Proceedings

3rd International Symposium on Wood and Furniture Conservation

Amsterdam, The Netherlands, 11 October 1996
Proceedings of the
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on Wood and Furniture Conservation

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VeRes / OR
1997
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Introduction

The International Symposium on Wood and Furniture Conservation is held every other year in Amsterdam to coincide with RESTORATION, the trade fair in Amsterdam RAI.
In 1996, it was the third time the Symposium was organized. The venue was the Van Gogh Museum, whose lecture theatre was just big enough to seat the 151 participants. With a call for papers placed in various national and international conservation journals, the organizers had managed to create a broad and interesting programme, consisting of lectures on the research of glues, old timber processing methods, dendrochronology and marquetry-conservation, as well as case studies on objects ranging from cabinets to elaborate organ clocks and staircase balustrades. The papers illustrated the fascinating variety of objects, materials and techniques and their inherent problems with which conservators, scientists and art-historians have to deal.
The persons presenting the papers came from France, Great Britain, Denmark, Belgium and The Netherlands. Representatives of ten countries participated in the symposium. It was fascinating how eager the participants were to exchange information. There were moments that lecturers or members of the audience had some difficulty to express themselves in English, the official language of the Symposium, and at times various languages were used simultaneously to discuss technical intricacies. It was courageous that also those whose English was not perfect actively contributed to a truly successful day. Special thanks are due to Mrs. Boucher, who not only presented the paper of her husband, but also acted as an impromptu interpreter between English and French speaking sections of the audience. She enabled detailed discussions which otherwise would not have been possible.
That sometimes the lecture theatre sounded like a tower of Babel served as evidence that two of the main aims of the organizing committee were realized: information-exchange and contact between professionals from different countries.

Paul van Duin
Head of Furniture Conservation
Rijksmuseum
The Marquetry Project at the ENSTIB

Marie-Christine Triboulot, Antonio Pizzi

Introduction

This paper summarizes research projects into glues and additives used for the conservation of marquetry, carried out by students of ENSTIB, École Nationale Supérieure des Technologies et Industries des Bois. Part of the University of Nancy, the Department of Wood Science and Technology (ENSTIB) has 3 primary missions: teaching, research and the transfer of technology for the wood industry.

The undergraduate degree programme trains about 40 students per year over a three year period leading to the degree of Engineer in Wood Science and Technology. Subjects are: comprehensive basic scientific training, technical training, training in economics and management, industrial training and personal development (teamwork, training periods).

During the third academic year, students carry out a research project. The time devoted to this work is about 250 hours, spread out over 5 months. The subjects proposed to the students are varied. The primary purpose of the research projects is to assist the industry with solving its problems and to help to develop new methods for the conversion of wood into consumer products.

‘Rehydration of animal glues during the conservation of marquetry’, by Élodie Lavigne et Laurent Montneau (1995)

In 1994, this project was proposed to the students by a group of furniture conservators. The project tested various glues and additives for the conservation of artificially aged marquetry panels:

- MC2: hide glue (different origins)
- AT400: food gelatin
- GT58: hide glue (cattle)
- HMB: fish glue
- Old animal glue cake: probably a mixture of hide and bone glue

Additives:

- Ox-gall: an animal additive widely used for the conservation of gilt woods
- Thiourea: H₂N-CS-NH₂
- Mixture of tannins: 1/3 chestnut tannins, 2/3 pine tannins (the chemical composition of this is close to that of oak tannins.)

Preparation and ageing of marquetry panels

Experimental set up

To study the properties of these glues and additives for marquetry conservation, 30 marquetry panels were prepared, reproducing as closely as possible the conditions existing in marquetry on antique furniture (Figure 3). Each panel measuring 310x180 mm is composed of three pineboards edged by oak cleats through tongue and groove joints. On each panel geometrical marquetry was applied in the form of thin sheets of sawn veneers with a thickness of 1,5 mm. The following materials were used: maple, hornbeam, padauk, ebony, animal horn and tin sheeting. An old, traditional collagen glue cake was used. The panels were sanded and french polished.

All panels underwent accelerated ageing according to the following cycle:

- 5 hours at 35 °C and 12% relative humidity
- 1 hour at 45°C under UV light
- 5 hours at 10°C and 85% relative humidity.

However, after 20 days of continuous application of above cycle, no delamination of the specimens had occurred, and the treatment was intensified to:

- 4 days at 55°C and 12% relative humidity
- 1 day at 55°C and 100% relative humidity
- freezing down to -7°C and immediately raising the temperature back to 55°C
- 1 day at 55°C and 100% relative humidity
- 1 day at 35°C and 12% relative humidity
- 1 day at 20°C and 65% relative humidity.

At the end of this treatment the panels resembled old marquetry, with surface cracks and partial delaminations. The panels were conserved using the rehydration method currently used by Nicolas Boucher, furniture conservator of the Museum.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Formulas of diluted glues</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2 alone</td>
<td>MC2 + ox-gall</td>
</tr>
<tr>
<td>20% MC2</td>
<td>20% MC2</td>
</tr>
<tr>
<td>80% water</td>
<td>10% ox-gall</td>
</tr>
<tr>
<td></td>
<td>70% water</td>
</tr>
</tbody>
</table>
of Decorative Arts, Paris. This method avoids lifting the marquetry in order to reglue it. The conservation procedure was as follows:

- humidification: covering the marquetry for two hours with moist blotting paper and a polyester film to retain the moisture
- removal of the paper and the polyester film
- applying the mixture of glue and additive onto the marquetry
- applying pressure at 3 bars for 24 hours.

Heating was applied exclusively for the first half hour, up to 65°C in the centre of the panel. After conservation, the panels did not show any delamination nor cracks and appeared in excellent condition.

The panels were cut into samples of 50x50 mm and were artificially aged for 4 days:

- 12 hours at 55°C and 95% relative humidity
- 12 hours at 35°C and 12% relative humidity.

Results

The results of this treatment are reported in Table 2. For no or slight delamination the results were described as 'good'; more than 66% delamination was 'bad'. Table 2 may indicate that different additives should be used for different wood species of marquetry as the difference in results between ebony and African padouk veneer illustrate. The gelatine + tannin combination gave the best overall results.

The case of tannin used as an additive is interesting: vegetable tannins are not additives currently used in marquetry conservation and what is reported is a novel and applicable finding. Tannins, however, suffer from two problems: the problem of colour, dark brown, which may stain light veneers in marquetry, especially if used in conservation. This is of course inacceptable. For this reason light coloured commercial vegetable tannins were tested the next year by Aurélie Garcel.

The second problem of tannins is the irreversibility of the glue bond. While the durability of the joint is greatly enhanced by the addition of tannin, complete 'tanning' of the collagen eliminates the reversibility which is one of the primary requirements of conservation. While for other applications of animal glues complete waterproofing by tannin will be very useful, in the case of marquetry complete tanning of the collagen needs to be avoided. Increased water resistance, as well as adequate reversibility could be achieved by a very much smaller proportion of tannin.

**Tensile stress tests after rehydration the glue**

Experimental set up

Tensile stress tests were carried out in order to study the properties of animal glues after rehydration. The test samples each consisted of a square beech block measuring 50x50x8 mm glued between two rectangular beech blocks of 63x50x12 mm. The surfaces joined were all cross-grain and for each of the two joints a different glue was used, to compare the glues with each other. Before mechanical testing, each specimen was immersed for 4 minutes in water at 95°C. After that, the force needed to cleave the sample is measured. Tables 3 and 4 summarize the results of the tests.

Results

From Table 3, it is evident that fish glue was most stable, followed by the collagen-based glues MC2, GT58 and AT400. However, because filamentous breaking of the glue occurred with GT58 and AT400, and breaking was approximately 3/4 in cohesion (in the glue line itself) and 1/4 in adhesion at the wood/glue interface, it became apparent that all that was tested was nothing else than the rate of rehydration of the glue in water at 95°C. Fish glue appears to be more resistant to

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Degree of delamination after ageing the conserved panels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MC2 alone</td>
</tr>
<tr>
<td>Ebony</td>
<td>average</td>
</tr>
<tr>
<td>Padouk</td>
<td>average</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Comparison of tensile stresses of different animal glues after rehydration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue type</td>
<td>Fish glue</td>
</tr>
<tr>
<td>Tensile stress (Mpa)</td>
<td>no rupture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Effect of different additives on the tensile stress of animal glue MC2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue and additive</td>
<td>MC2 alone</td>
</tr>
<tr>
<td>Tensile stress</td>
<td>0,47</td>
</tr>
</tbody>
</table>
rehydration than the other glues. While this is a considerable advantage for initial gluing durability, it might be inconvenient if ever one needs to rehydrate and reactivate such a glue.

The tensile stress results obtained with mixtures of glues and additives are shown in Table 4. The results only have significance within one table and cannot be compared with another table because the values are relative. The additives reduced the reversibility of MC2. It was clear that partial ‘tanning’ of the protein glue by the tannins occurred.

Viscosity measurements

Experimental set up

The viscosity of the formulas was measured using a Brookfield viscosimeter, as a function of temperature.

Results

In Table 5, the viscosity of the mixtures of glue and additive, in relation to the MC2 alone are reported. Important differences in viscosity became evident among the mixtures containing the additives. Thus the tannin noticeably increased the mixtures’ viscosity due to the well-known ‘tanning’ reactions with proteins as used in leather manufacture. The thiourea lowered the viscosity of the glue and for this reason this additive is used by furniture conservators.

Conclusion

The study carried out by Élodie Lavigne and Laurent Montieux (1995) established procedures for testing different additives and glues used in the conservation of marquetry. It was difficult for the researchers to establish the correct level of accelerated ageing.

‘Animal glues used for the conservation of marquetry’, by Aurélie Garret (1996)

It seemed really necessary for us to focus on the physical and mechanical properties of animal glues and of the effects of the additives used to improve the gluing, particularly thiourea. The different experiments were chosen because of their simplicity and their reliability. Glues tested were: MC2, GT58, fish glue and old animal glue cakes. Additives tested were: Thioureas: UCB, Prolabo, Merck and Touzart & Matignon (T&M) and tannins with a light color: Tara, Galla Turca, and Sommaco.

Measuring the solidification point: the temperature of change from the sol to the gel phase

Experimental set up

The test is described in the European Standard EN ISO9965:1995 "Adhesives - Animal glues - Methods for sampling and testing". The glue is cooled from 45°C to 20°C while being stirred with a thermometer, which is taken out regularly. The temperature at which the glue thread breaks for the first time is the solidification point of the glue.

Results

It was apparent that higher concentrations of glue resulted in faster solidification and higher solidification temperatures (Table 6). Thus, the solidification temperature is higher. The old glue cake had a lower solidification temperature, hence this glue offers more time for adjusting the glue joint.

The effects of additives was studied on the MC2 glue at a concentration of 33% (Table 7). The percentage of thiourea is a proportion of the glue solids content (33%).

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Viscosity of the formulas (in centipoises)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp.(°C)</td>
<td>MC2 alone</td>
</tr>
<tr>
<td>30</td>
<td>121</td>
</tr>
<tr>
<td>40</td>
<td>109</td>
</tr>
<tr>
<td>50</td>
<td>98</td>
</tr>
<tr>
<td>60</td>
<td>75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Solidification point of animal glues at different concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration</td>
<td>18%</td>
</tr>
<tr>
<td>MC2</td>
<td>24,8°C</td>
</tr>
<tr>
<td>GT58</td>
<td>23,5°C</td>
</tr>
<tr>
<td>Glue cake</td>
<td>21,5°C</td>
</tr>
</tbody>
</table>
Table 7  
Solidification point of the formulas with thiourea

<table>
<thead>
<tr>
<th></th>
<th>MC2 33%</th>
<th></th>
<th>Merck</th>
<th>T&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2 33%</td>
<td>UCB</td>
<td>Prolabo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1% thiourea</td>
<td>27.5°C</td>
<td>26.5°C</td>
<td>28°C</td>
<td>27.5°C</td>
</tr>
<tr>
<td>+5%</td>
<td>25°C</td>
<td>25°C</td>
<td>24.5°C</td>
<td>27°C</td>
</tr>
<tr>
<td>+9%</td>
<td>23.5°C</td>
<td>23.5°C</td>
<td>23°C</td>
<td>24°C</td>
</tr>
<tr>
<td>+15%</td>
<td>20°C</td>
<td>20°C</td>
<td>20°C</td>
<td>22°C</td>
</tr>
</tbody>
</table>

Thiourea delays the change from the sol to the gel phase, thus makes gluing easier. The Touzart & Matignon thiourea was least efficient in delaying gelification.

Determining the fusion point: temperature of change from the gel to the sol phase

Experimental set up
The test is described in the European Standard EN ISO9995:1995 "Adhesives - Animal glues - Methods for sampling and testing". A little cup full of animal glue and suspended from a glass stick concealed in the glue, is placed into a bowl containing 100ml water, which is slowly heated up. The temperature at which the little cup falls down from the glass stick is the fusion point.

Results
The different glues (Table 8) perform just as observed before (Table 6). The formula with the Touzart & Matignon thiourea needs a greater temperature increase to come back to the sol phase (Table 9). The Merck thiourea is slightly more efficient in lowering the fusion point of the glue.

Table 8  
Fusion point of the animal glues at different concentrations

<table>
<thead>
<tr>
<th>Concentration</th>
<th>18%</th>
<th>25%</th>
<th>33%</th>
<th>40%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2</td>
<td>25.5°C</td>
<td>26°C</td>
<td>32°C</td>
<td>36°C</td>
<td></td>
</tr>
<tr>
<td>GT58</td>
<td>25°C</td>
<td>26°C</td>
<td>31.5°C</td>
<td>34.5°C</td>
<td></td>
</tr>
<tr>
<td>Glue cake</td>
<td>24°C</td>
<td>24.5°C</td>
<td>27.5°C</td>
<td>32°C</td>
<td>36°C</td>
</tr>
</tbody>
</table>

Table 9  
Fusion point of the formulas with thiourea

<table>
<thead>
<tr>
<th></th>
<th>MC2 33%</th>
<th></th>
<th>Merck</th>
<th>T&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2 33%+15% thiourea: UCB</td>
<td>25°C</td>
<td>25°C</td>
<td>24°C</td>
<td>27°C</td>
</tr>
</tbody>
</table>

Table 10  
Initial and final dry content of the MC2 glue at different concentrations

<table>
<thead>
<tr>
<th></th>
<th>Initial %solids content</th>
<th>Final %solids content</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2</td>
<td>18%</td>
<td>70.82%</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>76.75%</td>
</tr>
<tr>
<td></td>
<td>33%</td>
<td>78.1%</td>
</tr>
<tr>
<td></td>
<td>40%</td>
<td>79.17%</td>
</tr>
</tbody>
</table>

Table 11  
Initial and final dry content of different animal glues

<table>
<thead>
<tr>
<th>Glue type</th>
<th>MC2</th>
<th>GT58</th>
<th>Glue cake</th>
<th>Fish glue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial %solids content</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Final %solids content</td>
<td>79.17%</td>
<td>79.64%</td>
<td>78.4%</td>
<td>51.72%</td>
</tr>
</tbody>
</table>

Table 12  
Initial and final dry content of the formulas with thiourea

<table>
<thead>
<tr>
<th></th>
<th>MC2 33%+15% thiourea</th>
<th></th>
<th>Merck</th>
<th>T&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UCB</td>
<td>Prolabo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial %solids content</td>
<td>36.5%</td>
<td>36.5%</td>
<td>36.5%</td>
<td>36.5%</td>
</tr>
<tr>
<td>Final %solids content</td>
<td>75.52%</td>
<td>76.57%</td>
<td>77.82%</td>
<td>69.82%</td>
</tr>
</tbody>
</table>
Glue stabilization

Experimental set up
With the exception of fish glue which comes ready to use, animal glues must be prepared in a particular manner. It is necessary to swell the glue pearls or the glue powder in water. Once swelling is achieved, the glue needs to be warmed in a water bath without reaching a temperature higher than 60°C. The glue is then ready to use. We were interested in the amount of water remaining in the glue after drying on a non porous surface. The amount of water which normally diffuses into the wood was not taken into account.

A 3 mm thickness of glue was deposited into plastic containers. These were placed at 20°C and 55% relative humidity and weighed regularly until a stable weight was achieved.

Results
The results are expressed in initial dry content (initial concentration) and in final dry content (after stabilization). The amount of water remaining in the glue after stabilization was higher for diluted than for concentrated glues (Table 10). The fish glue lost a smaller portion of 'solvent' compared with the other glues (Table 11). The thioureas limited water loss (Table 12). This was especially obvious for the Touzart&Matignon thiourea.

Elasticity tests

Experimental set up
The lack of elasticity of the glue joints seems to be an important cause of delamination. In order to test the elasticity of the glues, we used a test proposed by Livia Depuydt (1988).

A 4 mm thickness of glue was deposited into a plywood frame (Figure 1). The glue was allowed to dry at 20°C and 55% relative humidity. When the glue dries one can observe if it distorts the plywood frame.

Results
The old animal glue cake bent the plywood frame. The GT58 and MC2 glues also bent the plywood frame, but somewhat later. The fish glue remained pliable and did not bend the plywood frame. All the tested thioureas increased the elasticity of the MC2 glue: none of the formulas with thiourea distorted the plywood frame.

![Plywood frame](image)

Figure 1: Plywood frame

![Cleavage sample](image)

Figure 2: Cleavage sample

Cleavage test

Experimental set up
The cleavage tests are described by the English Standard BS 5350 Part C1: 1986. Figure 2 shows the form of the sample used for cleavage tests. Because the adhesives were always stronger than wood, it was necessary to artificially age the glue joint to observe any differences between the various adhesives.

<table>
<thead>
<tr>
<th>Table 13</th>
<th>Cleavage strength of the MC2 glue at various concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2</td>
<td>18%</td>
</tr>
<tr>
<td>Cleavage strength (N)</td>
<td>275 ± 110</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 14</th>
<th>Cleavage strength of the different animal glues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glue type</td>
<td>GT58 33%</td>
</tr>
<tr>
<td>Cleavage strength (N)</td>
<td>930 ± 355</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 15</th>
<th>Cleavage strength of the formulas with thiourea</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC2 25%</td>
<td>240 ± 140</td>
</tr>
<tr>
<td>MC2 25%+50% thiourea</td>
<td>UCB</td>
</tr>
<tr>
<td>Cleavage strength (N)</td>
<td>270 ± 130</td>
</tr>
</tbody>
</table>
The samples underwent accelerated ageing during 12 days according to the following cycle:
- 72 hours at 22°C and 40% relative humidity
- 72 hours at 22°C and 80% relative humidity.

Results
A diluted glue has less strength than a concentrated glue (Table 13). The fish glue has less strength than the other animal glues tested (Table 14). Except for the Merck thiourea, adding thiourea to the glue improves the mechanical strength of the glue lines (Table 15).

Conclusion
It is surprising to notice that the commercial thioureas had such different properties. The Merck thiourea was most efficient in improving the spreading of glue but lowered its mechanical strength. The results of the Touzart & Matignon thiourea were the opposite. Moreover, this thiourea limited the water loss more than the others did. This property might be related to the elasticity of the glue. Experiments carried out with tannins (not presented in this paper) indicated that they lower the elasticity of the glue. Formulas with both tannins (in small proportions) and thiourea could be tested in order to reduce the sensitivity to the effects of moisture whilst maintaining sufficient elasticity and adequate reversibility of the animal glue.

The next project: ‘Use of polyethylene glycol in furniture conservation’
Polyethylene glycols (PEG) are excellent dimension-stabilizing agents for wood. They accomplish this stabilization by bulking the wood fibers; that is, they tend to keep green wood in a swollen state by diffusing into the cell walls as water diffuses out.
Treatments with PEG are currently used for the conservation of waterlogged wood. Waterlogged wood will shrink considerably more during drying than green wood. The more degraded it is, the heavier the shrinkage will be. The wood is put into PEG solutions and the PEG diffuses into wood, replacing the water.
PEG could also straighten pieces of wooden furniture under some conditions still to be defined. The PEG swells the wood just like water does. So it could compensate for an excessive shrinkage of wood. PEG is not toxic and is water-soluble so it could be easily eliminated from the wood if necessary: the operation is reversible.
Dimensional stabilization of wood is also a means of improving the resistance of the glue joints. The next study will therefore centre on the use of polyethylene glycol in furniture conservation, treatment conditions, compatibility of PEG with animal glues, compatibility of PEG with varnishes and treatment durability.
Some conservators have begun to use PEG and these first experiences will be the starting point of the next project, which will be realized by two ENSTIB students, namely Judith Dos Santos and Nicolas Mourey.

References
A. Garcet, Étude des colles d’origine animale utilisées pour la restauration de marqueteries anciennes, projet de fin d’études, ENSTIB, 1996.

Manufacturers and Suppliers
MC2: YON, Parc d’activité des Gondoles, 118-120 Avenue d’Alfortville, BP43, 94 602 Choisy le Roi Cedex, France.
AT400 and GT58: System Bio Industries, 4 Place des Alles, 92461 Boulogne-Billancourt Cedex, France
Fish Glue: HMB, 8 Rue de Prague, 75 012 Paris, France.
‘Fiel de boeuf’: ColArt Int. SA, 5 Rue René Panhard, ZI Nord, 72018 Le Mans Cedex, France.
Thiourea: Prolabo, 1 Rue le Goff, 75005 Paris, France.
Thiourea: Merck, 5-9 Rue Anquetil, 94 736 Nogent sur Marne, France.
Thiourea: Touzart & Matignon SA, 2 Avenue du Pacifique, BP 310, 91 958 Courtabœuf Cedex, France.
Tannins: Tara, Galla Turca, Sommaco: Silva SRL, Via Torre, 12080 S. Michele Mondovi (CN), Italy.

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Figure 3: Marquetry panel
The Rehydration of Aged Animal Glues in order to Revive their Glueing Power

Nicolas Boucher

This paper presents a procedure used in the Museum of Decorative Arts in Paris for the rehydration of aged animal glues in order to revive their glueing power. Rehydrating old animal glue is a commonly used technique in furniture conservation, simply using a moist tissue and a hot iron to re-glue a piece of marquetry or a veneer.

In 1987, a commode, signed by Jean Charles Ellauwe and belonging to the ‘Musée Vouland’ in Avignon, was restored in cooperation with Mr. Payet. A significant proportion of the marquetry was reglued by rehydrating the existing glue. The condition of the marquetry of this commode has been stable since then, now for almost ten years. The same method was used six years ago on a transition commode signed by Jacques Aubry in the ‘Musée des Arts Décoratifs’ in Paris (Figure 1). The conservation of the marquetry of the top of this commode will be used to describe the method of regenerating existing glue. The marquetry of the top was lifting in numerous places. The thick joints of glue between individual pieces of marquetry had crystallized. The top of the commode was fissured and due to sanding during previous conservations the veneer was very thin in many places.

In order to treat the marquetry of the top of the commode, the cracks first had to be stabilized. The construction consisted of pine boards joined with a tongue and groove to a cleat at each end. The treatment started by removing part of the ebony and marquetry to gain access to the tongue and groove joints. They were separated using ethanol and the cracks between the boards were closed and glued. The board at the front remained in the same position, the other boards were moved slightly forward. A ‘polytoile’ was applied covering both sides of the joints between boards and cleats (Figures 2 and 3). Polytoile is polyester tissue impregnated with an acrylic glue on one side only. The acrylic side was glued onto the support using a PVA glue. As the joints themselves remained unglued, the pine boards of the support can move freely as the humidity changes and new cracks will not occur. The ebony veneer and marquetry which had been removed were glued onto the neutral side of the polytoile with MC2 Trobas, a cowhide glue.

After stabilizing the wood in this way the procedure of relaying the marquetry using the rehydration technique could start. The marquetry was humidified for a certain period. This varies for each piece of furniture and lasts up to four hours. In this case the marquetry was humidified for twenty minutes. The marquetry and glue were humidified using a wet tissue or piece of cloth or a previously wetted absorbant paper. Melinex, a polyester film, was used to cover the moist layer to ensure that the water did not evaporate. The humidification is stopped once the veneer began to deform (Figure 4). It was very important to leave the surface finish intact because it slowed down the humidification of the veneer, favouring the humidification of glue underneath lifting veneer as well as glue-joints between the pieces of marquetry. Removing the varnish would deform the veneer too rapidly. After the glue was rehydrated sufficiently, a diluted Trobas MC2 glue could be introduced with a spatula underneath the entire veneer surface. This glue ensured that the rehydrated glue did not set too quickly.

Two transparent 1.2 mm thick polycarbonate sheets were then placed on top of the marquetry, ensuring a flat surface of the marquetry (Figure 5). Two pieces of hard cardboard were placed upon the polycarbonate, with the temperature gauge in between, thus protecting it from coming in direct contact with the heating grill (Figure 6). The heating grill was then placed upon the cardboard, having been cut previously to the right size using a pair of scissors (Figure 7). Two aluminium bars, type AGS, were attached to each end of the grill (Figure 8). Finally, wooden panels and blocks were used to evenly spread the pressure applied by numerous cramps (Figure 9). The heating grill was connected with battery clips to a transformer set at 400 amperes and 4 volt. It took 20 to 45 minutes, depending upon the size of the grill, to obtain the required temperature of 65 centigrade. This temperature should be maintained, using a regulator, for 5 minutes. The cramps remained in position for another 12 hours to allow the glue to dry. The surface finish was removed and replaced by a wax polish.

The procedure of the rehydration of glue can also be applied to the conservation of Boule-marquetry. In this type of marquetry, the brass elements must be unglued in order to reglue them with fish glue HMB. Once in position, they are held in place with an adhesive tape. Once dry, the
tape is removed. The entire surface is then humidified and the glue underneath the tortoiseshell and brass is rehydrated in the same way as described above. It is also possible to rehydrate without unglueing the brass elements, if these are still firmly glued.

The results obtained by the procedure of the rehydration of animal glues are very promising. It is important that the treated object is placed in a controlled climate, with a relative humidity between 45% and 70%. The procedure also revives the colours of bleached marquetry. Water-soluble stains dissolve and move to the surface.

The encounter with Ms. Marie-Christine Triboulot, professor at ENSTIB (Ecole Nationale Supérieure des Technologies et Industries du Bois), the school of wood engineering, resulted in the formation of a study group called ADEN. This group of furniture conservators aims to advance the profession by formulating research proposals for ENSTIB, as well as exchanging information and experiences.

Initially consisting of 10 members, the group now has 50 participants. All persons wishing to participate in the different studies are welcome. The first study concerns the rehydration of animal glues during the conservation of wooden furniture. A second study concerns the utilisation of polyethylene glycol for swelling wood and thus redressing fissured and deformed panels. The group can be accessed through Internet, under the site ‘Musée des Arts Déco’: http://www.ucad.fr.

Manufacturers and suppliers
Glue MC2 Trobas 100 millipoises: Trobas, Steenstraat 9, PO Box 14, 5100 AA DONGEN, The Netherlands, Tel: 00.31.1623.14944.
Polysole non tissé référence 15-17 série B: Sennelier, 3 Quai Voltaire, 75007 Paris, France, Tel: 1.42.60.72.15, Fax: 01.42.61.00.69.
Polycarbonate, 1.2 mm thick, 250 x 125 cm: VT Plastique, 1 rue Embrouse Croizat, 95812 Argenteuil. cedex PO Box 9003 France, Tel: 01.45.13.20.26, Fax: 01.45.13.20.33.

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Figure 1: Commode signed by Jacques Aubry. Museum of Decorative Arts, Paris.

Figure 2: The joint between the top and its cleat covered with 'polytoile'.
Figure 3: Underneath the joint between the top and its cleat was also covered with polytoile.

Figure 4: The marquetry after humidification.
Figure 5: Thick polycarbonate (perspex) placed on top of the marquetry ensures a flat surface after glueing.

Figure 6: The temperature gauge is placed between two pieces of cardboard.
Figure 7: The heating grill attached to the transformer.

Figure 8: The heating grill in position.
Figure 9: Pressure is applied using cramps, plywood panels and timber.
The Conservation of a Witwerkers Cabinet

Hans Piena

Introduction
This article deals with the conservation of an early nineteenth-century painted cabinet. An attempt has been made to find a reason for its bad condition and to date the cabinet as accurately as possible. Special attention has been given to the materials and techniques with which the cabinet is made, indicating that it belongs to a special category, a ‘witwerkers’ cabinet. The major part deals with the treatment in which old and new techniques and materials were used.

The cabinet
The cabinet, owned by the ‘Openlucht Museum Erve Kots’ in Lievelde, a small village east of Arnhem, is used to store homemade linen, clothes as well as linen on a roll (Figure 1). It is exhibited in a ‘Loshoes’, a Saxon farmhouse. In this type of farm the stable and the living area form one large space. The climate inside the farm is the same as that outside all year round, partly because of the nature of the building and partly because the doors are now always open to visitors. For as long as the very aged owner can remember, the cabinet has been there.

The cabinet is made of softwood containing many knots and sapwood. Traces indicate that the boards were sawn by hand. The style of the cabinet is that of a mid-eighteenth-century Dutch piece. The vase on top dates the piece to a later period, towards the end of the eighteenth century. The cabinet has a mahogany coloured wood grain imitation suggesting that it is not produced earlier then the end of the eighteenth century, when mahogany furniture appeared for the first time in the Netherlands. There are imprints into the paint of stamped oval escutcheons. These escutcheons usually date from 1800-1830 (Egger, 1977, 171). There is no indication they are not original to the piece. The cabinet was in all likelihood made in the early nineteenth century.

The cabinet is unusually constructed using simple techniques and lacks any joints like rebates, tongue and groove joints or dovetails. The whole cabinet is butt-joined and nailed and there is no evidence that parts of the cabinet had ever been glued. The top half is divided in an upper and a lower part. The two parts are held together by four pegged mortise and tenon joints on the inside. The doors appear to be standard framed panels but this is a deception. The front boards are nailed onto two stretchers running across the back. By gouging out the front, a panelled door is imitated.

The cabinet entered the workshop in a deplorable state. Many parts were loose, missing or previously replaced. It had been extensively damaged by furniture beetles and different kinds of wood wasps. On top straw, feathers, down and egg shells, the remains of a chicken nest, were found.

In recent times the front had been finished with a mahogany coloured varnish and there were many discoloured retouchings. The surface was so crazed that it resembled a sugar crust. Much dirt had settled into this crust. The paint was flaking badly with many areas of loss.

Research
Before treatment the cabinet was studied under UV-light, which showed a vague greenish fluorescence of the top varnish. This only indicated that the top finish was not shellac but may have contained other natural resins or even nitrocellulose. The retouchings were visible by daylight but stood out more clearly under UV-light.

The build-up of the paintlayers was studied to find out more about the stratigraphy and the materials, and to find a reason for the flaking other than the bad climate in the farm.

Cross-sections of the paint, taken on each side, doors and drawers, showed a similar stratigraphy of 20-23 layers (Figure 3). The layers belonged to three very similar mahogany coloured woodgrain imitations on top of each other. These were also visible in damaged areas. Each imitation started with a gesso ground, sometimes mixed with reddish particles. On top a thin wash of reddish pigments was applied, covered by several different layers of brown varnish. The fact that a

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1 A Dutch version of this text is published in: Gelders Erfgoed, 1997, nr 2, p.1-6.
2 In this text both the term ‘witwerkers’ (those who made softwood furniture that was to be painted) and the term ‘witwerken’ (the painting technique or the painted products), are not translated.

3 A very similar cabinet is owned by Aniek d’Egelandier, Egelantiër gracht 93w, 1015 RF, Amsterdam. It has the same construction and the same painting. Only the model and the size are slightly different.
lot of these varnishes showed cracks and had dirt layers in between them indicate that there must have been some time between them. Their bright fluorescence and the fact that they easily solved in ethanol make it probable that they were plain resin varnishes and not fixed-oil varnishes. Only among the varnish layers on top of the last mahogany imitation were two dark coloured non-fluorescent layers, perhaps coloured oil varnishes. They could have been applied to restore a mahogany look without having to go through all the steps of gesso, reddish pigments and varnishes. The cabinet’s last finish was a resinous layer with many inclusions, probably dirt. The varnishes at the surface had warped into tiny cup formations showing cracks, some of which were several layers deep. In the cracks of the varnishes just below each new ground layer much greyish material had accumulated, caused possibly by sanding. Wet-sanding with pumice for instance was a common practice during the nineteenth century.

Contemporary literature on painting techniques shows that the above described technique of a gesso ground, pigment wash and varnish was fairly well known. Watin calls it ‘Chipolin’ (Watin, 1774, §2, 65-71). He praises this technique at length and gives a detailed description of the subsequent layers:

- a size of parchment glue
- a size of parchment glue and chalk
- a ground of parchment glue and chalk
- a paint of pigments and parchment glue
- a very thin parchment size for consolidation
- two or three layers of spirit varnish.

Chipolin was used to paint the panelling of interiors. The advantage was that it dried much faster than an oil based finish so the rooms could be used shortly after having been painted. The fact that this technique was probably also used on the cabinet is another tell-tale sign of the ‘quick and dirty’ way in which this cabinet is made.

In his chapter ‘Van het Witwerken’ [On whiteworking] Simis (1801, 289-282) describes a technique to paint cheap work. In its simplest version the recipe would produce the following build-up:

- a layer of glue and chalk
- a layer of glue with a higher proportion of chalk
- a size of animal glue
- a thin wash of colour, rubbed down in beer or vinegar
- a transparent or brown amber varnish.

Simis (1801, 282) does not mention the third layer of size when he describes yet another technique for wooden objects. Even up to recent times, people in Staphorst, the Netherlands, used watercolour in vinegar, covered with a varnish, to paint furniture (Salonière, 1966, 37).

In his chapter ‘Meubels in lijmverf’ [Furniture in Glue Paint] Bartels (1918, 270-272) describes a technique called ‘witwerken’ that, as he states, was used to paint cheap furniture. The subsequent build-up of layers is as follows:

- a layer of glue and chalk
- a layer of glue with more chalk
- a layer of oil paint for consolidation
- a coloured layer
- a layer of varnish.

He advises to add colour to the first two grounds to better reach the desired shade. The reddish particles in some of the ground layers on the cabinet may have the same function.

The recipes resemble the build-up of the layers on the cabinet. Only the glue size mentioned by Watin and the oil paint consolidation layer on top of the ground mentioned by Bartels do not seem to be present in this case.

To know to what extent the recipes mentioned above resembled the paint on the cabinet both in appearance as well as in cross section, a reconstruction was made. A pinewood sample board was covered with:

- a layer of diluted hide glue (25% w/v)
- a ground layer of chalk with hide glue
- a layer of ground with a higher proportion of chalk
- a wash of burnt sienna in diluted hide glue
- several layers of dammar.

On the surface the colour very much resembled that of the cabinet. Burnt sienna was also sold as ‘Mahogany Brown’ (Jacobson, 1868). The pattern (woodgrain) however, very much depended on the way the wash is applied. In this case a sponge was used which did not perfectly imitate the grain on the cabinet.

In cross-section the size had a bright white fluorescence. Experience shows that animal glues keep this fluorescence over time. The lack of such fluorescence between the wood and the first ground layers on the cabinet confirmed that probably no glue size had been used on the cabinet.

The wash of burnt sienna also looked different from that on the cabinet. On the sample board the pigments were held in a matrix of glue, whereas on the cabinet the wash only seemed to consist of pigment grains. In the several washes of pigments on the cabinet no binding medium was visible.

The last difference between the sample board and the cabinet was that the fresh dammar did not
fluoresce under UV-light whereas the old varnishes on the cabinet did, but this may have been due to ageing.

The ever-changing climate around the cabinet with very high and low humidities was no doubt the main reason why the paint was actively flaking. There were a few other reasons. The cross-sections show a fairly thick build-up of layers. Thick layers are less able to react in the same way as the wooden substrate does. Therefore they will more easily flake off, as is the case with this cabinet.

For varnished, gilded and painted wooden objects it was common practice to apply a gelatine based size first. In the case of Chipolin Watin (1774, 67-68) states that it prevents the future flaking of the paint. In the cross-sections there was no evidence of a size between the wooden substrate and the first gesso. This could be another reason why the paint was so actively flaking.

To summarize what has been established so far:

- the cabinet is an early nineteenth-century copy of a popular eighteenth-century Dutch type of cabinet
- the cabinet is made of low quality softwood
- the cabinet has no cabinetmakers joints but is entirely nailed and butt-joined
- the painting technique used on the cabinet is referred to by several contemporary authors as 'witwerken', a quick way to paint cheap work.

**Witwerkers**

In several Dutch and Belgium cities 'witwerkers' [whiteworkers] formed a separate section of the home carpenters guild, with their own set of rules. They were only allowed to use soft wood species, not oak, and their products were painted by others. From contemporary sources it is known that witwerkers made cabinets, commodes, all kinds of tables and trays, coffers, dressers, crates and utensils like shovels and watering-pots (Noordkerk, 1748). From 1600 onward they formed a separate section of guilds with their own rules. Up to 1900 'witwerkers' had a considerable production in the Netherlands.

'Witwerkers' furniture was not only made in cities but also in smaller places, in the countryside. In both cases it was probably very similar in materials and techniques, but outside the cities craftsmen did not have to obey the rules of a guild and subsequently were not forced to carry such titles as 'witwerker'. Therefore one it is not likely to find evidence of 'witwerkers' in the country. Furnituremakers in the countryside used more general titles as cabinetmaker, carpenter, entrepreneur or even tradesmen. Moreover they were not forced to make only one particular kind of product. Besides, furnituremakers in the country had to be more adaptable because of the smaller demand of one particular product. In general they had a wider range of activities that could include carpentry and a tool- and ironworks shop.

The materials and techniques found on this cabinet were used by 'witwerkers' and are referred to as 'witwerken' and although it is not known whether the maker called himself a witwerker our cabinet has all the characteristics of a 'witwerkers' cabinet.

**Treatment**

The surface was dirty and the paint was flaking. The question was what should come first, consolidation or cleaning? An initial consolidation had ingrained dirt just in and along the cracks. It was difficult to establish a technique that allowed the loose paintflakes to be cleaned without major losses. Therefore the paint was first consolidated and cleaned afterwards, accepting that some dirt along the cracks would become fixed.

To consolidate the paint an animal gelatine was chosen because it was compatible with the glue-based ground layers and because gelatins have a much longer record and are known to cause no future problems. Having consolidated the paint with gelatine it would still be possible to use gelatine or synthetics in the future while if consolidated with a synthetic glue future conservators might find that gelatins would not adhere.

From the different kinds of gelatins rabbitskin glue was chosen which in general is slightly acidic (pH 4.5-5.5) (Haupt, et al., 1990, figure 1). It has a better surface tension than Isinglass even though Isinglass runs better because it gells at lower temperatures (Haupt et al., 1990). Unfortunately Isinglass hardly has any elasticity (Haupt et al., 1990; Fosket, 1994). The agent used for consolidation had to be elastic since the wooden support of the cabinet and the thick layers of paint each react differently on changes in RH and temperature.

The flakes were consolidated with diluted rabbitskin glue (60°C), adding 1% of glycerine and 1% of Agepon (photoflow), a non-ionic wetting agent. The glycerin works as a plasticizer as it keeps the glue from dehydrating (Petukhova and Bonadies, 1993). Agepon was added to make the glue run better. It is a non-ionic soap which should not be absorbed by differently charged materials in the finish. Unfortunately Agepon does not evaporate. A drop of Agepon on an inert surface like glass leaves behind a greasy substance. In all probability Agepon also remains in the
substrate and even in very small quantities this is a negative aspect of this product. The wetting agents Surlynol 6 and Ammoniumchloride are said to evaporate (Schäfer, 1995, 151).

The glue was brought underneath the flake with a small brush. When the flake had become flexible enough, it was covered with melinex and rubbed down with a hot spatula (68°C). With this method the flake flattened perfectly. Unfortunately the glue had not always penetrated underneath the whole flake. Some spots had to be treated again. This was mainly caused by not having the right concentration and temperature of the glue.

Furniture conservators are trying more and more to preserve old finishes. In 1970 R. J. van Wandelen (1970, 543-544), furniture conservator of the Rijksmuseum, stressed that the finish of a piece is part of a piece and should be preserved. Furthermore, he warned that with the then current ways of conservation the remaining original finishes would rapidly disappear.

In the last decades much has been done to find out more about finishes and how best to preserve them. Wolbers (et al, 1990) developed methods for surface cleaning and found ways to selectively remove surface layers. Part of this has recently been updated and worked out by Schäfer (1995).

The less complicated techniques are slowly finding their way into a few furniture conservation labs in the Netherlands.

Since 1989, Wolbers’ methods have been analyzed and not all the results were encouraging (Gilsa, 1991). It was found that some of the cleaning components were easily absorbed by the substrate. Using all Wolbers’ methods safely takes a thorough understanding of both the chemistry of the object and of the cleaning materials.

With this in mind work started to restore the surface of the cabinet. The aim was to remove the dirt and the top of the heavily crazed surface so the mahogany coloured woodgrain imitation would become visible again. There were four requirements:

- to remove as little as possible
- to reach a esthetically satisfying result
- not to leave behind any of the materials used for cleaning
- not to cause any chemical or mechanical damage to the layer required to be kept.

In the past good results have been reached by sanding the surface of badly crazed finishes on wood (Landrey, 1984, 76). Sanding is advisable only on smooth surfaces that have superficially cracked and because the surface of this cabinet was very uneven it would cut through several layers of paint at the highest spots. Moreover, the sanding dust would accumulate in the open structure of the surface because the many cracks were several layers deep.

It seemed more appropriate to clean the surface with a solvent. After having done extensive solvent tests, ethanol turned out to be an effective enough solvent to remove the top whilst acting slowly enough not to dissolve the lower part.

How was the ethanol best applied? A gel made out of Carbopol and Ethomeen is known to bond with oxidized surfaces and would in this case be difficult to remove. Methylcellulose based gels are used as glues. They are absorbed by for instance wall paper or wood because of their hydrogen bonds. Because of these hydrogen bonds they could also bond with the oxidized varnishes of the cabinet and were therefore inappropriate in this case. Laponite, a synthetic clay, does not have this disadvantage. The surface on the other hand probably was too cracked and crazed to safely use gels. It would be difficult to rinse them off and a cotton cloth slightly wetted with ethanol was therefore considered to be the best method.

The effect of the cleaning was pleasing. The dirt was sufficiently removed, the crazed surface had gone and the top layers of varnish had already reached some saturation (Figure 2). Cross-sections taken before and after cleaning showed that, of the top varnish layers, the layer with the many inclusions was fully and the next layer only partially removed. Furthermore the cupped surface was smoothed down. The cotton rag with ethanol had removed the highest rims of the cupping. Cross-sections of initial cleaning tests also showed a thin deposit of dissolved material in the deeper areas like cracks and in the centre of cups. This amalgamation of old finish was still chemically degraded and would not form a stable surface. This problem was avoided by changing the cloth, using a clean section every few seconds.

After having cleaned the whole cabinet, the lacunae were filled. The losses were first sealed with rabbitskin glue to avoid penetration of filling material. The gaps were filled with gesso to reach the same level as the surrounding original paint and levelled using chisels.

Because of the extensive filling that had to be done, a gelatine based gesso would have swollen the ground layers in the original finish and probably caused further flaking. Therefore a gesso of chalk, Paraloid B-72 and xylene (10:1:10, w/w/v) was chosen, applied with a brush in several layers. The xylene was sufficiently non-polar not to effect the oxidized varnishes.

The white fillings were painted with watercolours covered with Orasol dyes in Paraloid B-67. The cabinet was finished with a few layers of Paraloid...
B-72 solved in xylene and ethanol (0.2:1:1 w/v/v). Paraloid B-72 was chosen instead of natural resins like shellac or dammar because it does not yellow, crack or become brittle as fast as natural resins. It also shows a slower increase in polarity (Horie, 1994; de la Rie, 1988). Paraloid B-72 was chosen instead of other synthetic varnishes because it has been used and tested from 1950 onwards, a relatively long time for a synthetic resin (Horie, 1994).

Because the infillings were all completely covered with B-67, the Paraloid B-72 could be removed without directly wiping off the retouchings. Paraloid B-67 is known to become brittle over time (Down, et al, 1996). Resins degrade by oxygen and UV-light mainly and the very surface of a layer is affected most. Here Paraloid B-67 is used covered with several layers of another varnish to keep the degradation to a minimum (Figure 4).

**Summary**

On the basis of its style, colour and traces of hardware the cabinet dates from the beginning of the nineteenth century. It is made of a poor quality softwood and is entirely butt-joined and nailed. No traces of glue were found. Cross-sections of the 20-23 layers showed that the cabinet was painted three times using the same materials and techniques. Each time a white ground, a wash of reddish pigments and a varnish were applied.

Painted softwood furniture is known to be a specialty of 'witwerken' a separate group of craftsmen within the cities guilds. Looking at the materials and techniques, the cabinet can be qualified as a 'witwetkeren' cabinet. The maker did not necessarily work as a 'witwerker' under the rules of a guild in one of the Dutch cities. This everyday kind of furniture is known to be made in many more places outside the influence of the guilds by craftsmen that were just called cabinetmakers or even had more general names.

The treatment involved the consolidation of the loose paintflakes with diluted rabbit's glue with an addition of Agepon and glycerine. The heavily cupped surface was cleaned with ethanol. No gels were used because it would have been difficult to rinse them out of the many cracks.

The aim was to save as many layers as possible. Cross-sections taken before and after an initial cleaning test showed that, of the five to six varnish layers on top of the last mahogany imitation, the upper and the top of the second layer had to be removed to make the mahogany coloured wood grain imitation visible again. Also a stable surface was created in this way as the most degraded varnish was removed.

The losses were sealed with rabbit's glue and filled with a ground based on chalk, Paraloid B-72 and xylene which did not effect the probably gelatine based original ground. The fillings were painted with watercolours and Orasol dyes. Because of the still open structure of the treated surface the cabinet was varnished with Paraloid B-72.

**References**


**Manufacturers and suppliers**

Rabbitskin glue: Kremer Pigmente, Farbmühle, D-88317 Achstetten, Germany.

Paraloid B-67 and B-72: Kremer Pigmente.

Agepon: Agfa Gevaert AG, D-51301 Leverkusen, Germany.


Orasol dyes: Rite Industries Inc., 1124 Elon Place, High Point, NC 27260, USA.

Gelders Oudheidkundig Contact
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Figure 1: The early 19th century witwerkers cabinet before treatment.

Figure 2: Left door of the witwerkers cabinet. The degraded varnish has been removed from the lower half.
Fig. 3
Cross-section of the layers on the upper drawer of the cabinet.

- A. Ground
- B. Thin wash of red pigments
- C. Varnishes
Figure 4: A combination of the two pictures of the witwerkiers cabinet, before (left) and after treatment (right).
The Cleaning and Conservation of the Balustrade of the Main Staircase of Hertford House

Paul Tear

History

On 10th November 1717 the Hôtel de Nevers on the rue de Richelieu in Paris was surveyed in order to adapt it as the Bibliothèque du Roi. The survey stated that the staircase had no balustrade, and calculated that a total of 11 ½ toises (1 toise = 1.94 m, total 22.31 m) of balustrade was required. However, on 10th May 1719 the Hôtel de Nevers, instead of becoming the Bibliothèque du Roi, was sold to the financier John Law for 400,000 livres to house the Banque Royale. The balustrade was probably installed on his orders between May 1719 and the end of 1720, when Law’s financial system crashed. In May 1724 Louis XV issued letters patent acquiring the Hôtel de Nevers for the Bibliothèque du Roi once again and on 20th August 1725 the Hôtel was surveyed by Charles François de l’Espée, who in his report made special reference to the balustrade: “Le Grand Escalier... une belle rampe de fer garnie et ornée de bronze”. The plan of the balustrade was recorded by Blondel 29 years later (Architecture Française, 1754) shows it as the single-sided balustrade of a three-flight staircase (Figure 1). The balustrade was described on the rue de Richelieu side of the Bibliothèque in 1782 by Le Prince, and again in 1787 by Thiéry.

The balustrade was eventually removed by the architect Labrouste between 1868 and 1874; it was bought by Sir Richard Wallace in about 1871 and was installed in Hertford House three years later by the firm of Geslin, who charged 54,938 French francs for altering and lengthening it to fit its present location (Figure 2).

Previous treatment

In June 1994 the Wallace Collection decided to refurbish the Main Entrance to improve visitor access and return it closer to its appearance in 1897 (the date of Lady Wallace’s bequest to the nation).

As an integral part of these works, it was decided that the Grand Staircase Balustrade (regarded as one of the finest surviving early-eighteenth-century masterpieces of French interior architectural metalwork outside France) should be dismantled, cleaned and conserved. It was last cleaned in 1967, when the mounts were soaked for long periods in a caustic solution of sodium sesquicarbonate to remove the discoloured lacquer, then if they were not considered sufficiently bright, they would be dipped in acid, rinsed and then hot lacquered.

In contrast, the emphasis now was much more upon scientific analysis and conservation, and from the outset it was the intention of all involved never to resort again to potentially harmful cleaning and ‘brightening’ techniques. In the event, the removal of the discoloured 27-year-old shellac-based varnish from the mounts has in itself
made an enormous difference to the visual appearance of the balustrade, and the use of a modern acrylic lacquer, Paraloid B72, with its inherent properties of long-term strength and stability, should ensure that this effect will not diminish with age.

**Conservation panel trials**

At an early stage in the planning process for the cleaning and conservation of the Grand Staircase Balustrade, advice was sought from the Wallace Collection Conservation Panel, comprising experts drawn from the United Kingdom, Europe and America. A range of alternative treatments and possible surface finishes was presented by the Wallace Collection Conservation Department for discussion and assessment, and a number of trials were carried out.

One of the latter involved deciding whether to wax or lacquer the mounts, or even to leave them completely untreated, once the old discoloured varnish had been removed. These three different surface treatments were applied to the three main parts of the centre section of the balustrade on the First Floor Landing, and members of the Panel were then invited to comment.

After long and interesting discussions with the members of the panel, who put forward various treatment proposals, from gently rinsing the mounts in mineral spirits (white spirit), to re-gilding the brass mounts, it was agreed that lacquering would offer the best option. Further trials to choose the most appropriate lacquer took place, the most favourable results being achieved with an acrylic lacquer, Paraloid B72. An important consideration in the final choice was this lacquer’s known longevity, since it was intended that the present treatment should last for at least the next twenty years; other lacquers (Ercalene nitrocellulose lacquer, for example), were known to become difficult to remove after such a time-span. It was decided to try and spray Paraloid B72 in order to get a good even covering on the mounts.

Up until this time we had been a brushing workshop, that is to say that normally, we would apply our lacquers by brush. We therefore carried out trials on copper coupons to ascertain the best solvent(s) and the percentage of Paraloid B72 to use (Table 1) and as you can see we also looked at how quickly it dried and it’s scratch resistance. This was carried out in a very scientific manner; We ran our thumb nail over the surface of the coupon, if it scratched, it failed, if the film remained intact, it passed. A 2% w/v solution of Paraloid B72 in acetone and diacetone alcohol (85%/15% v/v) was chosen as it was one that performed best during the tests. One coat on the back and four coats on the front gave good cover and an acceptable, non-glossy finish.

---

*Waxed (Renaissance) | Nitrocellulose lacquer | Untreated*

Figure 3: The top centre panel showing the three trials
Table 1  Results of lacquer trials

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Solute</th>
<th>Coats</th>
<th>Tack time</th>
<th>Scratch test</th>
<th>Matt finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylene</td>
<td>6% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>48 hrs+</td>
<td>1</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 175 ml Acet.</td>
<td>3% w/v B72</td>
<td>1</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>1</td>
</tr>
<tr>
<td>Mylands Duralac</td>
<td></td>
<td>1</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>2</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 75 ml Acet.</td>
<td>1.5% w/v B72</td>
<td>6</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>3</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 75 ml Acet.</td>
<td>3% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>4</td>
</tr>
<tr>
<td>75 ml Solvent Spirit</td>
<td>25% w/v Ercalene</td>
<td>1</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>5</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 275 ml Acet.</td>
<td>1.5% w/v B72</td>
<td>6</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>6</td>
</tr>
<tr>
<td>Xylene</td>
<td>3% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>7</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 175 ml Acet.</td>
<td>3% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>Fail</td>
<td>8</td>
</tr>
<tr>
<td>1-Methoxypropane-2-ol</td>
<td>3% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>24 hrs</td>
<td>9</td>
</tr>
<tr>
<td>1-Methoxypropane-2-ol</td>
<td>6% w/v B72</td>
<td>3</td>
<td>Acceptable</td>
<td>48 hrs</td>
<td>10</td>
</tr>
<tr>
<td>20 ml Diaacet. Alc./ 80 ml Acet.</td>
<td>2% w/v B72</td>
<td>4</td>
<td>Acceptable</td>
<td>18 hrs+</td>
<td>11</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 275 ml Acet.</td>
<td>1.5% w/v B72</td>
<td>1</td>
<td>Acceptable</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 75 ml Acet.</td>
<td>6% w/v B72</td>
<td>1</td>
<td>Too Slow</td>
<td>24 hrs</td>
<td>12</td>
</tr>
<tr>
<td>Acet.</td>
<td>6% w/v B72</td>
<td></td>
<td>Too Quick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diacet. Alc.</td>
<td>6% w/v B72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 175 ml Acet.</td>
<td>3% w/v B72</td>
<td></td>
<td>Acceptable</td>
<td>36 hrs</td>
<td>12</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 175 ml Acet.</td>
<td>3% w/v B72</td>
<td>4</td>
<td>Acceptable</td>
<td>18 hrs+</td>
<td>12</td>
</tr>
<tr>
<td>25 ml Diaacet. Alc./ 275 ml Acet.</td>
<td>1.5% w/v B72</td>
<td>6</td>
<td>Acceptable</td>
<td>18 hrs+</td>
<td>12</td>
</tr>
</tbody>
</table>

Key:
- Alc.: alcohol
- Acet.: acetone
- Coats: number of coats applied
- Tack Time: after 10 minutes the coating should have hardened enough to enable another coat to be applied.
- Scratch Test: after 24 hours a simple test (scratching with a thumb nail) was used to determine if the coating had adhered to the coupon.
- Matt Finish: the coupons were arranged in order, with 1 being the most matt and 12 the most glossy.

Conservation treatment

The ironwork frame

Only after work had actually begun on the first floor landing centrepiece section of the balustrade was it noticed that under the powerful arc lights then in use by the contractors working in the stairwell the colour of the painted ironwork (hitherto always presumed by everyone to be black) had in fact rather a greenish hue. Preliminary cleaning of some small areas with white spirit seemed to bear this out. Before any further cleaning was undertaken, a number of samples were taken of the paint layers present on the ironwork, and submitted for microscopic examination by Dr. Nicholas Eastaugh, Dr Ian Bristow and Patrick Baty. From the cross-sections thus analysed it was revealed that the probable original (1874) colour of the ironwork was a dark so-called ‘bronze’ green. Four layers of green were discovered, over one coat of red lead primer all applied in London after 1874, only the final (almost certainly twentieth-century) layer was black (Figure 4). Unfortunately, no trace was found of any earlier (pre-1874) colour schemes. Following this discovery, the green colour was matched and, disturbing the original surface as little as possible, the painted ironwork was de-waxed using white spirit and then repainted in modern Dulux-based eggshell, to return it to its 1874 colour. The decision to use a modern paint was taken after discussions with historical paint experts, it was thought that it would be better to use a modern paint, so that in any future analysis of the paint layer, it would be obvious that the top layer was modern.

The iron handrail

This had always been painted, but due to heavy use even the most recent coat, applied in 1992, was already wearing through. All the paint was removed and instead the metal was patinated and cold-waxed, thus requiring very little maintenance in future. The patination treatment chosen was Comet Gun Blue, this is a commercial preparation based on a mild solution of selenious acid (SeO₂+ HNO₃).
The mounts:
Each section of the balustrade was dismantled, individual mounts being mapped and numbered on a standard form devised for the purpose. Each mount was photographed in black and white, both front and back, prior to conservation. This has given us a permanent record of any marks or numbers, and the pre-treatment condition. The mounts were soaked in Industrial Methylated Spirit (IMS) overnight, then lightly brushed with a soft bristle brush and fresh IMS; small fragments of old lacquer were picked out with a swab stick. Shortly after starting the cleaning programme it was noticed that the mounts needed to be left to soak in IMS for longer periods of time in order to remove the old lacquer. We therefore looked for a different solvent, after consulting a tea chart we tried diacetone alcohol, this proved to be very successful, so we continued the soaking process with diacetone alcohol. Then after a final rinse in acetone the mounts were hung up to dry, and immediately spray-lacquered with Paraloid B72 to prevent oxidation of the surface.

The brass screws were retained in their original positions, though many were modern and there did not appear to be any original finish remaining. The Ercalene lacquer on each one was removed with 60% acetone/40% toluene (v/v) and further cleaning was kept to a minimum. A layer of Paraloid B72 was brushed onto the screwheads after final reassembly of each balustrade section.

Structural Analysis
This conservation project was an ideal opportunity to study and record the structure of the balustrade. No-one knew precisely how much was French early eighteenth-century, and how much was nineteenth-century, but in its original form it was shorter by nearly four metres so it must have been lengthened to fit its present location. Analysis and research was hampered by the sheer size of the task; over 1,000 gilt-brass mounts and nearly 26.5 meters of ironwork to assess.

As each panel was taken down and dismantled, the back of every mount was examined, photographed, and any marks or numbers struck into the metal noted. One construction phase was indicated by letters and numbers which were of an eighteenth-century style (often matching those struck on the ironwork supporting the mounts) dating back to the first assembly of the balustrade in the Banque Royale, and another was indicated by a complete absence of marks, mainly on mounts taken from the short panels (nineteenth-century in origin). Casting marks, together with plugged or altered attachment holes, provided further evidence of major structural alterations, presumably dating from the 1874 reconstruction. Eventually, all these details will be transferred to a computer database, so that the information can be more readily sorted and tabulated; this work is still in progress.

Metallurgical Analysis.
A systematic programme of non-destructive metallurgical analysis was carried out by Dr. Brian Gilmour of the Royal Armouries Conservation Department, using their energy-dispersive X-ray fluorescence (XRF) equipment (Table 2).

In a significant re-assessment of the balustrade, all the sections were found to contain nineteenth-century elements, some of the panels being entirely nineteenth-century. This suggests a considerable degree of reconstruction, even if we are still justified in regarding the long panels as predominantly original with the shorter ones added c. 1874 to make up the length (Figure 5).

XRF analysis has revealed that the mounts themselves are brass rather than bronze, as was previously thought. Metallurgically, the original early eighteenth-century mounts (approximately 74-81% copper to 16-24% zinc, plus impurities) differ from the nineteenth-century ones (67-73% copper to 26-32% zinc, with far fewer impurities). Three or four mounts examined, however, proved to be slightly different again; these were perhaps re-cast from others presumably either faulty or otherwise unusable in the re-worked design, so melted down for re-use.

In order to see if this grouping principle worked statistically, Dr Nicholas Eastaugh carried out for us ‘Principal Component Analysis’ from the XRF data. Principal component analysis is, basically a way of reducing the amount of information while retaining the most significant parts of it. Here we have taken the levels of various elements in each sample and extracted two new values, ‘factor 1 and 2’, which represent the first and second most variable components in the data (Figure 6). Factors 1 and 2 are combinations of the elemental levels, where F1 is the primarily related to all elements except nickel and F2 vice versa. Often (but not always) the first two factors (i.e., the most significant factors) show groups of data points, as we seem to have here; consequently we can distinguish graphically between what are probably the earlier and later brasses.
Table 2  Percentage of elements by weight

<table>
<thead>
<tr>
<th>Sample</th>
<th>Fe</th>
<th>Ni</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
<th>Ag</th>
<th>Sn</th>
<th>Sb</th>
<th>Comment</th>
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<tbody>
<tr>
<td>1</td>
<td>0.54</td>
<td>0.05</td>
<td>74.3</td>
<td>22.9</td>
<td>1.69</td>
<td>0.08</td>
<td>0.44</td>
<td>0.09</td>
<td>E</td>
</tr>
<tr>
<td>2</td>
<td>0.22</td>
<td>0.03</td>
<td>71.6</td>
<td>27.8</td>
<td>0.21</td>
<td>nd</td>
<td>0.09</td>
<td>0.05</td>
<td>?N</td>
</tr>
<tr>
<td>3</td>
<td>0.50</td>
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<td>21.7</td>
<td>1.64</td>
<td>0.10</td>
<td>1.04</td>
<td>0.06</td>
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<td>20.7</td>
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<td>0.49</td>
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<td>0.07</td>
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<td>0.03</td>
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<td>0.07</td>
<td>0.01</td>
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</tbody>
</table>

Key:  
E: c. 1720  
N: c. 1874  
nd: not detected

Dr Nicholas Eastaugh finds this method more useful than just ascribing each analysis to a group depending on the raw data alone. However, as I expect you have noticed, there is one value (bottom centre) which could be read as being in either group; we should probably treat this as a third group. I mentioned earlier that poor quality castings were remelted, resulting in the greater loss of zinc (possibly around 10% each time) which is possibly why we are getting this rogue result. Some of the nineteenth-century castings were made directly from the eighteenth-century originals, adapted where necessary during the moulding stage so as to fit their new locations. Plugged holes and brazed joints indicate that some of the old mounts were re-used in different positions from those for which they were originally designed.

XRF analysis of the gilding layer was undertaken to identify any traces of mercury, which would confirm the presence of original fire-gilding, but no trace was found; all the mounts appear to have been electro-gilded during the 1874 reconstruction. As one would expect, the early eighteenth-century finish of the mounts was probably mise en couleurs (brass, polished or acid-dipped to brighten them, then lacquered to preserve the finish), a well-known technique of the day used to simulate gilt-bronze. The relatively poor quality of the chasing tends to support this.

In order to supplement the XRF surfaces analysis, a small (2mm by 1mm) sample was taken from an eighteenth-century mount for electron microprobe testing by Dr. David Scott of the J. Paul Getty Museum. The results from this analysis confirmed that the mounts had been electro-gilded. There was also small traces of mercury (0.53%) present, but this level is too low for the gold to have been applied by the mercury
amalgam process and is properly due to mercury salts being added to the plating solution to aid the plating process.

**Conclusion**

Through analysis and the processes of conservation we have obtained firm evidence for many hitherto unproven theories, and ascertained the following:

- the mounts are brass rather than bronze
- there are two distinct groups of brass composition, which helps us to differentiate between the eighteenth and nineteenth-century brass mounts
- the large sections of the balustrade date from the early eighteenth century, but nonetheless contain a small percentage of nineteenth-century mounts
- the half-landing corner sections are eighteenth-century in origin
- the small sections date from the 1874 reconstruction
- the pair of griffin figures at the base of the staircase also date from 1874
- some of the eighteenth-century mounts were used in 1871-4 as models for casting mounts on the small sections
- there is no evidence that any of the mounts were ever mercury-gilded
- the gilding of the mounts is nineteenth-century (electro-plated)
- the ironwork was painted green in 1874 and was subsequently blackened (cross-section shows uniform paint layers with no dirt present between paint layers)

The Grand Staircase Balustrade at Hertford House, although undeniably a work of art, is still functional and in use every day; the choice of conservation treatments had to take account of this. The entire procedure of analysis and conservation took just over one year, but it is envisaged that no further large-scale treatment will be required for the next twenty-five years or more, other than routine monitoring of condition. As a direct consequence of the analytical work carried out on the balustrade mounts, Dr. Eastaugh has commenced a major project in conjunction with Christie's auction house, using a range of objects drawn from the Wallace Collection and other sources. It is hoped that this will establish an analytical database as a reference facility for the identification and differentiation of eighteenth and nineteenth-century copper alloys.

**References**

I am grateful to Dr Brian Gilmore for carrying out this analysis and for giving his permission to publish the results. Thanks are due to Dr Nicholas Eastaugh and Dr David Scott for their help and encouragement during this project.


Wallace Collection Files, F68.

**Manufacturers and supplies:**

Paraloid B72: Conservation Resources (Ltd), Units 1, 2, & 4 Pony Road, Horspath Industrial Estate, Cowley, Oxford OX4 2RP.


Chemicals: R & L Slaughter Ltd, Units 11 & 12, Upminster Trading Estate, Warley Street, Upminster, Essex, RM14 3PJ.

Comet Gun Blue: Parker Hale Ltd, Birmingham.

**Personnel involved in the project**

The Wallace Collection Conservation Department: Paul Tear, Head of Conservation; Robert Peace, Senior Conservation officer; David Edge, Senior Metals Conservation officer; Colin Jenner, Conservation officer; Alastair Johnson, Technician; Adam Webster, Technician; Larry McCarr, Technician.

Conservation Advisory Panel: Rosalind Savill, Director; Peter Hughes, Head Curator; Barbara Roberts; Nick Norman; Theodore Dell; Peter Mactaggart; Brian Considine; Jean-Nèrée Ronfort; Michel Janet; Anna Ostrup; Pierre Ramond.

Outside consultants: Dr. Nicholas Eastaugh; Dr. Brian Gilmour; Dr. Ian Bristow; Patrick Baty.

Interns: Igor Ravbar; Lasse Mattila.

Volunteers: Rachel Hyles; Deborah Ekes; Beatrix McIntyre; Andrea Cunningham; Ben Rawlinson Plant; Dominique Rogers; Liam Kenneddy; Fiona Lissamer; Sarah Pannell; Flavia Philp; Yann Ford.

The Wallace Collection
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Figure 2: The Main Staircase of Hertford House.
Figure 4: Cross-section of the paint-sample from the Balustrade, showing red lead primer and 4 layers of green paint.
Figure 5: A section of the balustrade dating from the 1874 reconstruction.
Figure 6: Principal Component Analysis of the XRF-results of Table 2.
The Conservation of the Baumgartner Casket from the Charles Henry Clay Organ Clock

David Wheeler

History and Acquisition
The Royal Collection organ clock by Charles Clay is probably the most complex and colourful of amalgamated works of art within the Collection, representing a host of craftsmen, artists and musical technicians, spanning a period of a hundred years (Roberts, 1995).

The clock is in two main sections, the upper decorative part being an elaborate silver-gilt, filigree enamel and engraved rock crystal casket in a combination of classical and eastern influenced style and decoration. The lid is surmounted by a bronze group of St George and the Dragon. The base plinth is of oak carcase work veneered in fiddle back mahogany with ebony panels and lacquered brass mouldings. The lower portion contains a pipe barrel organ and the upper section a small clock. The casket bears a panel inscription inside the lid in German, which can be translated as: "I Master Melchior Baumgartner have made this casket in Augsburg and covered it with silver in the year 1664".

Baumgartner was known to have supplied similar pieces of highly ornamented cabinet work for which Augsburg was particularly noted, to the courts of Munich and Brunswick but the original owner or commission for this piece is as yet unknown. The piece is first noted in a London newspaper advertisement dated 1743 in which Sarah Clay, widow of the clockmaker Charles Henry Clay (d. 1740), announced its exhibition as "the most curious and valuable piece of clock work left by her late husband The Temple and Oracle of Apollo" - only the figure of Apollo is now lacking.

Charles Clay, a notable London clockmaker, had at some time acquired the Baumgartner casket and used it as the crowning feature for one of his elaborate organ clocks featuring tunes composed by Handel. Another Royal musical clock 'The Temple of the Four Grand Monarchies', recently restored and rebuilt in the Cupola Room at Kensington Palace, had also been built by Clay but finished by John Pike after his death.

The clock was acquired into the Royal Collection by Augusta Princess of Wales (mother of George III) and was displayed at Carlton House and later during George III's reign at Kensington Palace where it is recorded in the drawing by Pyne in 'Royal Residences'.

George IV moved the clock back to Carlton House where it is recorded as being restored by the King's goldsmiths Rundell Bridge and Rundell, and the clock plinth remodelled using mounts of a similar design to those found on some of Daniel Quare's longcase clocks. Rundell's also added the group on the lid of St George and the Dragon attributed to Francesco Fanelli (1608-65) which might possibly be a survival from the collection of Charles I.

It was moved to Windsor in the mid 1820's to take centre place in the window of the Library - now the Green Drawing Room - and again early in Queen Victoria's reign to the Grand Corridor. The final addition was the Bible of General Gordon of Khartoum placed there by Queen Victoria after it had been presented to her by Gordon's sister Augusta in 1885. The organ fell into disrepair at the end of the nineteenth century and in 1929 the casket was removed from the organ clock and placed on a side table in the Grand Corridor. The clock and organ disappeared into storage and was only rediscovered about ten years ago. During the great fire of Windsor in November 1992 the casket, now in an advanced state of decay, finally succumbed to its violent upheaval during the evacuation and remained in storage until being sent to the Marlborough House Conservation Workshop for complete conservation.

Description and Construction
The casket is constructed on oak groundwork, built up in laminated and blocked sections presumably in an attempt to reduce the effects of shrinkage. There are three main sections: a lid, a main box with a lower compartment, accessed only by dismantling the piece but visible through side windows and crystal panels in the base of the main box, and a splayed base plinth. The oak carcass work is glued together with no formal jointing, and the heavily moulded edges have exact wooden replicas beneath the silver-gilt, mitred with great precision.

The lid, main box and lower compartment are set with forty rock crystal panels engraved with landscapes, figures and shipping scenes. They are also glued into place and surrounded with a small edge moulding in solid silver. The entire piece is overlaid with silver-gilt sheet both inside and out.
The main box is also decorated with applied rock crystal columns which stand away from the face which the upper frieze and lower plinth follow giving a highly reticulated outline to the mouldings. In the four corners are Greek goddess figures in gilt bronze, standing in niches. The lid is surmounted by a gilt-bronze group of St George and the Dragon.

**Condition**

The casket was in a severely decayed state having been untouched for most of this century (Figure 1). The silver-gilt surface was extensively corroded and large areas were covered in heavy tarnish deposits. Most of the silver-gilt covering was loose or had fallen off, especially the larger pieces inside, due to the decay of the glue. The oak ground work was also falling apart and delaminating due to perished glue and timber shrinkage. The enamel overlay was extensively damaged with many missing areas and pieces reapplied in the wrong place to fill gaps for effect only. In many areas excessive and inappropriate adhesive had been used although most of the enamels were lifting away from the silver. Extensive dust and greasy dirt had accumulated in the horizontal lid and base plaques, which together with the excessive and decaying glue obliterated much of the colourful design. During the evacuation from the fire a large section of the base had broken away and the casket was no longer in a presentable condition to return on display.

**Conservation**

With the knowledge that the organ movement, although decayed, was in existence and in a reasonably complete condition, and that the clock movement had survived, a decision was made to re-unite the casket to its base and return the entire piece to its former glory. The casket was first dismantled into three main parts and the middle section forming the main box was worked on first. On examination it became apparent that an entire rebuild would be necessary as most of the glue had perished over the piece and the oak carcass would need to be strengthened before any of the silver-gilt could be reapplied.

The large crystal panels and pillars were first removed, together with the lock and corner figures in gilt-bronze. The silver-gilt sheeting and mouldings were then removed and laid out in order on boards, keeping the enamels attached to the silver as far as possible. Many of the pieces fell away with ease, but some were held in position due to the overlapping nature of the carcass construction. This particularly applied to the areas around the hinged windows which were overlapped by the curved 'niches' behind the crystal pillars, and had carefully to be eased out. The silver mouldings sometimes came away with the wooden core moulding attached and sometimes leaving it affixed. Most of these core mouldings were removed, leaving a few firmly fixed as a guide.

Once all the decoration had been removed, the base of the box containing the crystal panels was taken off leaving only the four sides. The laminated construction was then consolidated by knifing hot glue between the layers where they had separated. This made the carcass rigid enough to be handled easily. Old glue was then cleaned off the surface of the wood. Scraping caused too much damage as the surface had originally been 'toothed' to provide a better 'key' for the glue. As it was water-soluble, the surface was scrubbed with warm water and toothbrushes and quickly dried. The surface was left clean and undamaged as the water had little or no effect on the stability of the oak timber. Other glues, used in later repairs, were either removed manually or with an appropriate solvent.

The wooden cores were removed from the mouldings, washed and refixed with new scotch glue. Once all the wooden mouldings and component pieces had been cleaned and refixed, attention was turned to the silver. The enamel strips and plaques were then removed from the silver sheet using methylated spirit to attack the glue joint. Where modern adhesives had been used for later repairs methylene chloride was used to decay the glue. The silver-gilt was washed in warm water and then placed in silver dip to remove corrosive tarnish and finally cleaned and burnished with silver foam, and after drying, burnished with a chamois leather. The Corinthian capitals and bases and frames surrounding the large crystal panels were likewise cleaned. These were then carried out to find a suitable glue to stick the silver sheet to the oak carcass (which was not completely flat). HMG, a conservationally approved aromatic nitrocellulose adhesive was tried as a contact adhesive. This worked reasonably well, but it was difficult to apply and hard to remove the excess. The silver also only stuck to the high points of the timber and was not supported by the glue in the gaps. Ordinary scotch glue was not sufficiently flexible for the larger sheets. Consequently a decision was made to use Secotine fish glue which, when bound with Polyfilla, made a stiff paste with a good initial tacky adhesion. When set it provided support on the uneven areas and imperfections in the timber.
Added to this, it was slightly more flexible when dry, after about twelve hours. Secotine alone was too thin, but that was overcome by applying it as a contact adhesive, to both surfaces, allowing them to dry partially, before being brought together. This method was used on the flatter surfaces (Figure 2).

Missing wooden parts and mouldings were made good using oak to match and flat silver was cut from sheet and electroplated to match. Silver mouldings were remade using the electrolytising process, contracted out to BJS Electroplating Ltd.

This involves making a rubber mould of a similar component applying an electroconductive paste and then plating in copper or silver until the desired thickness is reached. The result gives a perfect reproduction on the face side without the problem of shrinkage, which occurs when a casting is made. Copies were made of the longest lengths of the mouldings which were then cut up to replace the missing areas. They were then returned to BJS for electrogilding.

Attention was then turned to the enamels. Many of the 'plaques' and lengths were on inspection found to be fragments stuck together in a random arrangement, particularly on the upper frieze of the box. The enamels were soaked in a mild biodegradable detergent solution, each section separately in containers. Many fell apart into tiny pieces and it became apparent that previous repairs had involved glueing fragments back with animal glue in no particular order simply to cover the chips and missing parts. Many components had been swapped around and were not in their original positions. After cleaning and removal of all types of old glue (including Araldite, PVA, Uhu, Evostick) which had been used over the years in the repairs, the enamels were carefully examined.

Amongst the broken parts and fragments which formed the upper frieze was one complete piece in the form of an elongated lozenge. Most of the other pieces formed part of this particular design, although enamelled in different patterns and colours. The original enamel designs were on a thin repoussé silver ground, enamelled with colours on the decorative side and in plain white for balance on the back. The pattern was very florid and globular in construction; many had chipped badly where the silver had bent or fractured. The filigree nature of the designs meant they broke into very small pieces which were not easy to reconstruct. The unit designs were quite limited so component pairs and even small fragments became easily recognisable after continuous examination. The parts were all sorted and eventually replaced - these were usually immediately glued back with HMG nitrocellulose glue. Fragments from the base and lid enamels were found within the central section, recognisable by their slightly larger scale.

It was decided to rebuild the plaques as complete independent units rather than amalgamated pieces stuck together on the silver. This would mean trying to use as many of the fragments as possible to build up a set of complete enamels and reproducing missing areas where necessary. A medium was also needed to repair chips in the enamel and smaller areas where the repoussé silver foil ground showed through. Hxel Epoxy was chosen as a slow curing resin which, when mixed with fumed silica, formed a 'gel' compound. When dry this retained its meniscus and a glassy smooth finish which required no after-finishing or smoothing: an important consideration due to the large number of enamels to work on.

The one complete enamel from the upper frieze was repaired and strengthened. This and other complete sections from around the windows and gilt-bronze statues were sent to BJS for electroformed copies to be made in copper (Figure 3). The copies were cut out from the surrounding waste and the fragments cut in to replace the copper. Some were rebuilt using mostly surviving pieces, others contained mostly new parts. All were spot glued together with superglue before being amalgamated together with the Hxel resin. The new areas were repainted using enamel paints which had a very similar colour range to the original. All chips were built up with Hxel and retouched to match. Totally missing areas were also replaced with painted electro-formed copies.

The double row of scalloped edging just below the upper frieze was made up of original parts and later replacements in enamel. These were very similar though the later ones were slightly thicker as the enamel was fired onto flat copper. They were rearranged placing all the originals at the front and later parts at the back and sides, which gave a more harmonious effect. It was interesting to note that other areas of enamel, especially around the corner statues, were made up using the slightly different technique of enamel on flat copper. These areas were a very good match to the original and made with very much the same spirit with the exception of the green colour used which was not of the same tone. Broken chips and fragments from these enamels were also slightly different in colour and shape which made them easy to identify and return to their original place.

Three of the rock crystal pillars were broken and these were first reglued using an ultra violet curing
glass adhesive. Bad chips and knocks were repaired with clear HxTel resin which when dry was burnished making it blend with the surrounding natural faults.

The lid and base were treated in a similar way but had one or two different problems. Both were disintegrating badly and much of the block construction had to be rebuilt by the breakdown of the original glue. The front edge to the lid had also broken away having being repaired a few times previously as was evident by the amount of glue which smothered it. After removing all the gilt and the mouldings around the crystal windows the oak carcass was washed to remove all old glue. On the plinth the projecting bases to the pillars composed of small blocks were all removed and rebuilt away from the main section of the base (Figures 4 and 5). The wooden sub-mouldings to the edge of the lid and the plinth were all removed from the silver-gilt, cleaned and re-fixed.

The upper part of the base containing the enclosed lower compartment, lined in red silk, was unglued from the base and kept as a separate fourth part. It was deemed necessary to sacrifice the silk as it was too decayed and the base of the box having a large split running through it. New silk was first stuck to brown paper before being cut to fit the interior. This made it much easier to handle as well as preventing the material from fraying.

New silver-gilt moulding was electro-formed and cut into place. Large areas were missing on the edge of the lid and these being particularly small were quite difficult to cut and fit. This electro-formed silver was also used to replace poor previous restorations which, it was felt, would spoil the overall aesthetics of the finished piece. A steel template cut at 45° with a hardened edge to resist filing proved a valuable gadget for aiding the cutting and filing of some of the smallest sections to size.

Once finished, the exterior silver-gilt was given a coat of Frigilene lacquer to protect it from tarnishing. The enamel plaques were glued into position using clear HMG which dried invisibly should any glue have exuded through the filigree holes (Figure 6).

The organ case was also restored at Marlborough House workshops and the organ rebuilt by Stuart Dobbs of Messrs. Goetze & Gwynne in collaboration with Mr. Peter Ashworth, Royal Collection Clockmaker at Windsor Castle, who also restored the clock movement and coupling mechanism. The piece is now on display in full working condition for probably the first time this century and visitors to the Windsor Castle State Apartments can enjoy Mr Clay’s Masterpiece restored once more to its original status.

References


Manufacturers and Suppliers

Mr. S. Dobbs, of Goetze and Gwynne: 5 The Tan Gallop, Welbeck Estate, Welbeck, Worksop, Nottinghamshire S80 3LW.

BJS Company Ltd: 65 Bideford Avenue, Perivale, Middlesex UB6 7PP.

Sheppy glue: J. Mylands Ltd, 80 Norwood High Street, London SE27 9NW.

Polyfilla: Polycell Products Ltd, Broadwater Road, Welwyn Garden City, Herts AL7 3AZ, U.K.

HxTel epoxy, Glass Bond, HMG nitrocellulose glue and enamel paints: Stuart Stevenson, 68 Clerkenwell Road, London EC1M 5QA

Frigilene: W. Cannings, Great Hampton Street, Birmingham.

Secotine: no longer produced.

Royal Collection Trust
Stable Yard House
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Figure 1: The lid of the Baumgartner casket before conservation.

Figure 2: Central box with partially reapplied silver-gilt.
Figure 3: Rebuilt enamels from upper frieze to box and electroformed components for other enamel sections prior to cutting out.

Figure 4: Base carcass with projecting pillar bases removed.
Figure 5: Projecting bases to pillars on base section.
Figure 6: The Baumgartner Casket after conservation treatment.
Fifteenth- and Sixteenth-century Methods of Cutting Wood for Works of Art

A. Gérard and J-A. Glatigny

A practical study of an ancient method of processing wood into planks which was especially used in the manufacture of medieval and renaissance works of art.
The exhibition of Antwerp altarpieces, held in Antwerp cathedral, 1993, was the catalyst which provoked a renewed interest in the working methods and technological skill of the artists and artisans of the fifteenth and sixteenth centuries.
We supervised a number of conservation treatments of the Antwerp altarpieces on behalf of the Service de Restauration des Musées de France, and on behalf of the Institut Royal du Patrimoine Artistique, Brussels. During our conservation work we had the opportunity to examine the methods the artisans had of preparing the wood. The interesting fact we discovered was that the wood was processed into timber not by cutting or sawing but by cleavage (splitting). A method which is almost unknown and not practiced today.
The aim of our study was to understand and to reproduce this technique. We made a literary survey of old and recent texts. Articles on old methods of ship building and naval archaeology proved useful. To ensure the authenticity of the study it was necessary to use wood as similar in character as possible to that used by artisans in the past. They used oak of the highest quality, imported from the Baltic region. The wood was mostly transported from the port of Danzig by the Dutch merchant navy and as a result was known throughout western Europe as Dutch wood. Trees from this region were planted close together and consequently grew straight with few branches. This, coupled with a slow growth rate due to the climate, produced trees with a compact, homogeneous grain ideal for cleavage into planks and for making sculpture. Unfortunately purchasing an oak trunk from the Baltic region was too expensive for us. Roubo (1769-1772) states that Dutch wood and certain oak species from the Vosges region are very similar in structure and we therefore decided to use a tree from there. These trees were also very expensive (one hundred and fifty French francs per cubic metre). They are used by the timber industry in Germany to make veneers of the highest quality for use on furniture. Our oak was bought from the Office National des Forêts and came from the forest of Sturlzelbrom in the north Vosges. It had certain faults and we were able to arrive at a reduced price. We received it in the form of a log, seven meters long, with its side branches removed. We transported the log to a pond where we immersed it in water. This served the dual purpose of leaching out the sap and keeping the log humid. To study the effect of the length of time of soaking on splitting the wood, we cut the log into two and soaked one part for four months and the other for fifteen months.
Traditional cleavage tools such as froes of different sizes, metal and wooden wedges, sledge hammers, side axes and adzes were used. The log was split in the radial plane. From two cubic metres of wood we obtained a number of planks ranging in length from thirty centimetres to two hundred and twenty centimetres, which would be suitable for making altarpieces, sculpture groups and small panels for painting. The natural faults of the wood such as knots and meandering heartwood determined the length and thickness of the planks and made it difficult to produce the long thin planks that would be necessary for constructing larger panels. However, during the course of our study we became proficient in the use of the traditional tools and techniques of cleavage, an almost forgotten skill, and produced high quality quarter (radial) split planks. Cleavage can only be successfully carried out on green wood, full of sap or alternatively wood which is saturated with water. Cleavage can be carried out in the forest where the tree is felled.
In parallel with this study, during our every day work as conservators and restorers, we have had our attention drawn to the high quality of wood used in the fabrication of works of art in the fifteenth and sixteenth centuries. We can bear witness to the importance of quarter-split oak which has grown at a slow rate. This technical application of the anisotropic qualities of oak was initially based on empirical knowledge of wood. It was this ability of our ancestors to 'read' wood that allowed achievements remarkable for their exceptional technological efficiency.
The planks made during our study will be used in conservation when it is necessary to make reconstructions. They will also be used in research as study samples. For example, currently being carried out at L'Ecole de Restauration d'Oeuvres d'Art de la Cambre, Brussels, is a comparative study on the swelling and shrinkage of different
types of oak under the influences of hygrometric variations.
Certain aspects of our study deserve more profound research:
• monitoring the growth of a tree in a forest, in collaboration with a dendrochronologist and an agroecopedologist
• determining the relation of the physical qualities of the tree to its orientation and height
• defining the effects the length of time of immersion in water on the physical properties of wood
• comparing the results of the cleavage experiments with wood found in works of art during conservation treatment
• studying the wood samples in the Gdansk Naval Museum.

References

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The Use of Dendrochronology for the Analysis of Works of Art.

Catharine Lavier

In the interest of a better understanding of works of art, a new line of research has been developed in recent years. Dendrochronology, traditionally mostly used for the dating of archeological sites and historical monuments, has recently widened its scope to include objects and works of art. Methodology and above all a technological approach had to be reconsidered for this type of study. In this venture, the cooperation between the Laboratory of Chrono-Ecology at the University of Besançon and the Centre for the Conservation of Works of Art in Vesoul proved to be fundamental. This paper presents the principal phases of the investigations carried out by these two institutes.

The first aspect to consider, in dendrochronological analysis, is the species of wood to be studied. Whereas oak has been used for the last five thousand years and coniferous woods for the last thousand as the main timbers used in foundations and roofs, the species used in works of art are more varied. Oak is widely used for retables and paintings of the Northern Schools (Figure 1). It is not unusual to find oak boards of 60 to 80 cms in diameter, three centuries old, with an annual growth of about one millimeter. But the wood used also depends on the potential of different regions. We thus find much pine from the Vosges and the Black Forest in the painted works of the South German School. We also found Tilia, and sometimes Acer, Juglans, Populus and some Rosaceae such as Prunus and Pyrus.

The second aspect concerns the taking of samples. Although it is easy to cut slices or even a large piece of a beam, it is unthinkable to do so on works of art. With the help of the conservator, access to growth rings is possible by means of the base of a statue, by unframing paintings and by dismantling retables and pieces of furniture. In this way, numerous observations can be made on the way different components are cut and assembled. To measure the growth rings to within a hundredth of a millimetre, it must first be ensured that the object is in good condition: the absence of fungal attack, cracks and missing pieces provide ideal working conditions. After thorough cleaning of the surface to be examined, each species of wood must undergo specific micro-preparation to make the borders between the growth rings visible. This is carried out on a small area, either by micro-sandblasting for oak, thus freeing the pores of earlywood, or by micro-sanding, mostly for coniferous woods, to distinguish earlywood from latewood.

Photographs of very high quality are taken of the cleaned areas. For example, a hundred photos are easily needed to examine a retable. The rings as seen on the photographs are measured as if they were on the surface of the wood itself. The object is thus not further damaged by the numerous manipulations indispensable to dendrochronology during measuring and another advantage is that the photographs are useful for later study.

The third aspect is the number of different pieces of wood in a work of art: a building can be understood through the number of beams sampled, beams which will provide an overall image of the growth rings and the number of trees used. A statue, however, often has only one trunk and does not yield much dendrochronological information. A painting, on the other hand, often has several boards taken from the same tree, which allows for a reconstitution of the tree that was used. For a retable, it is possible to estimate the number of trees cut and even to establish if they come from the same ecological area.

The number of rings per sample is very important. Although it is relatively easy to obtain sequences of growth rings of at least a century on retables, statues are sometimes hollowed out, providing no information as is the case with paintings whose boards come from younger trees. A single object, made of oak with fewer than 50 rings, whose origin and period are not known, cannot be dated, quite contrary to a retable or piece of furniture having twenty components each with more than 200 rings.

The fifth aspect is dating: even when the art historian is able to date a work of art, it may be impossible to determine its date dendrochronologically, due to a lack of biogeographical reference data - local and regional - or to an inferior annual count; fewer than 10 woods per year. It is therefore necessary to establish chronological data specific to each biogeographical region: it takes about ten years to cover a certain region with any statistical significance.

The next aspect is the origin of the tree: a work of art is above all a mobile object. Although manners of construction and styles of painting are known, the forests which were the sources of the trees used are not, and the wood trade was highly developed throughout Europe as early as the Middle Ages.
It is currently possible to identify woods from Brittany, Burgundy, the Parisian Basin, the Vosges, and even, for example, from some Polish regions. Once the date of the dendrochronological sequence is known, the date the tree was felled must be determined, since woods are cut down, sawn and formed.

The cost of good quality oak was and is high and medieval regulations imposed discipline on the use of wood, for example, by condemning the use of sapwood and knots. We work on the basis of the minimal loss of wood by estimating the removed rings of the sapwood (Figure 3), which varies according to different European regions (generally from some up to 40 rings). In the case of coniferous woods the sapwood is not visible and therefore not removed, which reduces the time range by a few years.

Finally, the lapse of time between the felling of the tree and the construction of the object must be evaluated. Based on our observation of about a hundred works of art, this can be from one to a few years (Figure 2).

By working in close collaboration, the art historian, the conservator and the dendrochronologist can obtain essential information about the work of art itself, but also apply, transpose and adapt this information to other works of art on which little or no information is available. Such information can also be used for the examination of copies and the reconstruction of an individual piece or a collection that has been dispersed.

It is also possible to develop other techniques of data acquisition (complementary or not) that are equally non-destructive for highly fragile pieces, techniques such as infrared photography, x-rays and scans, although these attempts have not been very encouraging up to now.

To conclude, it must be remembered that the gathering of information is essential, and that it must be non-destructive, precise and carried out systematically on the work of art itself. It is therefore important to study a maximum of works with a maximum of wooden components.

The conservator-dendrochronologist couple can supply the art historian with much information through their know-how, experience and natural complementarity.

References


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Figure 1: The areas studied by the Besançon-Vesoul team, mainly the Northern European Schools. The results show that with good conditions the biogeographical origins of the woods used can be traced.
Figure 2: The replica of the Basilica ciborium in the Museo del Duomo, Florence, features a piece of wood that was once part of the Basilica. The wood was used to make the ciborium, and its rings provide a chronology of growth over time. The rings represent a number of years, and the date of the rings varies over a number of years, from a few rings to about forty years.

A measured wooden plank = a growth curve

Mean dendrochronological growth pattern

1168: First ring measured

1490: Last ring measured

317 years

TIME A.D. 1200 1250 1300 1350 1400 1450 1500 1550

HEARTWOOD

Missing Heartwood

+ Missing SAPWOOD ...

Estimated felling date 1500–1520
Figure 3: The prestigious collection of the Unterlinden Museum in Colmar (Alsace, France) includes about fifty wood paintings by artists known as the Primitives. The majority are of pine (Pinus sylvestris), the woods being mainly from the Vosges area.

This study allowed us to confirm that the estimated time between felling, cutting and forming, and the actual production of the work of art itself, is a few years at most.
The Conservation of Three Cabinets from Rosenborg Castle, Copenhagen.

Hans-Henrik Tungelund

The conservation of a pair of pietra dura cabinets.

Description
In 1709 Crownprince Frederik of Denmark, later King Frederik IV, bought, during an Italian trip, a number of pietra dura plaques in Florence. Around a year later a pair of cabinets was made in Copenhagen in which the pietra dura plaques were incorporated. The stands were added in 1740 and also made in Copenhagen (Figure 1). The cabinets are entirely constructed of oak. The sides are joined with dovetails to the top and the bottom. The shelves and partitions are housed in grooves and held in place by small wedges. The top is covered by a 5 mm thick oak board, which is nailed along the edges. The sides of the cabinets are decorated with panels of floral marquetry of different kinds of wood and green stained bone, in a background of walnut veneer. The marquetry panels are surrounded by a snakewood border. The mouldings, made of olivewood, are partly gilded. The drawers are made of oak except for the bases which possibly are of South American cedar, to prevent insect damage! The pietra dura plaques are set in a rebate and secured by strips of snakewood which form a border around the plaques.

Condition
The main problem which had to be solved was the conservation of the heavily damaged snakewood veneer on the sides, due to the shrinkage of the construction timber (Figure 2). Shrinkage cracks were present in the marquetry resulting in exposed veneer on the edges, plus loose and missing parts. Some areas of the pietra dura marquetry were loose. The left sides of the cabinets were very bleached. Many mouldings were loose. Of the mirrors belonging to the interior, one was broken and one was missing. The amalgam backings were cracked and unstable. The stands, constructed of limewood, were very dirty and the gesso and the gilding showed flaking. Parts of the carving were missing.

Conservation
It was decided, for aesthetic reasons and to minimise the risk of further losses, to close and fill the shrinkage cracks in the sides and to reglue any loose marquetry and veneer. To achieve this purpose, all mouldings were temporarily removed as well as the damaged horizontal snakewood veneer, using spatulas. The cracks in the marquetry could now be closed using serre-joints. When the cracks in the floral marquetry were thus closed, the blindwood still showed cracks in the areas where snakewood and mouldings had been removed. Balsawood strips were inserted to level the surface. To obtain a strong joint between the mouldings and the oak carcass gaps between the two were filled with balsawood, prior to regluing the mouldings. The eight horizontal snakewood borders were all completed and all pieces glued together under very high pressure, the finished side of the veneer covered with polypropylene foil and a piece of thick smooth polycarbonate. The back of the veneer was covered with teflon foil, 4 mm cork and 19 mm plywood. Cramps were used to flatten the veneer between the boards obtaining a perfectly flat surface. Under very high pressure teflon foil can cause an imprint from its structure into the surface. For that reason polypropylene-foil was used on the finished side of the veneer, though it must be absolutely dry before removal, so as not to spoil the surface. As a result of closing the cracks, the mitred ends of the snakewood had to be adjusted. Also, the old glue on the veneer and the carcass were no longer in alignment. To get the snakewood veneer level with the rest of the veneer, some old glue had to be removed and where missing, new glue had to be added. To obtain a new perfect fit, the friezes were glued with teflon-foil between the blindwood with glue (old and new) and the snakewood veneer. This was repeated up to five times for each piece of veneer frieze, with time to dry in between, until the appropriate level was reached. The friezes were eventually glued by applying a thin glue onto the veneer and wetting the glue layer on the carcass with water. The veneer was placed in position and covered with teflon foil, a 1 mm thick polycarbonate sheet, a 30 mm thick
rubber sheet as a compensation layer and on top 19 mm plywood. The rubber material was used as an experiment and worked very well especially because of its length (approximately 45 cm). Normally 14 mm thick cork or soft masonite is used, softened with hot water to even out the pressure onto an irregular surface.

To heat up the polycarbonate sheets, masonite and other materials an oven is used at 80º C. Infrared-lights or a Leister (200-250º C) are used for isolated areas and a hot plate for mouldings. The glue used was Dr. Kremer's rabbitskin glue, trying not to exceed eight hours of heating au-bain-marie.

Loose marquetry was reglued by lifting the very loose pieces, particularly the greenstained bone. For partly loose pieces, syringes with 0,4-0,5 mm needles were used to insert glue. If these methods posed too much risk to the edges, a thin glue was rubbed into the joints with the fingers, using a polypropylene-foil on top of the glue to prevent rubbing directly onto the surface.

Missing bone was replaced with new bone, stained green with an alcohol based stain after being degreased in acetone to avoid spots.

Seven pietra dura plaques were temporarily dismounted to remove the tension due to the shrinkage of the front of the drawers. The snakewood borders in order to lift the plaques. The rebates were then enlarged by 1-2 mm to compensate for the shrinkage. On one plate, half of the joint between the pietra dura and the slate underneath had loosened. On three other plaques the limestone friezes surrounding the pietra dura were loose. Originally the pietra dura was glued with resin, so it was decided to use a dammar resin as glue. To avoid heating and interfering with the rest of the marquetry, it was dissolved in white spirit 1:1, and either injected or applied with a brush until an appropriate thickness was achieved.

The surface on the pietra dura marquetry was quite dirty. A kind of varnish had probably once been applied on top. A cleaning test with water and ammonia 1:20 was carried out on two drawers. The dirty layer proved very difficult to remove. As yet, no decision has been taken whether any further cleaning is necessary.

The broken mirror was glued with Ablebond 342-1 epoxy glassglue. The missing mirror was replaced with an old 'look alike', this mirror however did not have an amalgam backing. Because the old paper covering the back of the mirror was very brittle and possibly acidic it was replaced with new acidfree paper. The surface of the mirrors was cleaned with water and ethanol. The mercury that had accumulated at the bottom of the mirrors was carefully collected and treated as chemical waste.

The back panels of the cabinets were dismantled, any cracks closed and glued and approximately 10 mm oak on each side was added to make up for the shrinkage. The original nails have all been taken out, and are now kept with the report. To replace the nails, six new stainless screws were used. Two of the screws secure the backpanel in the middle, using the old holes of the nails. The remaining four are placed two on each side, through elongated holes in the new oak, allowing the back to move.

Two varnish samples were taken from the interior of the cabinets to provide data for a research project of The National Museum of Denmark on original finishes on furniture. Sample 1 was taken from the front of a drawer and showed much colophony and a trace of a drying oil (linseed or walnut oil for instance). Sample 2 was taken from a moulding made of olive wood and indicated the use of a non drying oil (for instance corn or olive oil, the latter was much used at the time of construction).

However, the outside of the cabinets seemed to carry a shellac varnish, probably of a later date. Brush strokes and thin or missing varnish in corners difficult to reach were visible in UV-light. The surface finish was missing in certain spots. These were covered with a very thin shellac varnish, applied with a tiny brush. The surface was cleaned during glueing or later using a damp cloth, and a commercial product 'Centurio' has been used for the parts with a shellac varnish. On all varnished surfaces acidfree vaseline oil, mixed with kerosene 1:1, was applied to increase the colours, especially those on the bleached left sides, and to obtain a good general impression.

On the stands, the unstable gesso was fixed with rabbitskin glue. A total cleaning was then made with cottons wabs and saliva. Missing gesso was replaced and regilded with metal leaf (as the original) and protected with a layer of pigmented shellac to obtain the proper colour.

A few worm infected areas were stabilised with dammarresin and beeswax 1:5, which was injected and heated with IR-lamps. The surplus was removed using paper and a hot air gun, followed by paper and petroleum. The missing parts in the carved area were not completed, as they did not affect the general impression, an interpretation was therefore avoided.

The conservation report contains a short presentation of the furniture, a technical description, a report of the condition, an outline of the conservation and techniques and materials.
used, and notes of technical and historical observations made during the work. All conservation work has been documented with drawings, using colour codes for the different interventions: blue: reglueing with new glue; brown: replacements of missing parts; green: new material (excluding replacements); orange: removal of original material; black: wax stabilisation; red: missing parts; purple: previous conservations; yellow: references. This is by far the most voluminous part of the report. The drawings have been traced from black and white photos, taken before conservation, with a Rotring 0.18 Rapidograph F technical pen with hard-metal tip on a tri-acetate film and afterwards photocopied.

Furthermore the report contains the thermo-hygrometric charts from the period in the workshop, all photographic material and a list of samples taken for later analyses: old glue, resin, paper, wood (the samples are kept within the piece of furniture). Finally, it contains the timesheets showing how the time has been used.

The conservation was estimated to last 1760 hours and eventually took 1924 hours. Five persons were involved in this conservation project: two on furniture; one on gilding; one on the amalgam mirror and one cleaning the pietra dura marquetry.

The conservation of a Danish seventeenth-century ebony cabinet.

The cabinet was made for King Christian V by Johan Bielefeldt, known as 'the blind cabinetmaker', and delivered at Rosenborg in August 1678 (Figure 3).

This conservation project followed the same principles as the conservation of the pietra dura cabinets described above. For this piece only those aspects specific to this piece of furniture are described.

The construction of the cabinet is of oak and pine, veneered with ebony and embellished with mouldings, friezes and carvings, all in ivory.

The main problem were the loose and bent ivory mouldings on the sides. Some ivory mouldings were missing, especially on the front door, and also two carved ornamentations, one of which was replaced with a plaster casting in 1955.

The other damages were generally a repetition of those of the pietra dura cabinets.

Most of the ivory mouldings consisted of a sandwich of ivory and oak. Of the loose mouldings, either the entire moulding or just the ivory part had separated. One moulding, loose and bent in half of its length, had previously been fixed with a nail and was broken in the middle, due to the tension. The intention was to straighten the mouldings before reglueing them onto the carcass. Research has shown that ivory samples (8-10 mm cubes) exposed to a change from 5% RH to 50% RH (absorption) and from >95% RH to 50% RH (drying), reach 90% of their final moisture content after 48 hours and close to 100% after 100 hours (Lafontaine, 1982). Having ivory mouldings with a thickness of up to 4 mm., 4 days were considered as sufficient to obtain a new equilibrium.

First the mouldings were cleaned with either water or a mixture of water/ethanol 1:1 and cotton swabs. Secondly, notes were taken describing the form or curve of the mouldings, to be able to make an adequate counterpressure where needed. The mouldings were then placed in a 'climate chamber': a perspex box with a volume of 80 liter containing a bowl with water and some ethanol, to avoid mould, and a hygrometer. A relative humidity of over 95% RH was maintained for 4 days. The mouldings became soft, some straightened out but others bent even more, but were easy to manipulate.

An individual 'pressform' was prepared for each moulding, using 2 boards of plywood, a flexible 12 mm and a more rigid 19 mm (Figure 4). The mouldings were fixed onto the 12 mm plywood with polycarbonate 'clamps' (neutral material), placed so that the moulding straightened. Then the plywood was screwed (with stainless steel screws!) onto the 19 mm plywood with a suitable number of strips (1-4) in between, placed across where needed, to counterpress the moulding according to the notes taken. This assembly was once again placed in the 'climate chamber' and left for another 4 days with a slowly decreasing humidity, realised by slightly opening the lid, because we were afraid of exposing the ivory to a sudden fall in humidity (Figure 5). Although the humidity had not gone down directly from >95% RH to approximately 50% RH (workshop), experience demonstrated that most of the mouldings were already stable after 4 days in the climate chamber. A few had to go through the process once again and be left in the workshop in its pressform for several days. Some did not become as straight as was expected after the treatment and the pressforms of those had to be changed. Two mouldings even had to go through the process a third time. The humidity did not pose a problem for the joints of the mouldings consisting of both ivory and oak, even though the glue did soften.

The missing ivory mouldings were completed, with ivory from a small stock. Luckily, models existed for all the mouldings to be replaced. A
homemade ‘moulding machine’ was used with a cabinet scraper in which the profile was filed (Figure 6). A moulding was constructed of a strip of ivory, cut as thinly as possible, and glued onto a piece of oak. To obtain a very stable moulding, the oak was cut radially (in the direction of the joint) and the ivory was cut tangentially, because ivory is anisotropic like wood, but contrary to wood, shows larger dimensional changes in the radial than in the tangential axis.

The original glue, which was preserved, seemed to contain a filler giving it a grey/white colour. All ivory was both preglued and glued with sturgeon glue, with a long drying time, minimally overnight. The sturgeon glue was chosen because of its good properties and its low melting point of 40-45° C. Some samples found on the cabinet showed the use of a very transparent glue, and finally a recipe was found describing the use of sturgeon glue with zinc oxide for ivory objects (Keghel, 1959).

The sturgeon glue was made from an airbladder, swelled in water at 50° C using a heating plate with a magnetic stirrer, filtered through a fine strainer and poured out in a thin layer and dried. For priority reasons, the two missing pieces of ornamentation were copied in epoxy resin, using Araldit M with hardener HY 296. They might be carved in a 100 years if the craft still exists.

References


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Figure 1: The two pietra dura cabinets after conservation.
Figure 2: One side of a cabinet showing cracks and damaged veneer.

Figure 3: The ebony cabinet with ivory mouldings before conservation.
Figure 4: An ivory moulding in a 'pressform'.

Figure 5: 'Climate chamber' with water, a hygrometer and 3 pressforms.
Figure 6: 'Moulding-machine', making an ivory moulding.