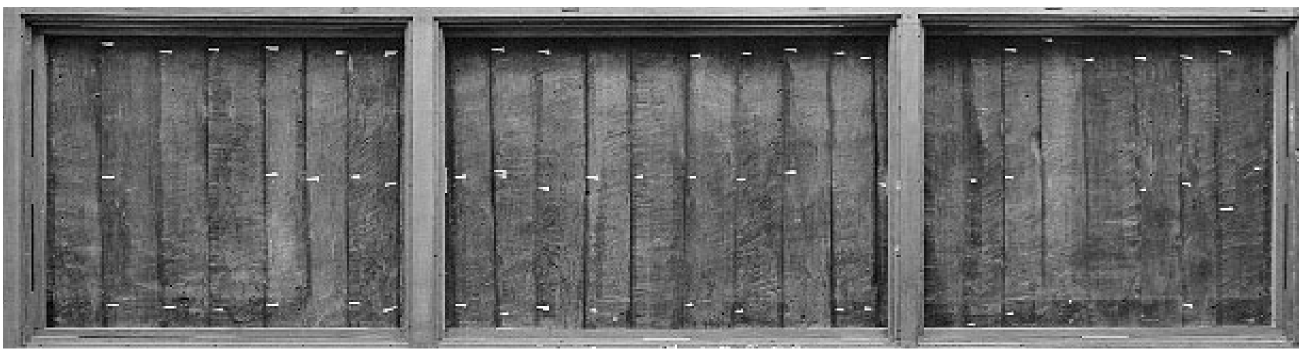

Figure 2
British school, Thornham Parva Retable, reverse. The white arrows indicate the placement of dowels. The frame is modern.

made up of horizontally aligned planks and measuring 129 × 180 cm, was commissioned by Elizabeth I and presented to her ambassador to France (Jackson-Stops 1985:82–83).

The arrival first of Daniel Mytens, and then of Rubens and Van Dyck at the invitation of Charles I, precipitated a renewed interest in painting and collecting. With the purchase of most of the collection of the dukes of Mantua between 1625 and 1628, Charles amassed the most spectacular collection in Europe, reflecting his passion for Titian and Van Dyck (Millar 1977:42–49). Painters came to England to satisfy the demand for commissions, predominantly portraits. Peter Lely settled in England around 1643 and found little competition to prevent his establishing a large and flourishing portrait studio. Talley has described the large number of painting treatises published in the seventeenth century, some of which contain advice on the conservation of paintings (Talley 1981:14–18). While this development undoubtedly reflects an increased interest in painting, it also occurs at a time when many old masters on canvas would be reaching the age when they would require lining for the first time (Percival-Prescott 1974). Many of De Mayerne's experiments in conservation in the first half of the seventeenth century were directed toward obtaining a more stable priming that resisted flaking, treating flaking with glue impregnation, strengthening unlined canvases with glue, and sealing the backs against dampness. The purpose of the passages on conservation in Robert Salmon's *Polygraphice,* published in 1695, is not clear. It is possible the instructions were enough to interest the public without providing practical instruction. The passage on panel paintings reads, "If your painting be wainscotting, or any other Joynery or Carpentary Work, you may take the Wood-ashes . . . and mixing them somewhat thick with Water, rub them over the Painting with a stiff Bristle Brush, as a Shoo Brush, and so scour, wash and dry it, as aforesaid, and then varnish it with common Varnish." A more gentle though abrasive treatment is suggested using water and smalt, in cases in which "the Painting be more curious, as Figures of Men, Beasts, Landscips, Flowers, Fruits etc." (Salmon 1695: addenda to chap. 3, secs. 4, 5).

Eighty years later Robert Dossie in his *Handmaid to the Arts,* published in 1764, has as the only section on panel treatment a set of instructions for the transfer of a panel to canvas, with a warning to practice "with some old pictures of little value" (Dossie 1764: addenda, 422–23). In his preface Dossie dismissed Salmon's *Polygraphice,* as the relevant parts are "confounded with such a heap of absurd stuff and falsities," but it is hard to imagine "the lover of the polite arts" finding Dossie's advice of any practical use either.

After the seventeenth century, panel supports (apart from those used for sketches) do not appear to have been used again extensively until the nineteenth century, with the manufacture of mahogany panels by artists' suppliers.[3] These panels are often extremely stable, having been primed on both sides. A panel of a triptych (otherwise on canvas) prepared in this manner, commissioned by Queen Victoria from her limner, Sir Joseph Noel Paton, survived years of neglect in a damp church without warping, although the paint and ground layer developed a marked craquelure (Fig. 3). Large panels, less well prepared, were also used in the nineteenth century by, for example, Sir William Allan (1782–1850), as an archaizing element in romanticized scenes from Scottish history. *Heroism*

Figure 3
Joseph Noel Paton, *The Good Shepherd* (right wing of a triptych), 1877. Oil on panel, 106.7 × 55.5 cm. Royal Collection, Sandringham.

and Humanity (Glasgow Art Gallery and Museums), painted on a mahogany panel measuring 127 × 197 cm, had originally been heavily battened and subsequently developed splits.

A notable exception is the series of large oak and mahogany panels used by George Stubbs in the 1770s and 1780s, when he was seeking a stable support for his experiments with media such as wax and animal fat. In a memoir of Stubbs's life given by his common-law wife to Ozias Humphry, Mary Spencer described Stubbs as taking conservation measures with his work; she recalled Stubbs as having a large portrait of George III lined before it was exhibited. The series of *The Haymakers* and *The Reapers* at Upton House in Warwickshire (National Trust), painted in 1783, have cradles attached to them. It is possible that Stubbs had the panels cradled as a preventive measure to make the wooden supports as dimensionally stable as the large ceramic plaques he had made for him by Josiah Wedgwood.

From this brief overview it is clear that apart from sixteenth- and seventeenth-century portraits, most panel paintings that have been treated since the seventeenth century were brought to Britain, principally from Italy, France, Holland, and Spain. Many were bought by agents, such as Nicolas Lanier, who negotiated for the Mantua collection for Charles I in 1626, or those whom Sir Charles Eastlake employed to find paintings in Italy for the National Gallery in London after his appointment as its first director in 1855. Many works of more variable quality were purchased as part of the grand tour, and, depending on the taste of the collector and of the period, particular schools would be favored. The cabinet at Felbrigg, for example, was remodeled by William Windham II in 1751 to house his collection of paintings purchased while on his grand tour in Italy a decade earlier, and to demonstrate his taste for Rococo Italian landscape (Jackson-Stops 1983:19–20). The Spanish collection at Kingston Lacy was put together by William Bankes from about 1814, when the disruption of the Peninsular War made the purchase of many fine paintings possible (Cornforth 1986[3]:1576–80). The collection has a panel of a *Madonna and Child with Angels,* attributed to Francisco Ribalta (Figs. 4, 5). The panel is in an untouched condition and has the original loose fibers glued over joints, as well as dovetailed battens that are set in, top and bottom, at right angles to the grain. Little work was carried out on the Bankes collection until it was bequeathed to the National Trust in 1984, and so this panel was never subjected to cradling and thinning.

The value of the archival material referring to the conservation of the Royal Collection was first recognized by Oliver Millar in his book *The Queen's Pictures,* which contains many references to reports, estimates, and accounts. There were two periods of particular activity in the conservation of panel paintings in the period covered by this article: the reign of Charles I and the period from 1857 to 1879, during Queen Victoria's reign, when the post of surveyor of Crown pictures was held by Richard Redgrave. Other periods during which the collection received particular royal attention have fewer references to panel conservation. The interest of Frederick, Prince of Wales, in augmenting and rearranging the collections, occasioned a report of a memorable visit to a restorer in 1732: "On Saturday in the evening her Majesty, the Prince of Wales, The duke and the five Princesses went in Coaches from Kensington to Chelsea Hospital, where after taking a turn in the Great Hall, they walked to the Water-side

Figure 4
Francisco Ribalta (attrib.), *Madonna and Child with Angels*. Oil on panel, 76 × 100 cm. National Trust, Kingston Lacy House, Dorset.

Figure 5
Francisco Ribalta (attrib.), *Madonna and Child with Angels,* reverse.

and went on board the Prince of Wales fine Barge, Lately built under the Direction of Lord Baltimore; and being attended by the Officers and Ladies in Waiting of the Court in another Barge, and a Set of Musik in the third Barge, they proceeded to Somerset House . . . there they viewed Mr Walton's Progress in cleaning and mending the Royal Pictures."[4]

George IV, when refurbishing Carleton House as prince regent, spent lavishly on paintings. The attempt to settle the prince's debts in the 1790s produced accounts from George Simpson for cleaning and repairing a large number of pictures (Millar 1977:129–30).

In his publication of the inventory prepared for Charles I by Abraham van der Doort, Millar published some of the earliest remarks on condition and conservation in English (Millar 1960). Van der Doort's inventory is spread over several manuscripts. One was a working copy annotated and updated by the surveyor.[5] The inventory usually records each painting bought from the Mantua collection as a "Mantua Piece." The paintings recorded in "Whithall [the Palace of Whitehall] in the Second and Midle Privie Lodgings Roome" include "A Mantua peece done by Julio Romano . . . Item [:] A Highe and Narrowe peece. In a carved whited and guilded frame. Being a Sacrifice of Some ffower [four] entire litle figures and a goat lying by to be Sacrificed."[6]

This painting is still in the collection.[7] Its indifferent quality has preserved it from attention and inevitable conservation. The construction of the softwood panel is untouched apart from woodworm attack, which has now been consolidated (Figs. 6, 7). This painting is indicative of the condition of pictures received into the collection at this time, when little structural work was required apart from treatment for flaking. Another painting after Giulio Romano, *The Rape of Europa,*[8] mentioned as being "defaced by quicksilver" from the voyage from Italy to England, has nevertheless survived, although it was probably repainted and enlarged soon after its arrival. Its panel, with the brand of Charles I on the back, has also survived untouched. The panel was constructed of three horizontal planks of softwood with an original vertical strip on the right side and a later addition along the top edge; the central joint has opened, and a split and separation have occurred where the wood grain meets at right angles. On the left side, where the horizontal planks are unrestricted, each plank has warped, so that a permanent washboard set has been formed. The linen strips reinforcing the joins are probably early repairs (Figs. 8, 9). Had the

Figure 6, right
Studio of Giulio Romano, *Sacrifice of a Goat to Jupiter*. Oil on panel, 123 × 66.5 cm. Royal Collection, 109.

Figure 7, far right
Studio of Giulio Romano, *Sacrifice of a Goat to Jupiter,* reverse.

Figure 8
Follower of Giulio Romano, *The Rape of Europa*. Oil on panel, 99.7 × 127.4 cm. Royal Collection (131).

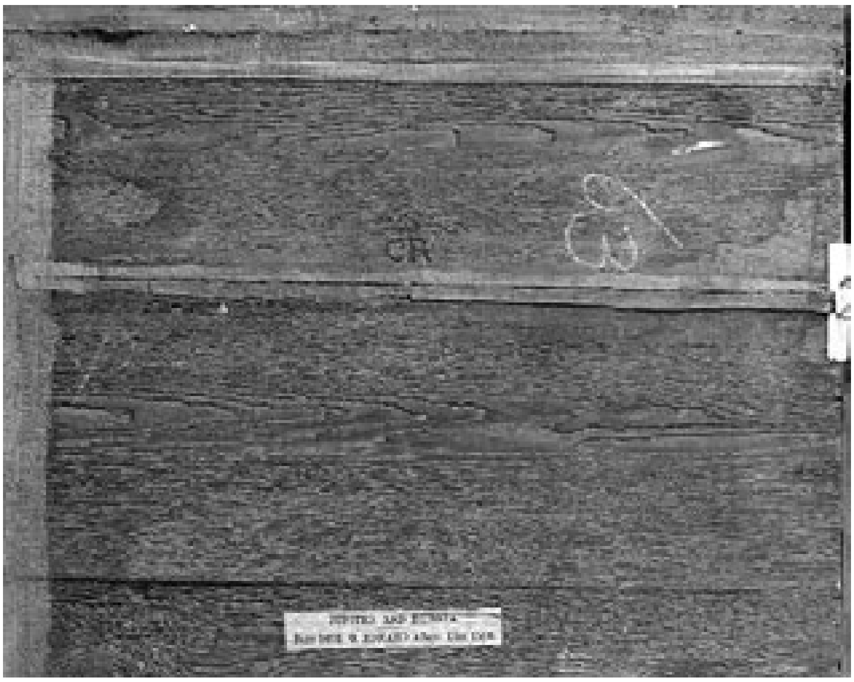

Figure 9
Follower of Giulio Romano, *The Rape of Europa,* reverse.

painting been considered of first quality, this complicated panel construction would have received major panel work: it would perhaps have been thinned and placed on a latticework, as was a posthumous double portrait of Sir Philip Sidney and his sister, attributed to Daniel Mytens, which was thinned to an overall thickness of 3 mm (Figs. 10, 11). The latticework may be datable to the early eighteenth century and is very probably English. Later, had the Romano panel received attention in the nineteenth century, it would have been thinned, flattened with moisture, and cradled—and it would have subsequently developed more splits after the cradle seized.

Figure 10
Daniel Mytens (attrib.), *Sir Philip Sidney and His Sister,* ca. 1620. Oil on panel, 46 × 66 cm. The condition before treatment is shown. Private collection.

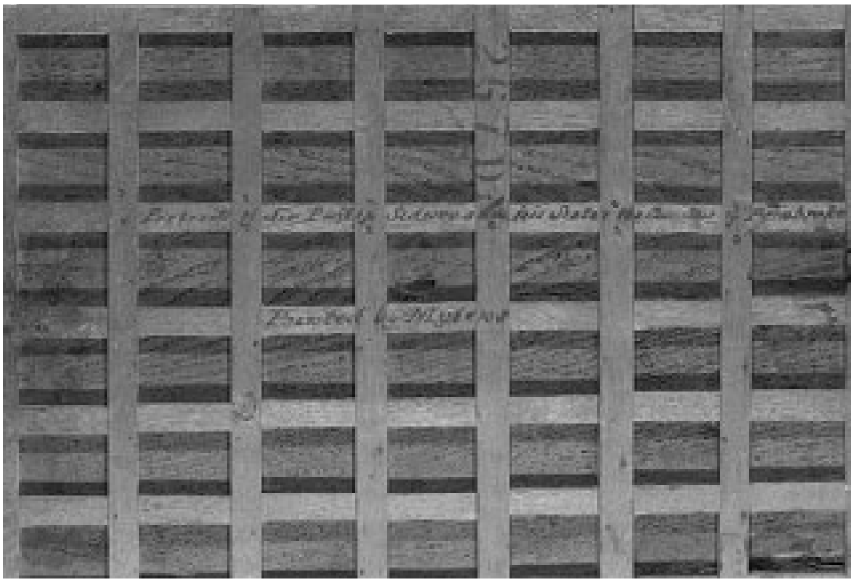

Figure 11
Daniel Mytens (attrib.), *Sir Philip Sidney and His Sister,* reverse.

The van der Doort inventory also gives a list of fifteen paintings recently repaired.[9] Van der Doort never spoke English well, and his notes seem to be phonetic renditions of his Flemish accent; among the problems treated were extensive flaking, blistering, splitting of the support (Holbein's portrait of Thomas More was described as "dikat" [decayed]), flaking due to "woreting" (presumably woodworm damage), warping, and cracking from being placed in a warm room.[10] Here the panel, a *Sacra Conversazione* by Giacomo Palma Vecchio, was affixed to another oak board, in which state it remains today (Figs. 12, 13).[11] Van der Doort also mentions restoration and said that works thought to be beyond repair had been restored.[12] In another note attached to a list of "34 pictures which are remaining in Nonsuch House this of March 1639," van der Doort noted that Mr. Sorffijor broke a little piece off a "jong brugel." Mr. Sorffijer promised to restore it.

Figure 12
Giacomo Palma Vecchio, *Sacra Conversazione*. Oil on panel, 60 × 81.1 cm. Royal Collection (181).

Figure 13
Giacomo Palma Vecchio, *Sacra Conversazione,* reverse.

When van der Doort mentioned the defacement of *The Rape of Europa* by quicksilver, he was referring to the damage to the paintings brought from Mantua by sea. The paintings were blackened when a cargo of currants fermented beside a cargo of mercury (by some process about which we can only speculate). De Mayerne, the physician to James I and later to the queen of Charles I, Henrietta Maria, suggested methods of cleaning. Jerome Lanier, the restorer brother of Nicholas, had success in cleaning the oil paintings but had less success with tempera panels.[13]

Some 225 years later, Richard Redgrave set himself the task of making an inventory of the paintings in the Royal Collection, which had steadily increased after a portion of the collection of Charles I, which was dispersed during the Commonwealth, was bought back after the Restoration (Millar

1988:86–92). Redgrave proposed that a catalogue be compiled, with a description and photograph of each painting. He started the project in 1858 and covered the pictures at Windsor, Buckingham Palace, and Hampton Court, completing his task in 1879. The catalogue sheets were specially designed and were updated by Redgrave and his successors.

The inventory survives to this day. The photographs are still legible. A small panel from Hampton Court of *Jupiter and Io,* attributed to Lucas de Heere, is recorded as having "the middle joint broken and ill-formed" (Fig. 14). The picture was examined in April 1869, and under the heading "State of the picture at the above date" is written, "wants atten-

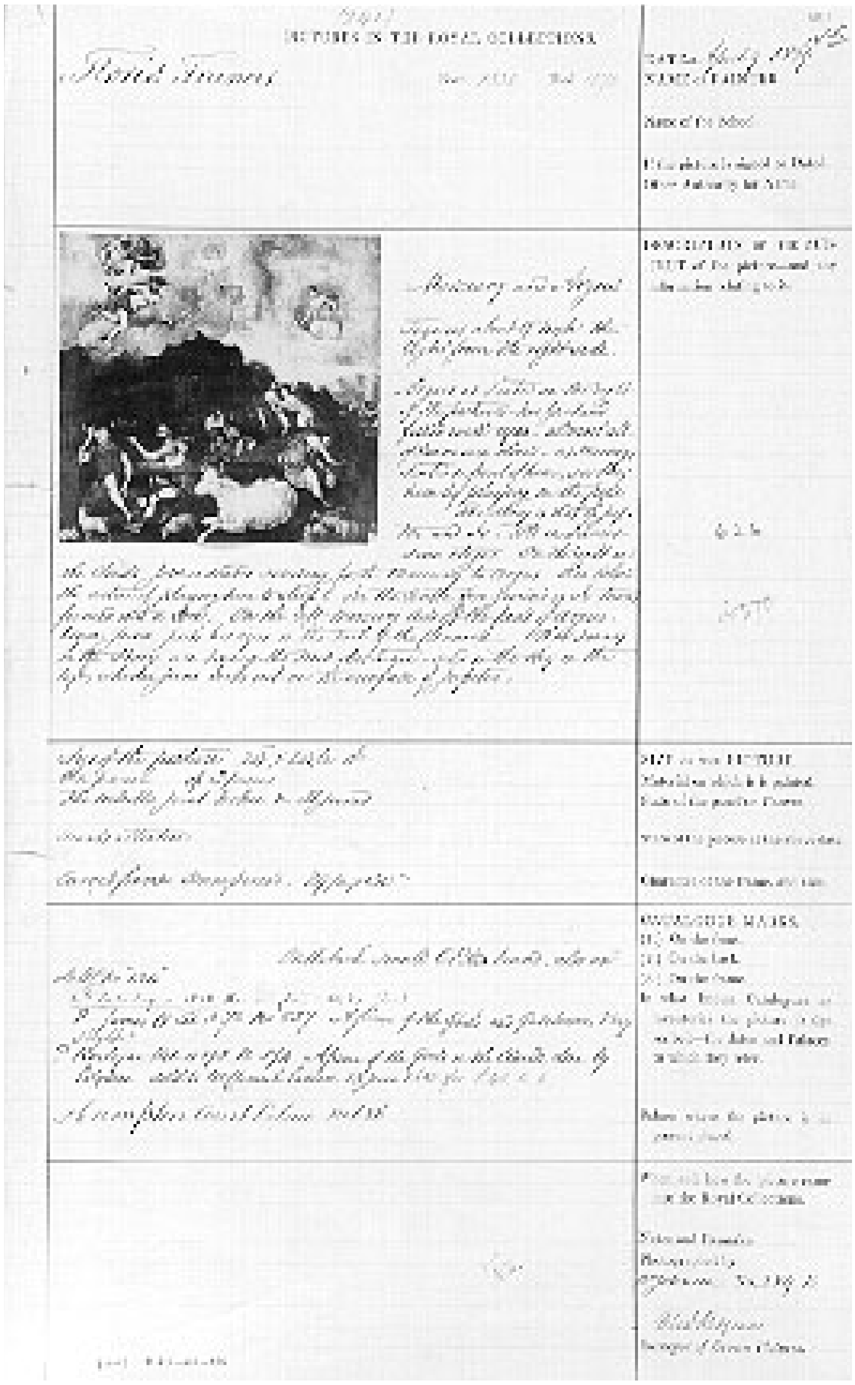

Figure 14
Redgrave Inventory, entry for *Jupiter and Io,* now attributed to Lucas de Heere. Royal Collection.

tion." Redgrave was able to obtain an annual sum for conservation and to plan programs of conservation. Other entries describe more extensive work. The sheet made in 1868 for Rubens's *Assumption of the Virgin* includes a photograph that shows the panel joins very prominently, as well as a split on the left side (Fig. 15). Redgrave notes that the panel has now been "carefully parqueted to keep together the 4 pieces sound." The careful parqueting of Rubens's *Farm at Lachen* (Royal Collection, Hampton Court Palace), recorded in March 1861, did not last, as the panel was treated for blistering in 1901, 1950, 1963, 1964, and 1975.

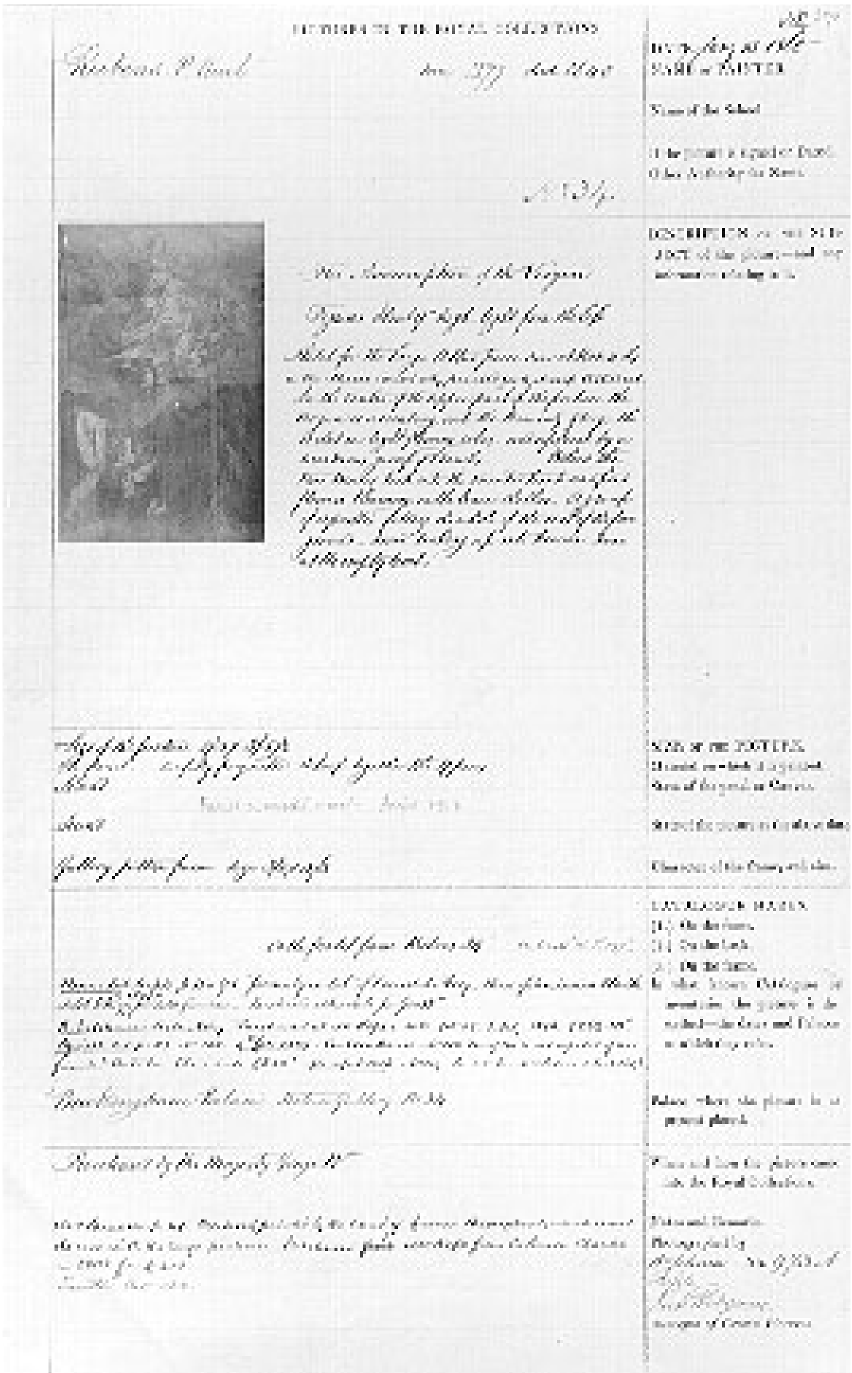

Figure 15
Redgrave Inventory, entry for Rubens's *Assumption of the Virgin*. Royal Collection.

Redgrave had most of the conservation work carried out by particular restorers. Morrills of Duck Lane submitted accounts for work from 1863, largely for lining and parqueting. The firm continued to work for the collection well into the twentieth century, recommending cradling as late as 1946. The company continued in trade until 1981. In the nineteenth century it had a wide practice and worked for the National Gallery as well as for private collections. The firm regularly stamped its cradles and favored quite radical thinning of a panel before the cradle was applied. The glued members often vary in width to cover splits and disjoins. Redgrave also employed restorers to treat the fronts of the paintings, as he was the first surveyor who didn't work on the paintings himself, although he was an artist of considerable talent (Millar 1977:189).

Redgrave also employed as a restorer Henry Merritt, who published a book on restoration in 1854 entitled *Dirt and Pictures Separated*. Although he briefly discusses the transfer of panel paintings, citing *The Raising of Lazarus* by Sebastiano del Piombo in the National Gallery, London, he is chiefly concerned with distancing the professional restorer from the "professors of picture-restoration . . . numerous in London, familiarly known by the sign hung out at their doors; generally, an old portrait, one half clean, the other half dirty, as a specimen to convince the unwary connoisseur that the proprietor of the shop can restore pictures" (Merritt 1954:64–65). The publication of this book coincided with the publication in 1850 and 1853 of the reports of select committees appointed to inquire into the management of the National Gallery. William Seguier, first keeper of the National Gallery beginning in 1824, had also worked as a restorer for the prince regent and had been appointed surveyor, cleaner, and repairer of the King's Pictures in 1820. His work on the National Collection passed without comment. However, the work done in 1852 by his younger brother John provoked criticism. While the evidence gathered by the committees is of great importance in displaying the widely differing views on cleaning and the terrible climatic conditions within the galleries, structural work is hardly mentioned (Bromelle 1956:186–87; Anderson 1990:3–7). Charles Eastlake, the Gallery's first director, recommended Francis Leedham as a skillful panel repairer. William Morrill took over Leedham's studio in 1861. Eastlake avoided controversy by having purchases in Italy cleaned and restored before importing them, often employing the creative talents of Molteni in Milan (Anderson 1990:6). Merritt worked on *The Incredulity of Saint Thomas* by Cima da Conegliano when it arrived at the National Gallery in 1870, but only removed varnish under the supervision of Eastlake's successor as director, William Boxall (Wyld and Dunkerton 1985:42). He worked with the artist George Richmond on the restoration of the portrait of Richard II in Westminster Abbey in 1866. They were observed by George Scharf, who had access to their reports on the progress of the work—"an elaborate daily record of operations kept by Mr. Merritt" (Scharf 1867). Unfortunately, these do not appear to have survived. The panel itself required little work: "The picture is painted on oak, composed of six planks joined vertically, but so admirably bound together as to appear one solid mass" (Scharf 1867:28). Merritt and Richmond removed layers of what was undoubtedly overpaint and, more controversially, removed the raised diaper pattern in the background, which they considered a later addition (it was, in fact, original). However, "a square piece of the diaper pattern in relief has been intentionally left undisturbed in the upper left-hand corner" (Scharf 1867:37).

While this account of the treatment of the portrait has a contemporary feel, restorers in Britain continued to work in an independent yet subservient tradition. Even as late as 1949, the restorer Johann Hell worked for two days in Cambridge cleaning the Fitzwilliam Museum's *Man in Fanciful Costume,* then thought to be by Rembrandt, supervised by the director of his office. The Conservation Department of the National Gallery was not established until 1947 (Bomford 1978:3–10). In 1917 Margaret Talbot Jackson still described cradling as a sound technique and decried as old-fashioned the use of fixed steel bars as battens (Jackson 1917:115–16). By 1933, however, reports in professional journals had created an increased awareness of advances in conservation practice. In that year, Plenderlieth published in the *Museums Journal* a report on the conference in Rome on the examination and preservation of works of art, held under the auspices of the League of Nations.[14] Different methods of transfer are discussed. Methods of facing are reported. Cradling is discussed critically and the edge-on type of cradle reported by Helmut Ruhemann supported. Professor A. P. Laurie contributed a discussion on the warping of panels; he recommended sealing the back and end grain of a panel to slow its response to changes in relative humidity, a topic that still occupies us today.

Acknowledgments

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Notes

1 See Millar 1977. There are many references to picture restorers and their work on the collection.

2 See Lillie 1932:pt. 2:4. For a description of the construction of the retable and its altar frontal, now in the Cluny Museum, Paris, see Norton, Park, and Binski 1987.

3 See Mogford ca. 1865: appendix, catalogue of Winsor and Newton. The catalogue advertises prepared panels ranging from 8 × 6 in. to 36 × 28 in. (20.3 × 15.2 cm to 91.4 × 71.2 cm). Mogford recommends "panels of well-seasoned mahogany . . . prepared with exceedingly firm and smooth grounds, for works requiring great detail and finish) (p. 16). The text is datable to approximately 1865, as Mogford describes the pigment aureolin (cobalt yellow) as among "the latest and most important contributions of science to the Artist's palette" (p. 15). Winsor and Newton introduced the pigment in 1861.

4 Quoted from *Read's Weekly Journal,* 15 July 1732, in Beard 1970:492.

5 Millar 1960, Bodleian Library, Oxford, MS Ashmole 1514.

6 Millar 1960:fol. 19.

7 Shearman 1983. Catalogued as workshop.

8 Shearman 1983, cat. 131:132. Catalogued as follower.

9 Millar 1960:191: “alta piturs dat er mended auff lat dat wer [extremely?] spijl and pilt auff vrom de bord and wor et and roten so dat auff som War but left te bord Was most all tu bi taken awar als ju M partlij knowes” (Bodleian Library, Oxford, MS Ashmole 1514, fol. 193).

10 Shearman 1983, cat. 181:178; Millar 1960:191: “[auff standing in a Warm rom?] itm da pis auff our ladi auff old palmo Wraff de bord Was Warp and Krack and Woren tin and muz [out of?] fram Was set opan a new streng bord terfor and in guldit new fram terfor 3 pant.”

11 Shearman (1983, cat. 181:179–80) records that the original panel, measuring 60 × 81.1 cm, was thinned to 0.4 cm. The oak panel affixed to the back measured approximately 0.7 cm.

12 Millar 1960:191: “item de [excellent?] Womans had inde kabinet auff beling Wij Was holij rint and pilt auff in a manner als if Eij taught it to hauff bin posibel tu bi mendis terfor 4 pant.”

13 See Trevor-Roper 1993:277; Talley (1981:203) quotes Symonds’s account of Lanier’s experiences of cleaning these paintings.

14 Plenderlieth 1933. The conference papers were published in *Mouseion* (1931) 15:13–16.

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The Conservation-Restoration of Wooden Painting Supports

Evolution of Methods and Current Research in the Service de Restauration des Musées de France

Jacqueline Bret, Daniel Jaunard, and Patrick Mandron

Since the 1966 campaign to restore the Italian primitives of the Campana Collection in the Musée du Petit-Palais in Avignon (see Bergeon et al., "Two Hundred Years of History in France," herein), several factors have influenced the evolution of the restoration of wooden supports in the Service de Restauration des Musées de France.[1]

Research

In the wake of the 1978 Oxford congress of the International Institute for the Conservation of Historic and Artistic Works, several studies were carried out jointly with the Centre Technique du Bois (CTB) during the 1980s to test and improve restoration methods.[2] An initial study focused on the behavior of experimental oak boards,[3] which were painted on one or both sides according to a technique of the masters[4] and subjected to artificial aging in a climate-controlled room.[5] Systematic testing was conducted to determine if the way the wood was sawn had an influence on its behavior when it was submitted to an alternation of wet and dry cycles; results confirmed that panels painted on both sides remained stable under variations of relative humidity (RH), whereas panels painted on one side only showed distortions and, moreover, retained some residual distortions throughout the entire sequence of cycles.[6]

These results led to the search for a product with a degree of permeability close to that of the paint layer but that would also be transparent, reversible, and applicable as a backing. A coating composed of a layer of gelatin and two sheets of Saran[7] proved to be most effective, but this isolated result has thus far not been extended into practical application.

The next study involved simulated repairs of cracks by the insertion of triangular-section pieces, according to a technique developed at the Istituto Centrale del Restauro in Rome. Some thirty test samples[8] were submitted to accelerated aging,[9] and the best results—little distortion, no splits or cracks—were obtained when the groove was shallow and at a 90° angle, and the inlay was made of wood cut on the quarter.

Another study tested two methods for backing severely thinned-down panels[10]—one with two superimposed layers of balsa-wood rectangles, the other with two layers of cork held rigid by an inert material.[11] After artificial aging, the cork-backed panel showed considerable distortion, whereas the balsa-backed panel remained flat. The balsa backing was therefore recommended; the last study of the behavior of experimental reinforced painted panels confirmed the validity of this option.

Restorations of the Last Twenty-Five Years

Data obtained from the observation of restorations done in recent years—involving supports as well as reinforcement systems—have enhanced understanding of the behavior of material when it is confronted with the various constraints caused by these interventions.

Such considerations are particularly interesting because the restorations in question were carried out on a large number of paintings from various periods and schools and, moreover, involved works marked by a long tradition of restoration, with its modifications, amputations, and, at times, complete elimination of the support.

Development of Preventive Conservation

In the museum world in recent years, an increased awareness of the importance of the conditions of conservation, particularly of works painted on wood, has allowed the staff of the Service de Restauration des Musées de France to design more minimal interventions and thus to respond better to the essential notion of respect for the integrity of the work.

The combination of the three factors mentioned above—research, observation of recent restorations, and the development of preventive conservation—has led the staff to develop a more rigorous protocol for the approach, the execution, and the follow-up of each particular case, with an endeavor to be as little interventionist as possible.

Once a scientific file has been assembled, the first choice to be made by the responsible conservators is whether to take simple conservation measures by acting on the environment (indirect action) or to restore the support by an intervention on the material itself (direct action), a process sometimes completed by the addition of a reinforcement system. Conservation interventions by direct action are described below; they are presented in chronological order for the sake of clarity.

Fungicide and Insecticide Treatments

The very first intervention, to be carried out before any actual restoration procedure, must aim at restoring the soundness of the material by halting insect attack and invasion by microorganisms, thus eliminating further risk of contamination. The remedial effectiveness of the means used will depend on the product penetrating evenly and thoroughly into the panel, which, in turn, depends on the accessibility of the areas to be treated; good preventive results will be achieved if the treatment is rigorously applied to all unpainted surfaces.

The presence of a paint layer limits the choice of fungicide and insecticide products that can safely be employed. Because of its high toxicity, lindane[12] is no longer used as an insecticide. Instead, such active agents as cypermethrine[13] in a heptane solution are brushed on, injected, or sometimes sprayed on. Nitrogen gas treatment is now beginning to be tested against xylophagous insects.[14] Mildewed paintings are carefully vacuumed, the dust being drawn through a biological filter (Cortet 1988); they are then placed in a controlled climate. After strain identification, fungi infestations are treated with the appropriate fungicide.

Repairs to Supports

It is important to keep in mind that a preliminary treatment of the paint layer is necessary when repairs must be made to the support. This treatment allows control of the cohesion and adhesion of the paint layer, as well as facilitating effective elimination of fillings and overpaintings.

Figure 1
School of Novgorod, *Crucifixion,* sixteenth century. Reverse. Tempera on panel, 71.2 × 57.3 cm. Louvre Museum, Paris. Detail of the reverse of an icon, showing readjustment of the inlaid crosspiece after shaping.

Conservation or removal of reinforcements on the reverse of the panel

The original reinforcing elements (Marette 1961), such as nailed crosspieces, are usually left in place; they are removed only if severe deterioration affects the front of the panel. Inlaid crosspieces that are blocked are made mobile again or, if necessary, shaped according to the curvature of the panel, as was done with an icon in the Louvre Museum (Fig. 1).

In cases of significant deterioration, original cross-grain elements such as rabbet joints or decorative elements applied to the front are rendered mobile and left attached to the support.

If reinforcing elements have been modified, or if some have been added—as, for instance, a cradle—the conservators try to loosen the panel to permit free movement again.

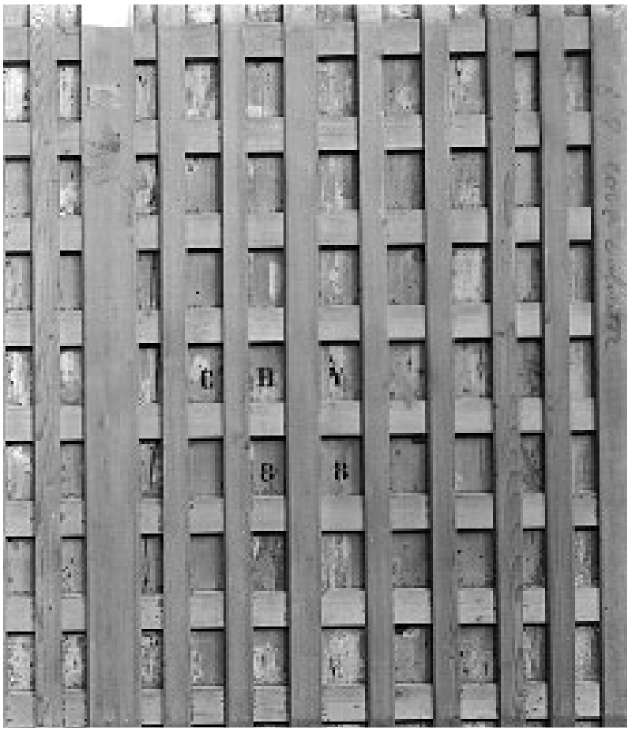
If the front of the panel shows significant deterioration, the elements applied to the reverse are removed, either completely or, if it is sufficient for treatment, partially. Such was the case with a painting in the Musée Condé in Chantilly, France, where only two vertical uprights were removed and changed to allow the treatment of joints and fractures (Fig. 2a, b).

Treatment of Fractures and Joints That Cannot Be Separated

Depending on the configuration of fractures or openings of joints that are sometimes accompanied by distortions, interventions can be carried out by means of simple gluings, which can sometimes be reinforced by V-shaped grooves and wooden inlays. The conservators try to keep the angle of the groove to a minimum, despite the results of the CTB study. This seems more suitable to the actual cases we encounter, and it also results in the least possible elimination of original wood. With the same concern for the preservation of the support, the V-shaped grooves are made only at the two extremities of the joint, as daily observation has shown that splits start more often at the ends of a board—rarely at the center.

The tip of the incision is in the axis of the fracture, and it usually reaches a depth of about two-thirds the thickness of the panel. The wood used for the inlay is always one whose density is equal to or less than that of the original material; it is sawn on the quarter and cut at regular intervals to limit tensions.

When, because of significant wood shrinkage, the two edges of a fracture are too far apart and can no longer be joined, a sliver of wood of the same species is cut to size and inserted into the fracture. It is glued along both sides to ensure renewed cohesion. When the joints cannot be separated because of the complexity of their assembly, and the gap between the two pieces is frontally visible and, therefore, aesthetically disturbing, the sliver inserted is glued on one side only; this procedure allows a reduction of the gap between the boards while preserving a clear reading of the structure, and maintains the free play of the wood necessary to prevent new fractures.



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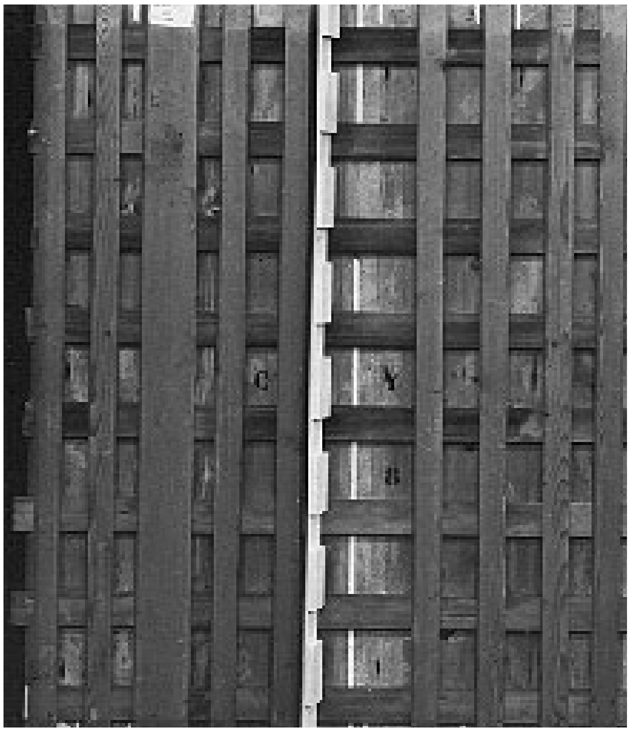


b

Treatment of Fractures and Joints That Can Be Separated

Figure 2a, b, above
Salvatore Rosa, *Christ Resuscitated,* eighteenth century. Reverse. Oil on panel, 109 × 96 cm. Musée Condé, Chantilly, France. A heavy cradle (a) that required partial removal of elements. During the process (b), a new vertical upright is shown before being placed.

For joints whose original assemblies still exist with no deterioration of their support but which have come apart because the adhesive has deteriorated, a simple regluing after preliminary cleaning is indicated; such gluing is also desirable in the case of simple fractures.

However, in treating joints and fractures that affect large or severely and unevenly distorted boards, it may be necessary to resort to inserting false tenons (Fig. 3).[15] In fact, the two flat surfaces presented by the upper and lower parts of the false tenon allow, when the edges are adjusted, a compensation for the difference in level between the two edges of the split; this is done by the application of a piece of wood of corresponding thickness to one of the false tenon's surfaces. Additionally, this technique provides good visibility of the work and easy access to the joints at the time of gluing, by reducing the need for clamps and other clamping devices. This method, which the staff of the Service de Restauration has used for a long time, has recently evolved toward a reduction in the size

Figure 3
Jean de Saint-Igny, *Adoration of the Magi,* seventeenth century. Oil on panel, 57.5 × 45.7 cm. Musée des Beaux-Arts, Dunkerque, France. Reassembly with false tenons of the central joint of a panel painting.

of the false tenons—and, hence, of the mortises made in the original supports as well.

Over the centuries, certain original joint assemblies, because of technical developments such as pegged false tenons and tongue-and-groove joints, have caused serious alterations to the paint layer. In such cases, their readjustment or modification seems necessary when the joint is repaired. Thus, for example, in the case of pegged false tenons, where the pegs generate splits, the staff removes some of those pieces, working from the back of the panel. This procedure eliminates the constraints caused by the initially blocking joint and allows the false tenons to move in the mortises when the wood undergoes dimensional changes.

Reestablishing the Panel's Structural Cohesion

Sometimes there is a need to first consolidate the structure of a wood badly weakened by various assaults. This brings up the problem of choosing a consolidant (taking into account its viscosity, reversibility, and aging properties) as well as the problem of finding a method of treatment aimed at preventing an overly heterogeneous consolidation that would cause areas of different rheological behavior to develop.

Consolidation is currently achieved with an acrylic resin, Paraloid B72, usually dissolved in toluene and usually applied by injection, brushing, or, should the panel so permit, by capillarity. Since, given the present state of knowledge, it is not always possible to diagnose the extent and effectiveness of the treatment, it is important to limit as far as possible the penetration of the consolidant into the material—especially considering that its reversibility is not total. It would be very interesting, in the future, to be able to measure the product's degree of penetration and its cohesive strength inside the work.

Accidental lacunae in the wood are filled with a material chosen according to several criteria: the state of conservation of the support, the localization of the lacunae, their influence on the structure, and their aesthetic impact.

Small lacunae are filled with an emulsion of polyvinyl acetate in 50% water mixed with sawdust or mechanically reversible Master Model Paste.[16] A large lacuna—after precise measuring and cutting that carefully respects the integrity of the work—is generally filled with a piece of wood of the same grain and species, inserted at a slightly lower level than the original wood. For severely worm-eaten panels whose density has been reduced considerably by insect tunneling or for areas not requiring any special mechanical property, the staff prefers to use balsa wood. And for very weak, seriously thinned-down panels, structural cohesion is reestablished by backing of their surfaces.

A specific restoration problem was posed by nineteenth-century works painted on supports that were composed of several strata of wood artificially held together. The best-known example was developed in 1845 by Tachet; he devised a method of gluing three crossed sheets with shellac, which was sprayed on and then heat sealed in order to reduce the wood's movement. However, with time, the glue weakened, the support loosened, and cracks appeared on the paint layer. The restoration method that has been developed to address such supports attempts to reconcile the necessities for recovering cohesion of the support, maintaining reversibility, and preserving the work's aesthetic appeal. It consists of replacing the thick central core with a thin sheet of plywood[17] and an interlayer of balsa, then regluing the painted wood on the front and the wood of the back on the reverse, so as to preserve intact the work's appearance, as was done for the *Study of Hands* by Jean-Auguste-Dominique Ingres at the Louvre Museum (Fig. 4a–d).

Present-Day Maintenance Systems

The elaboration and application of added reinforcements to the reverse of certain panels was made necessary by the gradual lessening of the initial support's mechanical properties, owing to centuries of drastic interventions.

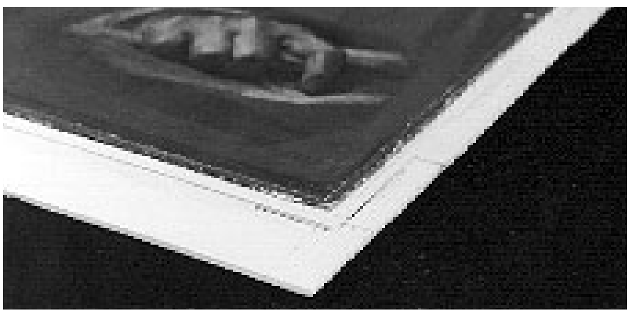
Until recently most maintenance systems required thinning down of the panel and leveling of the reverse to allow the positioning of a set of planed-down and sometimes sliding wooden pieces, such as a cradle. These interventions were meant to respond to the two priorities of straightening and flattening of the panel, but they did not take into account the fact that the wood becomes more reactive as a result of being thinned down and that, moreover, the thinning of the panel destroyed the precious information on the original reverse.

The systems elaborated in recent years perform the sole function of maintenance in "supervised freedom"; to do so they must respond to two contradictory requirements: first, they must provide support sufficient to slow and limit the play of the wood, and, second, they must provide support limited enough so as not to constrain the wood and risk the formation of splits. Moreover, they must respect the existing reinforcement by adapting to its unevenness while reducing the surfaces that are glued or

Figure 4a–d
Jean-Auguste-Dominique Ingres, *A Study of Hands,* nineteenth century. Oil on panel, 33 × 30.9 cm. Louvre Museum, Paris. Before restoration, the support had separated into three layers (a). This type of support was developed by Tachet, whose patent stamp is still visible (b). During the work (c), the painted sheet, plywood, and balsa are stacked; the reverse view (d) shows the back layer and the balsa layer.

a

b



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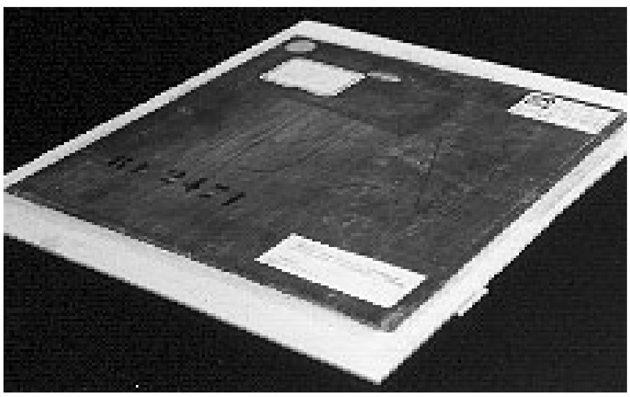

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that rub against each other. Last, their mechanisms must not be too complex for simple maintenance.

Three types of maintenance systems have been developed for application to the reverse of panels. They are (1) reinforcement systems that replace original elements on the reverse of panels, (2) maintenance systems that offset significant loss of cohesion of original supports, and (3) backing systems that consolidate overly thinned supports.

Reinforcement systems that replace original elements on the reverse of panels

These systems are used in cases where there is no risk that the weight or tension they exert could deform the support—that is, they are designed for supports that are sufficiently sturdy or structured. The most widely used system of reinforcement involves sliding crosspieces, or runners. Adapted to the curve of the panel, they are composed of pieces of mahogany fitted on both edges with U-shaped metallic bands into which slide Teflon or brass rollers attached to wooden cleats that are themselves glued to the original panel in the direction of the grain. The current trend is toward reducing the thickness of these crosspieces in order to make the whole construction lighter and more flexible.

Maintenance systems that offset significant loss of cohesion of original supports

These systems are used on panels whose structure is fragile because of their thinness or because of severely deteriorated areas. They are based on a perimetric maintenance of the object, either by fitting of the frame with a rabbet into which the painting will be positioned or by the assembly of such structures as the *châssis-cadre,* a modern version of the grooved structures into which the panels of the Nordic schools of the fifteenth and sixteenth centuries were imbedded and which surprise us still by their quality of conservation. Such a system is composed of a fitted wooden frame to which is screwed an L-shaped brass cornice that reinforces the perimeter of the painting (Fig. 5a, b); enough space is left to allow for expansion and retraction of the wood. It should be noted that the panel does not support the weight of the châssis-cadre. For large panels this system can be combined with sliding runners attached to the frame.

The current trend in stretcher-frame fabrication is toward enhanced flexibility and capacity to follow the dimensional variations of the panels. First, to lighten it, the frame is hollowed out slightly with a cylindrical bit. Insertion of a system of springs into some of the cavities thus created enables the panel to move in three directions, rather than exclusively in a line. The same result is obtained by replacing the frame's sliding runners with plain perforated crosspieces connected to the support by means of cleats equipped with springs (Figs. 5a, 6a, b); this also reduces the mechanical leverage effects produced by the traditional lateral arrangement of cleats with rollers. The L-shaped metal cornices are made somewhat less rigid by evenly spaced sections cut into the narrow side that is screwed onto the frame (Fig. 5b). Finally, to reduce friction, the inside faces of the frame are lined with Teflon.

In certain cases it will be necessary to replace the wooden frame with a sheet of Altuglass to allow an unobstructed reading of the two


a

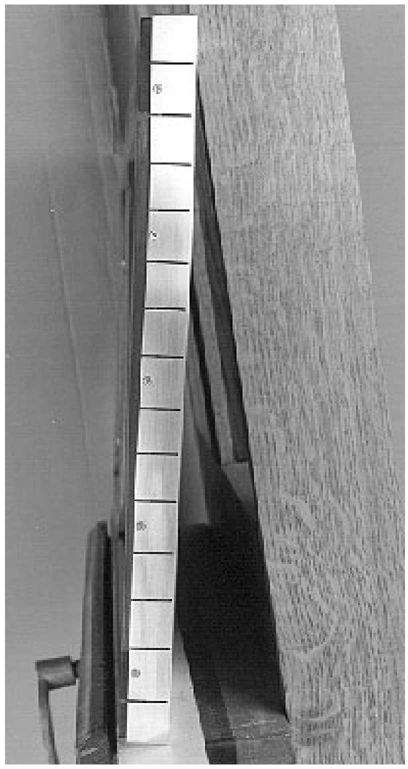
b

Figure 5a, b
Cosmè Tura, *Saint James the Great,* fifteenth century. Tempera on panel, 75.1 × 40.9 cm. Musée des Beaux-Arts, Caen, France. The reverse (a) shows the panel in a châssis-cadre with a central support; the side view (b) of the cornice shows that it is sawn at regular intervals.

faces of a panel. This system, called mobile backing, is also used for extremely fragile supports.

Currently the Service de Restauration is making less use of the châssis-cadre in favor of a specific rabbet arrangement for the frame. A structure specifically adapted to the curvature of the panel, usually made of balsa wood lined with Teflon and with flexible attachments, allows simple and effective maintenance of the perimeter (Fig. 7a–c).

Since few museums in France are climate controlled, and RH can vary considerably throughout the year, treatment can be completed by the use of a microclimate box that is secured to the back of the frame; the box


a

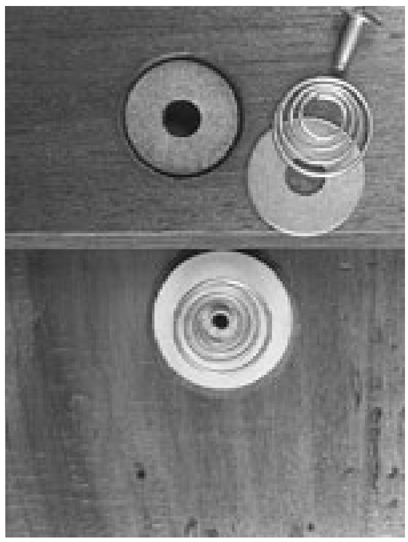
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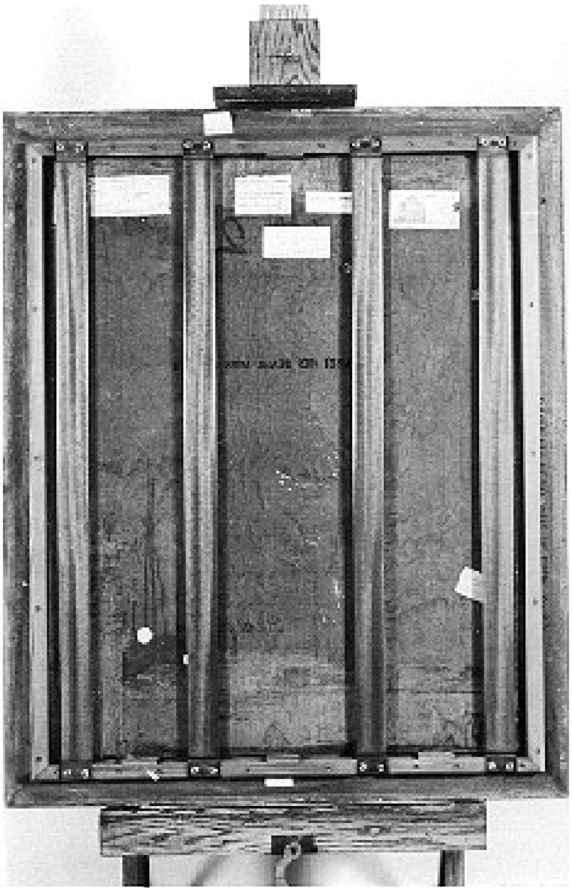
Figure 6a, b
Cosmè Tura, *Saint James the Great,* reverse. Two cleats that connect to the crosspiece are shown (a); the detail (b) shows a cleat with its double-spring support system.



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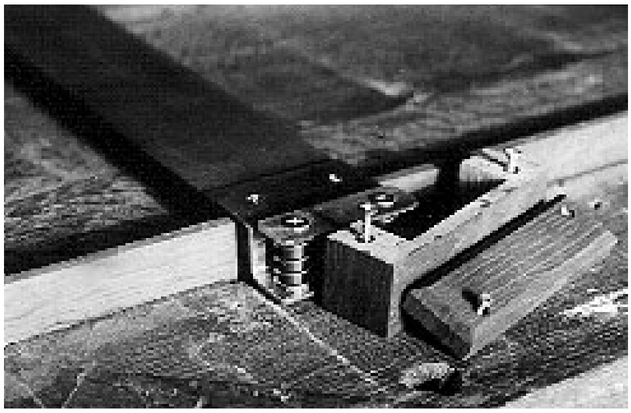

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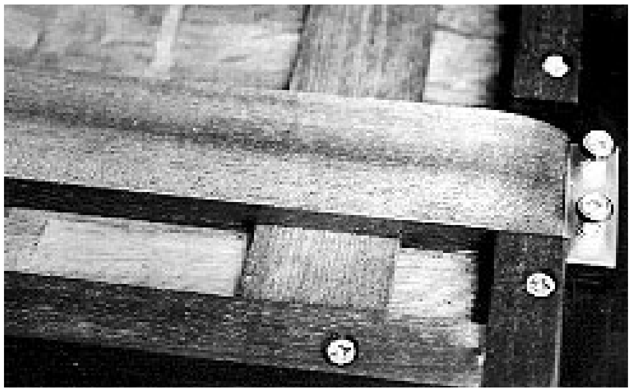


c

Figure 7a–c
Frans Floris, *Portrait of an Old Woman,* sixteenth century. Reverse. Oil on panel, 107.7 × 83.4 cm. Musée des Beaux-Arts, Caen, France. The panel is positioned in its frame (a), maintained by crosspieces fitted with compensatory springs. Two other panels (b, c) have different kinds of compensatory mechanisms with springs.

considerably limits the risks of hygrometric shock and, additionally, allows the work to move.[18] These boxes are particularly suitable for panels that, because of the nature of their wood or because of the deteriorations they have undergone, are very fragile and reactive.

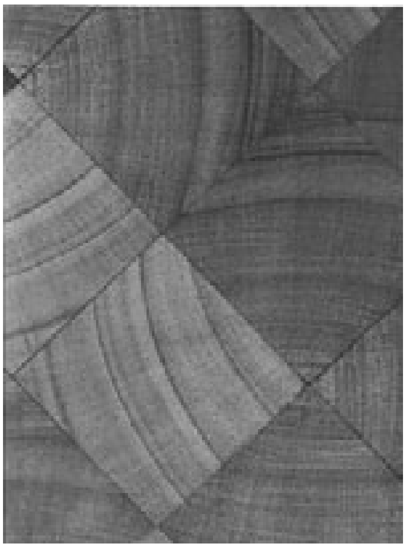
Backing systems that consolidate overly thinned supports

These systems are intended to restore enough cohesion and solidity to the work to make possible safe handling and display. The maintenance systems described above are not appropriate for severely thinned panels, as they require specific fixings not feasible with heavily deteriorated works. The more homogeneous distribution of mechanical stresses obtained by gluing a support system on the whole of the surface was a consideration that led the Service de Restauration to develop a number of backing methods.

Materials such as inert honeycombed panels will be used as replacement supports for the remounting of previously transferred panels, as the rigidity of their honeycombed structure prevents any possible movement of the material (Bergeon 1990:77, n. 10).

The use of square or hexagonal balsa elements cut along or across the grain and adhered with wax-resin seems a fitting temporary solution in certain cases (Fig. 8a, b). The low permeability of its cell walls as well as its low density give balsa wood a stable structure with a flexibility that enables it to absorb some of the stresses exerted by the panel. The use of wax-resin ensures rapid and total reversibility. Application of this tech-

Figure 8a, b
Reverse of panel painting (a) with a backing made of square balsa blocks cut along the grain (Lucas Cranach the Elder, *Saint Peter,* sixteenth century; oil on panel, 113 × 54 cm; Louvre Museum, Paris). Another panel (b) has a backing made of hexagonal balsa blocks, cut along the grain (Peter Neefs the Elder, *Cathedral of Antwerp, Interior View,* seventeenth century; oil on panel, 62 × 102 cm; Musée des Beaux-Arts, Grenoble, France).



a

b

nique was carried out in close collaboration with the Institut Royal du Patrimoine Artistique, Brussels (Glatigny 1990; see also Glatigny, "Backings of Painted Panels," herein).

Conclusion

The authors hope to have shown in this account that the Service de Restauration des Musées de France, heir to a long tradition of restoration of wooden supports of paintings, continues to explore working methods tending toward minimal intervention as well as use of lighter support systems.

Because of the highly specific nature of the material and the added complexity due to a paint layer, panel paintings must be restored by specialists who, through their daily contact with old techniques and earlier restorations, have acquired a deep awareness of the repercussions their interventions may have in the future.

In recent years, research on the treatment of wooden supports has shown a need for close collaboration between practitioners of various disciplines—curators and scientists—who should join forces to design a new approach to conservation. This approach seeks to emphasize treatment of the causes of deterioration and, in turn, assumes both a thorough knowledge of the material itself and a clear understanding of the material's environment: when the condition of the work is weighed against the treatment it requires, we are still facing the need to compromise between the benefits of the treatment and the drawbacks that intervention may entail.

Considerable research remains to be done, in particular regarding very thinned-down panels as well as disinfection and consolidation products and treatments, in order to improve their effectiveness and reversibility. There is, therefore, an urgent need for the kind of international collaboration that can improve our understanding and lead to the resolution of these problems.

Acknowledgments

The authors would paricularly like to thank France Dijoud, who was kind enough to read over this article; they would also like to extend their gratitude to Sophie Le Guischer for her help.

Notes

1 The Service de Restauration des Musées de France, currently under the direction of chief curators France Dijoud and Nathalie Volle, is the result of the merging in 1993 of the Service de Restauration des Musées Nationaux and the Service de Restauration des Musées Classés et Contrôlés (the state-controlled museums' conservation department). Its function is to restore the collections of the museums of France; work is performed in the studios of the Petite Ecurie du Roy at Versailles, in the workshop of the Louvre Museum, and in specialized regional workshops.

2 These studies were initiated by chief curator René Guilly, who was then in charge of the Service de Restauration des Musées Classés et Contrôlés, with the collaboration of France Dijoud; the studies were carried out by Jean de Leeuw, who was in charge of research at the CTB.

3 Twelve panels, 800 × 900 × 8 mm thick, composed of four to eight boards sawn in different ways.

4 A layer of sizing (a solution of 10% rabbit-skin glue in water); eight layers of ground (*blanc de meudon* [natural calcium carbonate] and rabbit-skin glue); one layer of yellow ochre diluted with turpentine; one final layer of Rembrandt varnish.

5 Originally, the twelve sample panels were placed for forty-nine days at 25 °C and 30% RH, then for thirty-six days at 25 °C and 65% RH. Next, four panels representative of the twelve were subjected to five seven-day cycles of aging at 25 °C and 30% RH, then seven days at 25 °C and 65% RH; they were then stabilized for thirty-six days at 25 °C and 30% RH. During these two periods, the masses, widths, and cambers of the panels were systematically recorded.

6 After the five cycles of aging at 30% RH, this residual distortion was from 17 mm to 21 mm for slab-cut panels and 18 mm for panels cut on the quarter; at 65% RH it was from 5 mm to 6 mm for slab-cut panels and 1 mm for panels cut on the quarter.

7 Saran F-310, made by Dow Chemical, which is a copolymer of acrylonitril and polyvinylidene chloride.

8 Poplar, 120 mm wide with the grain of the wood, from 290 mm to 450 mm long and 45 mm thick, painted on one side with the technique described above (n. 4); the angle of the grooves was systemically varied (60° or 90°), as was their depth (the tip is at 3 mm or 13 mm from the paint layer) and the conversion of the wood of the inlays, which were glued with vinyl glue.

9 Originally the test pieces were subjected to four long cycles (twenty-eight days at 25 °C and 30% RH, twenty-eight days at 20 °C and 65% RH, twenty-one days at 25 °C and 85% RH, twenty-eight days at 25 °C and 30% RH), then four shorter cycles (fourteen days at 25 °C and 85% RH and fourteen days at 25 °C and 30% RH); the masses and the cambers were regularly recorded; visual observation was simultaneously carried out to detect ungluing, splits, and craquelures in the paint layer.

10 Thinned to 3 mm.

11 Panel F-Ciba board, composed of an aluminum honeycombed laminate faced with fiberglass impregnated with epoxy resin.

12 Hexachlorocyclohexane, a fungicide and insecticide product.

13 Synthetic pyrethrinoid. Compare Gérard 1988.

14 Supervised by Marie-Odile Kleitz, research engineer and head of the preventive conservation department.

15 Unlike the tenon, the false tenon is a piece of wood set into mortises hollowed into both edges of the boards that are to be fitted together.

16 Master Model Paste SV/HV 427, made by Ciba-Geigy; compare Grattan and Barclay 1988.

17 Two mm thick, composed of three sheets of birch.

18 The atmosphere of the microclimate box is controlled with silica gel; the box was devised by Marie-Odile Kleitz.

Materials and Suppliers

Altuglass (polymethacrylate), ElfAtochem, Group elf aquitaine, 4, cours Michelet, La Puteaux-Cedex 42, 92091, Paris La Défense, France.

Master Model Paste SV/HV 427, S.A. Ciba-Geigy, BP 308, 92506 Rueil-Malmaison Cedex, France.

Panel F-Ciba board, S.A. Ciba-Geigy.

Paraloid B72, CTS, 2, passage Thieré, 75011 Paris, France.

Saran F-310, Dow Chemical Co., Main Street, Midland, MI 48674.

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The Restoration of Wooden Painting Supports

Two Hundred Years of History in France

Ségolène Bergeon, Gilberte Emile-Mâle, Claude Huot, and Odile Baÿ

In France today, the policy governing the stabilization of wooden painting supports can be summarized by the term "supervised freedom," indicating a delicate balance between restraint and freedom.[1] The evolution of this approach can be traced through two hundred years of panel restoration, from the earliest work carried out for the Louvre in the eighteenth century to the significant recent developments that are evidenced in the work on the Campana Collection, at the Musée du Petit-Palais in Avignon. The experience of two centuries has contributed to our present approach of minimal intervention, and this experience informs the choices that are currently made with respect to panel stabilization.

The History of the Restoration of Painted Panels in France from the Eighteenth Century to 1965

While the documentary sources are rich with information, they do not shed light equally on all areas of potential interest. The two major interventive procedures—transfer and cradling—have been well documented since the eighteenth century, but there are few references to the third important operation—backing—which emerged in the nineteenth century. There is even less mention of the practices of disinfection and the consolidation of worm-eaten wood.

These interventions, as well as interventions on canvas, from the simplest and most poorly documented to the most ingenious work on very prestigious paintings, seem to have been largely the product of two major Parisian studios—the first founded in 1740 by Jean-Louis Hacquin, at 4, rue des Bourdonnais, in the First Arrondissement;[2] and the second, established in 1841 by Paul Kiewert, at 17, quai des Grands-Augustins, in the Fifth Arrondissement. Through each of these studios has passed a long line of panel and canvas restoration specialists, workshop managers, and studio owners which continues to the present day.

The studio at 4, rue des Bourdonnais, Paris: From Hacquin to Joyerot

Writing in 1779, Jean-Louis Hacquin stated that "ever since a skillful incident of lifting pictures on wood and cradling them,"[3] he decided, in 1757, to qualify as a master cabinetmaker. These words are important for two reasons: they show that prior to 1757 Hacquin had gained some experience

Translated by Barbara Harshav

in cradling and transfer and that the corporations of the Ancien Regime played a role in approving the qualifications of artisans.

After Jean-Louis died in 1783, he was succeeded by his son, François-Toussaint Hacquin (1756–1832). The elder Hacquin had earlier recommended his son to the painter Pierre, then in charge of the studio of restoration in the administration of the Bâtiments du Roi.[4] François-Toussaint may have been more a reliner than a cabinetmaker, for although he was concerned with all types of support for pictures, he apparently did not make the cradles, consigning this job to a joiner. However, he did attach the cradles to the paintings.

Was François-Toussaint Hacquin, therefore, a "cabinetmaker" like his father? He seems to have diversified his profession, and although he himself was more concerned with canvas supports, he was assisted by genuine specialists in wood. But in what precise tasks? And to what extent? There are still many uncertainties with regard to the roles of the various actors in the early restoration of wooden supports.

François-Toussaint Hacquin was succeeded by his son-in-law, Guilloux Mortemard (1794–1870),[5] who also dealt with both wooden and canvas supports. Mortemard was quite skilled at relining and transferring, and in 1832 he was to transfer onto a new wood support a picture painted by Van der Werff.[6] While he was very active between 1827 and 1832, his traces disappeared in 1836. He reappeared at the competition of the Louvre of 1848, organized by Villot; he won that contest and received orders until 1870.

The studio at 4, rue des Bourdonnais, then became Maison C. Chapuis (a reliner mentioned as advisor to the Louvre by the curator Gruyer in 1882), qualified to work on supports of either wood or canvas. The studio became Maison Henry Leguay et Brisson, Successeurs Chapuis, until 1911; Maison Brisson until 1922; Maison Leguay from 1924 to 1938–39; and, finally, Maison Trinquier et Léon Gard, Successeurs Leguay,[7] qualified in all aspects of restoration, and focused especially on wood and canvas supports. Puget, who had specialized in cradles in the Gard studio in 1924,[8] trained Ernest Cosson (1882–1947), who subsequently trained his grandson, Jacques Joyerot (b. 1930), in the restoration of supports. Joyerot worked for the Gard studio (1945–48), then for the Malesset studio (1951–57); he finally began work for the Louvre in 1962, moving to 13, rue Sedaine, Eleventh Arrondissement, Paris, in 1964; in 1980 he moved to Gagny, near Paris. This studio still works on both wood and canvas supports. Joyerot makes cradles but no longer works on wooden supports for the Louvre.

The studio at 17, quai des Grands-Augustins: From Kiewert to Rostain

In 1841 Paul Kiewert,[9] a reliner who had come to Paris from Belgium, set up shop at 17, quai des Grands-Augustins and went into partnership with the restorer Govaert. At the beginning of the twentieth century, the senior Chauffrey, a reliner, went into partnership with Govaert.[10] In 1945 Gaston Chauffrey (d. 1955) went into partnership with Marc-Rodolphe Muller (d. 1955).[11]

The studio of Chauffrey-Muller subsequently became very important. In addition to Gaston Chauffrey, it comprised his son Jean, a painter; Marc-Rudolphe Muller, a restorer; and the specialists brought by Muller—

the cabinetmaker Paul Maridat and the reliners A. Pouget and Raymond Lepage.[12] Shortly after the end of the Second World War, Maridat and Lepage left the studio, establishing their own business together in 1948 and doing cradling work for the Louvre in 1949[13] before they separated.

Maridat, known as a reliner, moved in 1957 to 21, rue Cassette, Paris, and did work in 1957 and 1958 for the Campana Collection, independent of the studio of the Louvre.[14] Examination by S. Bergeon of the Campana paintings, which are still in excellent condition, shows that this work included cradles with slats placed on edge (*de chant*) or flat (*plats*), attached either to panels backed with oak or to a back that had been only somewhat thinned. Around 1968, Maridat, who by then had moved to 18, rue Dulac, was doing work for the Château de Versailles.[15]

Raymond Lepage established himself at 5, rue Christine, in the Sixth Arrondissement, between 1963 and 1968. In June 1963 he gave estimates for work on important paintings by David in the Louvre. This work involved adding dovetail tenons to the portrait *Mme Seriziat* and straightening curves on the *Portrait de Lenoir*. Lepage still followed the old tradition of inlaid dovetails seen in the system he provided for Clouet's *François I*.[16] René Bertin, a specialist in wood, was not really a part of the Chauffrey-Muller studio but did work for it around 1945. Later, Gilbert Malesset, who started out with Chauffrey-Muller, also treated wood on his own in the 1950s (Rostain 1994).

The studio became known as Chauffrey-Muller, Gérant Rostain, from 1954 to 1975. In its attempts to replace the expertise of Puget, Bertin, and Maridat, the studio eventually discovered the cabinetmaker Georges Huot. In November 1957, when the studio was contracted to transfer, back, and cradle the portrait *Clément Marot* for the Louvre,[17] the wooden support was subcontracted to Huot (Rostain 1994).

In July 1965 the Chauffrey-Muller studio performed another transfer onto wood for the Louvre: *La Circoncision,* of the Swabian School, painted in 1480.[18] A new support that by this time is used by Rostain is marine-grade plywood with a cradle often made in the Huot studio. However, transfer from wood onto canvas was still practiced, as seen in Lorenzo di Credi's *Le Christ et la Madeleine,* which Rostain transferred on 24 January 1968.[19]

The studio became the Rostain studio in 1975; it was located for 150 years at 17, quai des Grands-Augustins, and is now at 12, rue Gît-le-coeur. The studio works on the restoration of wooden and canvas supports as well as treatment of the paint layer. However, for museums it is authorized to perform work only on canvas supports.

The scope of the studio's work and the range of interests of its various managers has earned it premier status for more than a century. It has achieved an excellent knowledge of the complex and specialized world of restoration, which eventually led it to advise the Louvre to choose the fine cabinetmaker Claude Huot for the museum's own specialized cabinetmaker studio.

The roles of Landry (1840–1848) and Roger Castor (1953–1957) at the Louvre

The archives indicate that Landry, "reliner at the Louvre," 47, rue Saint-Denis, was very active between at least 1839 and 1848.[20] He did many relinings with *marouflage*[21] on the back side, as protection against humidity, for the Louvre, as well as for the studios of Versailles, Compiègne, Chantilly, and the Château d'Eu. In 1839 Landry put "four cleats and marouflage" on the back side of Rubens's *La Kermesse.* Among a huge quantity of work of unknown date are some invoices concerning wood, one indicating that he cradled a picture by Holbein.[22] In 1843 he removed the paint layer of *Portrait d'homme,* by an unknown artist, from its wood.[23] He also proposed to transfer Raphael's *La Vierge au voile,* because it was very worm-eaten. However, the latter intervention, proposed to the painter Granet, who was in charge of restoration at the Louvre, must not have satisfied Granet, and, fortunately, the transfer was not done.[24]

The administration of the Louvre has long held tests to select restorers.[25] When Villot, the new head curator of paintings, arrived in 1848, Jeanron, director of the Musées Nationaux, sent the minister of the interior a "report on the situation of the studios of restoration of paintings of the Louvre Museum and their reorganization." A plan for a competition for restorers and reliners was drafted. Landry was required to pass it, even though he had already been working in the Louvre for a long time. A rough draft of the decision resulting from the competition does not mention Landry but does mention others, including the elder Momper, Mortemard, the younger Momper, and Piolé (or Poile).

Yet, Landry—following the work of Robert Picault in 1750, J.-L. Hacquin in 1780, and F.-T. Hacquin in 1803—had performed the fourth transfer of Andrea del Sarto's *La Charité* in 1845 so perfectly that it still remains solid (Emile-Mâle 1982b). A cleaning has recently been done, but the support has remained in its 1845 condition. Perhaps Villot was annoyed by the length of time necessary for those works. He was a difficult man, who had an inspection made in 1848 when he arrived, which was especially unpleasant for Landry.[26]

Gruyer, curator of paintings, in his detailed 1882 report to Mantz, director general of the Musée des Beaux-Arts, on the state of the restoration of paintings, indicated that the paintings in the Louvre seemed neglected.[27] But a large-scale policy of restoration was not established, and by the end of the century the authorities and Gruyer's successors considered a single restorer—Briottet, followed in 1887 by Denizard, assisted by C. Chapuis—to be sufficient for all the interventions required for supports.[28] The wood specialist M. Bouvard, at 63, boulevard Garibaldi, Paris, was called on to assist with works that were particularly important, such as the Avignon *Pietà* in 1905 and, prior to 1911, the *Mona Lisa*.

Roger Castor (b. 1914) worked at the Louvre between 1953 and 1957. A cabinetmaker by profession, he was probably recommended to Germain Bazin, chief curator of paintings at the Louvre, by Lucien Aubert (restorer at the Louvre beginning in 1910). During Castor's tenure at the Louvre, he was entrusted with important paintings, and for the first time the invoices for interventions are very detailed.[29] His work has a somewhat traditional and systematic character: dovetail tenons across the grain inlaid in the thickness of the original panel, and cradles, which are either simple and functional or purely aesthetic, placed on backings of silver fir[30] or oak.[31]

But some of his works have an innovative nature, like the creation of frames in new material (Permali or Bakelized wood) fitted with corrugated iron in the groove.[32] He was also the first to use Xylamon[33] to disinfect worm-eaten panels, such as the *Annonciation* by Cosimo Rosselli. For that picture, he carefully preserved the existing mobile upper crossbar with iron pins—which was either an original or a very old restoration (Bergeon 1976:62)—and copied it to construct the lower crossbar.[34]

After 1957 there was no longer a cabinetmaker at the Louvre who specialized in painted panels. At that point, compelled by necessity with the purchase in 1956 of Sassetta's triptych of the Virgin and two saints,[35] and with the purchase of the *Calvaire* by J. Lieferinxe in 1962,[36] Germain Bazin sent these two pictures to Rome to be restored at the Istituto Centrale del Restauro, where particularly Angelini and then later Bellafemina, both restorers of wooden supports, had achieved an internationally recognized mastery. By 1965 Germain Bazin had come to recognize the need for a cabinetmaker specializing in wood supports at the Louvre and a specialized studio devoted to the restoration of panel paintings. The consequences of this realization will be presented below.

Techniques Used in the Studios Prior to 1965

Transfer

French artisans, particularly those working in the Hacquin-Joyerot and Kiewert-Rostain dynasties, became extremely skilled in the technique of transfer, which was practiced for a long time in France. The technique had already been practiced for several decades by the time Jean-Louis Hacquin established his studio.[37] It had originated in Italy, where it developed simultaneously in Cremona and Naples between 1711 and 1725. It was introduced into Lorraine by Léopold Roxin in 1740 and into France by Robert Picault between 1747 and 1750 (Emile-Mâle 1982a, 1982b, 1987). Considered perhaps the major development of the eighteenth century, transfer was widely seen as a genuine universal panacea. The replacement of the original support by another, "ideal" one was intended to remedy all the structural problems associated with wooden supports—curving, splitting, worm tunnels, and cleavage of the paint layer.

Robert Picault's particular technique of a "sparing" transfer, in which the paint layer is separated from the wooden support, saves the support at the cost of some uncertainties and dangers.[38] On one occasion, Picault gave a dazzling display of his expertise to the king and his whole court as they filed past Andrea del Sarto's *La Charité,* admiring both the painting and, next to it, its support of old, "rotten" boards. In spite of this, no one had much faith in the technique, and it disappeared. Picault was then dismissed as a charlatan (Emile-Mâle 1982b).

After Picault, it was Jean-Louis Hacquin, and, especially, his son François-Toussaint Hacquin, who advanced the other technique of transfer, which is better for the paint layer but destructive of the support.[39]

Although the legitimacy of transfer was not questioned for nearly two centuries, the nature of the new support had always given rise to very interesting misgivings, particularly with respect to the choice of material. In a 1799 report on restorations for paintings, Picault wrote that the new support should be the same as the original (copper or wood) support "to conserve the purity of the design, the honesty of the stroke and their enamels [*sic*] which the grain of canvas takes away from them."[40] However, canvas was the support recommended by Robert Picault in 1750 and Jean-Louis Hacquin in 1780 for Andrea del Sarto's *La Charité,* and by François-Toussaint Hacquin for Raphael's *La Madone de Foligno* (transferred in 1801) and for *Sainte Cécile* (transferred in 1803) (Emile-Mâle 1982b).[41] In 1798, after arguments with François-Toussaint Hacquin, Jean-Baptiste-Pierre le Brun, then *commissaire-expert* of the administration of the Musée Central des Arts, set the rates for payment for "lifting from wood and transfer on panel [as] 10 Frs per foot then 12 Frs per foot" (Emile-Mâle and Borelli 1957:410). Le Brun, a connoisseur with an excellent eye, seems to have preferred wood to canvas.[42]

Gruyer, curator of paintings at the Louvre, mentions on 8 June 1882, "eighty-nine pictures to be transposed onto new canvases or panels."[43] The usual choice at the time seems to have been a new support made of canvas, a material lighter than wood and "less sensitive to hygrometric change, hence not causing any more cleavages." Canvas was also not susceptible to attack by worms, and it provided flat support. The marouflage used between the paint layer and the new support was supposed to keep the grain of the canvas from appearing (Emile-Mâle 1983b:227).

Transfer was widely practiced until 1938, and it continued more sporadically until 1950. After transferring onto canvas several times, in 1950 Emile Rostain, in one of his last major transfers for the Louvre, used a rigid support of marine-grade plywood with a cradle for Francia's *Calvaire* (Rostain 1981:113–15).

Cradling

The cradle has been known in France since 1740, at about the time that the Widow Godefroid, a professional reliner who did not make the cradles herself, ordered one from a cabinetmaker. However, she prepared the back of the painting and placed the cradle herself (Emile-Mâle 1983a:871). In 1755 a number of prestigious artists (Restout, Louis de Silvestre, Carle Vanloo, Pierre, Boucher, Vien, Portail, Cochin) signed a document indicating that Rubens's portrait *Marguerite de Valois* had to be straightened out and the splits repaired with a cradle.[44]

In 1788 François-Toussaint Hacquin was said to have cradled the damaged *Saint Pierre dans sa prison,* painted by Steenwyck (Louvre).[45] In 1798 he was put in charge of cradling Titian's *Le Couronnement d'épines,* which was split in three parts. Between December 1800 and February 1801, Hacquin "joined the [disjointed] boards and applied a cradle of silver fir, which the joiner had prepared for him."[46] The archives provide proof of a closer collaboration between the restorers of the support and the joiners than we have imagined to this day. In 1796–97, the joinery enterprise of the Louvre "employed six persons for rough-hewing and *raplainssage* of a painting."[47] Similarly, in August 1798, on Rubens's triptych *La Pêche miraculeuse,* François-Toussaint Hacquin "joined the boards and directed the work necessary to apply a woodwork cradle to it" (Emile-Mâle 1994).

Were these early cradles badly devised? Apparently the one that Widow Godefroid placed on the back side of Rubens's *La Kermesse* (more than thirty years before Jean-Louis Hacquin was assigned to the work in 1770) had added to the damage. It must have been fixed, since the new cradle, devised by Hacquin, is "a new type that plays and anticipates unevenness of the wood during the change of seasons."[48] The sliding cradle is a great French discovery of the eighteenth century; the cross-grain crossbars, which ensure the real security of the panel, are mobile and slide in fixed slats, which are glued in the direction of the grain of the support (Fig. 1).

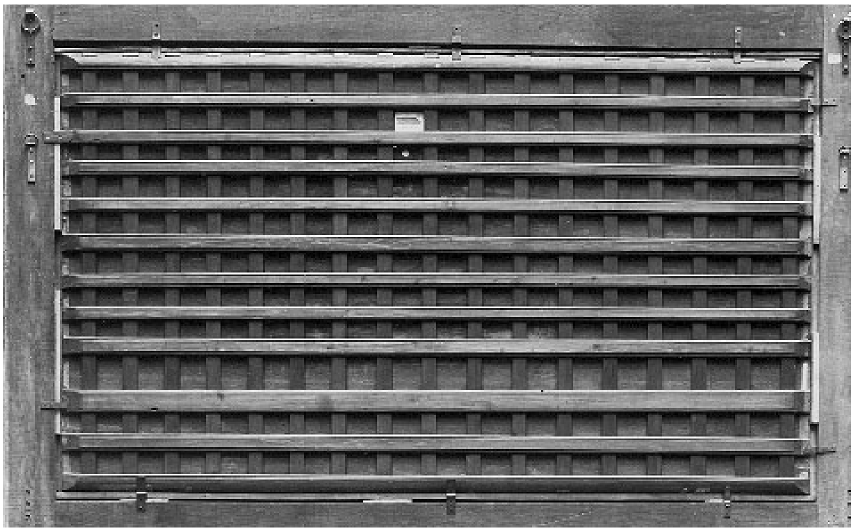


Figure 1
Peter Paul Rubens, *La Kermesse,* ca. 1636–38. Reverse. Louvre Museum (inv. 1797), Paris. Sliding cradle of the Hacquin type, with slats glued in the grain direction and mobile crossbars running against the grain. The first sliding cradle for this painting was placed in 1770 by Jean-Louis Hacquin. The cradle was redone by François-Toussaint Hacquin in 1825; perhaps it was then that the simple slats were replaced by slats ornamented with moldings.

Originally the purpose of these cradles was to hold a straightened panel flat while avoiding splits through the use of sliding crossbars. The straightening was carried out by thinning, the wood being first prepared by applying damp linen cloths to introduce moisture to the wood, then letting it dry under pressure and, if neccesary, inserting pieces of wood to prevent it from resuming its previous curvature. In general, the back sides of cradled panels present open worm tunnels, which allow the extent of the thinning to be assessed and the original thickness of the support to be deduced with more or less certainty. Moreover, cradling helps consolidate splits when crossbars are placed on both sides of a split.

The double function of straightening and repairing splits is included in Mérimée's major text of 1830, which talks of the "bars" of the cradle: "When a panel is split or is crooked, it is corrected by gluing behind what is called a cradle; this is a lattice of silver fir to which only part of the bars are glued, those which are in the direction of the grain of wood of the panel. The crossbars are held by the former in notches made in their thickness, in which they are engaged. They are not glued to the panel, for since the movement of the wood is always working on the width, they would not adhere there solidly; they serve only through their pressure to hold the panel so it can no longer be crooked" (Mérimée 1830:260).

In 1851 Horsin-Déon praised the work of the French cradlers, illustrated by the work of Constant in Paris, in whose hands the cradle was a creation of rare elegance carried out with unequaled lightness and perfection. He also spoke of the "uprights" glued in the direction of the grain and of the mobile crossbars in the uprights. The Gruyer report of 1882 also mentions recradling, which shows that cradles already existed and that their use, according to Chapuis, remained current.[49]

In 1909 Meusnier discussed the quality of work of the cradler and spoke of "support" slats (glued in the direction of the grain of the wood) and the mobile crossbars that are engaged in the former (Meusnier 1909:31–33). This is the first text to mention the "odd pieces, thin sheets of hard wood" inserted into the cavities after straightening and drying, in order to hold the whole thing flat, which corresponds to what is now probably called *sverzatura* (Bergeon 1976:20, 1990:20). Meusnier also distinguished between those mobile cradles "of absolutely French origin, in which our workers have achieved perfection, followed by Italy and Flanders," and the fixed, so-called simplified cradles for small pictures painted "on thin mahogany or tulipwood. . . . Cradles with glued [hence fixed] battens can also be applied to the back side of pictures painted on metal (copper and zinc)" (Meusnier 1909:33–35).

In 1938 *Mouseion* referred to the main purpose of the cradle as a remedy for curving or warping and mentioned the old, classical, so-called flat cradle, which is, in fact, French (*Mouseion* 1938:241–42). Various drawbacks were noted, among which are the risk of breakage on both sides of the glued slats, which are too strong in relation to the original support. In this text there is mention, for the first time, of another kind of cradle *de chant,* then called *de champ,* with crossbars placed on their narrow side.[50] The purpose of this type of placement is to reduce the surface area given to gluing and hence to stress, while increasing the resistance of the crossbars.

The cradle is a common intervention performed by cabinetmakers, such as Paul Maridat and Roger Castor, and by other specialists in wood who are "skillful at making cradles." René Bertin, who worked for Chauffrey back in 1945, is credited with having a role in their development (Rostain 1994). Cradles were also made by reliners in the Maison Leguay, such as Puget, in 1924.

It is difficult to get a clear overall idea of this subject. Reliners make cradles, while cabinetmakers do transfers and relining. The division between the two crafts is unclear, particularly since transfer, a major operation for wooden supports, often consists of replacing the wood with canvas.

The history of the cradle shows that while it started as a functional object, it eventually became an aesthetic one (Marijnissen 1967:46). Every painting on wood *must* present a cradle on the reverse, often of mahogany, sometimes of oak. It presents fixed bars, and the whole is carefully "patinated old wood." The cradle is sometimes nothing but an ornament without a functional role, for it is even found on the backs of some new stabilized wooden supports.

Backing

Backing is the addition of a new support on the back of an older support of a painting whose original wooden support still exists, at least partially, but has undergone thinning. The date of the beginning of this intervention is very uncertain. In 1909 Meusnier says that a little painting can have a double support "backed with strong glue" (Meusnier 1909:33). What was the new support? Likely it was wood, similar to the woods that were chosen for transferred paintings.

There are so many cases of paintings backed and then cradled that, in a cursory examination, the addition of a backing may escape the attention of the nonexpert.[51] The wood chosen is often solid oak, walnut, or mahogany; the panel is then equipped with a superb plain, "aesthetic" cradle of oak or mahogany, with glued slats.

It would be helpful to follow the possible uses of the so-called anhygrometric inert support, a discovery made in 1845 by Tachet, who took out a patent in Paris for it (Volle 1989:12). This support was composed of "alternating sheets of wood, impregnated with shellac, squeezed and heated to a fusion of the shellac and then pressed." This description corresponds to the beginnings of plywood, which is certified as an original support of painting, at least by Victor Mottez in about 1860 (*Portrait de son* *fils,* preserved in the Louvre).[52] This inert support was called *trésailles* (Lameere 1930:245). This word was used differently by Diderot in the eighteenth century, de Littré in the nineteenth century, and Larousse in the twentieth century.[53] This support is proposed for use in the backing of panels that have been thinned to 2 mm. In fact, this material, which was considered inferior to wood, does not seem to have been used very much, even though in 1948 Gilbert Malesset did use it to back one of the thinned boards of a famous Rubens painting, *Sainte Hélène,* at the Hospice de Grasse (Bergeon 1990:39–41).

Treatment of splits

In addition to the procedures of transfer and cradling, whose "longitudinal slats allow splits of wood to be repaired" (*Mouseion* 1938:242), the dovetail tenons inlaid across the grain seem to have been used very early to repair splits, as was the type of intervention made by Bouvard on the *Mona Lisa* before its theft in 1911. Two dovetail tenons inlaid in the panel against the grain (one of which still exists) in order to stop the progress of the upper split fulfilled their function perfectly.[54] This procedure was also to be used by the cabinetmaker Castor, who specialized in wood supports in his work for the Louvre between 1953 and 1957. But the constraining nature of the dovetail against the grain and the removal of the old wood were two important disadvantages of the method, which was usually used too routinely.

Treatment of worm-eaten wood

In the documentary sources, there is no mention of the different types of biological attacks to which wood is susceptible, and in any event, authors often seem to confuse mold with insect damage. The archives mention "rotten boards," but subsequent references suggest boards that have been attacked by worms and insect larvae rather than damaged by mold.

Removal of the worm-eaten wood was generally preferred, with radical treatment by transfer often proposed as the only means to restore the bearing function of the support. Lead white was chosen to fill in the cavities.[55] In the nineteenth century shellac was chosen, since it is a much better treatment for worm-eaten wood than lead white. Shellac rigidifies the inner tunnels but becomes reddish black, transforming the appearance of the wood by giving it a dark sheen. In 1950 Henri Linard, a restorer at the Louvre, gave up shellac in favor of wax-resin (beeswax and damar resin). Shellac was still used in the Louvre in the 1950s, although not systematically, as a rigidifier of the inner tunnels of worms. Worm-eaten wood was also replaced locally by an inlay of healthy wood, as can be seen in Bouvard's 1905 treatment of the *Pietà* of Avignon, for which he used tulipwood from Virginia (Bergeon 1990:35–38).

Early examples of frames fitted to panels

Germain Bazin has noted that pictures preserved in their old frames have often behaved better than others. Bazin, who was in constant contact with Cesare Brandi, the art historian and founder of the Istituto Centrale del Restauro in Rome, was well informed of international developments in restoration as of 1950 and, reflecting the spirit of the age, wanted prestigious paintings to be subjected to only minimal intervention. In 1953 he asked the cabinetmaker Castor simply to fit a frame for van Eyck's famous painting *La Vierge d'Autun,* or *La Vierge du Chancelier Rolin*. This frame was made of Permali, a very stable Bakelized wood, fitted with an ingenious system of corrugated iron in the groove to ensure a flexible hold for the painting.[56] Similarly, shortly before 1955, Castor equipped Antonello da Messina's *Portrait d'homme* at the Louvre with crossbars lined with felt and attached only to the frame. Even as early as 1951, the crossbars for Leonardo da Vinci's *Mona Lisa* were similarly shaped to the warp of the panel, lined with felt, and attached only to the frame, in order to hold the poplar support without stressing it (Fig. 2).[57]

Restoration of Painted Panels after 1965

Creation of a specialized cabinetmaker studio in the Louvre

In 1965 Germain Bazin, who was soon to create the Service de Restauration des Peintures du Louvre,[58] realized the need for a cabinetmaker specializing in wood supports at the Louvre, particularly for the important restoration program of the Campana Collection, consisting of more than three hundred Italian primitive paintings on poplar (de Loye 1976; Kjellberg 1976). Soon after meeting cabinetmaker Claude Huot, Bazin established the Louvre's first such specialized cabinetmaker studio, and Huot then turned his attention to paintings belonging to the state.[59]

From January 1962 until the beginning of his work for the Louvre, Claude Huot had been manager of the studio established by his father, Georges Huot. Founded in September 1939 at 24, rue St.-Lazare, the Huot studio had specialized in the restoration of eighteenth-century furniture. In October 1941 it moved to 26 and 28, rue St.-Lazare, and the building at number 24 became a storehouse of old wood needed for restoration. In July 1945 René Perche, a *compagnon* (an artisan who has completed apprenticeship but is not yet a "master") cabinetmaker trained in Brittany, brought his exceptional ability to the studio, where he remained until he retired in January 1977.

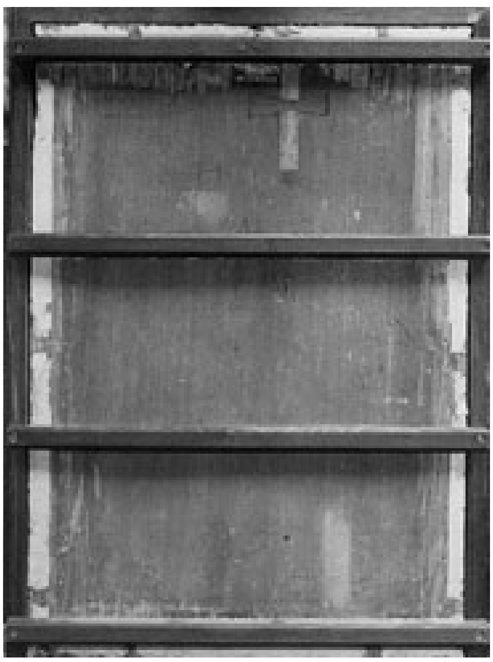


Figure 2
Leonardo da Vinci, *Mona Lisa,* ca. 1503–5. Reverse. Oil on panel, 77 × 53 cm. Louvre Museum, Paris. A dovetail tenon inlaid in the panel at the top was an early stabilization of a split. A flexible frame is made of attached crossbars designed to follow the warp of the panel and lined with felt. The original panel is made of a single poplar board.

Claude Huot began his apprenticeship in October 1951, studying theory in the cabinetmaking department at the furniture industry's Ecole d'Apprentissage and, after three years, acquiring a *certificat d'aptitude professionelle.* His teachers were his father and René Perche. At the same time, Claude Huot took courses in commerce and accounting. In 1964, two years after assuming the management of the studio, Claude Huot hired Robert Legris, and the studio carried out its first interventions on the wooden supports of paintings belonging to private owners, particularly those consigned by the Chauffrey-Muller studio, whose director was E. Rostain.

Huot's first work on paintings that belonged to the state were similar to the types of restorations that he had carried out previously for private clients.[60] (For examples illustrating the techniques discussed below, see Figures 3–17.) In 1965 the first mobile crossbars with hollowed-out surfaces on the side of the panel appeared; they were held by cleats adhered with a vinyl adhesive in the direction of the grain.[61] Also in 1965, the Huot studio performed its first thinnings of pictures either originally painted on poor-quality plywood (a picture painted by Picasso on wartime material) or on cross-grain boards.

In 1967, on Germain Bazin's advice, Claude Huot attended a monthlong course at the Istituto Centrale del Restauro. Upon his return, he immediately introduced at the Louvre the technique of consolidation with Paraloid, an acrylic resin tested and chosen for use by the Istituto Centrale, along with hollow, cylindrical mobile crossbars of the Carità type in wood cleats sheathed with brass.[62] In addition, Huot introduced the use of a system in which cross-grain elements of a frame could be reattached to the panel by means of screws placed in oval-shaped holes in the panel; this system allows the free play of the wood of the panel in the frame.

Figure 3
Rondinelli, *Le Miracle de la lampe.* Side view. Musée du Petit-Palais (MI 590), Avignon. Curve acquired by a panel cut tangentially to the rings of the tree and painted on a single side. The painting will not be straightened.

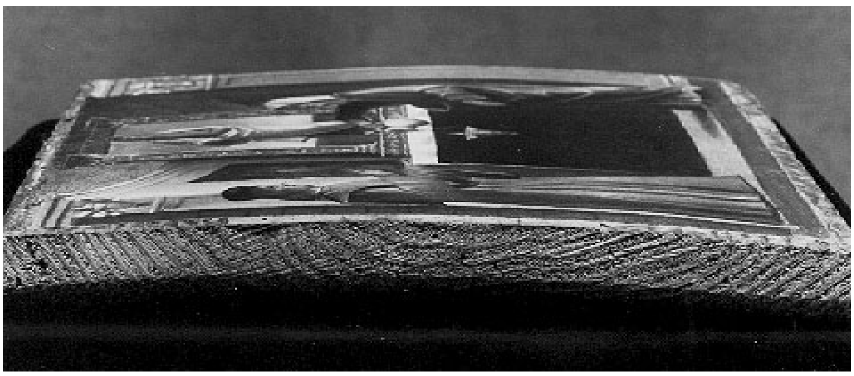
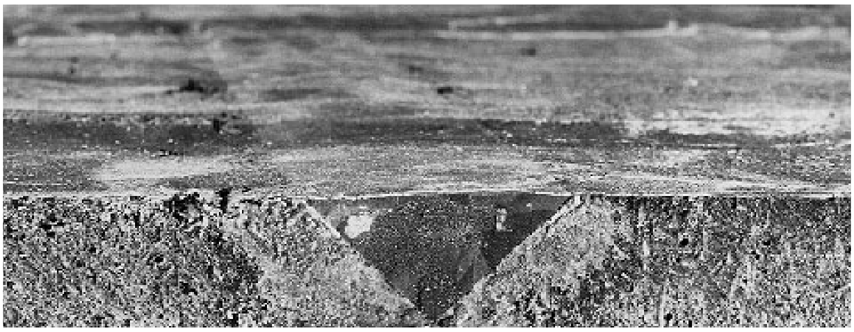


Figure 4
Il Sollazzino, *La Vierge d'humilité.* Reverse. Musée du Petit-Palais (MI 558), Avignon. Restoration of a split: incision and V-shaped inlay of the same type of aged wood is seen in section. The inlay allows the rejoining and the evening of the edges. This method was developed at the Istituto Centrale del Restauro, Rome.



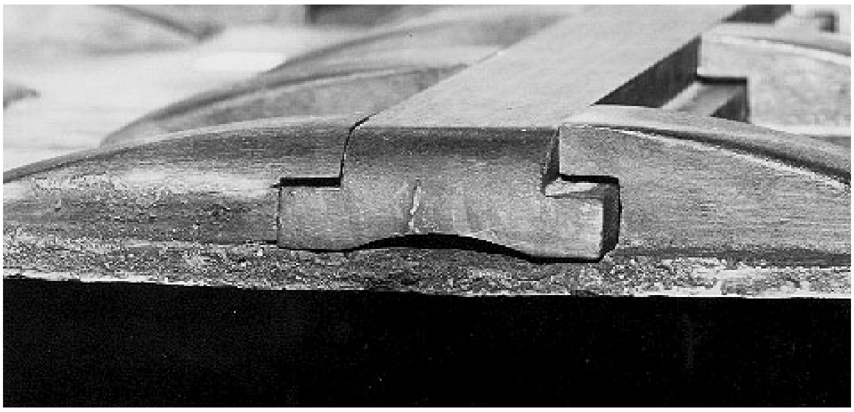


Figure 5
Benvenuto di Giovanni, *Martyre d'un évêque.* Reverse. Musée du Petit-Palais (M 514), Avignon. Hollowed crossbars. The wooden crossbar slides in cleats glued to the back of the panel. The hollowing reduces friction with the panel and improves mobility.

In 1969 Claude Huot made a second tour of Italy, visiting Siena, Florence, Bologna, and Rome, and he also had the opportunity to collaborate with aeronautical engineers on a number of ingenious procedures.

Other members of the Huot studio included Daniel Jaunard, a compagnon cabinetmaker from the Gaston Hullin furniture restoration studio, who was with the studio from 1975 until 1990. In 1983 the Huot studio hired Juan Garcia, a compagnon cabinetmaker from the F. Dolhen studio.

Techniques used by the Huot studio

The Huot studio carried out interventions for almost twenty years for the Service de Restauration des Peintures des Musées Nationaux, from its creation in 1965 to its move to Malmaison in 1982, and then to its final move to Versailles in 1985. These interventions illustrate a restoration policy that advocates removing the stress on the wood, treating splits minimally, gradually ceasing to do backing, reducing the amount of surface area affected by adhesives and friction, and minimizing "orthopedic" surgery. Eliminating surgery in favor of milder remedies also involved abandoning the sverzatura (straightening by incisions and insertion of a thin, triangular wood section piece), which was carried out only twice for the Campana Collection and was hardly practiced at all after 1968.[63]

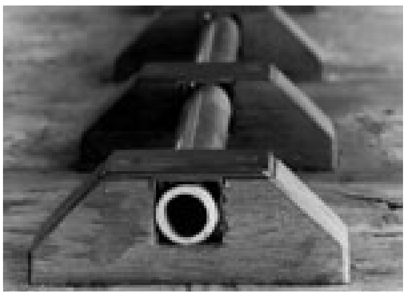


Figure 6
Carlo Crivelli, *La Vierge et l'Enfant trônant entre deux anges,* fifteenth century. Reverse, detail. Musée du Petit-Palais (MI 492), Avignon. Hollow cylindrical metal crossbar, which slides in cleats lined with brass. This system is called "Carità," after its inventor at the Istituto Centrale del Restauro, Rome.

Germain Bazin was well aware of the drawbacks of transfer and considered the removal of a painting's original support a genuine mutilation of an inherent part.[64] A new wooden support raises a risk of splitting and, inevitably, new cracks, while a new canvas support raises the risk of distortions, tearing, holes, and, inevitably, a new network of craquelure. The transformation of the condition of the surface, which acquires the grain of a canvas and a new "flatness," is no longer relevant to the original support; the work is therefore betrayed. The overall fragility of transferred paintings, whose gauzes soaked in glue can react to hygrometric variations, has been demonstrated for several years.

New supports were, therefore, very rarely devised. Solario's *La Déploration sur le Christ mort* at the Louvre required a change of support because of the development of microorganisms in the preparation layer and the chronic loss of adhesion of the canvas from the original marouflage of the original support. The painting was given a new support consisting of a metal honeycomb panel sandwiched between two sheets of fiberglass coated with epoxy resin; this panel was fitted on the front with

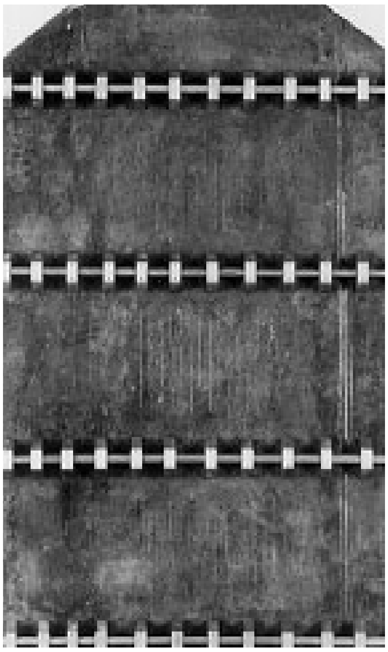


Figure 7
Bartolo di Fredi, *L'Adoration des bergers.* Reverse. Musée du Petit-Palais (C 71, inv. 20267), Avignon. This mobile support consists of Carità sliding crossbars. The warp of the boards was formerly straightened by incisions made in the direction of the grain; the edges were separated, and odd pieces of wood were inserted in the technique known as sverzatura.

Figure 8
Jacopo di Paolo, *Le Couronnement de la Vierge.* Reverse, detail. Musée du Petit-Palais (MI 428), Avignon. Crossbar of two aluminum U-shaped sections that slide on Teflon cylinders.

an intervening layer of balsa, shaped to follow the surface contours of the painting, while the reverse was covered by a rigid sheet material (Bergeon 1985:104; Volle 1989:18). *La Vierge et les Saints* by Botticcini (Jacquemart André), on which the double ground—thick chalk on the support and thick gesso on the side of the paint layer—had split in two, was treated in a similar manner. After several attempts to repair and preserve the support, it was changed to a metal honeycomb panel between two sheets of fiberglass coated with epoxy resin; as in the previous example, it was furnished with an interventing layer of balsa on the front and a sheet of oak on the reverse (Volle 1989:19).

In the mid-1970s, after much experience with transferred paintings being returned from exhibitions with signs of cleavage of the paint layer, the Louvre decided that if the certificate of condition issued by the restoration service mentioned "transfer," a painting in such a weakened state would not be allowed to travel.

The first backing the Huot studio did for the Louvre dates from 1966.[65] The painting in question was thinned, placed on marine-grade ply-

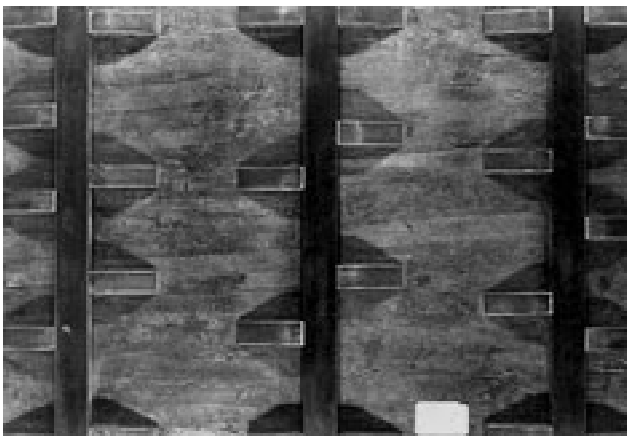


Figure 9
Jacopo di Paolo, *Le Couronnement de la Vierge,* reverse. The half cleats that hold the sliding crossbars are glued to the back of the panel; they can be staggered on either side of the crossbars.

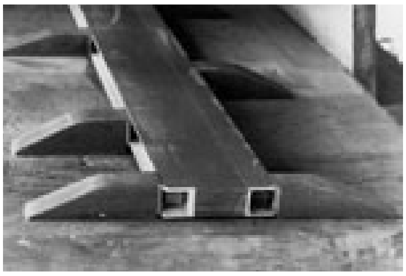


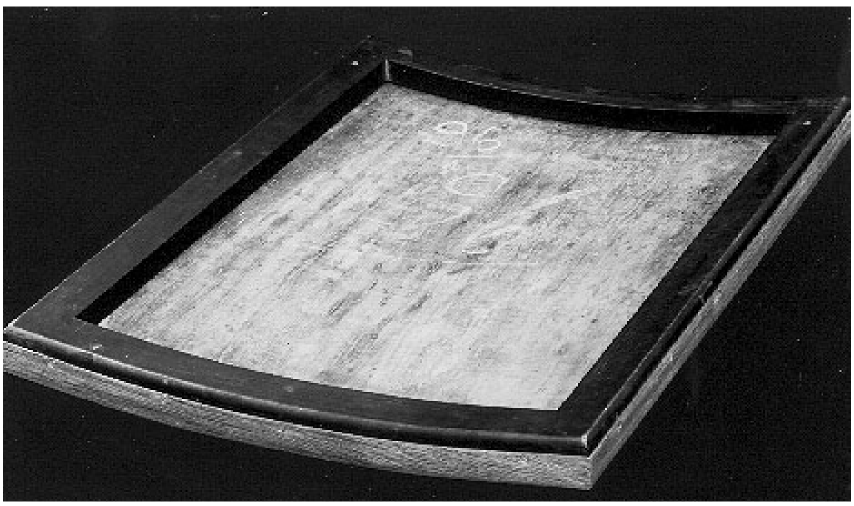
Figure 10
Master of Stratonice, *La Vierge et l'Enfant avec deux saints et deux anges.* Reverse, detail. Musée du Petit-Palais (MI 542), Avignon. Metal crossbar composed of two U-shaped aluminum sections and reinforced with mahogany. This system is suited to big panels.

wood, and equipped with a flat, aesthetic cradle. Other approaches to backing have appeared over the years. A simple gluing of a sheet of old wood replaced a nonfunctional cradle on the reverse of a plywood sheet in 1968.[66] A latté, consisting of two sheets of plywood sandwiching a number of juxtaposed wooden boards, replaced a plain plywood backing in 1970,[67] while in 1975 the last thinning followed by backing was done for the Campana Collection.[68] The choice of backing has moved toward the most inert supports possible and thus has led to the use of so-called marine-grade plywood, which is stronger than ordinary plywood, and to the use of a latté (1970)[69] system, honeycomb panels, first in cardboard (1968),[70] then in metal (1978),[71] and finally in balsa wood.[72]

Whenever fixed cross-grain crossbars, nailed through to the face of the painting, had caused splits, the shafts of the nails were sawn in order to separate the crossbars and thus to remove the stress. Whenever cross-grain crossbars inlaid with dovetails in the thickness of the wood had to be removed because they had contributed to splitting, the gap that remained was filled with wood in the direction of the grain to avoid the risk of local weakness. Joints that have completely come apart are connected with tenons and mortises one-third as thick as the panels. However, when the joints have only partially come apart, or when the split affects only a part of the length of the panel, the practice since 1965 has been to replace the old inlaid dovetail tenons by V-shaped incisions of a maximum of two-thirds the thickness of the panel, each followed by an inlay of the same section in the same kind of aged wood. The aperture of the V has to be as narrow as possible, so that little of the original wood is removed; at the same time it should be wide enough to allow good adhesion at the bottom of the V. Claude Huot adopted V-shaped incisions upon his return from one of his trips to Rome. By 1979 these inlays were sometimes replaced by cleats set on the reverse in the direction of the grain in the case of splits that did not have projecting edges (Emile-Mâle 1976:21), and by small tenons, as thick as one-third of the panel, placed at the ends of the boards in case of simple incipient splits.

To reduce the portions of the surface given to gluing, the fixed slats running in the direction of the wood grain of the panel were replaced by cleats and, in later work, by half cleats to support mobile crossbars. After 1965 the crossbars were made with hollowed-out surfaces facing the

Figure 11
Machiavelli, *La Vierge et l'Enfant avec deux anges.* Reverse. Musée du Petit-Palais (MI 522), Avignon. Châssis-cadre system. A mahogany stretcher for perimetric support was formed to follow the warp of the panel. The stretcher is secured with a brass L-shaped frame lined with felt. A space is left between the frame and the painting to allow for the play of the wood.



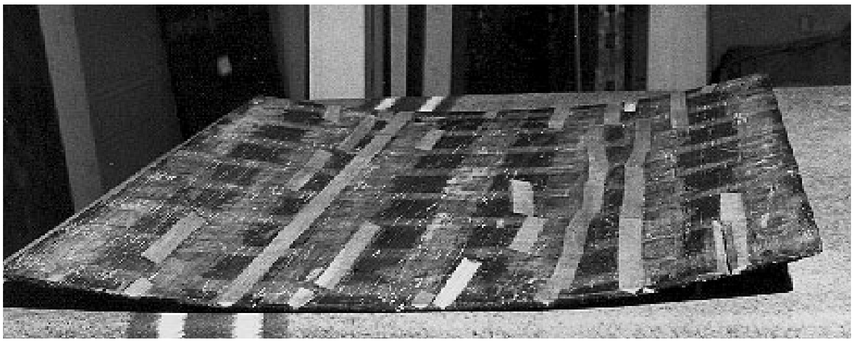


Figure 12
Cima da Conegliano, *La Vierge et l'Enfant*. Reverse. Louvre Museum (RF 2100), Paris. The wooden support of this painting, which was formerly thinned, is worm-eaten and split. After the old cradle was removed, it was disinfected and its fractures were reduced by incision and V-shaped inlays.

panel, in order to lessen the friction of wood against wood.[73] In the system of cylindrical steel crossbars used from 1967 to 1969, the crossbars slide in cleats sheathed with brass; friction is therefore limited to those areas. Finally, crossbars of H-shaped cross section, made of an aluminum alloy, began to appear in 1967. After 1970 these are sometimes reinforced by Bakelized wood or mahogany; this system limits friction to the small Teflon rollers that allow the metal crossbars to slide easily (Emile-Mâle 1976:113).

There was a gradual attempt to eliminate crossbars and the use of adhesives; by 1969 this progression resulted in a simple perimetric reinforcement: the *châssis-cadre* system. This device is formed of an L-section brass perimeter stretcher, lined with felt on the side of the painting, or formed of a frame of mahogany or Permali, possibly shaped to fit the warp of the panel and spaced 2–3 mm from the panel to allow for the possible expansion of the wood. Adhesives are no longer used, and there is a minimum of friction.

A variant of this procedure features a mobile backing in acrylic resin (Altuglass). First used as a flat sheet in 1970,[74] this type of backing was then contoured to follow the warp of the painting as of 1974. This system replaced the châssis-cadre system, with the Altuglass taking the place of the stretcher; it allows a thin, fragile, and locally brittle painting to be supported; weak areas of the panel can be reinforced with a local restraining cleat through the Altuglass. The advantage is a transparency that allows all the information on the back of the work to be read. The major drawback is the considerable weight of the whole.

When the picture is too thin to justify a châssis-cadre but too big to allow a mobile backing, a modified châssis-cadre can be prepared,

Figure 13
A rigid support plate of acrylic resin (Altuglass), shaped to follow the warp of the panel, in the treatment of Cima da Conegliano's *La Vierge et l'Enfant*.

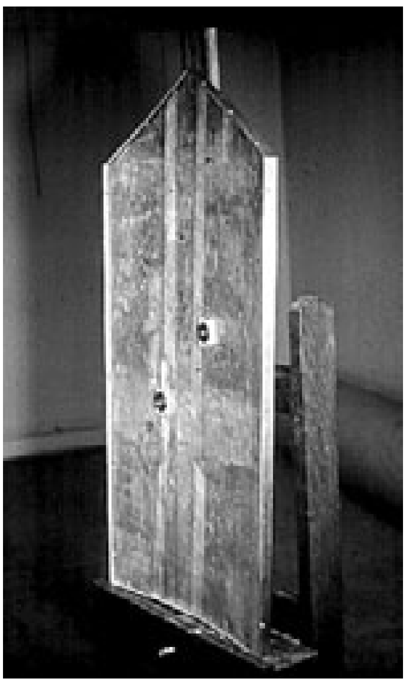
Figure 14
Cima da Conegliano, *La Vierge et l'Enfant*. The perimetric support, preserving the acquired curve of the painting, consists of a brass frame shaped to follow the contour of the panel. The frame is attached to the acrylic support plate by means of an L-shaped fitting. Felt lines the inner part of the metal frame that adjoins the painting.

with crossbars that slide within cleats equipped with rollers; this method was devised in 1971 for Titian's *Le Couronnement d'épines* and is still in use.

When the original elements are across the grain, a mobile framework based on the principle of elongated holes can be used. Examples of this technique can be found in the frames of several paintings in the Campana Collection which have been maintained like this since 1967.

Sometimes precious original tenons, even across the grain, can be preserved, as seen in the treatment of the *Pietà* by Enguerrand Quarton in the Louvre. The 1977 intervention on this panel was very extensive and exceptionally difficult, but it could be carried out because René Perche was still with the Huot studio at the time. Since Perche was due to retire, hesitations were overcome, and the decision was made to restore the support of the *Pietà,* which had been at risk for some time, so as to take advantage of Perche's extraordinary ability. The work required the preservation of original tenons across the grain of the boards and through four pegs; all these were preserved as elements of the original fifteenth-century joining work.[75] This intervention was Perche's last museum work.

Examples of minimal intervention—typified by the relinquishing of backings and the increased role of frames—can also be seen in the treatment of Tarascon's *Pietà,* treated in 1974, in the Musée Cluny, and in

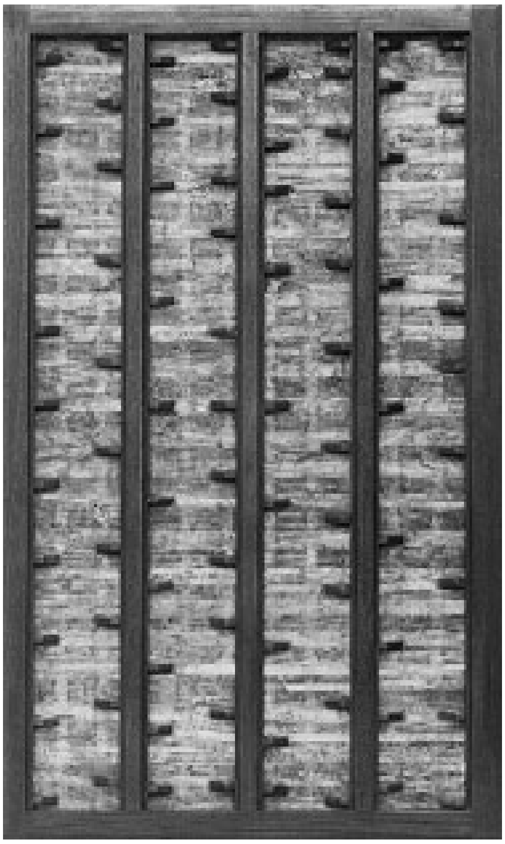


a

b

Figure 15a, b
Ombrie, *La Dormition et l'Assomption de la Vierge,* fifteenth century. Reverse. Musée du Petit-Palais (MI 453), Avignon. Mobile backing shaped to a panel with retaining cleats (a). In the Altuglass plate, a cavity is made slightly wider than the size of the small wooden cleat (b) glued to the panel. Fixed by a very short screw, the cleat holds a brass disk whose edges rest on the resin plate and secure the Altuglass to the panel.

Figure 16
Titian, *Le Couronnement d'épines,* sixteenth century. Reverse. Louvre Museum (inv. 748), Paris. Châssis-cadre. The perimetric stretcher of Bakelized wood has crossbars reinforced with Bakelized wood, which are attached to the frame. Cleats fitted with Teflon cylinders allow the crossbars to slide. The very large painting was too thin to support itself and required more than a perimetric support.



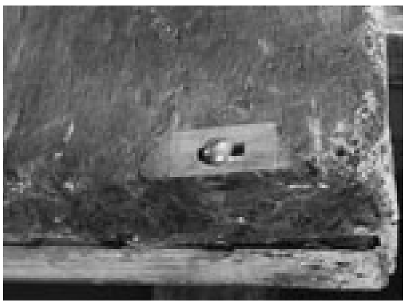


Figure 17
Florence, *Christ au tombeau,* fifteenth century. Reverse, detail. Musée du Petit-Palais (inv. 20253), Avignon. Screws placed in elongated holes; the mobile framework allows for the normal play of the wood, even if certain elements are across the grain.

that of Raphael's *Madone de Lorette,* treated in 1977, in the Musée Condé, Chantilly. For the Tarascon *Pietà,* a very precious and rare painting of the French fifteenth century, it was decided simply to place a cleat on the wood at the beginning of the split rather than to do a V-shaped incision and inlay. After regular surveillance and an eventual determination of the fragility of the painting, it was decided to fit a perimetric châssis-cadre instead of adhering crossbars and cleats to the back of that important artwork. A system of perimetric reinforcement following the exact contour of the painting was enough to mitigate the risks resulting from the inevitable handling.

Raphael's *La Madone de Lorette* from the Musée Condé, Chantilly, was treated in a similar manner (Bergeon 1979:48–49). The unevenness of a split required a V-shaped incision and inlay rather than just a cleat. Before crossbars were attached, the frame of *La Madone de Lorette* (even though not original) was adapted by the insertion of a brass perimeter frame shaped to follow the warp of the panel and lined with felt on the side of the painting. The edges of the frame had to be thickened so that it could receive the crossbars, which were also contoured, lined with felt, and fixed only to the frame.

The desire to maintain what exists and to reuse an old system by making it functional prevailed in the restorations carried out from 1978 to 1986 on Rubens's large *Sainte Hélène* at the Hospice de Grasse. The former glued stretcher, thick and of fine-quality walnut, was unglued and its crossbars hollowed and equipped with aluminum slats sliding over Teflon rollers fitted with cleats glued to the panel. It now constitutes a mobile support system (Bergeon 1990:39–40).

The same sensibility prevailed in a 1979 intervention on *L'Annonciation,* a work by the Master of the Altarpiece of Arceteri (Musée du Petit-Palais [MI 446], Avignon). In this work, the worm-eaten old crossbars were preserved, consolidated, and hollowed to receive two metal I-shaped pieces. The function of the crossbar has been reestablished and the old wood preserved.

With respect to insect damage, carbon tetrachloride is used to disinfect worm-eaten wood, on the advice of the Centre Technique du Bois. Consolidation with Paraloid dissolved in xylene has been standard from 1965 to the present.

Conclusion

From the first half of the eighteenth century, France enjoyed an excellent reputation with respect to the "mechanical" area of restoration—that is, in the treatment of the supports of painting.[76] Ever since the advent of those great innovations—the sparing transfer and the sliding cradle—French artisans of painting supports have been highly regarded. The art of the cradler has always seemed specialized and was generally admired, despite the facts that the work sometimes seemed undifferentiated and that some interventions were performed by specialists who described themselves as reliners.

The tradition of excellence in craft has continued. Cradles can still follow artistic standards, even if their functional role is now subsidiary to the aesthetic value they contribute to paintings; this is particularly true for cradles of the best period, which are especially prized since the art market has expanded.

The desire for the presence of a cabinetmaker in the Louvre devoted solely to wooden supports began tentatively, but by the 1960s the ground was ripe for a thorough consideration of the importance of having such expertise near at hand. There had been regular demands for the restoration of newly acquired works that previously would have been restored with the indispensable assistance of Italian colleagues. This assistance, however, became a keen indicator of the need for such skills in France. The need would eventually be filled by the Claude Huot studio, when the vast project arose of repairing the three hundred panel paintings in the Campana Collection, which was destined for a new museum in Avignon. This challenge was an extraordinary opportunity to initiate a policy of restoration on a technically homogeneous group of works, and it would compel Germain Bazin to seek the requisite technical, financial, and human resources for the task. The latest Italian thinking in this regard was combined with the excellent French techniques of cabinetmaking mastered by Claude Huot and his head compagnon and teacher of apprentices, René Perche, resulting in important new progress in the restoration of wooden supports.[77]

Cabinetmakers specializing in wooden supports, with their ever-lively curiosity, now constitute an important part of the studio team, and they work alongside curators who are highly interested in this technical subject and who have, in fact, specialized in restoration. The treatment of many different works has allowed the progressive evolution of methods, the pursuit of research informed by a dialectic between observation and thought, and the refinement of atelier practice—a combination indispensable to the progress of the proper care of works of art.

Acknowledgments

The authors wish to dedicate this article to René Perche, cabinetmaker (1913–89). They are especially grateful to Mme Y. Cantarel-Besson, in charge of the Archives of the Louvre, who has contributed her outstanding research.

Notes

1 This expression (Fr. *liberté surveillée*) was used by Bergeon (1976:22) in reference to the Campana Collection.

2 An inscription over the entrance gives 1740 as the founding date.

3 Archives Nationales, O^1 1922^A (1779).

4 Nouvelles Archives de l'Art Français, 1880–81 (p. 44).

5 For information on the Hacquin-Mortemard dynasty, the authors are grateful to Mr. Guilloux for the genealogical information conveyed to the authors on 26 March 1993.

6 Archives of the Louvre, P 16 (July 1832).

7 Oral communication from Jacques Joyerot, reliner at the Musées Nationaux, for the entire Leguay period.

8 We know Puget's thin face and silhouette from four photos that appeared in an article in *Science et vie* which reported on the techniques used at Leguay's studio (cf. Routy 1924:149–52).

9 A publicity label of 1914 that mentions cradling bears the name of Kiewert and the date 1841.

10 A publicity label of 1914 that mentions cradling bears the names of the partners Chauffrey and Govaert.

11 Before forming this important partnership, Muller had practiced from 1930 to 1931 on rue de Seine and then formed a partnership with A. Pouget. The studio became R. Muller Successeur (from 1932 to 1938 at 8, rue Christine, then, from 1938 to 1945, at 11, rue Jean Ferrandi) (Archives of the Rostain studio, Paris). There are bills from this period for cradling pictures of the Louvre (Archives of the Louvre, P 16 [1942–56], Muller, estimate of 10 October 1942).

12 Oral communication of E. Rostain regarding the entire Chauffrey period to the present.

13 Archives of the Louvre, P 16 (invoice of 2 April 1949).

14 Archives of the Louvre, P 16 (invoice of 1 August 1957).

15 Archives of the Louvre, P 16 (1968), Maridat.

16 Archives of the Louvre, P 16 (1957–74), Lepage.

17 Archives of the Louvre, P 16 (1957–74), Rostain.

18 Archives of the Louvre, P 16 (1957–74), Chauffrey-Muller, Gérant Rostain, 31 July 1965; and personal communication from Emile Rostain, 13 April 1964.

19 Archives of the Louvre, P 16 (1968).

20 In the Archives of the Louvre, there is no Landry file in the biographical index; however, there are many invoices for the period 1840–49 in the archives P 16 (1840–49).

21 Under Louis-Philippe there was a tendency to put a brown coat of oil on the backs of panel paintings as a means of preventing rapid shrinkage of the wood. This coat resembles the *maroufle,* the residue of the paint cup, oily and full of lead, often reddish, pigments, a composition with multiple benefits. As a nonaqueous adhesive, it is used to glue canvases to walls and ceilings without shrinking the fabric; it also functions as a barrier against humidity. However, there is the risk that any paint layer put on the reverse of a cradled panel could block a sliding cradle, causing eventual stress and thus a split (Bergeon 1990:30–31).

22 Archives of the Louvre, O 30.

23 Archives of the Louvre, P 16 (1843).

24 Archives of the Louvre, P 16 (1843); a letter from Landry annotated by Granet.

25 Selection tests for restorers are documented in the archives of 1769–98 and 1848; since 1936 they appear quite regularly.

26 Archives of the Louvre, P 16 (May 1848): draft by Villot, unsigned but in his handwriting.

27 Archives of the Louvre, P 16 (1882).

28 On the history of the restoration of paintings at the Louvre, see Emile-Mâle 1991.

29 Archives of the Louvre, P 16 (1942–56); see, for example, Castor, estimate of May 1953 for the repair of the *Retable du Parlement de Paris:* "to unglue all the sliding bars of the cradling, which were glued by a former painting [*sic*], to make each bar function in its notched slats to secure the effectiveness of the cradling. To tighten the two vertical fractures and fasten them with notched dovetails, the notched slats constricting the placing of the dovetails, which were taken off and then put back: 16,000 Fr."

30 Archives of the Louvre, P 16 (1957–74, invoice of 28 June 1957).

31 Archives of the Louvre, P 16 (1942–56, Castor, invoice of 15 December 1955).

32 *Museum* 1955; and Archives of the Louvre, P 16 (1953), Castor, van Eyck, *La Vierge du Chancelier Rolin*.

33 Xylamon: pentachorophenol and octochloronaphthalene (Baldi et al. 1992:217–18).

34 Archives of the Louvre, P 16 (1942–56), Castor: (M 503) Rosselli, *Annonciation*.

35 Rf 1956, Sassetta, *La Vierge et l'Enfant Jesus entourés de six anges, Saint Antoine de Padoue,* and *Saint Jean l'Evangéliste*. These three poplar panels, previously unbacked, were entrusted to the Istituto Centrale del Restauro in Rome between 1956 and 1959; the central panel was previously restored by Brisson-Leguay in 1903–4 but split in 1956. It was treated by (very narrow) incisions and inlays, then received a modern Italian-style cradling "of the edge [*de chant*]" (metal crossbars sliding on wooden cleats).

36 Rf 1762-1, Josse Lieferinxe, *Le Calvaire;* the walnut was particularly burred and worm-eaten, and the boards had come completely apart. Entrusted in 1964 and 1965 to the Istituto Centrale del Restauro, the panel received three sliding crossbars.

37 On transfer in France, see Marot 1950; Emile-Mâle 1957, 1962, 1982a, 1982b, 1983a, 1983b, 1987; Emile-Mâle and Borelli 1957; Emile-Mâle and Delsaux 1984, 1987. On transfer in Italy, see Baruffaldi 1834; Bodart 1970; and Bergeon 1975.

38 The sparing transfer was practiced in 1747 on Van den Meulen and that of 1748 on Palma Vecchio's *Mise au tombeau;* see Vindry 1969:46–47. The phrase "sparing transfer" means that the support is saved, or spared; cf. Vindry 1969. G. Emile-Mâle, in conjunction with the chemist Jean Petit (former director of research at the Centre National de la Recherche Scientifique), has demonstrated the technical possibility of such a procedure, although it is not without real danger, as this lifting of the paint layer involves a distinctive microfragmentation. This phenomenon is noted in Andrea del Sarto's *Charité* (transferred in 1750–51) and in Raphael's *Le Grand Saint Michel* (Louvre), which must have been transferred in the same way in 1751.

39 The transfer of the support with destruction of the original wood has been the usual procedure, in any case, ever since Raphael's *La Vierge de Foligno* (cf. O'Reilly 1801). It was probably already the procedure used for Raphael's *Sainte Famille* (Louvre), transferred in 1777, which has proved to be in only a slightly fragmented condition. *L'Incrédulité de Saint Thomas* by Salviati (Louvre), transferred in 1809 by the younger Hacquin, is in only a slightly fragmented condition, as is Raphael's *Le Portrait de Jeanne d'Aragon* (Louvre), transferred in 1810 by the younger Hacquin (cf. Lautraite 1983).

40 Archives of the Louvre, P 16 (26 May 1799).

41 Archives of the Louvre, Accounts, Year 11 (1803), fourth quarter; and Emile-Mâle 1983b.

42 Proceedings of the administration of the Musée Central des Arts, 28 nivôse, Year 7 (17 January 1799).

43 Archives of the Louvre, P 16 (1882).

44 Archives of the Louvre, P 16 (10 July 1755).

45 Vindry 1969; in fact, it was a picture of Neefs, *Saint Pierre délivré de prison,* Louvre (inv. 1591).

46 Inv. 748, Titian, *Le Couronnement d'épines:* Archives of the Louvre Z^4O-1796-sd (but actually from 31 July 1799). See also IBB^{4}Z (25 August 1798); IBB^5 (4 and 19 December 1800): and Archives Account, Year Nine (1801).

47 Archives of the Louvre, Accounts (second quarter, 1796–97), administration of the Musée Central des Arts.

48 Marijnissen 1967:n. 62: letter from the marquis de Marigny dated from Ménars, 18 September 1770. The cradle currently visible on the back of Rubens's *La Kermesse* (Louvre, inv. 1797) either is from 1770 or is the cradle that could have been redone in 1825 by François-Toussaint Hacquin (Archives of the Louvre, P 16, September 1825); it comprises twelve slats, one of which is thicker and glued (not molded), and seventeen mobile crossbars.

49 Archives of the Louvre, P 16 (1882) (cf. n. 43).

50 *Mouseion* 1938:243: this expression, "of field [*de champ*]," will become "of edge [*de chant*]" in Marijnissen 1967:319.

51 Painting on poplar backed with chestnut but not cradled: Ambrogio di Baldese, *La Vierge et l'Enfant avec six saints*. Pictures backed and cradled: Matteo di Giovanni, *Sainte Catherine de Sienne,* and Master of the Crucifix of Pesaro, *La Crucifixion* (Avignon, Musée du Petit-Palais, C 215, MI 369; C 200, MI 578; and C 216, MI 420, respectively).

52 Investigation of S. Bergeon, 1982.

53 See Diderot and d'Alembert 1765:596.

54 Archives of the Service de Restauration des Musées Nationaux. The very old split affecting the upper part of the *Mona Lisa* was the subject of a palliative treatment of two walnut dovetail tenons, glued with a fabric in between to prevent what was believed to be too much stress. These dovetail tenons required that the poplar be hollowed, but only slightly (less than a third of the thickness of the original panel). The restorer Denizard, who came to the Louvre in 1887, said that this repair was made by Bouvard; this examination of the back is mentioned in 1911, just after the theft of August 1911, as a major testimony for the identification of the work.

55 Lead white, basic carbonate of lead, with its excellent drying properties, has often been used mixed with oil. It was believed that this would harden wood. After such treatment, the back was covered up with brown paint: X radiography reveals the very worm-eaten condition of the wood when the tunnels are filled in this way (Rembrandt, *Le Boeuf écorché,* Louvre, M 169).

56 Permali is the commercial name of a wood impregnated with Bakelite, a hard resin, so that the wood is not highly reactive to variations of atmospheric moisture content.

57 Archives of the Service de Restauration des Musées de France: Leonardo da Vinci, *Mona Lisa;* attacked by worms, those very flexible beech crossbars were replaced in 1970 by similar ones of maple, which was aged and pretreated with Xylamon.

58 Initially part of the Musées Nationaux, but as of 1966, incorporated into the adminstration of the Musées de France.

59 For two centuries, it was the practice at the Louvre for an artisan or a member of a profession to work in a state building, to be supervised by the state within the large-scale apparatus of the state, but to retain private status and supply self-owned equipment.

60 Archives of the Louvre P 16 (1957–74, invoice of 15 November 1965). C. Huot's first work concerns the cradle of *La Déposition de la Croix,* by the Master of Saint Barthelemy.

61 Illustrated in Bergeon 1990:24, fig. 2: Benvenuto di Giovanni, *Le Martyre d'un évêque,* Musée du Petit-Palais (MI 514), Avignon; this precise intervention was made in 1967.

62 For a discussion of Paraloid, see Mora and Toracca 1965. For a discussion of the mobile crossbars, see Carità 1956.

63 In 1968 works of sverzatura were undertaken for Bartolo di Fredi, *Adoration des bergers* (C 71, inv. 20267), and Zanino di Pietro, *Polyptyque* (C 74, MI 421).

64 Bazin insists on "the importance of the support in the historical document which the painting constitutes"; the destruction of the support comes from "radical measures affecting the integrity of the object" (Marette 1961:11).

65 Archives of the Louvre, P 16 (1957–74), Huot RF 1981, G. Moreau, *Hésiode et la muse* (thinned to 2 mm; glued on marine-grade plywood of 8 mm and cradled): 900.

66 Archives of the Louvre (17 May 1968), C 426, Pérugin, *La Vierge et l'Enfant dans un gloire de séraphins* (MI 551).

67 See, for example, Archives of the Louvre (18 June 1970), Florence, Jacopo di Cione, *Le Mariage mystique de Sainte-Catherine* (MI 409, C 73) (thinned to 2 mm and glued on a latté with the back re-covered with a thin plate of old wood).

68 School of Romagne, *La Vierge et l'Enfant entre Saint-Pierre et Saint-Jean-Baptiste avec deux anges agenouilleés* (MI 491, C 267).

69 See Rostain 1981. The plywood approved for marine use derives its resistance to humidity and to severe external stresses from the choice of excellent wood and of adhesives that age well. The latté is composed of boards pressed between two thin sheets of wood the grain of which runs perpendicular to that of the boards. The thickness of the boards corresponds to three-quarters of the total thickness.

70 Fresco V. Mottez, *Mme Mottez* (Louvre, RF 1296), previously unfastened; the reinforcement of the support was done by Mme Berteaux (cf. N. Volle 1989, p. 16).

71 A. Solario, *La Déploration sur le Christ mort* (Louvre, RF 1978-35) (cf. Volle 1989:18).

72 The first experiments with balsa took place in the United States at the Fogg Museum and were carried out by R. D. Buck in about 1930. Balsa backings are still in use; the issue was recently discussed in Brussels at l'Ecole de la Cambre under J.-A. Glatigny (Habaru 1990–91).

73 Archives of the Louvre, P 16 (1957–74): Huot, 15 November 1965: Palmezzano, *Le Christ mort entre deux anges* (Louvre, MI 680), three wood crossbars hollowed on the side of the panel and cleats glued.

74 In working out the system of mobile backing in Altuglass, the important role of René Guilly (d. 1992) must be noted. Guilly advocated ongoing research as a component of the restoration policies governing wood supports.

75 The system of cross-grain tenons is found not only in Quarton's fifteenth-century work *La Pietà* but also in Hugo van der Goes's *La Mort de la Vierge* in Ghent; the system is found later, more rarely, in the seventeenth century, as in Le Sueur's series on the history of Saint Bruno for the charterhouse of Paris.

76 The term for "mechanical" (Fr. *méchanique,* It. *meccanico*) is generally used in the eighteenth century in archival texts and has to do with the supports of painting; this term is used in opposition to "picturesque"—referring to aspects that have to do with the paint layer.

77 Concurrent with the emergence in Rome of the study of the history of art, in late eighteenth-century Italy a great deal of thought was devoted to restoration. The comments of the restorers and their technical analyses of various styles were very influential (Chastel 1974). The philosophy of restoration was formalized with regard to architecture in 1809 by G. Valadier; only later was it formalized for painting, in 1936–38, by the art historian Cesare Brandi. Brandi's role was extremely important and explains why, from 1950 to 1970, Italy was the crucible of several experiments, including those concerning wood. The research projects of Giovanni Urbani in 1970–71 must also be mentioned.

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Richard Buck

The Development and Use of the Balsa Backing for Panel Paintings

James S. Horns

The notoriously reactive nature of wood to environmental conditions presents special problems for the conservation of panel paintings. Occasionally the construction and history of particular paintings have resulted in excellently preserved objects. Unfortunately, splitting, warpage, and insecure design layers of many panels have justly inspired concern for their stability.

Ideally, environmental control provides the least intrusive and best protection. This is not always possible, or it can sometimes be only partially achieved. Allowing an unencumbered panel to react with dimensional and conformational changes can prevent imposed stresses, but the movement itself can result in an unstable design layer. Moisture barriers and enclosures can reduce these changes, but in many cases it may be necessary to consider various forms of restraint and reinforcement to stabilize the panel structure. The discontinuous reinforcement of cradles and various batten systems has the disadvantage of allowing the panel to react to environmental change and subject it to unevenly distributed stresses. Reinforcement, which provides a continuous and uniform support, can take several forms. The complete transfer of the design layer to a new support has often been accomplished. Success in stabilizing and adding dimensional security has been reported for a partial transfer system in which the panel is substantially thinned and mounted on a more dimensionally stable support (Suhr 1932; Tintori and Rothe 1978).

Another approach grew out of work done at the Fogg Museum of Art of Harvard University in the 1930s and 1940s; this approach was developed by Richard Buck into the balsa-block backing that has been used successfully for many years. This system is intended to provide structural reinforcement, a moisture barrier, and some mechanical restraint of the panel, while keeping the alteration of the original to a minimum (Buck 1963, 1972; Spurlock 1978).

Treatments at the Fogg Museum of Art, 1927–1952

Under the direction of George Stout, the conservation program at the Fogg Museum of Art made many important contributions to the treatment of paintings, not the least of which is a treatment policy that stressed stability through removal of aspects of insecurity and addition of uniform reinforcement where necessary. David Kolch has provided an invaluable review of the development of this treatment approach and its results (Kolch 1977, 1978). He was able to compare the artworks' condition described at the time of treatment at the Fogg with their condition in the mid-1970s. The panels were found to be stable; flaking and other instabilities, which had plagued these paintings prior to their treatment, had been eliminated.

Stout, who initiated the consideration of characteristic panel paintings problems at the Fogg, was soon joined by Murry Pease and Richard Buck. Kolch documented the treatments done over the years from 1927 to 1952. The paintings treated suffered from unstable design layers and supports, wood deterioration and deformation, and inappropriate reinforcement. The intention of treatment was to stabilize and preserve the design and structure without removing more of the original than was necessary for consolidation. Furthermore, the treatments were designed to avoid the addition of reinforcement that would be incompatible or introduce new problems (Buck 1947; Stout 1955; Pease 1948).

While details of these treatments vary greatly, it will be useful to review the general approach. Additions such as cradles or previous transfer panels were removed where they caused damaging stresses or interfered with access for consolidation. Severely deteriorated or insect-damaged wood was removed. These removals occasionally extended to the gesso or paint layer in local areas, or even to the entire painting. The intention, however, was to preserve as much of the original structure as possible. Reconstruction materials included gesso, wax-resin, bulked wax-resin mortar, fabrics, redwood strips, balsa-wood strips and blocks, and aluminum strips and tubing in a variety of combinations. Where the original gesso or paint was exposed, gesso and fabric reinforcement were often used prior to the filling of voids with wax and balsa, or the building up of larger areas with wax and redwood strips. Several panels were flattened with moisture—a procedure aided by channels cut in the panel—prior to the final backing. Wax and fabric were often used to finish the back and to provide a final moisture barrier.

It is instructive to review several of these treatments to understand the development of this method. The information here is based on David Kolch's research on the conservation records of the Fogg Museum of Art, as well as some of the original treatment records (Kolch 1977). These records show that the end-grain, balsa-block backing method is an outgrowth of extensive treatment experience.

One of the earliest treatments reviewed was carried out from 1934 to 1936. The treatment involved a panel with areas of severe deterioration from insect tunneling. In the first stage of treatment, the powdery damaged wood was removed down to the original gesso in local areas, and the voids were filled with a layered structure of a damar-wax mixture (4:1), linen gauze, damar-wax putty with chalk and hemp fiber, and redwood blocks. Two years later, deteriorated wood was more extensively removed over most of the panel, but apparently a thin layer of original wood was left next to the gesso. In this treatment, wax-resin bulked with shredded cork and hemp fibers was used to level the back over the thin remaining wood. This layer was covered with fabric and layers of balsa wood strips embedded in the wax-resin putty. In Kolch's examination, this painting was one of the two that showed adverse effects from treatments. On this painting, a slight surface depression, visible in raking light, roughly follows the area of reconstruction; within this area a bulge (approximately 8×15 cm) is presumed to correspond to part of the first excavation and reconstruction. It is interesting to note that in the first stage of reconstruction, the adhesive used was made mostly of resin, with wax added. In contrast, the second stage used a largely wax adhesive, with resin added. The wax-resin mixture used in the second stage was also used in various forms in the subsequent reconstructions.

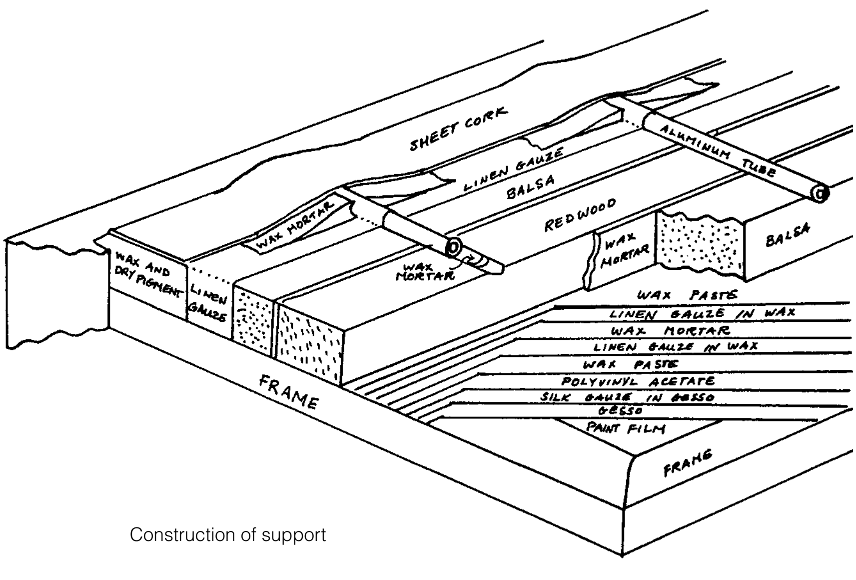
The treatment of many panels followed this general form: original panel material was removed where the wood was too damaged by insect tunneling to provide adequate support or where it seemed necessary to allow secure consolidation of the paint film. Occasionally this meant a complete transfer, but often the excavations were limited to only small sections of the panel. Sometimes these excavations extended to the back of the paint film, but, where possible, a layer of original wood was left in place next to the paint.

Where an overall backing was required, it was usually made up of wooden battens and cross bracing. A diagram taken from the treatment records shows the elements of the 1937 reconstruction of two panels (Fig. 1). Although he did not examine these panels personally, Kolch reports that the condition of the treated panels was stable as of 1966, while an untreated companion panel continued to show blistering of the paint.

In 1938 a set of four panels was treated to flatten and reinforce them. These panels were scored diagonally on the reverse and moistened to reduce the warp. Channels were then cut parallel to the grain and filled with bulked wax-resin and hemp fibers. This treatment also included the addition of aluminum tubing set across the wood grain to add strength. The stability and surface conformation of these panels were found to be excellent. Channels cut along the grain to reduce the warping and aluminum tubes or bars placed across the grain were used on several paintings in the following years.

A dramatic example of this reconstruction method was carried out in 1939 and 1940. The treatment record includes the initials of both Murry Pease and Richard Buck. The painting measured 170.5 × 123.0 cm and had a thickness of 1.9 cm. It had been thinned and cradled before 1917 and after that continued to show instability of the paint and multiple convex warps. Insects had done extensive damage to the panel. The treatment included the complete removal of the original panel, as well as much of

Figure 1
Diagram of a panel reconstruction, Fogg Museum Laboratory, 1937.



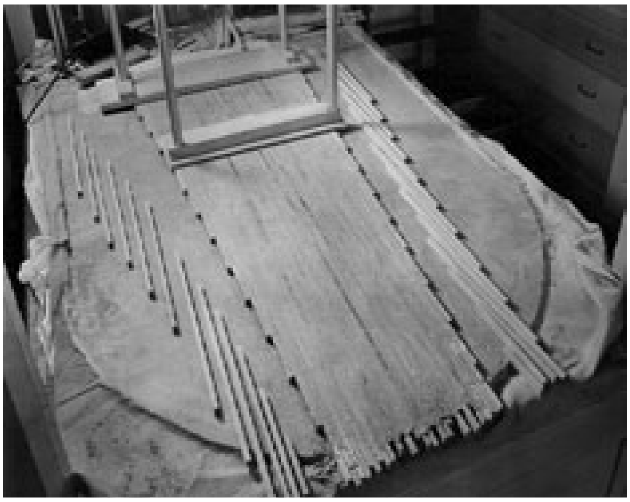
the gesso layer. New gesso and silk gauze were applied to the back of the remaining gesso layer, followed by a linen fabric and wax-resin paste. The backing was constructed with redwood strips parallel to the original grain of the panel; a wax-resin bulked with sawdust was used as an adhesive. This backing was reinforced with a grid of aluminum bars and tubing, and the spaces were filled with balsa-wood blocks. The back was then covered with linen fabric (Figs. 2–4). Kolch's examination found this painting sound, except for flaking in one small area that had been retouched.

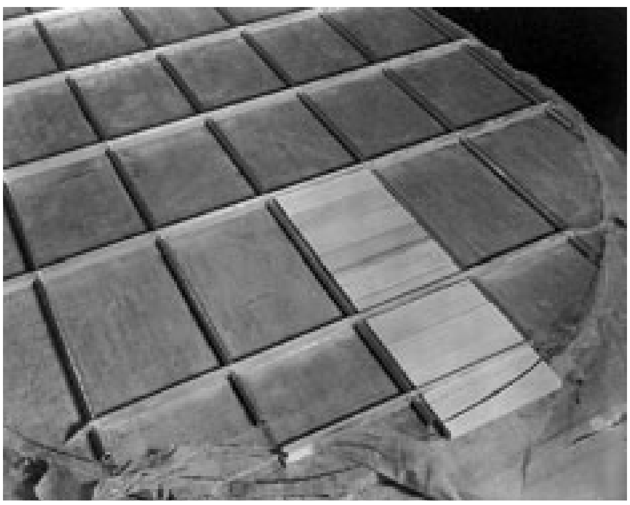
A painting treated in 1945 also involved the building up of a panel on a complete transfer in a similar way. In this case, because a previous transfer backing had left the paint layer insecure, the backing was removed. Unfortunately, the redwood backing applied to this painting differed from that described above, in that three horizontal strips of redwood were applied first, and the vertical strips applied between them were "nicked" to allow air and excess wax to escape. Kolch reports that a pattern from this backing is now visible on the face of the painting. It seems likely that structural discontinuities of wood-grain orientation and pockets of wax are responsible for this distortion. Other paintings built up with redwood strips do not show such distortions relating to the backing.

Figure 2, right
Panel reconstruction, Fogg Museum Laboratory, 1940. The attachment of redwood strips.

Figure 3, below
Panel reconstruction, Fogg Museum Laboratory, 1940. The addition of balsa blocks and an aluminum grid.

Figure 4, below right
Panel reconstruction, Fogg Museum Laboratory, 1940. The sheet cork and linen finishing layers.





Kolch quotes from a treatment proposal prepared by Richard Buck in 1948 that clearly illustrates the thinking behind these treatments:

> The weakness which contributed to the present disintegration lies in the gesso which was added at the time the painting was transferred to its present oak panel. This gesso is now chalky, and can be ruptured by minor tensions or compressions which are transmitted to it by the wooden panel. . . . The risk to the security of the painting can hardly be exaggerated. In order to get at this region of weakness, it will probably be necessary to remove the present oak panel, replace the granular gesso support with a safer gesso layer and rebuild a composite wood support which will relieve the dimensional compressions now plaguing the paint. The composite panel I speak of is one that was developed by George Stout and this laboratory, and has been used on a number of paintings. Its particular merit is that it is almost completely unresponsive to atmospheric variations. (Kolch 1977:41)

Two of the last treatments carried out at the Fogg Museum while Buck was there seem to lead directly to the balsa backings that were characteristic of those done in the early 1950s at the Intermuseum Conservation Association at Oberlin College, Oberlin, Ohio; this organization is a cooperating group of museums that supported a conservation center as a joint resource.

In 1950 a panel at the Fogg Museum that had been backed with a secondary mahogany board was treated by removing the backing and revealing the original panel. This panel was thinned, but no channels were cut to reduce the warp, and, in fact, the warp was intentionally retained when the back was reinforced with balsa boards (approximately 1.25 × 15 cm) that were adhered with a bulked wax-resin. These balsa boards were oriented with the grain parallel to the original grain of the panel.

The last treatment Kolch describes from this period at the Fogg Museum makes use of a grid of balsa blocks cut across the grain (Fig. 5). This grid was applied to the back of a small circular painting with a history of insecurity; it had been treated with consolidants since 1939. Finally, in 1951, the cradle was removed and the panel thinned to 2 mm. The treatment record includes the following description by Buck:

> The insect tunneling was filled with a gesso-like mixture of polyvinyl acetate and white inerts. Into this layer a piece of linen was pressed and allowed to dry under moderate pressure. A new support was built by applying a wax resin plastic filler, molten, to small rectangular crosscut blocks of balsa wood,

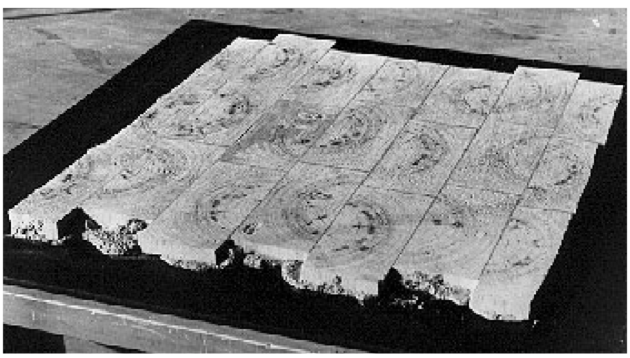


Figure 5
Balsa-block backing, Fogg Museum Laboratory, 1951.

> about $^5/_8$ [in.] in thickness. These blocks with adhesive were pressed by hand onto the fabric surface in a brick-like pattern and allowed to cool. After covering the surface of the painting, the edges were trimmed and light hardwood strips were attached with the same adhesive to all edges. The back of the construction was smoothed and a sheet of $^1/_8$ inch Masonite was attached to the back surface in the same adhesive. (Kolch 1977:46)

This panel has remained stable and free from the insecurities that had been chronic prior to the treatment.

Balsa-Block Backing at Oberlin

In 1952 Richard Buck established the Intermuseum Conservation Association at Oberlin College. There he continued to refine the backing methods. He and Delbert Spurlock used this end-grain balsa-block method with more emphasis on backing and reinforcement, less emphasis on excavation and reconstruction. The method also featured the inclusion of fiberglass cloth embedded in Saran F310 resin between the panel back and the block-and-wax backing. While this layer provided a moisture barrier, it was also designed to function as a natural layer of separation that would release if internal stress became too strong. This is possible because of a relatively weaker bond between the Saran and wax layers. Warped panels were generally backed in a relaxed state, with the backing conforming to the warp. Buck has reported that over the period from 1952 to 1970, the treatment of some fifty paintings in this manner greatly reduced or eliminated paint instability (Buck 1970, 1972).

The details of the balsa-block backing used at Oberlin are described elsewhere (Spurlock 1978), so the method will only be described here briefly (Figs. 6–10). All extraneous elements are removed from the back surface, and the exposed wood is coated with Saran F310 resin.[1] A layer of open-weave fiberglass cloth is adhered with a second coating of Saran resin. The balsa blocks are cut across the grain and attached with a wax-resin mortar made up of wax-resin bulked with wood flour and kaolin. Strips of pine are often added across the grain of the panel at the back surface of the balsa blocks as reinforcement. Finally, the back is smoothed and coated with Saran resin and a finishing varnish.

Buck did not view this method as a recipe for the treatment of all panel paintings but saw it, instead, as a method appropriate for many cases. He recognized that details of the method can be varied without compromise to the general principles. For example, the thickness of the balsa blocks and the use of pine battens can be adjusted to suit the panel. The Saran layer can be replaced with a more stable but less effective moisture barrier such as Acryloid B72, or the wax can be applied directly to the panel. Variations, however, should be considered in light of his summary of the desirable attributes of this backing method: "In theory this treatment combines the favourable aspects of the relaxed panel with those of the system of fixed mechanical control. The supplementary panel contributes high moisture barrier efficiency to reduce the movement of the original support, and imposes some mechanical restraint to persistent swelling and shrinking. It stabilized warp near the point of minimum normal strain. Although the applied panel has sufficient rigidity to serve its purpose, it possesses a degree of yield. The danger of panel rupture from the rigid control is not eliminated, though I believe it is not high" (Buck 1961:162).

Figure 6
Back of a panel painting after cradle removal.

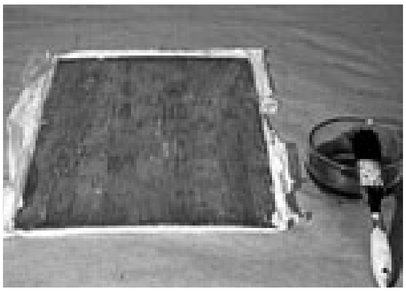


Figure 7
Fiberglass cloth and Saran F310 resin layer added to the panel back.

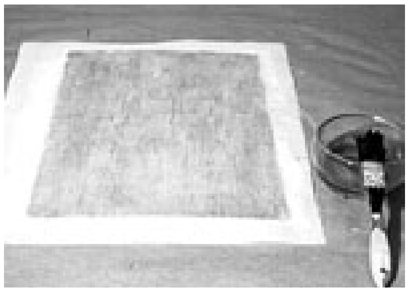


Figure 8
Fiberglass cloth and Saran F310 resin backing after drying.

Figure 9
Balsa-block backing in place.

Figure 10
Balsa blocks trimmed and smoothed.

Warp Reduction with Balsa Backings

Eventually the success of this backing system suggested that it could be used safely to reduce deformation in warped panels without thinning and channeling, as was done at the Fogg Museum. This process is accomplished by exposing the panel to moisture at the back surface until sufficient flattening has occurred. The Saran and fiberglass cloth layer is then applied, and while the panel is flat, the wax and balsa blocks are added (Buck 1972). The backing acts as a mechanical restraint while the panel, which has been flattened by exposure to moisture, slowly dries and undergoes relaxation of stress. This extension of the basic backing obviously adds many uncertainties and complications and was not a technique Buck frequently practiced. A painting treated by this method in 1967 (Buck 1972) has been examined recently; it remains in stable condition in its flattened state. At least one other flattening by this method has been published, with good results (Reeve 1981).

Moisture Movement and Panel Paintings

It may be useful to review some of the principles involved in interpreting the behavior of panel paintings, particularly as they illustrate the success of this backing method. Buck has carefully presented the essential material (Buck 1963, 1972); only a brief expansion on this framework will be attempted here.

Wood is clearly a nonuniform and variable material, for which sample differences can be of great significance. Certain consistent principles, however, can be used to understand and predict its behavior. Of particular importance is the relationship of wood and water. Buck demonstrated that aged wood retains its hygroscopic nature over time (Buck 1952).

He also demonstrated that while moisture barriers can slow the reaction of panels to environmental change, they probably cannot eliminate it (Buck 1961). Although wood structure, physical or chemical deterioration, environmental history, and so on, can affect the panels, in general, dimensional change follows moisture change. Many variables determine how this change manifests. In turn, these variables can be used to modify behavior in particular cases.

Wood can react to stress with changes that take the form of elastic or plastic deformations. By definition, elastic deformation will be reversed if the stress is removed, while plastic change will remain. In wood, however, the relation of these can be complicated, with moisture levels, moisture gradients, internal stresses, and external loads or restraints contributing significant variables. Buck, whose work was based in particular on that of W. W. Barkas (1949), stressed the importance of the potential for plastic change to take place below the fiber saturation point (Buck 1972). Barkas and Buck placed strong emphasis on the spring-and-dashpot model of elasticity and plasticity (Barkas 1949:80; Buck 1972:3). This description uses the spring to represent the totally recoverable elastic element and the dashpot (a plunger moving through a viscous material) to represent the plastic aspects of wood movement. The interaction of these two aspects is complex and highly dependent on moisture content and other variables. Buck has argued: "As the moisture content approaches the fiber saturation point, the bound water becomes almost a lubricant, permitting actual slippage of elements past each other under stress, as the much weakened bonds break and change partners. This kind of behavior is plastic. It creates none of the tensions that cause elastic reversal" (Buck 1972:4).

Barkas considered wood as a gel material and stressed the importance of moisture level and moisture movement in determining elasticity and plasticity in wood: "Wood fibres would behave elastically both longitudinally and transversely for strains which do not exceed the limit of bond recovery, but plastically for those strains which involve a change of hydroxyl partners. Also, if the moisture content were lowered while the displacement was maintained, the new shape would become 'frozen in' by the formation of a new set of direct hydroxel linkages in place of water bridges. But if the distortion were also to involve elastic strains, these would also be frozen in by the structure thus leading to the recovery when the wood is rewetted, even after a considerable lapse of time" (Barkas 1949:82).

While much work remains to achieve an understanding and theoretical model of these relationships, this passage reminds us of the importance of moisture movement in the development of elastic and plastic deformation. It is also important to remember that elasticity and plasticity can be dependent on defined conditions. For our purposes, for example, the elasticity released by very high moisture content and temperature could for all practical purposes be considered a stable situation in a panel painting; thus, the separation between plastic and elastic deformation becomes somewhat ambiguous.

Wood structure can retain two types of elasticity that can be undetected until released by mechanical or environmental change. The first type is differential stress in the larger wood structure. For example, if a case-hardened board is sawed, the two sections can show a pronounced warp due to the release of elastic strain. If such discontinuities are present in a panel painting, they could be released mechanically by thinning or environmentally by moisture change. The second type of elasticity involves the minute structure that Barkas has defined as a gel and that has the potential to revert when exposed to high or cycled moisture content.

The understanding of plasticity and elasticity presented by Barkas has been somewhat modified by evidence that places even stronger emphasis on the importance of moisture movement in wood in these behaviors. Since it is the cycle of moisture change that we know to be of concern for panel paintings, it is useful to consider this evidence.

Much work has been done by wood technologists on the phenomenon of creep. When wood is placed under load, it will slowly deform; the extent of this deformation depends on the stress and, in particular, on the moisture content. Beginning in the early 1960s, many studies have shown that cycling of moisture content greatly increases the rate and extent of creep (Armstrong and Christensen 1961). It has become clear that the movement of water in the wood structure is of primary importance in this behavior. The creep development that relates to moisture movement has come to be called mechanosorptive creep (Grossman 1976), while creep unrelated to moisture change is referred to as viscoelastic creep. As this second designation implies, creep unrelated to moisture movement is substantially elastic. Creep developed under moisture change also has elastic aspects. When the load is removed, the wood recovers somewhat, but if the sample is also then cycled through high-moisture content, there will be additional recovery. It has become apparent, however, that the permanent plastic deformation involved in creep depends primarily on moisture change.

A closely related phenomenon in wood is stress relaxation. If wood is placed under fixed strain, the stress will gradually decrease. Although much less work has been done on this behavior with cycled moisture than has been done for creep, moisture movement can also increase the potential for stress reduction (U.S. Department of Agriculture 1974:4–37). It should also be noted that there is some evidence that in stress relaxation, the potential for plastic change is as great in tension as in compression; under conditions of room temperature and moisture content below the fiber saturation point, it may even be slightly greater (Youngs 1957).

It seems then that moisture change and internal stresses may be significant in the development of warping. To elaborate on the functioning of the uniform backing, it is useful to consider the development of warping in panels and the potential for stabilizing or reversing it. The work done on creep seems to imply that moisture changes in the wood structure facilitate strain, which manifests in the direction of stress. In panel paintings, the typical convex warp can be the result of at least two factors. When a painting is brought into a drier environment than that of the original fabrication, the back surface can shrink, but the paint and ground layers restrain the wood on the front, and an initial warp develops. Subsequently, cycles of moisture change influence the back surface preferentially, and compression shrinkage develops as the outer layer of wood tries to expand against the restraint of the inner core, due to the uneven moisture gradient. One might wonder why the reverse process does not neutralize this effect during the cycles. If a panel equilibrated to a high moisture content dries preferentially at the back surface, would not a moisture gradient develop and a strain in tension reverse some previously established compression shrinkage? This outcome certainly could happen, as the well-known phenomenon of case hardening in the lumber industry illustrates.

Several factors reduce the ability of this process to prevent the development of warping in panel paintings. In the first place, many cycles of moisture change are short-term; therefore, the important changes do not penetrate to the core of the panel—thus, compression at the back surface is the predominant effect. Second, under extreme conditions, wood structure may be more easily altered in compression, where the structure can collapse in various ways; while in tension, structural changes are more difficult, and rupture can result before significant deformation is reached. Finally, studies of mechanosorptive creep have shown that it is difficult to reach a limit in compressive creep, but in tension, a limit does seem to be present (Mohager and Toratti 1993; Rice and Youngs 1990). The implication of these findings is that the warp in a panel painting can develop simply from the reaction to moisture cycles.

As an illustration, the author has produced a warp of this type. Six samples of poplar were coated on one side with a moisture barrier, and a strain gauge was applied to this side across the grain of the wood. The samples were then exposed to various moisture conditions at which their weight, dimensional change at the strain gauge, and warp were recorded. In two cycles where the samples were equilibrated to very high relative humidity (RH) and then equilibrated to lower levels, only a slight change in the measured warp was found. They were then exposed for shorter periods to high RH and equilibrated to the lower levels. After these shorter exposures, the warp of the samples increased noticeably. The strain gauge measurements suggest that this warp was due largely to dimensional change at the concave surface, which is analogous to shrinkage at the back of a panel painting. This study emphasizes the potential of short-term moisture changes to induce warping and, therefore, the important function that moisture barriers and environmental control serve. From this reasoning, one might infer that even if the sliding members are not restricted in their movement, a cradled panel could develop the typical "washboard" conformation because of the continued buildup of compression at the back surface. Of course, many panels, both cradled and uncradled, appear to have survived many cycles of environmental change with little or no warping. This fact emphasizes how difficult it is to generalize about a material when so many variables separate one sample from another.

Because it serves as a moisture barrier as well as a mechanical restraint, the balsa backing should protect the painting against the increasing stress or warp that can develop from exposure to short-term moisture fluctuations.

Flattening of Panels

When the balsa backing is used to reduce a warp in a panel, the potential for introducing compression at the paint surface increases, bringing the risk of insecurity between paint and support. Therefore, if one can produce deformation in tension at the back surface, this method may reduce compression at the painted surface that could aggravate paint insecurity. For example, Figure 11 shows that a warped board forced flat will develop planes of strain in which compression increases toward the formerly convex surface, and tension increases toward the formerly concave surface.[2] Thus, in a panel held flat by a cradle in elastic strain, one would expect substantially increased compression at the paint surface. Can this risk of compression be reduced? One way to do so would be to thin the panel prior to flattening. By reducing the distance between the neutral plane and the paint, the compression will be lessened. The intention of the balsa-backing method is to introduce as much deformation in tension at the back surface as possible. One of Buck's favorite demonstrations was to swell samples of wood and then glue battens to one side with their grain running perpendicular to that of the samples. When the samples were dried, the battens were removed, revealing a permanent warp due to the restraint the batten provided to the shrinkage of one side of the sample. Part of the intention of flattening with the balsa backing is to similarly restrain the shrinkage of the back surface and allow for plastic deformation and relaxation of stress as the panel slowly dries to equilibrium. By reduction of the warp with moisture and application of a balsa backing, it is hoped that the reduced compression of the painted surface will result in a panel with a minimum of elastic strain. Figures 12 and 13 show that it may be difficult to eliminate compression at the paint surface during any flattening with moisture. While strain gauge measurements on this sample show that compression at the upper surface was somewhat less during flattening with moisture than when the sample was simply clamped flat, there is still substantial compression. As the moisture content was raised past the point of initial flattening, this compression began to decrease (Fig. 14). Buck's description of the flattening and balsa backing includes just such an extended exposure (Buck 1972:8). This approach could help to reduce the risk of permanent compression being introduced at the paint surface. The individual circumstances of each flattening operation make the conditions at the paint film uncertain, however. There are risks with any flattening operation, and such treatments should be approached with the greatest caution.

Summary

Perhaps the most appropriate use of the balsa-backing method is for paintings that have a history of insecurity and that will be exposed to a poorly controlled environment. In the author's experience with balsa backings, panels show good stability after treatment, as well as a reduced susceptibility to movement and insecurity. One case in particular seems to illustrate this point. This panel is privately owned and has been subjected to the rather severe environmental fluctuations of a northern climate. The panel was brought to Minnesota in 1977 and immediately developed extensive tenting of the paint during the first winter. Previous losses indicated that this had been a chronic problem. A cradle (perhaps fairly recently applied) was present. It was restraining the panel in such a way that a slight concave warp developed. When the cradle was removed, the relaxed panel took on a slight convex warp. This warp was retained when the balsa backing was applied. In the years since the treatment, there has been no new flaking in the original paint, although recent examination found a small area of filling that had loosened. The owners indicate that some movement of the panel from season to season is visible in relation to the frame edge, but this has not been measured precisely.

Similarly, the balsa backings done at Oberlin of which the author is aware have shown good stability. There is one instance in which a mechanical problem led to a precipitous drop in RH in a gallery. Several panels developed tenting and insecurity in the paint, but two panels backed at Oberlin showed no adverse effects.

Although the elastic and plastic aspects of deformation are not easily separated, their presence has much to do with the treatment of

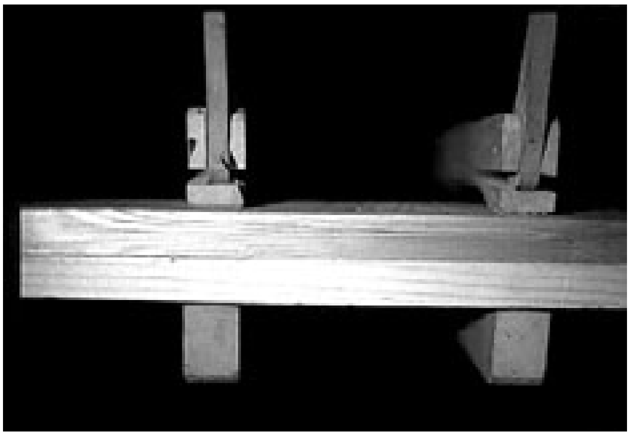


Figure 11
A warped wooden sample, with polycarbonate glued to one edge over a layer of silver paint, has been clamped against a flat surface to eliminate the warp. When illuminated with polarized light and viewed through a polarizing filter, this photoelastic material shows the variations in strain as colored fringes. The darkest lines (one-third of the way down from the top surface) represent the least strain. Compression increases toward the top, tension toward the bottom.

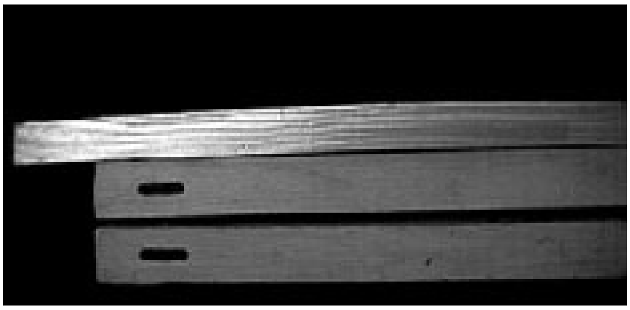


Figure 12
The same sample shown in Figure 11, after exposure to moisture at the concave surface for several hours. The warp was slightly reduced, and compression began to develop at the top surface. Swelling produced tension in the photoelastic material at the concave lower surface.

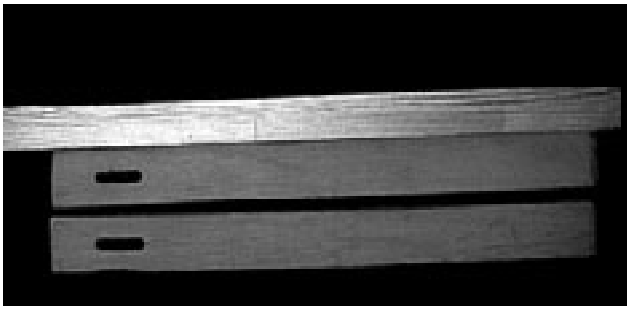


Figure 13
After twelve hours the sample was flat, and substantial compression developed at the top surface, along with tension from swelling at the bottom. Strain gauge measurements at the top surface indicated that the compression produced by this flattening was somewhat less than that produced by the clamping seen in Figure 11.

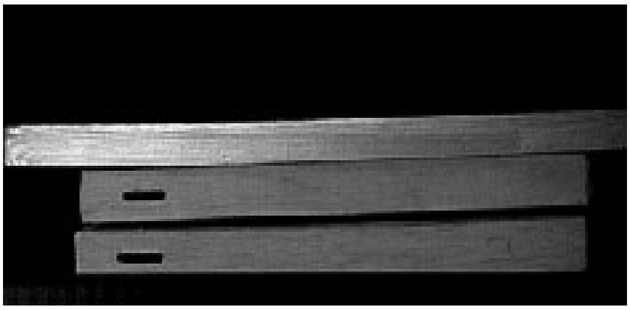


Figure 14
After further exposure to moisture, the sample began to develop a slightly reversed warp, and compression at the top surface began to decrease.

panel paintings. It seems fair to say that the intention of the uniform backing is to produce a panel with a minimum of elastic strain, so that the wood structure is as relaxed as possible. Thus, if a panel is warped and the backing simply supports this conformation, the previously developed plastic change is retained. In the event that the backing has imposed a reduction in the warp, it is intended that the reduction of warp will have a high degree of plasticity due to the gradual drying under restraint from the backing. Furthermore, Buck felt that although the balsa backing itself might tend to react to environmental fluctuations slightly, it would, nevertheless, provide some restraint to the movement of the panel, thereby reducing the stress imposed on the paint film (Buck 1963:162).

The uniform balsa backing can provide a stable support that resists warping from environmental exposure or from the release of undetected elastic strain. In addition, in future cycles of moisture change, this restraining backing may reduce some internal elastic strain, a factor that is particularly significant when the reduction of a warp is involved. In such cases it is anticipated that the restraint of the backing during the initial drying of the flattened panel and during subsequent cycles may allow a form of mechanosorptive relaxation to establish an increased internal stability in the wood structure.

It seems clear that the use of a uniform backing—and in particular the balsa-block method—has a history of success and is an important treatment option.

Acknowledgments

Use of the records and photographs from the Fogg Museum Laboratory, as well as permission to use unpublished material compiled by David Kolch, is through the courtesy of the Straus Center for Conservation, Harvard University Art Museums.

Notes

1 Saran F310 resin is soluble in methyl ethyl ketone for brushing.

2 For this sample, a 2 mm thick sheet of Lexan polycarbonate was attached with clear epoxy resin. In this sample, the author used an SR-4 model strain gauge (BLH Electronics).

Materials and Suppliers

Acryloid B72, Rohm and Haas Co., Independence Mall Street, Philadelphia, PA 19105; Conservation Materials, Ltd., 100 Standing Rock Circle, Reno, NV 89511.

Clear epoxy resin, Devcon Consumer Products, 264 Howard Ave., Des Plaines, IL 60018.

Lexan polycarbonate, (General Electric) Cadillac Plastic and Chemical Co., 1218 Central Ave. N.E., Minneapolis, MN 55414.

Materials specifically designed for photoelastic stress analysis, Photoelastic Division, Measurements Group, P.O. Box 27777, Raleigh, NC 27611.

Saran F310 resin, Dow Chemical Co., Main Street, Midland, MI 48674.

SR-4 model strain gauge, BLH Electronics Inc., 75 Shawmut Rd., Canton, MA 02021.

Strain gauges, Micro-Measurements Division, Measurements Group, P.O. Box 27777, Raleigh, NC 27611.

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