ICOM

COMMITTEE FOR CONSERVATION

Working Group n° 10

Conservation of Leathercraft and Related Objects

Interim Meeting

on the Treatment of and Research into Leather, in Particular of Ethnographic Objects

at the Central Research Laboratory for Objects of Art and Science
Amsterdam

5 - 8 April 1995

Postprints of the fourth Interim Meeting of the ICOM Committee for Conservation Working Group 10, Conservation of Leathercraft and Related Objects,
5- 8 April 1995 in Amsterdam.

Editors: P.B. Hallebeek, J.A. Mosk

DTP: J.A. Mosk

Word processing: S.F. Fontijn

The illustrations were provided by the authors.
Digital scans of photographs were made through the kind co-operation of Bas van Velzen, Amsterdam.

Contents

Preface

This publication is a compilation of the lectures given at the fourth Interim Meeting of the ICOM-CC Working Group 'Conservation of Leathercraft and Related Objects' held at the Central Research Laboratory for Objects of Art and Science in Amsterdam on April 5 till April 8, 1995.

Altogether 53 delegates from 14 countries: Belgium, Canada, Denmark, Germany, Greece, France, Italy, The Netherlands, Poland, Russia, Spain, Switzerland, the UK and the USA, and took part in the symposium. During three days twenty-two lectures were held which were followed by valuable contributions and discussions.

The main themes of this meeting were:
The conservation of parchment and gilt leather wall hangings, archaeological leather, book bindings, ethnographical objects and research. A special aspect to this meeting was the fact that on the first day there was a combined session of the ICOM-CC Working Group 'Graphic Documents' and the ICOM-CC Working Group 'Conservation of Leathercraft and Related Objects' with lectures on parchment and gilt leather wall hangings. This session could be held because both working groups organized an interim meeting in the same week and at the same place. It offered a perfect opportunity to combine the mutual interests of both groups just for this occasion.

This publication would not have been possible without the financial assistance of:
The Leather Conservation Centre
The ICOM Committee for Conservation
The Central Research Laboratory for Objects of Art and Science

Pieter Hallebeek
Co-ordinator

Marion Kite
Assistant Co-ordinator

The Transfer and Restoration of an Eighteenth Century Gilt Leather Screen

Thomas Bilson
24 Church Road
Piddington
UK-Northamptonshire, NN7 2DE

Céline Bonnot
ARC Nucléart, Centre d'Études Nucléaires de Grenoble
17 rue des Martyrs
F-38054 Grenoble Cedex 9

Abstract

This paper presents the first published account of the complete transfer of the silver, paint and varnish layers from a gilt leather screen onto a new support. The screen, an example of late eighteenth century *Chinoiserie*, was almost certainly produced in England, and consists of six rectangular folds, each supporting a single panel of gilt leather.

The screen was received for conservation in an extremely poor condition. The leather support had become highly acidic and friable and, more significantly, had also begun to de-laminate; precipitating the distortion, detachment and loss of the decorative surface.

The development of a transfer technique is discussed in terms of the other, less extreme, options available. The treatment is described, including cleaning, consolidation, facing and removal of the leather, the provision of a new support and extensive re-touching.

Introduction

The techniques by which a painted image can be transferred from a deteriorated substrate onto a new support have changed little over the past two hundred years [1-6]. From its origins in Antiquity for the transfer of wall paintings, to widespread use by mid-eighteenth century for the treatment of canvas and panel paintings, the procedure was regarded as the restorer's *tour de force*; its secrets shrouded in mystery [1]. However, by the end of the century, Montamy had published one of the first descriptions of the transfer of a canvas painting thereby revealing the operation to be relatively straightforward [2].

The perception and application of such an extreme technique has since altered in line with changes in the appreciation of the historic and artistic integrity of a work of art. For example, whilst Dalbon (1898) advised art lovers not to hesitate in having it performed on paintings whose paint was lifting; noting also the exaggerations made by other authors of the difficulties involved [3], Stout (1948) commented on the dramatic and sensational aspects of the technique. With greater objectivity than his predecessors, he cautioned against the detriment to pictures from its unwise use [4]. A current approach stressing both the inadvisability and danger of transfer, and the circumstances under which it may be the only option available to the restorer has been given by Wyld and Dunkerton (1985) [6]:

'To transfer a picture from its original support is an extreme and irreversible form of treatment, and should be avoided whenever possible.
The process itself is not without risk, a transferred picture is inevitably changed; the texture and appearance of the paint may be altered, ... and ... an unnatural flatness in the new support may be disturbing. Before a decision to transfer is made there must be some certainty that every conceivable treatment has been tried, and that developments in the techniques and materials of conservation will not, within the foreseeable future, lead to some new method of coping with the problems whilst avoiding transfer. This last point is not an easy one.'

The screen: construction and technique

The screen is divided into six folds, each comprising a single panel of gilt leather supported by a wooden stretcher. Each fold measures 2130 mm by 530 mm and, in common with many other screens of this size, each panel is made from three sheets of vegetable-tanned calfskin. These have been skive-jointed across their widths and adhered together with animal glue. The leather in each case was approximately 2.0 mm to 2.3 mm thick.

Although it is beyond the scope of this paper to investigate the origin and history of the screen, it is believed to have been produced in England during the last quarter of the eighteenth century; a gilt leather industry having been established in London from at least the early seventeenth century [7, 8, 9, 10]. The design reflects the popularity for *Chinoiseries*; the inclusion of Chinese or pseudo-Chinese decorative motifs into European works of art [11]. The main section shows various exotic species of birds amidst flowers, foliage and vines, whilst borders are formed at the top by a hanging garland of flowers, and at the sides by vases of flowers and blossom.

A cross-section of paint taken from the lower edge of the peacock's tail (fold five) shows a typical method of execution in which the leather has been prepared with a layer of size prior to being gilded with white metal leaf *(Fig. 1).* The dimensions of the leaves visible under the varnish are consistent with those of silver leaf [12]; confirmation being made with a micro-chemical spot test [13]. Despite the assertions of both contemporary and modern authors that parchment size was used to adhere the silver to the leather, the thickness and glassy appearance of this layer suggests that an oil size has been used [14, 15, 16].
The yellow varnish characteristic of gilt leather is clearly visible above the silver. Moreover, the presence of silver beneath several opaque layers of paint confirms observations that the whole support was gilded and varnished before the design was painted, rather than the gilding being restricted to the unpainted areas in which it would have been visible [17]. Pigments identified using polarized light microscopy include: a mixture of red lead and vermilion, lead tin yellow (also in mixtures with red lead to give orange), yellow ochre, brown and red earths, azurite (also mixed with orpiment to give green), Prussian blue, lead white and carbon black. The medium in each case is oil. Several areas of shallow embossing are present around the edges of the decorative elements, and along the vertical and horizontal lines separating the main design from the borders.

The flesh side of the leather was painted black originally, and decorated with a narrow border of green paper framed by the stretcher bars. This was now obscured by a restoration lining of coarse, plain-woven hemp. Leather cover-strips (later confirmed to be replacements made when the screen was lined) are present between the vertical edges of each fold, and are held in position with brass-plated, domed steel tacks.

Condition

The leather support had deteriorated to the extent that it no longer provided a stable substrate for the overlying layers of silver and paint. The processes of oxidative and hydrolytic degradation of collagen to which vegetable-tanned leathers are susceptible have been described in detail elsewhere [18]; in this case the pH of the fibres was recorded at between 2.3 and 2.6 indicating a severe degree of chemical deterioration.

Evidence of a dramatic loss of strength within the support was marked. In the first instance large areas of paint had been disrupted by cracks which followed the oblique angle of follicle growth through the grain surface and into the underlying matrix of fibres. More critically, several planes of de-lamination had formed through the leather running parallel to the paint surface. This damage was apparent either as large blisters above which continuous areas of paint hung loose, or as areas in which the paint had been completely lost. De-lamination was concentrated at the centre of each panel (especially panel five), and around the mid-point of each exterior, vertical edge; the latter perhaps as an unavoidable consequence of handling whenever the screen was folded or moved. Blooming of the varnish was also noted, together with some localized mould growth [19]. The silver leaf which would have been visible originally as gold under the yellow varnish had tarnished throughout each fold to a green-brown colour.

Although discrete de-lamination within gilt leather supports as a consequence of natural ageing is not unknown, a more likely explanation for its regular occurrence across each of the panels might be attributed to the restoration lining which was probably undertaken at some time during the late nineteenth or early twentieth century in an attempt to stabilize tears in the leather.

Tests on the adhesive used for lining yielded surprising results. Although clearly a mixture of wax and resin (historically beeswax and dammar), it was found to have a melting point in excess of 85°C, Feller (1958) describes mixtures of dammar and beeswax in varying proportions as resembling the behaviour of a material having a eutectic; the melting point remaining at around 47°C for increasing additions of dammar from 12% to 87%, after which it rises sharply to 86-89°C [20]. Although oxidation of the resin component over time would tend to contribute to this effect, the unusually high melting point of the lining adhesive may be more probably explained in terms of it having an unusually high resin-to-wax ratio. This could have been intentional had the restorer wanted to use the heat needed to melt the adhesive as a means of softening and laying down loose paint. It is certain however that the application of such a mixture would have exceeded the shrinkage temperature of the leather support, thereby inducing severe compression forces beneath the largely incompressible layer of paint. These may not have caused immediate de-lamination, however they may have been sufficient to precipitate its onset throughout the panels at a later, more advanced state of decay.

The decision to transfer and the evolution of a treatment

Lucas (1963) listed the four reasons necessitating the transfer of a painting from its original support as (summarized here): deterioration of the support, disintegration of one or all of the layers, lack of adhesion between the layers, and movement within the support [21]. The screen clearly exhibited each of these conditions, however it was necessary to explore other, less invasive treatments, if only to demonstrate their anticipated ineffectiveness. Foremost amongst these was the option of introducing an adhesive /consolidant through cracks in the paint to fill the underlying blisters. Trials with a range of materials including BEVA 371, Paraloid B67, B72, and acrylic emulsions proved however that a mixture fluid enough to flow through a crack and saturate a large underlying area of friable and absorbent fibres could not be introduced in sufficient final quantities to effect a firm bond. Such a treatment would also not safeguard better-preserved areas of leather against incipient decay, would not correct any of the distortions in the paint, and ran the disastrous risk of reducing the support to an uncontrollable, sticky mess.

The option of removing the hemp lining and at least part of the original leather remained the only treatment likely to stabilize the paint and prevent further de-lamination. Experiments on detached fragments of paint showed that leather remaining on the underside could be thinned down with a scalpel through and past the damaged layers, and into the last 0.2 mm to 0.5 mm of grain. The decision was therefore taken to dismantle the screen, remove all of the lining and unstable leather save a thin layer of grain as a margin of safety protecting the silver, and transfer the paint, silver and varnish layers onto a new, stable support.

Treatment

A scheme for choosing the adhesives and solvents for each successive stage was drawn up. This was based around the two most important and, ideally, exclusive adhesive systems to be used: those of facing and re-lining. The essential requirement was for a facing that could be applied and removed without disturbing either the new lining, the various consolidants and fillers used in the treatment, or the paint and varnish layers of the object itself. It was clear from this stage that the favoured lining adhesive would be the thermoplastic resin BEVA 371; a choice made in preference to cold lining with a solvent activated acrylic dispersion. Acrylics would have their place in this treatment, but as fillers to retain the corrected surface texture of the paint during lining; a time at which their relative insensitivity to the elevated temperatures needed to activate BEVA 371 would be an advantage. Therefore, if BEVA 371 was to be used to attach the new support to the underside of the paint, the adhesive used to attach the facing would have to be removed with a solvent to which BEVA was not sensitive. The chosen facing adhesive was therefore a Lascaux wax-resin mixture which, being highly thermoplastic, was unlikely to transfer its own surface characteristics onto the paint during re-lining.

Although various other combinations of adhesives could have been considered, a non-aqueous system of incompatible solubility was therefore built around white spirit and its capacity to act as a good solvent for wax resin, but as a poor solvent for both BEVA 371 and Paraloid B72 [22].

Dismantling, cleaning and consolidation

The folds of the screen were separated at their hinges, and the dome-headed tacks and coverstrips removed. The last operation was complicated by the presence of a thick layer of animal glue securing the strips to the surface of the paint and varnish. Beneath these were found fragments of the original coverstrips which had also been glued in position, however their removal during the previous restoration had destroyed much of the underlying paint. Separation of the gilt leather panels from their frames was finally achieved by removing a further eighty to one-hundred steel tacks which lay beneath the coverstrips. At this stage tracings were made of each panel noting the presence of cracks, holes, or particularly fragile paint. These were to serve as references during removal of the supports.

The paint surface was cleaned with odourless mineral spirits applied sparingly and removed with swabs. This was undertaken more as a means of removing particulate matter prior to consolidation and the application of a facing, than to bring about a visual improvement to the image. A consolidating solution of Paraloid B72 was then applied to strengthen the paint during the application and removal of the facing. As noted earlier, B72 would be insoluble in the white spirit used to remove the facing and would therefore act as a protective, isolating layer against which the last traces of wax could be removed.

Facing

The facing comprised a long-fibre, glazed, Japanese tissue which had been prepared with several coats of Lascaux wax resin. In order to improve the adhesion between the facing and the paint, some of the remaining wax solution was thinned to a liquid at room temperature and applied to the paint surface, after which the layers of tissue were smoothed into position. Sufficient solvent had evaporated after one day to allow the facings to be pressed, however a space of one week was allowed before a final bond was made using a warm iron. Several layers of cotton calico were then adhered above the tissue in order to provide additional strength and rigidity; the first layer possessing a particularly fine weave in order to avoid transferring a woven pattern through the tissue facings and onto the paint surface. The adhesive in this case was a mixture of sodium carboxymethyl cellulose in water and Lascaux acrylic dispersion which would enable the calico to be removed with water after transfer and re-lining without disturbing the underlying tissue.

Removal of the linings and the leather

As the hemp linings were both inflexible and heavy, and difficulties were anticipated in being able to remove them without causing unnecessary stress or further damage to the paint film. It was also likely that the alternative approach - cutting the linings into squares and removing them piece by piece - would be equally disruptive. As it was thought preferable to keep the paint and facing as flat possible, a wooden roller was fabricated onto which the lining could be attached progressively as it was cut away from the leather. The roller resembled a section of a wheel some five or six meters in radius; the curved side being approximately the same size as a single panel. Its position and movement was directed by a set of rails which also served to keep its curved side several millimetres above the panel to avoid crushing the paint. Removal of the lining and a significant proportion of the original leather proceeded quickly using a long-bladed palette knife to follow the existing planes of de-lamination.

Once the linings together with some attached leather had been lifted away, the remaining supports were thinned to within 0.2 mm to 0.5 mm of the silver through the cutting away of increasingly smaller quantities of leather *(Fig. 2).* The painted areas were now clearly visible through the back of each panel on account of the silver remaining well-preserved under areas of paint whilst having corroded to a darker colour where protected only by the yellow varnish. At this point it became clear that the grain surface of the leather had also been prepared originally with dilute parchment glue; a common technique in gilding whereby an unevenly porous substrate such as leather is sealed to promote even drying of the oil size [10]. Taking the removal of the support down to this saturated layer of grain satisfied us that all of the unstable leather had been removed, however, as a cautionary measure against further de-lamination, the remaining fibres were consolidated with a dilute solution of Paraloid B72. It was hoped that this would also seal the silver against further tarnishing.

Filling and re-lining

Concern over the buckled paint surface and the likelihood of retaining these deformations after treatment prompted the next step of laying the panels and their facings paint-side down on the warm surface of a vacuum hot-table. Once the paint had softened, the vacuum and cooling systems were activated and the panels, whose paint surfaces had effectively been ironed flat, were left to set. This procedure was carried out after tests had established the safe limits of temperature and pressure at which the embossed elements of the design would be preserved.

In contrast, as the preferred and safest method of re-lining the panels was to place them on the hot table paint-side uppermost, the possibility of transferring these deformations back into the paint surfaces together with any ridges or marks left on the reverse-side by the scalpel had to be addressed. With reference to a published treatment carried out under similar circumstances, it was decided to apply a filler to the now uneven, reverse-side of the panels in order to accommodate any irregularities [6]. For this task Lascaux Structura, a quartz-filled acrylic gesso was chosen as it had the advantages of extreme flexibility, low mass, and the ability to be sanded flat in much the same manner as a traditional chalk/glue gesso. A priming layer of Lascaux acrylic emulsion varnish was first brushed over the consolidated remains of the leather, after which the Structura was applied with a trowel. Several layers were needed to build up a thickness sufficient to cover all the surface irregularities, after which the Structura was allowed to dry and then sanded completely flat.

Each panel was re-lined onto a double thickness of polyester sailcloth which had previously been prepared with several coats of dilute BEVA 371 [23]. Each panel was placed face-up on the sailcloth and brought up to temperature under moderate pressure after which the cooling system was turned on and the panels allowed to set whilst still under vacuum.

Once the panels were re-mounted onto their temporary baseboards using the tack edge of the sailcloth, the facings could be removed.
Water was used to soften the mixture of sodium carboxymethyl cellulose and acrylic adhesive holding the calico in position; the wax-resin acting as a moisture barrier to protect the surface of the paint. Each layer of Japanese tissue paper was then removed by brushing with white spirit, waiting for several minutes for the wax to absorb the solvent and soften, and then gently peeling the paper away from the paint. Any wax remaining on the surface was removed by gentle swabbing with cotton wool moistened with white spirit.

Re-touching and final assembly

The physical stability and surface characteristics of the paint were revealed to be excellent, with good preservation of the embossing, however the very poor original condition of the panels and the full extent of the damage was now apparent. Whereas losses were visible previously against the sympathetic red/brown of the exposed leather, the Structura fills revealed all damaged areas in uniform, brilliant white.

Before each panel was re-mounted, backboards were attached to the stretchers to give protection against damage by impact to either the front or the back. The original decorative pattern revealed on the back of the screen during removal of the old re-lining was recreated by adhering black cotton canvas onto the hardboard, which was then decorated with a copy of the original green border and protected with a coat of varnish. The gilt leather panels were finally attached to the stretchers by stapling through an excess margin of sailcloth.

Re-touching was carried out over two coats of Paraloid B72. As the application of Structura from the backs of the faced panels prior to lining had effectively filled the losses flush with the surface of the paint, the need for further filling from the front was very much reduced.

The chosen re-touching medium of alkyd resin approximated closely the handling of the original oil medium, thereby facilitating the reproduction surface blends of colour and light impasto. The technique was based upon laying down a foundation colour which was then modified by the addition of a second or third colour in a pattern of small, irregular dots. The resulting optical mix of colours on the surface integrated well with the already visually complex surface of the original gilt leather and remains undetectable at distances of more than a few centimetres. Fine surface effects were achieved using glazes, again with alkyd medium before the application of a final varnish of Paraloid B67. As the chosen medium for re-touching was soluble in white spirit, the first coat of B72 acted as a surface upon which any mistakes could easily be removed, whilst a final varnish of Paraloid B67 carried the additional advantage of approximating the low-to-medium gloss typical of well-preserved gilt leather. Once the folds had been screwed together, new leather coverstrips were cut and secured in position with a combination of BEVA 371 and replacement dome-headed tacks. The final structure of each fold is shown in the diagram, *Fig. 3.*

Conclusions

It should be understood that the decision to transfer the paint layers onto a new support was not taken lightly. The time involved, the need for advanced craft skills and the complexities of re-touching should be considered by anyone attempting a similar treatment. An evaluation in terms of degrees of success is perhaps unsuited to such invasive work in which the regrettable need to remove of an original support must be weighed up against the undoubted visual and structural improvements to the paint surface. The treatment thus raises questions concerning the physical integrity of an object over its intended function. Although gilt leather is essentially a composite material, its meaning as decorative art resides principally within the clarity, texture and preservation of the painted image rather than the leather support. For a screen in this condition with an otherwise uncertain future, minimum intervention would have amounted to an absolution of intellectual responsibility in facing this fact.

Acknowledgements

The practical aspects of this treatment were undertaken by both authors whilst working at the Leather Conservation Centre. We would like to thank Christopher Calnan, who compiled the initial reports on the screen, for discussions held during the early stages of treatment. Special thanks are extended to the owner of the screen for permission to publish.

References

1. For a description of transfer techniques used in Pompeii, see:
Maiuri, A., Picturae ligneis formis inclusae note sulla tecnica della pittura campana, *Accademia dei Lincei*, **18**, Parts 7-10 (Assembly of 15 Feb. 1940), 138-160
see also: Mora, P., L. Mora and P. Philippot, *Conservation of wallpaintings*, Butterworths, London (1983). 246, 260
For a description of transfer by *stacco a massello* in the Renaissance, see:
Vasari, G., *Lives of the artists*, (trans. Bull, G.), Penguin, London **Vol. I** (1965), 218, 225, 279

2. Montamy, D.F. d'Arclais de., *Traité des couleurs pour Ia peinture en émail et sur Ia porcelaine*, Paris (1765)

3. Dalbon, C., *Traité technique et raisonné de Ia restauration des tableaux*, Paris (1898)

4. Stout, G.L., *The care of pictures*, Dover Publications, New York (1948), 72-74

5. Rostain, E., *Rentoilage et transposition des tableaux*, Erec, Puteaux (1981)

6. Wyld, M., and J. Dunkerton, The transfer of Cima's 'The incredulity of S. Thomas', *National Gallery Technical Bulletin*, National Gallery, London (1985), 38-59

7. Waterer, J., *Spanish leather*, Faber and Faber, London (1971), p 66

8. Huth, H., English chinoiserie gilt leather, *The Burlington Magazine*, **Vol. LXXI (**1937)

9. Koldeweij, E., De oorsprong van het goudleer en de Europese context, *Goudleer*, Uitgeverij Waanders bv, Zwolle (1989), p 20

10. Koldeweij, E., *Ledertapeten*, Galerie Glass, Essen (1991), p 7

11. The elements and history of *chinoiseries* are described in: Osborne, H. (ed.), *The Oxford companion to the decorative arts*, Oxford University Press (1975), P. 221

12. Mactaggart, P., and A. Mactaggart, *Practical gilding*, Mac and Me, Welwyn (1984), p 4

13. A spot test was carried out using a small excised sample of metal leaf. Filter paper was prepared by soaking in a 0.03% solution of 5-(4-dimethylaminobenzylidene) rhodamine in acetone and allowed to dry. The sample of metal was placed on the paper and moistened with a drop of water. A red-violet stain indicated silver.

14. Dossie, R., *The handmaid to the arts*: Vol. **I**, section **VII** 'of gilding leather,' Second Edition, J. Nourse, London (1764), 453-469

15. Jägers, E., On the deterioration after treatment of painted leather wall hangings from three castles in Rhineland, *Preprints of the Contributions to the Vienna Congress: Conservation Within Historic Buildings*, International Institute for Conservation, London (1980), 166-167

16. Van Soest, H.A.B., The Manufacture of Dutch Gold Leather, *International Leather and Parchment Symposium*, Deutsches Ledermuseum, Offenbach (1989), 185-192

17. Waterer, J., op. cit., p 38

18. For research within conservation on the deterioration of vegetable-tanned leather, see: Larsen, R., The STEP leather project: background and first results, and Calnan, C., Accelerated ageing studies, in *Conservation of Leathercraft and Related Objects Interim Symposium*, International Council of Museums, Victoria and Albert Museum, London (1992), 3-6, 2 1-24

19. Identified as *Aspergillus spp*.

20. Feller, R., *Report on wax-resin adhesives*, (National Gallery of Art Fellowship No. 345-8), Unpublished Report, Mellon Institute of Industrial Research, University of Pittsburgh (1958), p 26

21. Lucas, A.W., The transfer of easel paintings, in Thomson, G., (ed.) *Recent Advances in Conservation, Contributions to the IIC Rome Conference*, 1961, Butterworths, London (1963), 165- 168

22. For an account of a facing and transfer using similar techniques, see: Bilson, T.W., The conservation of a Roman Egyptian painted shroud fragment, *The Conservator*, 16 (1992)

23. The reasons for choosing a polyester sailcloth support are outlined in: Hedley, G., and C. Villers, Polyester sailcloth fabric: a high stiffness lining support, *Science and Technology in the Service of Conservation, Preprints of the IIC Congress*, Washington (1982).

Suppliers of Materials

A. P. Fitzpatrick
1 Barnabas Studios
10-22 Barnabas Road
London E9 5SB
Tel: 0181 985 7865
Fax: 0181 985 7659

Lascaux BEVA 371: mixture of ethylene vinyl acetate co-polymers, ketone resin N and paraffin.
Lascaux Structura: acrylic resin dispersion with modified quartz filler.
Lascaux Acrylic Varnish: acrylic resin dispersion.
Lascaux Adhesive Wax 443-95: micro crystalline wax and polyterpene resin mixture.
Lascaux 498HV Acrylic Adhesive: thermoplastic butyl methacrylate dispersion thickened with butyl-ester.
Paraloid B72: ethyl methacrylate/methyl acrylate co-polymer.
Paraloid B67: poly(iso-butyl methacrylate).

Richard Hayward & Co. Ltd.
c/o John Heathcoat & Co. Ltd
Tiverton, Devon EX16 5LL
Tel: 01884 257867, Fax: 01884 252866

Polyester sailcloth for restoration # 00169
(205 cm width, 4.6 oz/m^2).

Winsor and Newton
Whitefriars Avenue
Wealdstone
Harrow, Middlesex HA 3 5RH
Tel: 0181 427 4343
Fax: 0181 863 7177

Griffin alkyd colour, alkyd medium.

The authors

Thomas Bilson, B.Sc. Biological Sciences (1986), P.G.C.E. (1987). Post-Graduate Diploma in Textile Conservation from the Textile Conservation Centre and Courtauld Institute of Art (1991). Conservation Unit Internship, then Conservator at the Leather Conservation Centre, Northampton (199 1-1994). Currently Leverhulme Research Fellow in the Department of Conservation and Technology, Courtauld Institute of Art, London using computer image analysis to study the structure of nineteenth century paintings on canvas supports. Also working privately as a conservator of painted textiles and gilt leather.

Céline Bonnot, Maîtrise d'Archéologie (Lyon II, 1992), Maîtrise Sciences et Techniques Conservation Restauration des Biens Culturels (Paris I, 1994), Lauréate de la Fondation Marcel Bleustein-Blanchet pour la Vocation (1994). Currently leather conservator at the ARC-Nucléart (Regional Conservation Workshop) in Grenoble working on the analysis and restoration of archaeological waterlogged leather.

Résumé

Cet article relate la restauration exceptionnelle d'un paravent en cuir doré, intervention qui a nécessité le transfert complet de la couche picturale sur un nouveau support. Le paravent, un exemple probablement anglais de la fin du XVIIIème siècle avec motif dit le Chinoiserie, se compose de six battants, chacun supportant un panneau rectangulaire de cuir doré, estampé et peint.

Lors de sa prise en charge par les restaurateurs, l'état de conservation de cet objet était dramatique.

Le degré de détérioration acide du cuir était tellement sévère qu'il n'était plus en mesure de servir de support a la surface dorée et décorée. Il était pulvérulent et avait même commencé à se délaminer, précipitant la distorsion, la désolidarisation et la perte de la couche picturale.

La nécessité de procéder a un transfert de la couche picturale et de développer une méthode de travail est discutée et le choix de cette méthode radicale par rapport à d'autres solutions moins extrêmes est argumenté. L'intervention est ensuite détaillée et chaque phase de l'opération est décrite: le démontage, le nettoyage, la consolidation, le facing et le retrait du cuir, le nouveau support de doublage, la retouche et le ré-assemblage des panneaux.

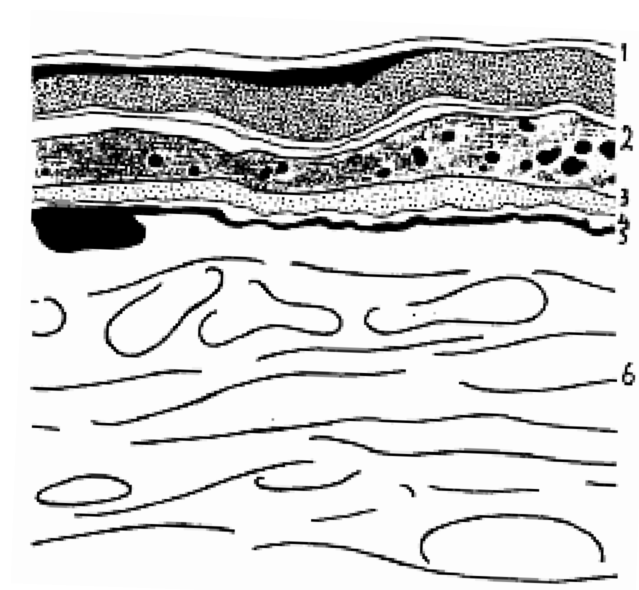


Fig. 1. *The layer structure of the cross-section of paint taken from the peacock's tail in fold five. There is an oil size (5) on the leather (6), then silver foil (4) with three layers of yellow varnish (3). There are five layers of paint (2) and two layers of varnish (1) on top.*

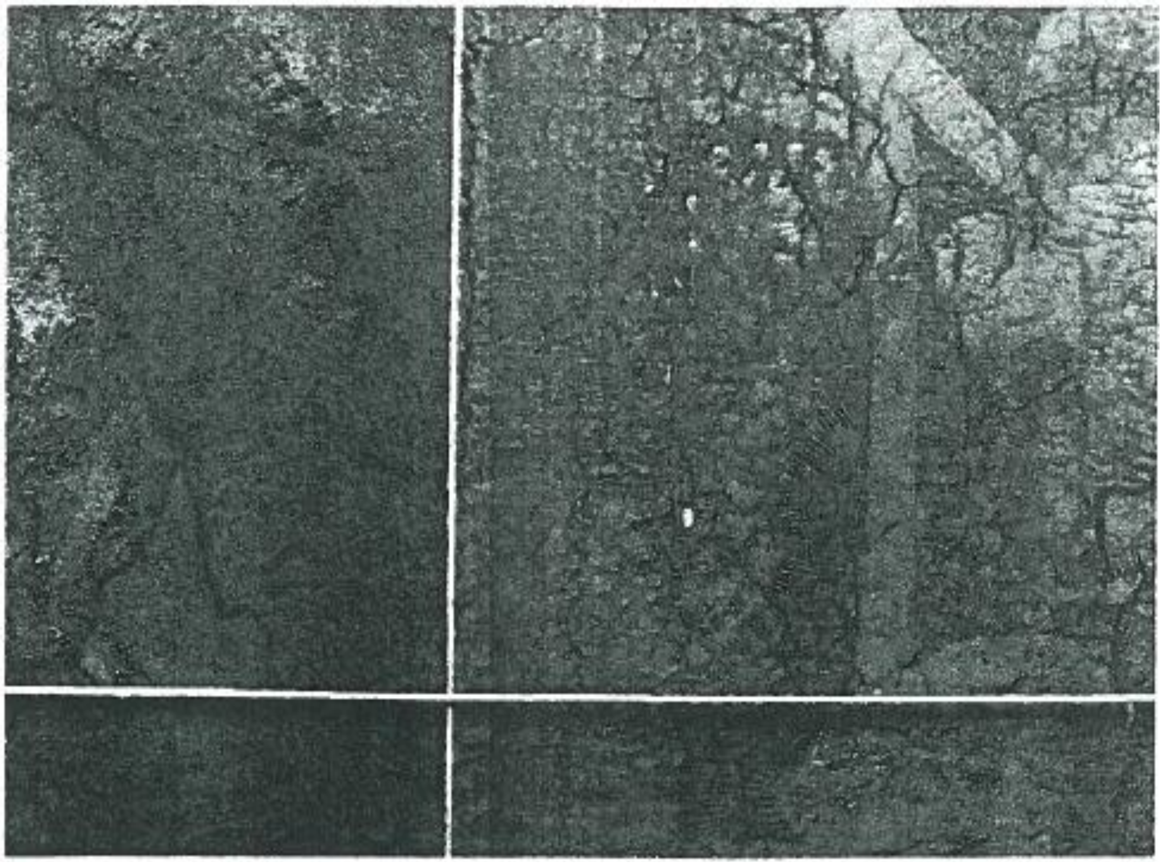


Fig. 2. *Removal of the leather support. Note both the design and embossing visible from the back through the final layers of grain.*

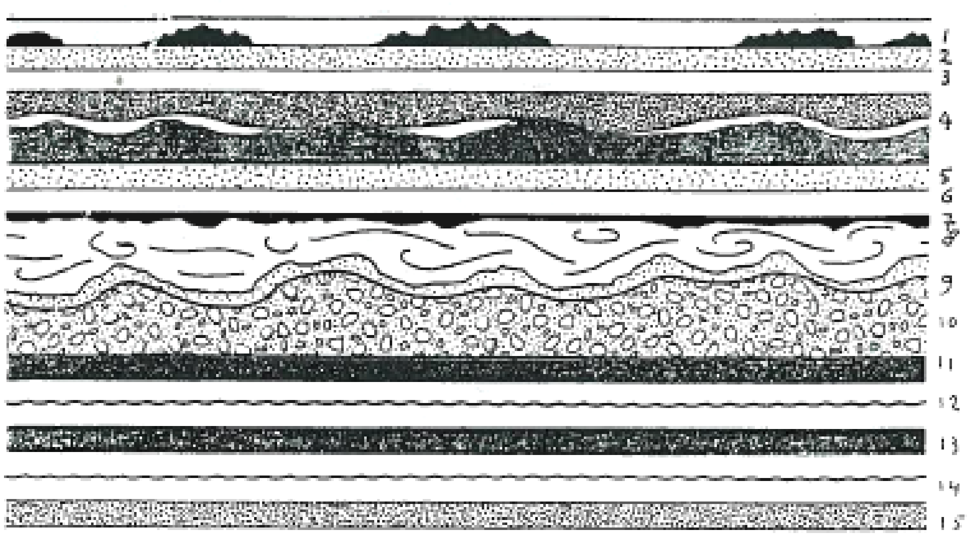


Fig. 3. *The structure of each panel after restoration. The original layers are: 8. leather; 7. oil size; 6. silver; 5. yellow varnish; 4. paint and 3. original varnish. Layer 2 is a Paraloid B72 intermediate varnish and layer 1 is Paraloid B67 varnish over re-touchings. The new support consists of: 9. acrylic primer; 10. acrylic gesso; 11. BEVA 371; 12. polyester sailcloth; 13. BEVA 371 and 14. polyester sailcloth. The backboard (15) is un-attached.*

Tensioning Gilded and Painted Leather: a Research Project

Mariabianca Paris
Istituto Centrale per ii Restauro
Piazza San Francesco di Paola 9
I-00 184 Roma

Leather is a material that responds to its surrounding environment, varying its dimensions in accordance with the variation of thermohygrometric parameters.
Mounting leather artefacts - in particular Decorative furnishings such as wall hangings, altar frontals, paintings, etc. - on a fixed support structure, frame or rigid panel, generally turns into a hindrance, a constraint of the natural movements with evident results. Over a period of time, in fact, various changes can become evident such as deformation of the structure of the material, lesions of the grain layer, detachment or tearing where the skins have been joined.

Only rarely has conservation considered support structures that adjust automatically tensioning of the leather artefact (see the system created by A. Schulze for the Moritzburg Castle wall hangings*).

The study of controlled tensioning structures has been included among the ICR research subjects since the early 1950's, with the planning and construction of stretchers to be used primarily for paintings on canvas and that could maintain by themselves the flatness of the painting over a period of time. These stretchers were based on two different systems. In both systems, the tensioning is controlled by helical springs which ought to compensate automatically for the changes caused in the dimensions of the paintings by variations of thermohygrometric parameters and by the constant weight factor of the painting itself.
In the first kind of supporting frame - originally used in the fifties for two paintings by Caravaggio kept in Malta (St. Jerome and The Beheading of St. John the Baptist) - the helical springs are coupled, by turnbuckles, to the canvas lining on one side and to the fixed frame to the other *(Fig. 1).*

*From a conversation with A. Schulze in 1994.

The system requires folding the canvas lining, longer and wider than the original painting. over the edges of the frame, edges that are rounded in order to lessen, almost eliminating, the slide-friction between canvas and frame *(Fig. 2).*
The canvas can thus slide over the edges of the fixed frame, expending and contracting in both directions, width and length.
The second type of frame was designed and first used in the sixties for the three paintings by Caravaggio in the Church of *San Luigi dei Francesi* in Rome. In this case, the springs are located inside a metallic stretcher, built to expand and to contract according to the variations of the dimensions of the painting. The canvas is fixed to the stretcher by a serrated flange instead of being nailed down; this facilitates attaching or removing the painting from the stretcher as needed *(Fig. 3).*

Since it was apparent that both systems had achieved in maintaining the flatness of the paintings over a considerable length of time and without subjecting them to over-tensioning, the Leather Department of the ICR decided to study an adaptation useful for gilded and painted leather.
Cooperation was obtained from the Department of Mechanical and Aeronautical Engineering of the University of Rome in order to study and experiment the little-known mechanical behaviour of antique decorated leather and to define the tensioning values of this material.
Using samples of old decorated leather, two different kinds of tests will be run from this viewpoint:
- long term iso-stress creep tests under controlled thermohygrometric conditions, within a reasonably extensive interval of values; the samples will bear a constant weight and the variations of their length over a given time will be measured by a differential transformer;
- tensile tests on samples with defects whose shapes and dimensions are known. These tests are meant to describe the concentration of forces borne by the leather artefact in a given average applied stress situation by correlating the defects of the samples and those of the altar-frontal that is going to act as a model in the final stage of the project (as described below).

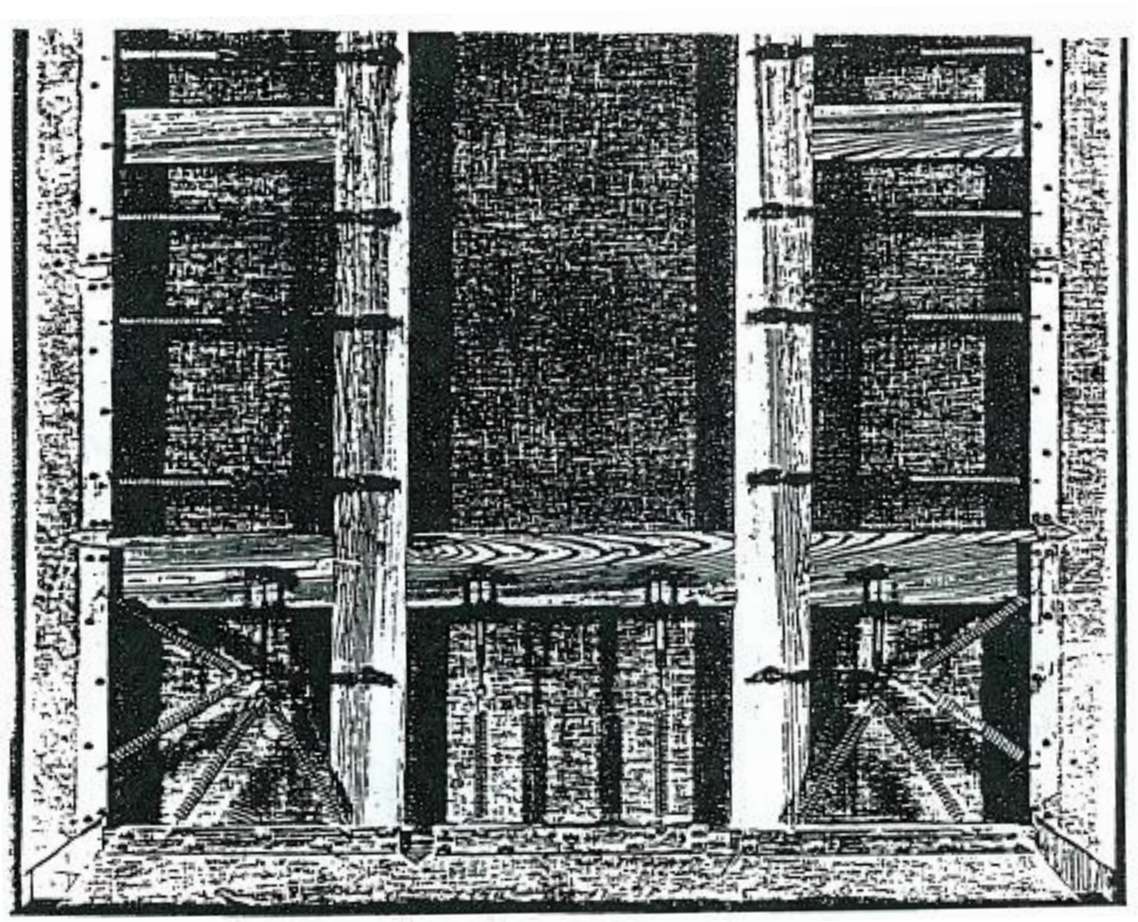


Fig. 1. *Automatic tensioning system of the painting by Caravaggio of St. Jerome (Malta)*

The purpose of the tests is first to evaluate the forces leather could bear without risk of structural damage and, consequently, to determine the mechanical characteristics of the springs to be used in the tensioning system.

The collaboration with the Department of Engineering includes as well the characterization of the type of adhesion established between leather and fabrics employed as connecting bands, by adhesives specifically identified for leather and indicated in the relevant literature. In particular, the tests to be carried out will describe traction breakage, peeling and creep using old decorated leather glued to various selected fabrics.

The final stage of the project is the construction of an experimental supporting structure to be used for an 18th-century Altar frontal from the Convent of San Francesco in Assisi. This artefact will prove interesting to test the tensioning system because of its size (92 x 310 cm), its composition (6 skins glued together overlapping along the margins) and for the kind of damages it shows. It was previously mounted on a fixed frame, nailed along the edges. This had caused a series of deformations (like ripples) generally parallel to the shorter sides, considerable lesions of the grain layer and partial detachment of the glued edges of the skins.

At this time, it would seem that the system to be chosen is the first described, that is the fixed frame on which the artefact is mounted, free to slide as its dimensions vary. Moreover this structure is found preferable because of:
- its relatively simpler construction;
- the fact that the tensioning elements (springs and turnbuckles) are located externally, facilitating the calibration, the setting up and the maintenance of the stretching system, particularly considering that it is still an experimental structure subject to constant checking.

Once the initial tensioning conditions are defined, the leather-stretcher system will be subject to continuous monitoring in order to check the distribution of tensions on the artefact over a period of time and thus to evaluate the efficiency of the system itself.

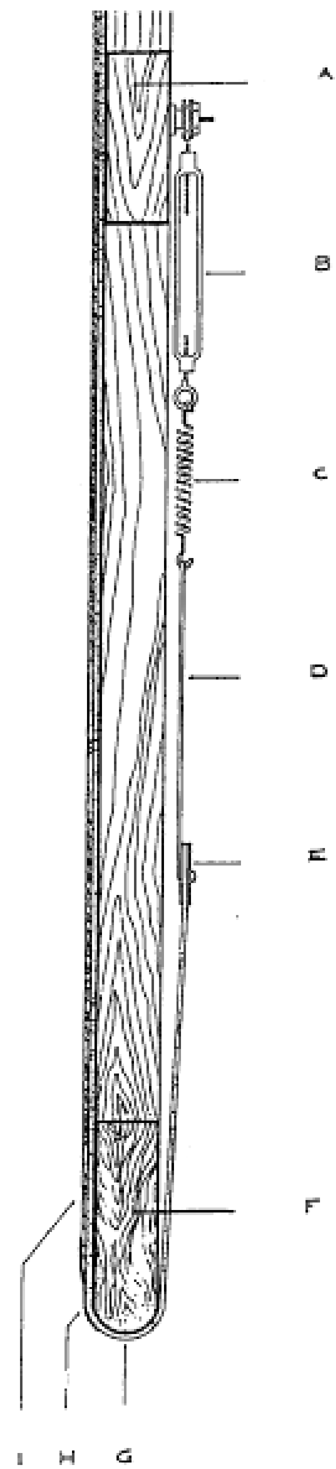


Fig. 2. *Cross-section of the lower part of the fixed frame showing the tensioning system of the canvas.*

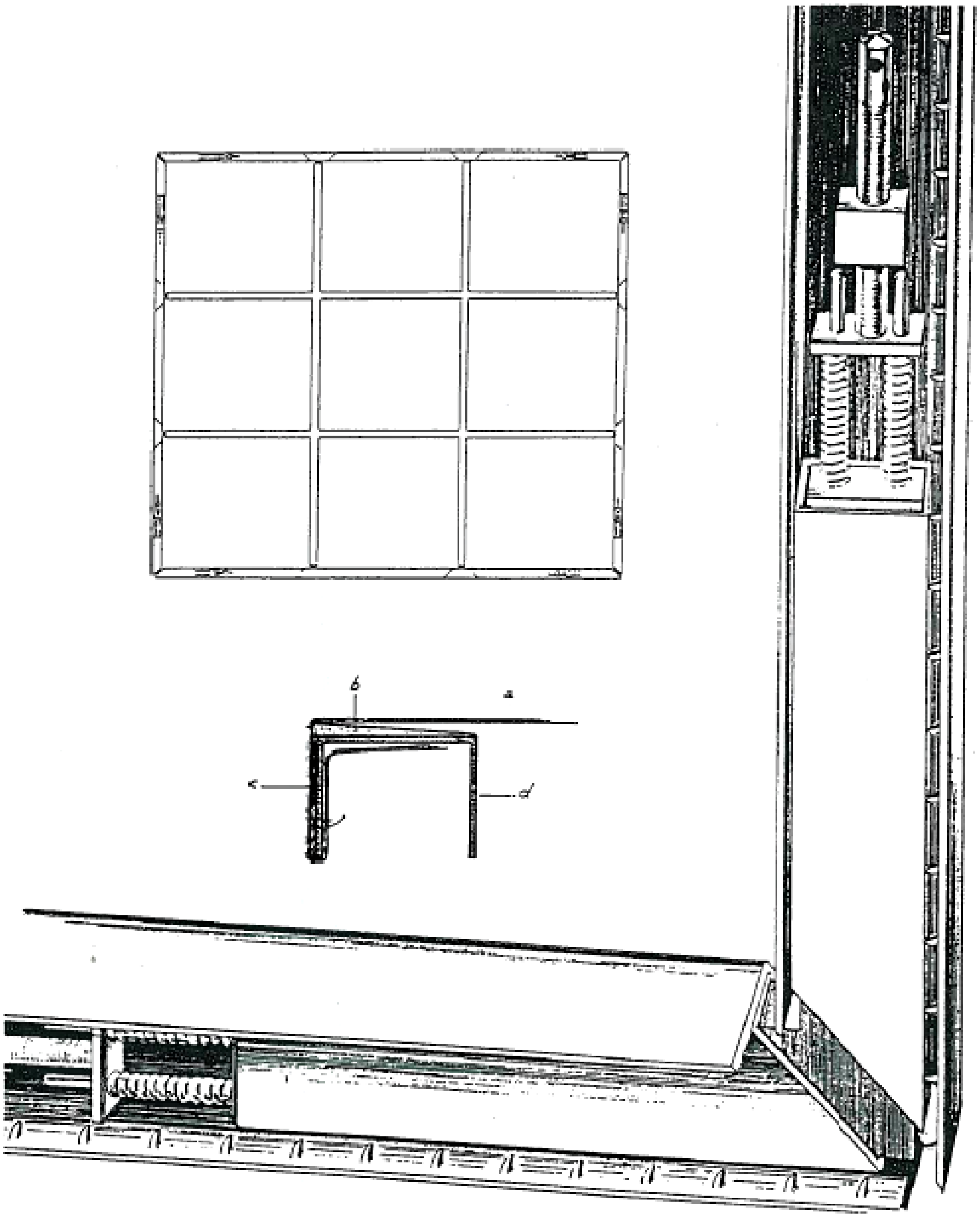


Fig. 3. *Section of the stretcher, used for Caravaggio's paintings in the Church of San Luigi dei Francesi (Roma), showing the second type of automatic tensioning system.*

The Formation of Cracks on Leather with Respect to Gilt Leather[1]

Richard Moroz
Westfälisches Museumamt
Zentrale Restaurierungswerkstatt Haus
Lüttinghof
Lüttinghofallee 3
D-458 96 Gelsenkirchen

Introduction

Most of us like the touch of smooth surface of leather products. But in time, the surface gets dirty, cracks, splits and becomes less attractive. Only objects of artistic or historical value are kept and cared for and their cracked surface is recognized as authentic and aesthetic. However the process of cracking and splitting continues until total destruction of the objects.
Examining the cracked surfaces an observer notices differences in the dimensions of cracks, their intensity and character and asks the following questions: why do surfaces crack and why do they crack in different ways?
The aim of this paper is not to solve the problems of cracking but to consider the forms of cracks and their dependence on the technological structure of leather objects. In the conservation literature one can distinguish two periods. In the initial period the interest in the original surfaces of the leather objects dominated over the interest in the inner structure. Now increased activity in research on the inner structure of ancient leather objects is evident. That is why this article tries to draw the attention to the relation between the inside and the surface of ancient leather, which is visually perceived.

The significance of the histological structure of leather

The basic components of leather are the collagen fibres. Their basic elements are composed of three polypeptide chains twisted together.

A larger number of protofibrils creates fibrils of which the leather fibres are built. The chemical and physical resistance of collagen depends on the frame of the polypeptide chain backbone and their cross linking. Attacked by bases, acids, oxidants, and enzymes they degrade to peptides and amino acids.
For thousands of years people prevented this by tanning the leather, using mainly tannins present in plant extracts and - less frequently - the properties of various mineral and organic compounds (fatty acid). Plant substances are divided into hydrolyants and condensants, and leathers treated with those have different properties and different ageing resistance.
In leather-coated objects mostly the smooth face side of the leather is visible. The flesh side of leather is rarely visible, only in objects in which it is also the construction element - e.g. shoes.
The main layers of the raw hide are:
- epidermis
- cutis
- subcutis.

Layers are divided into smaller layers. But only the more detailed structure of the cutis is important, because during leather production the epidermis is totally removed and the subcutis strongly reduced. The cutis is built of three layers:
- grain layer
- thermostatic layer (pars papillaris)
- net layer (pars reticularis).

The brief description of particular layers will be presented, starting from the lowest up to the visually most important one.
The reticular layer reaches the height of the tower ends of the hair roots and sweat glands and has different thickness during the growth of the animal. Contrary to the epidermis it is only a construction element composed practically exclusively of collagen fibres. Other elements of the skin structure (blood vessels, muscles) appear only on the edges of this layer. The flexible elements are only the walls of vessels and the reinforcing layer in the same time separating from the subcutis, which is removed during a production process.
In skins where there is no reticular layer and the hair grows directly from the subcutis (pig) the mentioned elastin layer does not exist.

1. This article includes some selected aspects of the formation of cracks on leather. A comprehensive survey will be given in the dissertation by the author, which is in preparation.

The thickness of collagen fibres is approx 0.2 nm and their twist is thicker and tighter.
The direction of fibres is horizontally only in the lower layer creating the gentle ending of the skin.
The wear resistance of leather, its tear resistance and its porosity do not depend on the collagen fibres themselves but on their weave.
The higher the rate of this layer in the leather the more resistant it becomes. Resistance of the reticular layer can be weakened by doubling or bending, improper lime treatment and hair removal as well as by loosening the structure by fatty tissue.
The papillar layer lies on the reticular one and is similar in thickness with most animals.
This layer is composed of relatively thin collagen fibres, which form a dense and delicate three-dimensional net. The closer to the upper parts of the thermostatic layer the thinner the fibres are and the net becomes more delicate, more dense and flattened. In the outer layer the net is extremely dense and woven of fibres of 0.05-0.06 nm and sometimes even 0.02 nm thickness (one half of the fibril's thickness in other skin layers). Fibrils are predominately built of type III collagen, which does not tend to form bundles, but zigzags and goes chaotically in various directions. Their short fragments are situated on the surface. The deeper into the skin the stronger the tendency to form bundles.
The degree of density makes this layer membrane-like.
Under the microscope the circular run of the fibril-stems of the cells of the basic layer of cuticle is visible. This layer (1 mm thick) is called grain layer and in tannery: face of the leather (grain surface). Due to its significance in tannery it shall be considered separately, because this one is the bearer of the leather look.
It is built entirely of collagen.
In the papillary layer there are many non-collagenous elements like glands, blood vessels, hairs, gat cells etc., planted in the net of the collagen fibres. The elastin net around the hairs is situated parallel to the skin surface (depending on the stretching of the skin), and is most extended on the level of approx. 1/3 of the papillary layer thickness. It builds the frame, giving the thin layer (being constantly in motion - emptying of glands, hair movements etc.) its stiffness. The papillary layer is usually weaker than the reticular layer. During the tanning process hollow spaces develop, the number of those decides on the resistance of future product (the bearer of resistance is the reticulary layer). While bending the finished product the grain layer can be separated from the papillary layer. The first symptoms are pleats and calluses. This lamination is programmed in the leather, that is why this layer is broken as far as possible by lime treatment because this weakens its bond with other layers of the leather. From this aspect the skin is stable with deeply planted hair, e.g. pig skin.
Characteristic features of this layer are: resistance to bases and acids, different ability to dye and absorb glue as well as little swelling in presence of acids and bases.

Refining and shaping of the leather object's surface

The surface of leather objects uses to be refined in two basic ways:
- flat; by covering with paints and lacquers (frequently already during production) and
- modelling; by shaping the surface by cutting, punching, and pressing (positive for embossed ornaments and negative for intaglio ornaments).

Used as trimmings multi-coloured leathers are also frequently ornamented with the help of one of those techniques.

In medieval Europe the techniques of blind-pressing and cutting were popular. Especially cutting allowed free graphic shaping of the surface. Examples of this type of decoration preserved until today are chests, book covers, cases and furniture coverings.
In the second half of the 15th century, through Spain and Italy, the technique of gold-pressing of leather-covered precious objects was introduced in Europe.

Surfaces of military objects used to be covered with paints and lacquers e.g. sheaths of belt-swords or dress-swords, saddles or, later, daguerreotype cases. The finest form of refining leather is gold-leather - typical Baroque wall coverings of the upper class interiors. The best calf, goat and sheep leather were used as material for gold-leather. The leather was covered with silver leaf, a golden lacquer was applied, then the leather was pressed or punched and in the last stage painted in various colours.

The influence of storage on the condition of objects

Two basic factors influencing the condition of leather are the relative humidity of air (RH) and the temperature of the environment.
The leather has an ideal humidity. Too high humidity causes absorbance of water from the air by the collagen fibres. By increasing RH from 35% to 70% the diameter of the fibres trebles. Together with water chemical substances from the atmosphere are absorbed into the leather. Especially ammonium and sulphur dioxide are dangerous. Together they form ammonium sulphate, whose crystals grow bigger while absorbing water from the surroundings causing deception of collagen fibres. Ammonium is created in leather during degradation of collagen by sulphur acid to amino acids and finally ammonium, among others.
Another degradation process in leather is the oxidation of fats, tannins and the collagen itself. In leather research oxidation and hydrolysis are used during accelerated ageing. Samples aged this way showed various plastic changes of the surface. Leather, like most of natural and synthetic substances, shrinks during the degradation process.
Another problem is the migration of tannins within leather caused by changes of relative humidity of the air.
Also the substances covering leather undergo ageing processes. Natural and synthetic resins cross-link and crystallize, and in time are covered by a net of tiny cracks, through which water migrates into the leather. Similarly, oil paintings are used to execute gold-leather cross-link crackle forms, which is known from easel paintings.
Leather objects always tend to match the changing relative humidity and temperature of the environment which increases tension, pressing and cutting forces in particular layers. Due to careless handling and intended damage mechanical forces add to the factors above.
In leather and coating layers various chemical reactions constantly occur. The light also influences the structure of the surfaces and its colours. Conservation mistreatment and technological failures are the factors increasing the decay of the objects. The effects of disasters such as fire or flood are unpredictable. One of the symptoms of improper storage is microbiological attack by bacteria or fungi, as well as insects and rodents.

The causes of cracks in the leather surface, especially gold-leather, and their influencing factors can be divided into two basic groups:
1. endogenous; depending on the technological structure of objects, histological structure of leather, failures in tanning, diverse reactions of leather components to ageing processes (chemical reactions: polymerization, oxidation, cross-linking), the structure of paint layers and lacquer coatings, plastic elaboration of the surface.
2. exogenous; depending on the external factors: storage conditions, changes in RH and temperature, absorption of surrounding gases, mostly aqueous vapours, conservation interventions and care of objects.

Reaction of gold-leather to climatic changes

Today research is undertaken to investigate the causes of cracking. Meanwhile it turned out that the exact causes are hard to determine because materials act together as well as against each other. Its reaction to climatic changes is the most important damaging factor for gold-leather. During natural fluctuations of RH various parts of the object absorb and release water vapour according to differences in their composition. Constant migration of vapour inside the leather is increased by changes of temperature and relative humidity between the face and the reverse side of an object.
Stretched leather is exposed to strong tension forces, which however are neutralized during natural, slow fluctuation of climatic conditions. That is why these slow changes are less dangerous than rapid ones, because both leather and paint layers can react to water in spite of their different resistance to water diffusion and become more flexible. Short term climatic changes cause tension and cutting forces between the layers. These forces are intensified by various delayed reactions of particular materials. Paint layers cannot compensate tension, and during a decrease of flexibility of binders cracks are formed and paint flakes. Particular areas react differently to the changes of tension and contraction of the support or to the changes of volume caused by swelling and contraction of the binding media.

Fig. 1. *The pattern of craquelure on a 17th-century chair (Lüdinghausen, Vischering Castle).*

The loss of interlayer bonds leads to paint layer cupping and contraction of the support causes separation of paint layers in the form of blisters. The effects of the processes described above occur over a long period of time, these effects are capillary cracks of paint layers defined as craquelure or net of cracks. Patterns and dimensions of the cracks are diverse, depending on the features of the paints and binders used as well as on the features of the leather.

Patterns of craquelure on paint layers of gild-leather

There are the following patterns of craquelure: in straight lines, grid-like, net-like, 'crocodile-skin', 'bark' (the surface is characterized by small, separate isles of paint and the cracks are extremely wide), palm-like (with delicate, irregular, separate lines), 'thistle' (cracks with determinate direction depending on the axis of painting, looks like irregular twigs of thistle), spiral (curved cracks, mostly on grounds with an excessive binder, e.g. oil), circular or spoke craquelure (characteristically curved and spoke cracks running from the central point, mostly caused by stress or a blow to face or reverse of the painting), and straining craquelure.

Due to the occurrence of cracks they are divided into 'old' and 'fresh'. Old cracks occur during climate fluctuations in the environment, when the support and paint layer undergo constant motion of swelling and contraction. Not only the leather but also the painting materials are unable to resist the increasing ageing process (decrease of flexibility) and in time cracks and flakes occur. They form a pattern of tiny lines depending on the features of support and ground layer.

The picture of damage on sloppily stored painted leather is more diverse than on leather attached to a rigid support (book covers).

Fig. 2. *The depiction of the pattern of craquelure on the gilt-leather from an armchair 'in the Royal Castle in Warsaw (Poland) illustrates the similarity to the patterning of the blood vessels on a calfskin and to the patterning on the chair from Lüdinghausen.*

The typical picture of damage caused by natural ageing is a system of slightly developed cracks. Developed paint isles bend picking up the surface of leather along the cracks (which are often dirty, especially visible on bright parts). The most frequent form of old cracks are grid-looking and net-like cracks.

Fresh cracks occur immediately during drying of the paints already in a few days or months after application of the paint layer. Drying of the oils is a chemical process (polymerization and oxidation), during which at first an increase in volume occurs followed by a decrease in volume.
When paintings dry in unnatural conditions, e.g. heat or exposed to strong sunlight (gold-leather in southern hail of Moritzburg Castle) or excessive dryers are added, early cracks may occur.
As it was mentioned before, the composition of the paints influences the form of cracks.
They depend not as much on the pigment as on its concentration compared to the binder.
More transparent pigments and dyes use to be applied in thicker layers. Excess quantities result in early cracking. Paints whose pigments are low oil absorbents (e.g. white lead or red lead) do not crack, or at least crack to a small extent. Also paints mixed with rough-grained pigments crack less than those whose finely ground pigments can absorb more binder. In paints containing bitumen cracking is disastrous.
Due to its thermoplasticity bitumen tends to penetrate and soften even old paint layers.
This complex hydrocarbon compound in oil binder never dries entirely.

Wide asphalt cracks unveiling the ground layer occur particularly when this paint is used as underpainting. Soft bitumen layers can even destroy overlaying resinous glazes.
The drying process of multi-layered paint is more complex. If a subsequent, quick-drying paint lies over a previous one which is not quite dry yet, cracks will occur in both of them.
The characteristic features of early craquelure are:
- cracks are wider than in old craquelure
- cracks occur only on paint layers, not penetrating the ground layer
- edges of cracks are usually rounded, because they gradually form a soft oil film
- they are mostly limited to particular areas of a painting.

The most frequent patterns of early craquelure are: thistle-like, palm-like, 'crocodile skin' or 'bark'. Craquelure of the varnish layer has different patterns. Varnishes, which are slightly brittle, form a gentle net of capillary cracks on the surface of a painting.
Hard layers of varnish accelerate cracking of a lower layer of silver and a grain layer of the leather. Capillary cracks increase ageing processes and the decay of binder because dust, moisture and air pollutants diffuse through them more intensely. The cracks widen further more, and the paint layer splits into flakes of paint.

Summary

1. The formation of craquelure depends on androgenous and exogenous factors (technological structure of the object and environment conditions).
2. The pattern of craquelure in leather is affected by the histological structure of leather, the way of tanning, and the way of ageing.
3. The pattern of craquelure in the paint layers is affected by pigments and dyes in combination with the binder and the painting carrier, which developed specific forms similar to scaly places. Apart from this some forms of crack have been noticed occurring in the paint layers of panel paintings.

References

1. Hallebeek, P., *Comparative investigation of six new bookbinding leathers*. Lecture given at Interim Meeting of ICOM working group, April 5-8 1995, Amsterdam

2. Bender, A., *Zlocone kurdybany w Polsce*. KUL Lublin, 1992

3. Herfeld, H., *Die tierische Haut, Bibliothek des Leders*. Band 1, (Umschau-Verlag) Frankfurt am Main, 1960

4. Nikolaus, K., *DuMont's Handbuch der Gemãldekunde*. (DuMont Buchverlag) Köln, 1986

5. Lasek, W., *Kolagen chemia i wykorzystanie.* (Wydawnictwo Naukowo-Techniczne) Warszawa, 1978

6. Calnan, C., and B. Haines, *Leather its Composition and Changes with Time*. The Leather Conservation Centre, Northampton, 1991

7. Rosa, H., *Kurdybany w Polsce i problemy ich konserwacji.* Seminarium Konserwatorskje in Warszawa, 1991

8. Rouba, B., *Plótna jako podobrazia malarskie*. In: Ochrona Zabytków, 1985

9. Slansky, B., *Technika malarstwa*. Wyd. Arkady, Warszawa, 1960

First Experiences with a Light Metal Stretching Frame-system for Leather Tapestries in Climatically Instable Rooms

Andreas Schulze
Landesamt für Denkmapflege Sachsen
Augustusstrasse 2
D-01067 Dresden

It is not new, that the success of all efforts for the preservation of the material evidences of human culture depends very strongly on the environmental conditions surrounding the objects. Therefore it is very important to provide for optimal conditions to exclude harmful influences.
This is mostly possible in modern museums with air-conditioning. There are a lot of problems, however, if sensitive objects are integral parts of monumental buildings. Stabilization of the climatic conditions in monuments is nearly impossible because of deep interferences in the historical substance.

So it was an important point in the concept for the conservation and restoration of the gilt leather wall-hangings in the castle Moritzburg near Dresden to find an advantageous method to remount the tapestries.

I. The starting-points for the concept

In the case of tapestries with sewn bindings between the panels, these clearly visible seams belong to the original appearance. So it is possible to divide big wall-hangings into different smaller sections, well-known as the 'Dutch Method' for the mounting of gilt leather tapestries.
But large, nearly seamless planes are characteristic of wall-hangings with glued bindings. Therefore the preservation of these large objects without any splitting in smaller formats was one intention of the restoration concept.

The wall-hangings in the so-called 'Damenbildniszimmer' were fixed with a lot of nails on wooden reglets, which were solidly connected to the walls. Research shows, that the very similar construction from the baroque was removed in the beginning of this century and was substituted by new wood.

This kind of mounting was the cause of a lot of incriminating damages on the leather.
Remounting the works in different periods in the past and the attack of wood-worms had weakened or damaged the edges of the tapestries.
The stiff fixing of these edges on the ground blocked up all natural motions. So on some edges the nails tore out and this was the cause for countless large deformations.

The 'Damenbildniszimmer' is located in the northwest corner of the castle between a stair-house and the chapel, is the room with the most instable climatic conditions in the castle. It has the largest and quickest changes of Relative Humidity.

Profound investigations of the climatic situation in the castle already in 1973/74 and of the reactions on the leather tapestries drew attention to this situation and to the scale of the natural reactions on the wall-hangings.
On a 2.65 m high tapestry very fast changes of the dimensions by more than 15 mm were measurable as a reaction to changes in the Relative Humidity in the room.

Therefore the following demands were to be made upon the mounting-system:
1. The tapestries should be removable for later conservational checks and treatments without additional damage to the edges.
2. The fixing of the tapestry-edges to the frames should be in such a way, that compensation of all tensions in the leather will be possible.
3. The construction of the frames should not block up the normal motions of the material and should prevent an overcharging of the leather through shrinkage in low air-humidity.
4. The climatic situation around the tapestries should be stabilized without any interferences in the historical substance of the building.

II. Technical execution

Stabilization of the climatic conditions around the wall-hangings was very important. The walls of the room bear a lot of information about decoration systems from the time before the

major reconstruction of the castle in the years between 1723 and 1730 and about the baroque design of this room, respectively about the original mounting system of the tapestries.
So it was impossible to use the normal modern methods of air-conditioning, for instance through a temperature-insulation or through the installation of air- conditioning equipment.
Also it was impossible to change the shape of this room. The space 5 to 6 cm between the wall surface and back of the tapestry had to be sufficient for all technical solutions.

A stimulus for the solution of this problem was the situation in the two main halls of the castle. In these halls the walls are covered with 6.50 m high paintings on gilt leather. These enormous sizes of the seamless, glued gilt leather areas (some walls of 90 m^2 tapestries) normally allow to expect very large changes of the dimensions. This was prevented in 1730 during the mounting of these tapestries in the following way: all walls were covered with wooden panels of about 30 mm thick pine. This gigantic quantity of wood buffered nearly all changes of the Relative Humidity on the flesh-side and can thus prevent the short-term reactions of the leather. This construction has been working for more than 250 years as a passively operating air-conditioning equipment without any disturbances, service or energy application and has prevented till today any damages through the shrinkage and expansion of the leather.
Following these experiences we have planned to cover the walls with wooden panels for the 'Damenbildniszimmer' too.
To get removable tapestries, it was necessary to create a frame-system, built of aluminium profiles, to be light but also stable enough. Round wooden edges - fixed on the metal profiles - prevent contact between the leather and the metal. The tapestry is fixed on the frame with little hooks of stainless steel.
These hooks are riveted on adapted stripes of vegetable-tanned calf-leather. The stabilizing stanchions of the frame also serve to mount the frame on the wall.
A device at the bottom of the frame is to compensate the dimensional changes *(Fig. 1).*
In the case of broader wall-hanging formats it is necessary to use such devices on one or both sides of the frame. Because the width of the first, completely conserved and restored tapestry was only 92 cm, this was not necessary here.

The compensation of the changes in length is brought about by a pivoted tube. One end of the tube holds a spring case with a spiral spring *(Fig. 2).* This spring was made after appropriate calculations and is 157 cm long, 3 cm wide and 0.35 mm thick. The hooks of the tapestry are fastened on the mounted rail *(Fig. 3).*
So the spring has a low spring-constant: the change of the elasticity per unit of length is relatively low. This shall prevent a permanent extension of the leather, as it is known from other spring-stretchers, for instance for canvas paintings. If the leather is shrinking due to low relative humidity, this spring - which is stretched only by very low power - gives way. So there is never any danger that the leather, the edges and the glued seams could crack or tear. If the tapestry is enlarged due to a high RH, the spring can prevent too big deformations. The main task for this compensator is to enable the normal reactions of the leather in times with lower Relative Humidity.

Fig. 3 illustrates this system further:
the wooden panels for the buffering of the humidity also work as a temperature-insulation to the wall and will be mounted at first separately with hooks. Then the frame will be fixed over these panels only on the stabilizing stanchions, also with screw-hooks. The profiles of the frame seize over the panels, so the distance between the surface of the wood and the back of the tapestry is only 6 to 8 mm. The little steel hooks on the edges of the tapestry can glide along the frame-sides and do not block up the compensations of occurring tensions and of the expansion - and shrinkage - of the leather.

The restored tapestry-width was exposed on the frame over one year in the air-conditioned rooms of our atelier, to be able to exclude all permanent extensions. Parts of an old hygrograph were used to record all changes of the length of the tapestry.
In February 1994 the frame was mounted on the primary place on the outside wall between a window and a corner in the 'Damenbildniszimmer'. It was only necessary to remove the wooden reglets. The plaster with all remains of earlier decoration systems etc. was left on the wall. Over the wooden panels, the tapestry-frame was hung up. It is very important, that the surface of the plaster has not any contact in any place with the frame or with the hooks.

At last the covering reglets were fixed with some millimeters distance in front of the surface of the tapestry.
The panels and the frame are inserted completely in the interspace between wall and tapestry, which had also existed before.

III. The efficiency of this system; first test-results

The registration of the dimensional changes of the leather along with the recordings of the values of the Relative Humidity and the temperature allowed the first conclusions about the efficiency of the frame-system.
During the exposure to the stable humidity of our atelier over more than a year no signs of permanent extensions were visible.
After the mounting in the castle Moritzburg distinct reactions to the climatic conditions were recorded. It was striking, that in spite of corresponding values of the Relative Humidity the recorded length values were located in the middle range in the time of spring and autumn, but in summer in the upper and in winter in the lower half of the diagrams.

In 1973 and 1974 research into the climatic situation and into the reactions of the gilt leather were undertaken. In this time very strong and short-term changes of the dimensions were recorded on a 2.65 m high tapestry, which was hung in the way which is typical for the ornamentally decorated gilt leather in Moritzburg, at a distance of some centimeters between wall surface and leather. These changes amount to 16 mm.

To compare the results of both recordings (the tapestries in the 'Damenbildniszimmer' are 3.27 m high), it was necessary to convert all recorded values into percentages to the proportion of the different lengths. Together with the curves of temperature and Relative Humidity these values were transposed graphically *(Fig. 4 and 5).*

Fig. 4 shows the values for the period November 01, 1973 until the end of July 1974. *Fig. 5* represents the period from May 09, 1994 until January 29, 1995. These periods do not cover exactly the same seasons and the measurement methods do not agree totally, but something is striking:

Despite of similar curves of the Relative Humidity we see very large and rapid changes in length around a uniform average value on the diagram in the case of the tapestry without wooden back panels. On the other hand the reactions of the gilt leather wall-hanging with wooden panels on the back are much more damped and show another, seasonal curve.
This effect appears to come from the buffering effect of the wood, which was to be observed also in both halls. It is well-known, that the moisture content of wood attains always a defined state of equilibrium to the Relative Humidity. This adaptation process runs - depending on the kind and the thickness of the wood - relatively slowly. Short-term changes of the Relative Humidity do not have major influences on the moisture content of the wood. The wood emits moisture to dry air, in moist air wood picks up moisture. Thus a micro climate will arise in the small space between the wood surface and the open, unprotected flesh side of the leather, on which the changes of the Relative Humidity in the room in front of the silvered and painted surface has not so much influence. More significant are the changes of the balance of the moisture content in the wood relative to the seasonal average-value of the Relative Humidity. So this moisture content in the summer time is lower than in winter. This again will be transferred over the microclimate in the interspace on the moisture content of the leather tapestries and thus influence their expanding and shrinking reactions.

In summary it is possible to state, that the wooden panels can damp the short-term reactions of the leather effectively, but the maximum and minimum values of the dimensional changes over the year are the same as the values of the first measurements of about 0.6% of their total length. The compensation mechanism allows to prevent an overcharging of the wall-hangings and also damages on the leather, the edges or the bindings between the leather panels. Therefore we have decided to use this system for all wall-hangings of the 'Damenbildniszimmer'.

Certainly it is impossible to transmit this solution unmodified on other objects and problems. This paper should rather be understood as a stimulus for complex reflections on the particular situation around a specific object.

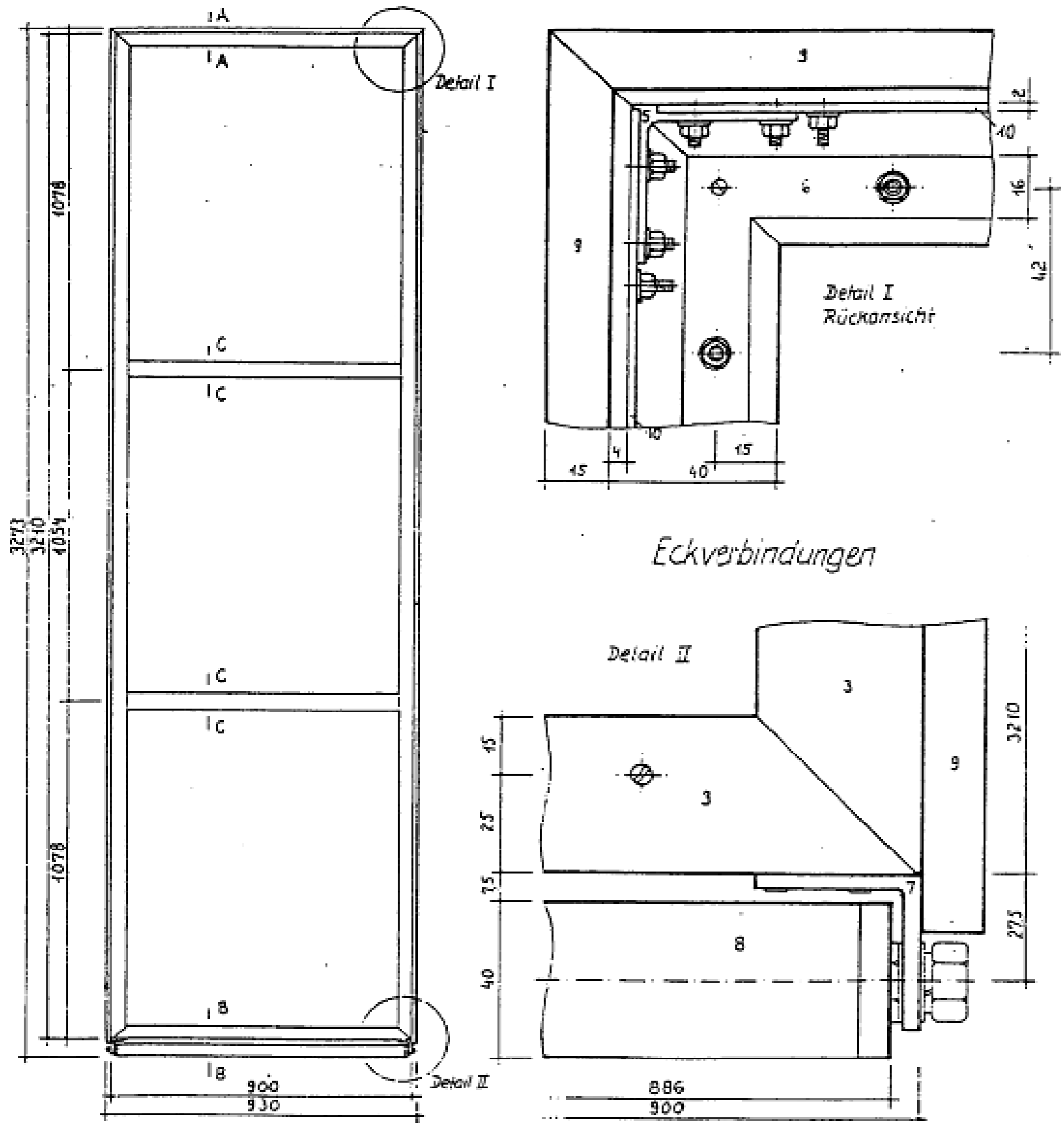


Fig. 1. *Construction and measures of the panel. Details of the corners; I: Upper right corner, viewed from the back; II: Lower right corner, frontal view.*

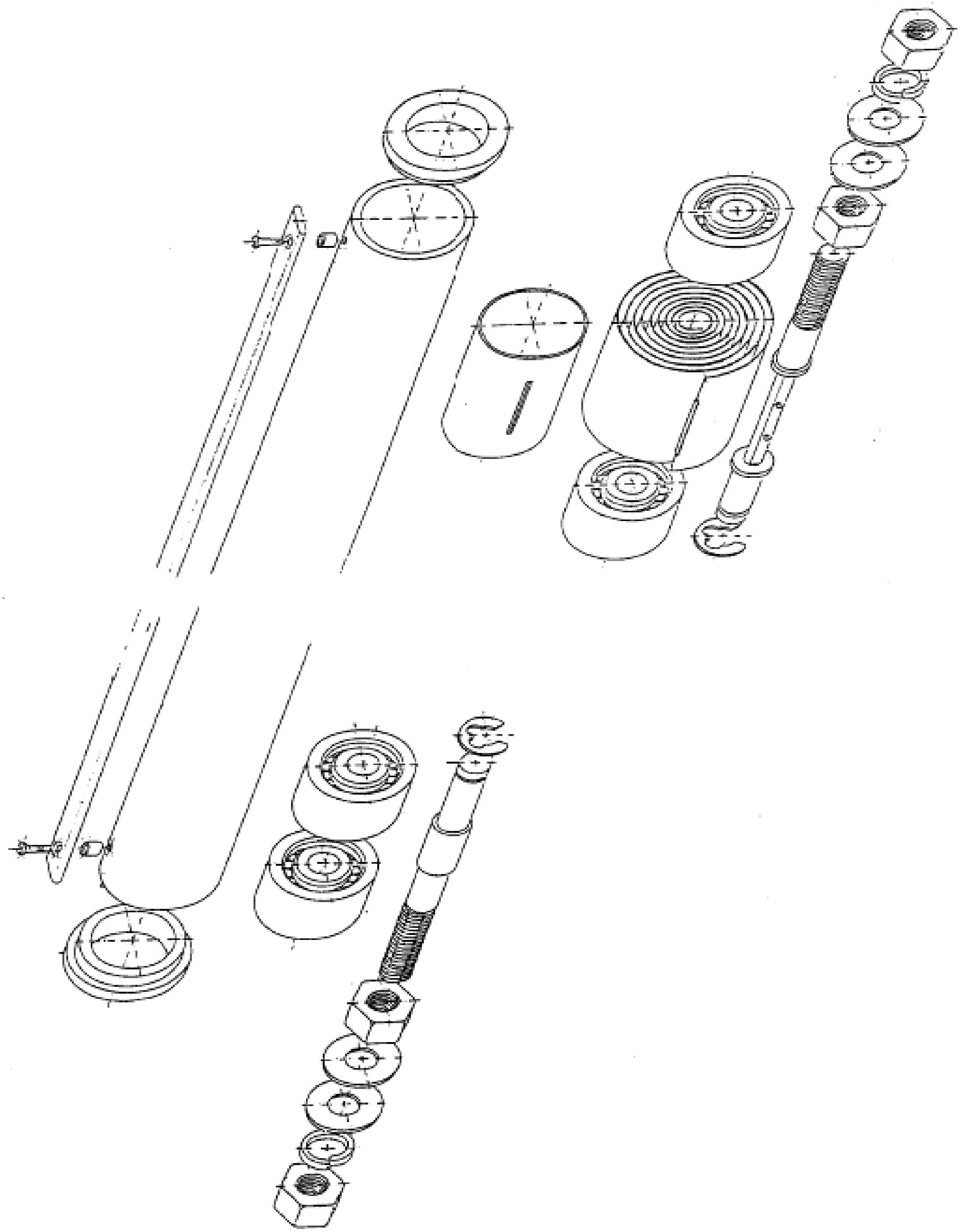


Fig. 2. *Construction of the pivoted tube with its spiral springs and ball-bearings.*

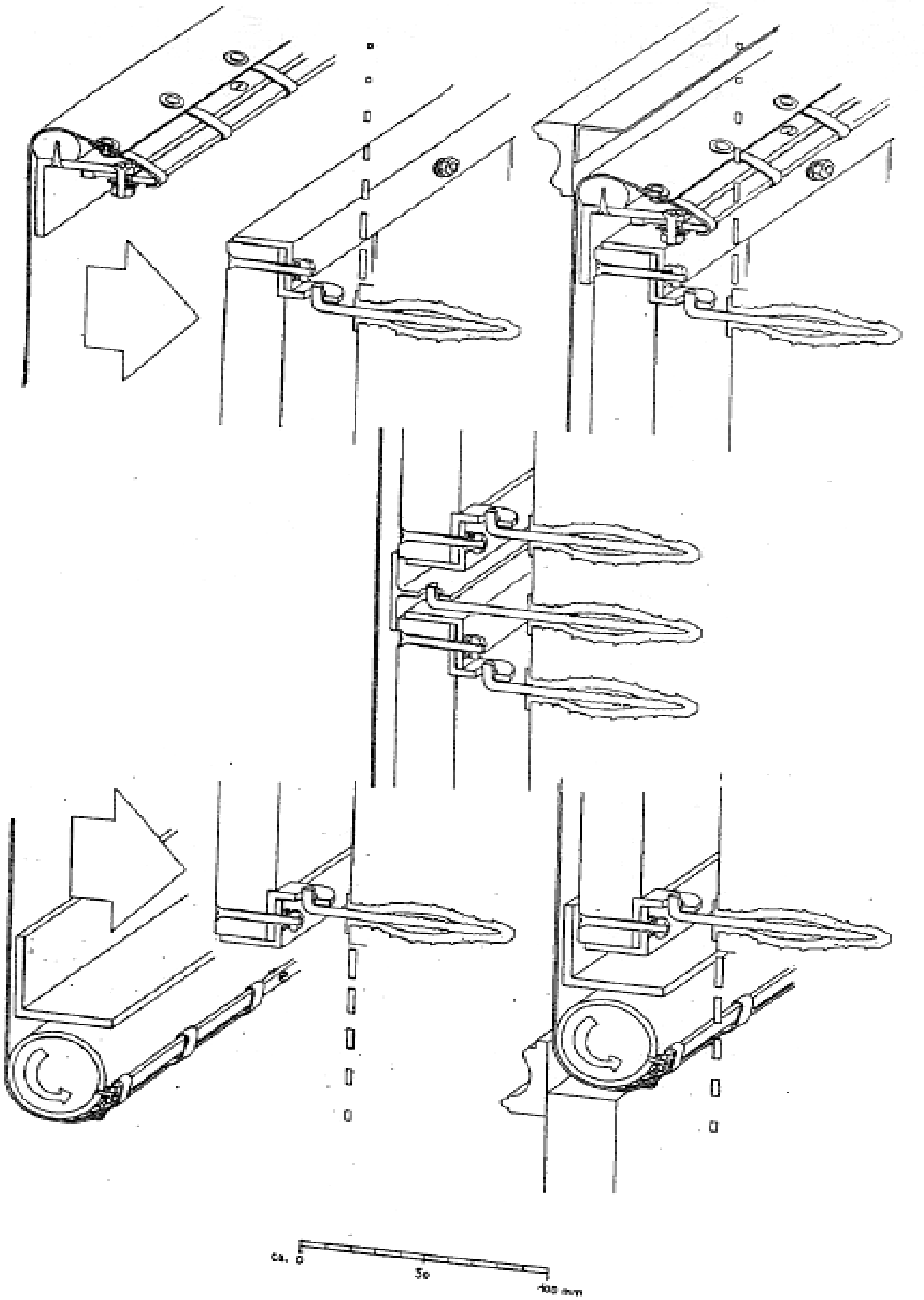


Fig. 3. *Scheme of the method of fastening of the leather to the frame and the pivoted tube; fastening of the frame to the wooden panel and of the wooden panel to the wall.*

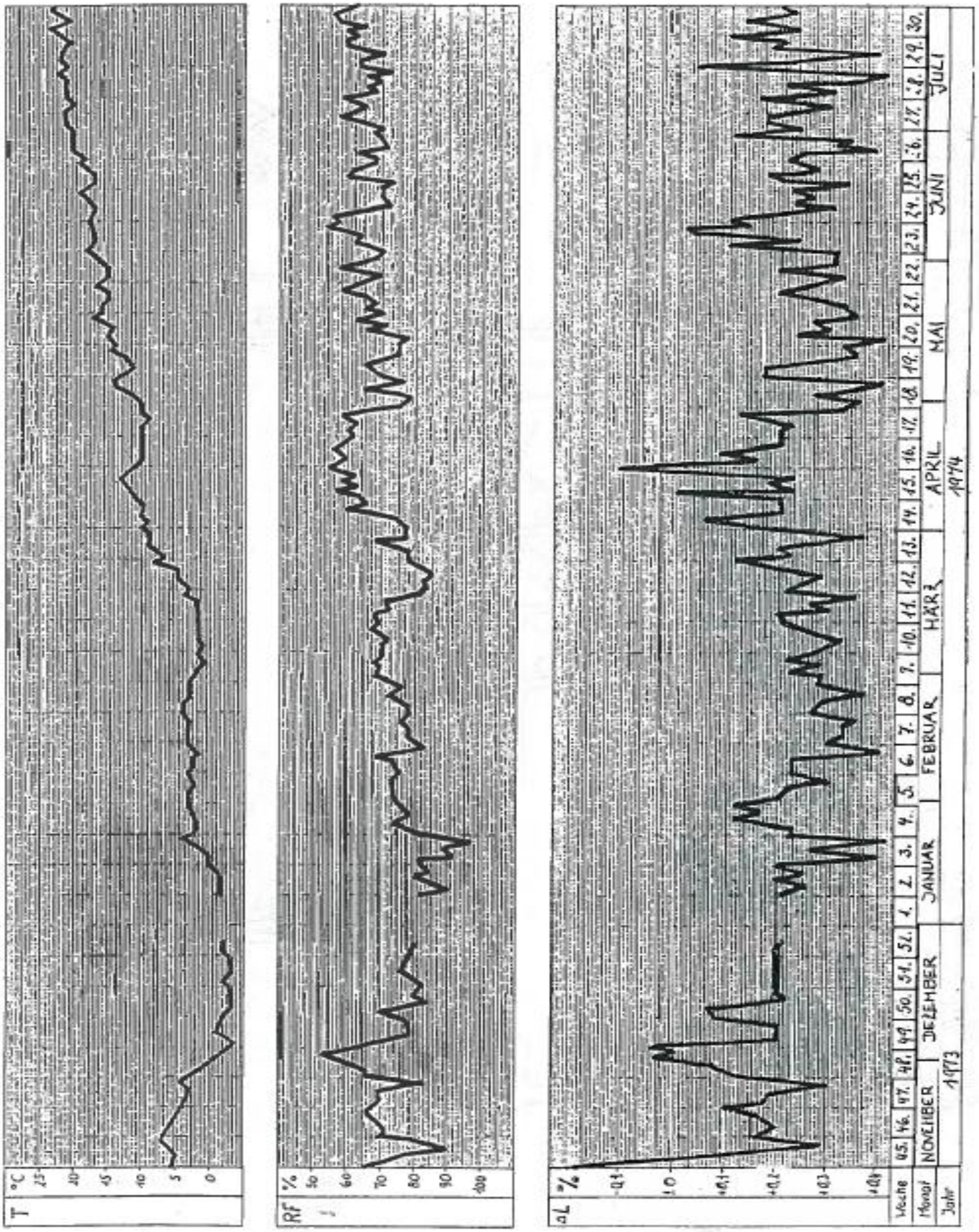


Fig. 4. *Plot of the temperature and the RH in the period indicated together with the plot of the proportional change in the length (ΔL). Leather wall-hanging without wooden back panel.*

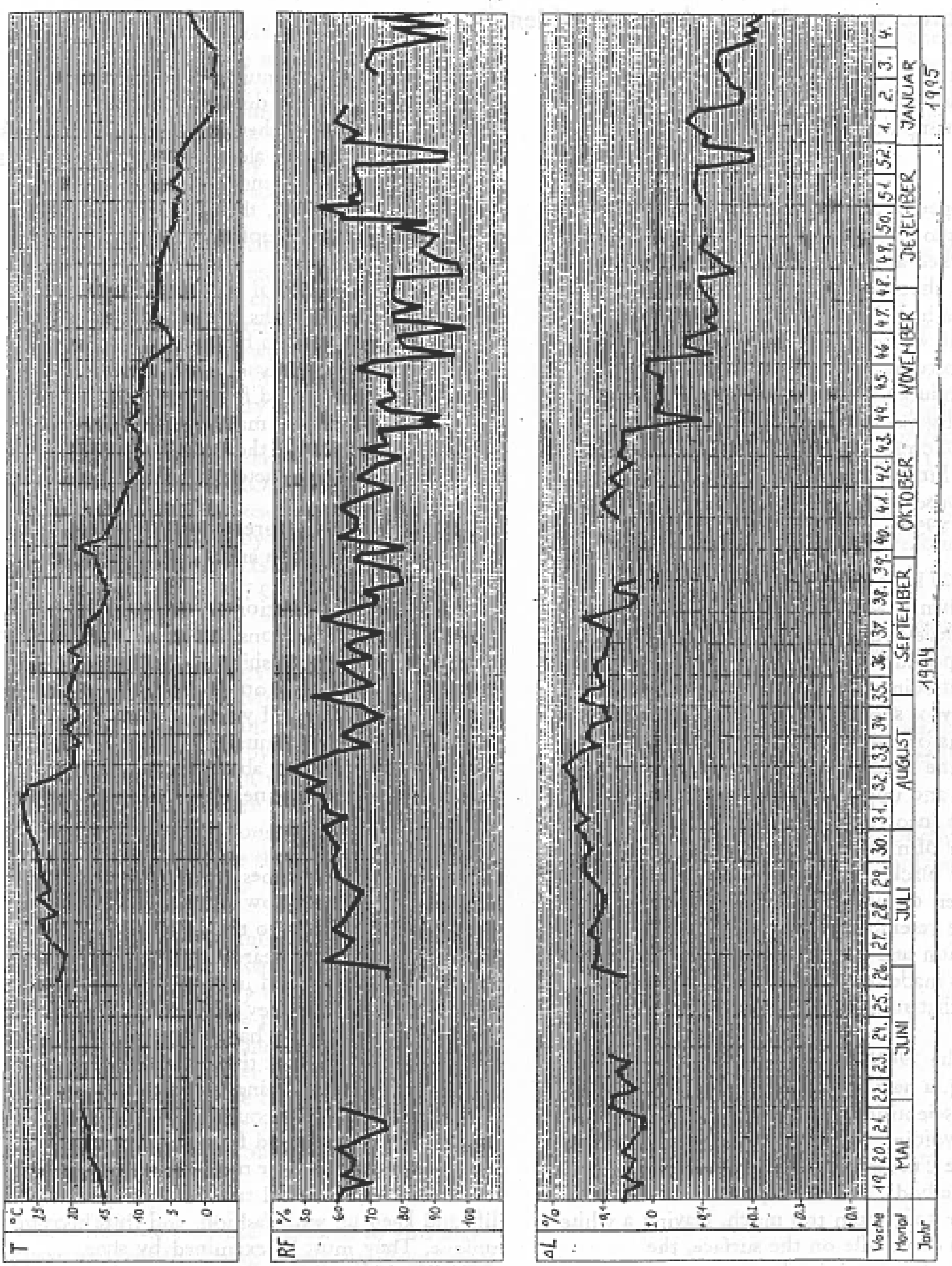


Fig. 5. *Plot of the temperature and the RH in the period indicated together with the plot of the proportional change in the length (ΔL). Leather wall-hanging with wooden back panel.*

Shoe Conservation: Freeze-Drying Problems?

June Swann,
28th Broadway
GB-Northampton NN1 4SF

I was Keeper of the Boot & Shoe Collection, Northampton Museum, 1950-1988, and have since worked as consultant on the history of shoes and shoemaking, visiting museums and collections in Britain and most continents around the world. I am also a member of the ICOM Costume Committee Working Group which produced Guidelines for Costume in 1989 and its subsequent editions (available from Costume Committee members, or Espoo City Museum, Finland). Thus I see the effects of the various conservation methods used both before and since 1950.

Before 1900 little seems to have been done to leather when it was dug up. But soon after that, building development in London suddenly began to produce quantities of shoes. More were saved, as it coincided with the huge interest in the history of shoe fashions shown in the shoe exhibitions of the 1890's. Being salvaged by builders, the shoes were allowed to dry naturally, and uppers and soles matched up, sometimes incorrectly.
A number of museums have such shoes, invariably black and hard. But nonetheless many when displayed in showcases have a reasonable resemblance to the original, show no deterioration and no problems, so long as no attempt is made to bend the leather, though I suggest that mismatched pieces be detached.

Then in the 1940's, with the war damage and rebuilding, a new generation of conservators an increased scientific awareness began to look for ways of avoiding the black colour and hardness. For a time Turkey red oil was applied by various methods, and in desperation to make the leather soft, often too much, leaving a white waxy film or puddle on the surface, the penetration being minimal.
In the meantime the British Museum had produced a dressing for its leather bookbindings still suffering from 19th century gas-lighting, as well as continual use. For the first time, the formula included a solvent to lead the lubricants into the leather.

I have found this formula utterly reliable when used according to the direction: sparingly, and massaged into the leather; except, of course, it is not suitable for white alum-tawed leathers, some native-tanned leather and leathers coated with lacquers of linseed etc, though for the latter, it can be effective if applied to the non-lacquered side.

It was understandable if no use for excavated leather just laid in baths of the dressing. Hides during tanning have to be worked, massaged by various methods to ensure penetration, and this must be borne in mind for conservation lubricants also. Please make yourself familiar with the principles of the various tanning methods and the characteristics they produce.

By the 1960's there were experiments with various other dressings and solvents, some more drastic than others.
There are briefly mentioned in the article by Ganiaris et al., The Conservator 6, 1982. Please note that energetic washing to remove dirt can also remove tans. It is one problem for leather to stay for hundreds of years in damp soil, quite another to soak indefinitely in water. If we are ever to learn anything about historic tans and dyes, which must be one of our aims, this must be avoided.

Here a plea for old shoes: shoes, because they are worn by all and now cheap and the plastics smelly, discarded (up to the recent past) only when impossible to wear longer, associated with corns and bunions, and inevitably take on the spirit of the wearer, they can provoke all too often a reaction in the handler, a subconscious fear of that spirit, or at the least distaste.
The large quantities being found can be overwhelming, and encourage a feeling that samples could be spared for experiments. Shoes are not expendable. For most were repaired and altered by cobblers and translators to prolong life and keep up with fashion, and thus become unique. They must be examined by shoe specialists before assumptions are made.

The latest methods developed in the 1970's, use freeze-drying, which has virtually turned the treatment into a mass-production system, and enabled the human associations to be ignored.

Freeze-drying was preferred as cleaner, safer to the operator than some solvents used for drying, while apparently giving similar results in flexibility, amount of shrinkage, and what some found a more acceptable brown 'leathery' colour, in reality equally as false as the black which preceded it. But some curators find it looks desperately dry.
By 1985 when the Museum of London produced Its Information Leaflet entitled Treatments for Excavated Leather, the conclusion was that freeze-drying was preferable. Their procedure was summarized: clean with non-ionic detergent and water. Rinse. Soak in 25% glycerol/water 3 days. Freeze, freeze dry about 2 days.

Here I want to draw attention to the work of a Dutch conservator at ROB, working sympathetically with excavated shoes, producing more attractive results by less drastic means, and with the long-term effects after twenty-five years looking preferable. Olaf Goubitz published this in 1981 and 1987.

I realise that conservators may be at a disadvantage in that, having treated the leather, it too often disappears into museum stores and ceases to be monitored by those who treated it. So I draw your attention to the problem that curators have been aware of since at least 1992, shoes from Wapping, conserved 1983-4, where powder appeared beside the shoes in carefully controlled display cases.

I have since been examining shoes and soles of sturdy cattlehide from Roman, through medieval to 16th-century dates. Even as it sat on the table before me, fine powder was dropping from the object. Most tanners would be very reluctant to freeze leather because its natural water content makes the danger of breaking the linkage between the fibres so obvious, and excavated leather may contain four or five times more water.

I realise that the evidence I present to you may appear unscientific, being largely based on visual appearance and some forty-five years experience of working with historic leathers. But it is obvious to me that something is wrong. I urge conservators and curators to check their conserved shoes, and where you find a problem, look up the methods used and report back to this committee.

It may be the fungicide or other chemicals involved, but it is no use continuing with this convenient mass-production method if the end result is the destruction of the object.

References

1. British Museum Leather Dressing for Library Use, c 1940

2. Plenderleith, H.J., *Preservation of Leather Bookbindings.* 1946, 1953

3. Ganiaris, H., S. Keene and K. Starling, *Comparison of Some Treatments for Excavated Leather*. The Conservator, 6, 1982, 12-23

4. Museum of London Information sheet: *Investigation into Conservation Treatments for Excavated Leather*. 1985

5. Goubitz, Olaf, K. Offerman, *Conservation & Restoration of a 16th century Leather Jerkin*. ROB, Amersfoort, 1981

6. Goubitz, Olaf, *Castor Oil Treatment for Waterlogged Leather*. Crispin Courier III, June 1987, 4-5

7. ICOM Costume Committee, *Guidelines for Costume.* Espoo City Museum, Finland, 1989-1994.

What is Wrong with Freeze-drying?

Olaf Goubitz
Rijksdienst voor het Oudheidkundig Bodemonderzoek
Sectie Conservering Organische Artefacten
Kerkstraat 1
NL-3811 CV Amersfoort

What is wrong with freeze drying?

A title with two faces, depending upon which words you emphasize, or I could also call it *'Who's afraid of freeze drying?'*

Well, I for one, am no longer afraid of the freeze drying process. In the beginning the whole complicated procedure was very dark and mysterious; the apparatus, the vacuum, and all the knobs and dials. How freeze drying works is still an arcane and complicated process to me, and strange enough, when I ask people who do freeze drying, they cannot explain to me what actually happens. Those who claim to understand the process understand it so well that they are unable to explain it clearly and simply to someone like me, who does not have a degree in applied physics.

Actually, I have no formal training in physics or chemistry, only some basic knowledge, which is perhaps why my laboratory is more like a kitchen. I have learned to use my natural senses instead of scientific meters and gadgets. I test the leather with my fingertips, use my nose to smell if it is sour or mouldy, feel the dampness of the drying leather with my cheek, and mumbling over the vats like an old wizard. 'Hmm, the leather looks bad today, let's give it a swim in the acid, and this ugly old sole needs an ultrasonic beating, that will teach that lumpy leather a lesson'.

Think what you will of my methods, but I wonder why the leather I conserve has no troubles afterwards; it doesn't dry out, it doesn't develop a rash or surface peeling, nor does it lump up or mold away. Even pieces that have been in dark boxes for over 25 years still appear happy and healthy. Maybe because I do not freeze dry leather. Could it be that simple?

What then do I use the freeze-dryer for? Wood! Just wood. It took me a year to figure out the whole mess, but now the results are satisfactory. Experience, with all its ups and downs, gives the best training, that also goes for the treatment of leather.

Even before I had a freeze-dryer, I had the feeling that freeze drying was not a good idea for the conservation of archaeological leather. There are other methods, simpler, cheaper, and less dangerous. Methods that I still use today. Sure, I put leather in the freeze-dryer, as a test of the method. I also read the reports in Studies in Conservation, Arbeitsblätter and other journals. From the incoherent confusion reported in the journals, one fact stood out, the leather still needed a lubricant. PEG 400 was recommended as a pre- and post-treatment, and most people seem to think that PEG 400 will solve all the problems of freeze-drying.
I have never used PEG 400, as it is too hygroscopic. Leather pre- or post-treated with PEG 400 tends to keep sweating excessively, even without working out, or when too diluted with water, it has no body and the leather dries out. The truth is that PEG acts the same as the glycols used in anti-freeze for cars. Even PEG 600 does not fully freeze at minus 30°C (which is minus 22°Fahrenheit, or 243 Kelvin, and 24°Reaumur). So PEG 400 as a pretreatment is self defeating, and as a post treatment, it makes the leather really wet again!

I regard the freeze-drying of archaeological leather as a money, time and energy wasting process. I am really not sorry to say that, especially when there has always been easier, safer and cheaper alternatives.
The main alternative I use is a gentle cleaning, some slight air drying, followed by a bath in PEG 600. Usually the leather is soaked in water, and I test with my fingers first to feel both the consistency of the soil and the quality of the leather. I can also feel the shape and size(s) of the objects(s). With that information, I can go on to do the investigative cleaning, using an extremely feeble source of running water, artists paintbrushes, and for the really heavy mud: a minuscule paint spatula. If the soil is heavy clay, or has metal deposits, a treatment with an ultrasonic cleaner can be used.

After a thorough yet gentle rinsing, the leather is placed on newspapers to dry until about 80 percent of the water has been absorbed by the papers. I can hear the cries: ‘But newspaper is acidic!’ Yes, but the leather does not sit on the newspapers longer than a few hours, which is not enough time to do any damage, so save your expensive acid free blotting paper for the things that need it.

Knowing when the leather has the right amount of dryness is something that can be learned by experience, though it does mean that you will have to trust your own senses rather than some scientific gadget. It is at this time the leather is closest to its original form, so this is the time to measure, draw, and record all important information.

The leather is then given a bath in PEG 600, diluted with 40 percent water. About 36 hours is enough, though if it sits longer no harm is done. The leather is allowed to dry on newspapers again. According to its destination - direct storage, near future reference, exhibition, etc., the leather can be stored in perforated polyethylene bags, and be put into boxes.

When taken out of the PEG 600 bath the leather is very dark, sometimes even black. As the PEG evaporates over the years, the leather becomes lighter in colour. Leather pieces that I have kept for over 25 years as reference pieces for typological and technological data have become light brown with time. I think that we have to accept the colour as it is because to change the colour, the leather would have to undergo, some bleaching treatment, which is probably not healthy for the leather, and also we cannot really know what colour the leather was originally and any attempt to force another colour on the leather would be misleading.

Because of this long experience with the treatment I know that some kinds of leathers may need re-treatment. This consists of a dip into PEG 600 for medieval leathers, a swim of about 5 minutes for a 16th century leather, and a real drowning for 17th century and newer leathers. But most of my leathers, including the medieval haven’t needed re-treatment and are still flexible and supple after so many years of storage.

As with all methods, there is some shrinkage after the treatment, varying from 5 to 15 percent, depending upon the type and thickness of the leather. This is one of the reasons why all measurements and registration should be done before treatment. With this low tech method of conserving wet archaeological leather in a span of three days one can conserve 10 to 1000 pieces of leather, depending upon available working space, whereas the freeze-drying method takes 10 or more days.

There is one other method I use to conserve leather, and that is with oils. If a piece is to be restored, sometimes glues have to be used and these will not stick to PEG treated leathers, the colour is lighter (which for some reason people find more ‘natural’), and the object can be polished lightly with oils, giving the object a bit livelier shine. Also in the case of Roman shoes which still have all their nails, the oils are less aggressive for the metal.

The recipe for the oil is:

Castor oil	35 Vol. parts
Glycerol	15 Vol. parts
Tertiary butylalcohol	50 Vol. parts.

No impossible to pronounce secret ingredients, no miracle snake oil potions, nor magic invocations are added. If the mixture is kept this simple there are only three components to be blamed for treason if anything goes wrong. In the treatment the leather is dehydrated before with methylated spirit.

I fully understand that by revealing my simple methods in this paper, that my approach is not the newest breakthrough of scientific advancement, and may be open to attack by those who need dials and meters. But the leathers that I have conserved are not having the problems now being seen in freeze-dried leathers. I know that it may be possible that the leather I am working with may differ in quality, soil type, and burial conditions, from leathers elsewhere, or it may be that the climate in the Netherlands is perfect for my methods.

You may want to ask me right now, what do I think gives me the right to speak so unscientifically about leather conservation. Well, ask my happily conserved leathers!

Congratulations and abusing letters to my address.

Bookbindings and Folders Made of Gilt Leather

Eloy Koldeweij
Valeriusstraat 213-11
NL-1075 EX Amsterdam

In 1719 the second volume of the book 'De Groote schouburg der Nederlandsche Konstschilders en Schilderesse' ['The big theatre of the Dutch painters and paintresses'] by the painter Arnold Houbraken was published.
In one of the chapters Houbraken relates about the political troubles in the year 1672, when the Dutch were amongst others at war with the French. At that time Houbraken was an eighteen year old boy and one day he was watching the plundering of the house of the mayor of the city of Dordrecht. The interior and the furnishings of this house were vandalized and torn. All the wall-hangings were tattered and parts of the gilt leather hangings were dragged on the street. One of the plunderers, who had his arms full with gilt leather dropped a fragment when he passed the young Houbraken. He on his turn, could not resist in picking it up and thought that it would be nice to make a folder out of this for his drawings and sketches. However, when he came home, his father spotted the fragment of gilt leather and ordered his son immediately to bring it back to the place where he found it.
Although the young Arnold Houbraken tried to persuade his father so that he could keep this gilt leather, his father was unconvincible and the young Arnold Houbraken had to return this fragment (1).
Gilt leather is mainly known as a material which was used for wall-hangings, but because of its nice decorated surface and its pliantness it was used for many other purposes too: as curtans, for screens, chairs and chests, as independent pictures, for table-coverings, frames for paintings, mirror- and comb-boxes, altar frontals, chasubles and pillows.
Also bookbindings and folders belong to this list and although they were not a prime use of this material, quite a few examples can be found. It is however important to realize that all these gilt leather bookbindings and folders are unique and singles. With only one single exception they were all made of gilt leather that was re-used in the same way as the young Houbraken wanted to use 'his' fragment.

Three different types of bookbindings and folders made of gilt leather can be discerned:
A. Those which have been made of used gilt leather, and have been cut out of a big panel. This is by far the largest group, which includes almost ninety per cent of all the known examples.
B. Those which have been made of used gilt leather which has not been cut or changed for this purpose. Just three examples are known of this type.
C. Those which have been made specifically for this use. Only one example is known which belongs to this type.
It cannot be said that one of these types is more important than the others: they all have their own value. Although it is not easy to say when a specific book got its binding, quite a few bindings of type A and B provide a date 'ante quem' for the leather. Type B adds three objects to the rather small group of so-called gilt leather mirror-boxes. Type C, the uniqueness of this single gilt leather binding which has been made as such speaks for itself.

Type A: *Gilt Leather Bookbindings and Folders which have been made of Re-used Material*

The earliest known bookbinding with a decorated surface is a monument in itself. This binding (190 x 137 x 40 mm.), which is in the library of the St. Gallen Abbey (Switzerland), contains an eleventh-century manuscript. The binding itself has been dated in the twelfth century and is obviously a fragment of a larger panel (2). The size of its pattern however is much too big for the manuscript, and most likely it was once part of a wall-hanging.
Both for leather and gilt leather wall-hangings this is extremely early: although a few records of such wall-hangings from the twelfth and thirteenth centuries are known (3), all the surviving fragments date from the fifteenth century onwards. The only piece of leather which can stylistically be compared to the St. Gallen binding is the altar frontal in the village of Oreilla near Perpignan in Southern France, which is attributed to the Valltarga master and dates from the thirteenth century (4).

In the collection of the University Library in Hamburg is a bookbinding (300 x 210 mm.) which covers a theological manuscript by Johannes Herolt from 1443 and shows amongst others birds, lions, dogs and lilies (5). Like the previous binding, this pattern has been printed with a black ink on the leather without any silvering or gilding. This binding fits into a group of bookbindings with similar patterns, made of both leather and textile, and all dating from the fifteenth century. Similar bindings can be found amongst other places in the University Library of Uppsala (Sweden) and the convent library in Melk, Germany (6).
Quite different is the bookbinding (ca. 350 x 230 mm) which covers a Grecian Lexicon from 1562 (7). There cannot be any doubt that this binding originally was part of a wall-hanging: a series of this design with the coat of arms of the Spanish Cardinal Pedro Salazar (1630-1706) has been preserved and the same pattern can also be distinguished on a painting by the Antwerp painter Gonzales Coques, dated 1640 (8). These leather panels have a very traditional pattern, which closely resemble Spanish and Italian silk-brocades from the mid-sixteenth century. A similar binding in the collection of the Bodleian Library in Oxford covers an Italian breviary of the fifteenth century (9). Its pattern suggests a Spanish or Italian origin dating from the fifteenth or sixteenth century, a complete panel with this pattern however has not yet been traced. Very much alike are two folders (355 x 220 mm and ca 330 x 200 mm) in the Episcopal Museum in Vic (Spain). According to their inscription they originally contained documents of 1646-1651 and 1661-1709 from the Parish of Susqueda, Les Guilleries near Barcelona (10). Most likely the gilt leather of which they are made will be Spanish or might even be from Barcelona.

Very different on the other hand is the binding in the Royal Library in The Hague which contains a Dutch medical manuscript from 1577 (11). Quite remarkable is that the gilt leather has been the wrong side out and it is obvious that the binding has not been made by a professional binder. This is nevertheless an important piece because the gilt leather dates from the early seventeenth century, and belongs as such to the earliest surviving pieces of gilt leather which have been made in The Netherlands (12).

A manuscript (316 x 216 mm) with genealogical notes of a Utrecht family from circa 1684 has been bound in gilt leather which can be dated around 1650 (13). The same pattern can be found on two panels in the collections of the Kunstgewerbemuseum in Dresden and the Grassimuseum in Leipzig, and the pattern has also been used for one of the chasubles of the Dutch priest Volquerus Herkinge who died in 1662 (14).

A gilt leather folder (370 x 550 mm) in the collection of the 'Museum van Sierkunst' in Gent dates from about 1720-1740 (15). The same pattern can be found on quite a few panels, amongst others in the Deutsches Ledermuseum in Offenbach am Main, but a complete wall-hanging of this design has not yet been traced. The last binding of this type dates from almost 200 years later, and covers a book which was published in 1912 to commemorate the Russian campaign of Napoleon in 1812 (16). The gilt leather dates without any doubt from the same time, and is a good example of the revival of gilt leather ca. 1900.

Type B: *Gilt Leather Bookbindings and Folders Made of Gilt Leather which has not been Cut or Changed for this Purpose*

The most important piece of this group is without any doubt the binding in the Jagiellonian Library in Cracow (217 x 143 mm) which contains a Polish manuscript from the mid seventeenth century (17). The binding is signed 'J.F.', the initials of the Amsterdam gilt leather maker Jacob Frijberger (*1606-1666), and the pattern is a splendid example of the so-characteristic Dutch auricular style of the mid-seventeenth century. The manuscript fits quite remarkably into the gilt leather cover.
The second binding of this group (143 x 117 mm), in the National Library of Scotland in Edinburgh, contains an Icelandic manuscript of theological tracts dated 1765 (18). The gilt leather, which lost almost all its colour, dates from the mid seventeenth century and which doubtlessly was made in The Netherlands.
The third binding, which is in the possession of the University Library in Amsterdam, has no contents anymore (19). It dates from the seventeenth century, but where it has been made is not clear at all.

From a stylistic point of view it might have been made in The Netherlands, but technically speaking it differs too much from the Dutch gilt leather so it will have been made elsewhere. These three bindings in Cracow, Edinburgh and Amsterdam were originally so-called mirror-boxes. The mirror-box which has been found in the shipwreck of the Swedish Royal Warship the 'Kronan', which sank in 1676 on the east-coast of Sweden, is indeed very similar (20), and so are the two mirror-boxes which are being preserved in Japan (21). Although they both lost their contents we know that they were originally mirror-boxes, because a detail of a similar one is illustrated in volume 6 of the Sokenkishu, written in 1781 by Inaba Tsuryu and has been described by him as such.

Type C: *Gilt Leather Bookbindings which have been made Specifically for this Use*

Of this type only one bookbinding is known at this moment. It is a pity that nothing is known about it because of its uniqueness. This binding has never been used and can only be dated and located on stylistic grounds (22). Most likely it has been made in France and will date from the second half of the eighteenth century.

Conclusion

Up till this moment hardly anybody knew about the existence of gilt leather bookbindings and folders. Quite a few examples have been located and these are mentioned in this short survey, but hopefully many more will appear. In conclusion we can say that these gilt leather bookbindings and folders are an exceptional and important group, both for the study of gilt leather and bookbindings.

* This article would not have been possible without the help and kindly supplied information by Maarten Jan Bok (Utrecht), Maria Cubrzynska-Leonsrezyk (Biblioteka Uniwersyteca, Warsaw), Marijke Detremmerie (Museum voor Sierkunst, Gent), Lars Einrasson (Kalmar County Museum), Richard Gerecke (Staats- und Universitätsbibliothek Hamburg), John Morris (National Library of Scotland, Edinburgh), Paul W. Nash (Bodleian Library, Oxford), Andreas Schulze, Dresden, Henk van Soest (The Hague), Prof. dr. J.A. Szirmai (Oosterbeek) and Jan Storm van Leeuwen, Ad Stijnman and Rens Top (Koninklijke Bibliotheek, The Hague).

References

1. Houbraken, A., *De Groote Schouburgh der Nederlantsche Konstschilders en Schilderessen*, Amsterdam 1718-1721, Vol. II, p 149

2. Szirmai, J.A., 'Einbände/Bindings', *Restauro*, 98 (1992) 155-156

3. The Spanish King Alfonso IX gave in 1197 two '*guadamecis*' to the church in Castro de los Judios, and this material is also mentioned in an inventory of Toledo from 1273. Risco, M., *España Sagrada: Estado antiguo y memorias de la Santa Iglesia esenta de Leon,* Madrid 1786, Vol. II, p. 259; Leguina Juárez, E., *La Industria Artistica del cuero en España*, Vic 1920/1989, p 79

4. Aguilo, M.P., 'Cordobanes y Guadamecíes', *Historia de las artes aplicades e industriales en España*, Madrid 1982, p 335;
Post, C.R., *A history of Spanish painting*, Cambridge 1938, 725-728, pl. 273

5. Herolt, J., *Sermones Dominicales de Tempore. Pars Aestivalis*, Mainz 1612 (Staats- und Universitätsbibliothek Hamburg, pressmark: Cod. Theol. 1097). This manuscript has been described in: Becker, P.J., *Die theologischen Handschrzften der Staats- und Universitãtsbibliothek Hamburg 1: Die Foliohandschriften,* Hamburg 1975, 58-59

6. Henschen, I., *Tygtryck i Sverige 1. Före 1700*, Stockholm 1942, 83-85, pl. 18-22; Wilckens, L. von, 'Der spätmittelalterliche Zeugdruck nördlich der Alpen', *Anzeiger des Germanischen Nationalmuseums,* (1983) 14-15, pl. 19-23

7. Gesner, K., *Lexicon Graecolatinum ... Basileae:* ex off. Hier. Curionis 1562 (Biblioteka Uniwersytecka, Warszawie (Poland), pressmark: 28.20.2.1022)

8. Koldeweij, E.F., ‘How Spanish is ‘Spanish Leather’?’, *Conservation of the Iberian and Latin American Cultural Heritage. (Preprints of the Contributions to the Madrid Congress, 9-12 September 1992)*, London 1992 (ed. Hodges, H.W.M., Mills, J.S. & Smith, P.), 84-88

9. Bodleian Library, Oxford, pressmark: MS. Ashmole 46. Strickland G., ‘Decorated leather bindings’, *The Bodleian quarterly record*, I, nr. 9 (April 1916) p 241

10. Inv. nrs. 17157 & 17158

11. Sweerts van der Boorcht Meerbeque, G., *Het Gulden Recept bouck van diverssche medecijnen...*, [Mechelen ?] 1577 (Royal Library, The Hague, pressmark: 133 M 27).

12. Its pattern can closely be compared to the gilt leather wall-hanging signed by Hans le Maire, gilt leather maker in The Hague and Amsterdam, which is in the Swedish Royal Collection

13. Rijksarchief Utrecht, Inv. nr. R 56-1, nr. 28: ‘Genealogische aantekeningen van de familie Van Abcoude van Meerten door Jan Louis van Abcoude van Meerten’, ca. 1684

14. Koldeweij, E.F., ‘Een zeventiende-eeuws kazuifel van goudleer’, Catharijnebrief, 11 nr. 43 (sept. 1993) 8-10

15. Inv. nr. 5095

16. Ségur, Ph. de, *1812-1912. Napoléon. Texte tiré de Ia campaigne de Russie 1812*, Paris, no year

17. Zwinogrodzka, E., P. Hordinski & J. Storm van Leeuwen, *Poolse boekbindkunst, 1400-1800 uit defagiellonski bibliotheek*, Den Haag 1990, p 106, nr. 142; Storm van Leeuwen, J., ‘Between East and West: Polish bookbindings in The Hague’, *The New Bookbinder. Journal of designer Bookbindings,* XII (1992) p 65, pl. 8

18. National Library of Schotland, Edinburgh, pressmark: Adv. MS. 21.8.9. Very alike is the wall-hanging in Charlecote House (Engl.) which dates from the second quarter of the seventeenth century

19. Pressmark: Hs. 1 G 8

20. Kalmar County Museum, Kalmar (Sw.), Inv.nr. Kronan F. 2015

21. One is in the Tokugawa-museum in Nagoya, the other in a private collection in Tokyo. Scholten, F., E.F. Koldeweij, a.o., *Goudleer Kinkarakawa. De geschiedenis van het Nederlands goudleer en zijn invloed in Japan*, Zwolle 1989 (exh. cat.), cat. nr. 7, pl. 16, 18; Tanaka-van Daalen, I., ‘Chiyohime no Kinkarakawa’, *Museum, Art Magazine edited by the Tokyo National Museum*, nr. 425 (augustus 1986) 21-34 (article in Japanese with an English summary)

22. This binding came up at auction in Paris in 1990, and was part of a large collection of gilt leather panels which was sold. Etude Néret-Minet - Coutau-Bégaire, *Toiles Imprimées, Cuirs Repoussés, Papiers Peints*, Paris 22/09/1990 (Auction Catalogue), nr. 148

Durability Test of Six New Bookbinding Leathers

Pieter B. Hallebeek
Central Research Laboratory for Objects of Art and Science
Gabriel Metsustraat 8
NL-1071 EA Amsterdam

Abstract

Comparative investigation into the sensitivity for different forms of artificial ageing of six, commercially available new leathers for bookbindings. A relevant choice of parameters has been made and the data from the measurements of this parameters give information concerning the degree of degradation. The acquired data from the new, unaged leathers are used as reference and compared with the data from the same measurements after artificial ageing with different parameters of the same material.

As most relevant chemical and physical parameters are chosen the determination of the degree of acidity, percentage soluble sulphate, shrinkage temperature, tensile strength and tear strength.

Other relevant parameters for the comparison of the bookbinding leathers are physical characteristics such as color, flexibility and thickness to be determined by the book conservators. The ultimate goal for the project is to set up quality standards for new bookbinding leathers. The ageing tests are partly executed in the Central Laboratory and partly by the Leather Conservation Center in Northampton, England.

1. Ageing experiments

Artificial ageing was executed in three different phases:

First phase: oxidative without atmospheric pollution in order to study the behaviour from already present, free or bound sulphur containing compounds.
Conditions and parameters: three days dry heat at 150°C, followed by eleven days ageing with:

Temperature	: 40°C	ozone (O_3)	: 5 ppm
Relative humidity	: 70%	light	: UV

Second phase: hydrolytic
Parameters: Fourteen days ageing with:

Temperature	: 40°C	SO_2	: 25 ppm
Relative humidity	: 50%	NO_x	: 25 ppm

Third phase: oxidative and hydrolytic; samples from the first phase are aged again with the parameters of the second phase (1).

2. Experimental

Chemical and physical parameters to be measured before ageing:

1. Acidity (pH)
2. Bound and soluble sulphate
3. Bound and soluble suiphide
4. Bound and soluble sulphite
5. Total sulphur and metals
6. Tanning materials
7. Shrinkage temperature
8. Tensile strength
9. Tear strength

Chemical and physical parameters to be measured after ageing:

1. Acidity (pH)
2. Soluble sulphate
3. Soluble sulphide
4. Soluble sulphite
7. Shrinkage temperature
8. Tensile strength ALCAE15
9. Tear strength ALCA-E10
10. Water soluble ALCA B8

3. Analytical methods and equipment

The methods are described in references (1), (2), (3) and (4).

4. Measured values of properties of unaged new leather

Type	pH	SO_4 sol	SO_4 insol	SO_4 tot	T_s	Tensile	Tear	Tanning
Elzas	5,2	0,5	1,1	1,6	74,3	247,1	43,8	Valonea
Glaser	3,9	0,9	1,5	2,4	69,3	329,1	41,3	Myrobalanen
Hewit 1	4,6	0,3	1,2	1,5	> 100	252,1	29,8	Kastanje/Al
Hewit 2	3,2	0,2	1,6	1,8	67,6	285,0	37,9	Valonea/Cr
Pearce	5,4	0,07	1,7	1,7	> 100	298,4	27,0	Al/Cr
Pessers	3,4	1,1	2,3	3,4	94,2	202,2	39,8	Quebracho/Cr

5. Changes in measured values of properties after different types of ageing

5.1. Degree of acidity, decrease as % of original pH value

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	19	2	58
Glaser	8	0	41
Hewit 1	7	4	13
Hewit 2	0	0	34
Pessers	12	0	9
Pearce	6	17	22

5.2. Soluble sulphate, increase as % of original value

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	106	250	326
Glaser	90	111	183
Hewit 1	236	357	693
Hewit 2	370	30	470
Pearce	685	2414	2714
Pessers	288	76	369

5.7. Fall of the shrinkage temperature, % of the original value

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	0	4	50
Glaser	43	0	31
Hewit 1	25	15	35
Hewit 2	27	2	40
Pearce	4	2	49
Pessers	49	0	20

5.8. Tensile strength, change in % of the original value (+: increase, -: decrease)

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	+8,5	-35,5	+10,8
Glaser	+8,5	+8,4	-1,7
Hewit 1	+1,6	+1,6	-38,2
Hewit 2	+9,9	-5,0	-32,0
Pearce	-52,4	+15,8	-8,2
Pessers	-45,0	-21,5	-20,0

5.9. Tear strength, change in % of the original value (-i-: increase, -: decrease)

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	- 29,5	-27,9	-24,4
Glaser	-28,9	-28,2	-24,2
Hewit 1	-15,0	-1,8	-50,4
Hewit 2	-15,0	+1,7	-54,5
Pearce	-38,5	+0,7	-14.8
Pessers	-72,4	-19.8	-45,5

5.10. Percentage water soluble

Type	Oxidative	Hydrolytic	Oxid. + Hydrol.
Elzas	1,2	4,1	4.2
Glaser	0,4	5,7	5,9
Hewit 1	0,3	2,4	2,8
Hewit 2	3,3	6,8	7,5
Pearce	0,3	2,9	2,8
Pessers	1,8	2,8	3,0

6. Conclusions on the results of the measurements on artificially aged leather

6.1. Degree of acidity

Oxidative

The degree of acidity from all types of leather has fallen but is still within the limits for sound leather: between pH 3,5 and pH 6,0. In theory there should be no change in pH after oxidative ageing without the presence of sulphur containing salts because no gases are absorbed which could cause formation of acids. In practice oxidation enhances formation of acids by oxidation from in the leather present free and bound sulphate, sulphide and sulphite. From the results of the determinations on new, not aged leather it is obvious *Pearce*, *Hewit 2* en *Pessers* contain a high percentage bound sulphate. Only *Pessers* has a large proportional drop in degree of acidity. There is not enough evidence for a direct connection between the presence of a high percentage of total sulphur and a large drop of pH caused by the formation of sulphuric acid from already present sulphur containing salts.

Hydrolytic

The degree of acidity from *Hewit 1*, *Elzas* and *Pearce* has dropped after hydrolytic ageing. pH is still within the limits for sound leather: between pH 3,5 and pH 6,0. The influence from already in the leather present bound and soluble sulphate is after hydrolytic ageing not detectable.

Oxidative + Hydrolytic

Degree of acidity from *Glaser, Hewit 2, Elzas* and *Pessers* sinks after combined ageing below the critical limit of pH 3,5.

6.2. Sulphur content

Oxidative

All tested types of leather contain soluble and bound sulphur, brought into the leather during the use of sulphur containing chemicals. For all types of leather the percentage free or soluble sulphate rises at oxidative ageing, although no gaseous sulphur containing substance is used in the atmosphere from the ageing chamber. Especially in *Pearce* and *Hewit 2*, a great part of bound sulphate is converted to free sulphate. It may be concluded that there is a contribution from during manufacture of the leather added and not washed Out sulphur containing chemicals to accelerated (oxidative) ageing of the material.

This fact is not confirmed by a proportional lowering of the pH. Probably free sulphur compounds are nor yet converted to sulphuric acid.

Hydrolytic

In all types of leather the percentage sulphate increases during hydrolytic ageing. Especially for *Hewit 1* and *Pearce* this rise is considerably. These types of leather absorb more sulphur dioxide from the atmosphere than the other tested leathers. *Hewit 2* and *Pessers* absorb much less sulphur dioxide.

Oxidative + Hydrolytic

All types of leather show a considerable increase from the percentage soluble sulphur compounds at the combined oxidative and hydrolytic ageing. Especially for *Hewit 1* and *Pearce* there is a considerable increase. For *Pessers* with a high percentage total sulphur this effect can not be measured.

6.5. Total sulphur and metals

New Leather

The result from the determination of total sulphur with RFS compared to the total of the percentages from soluble and bound sulphate, sulphide and sulphite is not the same figure. For low percentages the difference is small, for higher percentages the difference is greater. A possible explanation could be the presence of probably bound, organic sulphur compounds, not to be determined separately.

6.6. Tanning materials

New Leather

Hewit 1 contains aluminium and vegetable tannins and is a vegetable-tanned leather, re-tanned with aluminium. *Hewit 2* is a vegetable-tanned leather, re-tanned with chromium. *Pessers* is probably a combination tanning. *Pearce* is a chromium tanned leather, re-tanned with aluminium or a aluminium/chromium combination tanning. *Elzas* and *Glaser* are pure vegetable-tanned leathers.

From the detected vegetable tannins only quebracho belongs to the group of the condensed ('catechol') tannins. It is known that tannins belonging to this group have less resistance against ageing than the hydrolyzable ('pyrogallol') tannins, like sumac. The other analyzed vegetable tannins belong to this group. In general leathers, tanned with mineral tannins have a better resistance against ageing than leathers, tanned with only vegetable tannins.

6.7. Shrinkage temperature

Oxidative

Values for shrinkage temperature after oxidative ageing are favorable for *Elzas* and *Pearce*, a pure vegetable-tanned leather and a pure mineral tanned leather. For *Pessers* and *Glaser* there is a larger drop in shrinkage temperature, a combination tanning and a pure vegetable-tanning.

Hydrolytic

The drop in shrinkage temperature after hydrolytic ageing is in general lower than after oxidative ageing. There is no fall for *Pessers* en *Glaser*. Remarkable is the reversed order in the results compared to oxidative ageing. There is a high percentage in fall for *Hewit 1*. Leathers that resist oxidative ageing are less resistant against hydrolytic ageing and the other way around.

Oxidative + Hydrolytic

After combined ageing there is a fall in shrinkage temperature for all leathers. Highest drop in percentage for *Elzas* and *Pearce*, reversed order from oxidative ageing. Lowest drop in percentage for *Pessers* and *Glaser*, also reversed order from oxidative ageing. Also in this case are leathers that are resistant against oxidative ageing less resistant against oxidative and hydrolytic ageing and the other way around.

6.8. Tensile strength

Oxidative

Largest fall for *Pearce* and *Pessers.*

Hydrolytic

Largest fall for *Elzas* and *Pessers*.

Oxidative + Hydrolytic

Largest fall for *Hewit 1* and *Hewit 2*.

6.9. Tear strength

Oxidative

Largest fall for *Pearce* and *Pessers*.

Hydrolytic

Largest fall for *Elzas* and *Glaser*.

Oxidative + Hydrolytic

Largest fall for *Hewit 1* and *Hewit 2*.

6.10. Water soluble

Oxidative

Rise in percentage is high for *Hewit 2*, *Pessers* and *Elzas*.

Hydrolytic

Rise in percentage is high for *Hewit 2*, *Glaser* and *Elzas*.

Oxidative and Hydrolytic

Rise in percentage is high for: *Hewit 2*, *Glaser* and *Elzas*.

7. Discussion

From the results it is obvious that occurred changes in the measured parameters not all point into the same direction. The question has to be asked which parameters should be measured to get relevant information concerning the degree of degradation and the velocity of the degradation to be expected in the future.

In this case where new leather is compared with artificially aged leather and the same parameters are measured, it seems that most relevant is the measurement from:

- degree of acidity
- soluble sulphate
- shrinkage temperature
- tensile strength
- water soluble material

For the establishment of quality demands for leather for bookbindings it is important to have a scheme of analyses to be used as a means for control. Possible analyses are:

- tanning method
- shrinkage temperature
- degree of acidity
- total and soluble sulphur content

It seems from the results of the measurements that for new leather the measurement of total sulphur is an important factor in the determination of the resistance from the leather against natural oxidative ageing.

8. Conclusions

From the results it may be concluded that:

- *Pearce*, *Hewit 2* and *Glaser* have a relatively good resistance against oxidative ageing
- *Pessers*, *Hewit 1* and *Elzas* have a relatively good resistance against hydrolytic ageing
- *Pessers*, *Glaser* and *Elzas* have a relatively good resistance against oxidative and hydrolytic ageing. In general, as to the fact that combined ageing is most representative for practice, results from this measurements will be most indicative to give an indication concerning the resistance from the tested leathers against natural ageing.

Summary of Results in Ranking Order

	Advantages	Disadvantages
Pessers	degree of acidity soluble sulphate shrinkage temperature water soluble	
Glaser	soluble sulphate tensile strength tear strength	water soluble degree of acidity
Elzas	soluble sulphate tensile strength tear strength	degree of acidity shrinkage temperature
Hewit 1	degree of acidity water soluble	soluble sulphate tensile strength tear strength
Pearce	tensile strength tear strength water soluble	soluble sulphate shrinkage temperature
Hewit 2		tensile strength tear strength water soluble

From this order the greater resistance from vegetable/mineral-tanned leather against ageing is obvious in contrast with pure mineral or pure vegetable-tanned leather. *Pessers* leather, although tanned with a less suitable vegetable tannin, but re-tanned with chromium, is nevertheless most resistant.

This type of leather could be more resistant if a vegetable tannin from the group of hydrolyzable ('pyrogallol') tannins should be used, for instance sumac. Both pure vegetable-tanned leathers *Elzas* and *Glaser* are less resistant, but a positive factor are the relatively good values for the fall in percentages from the physical tests, tensile strength and tear strength. When a starting-point is that only vegetable-tanned leather is suited for restoration of bookbindings *Elzas* or *Glaser* are a good choice. If *Pessers* leather, which is a combined tanning is to be considered as a restoration leather, depends on the practical possibilities of manipulation from the material.

Materials

From each type of leather five complete skins are available in order to perform the tests, especially the physical tests in at least five fold. New bookbinding leathers from manufacturers and importers are indicated with the names of the suppliers as:

Pessers
Glaser
Hewit 1
Hewit 2
Elzas
Pearce

No chemical or physical data are available for the qualification of the materials with the exception that *Hewit 1* en *Pearce* according information from the suppliers are re-tanned with aluminum. The different types of leather are financed and provided by the Royal Library, The Hague, Holland.

References

1. 'Interim rapport STEP leather project, First Progress rapport', March 1992

2. Hallebeek, P.B., H.A.B. van Soest and T. Stambolov, 'Conservation of leather,' *Studies in Conservation 29*, no. 4 (1984), 21-31

3. Willis, J.E., and W.T. Chase, 'A New Energy Dispersive X-ray Fluorescence Object Analyzer for use in Conservation,' Brochure from 'Data Acquisition and Control, Inc'.

4. Calnan, C.N., 'Retannage with Aluminium Alkoxides, a stabilizing treatment for Acid Deteriorated Leather', Paper delivered at the *Second Interim Meeting of the International Council of Museums, Committee for Conservation, Working group on Leathercraft and Related Objects,* Offenbach, May 8-12, 1989

Preliminary Report on the Examination of Leather Bookbindings Belonging to the National Library of Greece

Ekaterini Malea[1], Angeliki Stassinou[2], Vassilis Kilikoglou[3], Ioannis A. Ioannidis[4], David Watkinson[1]

Introduction

In the National Library of Greece, in Athens, there are a large number of important leather book bindings, which are in a bad condition and at the same time are poorly preserved. Among the many reasons that may have caused this result, the atmospheric pollution of Athens is the most important, when combined with the poor house-keeping conditions in the storage areas.

There is no doubt that the first stage of any conservation project should always be a detailed study of the material and its environment with the aim of gaining a full understanding of deterioration processes, in order to facilitate the choice of an appropriate conservation treatment. Furthermore, the necessity of analyses prior to the actual conservation of leather has been often stressed by many scientists, who are involved with this subject (1, 2).
Analytical methods can be used to:
- assess of the extent and mechanism of deterioration at the molecular level,
- evaluate of the effects of previous conservation treatments
- monitor the environmental parameters which could affect the storage and display of the books.
In the present case study, the quantity and importance of the old leather book bindings, as well as their poor state of preservation, warrant greater efforts to develop improved methods of treatment.

Adresses at the time of the investigation:

1. School of History and Archaeology, University of Wales Cardiff, P0 BOX 909, Cardiff CF1 1XU, Wales, U.K.
2. 20 Asclipiou str., 10680 Athens, Gr.
3. Laboratory of Archaeometry, NCSR Demokritos, Aghia Paraskevi, 15310 Attiki, Gr.
4. MEMED Consultants for the Leather Industry, 23 Aristodimou, 10676 Athens, Gr.

The main objectives of this project comprise the examination of the structure of leathers used for old book bindings, and the assessment of their condition in relation to the environment prevailing in the south Mediterranean European region, with emphasis given to the heavily polluted atmosphere of Greece. The first results reported here, give an indication of the adopted research approach, which for the present time is only at the embryonic stage in Greece.

Experimental

Eight samples were taken from books dated between 1535 and 1727*[1].
All the bindings are in an advanced stage of decay, regardless of their actual age.
The condition survey of the selected books for sampling present the following macroscopic signs of decay:
- breaks along the spine
- missing parts
- scratches on the surface
- embrittlement
- cracking
- delamination
- obscure stains (possible fungi; microbiological analysis in progress)
- holes caused by insect activity
- superficial colour darkening (dark brown-red coloration)
- significant tensile strength reduction.

The first stage of the work was the tentative identification of the animal origin of the samples, using a binocular optical microscope (3, 4). The samples were compared to modern domestic, French and English leathers used for bookbinding and conservation.

At a second stage, the samples were examined by means of scanning electron microscopy (SEM), coupled to an X-ray dispersive energy

* The samples were supplied by the National Library to A. Stassinou for the study within the framework of her Diploma Thesis: 'Leather bindings from Archetypes of the 16th-17th century in the National Library of Hellas. Leather Technology and Manufacture, Damage and Conservation', (1995), TEI, Athens

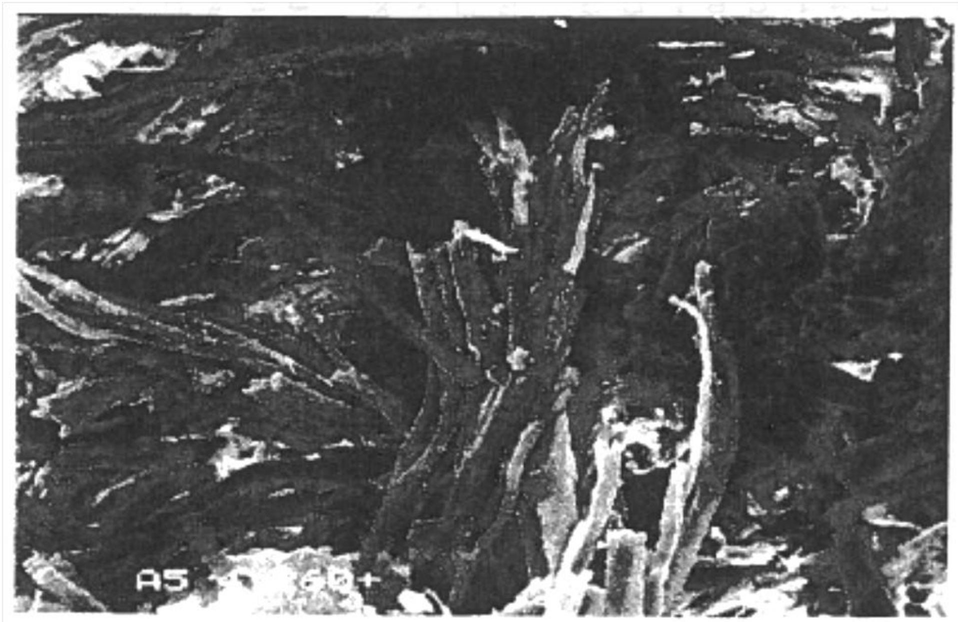


Fig. 1. *Photomicrograph of gold coated leather sample n. 4, under the SEM, magnification 260x.*

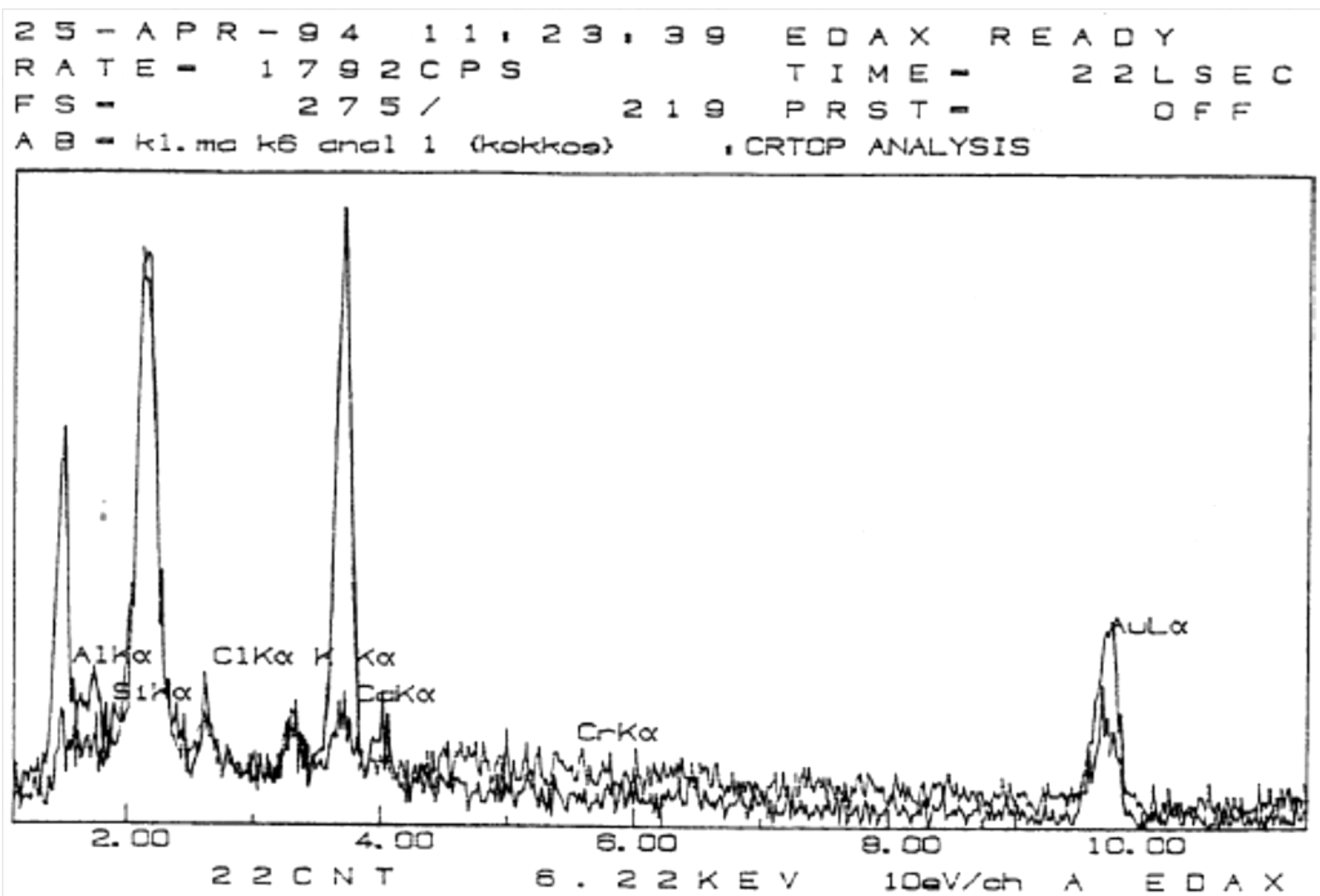


Fig. 2. *Scanning electron microscopic/X-ray microanalytical studies. Energy dispersive diagram of historical leather (gold coated) sample n.2. Low energy beam SEM-EDAX (6.22 KeV).*

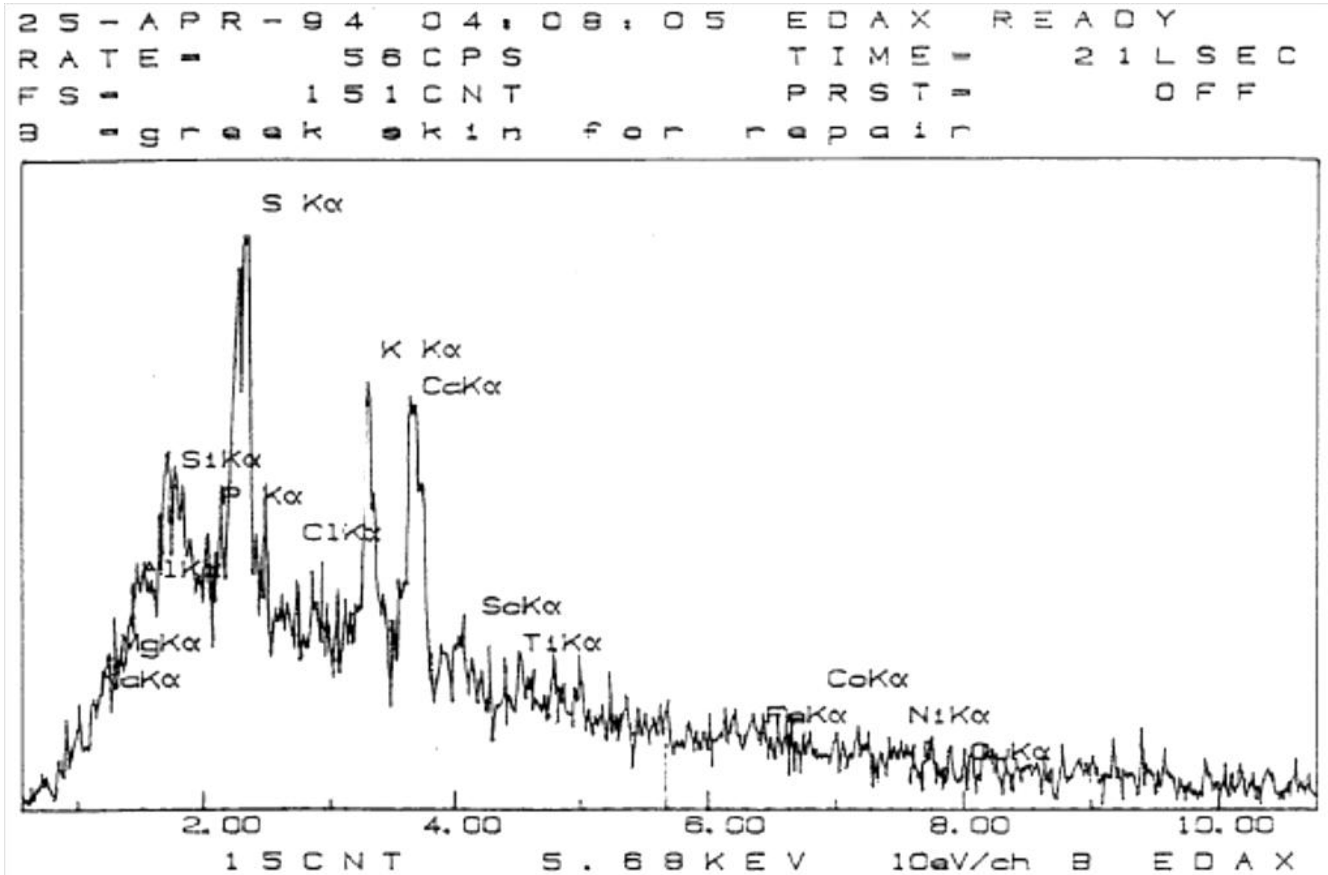


Fig. 3. *Scanning electron microscopic/X-ray microanalytical studies. Energy dispersive diagrams of modern leather (carbon coated) sample n.A2. Low energy beam SEM-EDAX (5.68 KeV).*

analyzer (EDAX) in an attempt to explore the morphology of the sample and the distribution of the inorganic elements such as: sodium, potassium, calcium, chlorine, sulfur, chromium and aluminium (5, 6).
Samples for SEM were prepared as follows:
A small piece of leather, of about 2x2 mm, was cut off from the most damaged area of the binding and attached using conductive carbon on a aluminium stub with its cross section facing upwards. Then stubs were coated with gold to create a conductive surface.

Measurements to determine the hydrothermal stability (shrinkage temperature) by the micro-hot table technique (MHT), were carried out using an optical microscope with a heating stage connected to a precision temperature control system (Zetopan research M/S, Linkam TMS 90/TH 600 Heated Stage). This measurement technique is claimed to be a reliable indicator of the hydrothermal stability of collagen (1, 7, 8. 9), which gives some indication as to the degree of leather deterioration. Each specimen consisted of a group of fibres which had been teased from the sample. These were first washed with deionized water for 24 hours, then placed in a small container made of a microscope cover slip adhered to the bottom of a brass ring, which was then filled with glycerine/water mixture (50/50). This was topped with a coverslip, taking care to exclude all air bubbles, and was then placed on the hot stage of the microscope.

The fibres were observed at x40 magnification whilst the temperature was raised at a rate of 2°C/mm. A glycerine/water mixture was used instead of deionized water to reduce the build up of air bubbles during heating. Deionized water alone produced many air bubbles, such that above 60°C it was impossible to see the fibre, which was constantly moved about as the air bubbles formed. Three temperatures were recorded during heating - the point at which the fibres begin to move, the temperature at which the fibres presented a great mobility and the temperature at which they ceased to move.

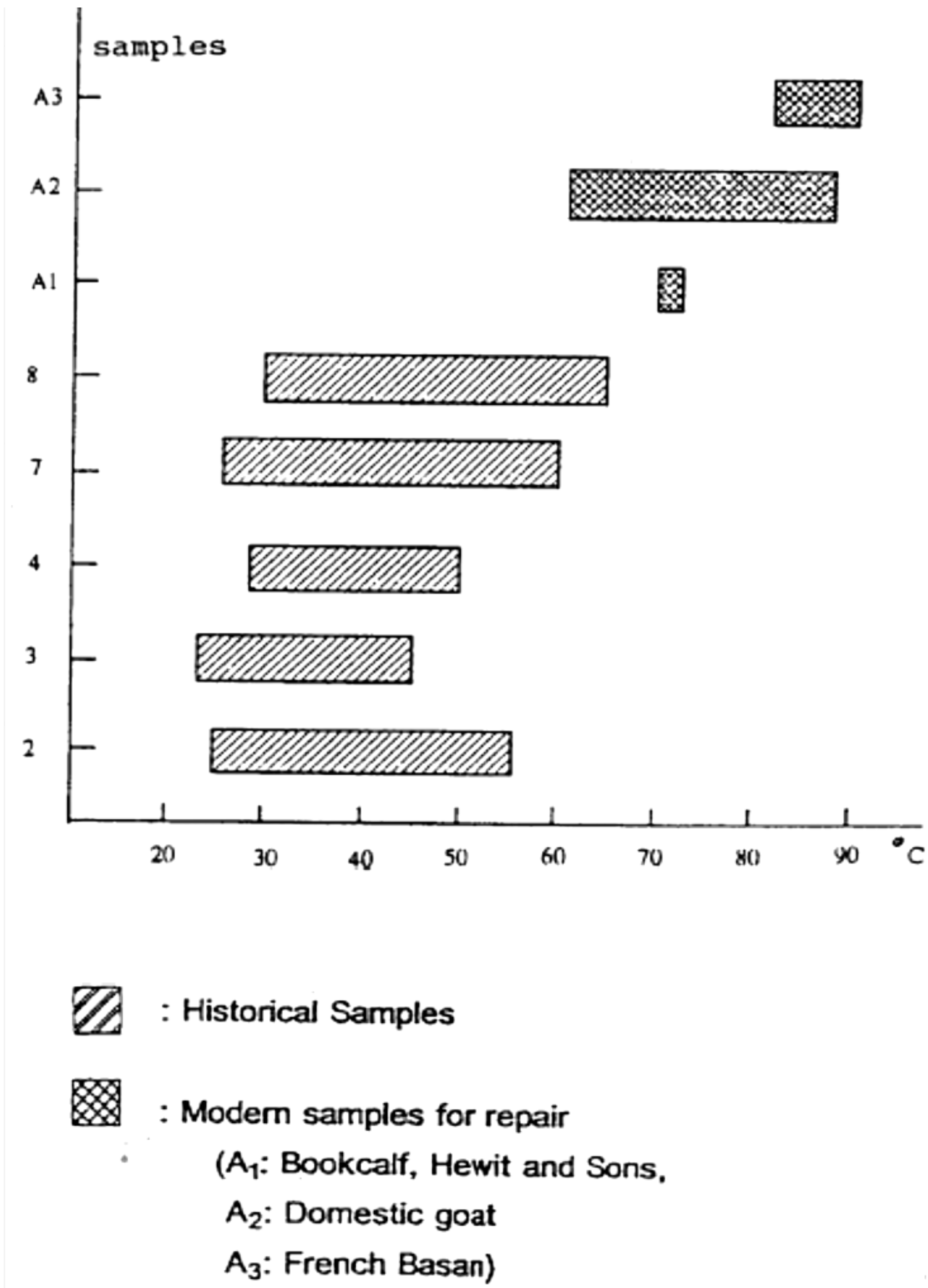


Fig. 4. *Diagram of the temperature measurements using the MHT. Samples n. 2, 3, 4, 7 and 8 correspond to historical leather samples, while A1, A2, A3 correspond to modern leather samples.*

Results

The results reported herein are only indicative of the leather condition. The microscopic examination did not provide any information on the animal origin, since the majority of the samples suffered in most cases superficial damage to such an extent that a grain pattern could not be recognized and characterized with any accuracy. Examination of the historical samples under the SEM (Philips 515), and the photomicrographs showed discontinuity and adhesion between the fibres *(Fig. 1)*, as compared to modern samples. Two historical and two modern samples were examined and their energy dispersive diagrams using a low energy beam are shown in *Fig. 2* and *3*. The SEM-EDAX analysis of the two historical samples using multiple scans, from the grain to the flesh side showed the following results:

- The high peak corresponding to aluminium is assigned on the diagram *(Fig. 2)* and in

combination with the white colour of the binding, lead to the conclusion that we are dealing with alum tawing (potassium-aluminium double salts) leather.
- The fact that the aluminium-concentration is higher at the grain side, is likely to be indicative of the migration of the water-soluble aluminium-tawing species to the surface.
- For both historical samples n2 and n4, high concentrations of sulphur were detected. It may originate from the organic and inorganic compounds used for leather manufacture and/or from sulphur dioxide or other sulphur containing atmospheric pollutants.
- In the modern sample of domestic goat leather used for binding were detected high concentrations of calcium and sulphur.
The calcium concentration is indicative of inappropriate deliming process, sign of poor quality. On the other hand, the observed sulphur concentration is due to the sulphur compounds used for the leather manufacture and not to sulphur containing compounds which originate from sulphurous atmospheric pollutants.

The temperatures recorded using the MHT are shown in *Fig. 4*. Sample codes have been placed on the y-axis, with temperatures on the x-axis. It can be seen that the values for the old samples ranged between 24.6°C to 65°C, systematically lower than the respective temperatures for modem leathers. This may suggest that partial or total detannage of the old samples has taken place. It is worth noting that the temperatures measured for sample 2, which according to the SEM examination was alum tawed, were not as high as expected, but at the same level as the rest. As already mentioned, three modern samples from standard leather used for both binding and repair purposes at the National Library, were also examined, with the following results:

- The English book calf of 'Hewit and Sons', exhibited a narrow temperature range of 70.8-71.3°C. Considering that vegetable-tanned leathers present a shrinkage temperature range between 75°C and 85°C (7), it can be concluded that the above mentioned leather demonstrates an homogeneous tannage but insufficient hydrothermal stabilization reflected by the relatively low temperatures measured (70.8-71.3°C) for vegetable-tanned leather.
- The French 'Basan', exhibited a narrow temperature range of 82°C to 90°C characteristic of combined vegetable-aluminium tannage
- The Greek goat, exhibited a wide temperature range of 62°C to 87°C, sign of non-homogeneous tannage.

It should be noted here that the use of MHT is the cheapest and most practical technique in terms of instrumentation, cost, complexity and sample size (8, 9). It is also relatively simple to carry out. However, an array of problems has been reported, regarding the resolution especially at high temperatures where there is an increased mobility of the whole system (glycerine-water-fibre). Also it is a subjective method, at least for the estimation of the initiation of shrinkage (1, 7, 10).

Further Work

It is intended to carry out further physical and chemical analysis in order to determine the most appropriate conservation treatment. Although this will be influenced by financial factors, access to advanced instrumentation, sample requirement and the state conservation policy, we could suggest the following scheme of analysis (11, 12, 13).

* Examination of the samples under the TEM (Transmission Electron Microscope);

* Physico-chemical Analysis using:
Chromatographic Techniques (GC/MS: Gas Chromatography-Mass Spectrometry; TLC: Thin Layer Chromatography; HPLC: High Performance Liquid Chromatography), Solid State Multinuclear Spectroscopic studies (NMR: Nuclear Magnetic Resonance), Differential Scanning Calorimetry (DSC);

* Chemical Analysis:
- pH measurement
- Fat content
- Elemental Composition of the leather ashes
- Total Nitrogen content
- Soluble Nitrogen content
- Sulphate content
- Total moisture content
- Tannin content
- Trace analysis of metals: Fe, Al, Cu, Mn.

Acknowledgements

The authors wish to thank Peter Fisher (University of Wales, College of Cardiff), for his excellent technical assistance and advice during the application of the MicroHot Table Technique.

Thanks are also due to V.I. Peltikoglou for the supply of samples and good collaboration for the survey currently in progress at the premises of the National Library of Greece, Athens.

References

1. Young, G.S., 'Microscopical Hydrothermal Stability measurements of skin and semi-tanned leather', ICOM Committee for Conservation, 9th Triennial Meeting, Dresden, Working Group for Conservation of Leathercraft and Related Objects, Vol. II, (1990), 626-631

2. Van Soest, H.A.B., T. Stambolov and P.B. Hallebeek, 'Conservation of leather', *Studies in Conservation*, 29, (1984), 21-32

3. Haines, B.M., '*The fibre structure of leather*', Monography, Leather Conservation Centre, (1981)

4. BLMRA, '*Hides, Skins and Leather under the microscope'* British Leather Manufacturers Research Association, Egham, (1957).

5. Cot, J., M. Marsal and C. Aramon., 'A study of the grain layer using a scanning electron microscope (SEM) fitted with an energy dispersive X-ray analyser: Part I. The contribution to quality improvement in defective chrome tanned leathers', *JSLTC*, 73, (1989), 42-46

6. Ioannidis, I.A., '*The mechanism of tanning collagen with aluminium alone and in combination with mimosa; The development of novel tanning processes'*, PhD, 1989, University of London

7. Haines, B.M., 'Shrinkage temperature in collagen fibres', *Leather Conservation News*, Vol. 3 Number 2, 1987

8. Larsen, R., M. Vest, K. Nielsen, 'Determination of hydrothermal stability (Shrinkage temperature) of historical leather by the Micro Hot Table Technique', *JSLTC*, Vol. 77, (1993), 151-156

9. Larsen, R. et al., '*Determination of Hydrothermal Stability'*, STEP-Second Progress Report, (1993), 61-73

10. Ioannidis, I.A., G. Panagiaris, E. Maleka, '*Systematic Investigation of the Nature and Conservation of Archaeological and Historical Organic Materials'*, Progress Report, June 1994, Delft Conference. European Conference on the Conservation of the European Cultural Heritage: Research and Policy issues related to the Conservation of paper and leather

11. Wouters, J., *'Evaluation of small leather Samples Following Successive Analytical Steps'*, ICOM Committee for Conservation. Conservation of Leathercraft and related objects, Interim Symposium, Victoria and Albert Museum, London, (1992), 31-33

12. Convington, A.D., R.A. Hancock, I.A. Ioannidis, 'Mechanistic studies of mineral tanning-Part I: Solid State Aluminium-27 NMR Studies and the Thermodynamics of shrinking', *Journal of the Society of Leather Technologists and Chemists*, Vol. 73, (1989), 1-8

13. Larsen, R., *Evaluation of the correlation between natural and artificial ageing of vegetable-tanned leather and determination of parameters for standardization of an artificial ageing method:* STEP Leather Project (1993), ECHNLR Vol. 7, N 1-4, 19-26

Revised Guidelines for the Conservation of Leather and Parchment Bookbindings

Ko van de Watering
Book restorer
Royal Library
P.O. Box 90 407
NL-2509 LK The Hague

The Central Research Laboratory for Objects of Arts and Science and the Royal Library will shortly publish new guidelines for the conservation of leather and parchment bookbindings.
The new approach to the conservation of leather and parchment bindings differs considerably from the earlier versions which sequentially appeared under the same title in 1983 and 1987, and which gave one basic method for the treatment of all leather-bound books.
The recipe it contained had as its main ingredients lanoline, neatsfoot oil and a buffering agent, imidazole, dissolved in aromatic-free benzine.
As with the previous ones, the new guidelines have been prepared and edited in concert by the Central Research Laboratory and the Conservation Department of the Royal Library.
In this new version a procedure is introduced that enables a restorer or conservator to closely examine each book separately with a view to defining the particular treatment which goes with a binding in need of care.
When a suitable treatment for a binding is chosen in accordance with the criteria as specified in this version (q.v.) the restorer is also in a position to state precisely which part of a particular binding calls for the chosen treatment.
As distinct from the previous versions, this one does not follow anymore the policy of prescribing one method of treatment that is considered applicable to virtually all leather bindings.
This practice of one standard treatment of decaying bindings had in the past, as a matter of fact, been inspired by the wish of a great number of restorers to have at their disposal a method by which they could treat any leather bookbinding without running any risk in doing so. However in the course of time it became increasingly apparent that to act in this way was to act erroneously; the more so because avoidance of risks in this particular field of conservation made the restorer tend to favour the treatment of all bindings indiscriminately and in their entirety, irrespective of the material involved and despite the uncertainty as to whether each one of those bindings really needed any treatment at all.
As a consequence, on quite a few leather bookbindings dressing was applied too vigorously, causing demonstrable problems.
Another distinction from the earlier versions is that in the new guidelines a great deal of attention is given to parchment, the treatment of which had almost entirely been neglected in the past editions, even though it was then, as it is now, undeniable that parchment may need just about as much preservation as does leather.
On account of such considerations as the above stated, we felt compelled to terminate the routing procedure we have been adhering to so far, of treating bookbindings by one and the same method, thereby using just one recipe.
Instead we now introduce a diversified approach.
Accordingly, prior to conservation, the bindings in need of care are categorized, visually, in such a way that the restorer can treat each binding in the manner given in the category in which a particular binding has been classified.
We have therefore, in pursuance of this new objective, added to the set of recipes listed in the earlier versions, several newly formulated recipes for cleaning fluids, degreasing fluids, a separate buffering fluid, emulsions and dressings for leather, a dressing for parchment, and a reinforcing agent for leather bindings in a state of advanced decay.
In order to be able to assess the condition of a particular binding and, based on that assessment, also choose the right treatment for that binding, we indicate for the benefit of the restorer a number of relatively easy tests for the determination of the pH and of the ammonium sulphate contamination - two parameters which show whether a given binding is deteriorating.
Conservation of library and archive assets in the past has supplied us with enough evidence on which we now base the view that the best results when treating leather and parchment are to be attained at 70% Relative Humidity.
At Relative Humidities lower than that the fatty substances do not penetrate leather and parchment well.

Low Relative Humidity also implies a low moisture content of the binding material, and an insufficient moisture content is quite adverse to the binding, in that it is bound to interfere with the binding's textural strength and to speed up the concentration of fat in the very' surface of the binding, where in fact it is least needed.
With the intention to circumvent such drawbacks we have increased the percentage of lanoline in the formulations for dressings and emulsions referred to in the present version; this against the background that lanoline is known to be not only quite hygroscopic but an excellent lubricant as well.
Preparing this new version took about 18 months, and included a test-program on a group of about 20 books.
The resources that were made use of to compose it are in the data which emerged from the applied research that had been carried out by Henk van Soest in cooperation with the staff of the Conservation Department of the Royal Library.
Taken into consideration were also the comments and criticisms that had been aired on this subject by fellow restorers and conservators at one time or another.
Bearing these signals in mind, in editing this new version we have tried to amend the old text accordingly.
However it goes without saying that any criticism of the revised text, when it is available, will be welcomed by us.

Criteria for the Conservation of Leather and Parchment Bookbindings

A few introductory remarks:
* Be mindful of the possibility that not the whole binding but rather parts of it, usually the spine and the hinges, are in need of a treatment.
* Fumigation with ammonia always precedes treatment with a buffering fluid. Allow an one-week interval between fumigation and the next treatment.
* Examine every book thoroughly and determine, on the strength of the criteria described below, which treatment is necessary for which particular book.
* In the guidelines to be published the different categories are given a standard colour. A strip of paper is marked with this colour and then placed in the book.

Treatment code colours

Code White
No traces of mechanical damage or chemical degradation.
Outward signs: none.
Treatment: such bindings do not need any treatment other than the removal of dust and dirt.

Code Yellow
Visible damage due to either too much dressing in the past or deficient fat content. No apparent chemical degradation.
Outward signs with regard to leather: fine fissures, loosening of the grain, broken hinges, and, in the case of too much dressing, a tacky feel and darkening of the leather.
With regard to parchment: splitting of the texture, broken hinges, fissures along the spine.
Treatment:
- Removal of dust and dirt.
- Excessive dressing removed with a degreasing fluid.
- Conditioning at 70% Relative Humidity.
This must always precede any intended treatment.
- Application of an emulsion (in the case of leather) or a dressing (in the case of parchment).

Code Blue
Visible chemical degradation and mechanical wear.
Outward signs with regard to leather: (local) discolouration tending towards dark brown-black; presumably the side-effect of marbling or damage by water (if in doubt use a magnifying glass). Leather attacked by sulphuric acid looks as if burned. There is also a distinct pulverization of the grain.
With regard to parchment: gray discoloration, especially along the spine, splitting of the texture along the spine, broken hinges.
Treatment:
- Removal of dust and dirt.
- Fumigation with ammonia.
- Treatment with a buffering fluid.
- Conditioning at 70%RH.
- Treatment with a dressing, or in the case of parchment, a dressing for parchment.

N.B. With speckled or iron-stained bindings, avoid the use of an emulsion, because of its water content!

Code Red
Visible, extensive, chemically induced, degradation, and as a consequence - an advanced decomposition of the texture.
The Code Red holds only for leather, as in practice this stage of decay is beyond parchment.
Outward signs: pulverization and red rot.
Treatment:
- Removal of dust and dirt.
- Fumigation with ammonia.
- Treatment with a buffering fluid.
- Conditioning at 70%RH.
- Treatment with a dressing containing 8% lanolin and 2% neat's foot oil.
- Impregnation with the reinforcing agent H 51 at 55%RH.

The Recipes

The new set of guidelines will contain various recipes corresponding with the diversified approach:
* A cleaning agent for fixed surface dirt, and a degreasing fluid for leather or parchment (wrongly) treated in the past.
* Different dressings for leather and parchment, and emulsions for leather, the latter containing both distilled water and a solvent (aromatic-free benzine).
* A buffering agent, to be applied separately (a solution of imidazole in isopropyl alcohol and aromatic-free benzine).
* An impregnating agent (H 51) as a last resort for severely decayed leather. This will homogenize the fiber material, but may darken some leathers.
* The formula for calculating the amount of dressing or emulsion needed which was included in the previous version of the directives has been deleted, since we feel that it should always be applied sparingly, once or twice.
* For a complete listing of the ingredients and concentrations please refer to the upcoming publication of these new guidelines.

Epilogue

In the past questions have been raised as to the effectiveness of 'leather dressing' as such, even its adverse effects.
We have come to the conclusion that conservation of leather and parchment bookbindings should never be a routine operation, just because these fancy old bindings are there.
There may be a conservation problem with old leather and parchment bindings, or not. That is something to be established by a professional restorer or conservator.
Leather and parchment will discolour with the passing of time and will lose some of their flexibility, that's only natural and as such no reason for a large-scale treatment.
It is only when it is obvious that the material is breaking down or that the flexibility is no longer there where it is needed, for example on the spine or the hinges of books, that it may be necessary to act, and then sensibly.

Stabilization of a Large Rawhide Shadow Puppet. Ethics, Materials, Micro Environment

Diana H. Dicus
Objects Contract Conservator
305 N. 17th Street Suite 315
Boise,
USA-Idaho 83702

1. Introduction

A large rawhide shadow puppet, approximately one square meter, was treated in the Ethnology Laboratory at the Canadian Conservation Institute.
This paper includes cultural background of the puppet, condition, treatment materials and techniques, and storage micro environment.

1.1 Culture

The Cambodian giant shadow puppet belongs to the Anthropology study collection, at the University of Montreal. It is important to note its historical significance. Most of the large shadow puppets of Cambodia were made between 1860 and the early 1900's. Because of the contemporary political upheaval and consequent disruption of traditional culture in Cambodia, the giant shadow puppet theatre tradition is seldom or never practiced today.
It is unlikely that many of the giant puppets have survived, other than in museum collections outside of Cambodia [1, 2].

The puppeteers were skilled dancers and manipulators, telling traditional tales. The large shadow puppets did not have articulated limbs, as do the smaller Indonesian and Southeast Asian puppets. The sense of movement was provided by the talented puppeteer's motion, with the traditional instrumental background music [3, 4, 5].

1.2 Fabrication

The shadow puppet is made of a large piece of rawhide, supported and manipulated by two vertical bamboo sticks. There is one main piece of rawhide with two smaller side pieces, sewn on with thin strips of skin. Each handling stick is split in half longitudinally. The rawhide is sandwiched by the sticks, and held firmly by nails which go through the hide and bend back on the sticks. It is questionable if these sticks are original. Handling sticks were commonly slender, unsplit bamboo sticks, attached to the puppet with sewing techniques [6].
Traditional preparation of rawhide is to soak the hide in salt water or water mixed with calcium carbonate. The hide is then stretched to dry, and dehaired by scrapping. For the giant puppet, the hide was usually ox hide, cowhide, or male water buffalo hide [7, 8, 9].
The decorative pattern is drawn on the prepared hide, and cut using specially adapted knives and tools known as cutting heads. The design detail is created by holes of different sizes, which create traditional patterns. Charcoal black was applied to give additional design definition.
A finish of animal glue was sometimes applied, but that is not the case for this puppet [10, 11].
In reflected light, it is difficult to interpret the design and pattern in a shadow puppet. With transmitted light, the pattern is dramatic. *Fig. 1* shows the puppet in silhouette, before stabilization. Areas of loss and separation can be seen.

1.3 Condition

The rawhide is typically stiff and somewhat brittle. When the puppet came to the lab, there was accumulated surface dirt and much surface distortion, cockling, folds and tears in the hide; some parts of the puppet were entirely missing. Unstable relative humidity, wetting and uncontrolled drying, excessive light, or some combination of these factors, have caused deterioration of the rawhide. There is no evidence of gelatinization or microbial decay, but there is some delamination of the hide.
The bamboo handling sticks are in good condition. The nails are structurally sound but evidence some surface corrosion.
Both sides of the puppet display mottled colour. There are patches of a light brown accretion on the hide, which appear to have been spattered or dripped. Analysis identified the presence of cellulose, lignin, silicon dioxide (quartz) in these accretions [12]. There are small areas of blue and green colour on the recto and small patches of red and white on the verso. The blue resembles crayon, the white and red appear to be paint spots, and the green is similar to an inorganic stain.

Fig. 1. *Giant shadow puppet silhouette before stabilization treatment. Puppet dimensions: 102 cm x 90 cm x 2 mm.*

2. Ethics

Commitment to the ethnographic conservation ethic guided the treatment decisions. The goal was to stabilize the puppet, to retain evidence of the puppet's history an to improve the puppet's environment. It was hoped to achieve a maximum amount of stabilization with a minimum amount of intervention.

2.1 Stability

To stabilize the artifact, the surface was cleaned mechanically to remove hygroscopic and abrasive dirt. Humidification was planned, to relax and flatten the rawhide surface; tear repair was undertaken, to give physical stability and visual continuity to the puppet.

2.2 History

The surface accretions appeared stable, and it was decided not to remove them. They may be helpful in future provenance and dating work. It was also decided to leave the handling sticks in place. They represent a portion of the puppet's history, although there is some question as to their original placement and attachment technique.

To achieve visual continuity, it was decided the repair areas would be colour toned to blend with the surrounding rawhide surface. No new pattern perforations would be made, and existing pattern would be as little altered as possible.

All work was to blend with the overall appearance of the puppet, but be easily identified. It is important to note that the repairs blend with the surface of the puppet under reflected light, but are not translucent with transmitted light.

2.3 Environment

Collection conditions at the university include reduced staffing, open storage shelving, unpredictable environmental circumstance, informal access to the collection, and limited study or work surface. These circumstance cannot be altered. It was decided to create a micro environment which would give a more stable micro climate and facilitate accessing or moving the puppet.

3. Materials

3.1 Considerations

In the cultural context, puppets of this type are often repaired with prepared skin and protein glue or sewing techniques. In conservation, repair treatment has'often been done with parchment and animal glue [13]. In both cases, a butt join or a sculptured bridge (a technique known as scarfed) join have been commonly used.

For this treatment, it was decided to use a flat backing bridge repair, with no fills. A long fibre Japanese tissue, Aiko 109-S Kozo (S), and an acrylic emulsion adhesive, Lascaux 498HV, were chosen for the repairs. These materials and the flat bridging technique proved adaptable to the puppet's surface problems. These problems included: a large number and a great variation of tears and separations, a one to three millimeter variation in hide thickness, the absence of a flat rawhide surface, the smooth texture of the hide, and the limited surface contact for a repair.

A parchment butt or scarfed repair did not seem as adaptable to these surface problems as a paper repair could be. Parchment would have had to be prepared by humidification, as well as the rawhide substrate. Upon drying, the repair would have been under great tension.

The puppet is no longer in its traditional culture, and will not be seen or used in traditional performance with transmitted light. When used as a study piece under reflected light, the puppet form and surface are easily understood with the opaque repair materials chosen. The distinction between conservation materials and original materials is clear.

3.2 Bridge

Application of a flat paper bridge over the void, on the verso, proved to be an effective technique to stabilize the edges of the tears and separations. The long fibre paper added little additional bulk or thickness to the substrate.

The Japanese Kozo paper bridges were torn to size, giving many long fibres, which could be in contact with the hide surface. When a repair was in place, all the fibres in contact with the hide were burnished.

Humidification tests indicated that the paper repair would respond differently to changes in relative humidity than a parchment repair or the rawhide substrate. The differential response of the Japanese paper and the parchment suggests the paper bridge repair can absorb some of the stress caused by changes in the environment, relieving some of the strain on the puppet rawhide and the join itself.

The mechanical flexibility of the paper repair also creates less stress on the torn or separated hide edges when the puppet is moved.

3.3 Adhesive

The acrylic emulsion adhesive, Lascaux 498HV, was chosen for its ease of application and its ageing characteristics. Its water solubility in application enhanced the adhesive penetration of the paper fibres and the hide surface. The adhesive dries as a clear, non-tacky flexible film, with an acceptable pH range [14, 15].

After drying, the Lascaux 498HV is insoluble in water. This means the adhesive can function as a barrier coat in the colour toning of the repairs, and that dry pigments in a water binder can be used without diminishing the adhesion of the repair. The Lascaux 498HV dry film is soluble in acetone, allowing removal or adjustment of a repair with no further wetting of the rawhide, or disturbance of the water soluble toning.

4. Stabilization

4.1 Cleaning
In the actual treatment, simple tools were used. The rawhide recto and verso surfaces were cleaned using brushes, a controlled suction vacuum cleaner, and polyvinyl chloride erasers [16, 17].

4.2 Humidification
It was hoped to then flatten the rawhide to improve its appearance and to facilitate the repair work.
Shrinkage temperatures [18] of 49.5-60°C and surface pH readings of 4.0-5.5 pH [using paper indicator sticks and distilled water] suggested humidification could be safely undertaken.
A vapour moisture membrane system was chosen, using the Gore-Tex membrane and a 50:50 distilled water:95% ethanol mixture [19].

A support of Ethafoam and polyethylene sheeting was made to hold the puppet during the humidification and repair.
The hide relaxed when humidified, but returned to its previous conformation when dry. Weighting did not help. Movement of the hide was severely limited by the nailed handling sticks. Although there was some shifting of planar distortion, there was no way the relaxed rawhide could move enough to lie flat. Removal of the sticks was reconsidered. The nails were slightly corroded and did not respond to moderate force. The sticks were not removed.

4.3 Repair
Tears and separations were locally humidified, with the vapour membrane system, and flat bridge repairs were applied while the hide was moist and relaxed. The Kozo paper was pasted out on one side, with the Lascaux 498HV, and applied to the repair area on the rawhide verso. The paper bridge repair was burnished, covered with silicone release paper, weighted with an acrylic separator and a lead weight, and covered with polyethylene sheeting for slow, controlled drying.

When dry, any perforation pattern obscured by the repair was opened with a number 11 scalpel and a sacking needle. A light coating of Lascaux 498HV was brushed on the recto of the paper repair as a barrier coat, and both sides of the repair were toned. A small amount of a distilled water: 95% ethanol 90:10 mixture was brushed on the repair to wet it before toning.
Dry natural mineral pigments in an aqueous binder were used, with a small amount of Aquapasto (gum arabic and silica gel) to prevent pigment cracking. The repairs were toned to blend, in reflected light, with the hide surrounding the repair site.

5. Micro Environment

A micro environment was created as the final treatment phase. It consists of a passive buffered box, a rigid mount board, and a soft support.

5.1 Box
The box is 1.3 meters long by 1 meter wide by 2 meter deep. The box and lid are constructed with an external wood skeleton of 1” x 1” pine, stapled, glued, and sealed. Exterior walls of Coroplast and interior walls of double wall pH neutral grayboard are attached to the wood skeleton with wood screws from the inside of the box. The box interior, including the underside of the lid, is completely lined with the grayboard, eliminating from the interior the static electric characteristic associated with Coroplast. No glue is used in the interior box construction. All interior components are hand sewn or attached with screws.
The external wood skeleton provides structural integrity for the storage box. The double wall construction gives short term protection against extreme temperature change. The double walls and the hygroscopic interior materials provide relative humidity buffering capability.
The double wall construction and baffled interior corners slow the permeation of vapour phase pollutants [20]. The closed box gives important protection from dust and particulate matter, moisture, smoke, and soot.

There is less than a half millimeter gap at the lid and box interface, when the lid is closed.

5.2 Mount

A rigid mount board was needed because of the weight and size of the puppet. It had to be suitable for study and transit of the puppet within the collection area. The mount is made of two pieces of Hi-Core, positioned with the fluting at right angles to increase the board rigidity. The two pieces are held with a matrix of plastic rivets, and covered with Micro Foam, Insulite, and washed and dried off-white cotton twill fabric. The mount board fits securely in the box. Linen tabs facilitate lifting the board from the box.

5.3 Support

A soft, contoured support was hand-sewn to the mount board. Approximately 80% of the surface of the puppet rests on the support. The irregularity of the planar surface of the puppet prohibits 100% contact. The support is constructed of Polyfil needlebonded polyester batting, covered with washed and dried cotton muslin. Extra support is given to the handling sticks, using rigid ethafoam covered with muslin. See *Fig. 2* for installation of the stabilized puppet on its support and mount, in the storage box, without the lid. The inverted box lid can also serve as a study or work surface, or as an aid in transporting the puppet.

5.4 Micro Environment Maintenance

There is 10% of free air space in the box. More than 90% of the interior is filled with the mass of the puppet, and the interior box fittings. These fittings include all cotton covered supports and a one centimeter thick cotton covered quilt. More than 50% of the mass in the box is of organic material, contributing to the buffering capability of the system.

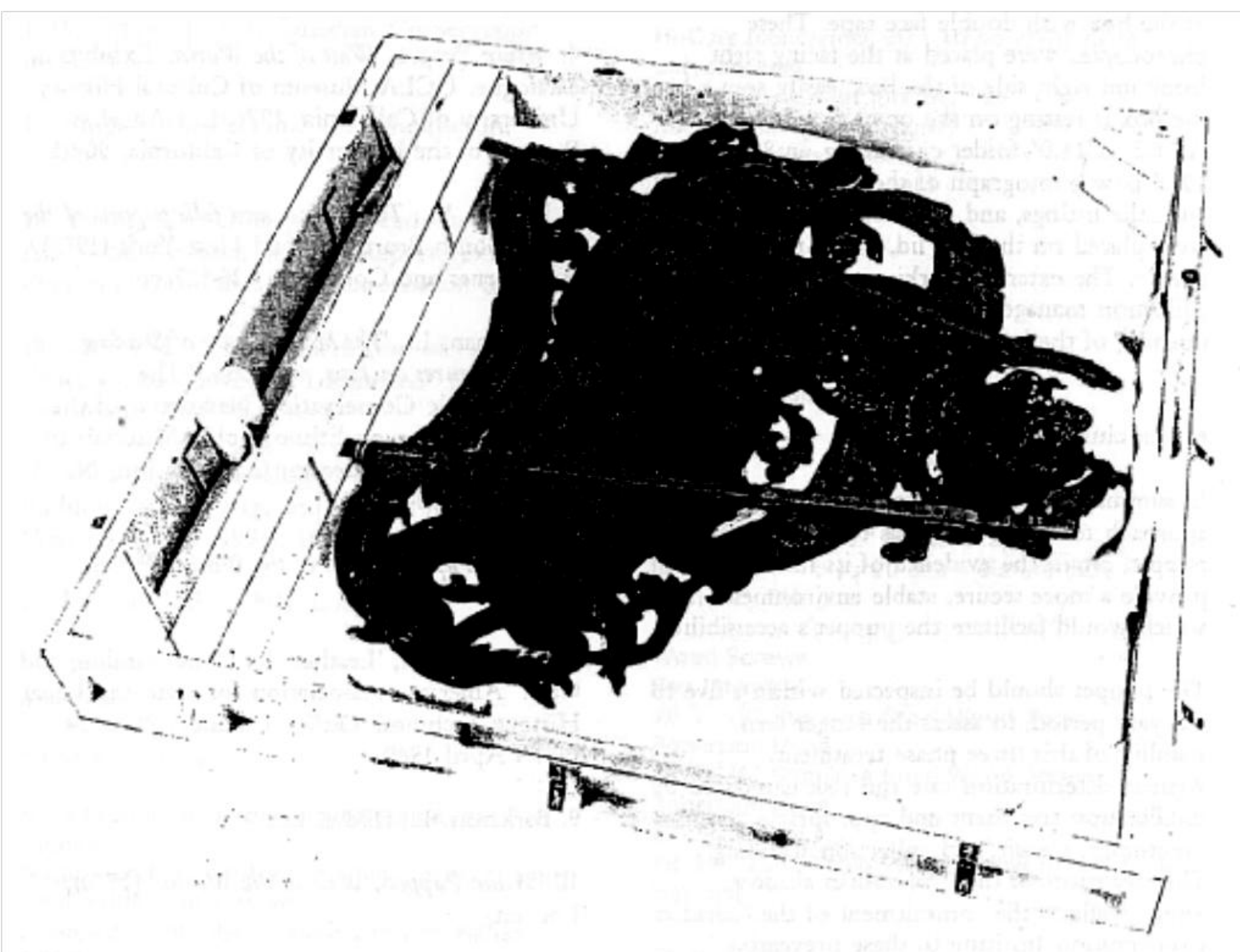


Fig. 2. *Shadow puppet, after stabilization treatment. Puppet p/aced on mount board and support, in Coroplast and pH neutral grayboard double walled box.*

Given the area of the box interior and the mass of the contents, it is estimated that the air exchange in the box is less than four per day. The lifetime of a conditioned humidity in this enclosure would be about 400 days, if the box were not opened {21].

The box design is intended to give passive environment control, limiting the amount of maintenance necessary to hold an appropriate environment. The box is, however, designed to safely accommodate conditioned silica gel or a scavenger if conditions should make this necessary.

As a passive system, the box can be reconditioned on a regular schedule, by placing it open in a controlled climate area with the required temperature and relative humidity.

5.5 Collection Management

Two 4” x 4” photocopies of the puppet silhouette and its accession number were encapsulated in mylar and placed on the outside of the box with double face tape. These photocopies were placed at the facing right front and right side of the box, easily seen when the box is resting on the open storage shelving. An 8.5” x 11.0” folder containing an 8.0” x 10.0” b/w photograph of the puppet in the box with the fittings, and the packing instructions, were placed on the box lid, lower right hand corner. The exterior markings facilitate collection management and restrict unnecessary opening of the box.

6. Conclusion

In summary, the ethnographic conservation approach to this artifact was to stabilize the puppet, retain the evidence of its history, and provide a more secure, stable environment which would facilitate the puppet’s accessibility.

The puppet should be inspected within a five to ten year period, to assess the longer term stability of this three phase treatment.

Artifact deterioration rate and risk is reduced by stabilization treatment and appropriate housing for storage, transit, and collection handling.

The treatment of the Cambodian shadow puppet reflects the commitment of the Canadian Conservation Institute to these preventive conservation principles.

Acknowledgement

The work discussed here was done during my 1993-1995 Ethnographic Conservation Fellowship at the Canadian Conservation Institute (CC1). I want to thank the CCI staff for their assistance and encouragement in carrying out the conservation work described in this paper.

References

1. Tilakasiri, J., *The puppet theatre of Asia.* Published by the Department of Government Printing, Ceylon. (1986), 44-45, 101-104

2. Kerdchouay, E., and M. Smithies, ‘Giant Shadow Play of Thailand.’ *Orientations* (August 1973), 47-50

3. Tilakasiri, J., (1986), Loc. cit.

4. *‘Asian Puppets, Wall of the World.’* Exhibition catalogue. UCLA Museum of Cultural History. University of California, 1976. Los Angeles: Regents of the University of California, 90-91

5. Malkin, M., *Traditional and folk puppets of the world.* South Brunswick and New York (1977), A.S. Barnes and Company, 126-127

6. Barkman, L., *‘The Manufacture of Shadow Theatre Figures on Java, Indonesia.’* The Ethnographic Conservation Newsletter of the Working Group on Ethnographic Materials of the ICOM Committee for Conservation, No. 5 April 1989, 30-32

7. *‘Asian Puppets, Wall of the World.’* (1976), Loc. cit.

8. Guldbeck, P., ‘Leather: Its Understanding and Care.’ American Association for State and Local History Technical Leaflet 1, *History News* **24** No. 4 April 1969

9. Barkman, L., (1989), Loc. cit.

10. *‘Asian Puppets, Wall of the World.’* (1976), Loc. cit.

11. Helwig, K., *Analysis of Surface Coatings.* Analytical Research Services Report 3292. Ottawa (1993), Canadian Conservation Institute

12. Helwig, K., *Analysis of Surface Accretions*. Analytical Research Services Report 3291. Ottawa (1993), Canadian Conservation Institute

13. Barkman, L., (1989), Loc. cit.

14. Down, J., M. MacDonald, J. Tetreault and S. Williams. *Adhesive Testing at the Canadian Conservation Institute - An Evaluation of Selected Poly(vinyl acetate) and Acylic Adhesives*. Environment and Deterioration Report No. 1603. Conservation Research Services, Ottawa (1992), Canadian Conservation Institute

15. Down, J. Personal Communication, (1995)

16. Moffatt, E., *Erasers and Related Dry Cleaning Materials.* Analytical Research Services Report 1738. Ottawa (1981), Canadian Conservation Institute

17. Burgess, H., Personal Communication, (1990)

18. Young, G., *Shrinkage Temperature*. Analytical Research Services Report 3291. Ottawa (1994), Canadian Conservation Institute

19. Singer, H., 'The Conservation of Parchment Objects using Gore-Tex Laminates.' *The Paper Conservator* **16** (1992), 40-45

20. Michalski, S., 'Leakage Prediction for Buildings, Cases, Bags and Bottles. *Studies in Conservation* **39** (1994), 168-186

21. Michalski, S., (1994), Loc. cit.

Materials

Surface cleaning:

Mars Plastic Block (polyvinyl chloride, no sulphur)
Magic Rub Pencil (polyvinyl chloride, no sulphur)
small sable bristle brush
screened, controlled suction vacuum, Nilfisk GS9O

Humidification:

Ethafoam (expanded cell polyethylene)
Polyethylene sheeting [polymethylene]
Blotter (cotton rag)
GoreTex membrane (expanded Polytetrafluoro-ethylene [PTFE] laminated to polyester felt)
Reemay (non woven polyester textile)

Repairs:

Kozo (S) Aiko 109-S Lignin free, pH 5.15 (Japanese tissue)
Lascaux 498HV (Acrylic emulsion adhesive)

Toning:

Natural mineral dry pigments
Distilled water
Winsor and Newton Aquapasto (translucent gel of gum arabic and silica)

Mount Board:

Hi-Core (copolymer 90 : 10 polypropylene : polyethylene)
Adjust-A-Lok rivet (plastic)
Micro Foam (polyethylene)
Insulite (polyester felt)
Linen cloth tape (woven)
Cotton twill fabric

Puppet Support:

Polyfil (polyester batting)
Cotton Muslin
Cotton Thread

Storage Box:

Outer Skeleton 1" x 1" Pine
Stainless Steel 1/2" Monel Staples
Isothane ME Polyurethane moisture cure
High tack fish glue

Wood Screws
Box anterior
#8 1 1/2" Stainless Steel Wood Screw Robertson Head
#8 1 1/4" Stainless Steel Wood Screw Robertson Head
Box Exterior
#8 3/4" Zinc Plated Wood Screw Round Head, Flat Slot

Exterior Walls
Coroplast Copolymer 90:10 Polypropylene: Polyethylene

Interior Walls
pH Neutral Grayboard,
Double Wall corrugated paper board

Closure Hardware
Simmons #3

Interior Fittings forms, braces, and supports rnade of:
Ethafoam
Insulite
Cotton Twill
Cotton Muslin
Polyfil

The Effect of the Thermo-Lignum Pest Eradication Treatment on Leather and Other Skin Products

R.S. Thomson B.Sc., C.Chem., F.R.S.C., F.S.L.T.C.
Chief Executive
The Leather Conservation Centre
34 Guildhall Road
GB-Northampton, NN1 1LW

Although species belonging to a number of orders of insects have been reported as having attacked leather (1), properly tanned skin appears to be relatively unpalatable to most insect pests. Damage does, however, occur frequently to composite objects made partly of leather such as books, furniture or leather covered boxes. Here, the insect burrows through or along the under surface of the leather as it seeks a more nourishing substrate. Untanned or partly tanned skin, on the other hand, such as may be found in ethnographic or musical instrument collections is liable to direct insect attack. This is particularly so if the hair or wool is still attached to the skin.

In the past skins and leather were rendered proof to insect attack by treating them with arsenic compounds. Many objects in museum collections contain significant levels of these. They killed most insects but they didn't do the museum curators much good either! Later, fumigants such as methyl bromide, phosphine, ethylene oxide or hydrogen cyanide were employed very effectively. Alternatively the, then, new insecticides like DDT, dieldrin and gammexane were thought to be the complete solution to the problem of insect infestation. We now know differently.

Today a wide range of insecticides is available which it is claimed are less toxic to human beings but, with the bad experiences of the recent past, many non-specialists are wary about using any poisons whatsoever. Investigations have, therefore, been made into non-poisonous methods for eradicating insects. Heating, cooling, freezing and the use of radiation or anoxic atmospheres have all been looked into, but each system seems to have its own set of disadvantages. The up to date situation has been reviewed recently in the latest edition *of Insect Pests in Museums* by Pinniger (2).

Last summer, conservators, museum staff and furniture restorers in Britain were approached by Thermo-Lignum (UK) Ltd. introducing their new pest eradication process (3, 4). This had been developed three years earlier by the conservator-restorer Herr Werner von Rotberg in Heidelberg. It was initially designed to eradicate wood boring beetles in furniture.
It relies on the fact, known for many years, that the majority of insects in all of the various stages of their life cycle, egg, larva, pupa, nymph and adult are killed if they are held at temperatures above 50°C for an extended period of time. Herr Werner von Rotberg's secret was that by controlling the moisture content of the atmosphere accurately, he prevented the wood from dehumidifying as the temperature increased. In this way the resultant splitting, twisting and warping of the object being treated was prevented. As well as a range of woods, the method has been tested successfully on animal glue, various wood finishes, paintings and a number of textiles (5).

The relationship between the relative humidity and temperature of the atmosphere on the one hand, and the moisture content of wood on the other, is not linear. The actual inter-relationship is shown on the Keylwerth diagram with lines of constant woodmoisture content in a plot of temperature versus relative air humidity (6).
In order to keep the moisture content of the wood constant, the isotherm must be followed closely. The Thermo-Lignum process does this by using a system which constantly monitors both the atmosphere and the core temperature of the object. The data obtained is fed into a computerized system which continually modifies the conditions as required.

At a presentation of the process made at the Thermo-Lignum (UK) Ltd. workshop in London, fears were expressed regarding the effect of the combination of heat and humidity employed on old, partially deteriorated leathers and on untanned materials. A literature survey suggested that even if the shrinkage temperature was not exceeded, damage could occur.
Balfe and Humphreys (7) for instance showed in the 1940s that vegetable-tanned leathers heated to between 50 and 60°C at high relative

humidities showed signs of damage after 'some hours' and was severely damaged after only six hours at 70°C. Seligsburger and Mann (8) showed that leathers could lose over 50% of their strength after ten months storage at 35°C and 100%RH. Bowes (9) also showed that leathers lost up to 70% of their strength after storing them at 4°C and 100%RH for six months. In a follow up trial (10) she showed that all leathers were seriously damaged after two weeks at 60°C and 100%RH. As expected, at 40°C the rate of deterioration was less rapid. Nevertheless, even at this temperature significant damage was apparent after 12 weeks. More recently Calnan (11) showed that storage of a variety of vegetable-tanned leathers at 40°C and 80%RH for two years resulted in significant damage, manifesting itself in a migration of loose materials to the surface causing darkening, loss in flexibility and an increase in crackiness. There were also chemical changes to the collagen, the vegetable tannins and the fatty materials in the leather and a resultant drop in shrinkage temperature.

All these previous trials, however, took place at a higher temperature or relative humidity or over a much longer period than is met in the Thermo-Lignum procedure. The operation involving leather met in practice and having conditions nearest to the Thermo-Lignum process is the heat setting of shoes. In the manufacture of a shoe it is necessary to take a flat piece of leather and mould it into a complex three dimensional shape. Certain areas of the leather have to stretch and others contract if the desired smooth profile is to be achieved. In the past leather was damped, pulled over the last and allowed to dry out and mould to its new shape over a period of up to a week.
This needed time, led to the requirement for a large number of expensive lasts and took up valuable space. In the 1960s a rapid lasting method, using a combination of heat and moisture was developed. It was found that, while chrome tanned leathers gave no problems, some vegetable-tanned materials stiffened and became cracky (12).

In view of the potentially damaging effects of the Thermo-Lignum process, it was decided to undertake a short, initial research programme. In this, a number of representative leathers and other skin products would be subjected to the process and the effects on some of their chemical and physical properties examined.
It was also agreed that a similar series of collagen based materials would be put through an experimental, modified process which is being developed. In this, the objects are heated to lower temperatures but in inert atmospheres, again with a controlled relative humidity. Normally an atmosphere of nitrogen containing 2.5-5% carbon dioxide is used, but other inert gases and mixtures are being investigated.
The details are as follows.

Raw Materials

New Materials

1. Mimosa tanned calfskin, prepared as described in the STEP Leather Project (13) and representing leathers made employing condensed tannins.

2. Sumac tanned calfskin, again prepared as described in the STEP Leather Project reports and representing materials made using hydrolyzable tannins.

3. Oak bark tanned cattle hide leather made by J. Croggon & Son Ltd., Manor Tannery, Grampound, Truro, Cornwall. Oak bark was the only tannin permitted by law to be used for heavy leather up to the beginning of the nineteenth century (14).

4. Calfskin parchment made by William Cowley, 97 Caldecote Street, Newport Pagnell, Bucks.

5. Alum tawed calfskin made, using traditional recipes, by William Cowley.

6. Alum tawed calfskin manufactured by J. Hewit & Sons Ltd., Kinauld Leather Works, Currie, Edinburgh.

7. Brain and smoke tanned deerskin prepared experimentally using methods employed by native North Americans (15). This material is representative of many leathers held in ethnographic collections.

8. Acetone dehydrated delimed pelt prepared as described in the STEP Leather Project reports and representing rawhide and other untanned materials.

Old Materials

9. Chrome tanned bovine side upper leather probably tanned in the 1950s by W.E.& J. Peabody Ltd., Cowper Tannery, Olney, Bucks.

10. A mid nineteenth century Russian leather seat cover.

11. Parchment from an early nineteenth century book binding.

12. Vegetable-tanned calfskin from a mid nineteenth century book binding.

13. Vegetable-tanned hide from an early nineteenth century leather bucket.

Procedure

Two pieces approximately 30 cm x 20 cm were taken from the central portion of each of the skins and appropriate samples cut out for physical and chemical tests before treatment. The pieces were sent to Thermo-Lignum UK to be put through one or other of the two pest eradication treatments.
In the first treatment the pieces were placed in the chamber and heated gradually from an ambient temperature of 20°C up to 52°C over a period of 11 hours. They were held at this temperature for two hours and allowed to cool back to 20°C over a further 10 hours. During the treatment the relative humidity was increased following the appropriate isotherm on the Keylwerth diagram from 50% to 60% and then back to 50%.
In the second treatment the pieces were placed in a chamber which was flooded with argon to give an atmosphere of less than 1% oxygen. The samples were then heated to 38°C over a period of eight hours, held at that temperature for three days and then allowed to cool over a further eight hours. During this treatment the relative humidity was increased from 50% to 55% as the temperature increased and then dropped back to 50%.

The treated pieces were returned to the Leather Conservation Centre where further samples were cut out for chemical and physical tests.

Results

Appearance

There was no visible change in colour, surface texture or overall appearance caused by either of the two processes to any of the samples.

Shrinkage

The samples were conditioned for 48 hours to 20°C and 65%RH and marks were made 10 cm apart, both parallel and perpendicular to the backbone, before the leathers were treated. The distances between these marks were measured again after treatment and further conditioning. No shrinkage was observed.

pH

The pH values of the treated and untreated leathers were measured in duplicate according to BS 1309:9 and the average results are shown in *Table 1.*

The results obtained indicate that neither of the treatments had a significant effect. The pH values obtained for both of the parchments and for the leather from the bucket were very variable and the apparent differences in the average figures are not statistically significant.

Shrinkage Temperature

The shrinkage temperature was measured in duplicate according to BS 3 114:17 and the average results shown in *Table 2*. In order to observe small differences in shrinkage temperature, samples of treated and untreated leathers were measured at the same time, side by side, using a single water bath.
The results indicate that neither of the treatments resulted in a drop in shrinkage temperature. This suggests that there has been no reduction in the chemical stability of the protein structure.
As expected, with the exception of the parchment, the old samples had lower shrinkage temperatures than equivalent, freshly prepared materials.

Softness

This was measured in duplicate using the ST300 softness meter developed by the British Leather

Confederation and currently being considered as an Official Method of the Society of Leather Technologists and Chemists (16).
The results are shown in *Table 3.* Higher figures indicate a softer leather. Again there has been no significant effect caused by either of the treatments.

Tensile Strength

Tensile strength and extensibility were measured according to BS 3144:5. Duplicate samples were taken both parallel to and perpendicular to the backbone and the four results averaged.
The results are shown in *Tables 4 and 5*. Neither of the treatments caused any significant reduction in strength or extensibility. Once again, apart from the parchment, the old samples have a significantly lower tensile strength then the new ones.

Stitch Tear Strength

The tear strength was measured according to BS 3144:6. Duplicate samples were cut both parallel to and perpendicular to the backbone and the results averaged. The results are shown *in Table 6.* Again the treatments do not appear to have had any effect.

Lastometer

The strength and extensibility of the grain layer were measured using the lastometer or ball burst test according to BS 3144:8. The results are shown in *Tables 7, 8 and 9*. As before, the treatments have had no deleterious effect and the old leather samples were weaker than the new.

Flexibility

The flexibility was measured using the MIT flex endurance machine according to BS 5131:4.2. The results are shown in *Table 10*. As with all the other measurements, there was no significant reduction in flexibility as a result of either of the treatments.

Discussion

At the outset of this programme it was expected that untanned and partially tanned materials and deteriorated leathers would be damaged by a process involving temperatures of 52°C and relative humidities of 50% and above. It was also expected that the newer method, involving the use of lower temperatures and anoxic atmospheres, would have no adverse effects.
In the event the first assumption was proved wrong. Under the carefully controlled conditions as experienced in the Thermo-Lignum procedure, no measurable changes were observed, even with materials having a shrinkage temperature as low as 50°C.

It is known that the moisture content of a leather has a significant effect on its shrinkage temperature (17). This is why, when carrying out the standard shrinkage temperature determinations, it is essential to ensure that the sample is fully saturated with water before heating commences. Vegetable-tanned leathers absorb only between 12 and 16% moisture at 60%RH. The moisture content only begins to increase rapidly if the humidity rises to above 80% (18). It can only be assumed that it is the relatively low moisture content experienced during the treatment process which protects the collagen based materials from damage.

Conclusions

From the results obtained it can be concluded that the Thermo-Lignum pest eradication process had no observable effects on a wide range of new and old leathers and other skin products having shrinkage temperatures of 50°C or above. The process therefore appears suitable for the eradication of insect pests from the majority of objects made wholly or partly of leather. Further work will be required to determine the effects of this process on the most severely deteriorated leathers having even lower shrinkage temperatures.

Acknowledgements

I would like to thank Karen Lewis and Karen Roux of Thermo-Lignum UK for arranging for the leathers to be put through the two processes and Tony Lochmuller for assistance with the physical testing.

Table 1. pH

	52°C 2 hours		**38°C, argon 3 days**	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	4.0	4.1	4.1	4.1
Sumac calfskin	3.9	3.9	3.9	3.9
Oak hide	5.4	5.4	5.4	5.4
Parchment calf	8.5	7.1	8.3	8.0
Alum calf (Cowleys)	4.6	4.5	4.5	4.6
Alum calf (Hewits)	5.0	5.1	5.0	5.1
Brain/smoke deer	6.7	6.0	6.8	6.5
Untanned calf	6.7	6.6	6.7	6.7
Old material				
Chrome side	4.3	4.2	4.3	4.2
Russian seat cover	4.7	4.4	4.5	4.6
Parchment	7.4	6.5	6.6	6.7
Vegetable bookbinding	4.1	4.0	4.5	4.0
Hide Bucket	3.7	3.3	3.6	3.4

Table 2. T_s (°C)

	52°C 2 hours		**38°C, argon 3 days**	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	78	78	78	78
Sumac calfskin	74	73	73	73
Oak hide	77	76	78	77
Parchment calf	57	56	58	58
Alum calf (Cowleys)	50	50	50	50
Alum calf (Hewits)	79	78	78	78
Brain/smoke deer	58	58	58	58
Untanned calf	60	60	61	60
Old material				
Chrome side	86	88	86	86
Russian seat cover	68	68	69	70
Parchment	56	56	55	55
Vegetable bookbinding	54	52	54	54
Hide Bucket	62	59	61	61

Table 3. Softness (arbitrary units)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	14	13	16	19
Sumac calfskin	16	13	13	11
Oak hide	2	2	3	2
Parchment calf	12	11	12	11
Alum calf (Cowleys)	19	19	21	24
Alum calf (Hewits)	20	20	15	17
Brain/smoke deer	74	68	78	68
Untanned calf	6	6	5	6
Old material				
Chrome side	21	21	23	21
Russian seat cover	15	17	26	19
Parchment	12	11	12	9
Vegetable bookbinding	18	20	20	16
Hide Bucket	8	9	11	9

Table 4. Tensile strength N/mm^2

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	18	25	22	21
Sumac calfskin	13	16	16	13
Oak hide	18	21	17	17
Parchment calf	87	95	90	84
Alum calf (Cowleys)	34	26	22	20
Alum calf (Hewits)	27	34	33	35
Brain/smoke deer	42	37	47	39
Untanned calf	30	29	29	32
Old material				
Chrome side	12	13	15	13
Russian seat cover	4	4	4	6
Parchment	27	25	40	36
Vegetable bookbinding	5	7	6	6
Hide Bucket	3	3	4	4

Table 5. Extension at break (%)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	46	37	30	48
Sumac calfskin	58	28	40	29
Oak hide	36	40	40	40
Parchment calf	14	20	20	15
Alum calf (Cowleys)	62	60	66	68
Alum calf (Hewits)	50	42	38	41
Brain/smoke deer	81	80	100	110
Untanned calf	42	29	57	46
Old material				
Chrome side	49	52	53	54
Russian seat cover	26	44	30	28
Parchment	26	25	16	14
Vegetable bookbinding	6	6	6	6
Hide Bucket	12	12	13	10

Table 6. Tear strength N/mm

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	35	34	34	36
Sumac calfskin	29	25	25	28
Oak hide	41	50	43	42
Parchment calf	74	86	71	74
Alum calf (Cowleys)	105	88	114	90
Alum calf (Hewits)	31	32	27	29
Brain/smoke deer	219	204	206	192
Untanned calf	61	62	64	56
Old material				
Chrome side	21	22	24	20
Russian seat cover	13	18	13	13
Parchment	61	59	76	75
Vegetable bookbinding	23	13	16	15
Hide Bucket	32	24	32	30

Table 7. Lastometer test. Pressure to grain crack (kg force)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	28	25	38	23
Sumac calfskin	19	20	15	18
Oak hide	23	70	60	26
Parchment calf	X	X	X	X
Alum calf (Cowleys)	19	21	31	20
Alum calf (Hewits)	40	28	32	44
Brain/smoke deer	X	X	X	X
Untanned calf	25	45	38	30
Old material				
Chrome side	20	18	18	19
Russian seat cover	5	4	5	3
Parchment	6	10	12	5
Vegetable bookbinding	2	X	2	2
Hide Bucket	X	7	6	X

Table 8. Lastometer test. Pressure to burst (kg force)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	55	52	60	44
Sumac calfskin	31	35	36	29
Oak hide	>80	>80	>80	>80
Parchment calf	31	35	28	24
Alum calf (Cowleys)	47	55	60	57
Alum calf (Hewits)	57	38	41	60
Brain/smoke deer	>80	>80	>80	>80
Untanned calf	73	66	59	50
Old material				
Chrome side	26	22	24	27
Russian seat cover	9	7	9	7
Parchment	12	17	15	11
Vegetable bookbinding	4	3	3	5
Hide Bucket	15	15	22	24

Table 9. Lastometer test. Extension at burst (mm)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	971	920	980	930
Sumac calfskin	776	801	820	703
Oak hide	1064	783	720	1004
Parchment calf	669	744	760	697
Alum calf (Cowleys)	959	1256	1300	1257
Alum calf (Hewits)	859	900	861	903
Brain/smoke deer	1279	1871	1414	1100
Untanned calf	934	1321	1632	868
Old material				
Chrome side	971	947	868	915
Russian seat cover	634	584	575	589
Parchment	508	572	582	517
Vegetable bookbinding	600	350	448	445
Hide Bucket	840	800	1004	928

Table 10. Flex test (No. of flexes to break)

	52°C 2 hours		38°C, argon 3 days	
	Untreated	Treated	Untreated	Treated
New material				
Mimosa calfskin	14380	17129	16070	14647
Sumac calfskin	15436	14723	11369	16072
Oak hide	-	-	-	-
Parchment calf	76959	68673	65673	69837
Alum calf (Cowleys)	44061	44584	44131	46703
Alum calf (Hewits)	20144	19028	37616	29252
Brain/smoke deer	123696	132231	141951	141192
Untanned calf	6096	6628	8622	5679
Old material				
Chrome side	20805	14216	11669	11966
Russian seat cover	549	965	13	5
Parchment	20144	23156	26044	251118
Vegetable bookbinding	5	13	10	2
Hide Bucket	360	120	484	102

References

1. Musgrave, A.J., ‘Entomology and the Leather Industry’. In: *Progress in Leather Science*. British Leather Manufacturers’ Research Association, 1948, 473

2. Pinniger, D., Insect *Pests in Museums*, 3rd ed., Archetype Publications, 1994

3. Child, B., ‘The Thermo Lignum Process for Insect Pest Control’. *Paper Conservation News*, 1994, **72**, 9

4. Barrington, R., ‘The Treatment of Object Affected by Pest Attack’. *Conservation News*, 1995, **56,** 44

5. Ertelt, P., *Research into controlled temperature treatment of pest infested wood*. Unpublished Diploma Thesis, Dept of Wood Technology, Fachhochschule Rosenheim

6. Kollmann, R., *Technologie des Holzes*. Heidelberg (Springer Verlag) 1982

7. Balfe, M.P., and F.E. Humphreys, ‘The Effects of Heat and Moisture on Leather’. In: *Progress in Leather Science*. British Leather Manufacturers’ Research Association, 1948, 421

8. Seligsberger, L., and C.W. Mann, The Stability of Tannage. In: *The Chemistry and Technology of Leather*, O’Flaherty, F., et al. (eds). New York: Reinhold, 1958, 2, 489

9. Bowes, J.H., *A Fundamental Study of the Mechanism of the Deterioration of Leather Fibres.* British Leather Manufacturers’ Research Association, 1963, 16

10. Bowes, J.H., and J.E. Taylor, ‘The Effect of Dry Heat on Collagen and Leather’. *J. Amer. Leather Chem. Assn*., 1971, **66**, 96

11. Calnan, C.N., ‘Ageing of Vegetable-tanned Leather in Response to Variations in Climatic Conditions’. In: *Leather Its Composition and Changes with Time.* Northampton (The Leather Conservation Centre) 1991. p. 41

12. Milton, R.G., et al., ‘Steam lasting of upper leathers’. *J. British Leather Manufacturers’ Research Association*, 1963, **6**, 99

13. Calnan, C., ‘Production of experimental leathers’. In: *First Progress Report STEP Leather Project*, 1992

14. Thomson, R.S., ‘Leather, Man’s First Manufacturing Process?’ *Trans. Newcomen Soc.* 1981, **53,** 139

15. Haines, B.M., *A Survey of Native American Indian Leather Processing*. Unpublished report. Northampton (Leather Conservation Centre) 1988

16. Alexander, K.T.W., and R.G. Stosic, ‘A new Non-Destructive Leather Softness Test’. *J. Soc. Leather Technologists and Chemists,* 1993, **77**, 139

17. Nayudamma, Y., ‘Shrinkage Phenomena’. In: *The Chemistry and Technology of Leather.* O’Flaherty, F., et al. (eds). New York (Reinhold) 1958, **2**, 28

18. Humphreys, F.E., ‘Drying of Leather’. In: *Progress in Leather Science*. British Leather Manufacturers’ Research Association, 1948, 625

Study on the Stability of Leather Treated with Polyethylene Glycol

Claire Chahine, Christine Rottier
Centre de Recherches sur la Conservation des Documents Graphiques
36, rue Geoffroy-Saint Hilaire
F-75005 Paris

Polyethylene Glycol (PEG) has been used for years with excellent results for the conservation of leather as well as wood, providing excellent quality to these materials. Particularly it helps in the rescue of waterlogged leather, preventing dimensional shrinkage during drying, by maintaining a certain amount of requisite water in the structure. It also has a plastifying effect on the material, making it supple and flexible.

The decomposition of PEG has been for long an area of interest and it has been shown that, as other polymers, it can undergo oxidative breakdowns, via free radical mechanisms.
The decomposition is accelerated by heat, light, γ radiation and various oxidants (1, 3, 4, 7, 9). Hydroperoxides are released as primary by-products, then they initiate other chain reactions. The deterioration produces depolymerization of PEG, and the low molecular products obtained at the end of the reaction are essentially formaldehyde and other aldehydes, formic acid, ethylene glycol, diethylene glycol, diethylene glycol mono- and di-formates, formals. It was shown also that water and anti-oxidants can inhibit this process, by decreasing the formation and decomposition of hydroperoxides.

In the field of conservation the problem of the innocuousness of PEG was first raised by Brownstein (2), and different authors have observed the oxidative decomposition of PEG, even at low temperature. More recently, de Simone et al. (10, 11), and Padfield et al. (5, 8), working on PEG 200 and two of its oligomers, hexa- and tetraethyleneglycol, heat aged between 50 and 80°C, have similarly observed the release of aldehydes, hydroperoxides and acids. Water, gallic acid (an anti-oxidant), and ions such as Cu^{2+} and Fe^{3+} slow down the deterioration. These ions would inactivate formaldehyde and hydroperoxides by oxide-reduction reactions. But unfortunately, other ions such as Ni^{2+} promote the deterioration.

Although PEG has proved its beneficial effect for the conservation of leather, a doubt arises on the soundness of its use, when considering how it can decompose. Indeed what would be its influence in the long term? In an attempt to answer this question, we have undertaken a study on the ageing of the composite material: leather + PEG.

Experimental part

Materials
Experiments were carried out on new calf leather prepared with vegetable tannins of condensed type. They underwent a pre-treatment with water-acetone (v/v) to remove part of the unfixed tannins, in order to simulate archeological leather on which all of them are washed out during burying (burial), particularly in the case of waterlogged leather. We worked both on washed and unwashed new leather to obtain as much information as possible. In fact, the comparison between untreated and PEG treated leather is not completely accurate. Indeed, since PEG solubilizes tannins itself, these two types of leather will contain different amounts of tannin, resulting in different materials. However, this approach turns out to be the best simulation when working with new leather.

Fragments of medieval archeological leather were also used for the experimentation.
All the leathers were immersed in water, then half of them were treated either with PEG 200 or with PEG 400 in 30% aqueous solutions, the other half being the untreated reference. At the end they were freeze-dried.

Artificial ageings
The samples were, aged together to compare their reaction and know the influence of PEG during ageing.
According to literature, the deterioration of PEG is accelerated by heat and light, so these two agents were used, sometimes in combination, with a preference for heat which allows the treatment of a larger sampling.
- dry heat: 50, 70, 100, 120°C
- xenon light used simultaneously with dry heat

An experiment was also carried out under pollution.

Tests
The deterioration during ageing was followed with several tests. They were generally adapted according to the sample size and were variable for each sample.

- *Measurements of the denaturation temperature (T_d)*
They were performed with a Differential Scanning Calorimeter Perkin-Elmer model DSC 7. Denaturation, which is the transformation collagen gelatine occurs at a determined temperature named Td, absorbing a certain energy, ΔH. Both T_d and ΔH decrease with deterioration.

- *Mechanical testing*
Tensile test, elongation at break and tear test were performed according to Normes Afnor on a Lhomargy DY2Q dynamometer.

- *Evaluation of the soluble nitrogen content*
This analysis includes both proteinic compounds determined after digestion of a soluble extract, and ammonium salts. The former correspond to small peptides detached from the collagen molecule by various breakdowns and the latter represent the ultimate step in deterioration of the protein. They give a rough indication, but yet useful, on the state of collagen deterioration.

- *Amino acid analysis*
This more precise analysis is carried out after acidic hydrolysis. It shows up the modifications due to oxidation resulting in a different amino acid composition. It was performed in Copenhagen by René Larsen (6) which the authors gratefully acknowledge.

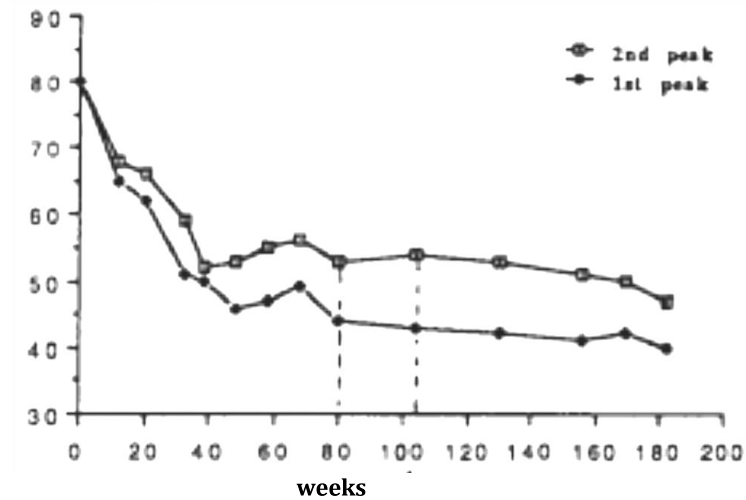
Results and discussion

The first ageings were realized at 50°C, a very interesting condition because it is not far from natural ageing. But since ageing at this low temperature requires a long exposure, the later ageings were realized at higher temperatures to accelerate the deterioration.

Ageings at 50°C

The deterioration during the long term experiment was followed using Differential Scanning Calorimetry (DSC) analysis, T_d being measured at different intervals. In one experiment carried out on new leather no. 1 pre-washed with water-acetone, we observed several interesting characteristics as shown on *figure 1* where T_d is plotted versus ageing time.

T_d °C **a) leather n°1 washed with water acetone**



T_d °C **b) leather n°1 washed and PEG treated**

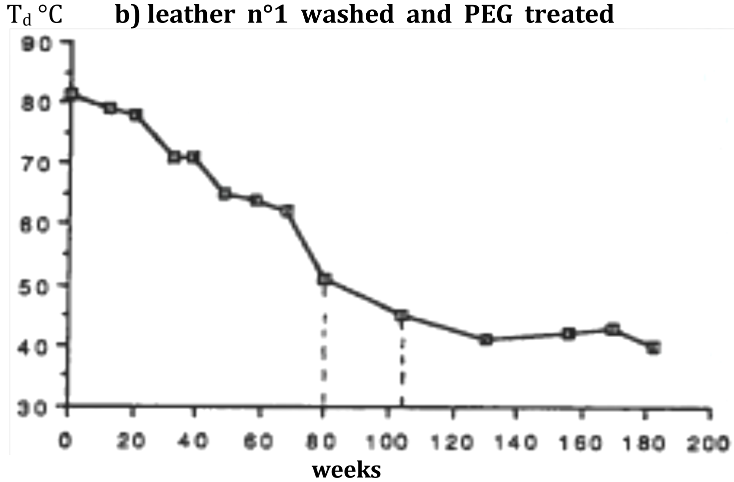


Fig. 1. *T_d evolution during ageing at 50°C of a new leather washed with water-acetone; a) not PEG treated, b) PEG treated.*

The thermogram of the pre-washed leather exhibits, from the beginning of the ageing, two peaks which indicate the presence of two populations of collagen fibers, one being more resistant than the other, as a result of the partial detannage due to the water-acetone treatment. At first, the two peaks are very close, but after 40 weeks they separate, the most resistant population remaining quite stable, while the weakest decreases slowly. It is interesting to note the absence of splitting in the leather treated with PEG. Comparing the evolution of the two leathers, we observe a first period, until around 80 weeks, where the hydrothermal stability of the treated leather is higher than the stability of the untreated.

Then we can see a change, and progressively, the T_d of the former reaches the level of the strongest population of the latter, and from 104 weeks (2 years), the level of the weakest. At 186 weeks, the energy involved in the denaturation was measured:

186 weeks at 50°C	T_d °C	ΔH
untreated	40	17
PEG treated	40/47	19

Table 1. *T_d measurements of a leather washed with water-acetone, after ageing at 50°C*

The two peaks of the treated leather lie at 40 and 47°C, while the only peak of the untreated lies at 40°C, but with a tail in the highest temperatures. This makes the energy of the two almost equivalent, so that differences between them may be considered as minor.
In order to assess the influence of copper and iron, which are often associated to archeological leather, the long term ageing was also carried out on the same washed leather in presence of copper and iron salts. On *figure 2*, we can see that these salts slow down the deterioration of leather, at least to a certain extent, and especially Fe^{3+} This agrees with previous studies (5, 8, 10, 11), although the protection is not so high compared to that of the leather treated only with PEG, and moreover after 160 weeks the three leathers reached the same level. Nevertheless it is most reassuring to see the absence of adverse effect of these ions during ageing.

T_d °C **leather n°1 washed with water acetone**

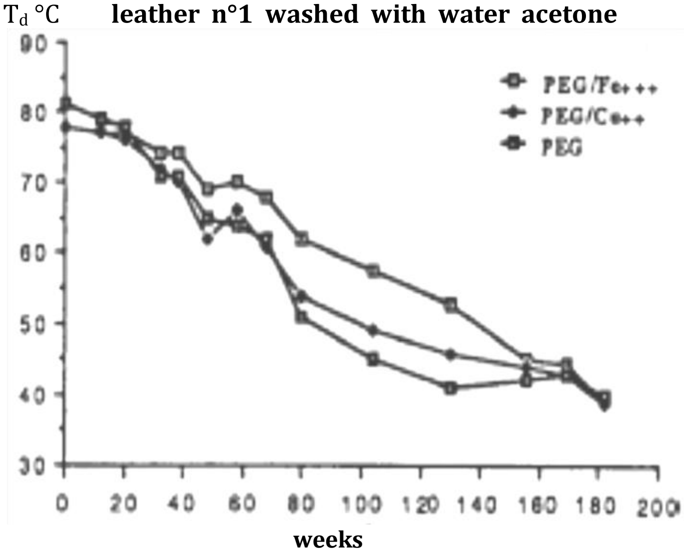


Fig. 2. *T_d evolution during ageing at 50°C of a new leather washed with water-acetone and treated with metallic salts.*

The long term ageing was repeated on other new leathers, comparing in one experiment during 2 years, leather pre-washed with water-acetone to leather not pre-washed. The T_d of the leathers treated with PEG remained higher during all that time, particularly when the leather is not washed, as we illustrate on the following graphs.

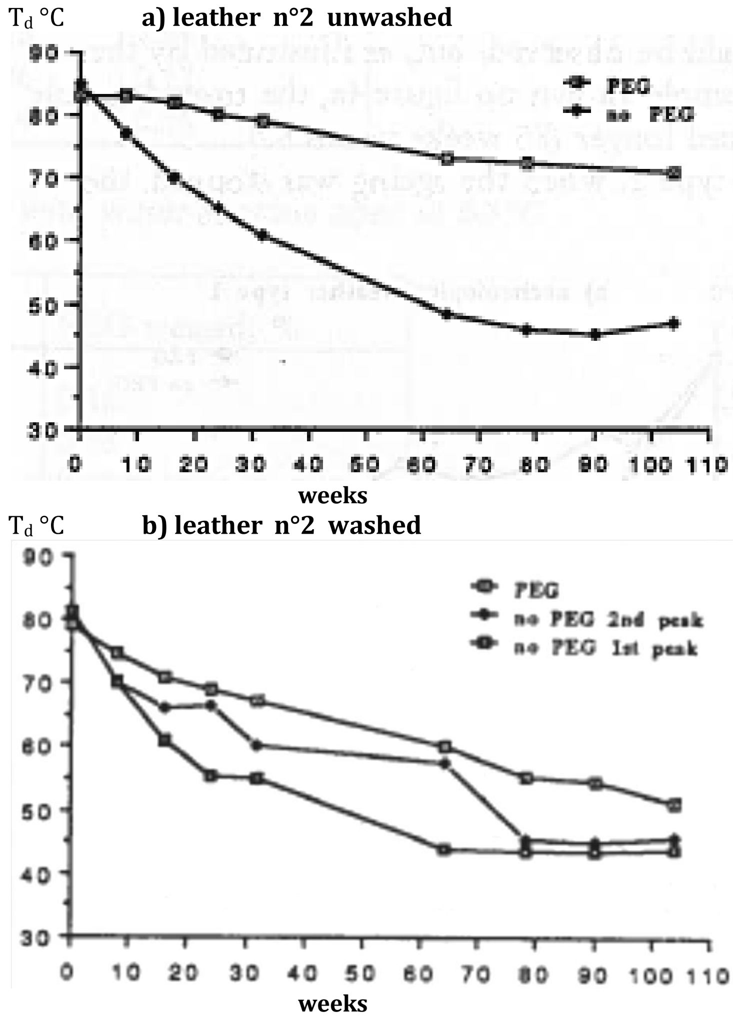


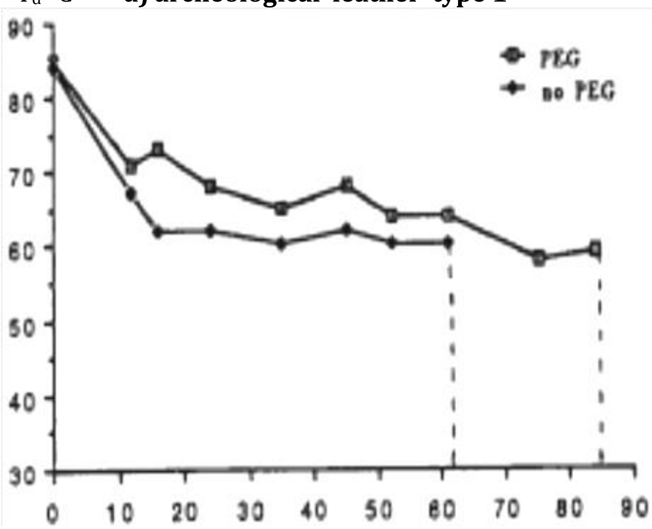
Fig. 3. *T_d evolution during ageing at 50°C; a) unwashed leather, b) washed leather.*

On *figure 3b* we can see that the washed samples present also a splitting, but its evolution is different of that of leather no. 1 *(Fig. 1).* Indeed, from almost the beginning to 78 weeks, the two peaks were clearly separated, but after 80 weeks they became very close. It is interesting to note that the T_d of the PEG treated leather, unlike leather no. 1, remained higher than the highest population of the untreated, at least until 104 weeks, end of the experiment.

Several archeological leathers were also put to the same ageing test, and all of them behaved similarly: all the PEG treated leathers

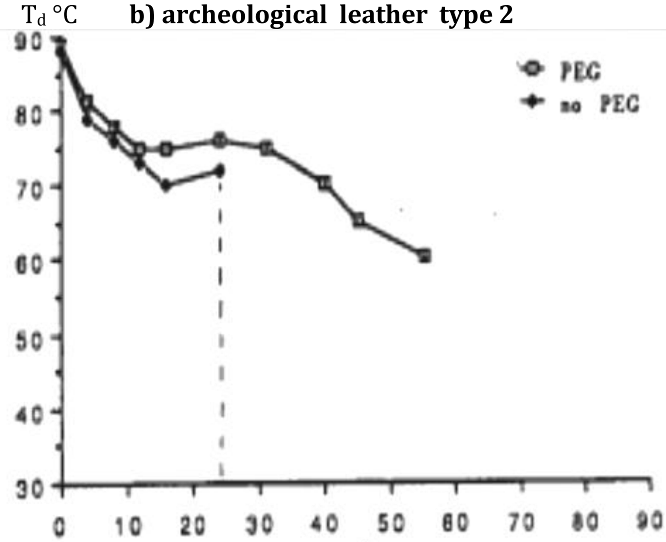
underwent the slightest falls of Td, and in the same time the slightest decreases in energy. During ageing of leather, the energy involved in the denaturation decreases according to the deterioration, and at a certain point becomes so low that it is not anymore measurable.
This occurred much before for the untreated leathers than for the treated. In fact, all the measured archeological leathers belong to the two types presented on *figure 4*. In type 1, the experiment lasted as long as a phenomenon could be observed, but, as illustrated by the example shown on figure 4a, the treated sample lasted longer (85 weeks versus 62).
In type 2, when the ageing was stopped, the untreated leather was for long unmeasurable, while the treated sample was still clearly resistant. On the graph presented on figure 4b, we can see that the last measurement of the untreated was realized only after 24 weeks, while the treated sample could have been extended beyond 55 weeks.
Similar results were obtained with a leather containing metallic contaminants, which an elemental analysis revealed to be iron. *Table 2* shows the highest T_d values of the PEG treated sample over the all experiment. This one lasted 14 weeks which represented the maximum exposure that the untreated could stand, this leather belonging to type 2.

T_d °C **a) archeological leather type 1**



weeks

T_d °C **b) archeological leather type 2**



weeks

Fig. 4. *T_d evolution of archeological leather during ageing at 50°C; a) type 1, b) type 2.*

Ageings at 50°C	Untreated leather	PEG treated leather
0	88°C	88°C
8 weeks	71°C	78°C
10 weeks	-	75°C
12 weeks	66°C	75°C
14 weeks	68°C	76°C

Table 2. *T_d measurements of an archeological leather containing iron, after ageing at 50°C.*

Amino acid analysis was carried out on new leather no. 1 washed with water-acetone after two periods of ageing, 80 and 156 weeks. They were performed by R. Larsen from the School of Conservation in Copenhagen. A few data are extracted from his results and presented on Table 3. They show the amino acids which are the most subject to changes during oxidation. Compared to a new leather, the modifications of the four aged leathers point towards an oxidation. But the two PEG treated leathers are more oxidized. Especially when looking at the di-basic amino acids, hydroxylysine (Hyl), lysine (Lys), arginine (Arg) which decrease while the di-acidic, aspartic acid (Asp) and glutamic acid (Glu) increase, resulting in a B/A ratio which decrease with oxidation (6). We observe that the slowest ratios are for the PEG leathers. We note also a decrease of the proline (Pro) content and the release of one breakdown-product, aminoadipic acid (Ada).

Amino acid		weeks 80		weeks 156	
	new leather	no PEG	PEG treated	no PEG	PEG treated
Asp	4,5	4,71	4,72	4,68	4,87
Glu	7,50	7,39	7,41	7,38	7,60
Pro	12,55	12,02	11,92	12,05	11,81
Hyl	0,67	0,60	0,46	0,61	0,43
Lys	2,63	2,15	1,82	2,17	1,75
Arg	4,94	4,96	4,82	4,88	4,82
Ada	0,00	0,03	0,11	0,06	0,12
B/A	0,69	0,64	0,59	0,64	0,56

Table 3. *Amino acid analysis of leather no. 1 washed with water-acetone aged at 50°C.*

	no PEG, %	PEG treated, %
ammonium salts	0.03	0,16
soluble proteinic compounds	2.05	0,53
total	2,08	0,69

Table 4. *Soluble nitrogen content of leather no. 1 washed with water-acetone; and aged during 186 weeks at 50°C.*

Thus, changes due to oxidative breakdowns occur in all the heat aged leathers, but they are more serious when PEG is present, and moreover in that case, they are produced faster. These results indicate clearly a modification of PEG inside the leather during ageing.

The soluble nitrogen content of this leather was evaluated after 186 weeks. *Table 4* brings into focus something very interesting indeed. The content of the ammonium salts is much higher in the PEG treated leather, indicating that oxidative breakdowns responsible for the NH_3 formation were produced in a larger number, and this is in agreement with the amino acid analysis. But in the same time, the content of the soluble proteinic compounds is much lower, indicating that in this leather less small proteinic fragments were detached from the collagen molecule during ageing.

All of this appears conflicting and reflects a e decomposition of PEG with release of various compounds. Nevertheless, in the other long term ageing carried out on leather no. 2 over two years, we showed *(Fig. 3)* that the T_d values of the PEG treated samples remained clearly higher, while in leather no. I modifications were observed from 80 weeks.

We found also lower values of the soluble nitrogen compounds, and especially of the ammonia content, which indicated that less breakdowns had been produced. Apparently the kinetic of the deterioration was different.
We intend to do amino acid analysis to establish a comparison with the results obtained in the first experiment.

But considering what happened with the first leather during ageing, we can assume a possible re-arrangement of the collagen molecule which on the one hand undergoes oxidative break-downs on the side chains, and on the other hand undergoes cross-linkings. The first phenomenon could be due to hydroperoxides, while the second is obviously the result of the action of aldehydes which re-tan the leather. At that level of the ageing, 186 weeks at 50°C, the balance between the two phenomena is still in favour of a protection, but what will it be on a longer term? Moreover, still referring to that first leather, and especially to the results obtained in DSC, two periods in the reaction of the PEG treated samples were observed: a first one during which the protection was clearly established, followed by a stage where a different behaviour was detected.

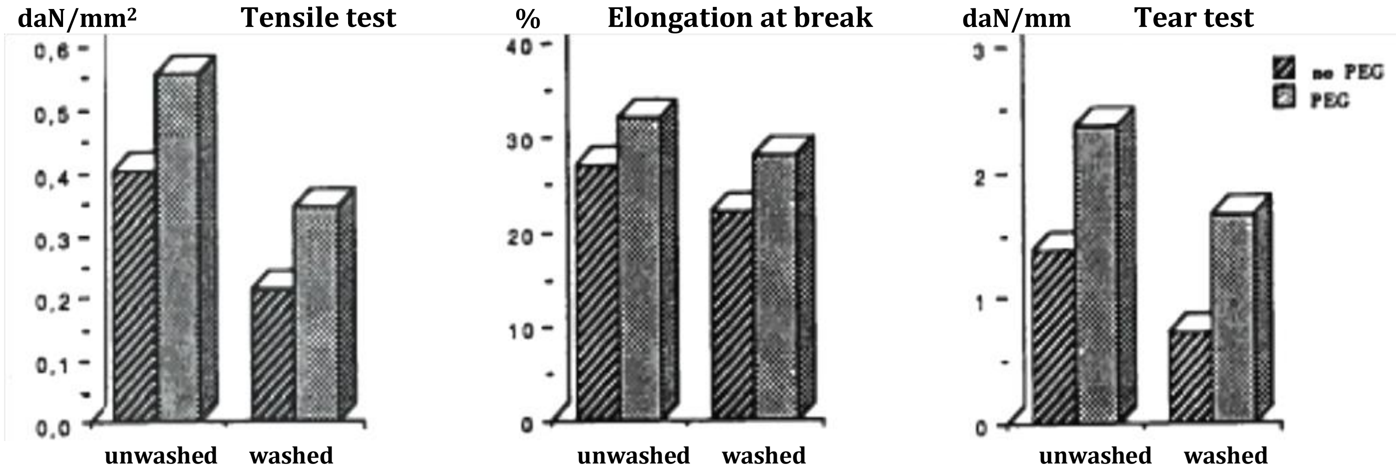


Fig. 5*. Mechanical tests of a new leather (pre-washed and unwashed) after ageing 20 weeks at 70°C. The tests were performed in the two directions of the skin, paralleled and perpendicular to the backbone, and the values are the mean between their results.*

Could there be a third period in which the treated leather would deteriorate faster than the untreated? In order to reach this possible third period faster, we aged our leathers at higher temperatures. One experiment was also realized using a xenon light together with dry heat, and one in a pollution chamber.

Ageings in more severe conditions

- Higher temperatures
Experiments were carried out under the following conditions: 70°C up to 20 weeks, 100°C up to 5 weeks, 120°C up to 140 days. Mechanical testing performed on these leathers revealed a better resistance of the treated samples in all cases, whichever the ageing temperature was.
Figure 5 illustrates, by way of an example, the results obtained on leathers aged during 20 weeks at 70°C, (half of them being pre-washed with water-acetone, the other half unwashed). The graphs point out that for the 3 tests the highest values come from the PEG treated leathers. The tear test, which was generally high, reflect the increase of cross-links due to re-tanning.
Fig. 6 shows the results obtained by ageing at 120° C new leather no. 3 (both pre-washed and unwashed) during 140 days. Only tear tests were performed, since it seemed the most representative of the changes occurring in the leather. The graphs point out that the leather retains its strength better when treated with PEG.
Moreover we see that the untreated leathers are destroyed much before those treated with PEG. In fact this happened after 90 days for the washed samples and 120 days for the unwashed which are more resistant. After 140 days, the treated samples maintained their strength at 1.57 and 2.28 daN/mm respectively. The experiment is still under progress, to make sure that there is no risk of a regular increase of reticulations in the unwashed leather, which could be responsible for too important a stiffening.

The evaluation of the soluble nitrogen content of the leathers aged at high temperature revealed that the amounts of proteinic compounds were always less important when PEG was present, so indicating less breakdowns in collagen. But the ammonium salts were found in very low concentrations, as a consequence of the elimination of ammonia as it was produced. No information could then be obtained from this test.

We must say that the leather treated with PEG is rather stiff after ageing at that high temperature. But in the same time, also the untreated leather became very stiff, lost all its strength, breaking as easily as glass. On the other hand, a piece of archeological leather treated with PEG and being stored for almost 4 years at 50°C is still quite supple.

- Light ageing
We used a xenon lamp emitting between 300 and 700 nm and providing 45 watts per square meter. The leathers were exposed during 5 weeks at 70°C. In that case we also observed a better resistance of the samples treated with PEG.

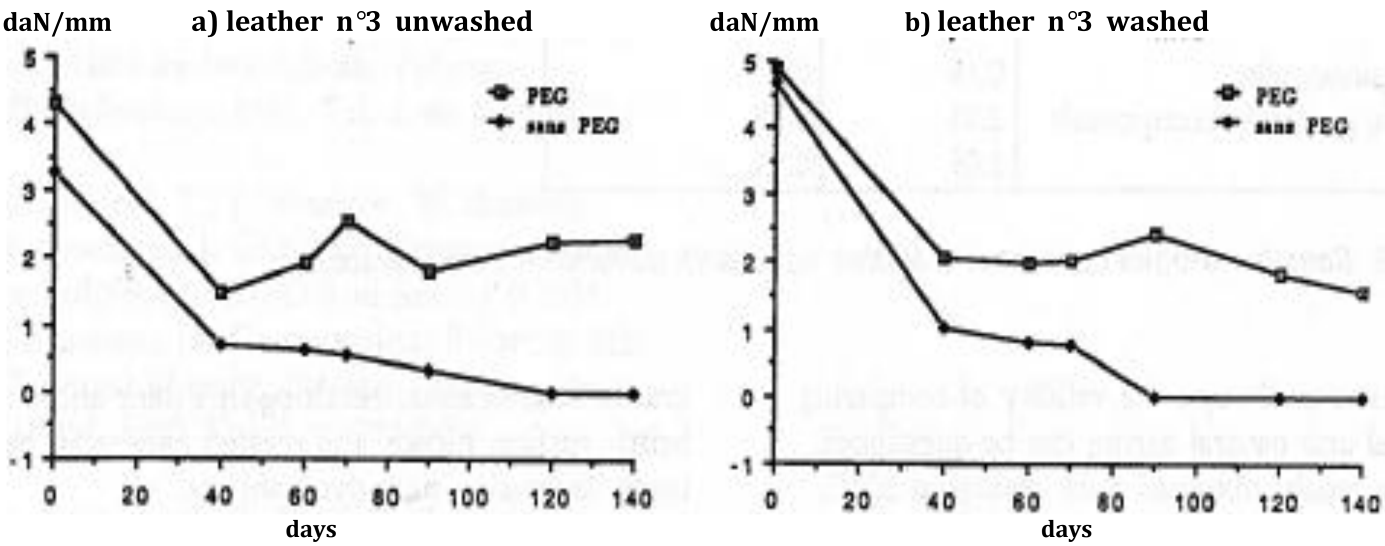


Fig. 6. *Tear test evolution of leather no. 3 during ageing at 120°C.*

- *Pollution ageing*

This experiment was performed on new leather no. 4 not pre-washed with water-acetone, in a pollution chamber under the following conditions: 25 ppm SO_2, 10 ppm NO_2, 40°C, 30%RH. These conditions are known to produce more hydrolysis than oxidation, and were chosen to complete the informations obtained with heat and light which favour oxidation.

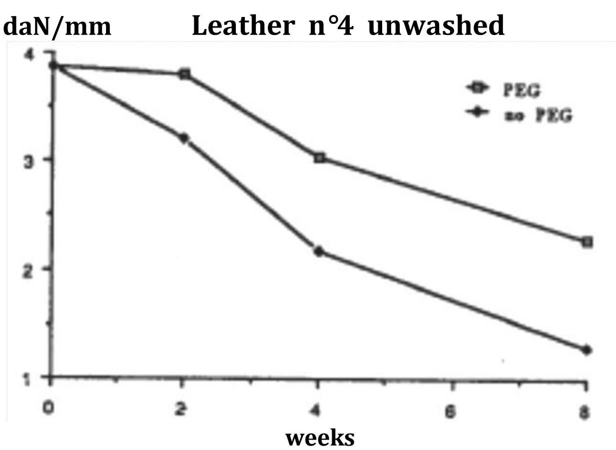


Fig. 7. *Tear test evolution of leather no. 4 during ageing with pollution.*

The deterioration was followed using tear test, samplings being done after 2, 4 and 8 weeks. All along the ageing, as seen from *Figure 7*, the PEG treated leather proved to be more resistant.
The soluble nitrogen content was evaluated on the 8 weeks samples, and the results are presented on *Table 5*. It is interesting to note that unlike what we observed in the 50°C ageing, the content of the ammonium salts of both leathers is almost equivalent (though a little lower for the PEG leather), and rather high for pure hydrolyzing conditions. On the other hand, the proteinic compounds are much more important in the leather not treated with PEG, indicating a higher level of deterioration, and these same results were observed in the moderate heat ageing.
In this case also, an amino acid analysis will further be performed to explain all these data. But, as for heat ageing, and although the process of deterioration is completely different, the results obtained after pollution point out to an effective protection offered by PEG.
As an explanation we think of an oxidative decomposition of PEG with release of aldehydes able to reinforce leather against acid attacks.

Conclusion

The results of our study show indubitably that PEG decomposes in leather during ageing, and this despite the presence of vegetable tannins which are anti-oxidants. From the previous studies carried out in the field of conservation, a better protection against oxidation could have been expected from these compounds. This decomposition appeared in all cases of ageing we performed using heat, light or even pollution. The released breakdown products, amongst which hydroperoxides and aldehydes are found, react with leather, producing two types of reaction on collagen: oxidative breakdowns on the side chains which is a negative effect, and cross-linking between chains, a positive effect in terms of conservation. The balance between these two conflicting reactions seems to be in favour of a protection during ageing.

	no PEG, %	PEG treated, %
ammonium salts	0.16	0.12
soluble proteinic compounds	2.93	0.39
total	3.09	0.51

Table 5. *Soluble nitrogen content of a leather aged with pollution during 8 weeks.*

Of course, as always, the validity of comparing artificial and natural ageing can be questioned. But the results obtained with ageings at 50°C, conditions not far from natural ageing, encourage these extrapolations.
Beside the role it plays in the conservation of wet leather, by maintaining proper dimensions during drying as well as plasticity, we can say that PEG constitutes a preventive treatment against deterioration. This comes from the re-tanning due to the aldehydes released during decomposition, and we have proof of an early re-tanning from the DSC analysis of the experiment carried Out at 50°C on leather no. 1. In fact the introduction of PEG in the leather pre.-washed with water-acetone, and so partially detanned, prevents the apparition of a double peak during denaturation, a phenomenon which occurs when the same pre-washed leather is not treated with that compound.

The treatment with PEG resulted in a stiffening of the new leather we used for our experimentation, because in that case, it is rather an over-tanning than a re-tanning which is produced. But new leather does not require PEG because deterioration has not yet modified the way water is bound to collagen in its structure, and therefore could tolerate drying with no important dimensional shrinkage.
But, for an old leather the PEG treatment is beneficial, by re-tanning of a weakened material detanned during natural ageing. Of course this re-tanning modifies its structure, but this is accepted in other conservation treatments to extend the life time of a leather object when it is deteriorated.

Warning
We cannot conclude without drawing the attention to a phenomenon we mentioned elsewhere and for which we have at the moment no explanation. On some kinds of dyed leathers, and particularly bookbindings, PEG can cause a drastic deterioration, resulting in a dark and brittle surface. Hence, the greatest care must be taken in treating such dyed objects.

Bibliography

1. Afifi-Effat, A.M., J.N. Hay, The thermal stabilization of polyethylene oxide. *European Polymer Journal*, 1972. Vol. 8. 289-297

2. Brownstein, A., *The chemistry of PEG.* Discussion during ‘Proceedings of the ICOM Waterlogged Wood Working Group Conference’. Ottawa 1981

3. Crouzet, C., J. Marchal, Caractérisation des réactions primaires de dégradation oxydante au cours de l’autoxydation des polyoxyéthylènes à 25°C: étude en solution aqueuse avec amorçage par radiolyse du solvant. I. Etude viscosimétrique: stabilité des hydroperoxydes du polyoxyéthylène et cinétique de production des coupures. *Die Makromolekulare Chemie*, 1973, Vol. 166. 69-84

4. Feadet, A., E. Marechal, Oxidative degradation of various oligomers. *Journal of polymer Science: Polymer Letters Edition*, 1978. Vol. 16. no 8. 409-411

5. Glastrup, J., T. Padfield, *The thermal degradation of tetraethylene glycol, a model molecule for polyethylene glycol*. ICOM Committee for Conservation. Preprints, 10th Triennial Meeting. Washington, Los Angeles: ICOM, 1993. Vol. 1, p. 251-256

6. Larsen, R., *The STEP Leather project. Background and first results.* ICOM Committee for Conservation. Conservation of Leathercraft and Related Objects. Interim Symposium. Victoria and Albert Museum. London, 24 and 25 June 1992. 3-6

7. Mel'Nikov, M.Y., E.M. Lipskerova, O.M. Mikhailik, N.V. Fock, Photoageing of polymers simulated by free radicals. *Polymers Photochemistry.* 1982. Vol. 2. no 2. 133-150

8. Padfield, T., J. Winslow, W. Batsberg Petersen and J. Glastrup, *Decomposition of polyethyleneglycol (PEG) on heating*. ICOM Committee for Conservation. Preprints. 9th Triennial Meeting. Dresden. Los Angeles: ICOM, 1990. Vol. 1, p. 243-245

9. Reimann, I., G. Hollatz, Th. Eckert, Untersuchungen zur lichtinduzierten Autoxidation von Polyathylenglykolen. *Archiv der Pharmazie*. 1974. Vol. 307. no 5. 328-332

10. Simone, V. de, Etude de Ia stabilité de 'polyéthylène glycols' et leur interaction avec le cuir. Thèse de doctorat. Chimie Analytique Paris VI. 1991. 119 p

11. Simone, V. de, F. Flieder, S. Bonnassies, 'Comportement du polyéthylène glycol'. In: *Les Documents Graphiques et Photographiques. Analyse et conservation: Travaux du Centre de Recherches sur Ia Conservation des Documents Graphiques* 1988-1990. Paris: Archives Nationales; La Documentation française. 1991. 73-119

Acknowledgement

The authors would like to acknowledge the Archives Nationales de France for their financial support which made this work possible.

The Collection of the Egyptian Department of the Musée du Louvre: Primary Results of the Study

Véronique Montembault
10 Grande Rue
F-89500 Egriselles de Bocage
(translation by L. Gartenne-Marot)

Within the view of the rearrangement of the Coptic exhibition rooms of the Louvre Museum in 1997, and, in particular, the renewal of the exhibited collections, the presentation to the public of objects in leather not displayed up to now was made conceivable. Most of them were still as they had been excavated at the end of the last century, and thus it was necessary to plan some restoration interventions.
The selection of objects to be presented was rapidly incurring major problems such as: lacks in the inventory, misknowledge of the restoration interventions done before, ignorance of the date as well as exact provenance of most of the objects.
As a matter of fact, most of the artifacts belong to the old collections of the museum (gathered mainly in the XIXth century as well as in the beginning of the XXth century), and most of the people that intervened previously on the object, whether finders, curators or conservators, have worked according to the principles of their time. As such, a lot of informations judged essential nowadays (such as an inventory with a description and a code for each piece) has not been recorded. As an example, we may cite the donation made by the Doctor Clot-Bey in 1853, recorded in the inventory books under the following mention:
“2397 objects en matières diverses formant la seconde partie de l’acquisition Clot-Bey, dont le détail et la désignation sont portés sur l’inventaire particulier de cette collection. La seconde partie, dont ii s’agit ici, comprenant les caisses 16 à 37”.
(“2397 objects in diverse materials making up the second part of the acquisition Clot-Bey, the detail and the designation of which are written down on the specfic inventory of the collection. The second part, which is being dealt with now, including the boxes 16 to 37’).

1. Leather conservator and specialist into the technical and historical study of the collections.

That is why, at the first January 1994, the collection could be said not to be composed of a precise number of objects duly registered but of many hundreds of fragments mixed up in one lot from which only rare pieces which have kept their registered number could be miraculously pulled out.

As a preliminary step to any restoration, it was urgent to do a sort of diagnosis of the collection, firstly by comparing inventories with existing pieces, secondly by evaluating the degree of deterioration of the objects.
This study,. planned for four years, was organized in sets of operations, spread over years. In order to give a unity to all of the research, programmes have been set for each of the periods of intervention.

Thus, 1994 was devoted to recognition of the pieces and to the cross checking between objects and inventory books. This stage of recognition of pieces that can be pieced together may be looked upon as long and tedious when the number of elements is high. For this collection it has been quite rapid; the leather pieces have kept their original dies and could be more easily gathered together by families of colour. Decorative techniques as well as iconographic motifs then helped to refine this first sorting. Together with this sorting, a typological identification was done. Thus groups such as the shoe group were created (itself divided into secondary groups like the sandals, the boots etc.) and the belt one, the basket one, the case one, the one registered as ‘bookbinding’, the clothing elements ones, and so on.

However, if, in the majority of cases, these associations of fragments were found out, still some elements remain of which the origin could not be determined. Still, recognition through types, colours and ornamental techniques has made possible a regrouping by sets.
To compare isolated elements to the rest of the collection in order to find Out possible associations, was too much time-consuming; it was thus decided to put those elements temporarily aside and to conduct this type of research only within the realm of secondary groups.

Considering an isolated object, one often sees that its inventory number is gone and ought to be searched for. However, the sources of the Louvre collections are much diverse. Along the archaeological pieces taken to the museum as soon as they were excavated, we find private collections donated or bequeathed, objects bought either from antique dealers or in auction sales, transfers from other French museums...
The majority of those pieces bear a double, sometimes even a triple system of numbering: some corresponding to succeeding owners, others to the Musée du Louvre codes.
For a donation or the purchase of some private collections, the museum staff opened an account book where the pieces were numbered according to their location in the boxes.

In parallel to this an official inventory was done, but the definite number of the Louvre was not systematically transcribed on the temporary book and, in the registers of the Museum the descriptions are too laconic.
So, when an object lost one of its labels, such cross-examination of both existing objects and inventories contents is made impossible.

Certainly in order to give more spice to the works of future researchers, it was decided from 1849 on to change the way of the inventory of the museum. Pieces up to then inventoried using a code N (for: Napoléon III) followed by a number were registered with a new code of E (for Entrée) followed by a number. Part of the items classified according to the former system was, by mistake, inventoried all over again and therefore, no cross checking was established between the two registers ...

What was to happen, happened. Labels came off and that is why 64 shoes or sets of shoes are mentioned in the different inventories known to the museum, whereas only 54 objects have been identified. When the same identification did correspond to shoes of different types, it has not been possible to recover the whole of the lot. Thus, 51 pieces did not bear any registration marks and it could well be either objects that had never been inventoried or items for which the description is too concise to make the identification of the number on the books possible. In such case the pieces are given a special code, AF followed by a number, and are reported in another register book.

In the course of this austere and little gratifying work, we are sometimes faced with a more detailed mention, specifying dimensions, colours, type of the decoration together with its location. It concerns pieces whose exceptional nature seemed to warrant a less concise descripttion, but, at different periods of time, some articles have been submitted to conservation attempts and very often the result does not prove equal to the expectations (i.e. the colour became black even for originally red coloured items). Moreover, when documents relative to treatments do exist, they are very concise, and do mention neither the whole of the performed operations, nor the precise nature of the used products.

In two months, most of the fragments have been reassociated among themselves: 175 articles were listed, including 115 shoes, 5 clothing elements, 24 ‘mummy braces’, 12 belts and straps, 5 scabbards, 2 baskets, 5 music instruments, 1 bookbinding, 4 undetermined articles. Computerized inventory cards were established for each object. Among all the elements mentioned in the inventories, 10 have not been identified *(Table 1).* They certainly correspond to objects found without any serial number, but their description is not sufficient to identify them undoubtfully.
The study was carried on in 1995, essentially focussed on the shoes, including footwear manufactured in other materials than leather, e.e. 19 objects among which 9 articles of wood and 10 of plant fibre.
Because of the unknown accurate dating of most of the articles, it was impossible to distribute the collection in chronological groups and to study each of these successively.
We have therefore chosen to perform a general study of the collection in order to determine if, in the course of the inquiry, a distribution according to shapes, manufacturing techniques, together with iconographical parallels, as well as with comparison with similar collections from other museums, could allow to suggest a dating of the Louvre collections.
The typological headfamilies had already been established in the course of the first part of the work; in order to identify subgroups, we selected as predominant features the general shape and manufacturing technique of the article, that is the number of constitutive elements as well as the technical construction.

Some pieces are decorated, but we only considered the decoration as a recessive feature of the classification.
As early as the beginning of the work it appeared necessary to perform, when the state of conservation made it possible, a technical drawing of the article. This pattern is not meant to be an accurate drawing of the object, but is a flat representation of its different constituents. Indications relative to the manufacturing technology, such as the stitches, the shape and decoration technique, are reported on this sketch *(Fig. 1)*.

If the fragments are too much deformed to be drawn, or if a doubt remains about the accurate shape of an element, we do prefer to represent the different parts being connected and to indicate the differences of levels and materials by using different drawing pattern codes (*Fig. 2)*. In the case of some articles, like boots, it is very difficult to visually project volumes on a plane. In this case, a drawing is made first on a taped last. Then the taped main form is removed from the last and flattened according to the techniques used nowadays for shoe pattern cutting. Drawing is a time consuming stage and to this day only the sandal family could be drawn.

Leather is the best represented class, with 33 articles out of 48. It has been therefore decided to begin with this typological series, for which we have selected only the pieces corresponding to the definition of the 'Technical Dictionary for the Shoe Industry' written by Rama, where we can read for the sandal: 'simplified shoe made up of a sole, more or less wide, and variously joined straps or bands, between which the foot remains visible'.

At the time present we have only worked on the 33 leather pieces whose classification has been made as a function of the design of the junction point of the straps behind the foot.
It seems that three groups have to be distinguished:
- one for which sole and junction are integral and constitute only one object;
- one for which the junction clip is a strap which either is sandwiched between the two soles, or crosses the first sole by means of splits set out parallel to the border;
- one for which straps are directly fixed on the sole, without the aid of a clip.

The technological and typological study of the collection, although at its early beginning yet, allows to foresee encouraging results. This work will lead to a better knowledge of the articles; we hope it will allow to select among them the most representative items of the collection, and to conceive the best restoration and presentation respecting the wholeness and the integrity of the object.

References

1. Goubitz, 0., 'The drawing and registration of archaeological footwear'. *Studies in Conservation*, 1984. 29. 187-196

2. Krieger, P., 'Note concernant les numéros d'inventaire des objets conservés au Département des Antiquités Egyptiennes du Musée du Louvre'. *Revue d'Egyptologie*, tome 12. 1960. 93-97

3. Montembault, V., 'La restauration du cuir archéologique'. In: *Journées sur Ia conservation-restauration des biens culturels - Recherches et techniques actuelles.* Paris 15 et 16 Octobre 1987. 36-45

4. Pfister, D., 'Les chaussures coptes'. *Revue de calcéologie*, 1986. 3. 12-15

5. Rama, L., *Dictionnaire technologique de l'industrie de Ia chaussure*. Lyon. (1973) 406 p.

6. Rutschowscaya, M-H., *Catalogue des bois de I'Egypte copte*. Paris. (1986) 173 p.

7. Vincent, Ch., *Histoire de Ia chaussure, de Ia cordonnerie et des cordonniers célèbres*. Paris (1859) 319 p.

8. Ziegler, Ch., *Catalogue des instruments de musique du Département des Antiquités Egyptiennes du Louvre*. Paris. (1979) 135 p.

Table 1. *Comparison between the descriptions in the inventory books and the objects rediscovered in 1994.*

Descriptions of objects in the inventory books N, E and AF											
Inventory	shoe	dress accessory	belt	case	ball	gourd	music in-strument	book binding	bracelet	tool	basket
N	8	6	0	0	1	0	3	0	0	2	1
E	55	3	2	7	0	1	0	2	2	0	2
AF	1	1	3	1	0	0	1	0	0	0	0
Retrieved objects corresponding to the inventory books descriptions											
Inventory	shoe	dress accessory	belt	case	ball	gourd	music in-strument	book binding	bracelet	tool	basket
N	4	3	0	0	1	0	3	0	0	0	0
E	50	2	0	6	0	0	0	1	0	0	2
AF	0	0	1	1	0	0	1	0	0	0	0
objects not located	10	5	4	1	0	1	0	1	2	2	1

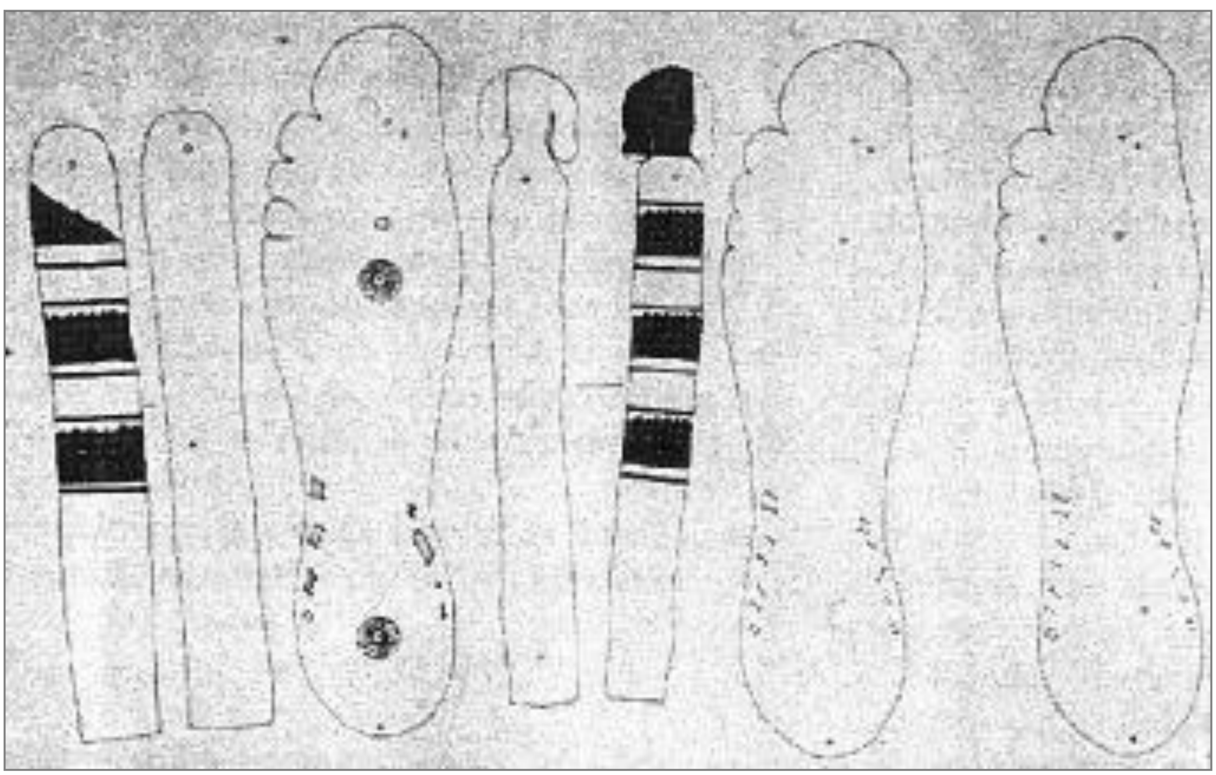


Fig. 1. *Drawing of sandal no E 12 562 (c Louvre, Ch. Larrieu, La Licorne).*

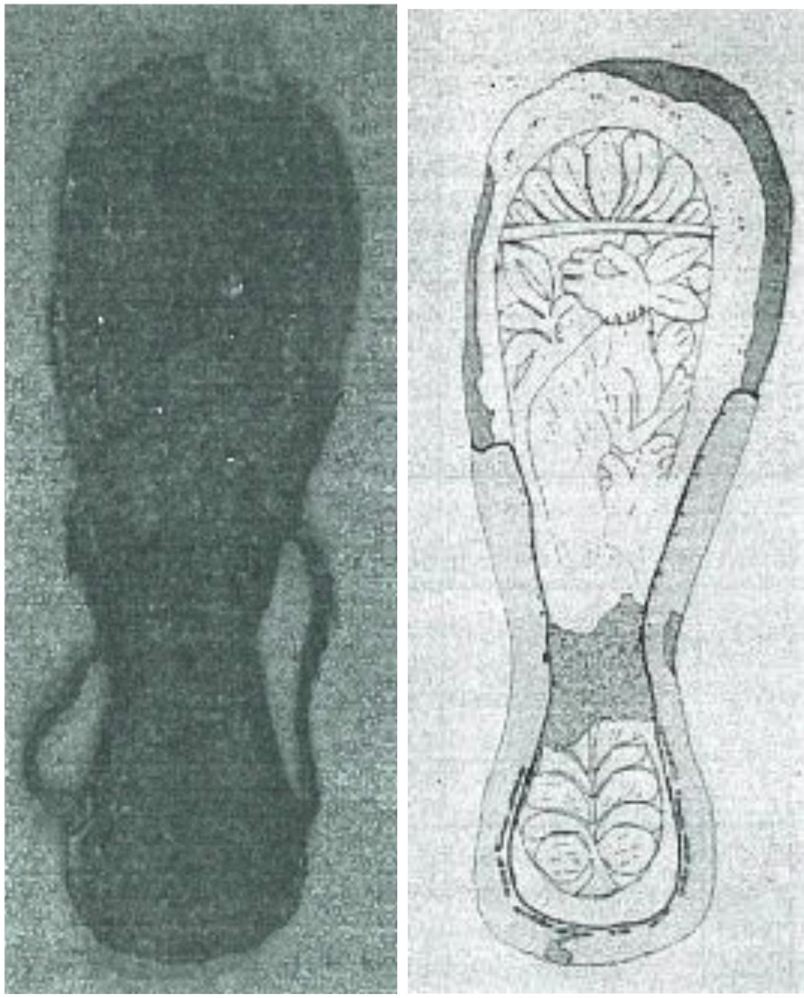


Fig. 2. *Drawing of sandal no E 13 887 (c Louvre, Ch. Larrieu, La Licorne).*

Some Conservation Problems Encountered when Treating Shoes

Marion Kite
Textiles/Organics Conservation
Victoria and Albert Museum
South Kensington
UK-London SW7 2RL

Abstract

Footwear has, at one time or another, been made from almost every type of material, but processed skins or leather are by far the most common. The skins of almost all genera have been used: fish, mammals, reptiles and birds. These skins may have been treated in almost any imaginable way in order to make highly coloured, decorative or fashionable footwear. The skins (including furs) will most likely have been dyed. They may have been painted, gilded, embroidered, transfer printed, embossed or stamped, and coated with shellac, oil, varnish, wax or any type of 'modern' polymeric material to give a final protective coating.
In most shoe collections a wide range of these materials and decorative permutations is usually represented but whatever condition these materials are in, the already complex problems involved with their treatment and care have often been further complicated by poor storage and by some of the treatments that have been applied by conservators in the past.

This paper aims to address some of the problems associated with the decorative elements found on footwear and to take note of some of the previous treatments that may have been undertaken by conservators in museums over the last 20 years. It also outlines how simple relaxing, reshaping and storage preparations can greatly improve the condition of a collection of shoes without recourse to complex invasive treatments.

It is intended that this paper be an introduction to a more in depth study to be undertaken during the course of 1995.

Introduction

In the context of costume history shoes are extremely important objects, and in recent times the current fashion of shoes has had high profile press coverage. There can be few people who are not aware of the unusual high platform shoes that the fashion model Naomi Campbell was wearing when she fell over on the Paris catwalk in the fall of 1994.
From the study of historic shoes much may be learned about fashion and taste of the day and by close scrutiny much may also be learned about the wearer.

In European culture the study of shoes reveals a direct link with other elements of fashion of the day. The design motifs and colour pallet represented in fashionable dress may be directly linked to those chosen for footwear, similarly the choice of fabrics for fashionable dress are also found in footwear of the same date. Eighteenth century silk brocades and wool damasks are commonly found in eighteenth century shoes. During the 1920s the beaded chiffons so favoured for evening wear were also used for evening shoes.
The wearing of shoes is something that crosses all cultural, social and economic boundaries and the materials which may be incorporated in them may be representative of almost all material disciplines covered by the conservation profession.

Conservation

Throughout history footwear has been made from animal skins, most processed into leather, but this is very much a generalization as there are many other materials incorporated into footwear which are just as important.
These materials may be found either as part of their structure or as decorative elements and may include leather, fur, feathers and many other 'animal' products, plant fibres, textiles, paper, timber, glass, metals (both base and noble), rubber and a huge range of modern polymeric materials (plastics). The decorative elements may also incorporate embroidery, painted surfaces, transfer printed decoration, and all manner of applied embellishments.
Shoes may be finished with varnish, lacquers, waxes and many other substances.

When considering the conservation of footwear the presence of all these materials and finishes must be taken into account when working out a treatment strategy.

Previous treatments must be noted in order to ensure the compatibility of any subsequent treatments. Records of previous treatments to leather may not always be available so a knowledge of what treatments may have possibly been used at a given time may be helpful. Occasionally evidence of past treatment is present and visible. The surface of the object may be sticky or have a deposit of salts on it which may be sampled and analysed using Fourier Transform Infrared Spectroscopy to try to determine the composition and if they are the result of a past treatment or if they have come directly out of the leather and could be associated with the original tanning or manufacturing process. Scientific analysis may not provide a conclusive result but coupled with a general knowledge of what could have been used at a given time a possible treatment history can sometimes be worked out.

At the end of this text is included a survey of treatments which are known to have been used on leather in the past and are most likely to have been used on boots and shoes.

Storage

The properties of all incorporated materials must be considered when preparing shoes for storage. Because of the huge range of materials used the selection of the best storage conditions will be difficult and always rely on a compromise.

Basic principles relating to the storage of organic materials have set the preferred standard at a stable environment with temperature of not more than 17°C plus or minus 2 degrees, relative humidity of 55% and storage in the dark but this is only a starting point when considering the ideal storage conditions required for a mixed collection of shoes incorporating a wide range of materials.

Certainly, sufficient storage space is very important. Shoes should not be stored touching one another nor boots leaning against one another. It has been shown that where linseed oil finishes have been used in the manufacturing process and a boot has been stored in direct contact with another or with a hard storage material then marking and bruising of the finish has occurred resulting in lasting disfigurement and damage.

Storage materials such as acid free tissue should be used only after much forethought and not as a matter of course to wrap and isolate a shoe. It has been seen that where complex finishes and coatings have been used, the tissue often sticks to the surface as the coatings degrade. Removal is not always possible without causing further damage.
However in general, it is advisable to store footwear with appropriate padding inside if possible in order to give support to the shape and limit the damage caused by the shoe collapsing in on itself and the original shape being lost.

Stability of the environment is essential but where ‘plastics’ (20th century polymeric materials, particularly PVC) are incorporated a slightly cooler temperature is advisable in order to try to retard the breakdown of unstable polymers. It is impossible to be specific to an exact temperature range here as there is a large range of polymers, all with slightly different requirements, and as yet not enough work has been carried out on this. Careful storage of footwear incorporating ‘plastics’ is important as the attendant consequences of polymer breakdown are the release of hydrochloric acid and the plasticizer migrating out to the surface of the polymer material leaving a wet sticky deposit. A good circulation of air is important in the storage area where ‘plastics’ are kept in order to prevent a build up of the hydrochloric acid breakdown product. If it does build up then degradation will be accelerated and there will be high risk of damage being caused to the other materials present in the shoes, particularly the leather, textile and metal parts.

Rubber is a common component of footwear but it is an unstable material and subject to degradation by oxidation. The result is either chain scission which causes the rubber to become soft and sticky or cross linking which causes it to become hard and brittle.
Much work has been done using ‘Ageless’ oxygen scavenger in a sealed environment for the storage of rubber objects but many shoes have rubber only as a component part of the whole and often it is found together with other polymeric materials such as PVC. In this instance enclosed storage may not be a good idea as a microclimate would be created allowing a build up of hydrochloric acid in the storage capsule as the PVC degrades.

Where other polymers are incorporated such as a polyurethane a closed storage system using an oxygen scavenger may be suitable depending on the needs of all other materials being taken into account.

These examples serve to show the importance of identifying what materials are incorporated in each item of footwear before the appropriate environment and method of storage is chosen.

Other Problems

Insect pests can be a problem in a collection of footwear as in any other collection of organic materials. Moths, carpet beetles and wood boring insects may be found. It is common practice to use freezing to -30°C as a method of control for some pests but where modern polymeric materials are incorporated this is not advisable and would most likely cause crazing and damage to the 'plastic' present.
Where wood-borers are present the use of 'Cuprinol' solution, a common treatment on timber, is also not possible due to the risk of contaminating and staining fabric coverings or adjoining materials. Recently, thermo-lignum heat treatment has been carried out for the control of wood—borers but this is also not possible where 'plastics' are present as it could cause accelerated degradation of the 'plastic' concerned. Treatment in a CO_2 or nitrogen rich environment is however a possibility.
Mould can be a problem on most organic materials when the humidity and temperature rise above 65-70%RH and 19°C. Stability and environmental control is therefore very important for a collection of footwear. It is only by controlling the temperature and RH that an outbreak of mould can be prevented or controlled when it has occurred. Current EC regulations on the Control Of Substances Hazardous to Health have made previous chemical treatments for mould illegal and unavailable for use.

Repair

The repair of shoes is usually a complex issue but it should always be kept in mind that previous repairs are part of the history of the object and usually should not be removed.

Reshaping is often a necessary treatment as poor storage may have resulted in deformation of the footwear or crush damage. To do this it is frequently necessary to humidify the shoe to relax the leather or fabric components and allow them to be manipulated back into their original form. A humidity chamber is essential but if one is not available, a simple structure may be built to serve the purpose using polyethylene sheet, some adhesive tape and a simple means of introducing moisture, such as an ultra sonic humidifier.

Once relaxed the shoe may be reshaped then padded out with acid free tissue to hold the shape while it returns to ambient humidity and sets in the correct shape. After reshaping, the tissue supports may be retained or purpose made supports fashioned from inert materials should be provided ensuring full support for the object whilst it is in store.

Time and effort spent on simple reshaping, providing supports and good storage facilities with appropriate environmental control will go a long way to reducing the need for complex interventive treatments in the future. In some instances where there are highly reactive and rapidly degrading materials, adhering to the principals of good storage could prevent, or at least retard the possibility of total loss of the object.

Known Previous Treatments

Aluminium Alkoxide, 1 % in mineral spirits: used as a retanning agent, having a consolidative effect. The aluminium ions cross-link with the collagen in addition to having a buffering effect.

Bavon Leather lubricants based on alkylsuccinic acid:
- *Bavon ASAK ABP*: leather lubricant applied from a solvent solution. Provides good flexibility at low levels of use. Based on synthetic paraffin long chain polymers with non-ionic water in oil emulsifying agents.
Soluble in white spirit, petroleum spirit or 1,1,1-trichloroethane, used in 2-25% solutions (10% is normal).
Painted on leather with 15 minute intervals between coats (10 coats normally sufficient to allow manipulation).
Very brittle leather may be immersed and soaked.

- *Bavon ASAK 520S:* highly polar leather lubricant based on an alkylsuccinic acid modified to give complete water solubility.
Used on intestines, bladders and other fine membranes. Very effective on drumskins and can be used on objects particularly when reshaping; water content being used to advantage. 5-20% solutions. Often useful to start at 5% working up to 20%.
Can produce a spew over time, which can be removed with white spirit.
Supplied by Frank Joel.

Bedacryl 122X, polymethacrylate ester: a consolidant for wood and some types of leather. Supplied in a mixture of xylene and n-butanol, or xylene and cellosolve acetate, or a petroleum solvent. Cellosolve = 2-ethoxy-ethanol.

Beva 371: a heat seal adhesive dissolved in a petroleum fraction. A blend of ethylene-vinyl acetate copolymers, Ketone resin and paraffin.

DDT (dichloro-diphenyl-trichioroethane): now banned but older collections may have been treated with it as an insecticide. Used on skins, leather and wool.

p—Dichlorobenzene (PDB, 1,4-dichlorobenzene, one of 3 isomers): mothballs

Draftclean: ground rubber

Ethylene glycol: solvent, substitute for glycerol in conjunction with olein soap for softening ethnographic, semi-tanned leather.

French chalk: used to clean feathers fur and chamois leather.

Fullers earth: used as a powder often mixed with magnesium carbonate. Sprinkle over feather, leave overnight and then brush off. Also used mixed to a stiff dryish paste and brushed onto surface. leave to dry, then brush vacuum off. Only suitable for strong good condition furs.

Invasol S: used as a leather lubricant. Soluble in water (up to 20%); apply in several coats with swabs. Softens leather well but it has been recorded that light coloured leathers darken.
Ciba Geigy.

Isopropanol or isopropyl alcohol (2-propanol): solvent used to soften and swell leather; to lead in water to soften hard and brittle parchment. Properties between ethanol and acetone.

Lanoline, anhydrous: used as a leather lubricant

Magnesium carbonate: as absorptive cleaner, particularly for feathers, fur, chamois leather

Opodeldoc: soap liniment of the following composition:

Camphor 40 g
Oleic acid 40 g
Alcohol (90%) 700 ml
Potassium hydroxide sol. 140 ml
Rosemary oil 15 ml
Purified water to 1000 ml.

PEG 400, polyethylene glycol 400. (25-35% in tap water): Impregnation period between 1-5 weeks. Used for treatment of waterlogged archaeological leather.

Pilantine (British Museum Leather Dressing, standard and special C): thick brownish liquid: lanolin, cedarwood oil, beeswax, 1,1,1-trichloroethane. Special G omits the beeswax. Used as a dressing for hard, brittle leather.

Pliantex: flexible polyacrylic resin based on ethyl acrylate. Supplied as a 30% solution in ethyl acetate. Used for the consolidation of fragile leather, particularly where 'red rot' is present. Used up to 10% dilution in ethyl acetate or amyl acetate (ethyl acetate is used as a solvent for nitrocellulose lacquers and varnishes).
The polymer is stable in light and flexible.
It is not swelled by water and non-tacky.
The material will not harden because no C=C double bonds remain in the polymer molecule. Because of this, subsequent polymerization of the dried film cannot occur. Ageing does not produce cross-linking with its lack of solubility. Supplied as a colourless 30% solution in ethyl acetate, it is diluted 1:4 for use. Diluents are: esters, ketones and aromatic hydrocarbons. Produces a very soft film after the evaporation of the solvent (Waterer, J.W., *Studies in Conservation* 17 (1972) 126-30).

Renaissance Wax: microcrystalline wax used for cleaning and sealing leather and ivory. High shine can be achieved useful for patent leather.

Saddle soap (Proparts): commercial leather cleaner. Alkaline pH: 9-10. Based on Neatsfoot oil, cod or sperm oil, emulsified with soap in water to produce an emulsion fat liquor. Considered obsolete, extremely alkaline 9-10 when 4-6 is most favourable for leather. Spew formation can occur and in time stiffening of the skin. See *LCN* Vol. 9, 1993

Silicone leather wax: used as a leather cleaner and lubricant

Tannic acid, gallo tannin, gallotannic acid: sometimes used to treat archaeological leather

Thymol: fungicide for leather, furs, paper, Parchment

1, 1, 1-trichloroethane: solvent, component of most leather dressings

Vulpex (potassium methyl-cyclohexyl-oleate): soap; for leather, featherwork etc. where use of water is impractical. pH 10.5-11 .5; soluble in white spirit, trichloroethane or water

White spirit (Stoddard solvent): mixture mainly of alkanes of boiling range 150-200°C. Miscible with acetone. Used as a solvent, for dry cleaning and leather treatment

The conservation of some leather upholstery from Brodsworth Hall

Aline Angus
The Leather Conservation Centre
34 Guildhall Road
GB-Northampton NN1 1EW

Saiwa-Victoria Joram
Fachhochschule
Claudiusstralk 1
D-50678 Köln

Introduction

This paper deals with a project undertaken by the Leather Conservation Centre last year. The problems encountered are commonly found, and the solutions which were worked out, may be useful to other conservators. The system of conservation was developed by Amber Rowe, who was working as a senior conservator at the Leather Conservation Centre at that time, and Salwa Joram, an intern student from Cologne.

English Heritage have recently acquired Brodsworth Hall, a large country house in south Yorkshire. The house was built in the 1860s and was continuously occupied by the same family until 1988. The decision was taken to maintain the house interior as it was found, in order to preserve the ambience of gentle ageing. To keep the worn and faded condition of the interior, only such conservation as was needed to stabilize the contents was considered. A major conservation effort was set in motion, with a time constraint as the House is due to open to the public during the summer of 1995.

Condition

Amongst other items, the Leather Conservation Centre was asked to conserve a set of eighteen matched leather upholstered chairs from the dining room. These chairs were in a range of conditions. The chairs are wooden framed with their original, deep buttoned, red leather upholstery. Many of the chairs had tears and losses revealing the padding beneath. In places the red grain layer had worn or been abraded away, leaving a cream patchy appearance.

In addition, crude repairs had been made in the past using some kind of scrim (loose woven bandage) stuck down and coloured with thick red gloss paint.

Some other furniture in the house had been treated similarly, and we were told that a man from the village had made these 'repairs' some time in the 1970s. These repairs had made the leather very stiff and had pulled at the surface, causing flakiness at the edges of the scrim. It also seems that a dilute coat of red paint had been applied unevenly in areas in an attempt to improve the appearance of the upholstery, but with subsequent grain loss the colour variations had become all the more noticeable. The chairs were also dusty and dirty, particularly in the deep buttoning, but the wooden frames and legs were in good condition (*Fig. 1* shows a chair before treatment).

Treatment

In close consultation with English Heritage curators, a method of conservation was worked out to reduce the speed of deterioration of the chairs with minimum intervention. It was decided that it was unacceptable to disassemble the chairs for conservation, and that the old repairs should remain. A system of steps was set up which was adaptable to the various conditions of the chairs.

1. Cleaning
Each chair was carefully brush vacuumed, the deep buttoning and the scrim repairs being particularly dusty.

2. Consolidation
The lifting surface flakes, generally found around the edges of the previous repairs, were treated with 5% Paraloid B72 in toluene to consolidate. Then the flakes were set down in place using EVA Vinamul 3254. These materials were selected for their ease of use and stability.

3. In-painting
In the areas where the grain layer was missing, leaving a bright cream colour, a diluted solution of Stahl leather dyes was painted on to reduce the visual impact.

4. Replacement of leather losses
In the places where the leather was missing, the cream kapok or black horse hair padding was visible.

Thick japanese tissue (from Falkiner Fine Papers) was coloured using acrylic paints (Winsor and Newton) to tone with the red leather. This was cut to shape and placed behind the area of loss. If necessary, the edges of the leather were tacked down onto the paper using a little Vinamul 3254, although for the most part the paper insert was held in place by the pressure of the surrounding upholstery.
The japanese paper has an even and natural texture which blends well with the leather, whilst still being visible as a repair. It is also easy to colour and use.

5. Support and protection of the leather
Different methods of holding the surface together, strengthening the leather and reducing further damage to the flaking grain layer were considered. The seats and the seat backs, which had sustained the most damage, required support with an appropriate material. As it was not possible to work from the underside of the leather, weak and torn areas would have to be supported from the top surface. The most suitable material was found to be a woven nylon net, which has been used widely in textile conservation. When the net was dyed to tone with the upholstery, it was only slightly visible and also had the effect of suggesting a more even colour and improving the visual appearance of the, leather.

All of the chairs required netting on the chair seats, and most of the chairs needed either the top of the chair backs and the reverse of the back covered, or both. The woven nylon net (Dukerie Textiles, Nottingham) was dyed specially for the chairs using Ciba Geigy Lanaset dyes. It was then pre-coated with Beva 371 diluted in toluene and Genclene (1,1,1-trichioroethane) to which a small amount of red/brown Stahl leather dye had been added to reduce surface ghosting. Beva 371 was selected for its long term stability, reversibility and ease of application. It was adhered to the surface of the upholstery by heat activating the adhesive film using a heated spatula set a 80°C.
The net for the seats was pasted only around the sides, leaving the top without adhesive. The net was not completely adhered to the surface of the seat because it was better from a reversibility point of view to have as little of the adhesive in contact with the leather as possible.

It was also considered that to cut and shape the net into the areas of deep buttoning would be too time consuming. If netting was required on the top of the chair backs, it was trimmed unevenly across the front to disguise the edge (*Fig. 2* shows a chair after treatment).

Conclusion

Once this system was established, it was found to be applicable to other upholstered leather furniture items from Brodsworth Hall, either wholly or in part. Aspects of the treatment have also been used in other projects unrelated to the Brodsworth Hall collection, the Japanese tissue infills having been particularly useful.
It is recognized that this treatment is by no means a permanent solution. The conservation of the interior of Brodsworth Hall is a very large project, with constraints on time and money, and having a policy of keeping the contents looking used. However, the chairs are stabilized for the moment, until Brodsworth Hall is up and running and a rolling conservation programme can be started.

Product Information

Beva 371 (thermoplastic wax/resin mix adhesive): available from AP Fitzpatrick
Studio 1
10-22 Barnabas Road
London, E9 5SB
(The sole authorized producer in Europe is: C.T.S. s.r.l., Via Piave 20/22,36077 Altavilla Vicentina (VI), Italy)

Japanese Tissue: available from Falkiner Fine Papers
76 Southampton Row
London WC1B 4AR

Lanaset Dyes: available from Ciba Dyes and Chemicals
Hulley Road
Macclesfield
Cheshire SK 10 2NX

Nylon bobbin net: available from Dukerie Textiles and Fancy Goods
Fearfield Buildings
4 Broadway
Lace Market
Nottingham NG1 1PR

Paraloid B72 (ethyl methacrylate co-polymer, in solution with toluene): available from conservation suppliers.

Stahl leather dyes (water soluble dye solution): available from Stahl GB Ltd
Bakewell Road
Loughborough
Leics. LE 11 ORD

Vinamul 3254 (vinylacetate-ethylene copolymer, available as an emulsion): available from conservation suppliers.

Fig. 1. *A chair from Brodsworth Hall before treatment*

Fig. 2. *The same chair after treatment*

Some Remarks on the Conservation and the Exhibition of Ethnographic Leather

L.M. Chiotasso, C. Sarnelli
Vejle - Restauro Conservazione Cuoio Tessuti
Via P.A. Grammatico 52
I-00 144 Roma

Introduction

Every ethnographic object has its own life we can schematize along a temporal axis with a starting point corresponding to the time of the manufacturing of the object. Along this axis it is possible to locate two full stops and several variables. The two constants are: the pre-existent conditions of the artifact before its arrival to the museum's collection and its present condition and location. As the first constant divides the temporal axis in two parts we can imagine two different lives of an ethnographic object: the former in the place of origin and the latter in a private or public collection.

Sometimes the position of the first constant along the axis changes from case to case and often it can be coincident with the manufacturing itself because a considerable part of these objects, as we know, were ordered by explorers or missionaries. As these objects were not made to be used but to be taken from their place of origin to end up in a private collection or museum, they have a different value from those that were made to be used. As well as conceptual differences, real ones such as the lack of signs of wear and tear and possible changes in the normal aboriginal manufacture occur.
On the contrary the variables could have resulted from moving the objects from their original location to their present one or from the methods used in their preservation. This last variable is often lacking as a lot of specimens of Italian ethnographic collections are still in packing cases or resting on some shelf, table or frequently on the floor in a sort of limbo.
Some of these variables could be already present in the first life of an object. The example of the harness belonging to the Pigorini National Museum is peculiar for its original repairs. Damask cloth covering the saddle had a strange patch in the middle made of a similar damask. This patch was an aboriginal repair to hide the underlying shabby part before the harness was to be given as a present to the King of Italy, Vittorio Emanuele III. However this is a singular case as generally, the artifacts that we have conserved, have been used as in the case of a quiver with a hunter-pouch coming from Somalia. This object showed obvious signs of wear and inside the pouch were still to be found organic remnants, like feathers, berries and vegetal fibres. On the other hand a pair of kabu (feminine sandals) could be the result of a specific request as they do not show any sign of wear.

In the second life of the ethnographic object, starting from its arrival in Italy, the situation grows more complex *(Fig. 1,)*: we can presume six routes in which each of them has two moving variables, exposition and storage. In the first two examples the situation is simple as the object has always been exhibited or it has not. In the other hypothesis these two variables alternate and can move along the temporal axis. However this temporal axis related to the object's life is something of an ideal, it is the goal we have to reach before conserving or restoring. In fact a typical situation corresponds to a broken line with several gaps as the information on constants and variables is often incomplete. Unfortunately both carelessness and thoughtlessness may occur in a chain of events causing a loss of data. In order to have a complete picture on ethnographic objects we have to consider all of these points because the presence of a gap along this axis would prevent a complete understanding of the condition of the artifact.

We must fill these gaps using all the suggestions at our disposal as every kind of written information, former or present, any visual evidence (drawings and photos) belonging to the museum or related to other collections and last but not least the so called oral tradition reported from the curators themselves. Collecting this data before starting treatments, enables us to operate in the best way possible as we know everything about the object.

Two different situations of ethnographic collections: central, or the Pigorini National Museum of Rome and peripherical, or the Ferrandi Civic Collection of Novara.
The Pigorini National Museum is carrying out its plan for the new exposition of its collections.

This plan follows a technical filing and a preventive conservation on artifacts started in the '80s and still in progress [1]. A part of these artifacts came from previous expositions and a part was still in storage. The entire project is coordinated and executed by the museum's staff with a contribution during the last years of private conservators. The technical filing emphasized the condition of the artifacts and enabled us to establish a plan of priority in the conservative treatments. We identified traces of pests, so reducing deterioration factors. On the other hand the preventive conservation of the objects in the Novara Civic Collection was an attempt to repeat, in a different way, a similar experience restricted to African artifacts, in particular from Somalia, and noted by the National Museum's curators.

The damages we have found in the objects are due to wrong exposition or incorrect storage. The leather conditions of the specimens belonging to the Ferrandi Collection were not so disastrous. Generally there was a medium stiffness of the skins and many of them were covered with a thick sedimentary layer of dust. The leather conditions got worse where particularly mechanical damage was connected with the objects' exposition. Leather shields were hanging on the wall by means of metal wires driven in the edges while the sandal labels were brutally attached to their inner soles. Moreover many leathers were covered by a kind of varnish irrelevant to the object as in the case of a leather pillow-case; the varnish made both pattern and colours illegible. Thanks to the oral tradition of the curators themselves we knew that it had been over-zealous action of custodians doing their duty. These coverings were easily removed by an organic solvent.

In other specimens the mechanical damage was the result of clumsy handling which occurred during the removal from the old exposition to the present temporary storage.

In a container made of pumpkin the tape bearing the name of Gondrand, the haulage contractor, was still visible screening a split in the rind. In other African objects of the Pigorini Museum, we noticed a series of damages due to exposition, in fairly sound leathers. A wrong support with evident tensions caused the considerable deformation of a lion skin mantle lined with satin. The fabric's abrasion along the edge of a shield was due to rubbing on something hard in the past, maybe a shelf.

The situation got worse in ethnographic Eskimo objects. Semi-tanned leathers are usually weaker than the fully tanned ones and they need more particular care to protect them from the effects of pollution and leather pests. The poor durability of this kind of skin increases the seriousness of the damage caused by mistakes in exposition or in storage. An Eskimo coat, according to the museum's card, has suffered several damages due to pest attacks, heavy disinfection, unusual dressings and storage without any proper support. Every one of these factors has caused a fast biodeterioration visible in the hood's splits and in the considerable thinning of the sleeves.

In many cases irreversible damage to ethnographic objects, made wholly or partly of leather, occur more often from the type of support they received during expositions than from the softening agents and the repair materials used to reshape and to strengthen them.

Case Study: Inuit Parka

In preparation for the permanent exhibition 'America' at the Pigorini National Museum of Rome, an Inuit parka was chosen to be displayed on a support simultaneously constructed to the conservation work.

This artifact, belonging to the Angmangsalik culture, has a long life or a long temporal axis because it was already described and illustrated in the 1667, as we know from the museum's card, on the Breve Descrizione del Museo Cospi.

Condition

The overall condition of the parka as received was fair. In particular we found out four levels of condition: good for the back prolongation, medium for sleeves and body, poor for the shoulders and bad for the hood called Amaut in Inuit language. Every level corresponded to a different thinning of the sealskin. For example: a good consistence of the back prolongation corresponded on the front side to a progressive thinning upwards; the sleeves with regard to the body were much thinner and stiffer; the top of the hood had reached a dangerous pergameneous consistence.

Traces of old pests were visible from the small and the medium holes on overall checking, particularly on shoulders and hood.
A loosening of seams with loss of the sinew threads had occurred on the sleeves, hood and in the upper part of the breast. Previous conservative treatments had replaced the lost sinew threads with white cotton yarn so that they joined the various parts of the hood and the neck. This treatment, even if questionable from an aesthetic point of view, has avoided the risk of losing important fragments. A serious tear of the right sleeve was the consequence of of wrong exposition or clumsy handling.
The Pigorini's example is very symptomatic.
The different colours of the parka sealskin are due to several reasons: the manufacturing itself, the ageing and last but not least the previous tests of dressings with olein emulsion soap as mentioned on old museum cards.

Conservation

The goal of the restoration was the conservation of the artifact and its exhibition on a specially constructed support. On account of the condition and since the shoulders and the hood, in an exhibition on a support, should be stretched a under their weight, we decided to reinforce the weakened areas with a consolidating support with the exception of the back prolongation.
The steps of the restoration were, in summary:
- softening and turning the parka inside out
- consolidating support
- integrations and seams
- lining.

Softening and Reshaping

Several leather treatments normally used were tested to determine which method would soften the sealskin and maintain the original appearance without darkening. Both the incorporation of olein soap in emulsion form [2] and the impregnation with humectant [3] do achieve a softening, but in our specimen these methods really changed the surface appearance contrary to previous literature [4].

It is to be pointed out that the subjection to high humidity did not change the color of the sealskin [5] but did not soften it sufficiently to be able to turn it inside out.

Based on this experimental data, sorbitol was chosen as the softening and reshaping agent in our specimen which was particularly dried, quite crushed and light coloured.

According to Stambolov's experiments [6] and after Sturman [7], on objects of the same nature, we slightly modified her recipe and the solution of 1.5% sorbitol, ethanol:water, 1:1 to which several drops of Preventol® were added, was satisfactory.

Consolidating Support

A variety of materials are used to support weakened areas. We tested new leather, silk crepeline, nylon net and nonwoven fabric [8]. Silk crepeline and nylon net proved to have no sufficient mechanical strength and in addition to this the nylon net became very stiff when treated. On the other hand the use of new leather and nonwoven fabric involved an high increase in thickness to obtain a satisfactory resistance to the mechanical traction.
An alternative supporting material was tested with good result in this specific case i.e. the Stabiltex® 4/3. Stabiltex® is a polyester multi filament cloth used for textile preservation work as a support fabric with stitching and adhesive techniques. It is heat set, not finished and available in different grades. Stabiltex® 4/3 is a fine plain weave where number 3 is the color indicator, it has a good resistance to mechanical tractions at a minimal thickness.

Choice of Adhesives

The adhesive had to satisfy the following requirements: retention of the appearance and character of the skin; reversibility in accordance with the directions of the Museum.
Generally, leather objects have been treated with a variety of adhesive including: vegetal glues [9], animal glues [10], polyvinyl acetate, epoxy resins [11] and so on. However leathers and skins, in the case of ethnographic objects, are so variable that the effect of an adhesive is not consistent from one artifact to another. Excluding the epoxy resins for ethical reasons, although they are sometimes used, and the vegetal and animal glues because they are subject to attacks by insects, we chose polyvinyl acetate after negative tests with acrylic resins.

In particular we selected three PVA emulsions (Neovil R, AB 52 and BM 400).
After visual results the first of these was chosen. Neovil R is a viscous, quick-drying polyvinyl acetate emulsion with a slightly acid pH, a low penetration and a higher flexibility than the other two tested (AB 52 and BM 400).

Supporting

Prior to any operation a full size scale plot of all the parts forming the parka was done with the exception of the back prolongation.
Every single part was numbered, transferred onto tissue-paper and then onto Stabiltex®.

As in dressmaking each part was left projecting some 2 centimeters beyond the perimeter of the tissue-paper patterns. The adhesive was spread on the flesh side of every single 'tessera' (one of the parts forming the parka) and an equally spare layer of adhesive was spread on the corresponding Stabiltex® part and pressed onto the artifact.

The orthogonal grid of Stabiltex®, in this case, enabled us to spread the emulsion equally and sparingly and also to check the surface and to remove an eventual surplus of adhesive.
The stages were conducted step by step in a humid chamber (70% RH) keeping the artifact softness under control in order to turn it back again.

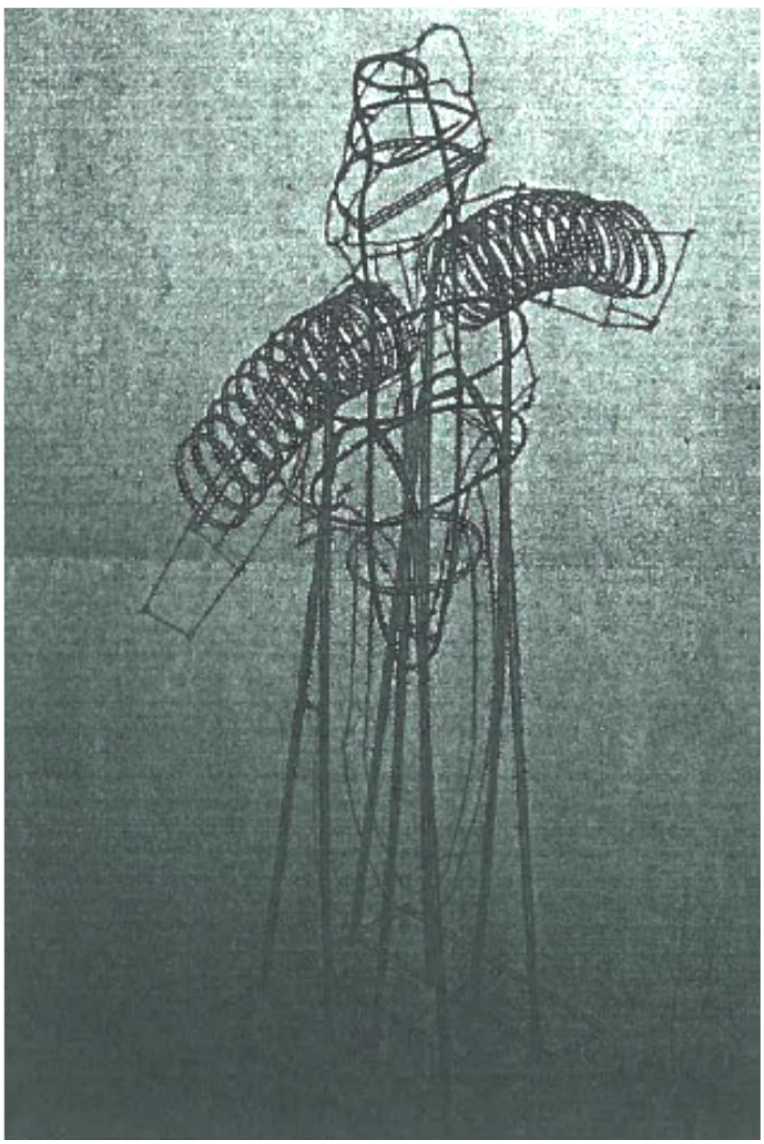


Fig. 1. *Support for the parka: a schematic mannequin made of stainless steel wires; progressive stage of the support with its basic parts.*

The large tears were mended with leather and the loose seams were replaced with silk thread. The use of silk reduced the stress in the original holes avoiding their breaking.

The support

The research into and the manufacture of a suitable support were conducted simultaneously to the conservation work. This approach was already employed in two cases, similar in brittleness but different in culture, period and material: the wig of Merit [12] and the sandals of the Queen Nefertari both dating from the New Kingdom, Ancient Egypt and conserved in the Egyptian Museum of Turin. The supports are based on the fundamental idea of a grid. The use of reticular typology supplied several supporting points to most parts of the artifact. Every line or point is necessary to sustain and sometimes to fix individual parts of an object. It was the case of the archaeological finds above-mentioned, for example, where every single braid or many fragile parts of the vegetal fibre needed systematic anchorage. Moreover the reticular typology can be changed on every moment, as occasion may require, or altered because its structure is composed by moving complex curves like meridians and parallels. Our intent was to achieve a shape keeping to the internal form of the parka, avoiding dangerous creases to the skin and allowing a good exposition without being intrusive or conspicuous.

The support is a sort of a schematic mannequin *(Fig. 1)*: it is not formed with closed volumes fitted together as those used in costume collections or in dressmaking but it is formed with open volumes made of thin metal wires. The parka's lightness and frailty made it necessary to resort to an easily workable material i.e. an harmonic stainless steel (18/8-1.5/3/8 mm ø). Information about the anthropometric study on the Inuit was supplied by the collection's curator. It was the starting point for plotting the specimen. Realization was improved by the progressive work of moulding the support. When necessary it was possible to change simultaneously from the practical execution on the model to the full-size scale drawing. All the crossings have been fixed by micro-soldering.

Conclusion

In Italy the recognition of the ethnographic collections is a comparatively modern event. These collections have often been viewed as a sort of Wunderkammer: a place where a collection of heterogenous objects, often unusual, and unfortunately was treated with no particular attention because of their strangeness.
So the museum life of these artifacts can be long, complex and subjected to mishaps and deterioration along the way. Conservation work, when necessary, can start when the objects are recognized in their own specificity as an aboriginal work of art or as an expression of material culture. A philological research settling the efficacy of every object and a scientific one testing the material condition have to be prior and basic to the conservation work. Moreover the recognition of the physical state of the object is connected with that of its placing in space. Conservation in its entirety must include the preservation of the materials from which an object is made, the way in which it is exhibited and the surroundings in which it is exhibited in order for it to give maximum enjoyment.
In tridimensional objects the conservation should be carried out when necessary with the use of a support that is able to convalidate the position of the object in space.

Acknowledgements

We are indebted to the Pigorini National Museum of Rome for the opportunity to work and experiment continually on ethnographic specimens and also Dr. M. Montanan, Works Director of the museum itself. We are also grateful to Dr. C. Nobili and Dr. Antinori, Pigorini National Museum's curators, for suggestions and helpful discussions.

References

1. Fossá, B., 'Les interventions pour la conservation préventive des collections ethnographiques du Musée National Préhistorique et Ethnographique 'L. Pigorini' a Rome'. *Troisième Colloque international de l'ARAAFU*, Paris. 1992. 145-153

2. Schaffer, E., 'Properties and Preservation of Ethnographical semi-tanned Leather'. *Studies in Conservation* 19 (1974) 66-75

3. Stambolov, T., 'Conservation and Restoration of Gilt Leather'. *Konservering og Restaurering af Laeder, Skind og Pergament*, København (1980) 309-3 14

4. Hallebeek, P. and H.A.B. van Soest, 'Conservation of Caskets and Furniture Covered with Leather'. *Preprints to the 6th Triennial Meeting, Ottawa. ICOM* (1981)19/4-1
Schmitzer, W., 'Conservation of Leather Objects in Ethnographic Museums'. *Preprints to the 5th Triennial Meeting, Zagreb. ICOM* (1978) 3/3/1

5. Peacock, E.E., 'The Conservation and Restoration of some Anglo-Scandinavian Leather Shoes'. *The Conservator* 7 (1983) 18-23

6. Stambolov, T., 'Manufacture, Deterioration and Preservation of Leather'. *2nd Triennial Meeting, Amsterdam. ICOM* (1969) 56

7. Sturman, S.G., 'Sorbitol Treatment of Leather and Skin: a Preliminary Report'. *Preprints to the 7th Triennial Meeting, Sydney. ICOM* 84.18.22

8. Peacock, E.E., op. cit., 21-22

9. Hallebeek, P., and H.A.B. van Soest, 'Gilded Leather'. *Preprints to the 5th Triennial Meeting Zagreb ICOM* (1978) 19/2/1

10. Stambolov, T., op. cit., 62

11. Waterer, J.W., *A guide to the conservation and restoration of objects made wholly or in part of leather.* London (1973) 39

12. Chiotasso, L.M., and C. Sarnelli, 'La parrucca di Merit'. *Sixth International Congress of Egyptology.* Vol. I, Torino (1992) 99-105

Materials and Suppliers

Sorbitol: Ardet Trading, via Vittoria 32, 10100 Torino

Neovil: Bielli, Via Catania 39, 10100 Torino

Preventol: Bayer Italia SpA, Viale Certosa 126/1 30, 20156 Milano

Stabiltex®: S.S. Zurich do Ballerini, Via Edison 193/1 95, 20019 Settimo Milanese (Milano)

Planning & Realization of the Support:
P. Chiotasso, G. Rigoni Garola do Via Balbo 33, Torino

The Deltaplan and Skin-Related Materials

Jaap van der Burg
Projectmanager Deltaplan
National Museum of Ethnology
P.O. Box 212, NL-2300 AE Leiden

Since preventive conservation for wood or paper is quite similar to preventive conservation for textile and leather this paper deals with preventive conservation in general. However I will focus on the problems in conservation of leather and skin-related materials, as parts of a large scale project in preventive conservation, moves, documentation etc.

The Why of the Project

Every year the Dutch General Audit Office controls a Government organization. In 1988 it was the National Museums turn. To cut a long story short: they came to the conclusion that the Dutch National Cultural Heritage, its storage and its preservation was, to say the least, in a very poor condition. Bad enough to be called a National Catastrophe. Because of the magical combination of the terms National and Catastrophe a relative large amount of money was set aside to stem the tide covering however only 10% of the estimated backlog.
Dealing with government money, the flow and use of the funds had to be regulated through a plan. This was the Deltaplan for Cultural Heritage.

The National Museum of Ethnology in Leiden is the biggest user of the Deltaplan for Cultural Heritage in The Netherlands. The funds are used to move the complete collection of over 200.000 artifacts, of which Ca. 20.000 with leather related materials, from the old storages in attics and cellars to new storages in storehouses and renovated attics. The new storehouses are located at ‘s-Gravenzande, 37 km from Leiden. This project was initiated in 1991 and will take about 5 years; during this period it will provide work for over 30 people working as Conservation Technicians.

A large part of these project-workers originate from the unemployed people pooi of Leiden. After a one-year period of training, during which they were paid out of Social Security funds, they were hired for the duration of the project. Since museum work and especially conservation was new to them they had an ‘on the spot’ training by conservators. This training ended for the technicians with a certificate from the State School for Conservators and for the training itself in a National education for Conservation Technicians. The conservators still have a very big input in the projects since they are responsible for, what we call, quality control.

Once you start working on a complete collection like this you tend to use this ‘once in a lifetime’ opportunity to do as much as you can squeeze in. So apart from just moving the artifacts we decided to enter them in a database, dust, label, photograph and, where necessary, support them as well.

During the span of the project a part of the museum is renovated, and another part will be renovated soon. During these renovations about 90% of the collection will have to be housed in our Outside Storage. After the renovation about 30% will return to be stored inside the building in Leiden. We estimate that eventually about 3% will be on display. To add to the confusion; two of the outside storehouses are ‘upgraded’ from just a stone building with heating equipment to proper museological storages.
I will not go any further into the inroads this makes in the project. You do not need much imagination to perceive what this means for planning, logistics and double and triple moves, not to mention the demotivation of the people involved. This is enough for a presentation in itself.

What kind of problems do we find?

Next to the well known artifacts as shoes and harnesses made out of tanned leather and coats and hats made out of fur, we encounter skin-related materials in a lot of other objects, for example drums, string-instruments, pouches, belts, floaters, canoes, tubes, plugs, dolls, figurines, etc.

Materials involved are; gut, bladder, dried skin, hide, tanned skin, hair, feathers, fish skin, horn, etc. Many of the artifacts are just dusty. Unfortunately all the other thinkable damages are there as well.

To name several; brittleness, loss of hair, tearing by drying, mould, infestations by insects and rodents, distortion, rot, loss of stability, excess of fat and grease, sticky varnish, unbound pigments.

What do we do about the problems?

I will run you through our project by following a Kalimantan warcoat. Together with 15 others this warcoat was improperly 'stored' in a wooden drawer. First we removed them from their old, humid, storage. Then, one by one, we dusted the artifacts. No solvents or liquids were used, only brushes and moving air.
If, as in this case, there is mould on the object, we use a separate room kept for 'mould-treatment'. Here we brush the mould from the object. The spores are suctioned out into the open air. When the mould is growing on hair, we do not use the brush in a stroking direction since the risk of pulling the hairs out of the skin is too severe. Instead we tap the hair. Usually this is enough to release the visible mould growth. We do not use any other treatment against mould. We try to prevent a new growth by means of adequate storage. Stains and discolouring are not treated at this stage.
Quite often we find insect infestations or debris as well. We usually try to remove these with a pair of pincers. This work is done only by our conservators. Sometimes the leftovers of a former hair growth are the only indication left on the slin. Then we will try to leave it in place for future reference. Of course we secure these objects from the rest.

Once the Kalimantan warcoat is 'cleaned' its label will be selected from the pre-printed stack. With use of the bar codes on the label the object is photographed and its image stored in the computer. For transport and storage we try to support the objects wherever necessary, using Ethafoam, foambord, fiberfill and acid-free tissue. Of course we try to use our space as economically as is possible but in the end we prefer to move and store cubic meters of air to incurring a possible risk for the objects.
When we are certain an object is carrying an active infestation, we fumigate it before any other treatment. For this we use CO_2in a minimal concentration of 64% over a 28 days period at a temperature of 25°C.

We use this particular method mainly because it was commercially operational at the start of the project. Now we are looking into alternatives like freezing, low O_2 and N_2.

Because we have to move our objects quite often, and most of the temporary storages have not been disinfected before use, all objects made of organic material which are susceptible to insect infestation are fumigated as a standard operation before they are placed in their new storages.

For this particular Kalimantan warcoat a total of 46 minutes was spent in treatment, including (shared)transport from storage to fumigation and back. All objects which for the greater part are made out of skin or hide we store in a cool-cell. Unfortunately this cell will only maintain a minimum temperature of 10°C. With this low temperature we hope to slow down any chemical deterioration as well as most infestations. Of course we try to maintain a regular airflow and normal humidity of 55% RH.
The other artifacts are stored in the large storage rooms.

Despite our lack of space, objects we deem 'fragile' will not be moved more than is absolutely necessary. For this special category we have reserved some of the storages in the main building in Leiden. Whenever possible and necessary we will call in external expertise, Mr. Van Soest, a leather conservator, who does most of the urgent active conservation.

What do we leave and is left to be done?

First of all we leave a complete change of scope. Usually a conservator is likely to focus on one object or a small group of artifacts at the time, that he or she wants to treat for 100%. We were confronted with a mass of 200.000 artifacts that all had to benefit, as much as possible, from our limited resources. So choices had to be made. Our preferred treatment as we did at the start of the project took us 48 minutes per object excluding all extra moves etc. and without any active conservation. Because we had to show the financiers (politicians) results we had to cut the total project up in two phases. In phase one our limited time and resources forced us to cut the average treatment down to 24 minutes per object, including transports etc.

So we will do about 30% of the total task. The total task then includes all active conservation on individual artifacts. Phase two will have to take care of the rest. For this several smaller projects will have to be defined. Most of the artifacts we have handled will not deteriorate any further in the near future.
At the beginning we made a condition report of every damaged artifact we treated. This resulted in such an amount of data with such a varied reference that we decided to take this task from our schedule. Our conservators are working on a condition-report that can be used for groups of artifacts instead of individual artifacts.
After this large move we will, for the first time in this museum's history, have an inventory of what we have and how bad its condition is.
We will use these data to plan follow-up projects. Part of the collection will be out of immediate danger at the end of phase I; another part will be stored, packed in boxes. Both for accessibility and for preservation these boxes will have to be unpacked in the near future. Some of the projects will include improvement of storage (-systems). In others we will go into further active conservation of materials that still do deteriorate and in the odd instance restoration. Further, we hope that we can convince our board that a larger, and cooler, storage is wanted for leather.

Projects including skin-related materials might be:
- maintenance
- reuniting parts of artifacts with their main bodies
- stabilization of unbound pigments on skins
- further improvement of individual storage in the refrigerator
- better individual support for Shadow Puppets
- treatment of feathers
- degreasing sea-mammal skins
- future pest eradication treatments and
- old restorations
- last but not least our aim is to have as many museums and institutions benefit from our experience.

The project we are involved in is one of the largest in its sort. I am sure we made some, if not several, mistakes. I am equally sure we found solutions and gained expertise which might be of use to you and others.

We might not have all the solutions yet, but we sure do know most of the problems related to storage, registration, logistics, preventive conservation, and as it is called nowadays, human resources management.

Usually we all shrink back from working at basic 'all-over' improvement in our collections storages. This is usually caused by the sheer magnitude of the task. We learned that slicing up this task into smaller, digestible, portions has two positive sides. First a short term result expectation will make the project more interesting for the financiers (usually politicians). Secondly, and maybe even more important, there is the effect of results on the moral and motivation of everybody involved.

There is a big risk though as well. The short term result might be judged to be enough, and finances for a follow-up or second phase might be endangered by that. We laid the foundations and built most of the groundfloor of a, possibly very beautiful, building. But our work derives its merit from what is done with its results in the future.

The building will have to be finished, at least a roof has to be put on, and the maintenance crew will have to pay it a regular visit.

Acknowledgement

I would like to express my thanks to Birgit Kantzenbach and Netta Krumperman for their assistance in putting this paper together.

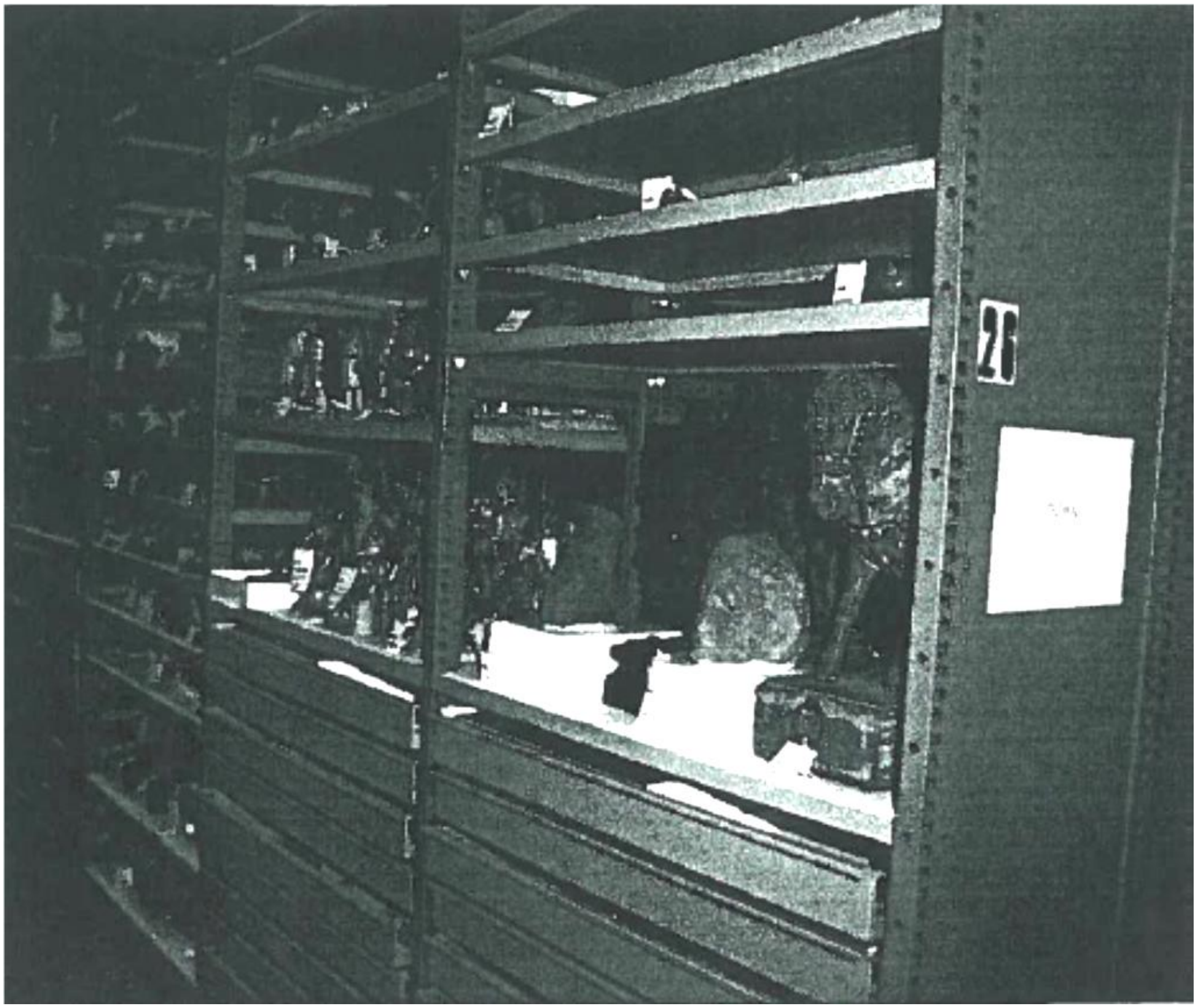


Fig. 1. *New storage facility with metal shelving. Ample space for objects and figurines from India.*

Conservation of a 17th- and 18th-Century Polish Gala Saddle Accessories from the Collections of the National Museum in Poznań

Dorota Jutrzenka-Supryn, Halina Rosa
Nicolaus Copernicus University
Laboratory of Paper and Leather Conservation
P-Torun

The 17th and 18th century gala saddle accessories from the National Museum in Poznañ, which underwent conservation work, were composed only of leather parts of the proper accessories i.e. headstall, crupper and breastplate. The reins and bridle were missing from the breastplate. The saddle was made of horse leather, painted red, sewn with silver thread and richly ornamented on the grain side with silverpieces with Niello decoration or gilded and set with precious stones.
The individual parts of the accessories were joined with large buttons and sheet metal which were silver, niello engraved, gilded and set with precious stones.

The object presented a very complex conservation problem because of the variety of materials of which it was made. Therefore it was necessary to prepare a wide range of work taking into consideration different properties of individual materials and other conservation methods to be applied. Another problem was related to the fact that some elements could not be separated.

The conservation of the saddle accessories aimed, first of all, at an improvement of its damaged condition and at stopping in process of ageing. As the object had a very significant historic importance combined with a great decorative value, a decision was taken to reconstruct the missing silver elements and precious stones. The purpose of the task was to complete the artistic outlook of the whole and to join together the elements of accessories which had been separated earlier (1).

Techniques of Execution

The main structure of the described saddle accessories is made by straps of horse leather tanned with plant substances and painted red. They are sewn on the flesh side with flaxen threads and on the grain side with silk threads on silver warp.

The joining areas of individual leather elements are decorated with silver buttons and sheet metals. The grain surface of belts is decorated with silver pieces too.

The pieces were formed into the shape of flattened rings and pulled on the straps of grease-tanned leather owing to which it was possible to attach (sew) them to the straps of the basic structure.

Silver sheets, buttons and pieces are decorated with ornaments executed in three techniques: niello and/or engraving with punching.
The engraved and punched fragments were gilded. Buttons and metals as well as all the gilded pieces are additionally set with precious stones. Carnelians were used for this purpose. On four of the largest buttons and metals, tourmalines and pomegranates were applied additionally, set together, 5 or 3 in a row.
A delicate, geometrical sketch was shallow-engraved and gilded in the carnelians, used to set buttons and metals as well as pieces for the crupper with precious stones.

Condition of preservation

The individual parts of the saddle accessories showed different levels of deterioration.
The headstall was relatively the most damaged and the crupper the least.

The leather parts underwent mechanical, physico-chemical and biological damages.
The leather grain was frayed in many areas so as to show its thermostatic layer. A source of mechanical deterioration was the fact that some robbers tore silver parts off the leather.
Two original silver buttons which must have existed on the connection between the nose band and the cheek straps were removed in a way which involved 'tearing out' of the end fragments of the nose band. The edge of the brow band was damaged too through cutting off so deep as to show the inner structure of the stitch. The physico-chemical deterioration included visible drying up of the leather which resulted in a tendency to break into pieces and powder, particularly on the flesh side.

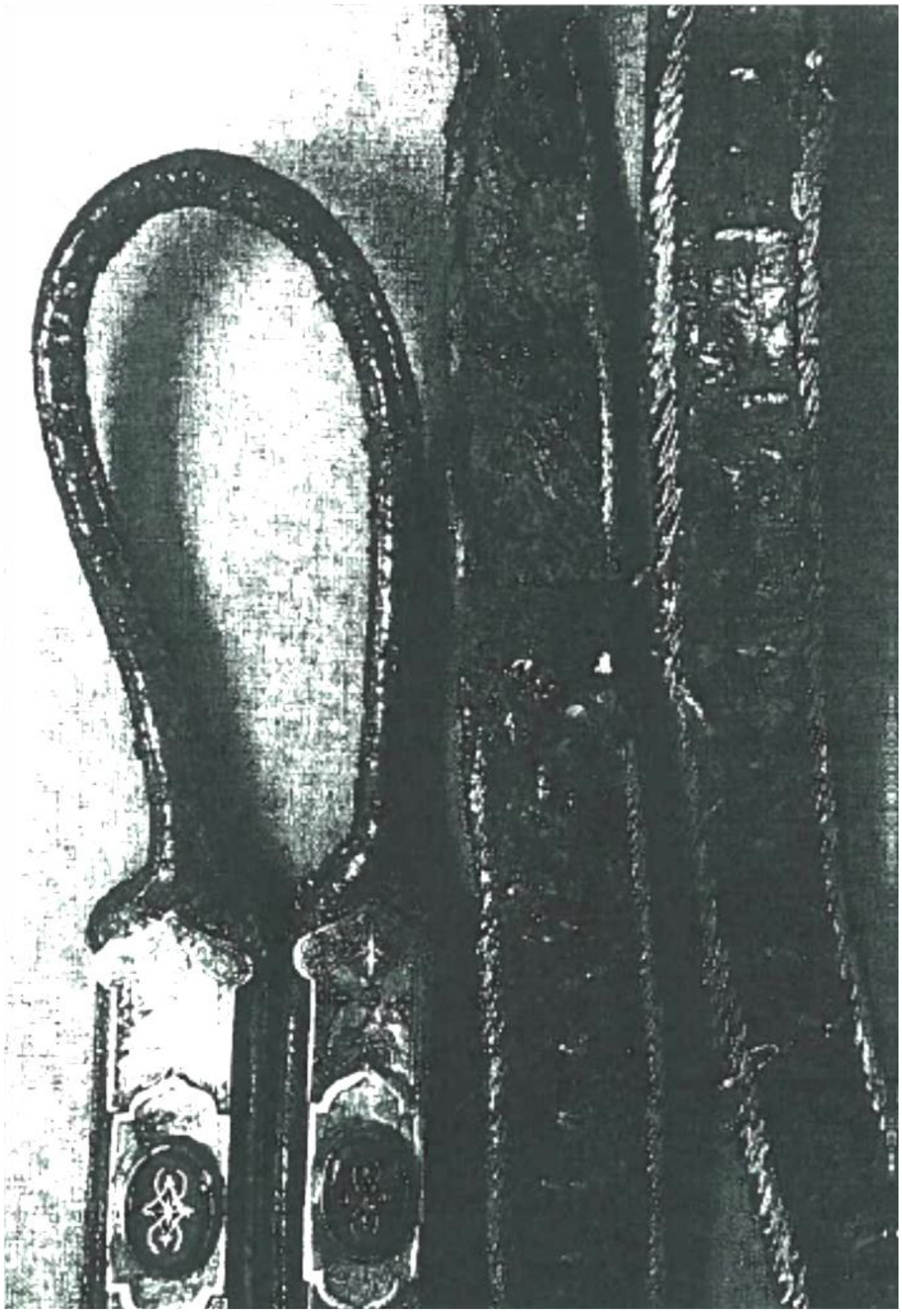


Fig. 1. *The saddle accessories before conservation, detail.*

The leather became very stiff in the areas where the saddle accessories were exposed to the sweat and foamed saliva of the horse. The incrusts on the inner side of the nose band were particularly extensive. They were also present on the flesh side of the crupper straps close to the crupper loop and on the flesh side of the cheek straps in the areas where the bridle was attached.

The microbiological deteriorations were caused by the activity of insects (a dermestid, *Attagenus piceus*). The most susceptible to their attacks were those parts of the leather which had been joined together with the use of starch glue.

Particularly extensive deterioration was ascertained in two leathers glued together, under the metal of the nose band.

It was possible to notice a relation between the level of impregnation of the leather through incrusts and the choice of feeding grounds made by the insects (they devoured impregnated areas with greater intensity).

Silver threads of the decorative sewing of straps got crushed (particularly in the head parts). As a result of this phenomenon, the uncovered silver warp was getting frayed until it got torn off and losses were incurred.

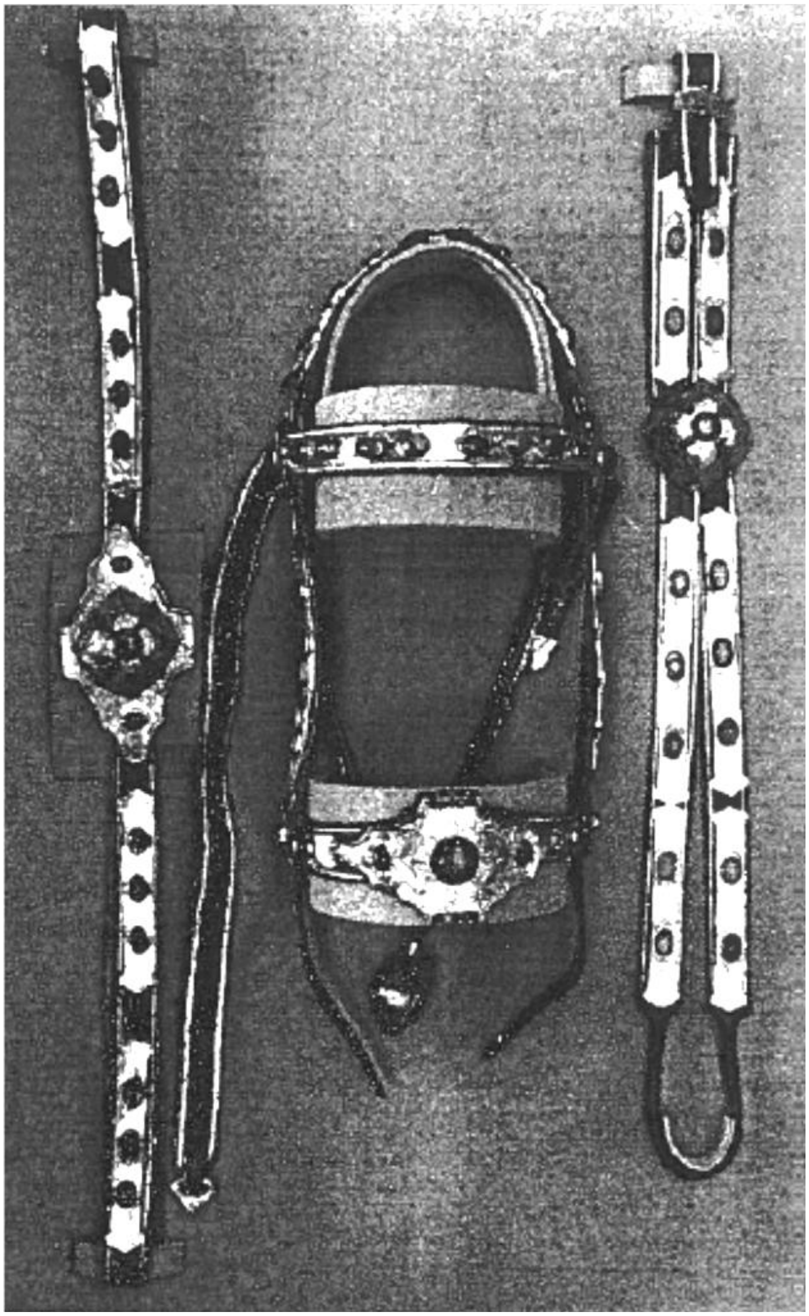


Fig. 2. *The saddle accessories mounted, after conservation.*

The flaxen thread sewing got preserved to a large extent. It was torn off in a few areas and in very short sections. The silver parts belonging to the saddle accessories suffered, above all, mechanical damage. The pieces with the niello ornaments were more or less deformed. There were some losses in a few of them. Other deteriorations relate to the pieces set with precious stones. They were caused when removing the stones. The edges of binding were bent aside and even torn off. The stones were removed a few pieces, and also from the button on the headpiece, from the metal on the noseband and from the buttons of the alsbant.

The silver parts suffered from corrosion to a small extent. Black residue of silver sulphide was found in small quantities on the parts which were punched.

Green residue of basic copper carbonates $Cu(OH)_2.CuCO_3$ and $Cu(OH)_2.2CuCO_3$ (which were formed as a result of the corrosion of copper as part of the alloy) was found out in small quantities inside the silver pieces.

This caused the fact that the residue dyed also partly straps of leather tanned with grease, on which the pieces were put.

The assembly of silver decorations of the saddle accessories was not complete.

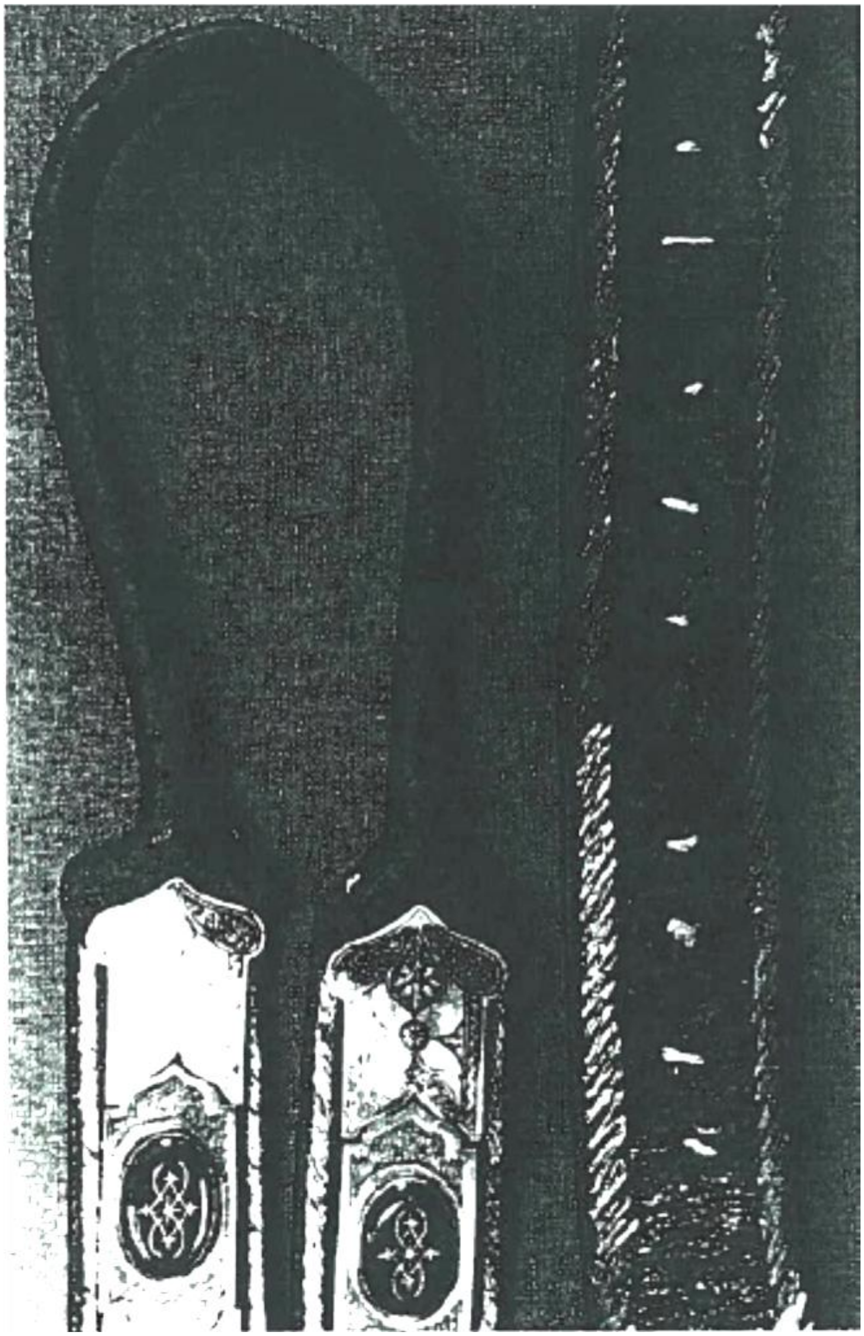


Fig. 3. *The saddle accessories after conservation, detail.*

A few silver pieces were missing, just as two buttons and two buckles which served to cover the connection of the cheek straps with the nose band and to fasten the endings of the cheek straps after the snaffle had been mounted.

Conservatory work carried out

As we have already mentioned, the main goal of the conservators was to bring the object to a condition to enable it to be incorporated into the museum collection. Therefore a series of treatments was executed including the conservation of leather straps, threads and silver elements. A reconstruction of missing silver elements and precious stones was carried out. In the first phase of the work the silver parts were separated from the leather parts of the saddle accessories. However, the idea to remove the headpiece button, the ornamented endings of the alsbant and the throat lash from the straps was given up as it could endanger the leather condition.

Conservation of silver elements

The work on the conservation of silver ornaments included their cleaning, restoring the original shape to those which were deformed, and protection from corrosive activity of outside conditions.
Surface dirt was cleaned off the silver parts with a soft rotary rubber. Because of the corrosion products being present, a chemical treatment of cleaning was also carried out by means of Seignette's salt (sodium-potassium tartrate) ($NaOOC-CHOH-CHOH-COOK.4H_20$) in sodium hydroxide solution in the lowest concentration recommended for the conservation of silver, neutralized afterwards with 3% solution of citric acid. The applied solution cleaned the surface of the silver very well, and its application enabled a better cleaning of the punched fragments and of the inside of the silver pieces. The silver elements which were connected with the leather elements were cleaned with swabs soaked alternately with salt solution and distilled water. A special attention was paid not to let the cleaning agent touch the leather. Subsequent rinsing and necessary neutralization of the salt solution were carried out in a similar way.

The deformed parts of the pieces ending the sequences were delicately hammered out with a jeweller's hammer through a flannel, after being a little warmed up to avoid metal micro-cracks and to make it more flexible. After of these treatments, the grease was removed from the silver surface and it was covered with a protective coat, through immersing it in 10% solution of Paraloid B72, in toluene. On the elements joined to the leather, it was necessary to put the layer of Paraloid with a soft brush.

Leather cleaning

The conservatory treatment of the leather parts of the saddle accessories was carried out without unstitching the straps in order not to damage the weak silver warp of the silk threads.
At first the grain and the silver threads were cleaned mechanically with soft rubbers to remove the surface dirt. Then some trials of chemical cleaning of its surface were executed by means of foam made on the premises from CANPAC soap and Marseille soap, afterwards they were washed off with a mixture of water and isopropyl alcohol (1:1). The activity of both soaps turned out to be unsufficient in case of hard incrusts, present in the leather.
Their reaction was caused only after a shallow washing bath was supported by the activity of ultrasound. A medical apparatus, Ultraton, was applied with a potential for the ultrasound to act locally. After this treatment the soap was washed off the leather with a mixture of water and isopropanol in various proportions, gradually increasing the participation of alcohol to partly dehydrate the leathers. Taking profit of the wet condition of the leather, it was soaked in 7.5% potassium lactate and it was additionally tanned with a 5% water/acetone solution of sumac. After the leather had dried, it was found out that the effect of the last treatment was good. The darkening of the leather caused by the incrusts got oniy a little lighter, but its elasticity was restored. After the said treatments the straps were straightened under a light load. For this purpose, special cardboard shapes were prepared, and they made it possible to flatten the protruding stitch.

Filling of losses in the leather elements and repair of the straps weakened by sewing

After the cleaning and the application of buffered solution to the leather, some scales were glued in the frayed areas with Klucel glue. Tiny losses in the leather, as well as deeply frayed areas were filled with suitable cut pieces of calf skin, glued with Klucel. Large losses caused by the activity of insects, particularly in the noseband, were firstly filled with putty made from leather chips and polyvinyl acetate (PVA) and then they were covered with fragments of calf skin grain, cut to fit exactly the shape of the losses. The same skin was also applied to prolong the endings of nose band leather strap and to fill up the cut edge in the brow band-throat lash leather strap. In this case polyvinyl acetate glue was applied as it has a stronger binding force than Klucel, and the additions carried out must play a constructive role. The repair of the frayed stitches was effected on the grain side with synthetic threads of a colour fitting the silk threads, whereas on the flesh side flaxen threads were used. The repairs were carried out sewing the threads with a thin needle, putting in into the old holes, and partly gluing them in by means of 7.5% Klucel.

Extensive loss of stitches on the brow-throat leather strap were replaced on the grain side with synthetic threads, and on flesh side the preserved elements of flaxen threads were sewn in, with some new threads added.

Leather currying

The leather was curried on the grain side and where possible on the flesh side too, with oiling agent according to Van Soest based on bubulum oil and lanoline in isopropyl alcohol mixed with mineral spirits.

As there was no possibility to check the grease contents in the leather it was determined (based on earlier experience of the atelier) to spread the prepared solution three times with a paint brush. The oiling agent caused no colour changes in the leather.

Colour unification of leather additions and silver threads

Water colours were used for the purpose of colour unification of the leather surface.
The grain of the skin used for additions was also suitably unified with the colour of the original skin. The punchings were covered with a thin layer of retouching varnish.
The added stitches had to be made look like silver. Specimens of synthetic threads were soaked in various glues which were to decrease their elasticity, fluffiness, and absorbability, whereafter it would be easier to put silver powder in 10% PVA upon them and after drying of the filler metal, to polish it. All the methods of stiffening were considered insufficient for the synthetic threads.
Good results were obtained by soaking a fragment of the original silk threads (without the silver, which was not preserved) in 10% Paraloid B72. Leather thread soaking in the solution of this resin was also advantageous for another reason; it protected the preserved silver warp against corrosion processes. Afterwards silver powder in PVA was spread with a thin paint brush, trying to cover with it each thread separately. After the binding agent had dried, the silver plating was polished and protected with a thin layer of retouching varnish.
The idea of silver plating was given up for the synthetic threads.
Instead they were colour unified with the whole of sewing, through stitching to them or partly gluing polyethylene silver threads. The latter had the same thickness as the original silver silk threads and their shade was only a little lighter. Their application made it possible to gain a skew effect, a decoration system of sewing in the large losses. These threads were also protected with Paraloid B72.

Waxing of leather

The last treatment consisted in covering the leather grain with 10% solution of bees-wax in mineral spirits. The wax was applied on swabs, avoiding touching the threads. 24 hours later the straps were polished with a soft rag until a uniform, delicate gloss was achieved.

Making copies of missing silver elements and precious stones

As the saddle accessories were designated to be exposed, it was decided to make copies of the missing silver elements and precious stones. This decision was not only made in order to restore the full artistic value of the whole set, but it also resulted from the need to connect the parts of the head straps which had been separated. Before taking up the decision on reconstruction, all the silver pieces were thoroughly examined to ascertain how many of which elements were missing. Particular attention was paid to the manner the brow band was connected to the cheek ones.
An analyses of the construction of other saddle accessories of this historical period (Military Museum in Warsaw, Wawel Castle Museum in Krakow. The Czartoryskis' Museum in Kraków, the Castle Museum in Malbork) showed that the elements which were situated on the crossing of the cheek bands with the nose and brow bands were repeated several times in each of them.
During reconstruction, endeavours were undertaken to use the material and techniques as close to the original as possible. Copying of the niello ornament became a problem.
This technique of metal ornamenting is no more applied as it requires an additional equipment for the goldsmith's atelier and high artisanal qualifications. The costs of re-making turned out to be very high too.

Therefore it was determined that the ornament would be performed in ZKPiS (Polish abbreviation for Atelier of Paper and Leather 1k Conservation at the University of Toruń) in a r. technique similar to the niello decoration.
Forging of the basic shape of silver ornaments together with the execution of engraved ornament, carving and gilding was commissioned with M. Milanowski, an artist from Gdańsk.
For the imitation of the niello technique at first suitably formed silver pieces were covered with black varnish. When its coat hardened, a negative sketch was executed, uncovering the lines which were to be subjected to etching afterwards by means of a specially prepared scalpel. Next the pieces were immersed in 50% he $HNO_3$and the process of etching was under control. After the sketch was etched the pieces were rinsed in running water to stop the activity of the acid, whereafter the varnish was removed through baths in mineral spirits.
Pigment in acrylic binding medium was introduced in the concave relief. In the end, the surface of the pieces was polished whereby the surplus of the pigment was removed. The side surface of the pieces were gilded with an imitation of flake gold, put of on gold size and protected with Paraloid B72 too.
In the first trials to reconstruct the precious stones a chemico-hardened epoxy resin Epidian 5 with hardening agent Tecza Zi and suitable pigments were used. For this purpose a caoutchouc negative mould of the polished section of the preserved stones was made.
The resin was poured into this mould in two layers. The first one contained less pigment and was to stay half transparent, the other one had more pigment and had a decisive effect on the final colour of the imitation. After the resin hardened, the effects were verified. Epidian 5 imitated the shape of the stones polished section very well. The trial to get the depth of a mineral was positive too. The fault of the imitation was the fact that high glitter of carnelian was missing. A coating of Paraloid B72 increased the glitter a little, but 'made more even' the sharp edges of the polished section.
The trials to make the imitation were considered successful, but only the stones repeated in the saddle accessories could be restored in this manner (because of the need to execute a caoutchouc negative mould firstly). However, the reconstruction of the largest missing stones was necessary to restore the full artistic value.
The reconstruction of the stones was commissioned with 'Corundum' Atelier of Jeweller's Stones Polishing Magdalena Korpaiska & Piotr Błoński (Wrocław). The employees of this atelier undertook the task of polishing and fitting to the mounting the missing stones with reconstructed, irregular 17th century polished sections. Therefore before the reconstruction was started, a few trial polished sections had been developed. The experimental polished sections imitated the original treatment of the stones faithfully. It is worth mentioning that it was decided to use the materials which had been primarily applied to ornament the ancient saddle accessories for the reconstruction.
It turned out not to increase the costs and it significantly emphasized the artistic value of the object.

The engraving on the stones was carried out in ZKPiS. Before the work was started a few trials of engraving had been carried out on a lump of mineral (carnelian) with one face polished. Firstly, the stone was covered with a layer of white ink. Upon it the sketch was drawn in pencil, and afterwards it was engraved with a diamond ending, fixed onto a high rotation grinder (Poxon). Then the white ink was washed off, and where needed, the relief was deepened. The concave sketch, prepared thus was filled with gold size by means of a thin paint brush and 8 hours later it was covered with gold powder. The experimental engraving and gilding was very successful and the polished stones were treated in the same way.

After the described treatments and the copied elements had been completed the object was assembled. The silver elements were joined to the leather elements according to the condition before the conservation.

Notes

1. The conservation of the saddle accessories was carried out in the ZKPiS - The Atelier of Paper and Leather Conservation at the University of Toruń, as a final thesis with the assistance of Dr Halina Rosa

2. Information obtained by consulting Prof. Z. Zygulski and A.R. Chodyński.

Preserving unique specimens

Anne Lisbeth Schmidt
Bevaringsafdelingen
Nationalmuseet i Brede
DK-2800 Lyngby

When studying which objects are selected for exhibition, it is Often found that the same objects are exhibited again and again, year after year. To find out what made a particular object special and unique is a matter of interest to the people who handle them. Such objects often require more attention than others which are left to themselves in darkness in climatized, dustfree storerooms.

The Ethnography Department of the National Museum in Copenhagen holds one of the world's largest collections of Inuit objects. The expedition that has contributed with the largest part of the increase in the collection is *The Fifth Thule Expedition, The Danish Ethnographic Expedition to Arctic North America 1921-1924, headed by Knud Rasmussen.* Approximately 15,000 specimens of skin, bone, wood, etc. were collected among Canadian Inuit groups and sent to Denmark to be incorporated into the National Museum.

Netsilik Eskimo amulet boy's costume

Frequently it was Knud Rasmussen himself who persuaded the Inuit families to barter their costumes and tools for the expedition's tobacco, textiles and other goods. More than any other group, the Netsilik Eskimos lived at subsistence level. The Netsilik area is close to the magnetic North Pole where the winter is extremely cold and the summer is short and humid. Peter Freuchen, member of the expedition, wrote about a Central Inuit tribe: 'We shall not be able to collect much among these people... not because of laziness, but these people have no possessions. They are the most terrible Eskimos I have ever seen. No-one has more than one costume, and it is almost impossible to get skins for new clothing. Knud has had to put all his authority into procuring just one costume of each kind and could not get more.'[1]
Among the items Knud Rasmussen succeeded in collecting among the Netsilik Eskimos was a costume of a small boy, Arssautilik Tertâq, made of caribou skin to which no less than 80 amulets were attached. Knud Rasmussen described the coat and its amulets in detail in Report of The Fifth Thule Expedition[2].
The objects from the Fifth Thule Expedition were entered into the inventory of the Department of Ethnography, from which I quote:
"P29.5O1ab, a boy's inner coat with amulets.
a) caribou skin coat, usual cut with hood. Suspended on the back are... caribou skin ('luck in salmon fishing'); dog harness ('fighting strength')... Over the shoulder a strip of bearded seal with bear teeth ('health and vigour') ... hair from an old man's temples (sewn onto the hood's temples, assures long life) ...
b) raven skin carried around the neck ('to get close to the caribou where they swin without being seen')" *(Fig. 1).*

The amulets were supposed to give the boy strength and vigour to survive in this harsh country. One can wonder why the family would be willing to relinquish such an important piece of garment. Jørgen Meldgaard, curator at the Ethnography Department of the National Museum, has explained that the power of the amulets will remain with the individual to whom they were first given. And it came true. In the 1960s, Jørgen Meldgaard was informed that Tertâq had become mayor of the small town of Pelly Bay in the central Netsilik Eskimo area in Canada's north-west territories. And Tertâq had been conferred the order of merit by Canada's president Pierre Trudeau for having contributed to creating a sound Inuit community with church, school and library.

After the return to Denmark of the Fifth Thule Expedition, a number of minor, short exhibitions were arranged presenting some of the many objects collected on the expedition. Very probably the amulet boy's costume was among the objects displayed. On June 6, 1936, almost two years before the opening of the enlarged National Museum, the Ethnography Department opened 20 new permanent exhibition rooms with Inuit specimens; half of these rooms were reserved for objects from the Fifth Thule Expedition. The amulet boy's costume was displayed on a stand in a centrally placed showcase near the windows.

Fig. 1. *Arssautilik Tertâq in his amulet costume. Photo: The Fifth Thule Expedition, Ethnography Department, National Museum of Denmark*

In 1970 the outdated permanent exhibitions were removed, and in 1975 the Department of Ethnography opened its new permanent Inuit exhibitions. The number of exhibits was smaller this time, but the Fifth Thule Expedition was still represented, e.g. with the amulet boy's costume. Filled with tissue paper, the costume was displayed mounted on a dais in a wall showcase with built-in light.

The Eskimo exhibits were closed in 1988 in connection with the renovation of the National Museum.

Fig. 2. *Display of the amulet costume as from 1992, mounted on cotton-covered support. Photo: John Lee, National Museum of Denmark*

It was then known that the museum's Inuit skin objects contained large quantities of insecticides, (DDT, Lindan, etc.). The conservation staff wore breath masks and disposable overalls when removing the objects. The author of this article took down the amulet boy's costume. A gentle touch of the garment tore the shoulder apart - what a shock to see the skin torn and to have damaged this rare and outstanding specimen. Tears and perspiration ran, but this was not the time for making good the damage. With great care, the amulet costume was packed, together with the other Inuit objects, to be placed in temporary storage in Brede.

When the renovated National Museum opened on June 4, 1992, the amulet boy's costume was back in its place in the Ethnography Department's permanent exhibit *Peoples of the Earth*,

now as one of only a few objects emanating from the Fifth Thule Expedition. The shoulder tear was mended and almost invisible.
The costume was mounted on a flexible form made of cotton batting and cotton jersey, and the form was mounted on a metal brace *(Fig. 2).*

Analysis of the state of preservation of skins

Through my work with the amulet costume and other skin objects, I became interested in studying the causes of skin decay. I examined the state of preservation of Inuit skins in the Ethnography a nd Conservation Departments in relation to physiological and chemical analyses. The study for which I was conferred a M.Sc. degree in 1991, comprised 35 pairs of men's boots and 5 garments of ringed seal or caribou skins collected on the Fifth Thule Expedition. The boots had been in storage app. 70 years, and the garments had been exhibited for more than 20 years, and the amulet boy's costume had been on show for almost 50 years[3].
There is much variation in skins of ringed seal and caribou. With sealskins the flesh side can vary in colour from pale white-yellow to dark orange. The skin can be anything from supple to stiff or hard as wood, depending, of course, on the purpose for which the skin has been dressed. The smell may be quite distinct.
The flesh side of caribou skins is less variegated in colour; it goes from white to light yellow Most often the skin is soft or slightly stiff. Normally it is odourless.

The original plan was to find out if it was Possible to compare the state of preservation o f skins, i.e. exterior characteristics such as colour, stiffness, hair loss, etc., with physiological and chemical analyses. However, it soon became apparent that a small, experienced panel of museum workers had entirely different opinions on the colour, smell and stiffness of the skins, so the clinical observations were stopped. Instead test material, i.e. fibres scraped off the flesh-side, was taken to measure the shrinkage temperature and to analyze the composition of fatty acids and amino acids.
The other analyses are described elsewhere[4].

I shall only discuss the analyses requiring the smallest quantity of sample material and the shortest time, i.e. the measurement of shrinkage temperature.

The shrinkage temperature is defined as the temperature at which protein, i.e. collagenous derm or skin material, is destroyed in water. Collagen are thread-like fibres which shrink to 1/3 of their original size when heated in water. Collagen can be described as the derm tissue's most important building block, and its shrinkage temperature is therefore an expression of the collagen's condition.

Skins dressed the Inuit way, i.e. mechanically processed without the addition of real tanning, will in the fresh state have shrinkage temperatures a little above the temperatures of raw hide, i.e. above 62-68°C.
Shrinkage temperatures below 62°C indicate collagen deterioration. Much decayed skins will shrink at normal room temperature's humidity. Young's method was used for the analysis of the skin specimens from the Fifth Thule Expedition: microscope and slow heating of the test material on a heating bench. Two temperatures were registered: $T_{S, start}$' at which ca. half of the skin fibres in the visual field had shrunk, and $T_{S, end}$' at which all of the skin fibres had shrunk[5].
It must be noted that this analysis requires the person doing the measurements to be extremely well trained. Larsen et al. have in recent years done much work with the analysis.
Their definitions of when shrinking will occur are different and more accurate to-day[6].

Shrinkage temperature of stored and exhibited specimens

The average shrinkage temperatures of the men's boots from the Fifth Thule Expedition which have remained in storage were almost the same as those of newly tanned skins, i.e. $T_{S\ start}$: 59.7°C and $T_{S, end}$ 68.9°C. This is highly surprising at a first glance, seeing the poor conditions under which they had been kept in former times: piles of skin objects in unheated, non-climatized storerooms exposed to light, dust, insect attacks, insecticides, desiccation, water damage, mould, etc. But surprisingly, the stored skin specimens were in a good state of preservation in view of the shrinkage temperature measurements.
Test samples from the amulet boy's costume showed a low shrinkage temperature: $T_{S\ start}$ 48°C and $T_{S, end}$ 59.6°C, indicating decay in the collagen contents of the garment.

Test material sampled and analyzed in December 1994 showed similar shrinkage temperature, and it can therefore be concluded that the decay does not seem to have accelerated during the eighteen months the costume has been exhibited, as far as indicated by the shrinkage temperature analysis. No new tears have been formed in the fur.

Conclusion

We know that light affects organic materials. On skins, prolonged exposure to light will cause deterioration of the proteins. Tears and cracks are visible signs of this.
The amulet costume has been exposed to the action of massive light during the almost fifty years it has been on show. The first 34 years, from 1936 to 1970, the costume was exhibited both in daylight and artificial light. However, the light did not focus on one particular spot on the costume, it was diffused over the whole surface facing the windows. The next 13 years, 1975 - 1988, the costume was on display in artificial light which focussed on the shoulder area. The temperature in the showcase is likely to have been relatively high on account of the light being mounted inside the showcase; this caused low humidity and desiccation of the skin. Exposure to light, and desiccation caused by low humidity, made the skin so fragile that even the gentlest touch made a tear.
The most desirable way of preserving the amulet costume for the future would be to keep it stored in a dark, climatized room.
The Department of Ethnography, however, cannot dispense with the amulet boy's costume in the exhibition. Its magic and its history makes it very special, almost alive!
The future conditions for preserving the amulet costume must be: least possible exposure to shortest possible, changing illumination, optimum climatic conditions, regular inspection (through the glass of the showcase), and a minimum of handling. The costume should never travel. The state of preservation should be controlled at regular intervals through measurements of the shrinkage temperature.

High priority should be given to keeping a scrupulous record of the amulet costume's life and fate in the years to come.

This also goes for all other objects on show, be they unique specimens or not. Paradoxically, the claim for popularization and exhibition is at the root of any object's final destruction.

Notes and references

1. Letter dated May 16, 1923, from Peter Freuchen to Thomas Thomsen, Curator. Archives in the Ethnography Department

2. Rasmussen, K., *The Netsilik Eskimos. Report of the Fifth Thule Expedition 1921-24*, Volume 8, København, Gyldendalske Boghandel, Nordisk Forlag, 1931, p. 256

3. Schmidt, A.L., *Eskimoiske skinds bevaringstilstand belyst ved hjaelp af fysiske og kemiske analyser*. Konservatorskolen, Det Kongelige Danske Kunstakademi, 1991

4. Schmidt, A.L., Feldthus, A. and Carisen, L., 'On the Changes of Skin Characteristics Through an Inuit Tanning Procedure'. *ICOM Committeefor Conservation, Preprints for the 10th Triennial Meeting, ICOM,* Vol I, Washington D.C.: 1993, p. 182-186

5. Young, G.S., 'Microscopical Hydrothermal Stability Measurements of Skin and Semitanned Leather'. *9th Triennial Meeting. Dresden, German Democratic Republik 26.31 August 1990, ICOM,* Vol. II, Los Angeles: 1990, p. 626-634

6. Larsen, R., M. Vest og K. Nielsen, 'Determination of Hydrothermal Stability (Shrinkage Temperature)'. *STEP Leather Project,* Research Report No 1, The Royal Academy of Fine Arts, School of Conservation, 1994, p. 151-64

Remounting gilt leather tapestries with Velcro

Vivi Lønborg Andersen
Conservator, Department of Conservation
The Nationalmuseum
Brede
DK-2800 Lyngby

Vemmetofte monastery in Denmark has three rooms with gilt leather tapestries which were ordered around 1730 by the Danish prince Carl. The monastery was restored in the years 1890-1900 and all the gilt leather was restored and remounted with nails directly to the walls, where wooden laths were built into the wall.
In the ladies' room on the east outer wall the gilt leather had torn the sewing, and on the west inner wall the leather was torn, and showed several gaps. It was decided to take two pieces of the leather tapestries down for conservation.
When the tapestry from the west wall came down it was soon realized that it was necessary to reinforce all the sewings. It was also clear that two rows of leather were newer, and in poorer shape.
The old animal glue was removed mechanically since it would not dissolve in either water or solvent. The edges of each piece were laminated with a backing of calfskin glued on with PVA-emulsion. Gaps were laminated on the back, also with calfskin, and retouched with acrylic colours.

Remounting

There were several ways of remounting the tapestry. It could have been nailed as it had been previously, but it was obvious, that the leather would once again be perforated and easily torn. It was impossible to mount it on frames since the pieces had to fit into the existing panels and onto the rest of the tapestry, which had not been taken down. We tried Lycra, because we liked the idea that the leather should be kept stretched with changes in humidity. However the kind of Lycra we could get hold of was not good enough. Once wet it lost its flexibility.

From our own experience of restoring gobelins we knew that Velcro had been used with good results.
Velcro consists of two pieces, one of which is soft and flexible, and the other which is stiff, with 'hooks' to grab the soft part.
It was decided to use Velcro on the edges of the pieces of tapestry since they would be at the right level on the wall, and they would be easy to mount.

We used the 10 cm soft Velcro which we sewed to polyester linen, and then glued to the back of the leather edges with PVA-emulsion (Vinnapas EP1). The leather was divided into three big pieces and all the sewing was replaced.
They were then easier to handle. At the edges where leather met leather we used 5 cm Velcro *(Fig. 1).* It was very important to use a good deal of pressure to get the Velcro/polyester linen to stick to the tapestry.

When this was done we went to the monastery to remount the tapestry. The stiff Velcro was nailed to the wooden laths in the wall with electroplated nails. The tapestry which was left on the wall was loosened, and soft Velcro on polyester linen was glued on. This time we used BEVA 371 which was easier to work with in situ.

It was then very easy to get the tapestry in place, and easy to adjust it so that it situated on the wall perfectly. The three pieces of leather which had to fit together were assembled at the back with a 10 cm stiff Velcro.
There were two gaps which we couldn't close. On an extra piece of gilt leather we glued the soft Velcro, so that it could easily be put into the gap, and made almost invisible.
There is just one problem we still have to solve. It was very difficult to stretch the leather so that it would be perfectly flat against the wall. The Velcro makes the edges inflexible. We glued the Velcro on the leather when it was all slack because we thought that it would grow taut when dried to its normal humidity content.
It didn't. We then hoped that the leather would tauten in the dry wintertime, but it remained as we had left it all year along.
In spite of these problems we think it is a good method because it is so easy to handle the leather when remounting onto the wall, but it requires further research to overcome the problems of stretching the leather.

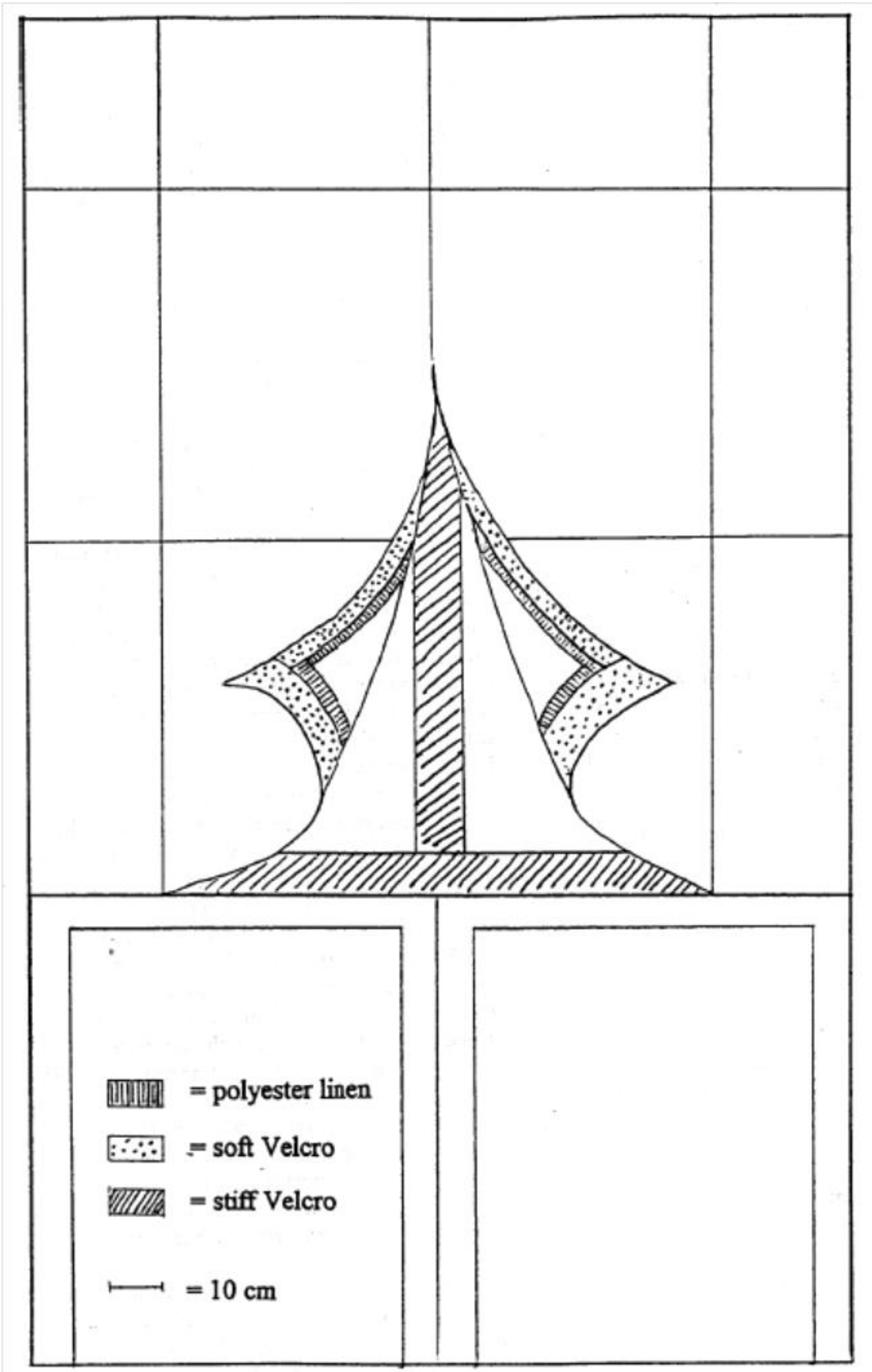


Fig. 1. *Design of the mounting system using Velcro.*

System to Refill Lacunae

Mª Isabel Herráez Martin
Instituto de Conservación y Restauración de Bienes Culturales
Ministerio de Cultura
c/ Greco, 4. Ciudad Universitaria
E-28040 Madrid

Introduction

The reintegration of gaps is a normal process in the restoration of leather objects, not only in order to structurally reinforce the object but also to achieve an optical or aesthetic effect of unity.

The materials traditionally used for this purpose, such as fabric or paper, attempt to mimic the special characteristics of leather (flexibility, elasticity, tensile strength, etc.) as closely as possible. However results are not always satisfactory. Currently, synthetic resins are used, with or without thickening agents, but their appearance is usually unsatisfactory from an aesthetic point of view. On the other hand, the most effective solution, that of using new skin or leather, has certain drawbacks from an ethical point of view or in terms of intervention criteria (1, 2, 3, 4, 5).

Description

The object to which this article refers is a hemispherical helmet made of reptile skin over an inner basketwork frame. It belongs to the collections in Madrid's Naval Museum and has been dated to the 19th century, although we lack details regarding its cultural attribution and provenance.

State of conservation

The helmet had been rather poorly conserved and was covered with dust and other environmental contaminants. Material was missing in numerous points, both in the basketwork frame which was fractured and shredded, and in the skin itself which had large gaps, fissures, open cracks and general erosion.

Work procedures

First the surface of the helmet was cleaned by soft brushing and vacuuming.
Once clean, broken basketwork elements were fixed with polyvinyl acetate (Mowilith DMC2).
The skin was cleaned with small cotton swabs soaked in demineralized water and ethyl alcohol (1:1). Loosened dirt was immediately removed and any moisture dried with blotting paper.
Once the skin was clean the edges of the gaps and the eroded areas were consolidated with an acrylic resin (Pliantex in 1,1,1-trichioroethane, 1:4). Finally, we applied a very thin coat of a leather lubricant (standard Pliantine).
During the restoration process and in view of the extent of material loss, we were faced with the need to reintegrate the skin, for aesthetic reasons as well as to preserve the helmet's mechanical resistance. Traditional systems employing paper or fabric did not work, since their appearance was not aesthetically pleasing. The use of new skin resembling the original was ruled out by the impossibility of obtaining similar material. We turned to the use of synthetic materials as a last resort, basing ourselves on an old article by John W. Waterer (6) in which gaps were filled using an acrylic resin (Pliantex), the same resin we had used to consolidate edges. To this end, we carried out a series of tests which gave us small fragments of resin film, moderately elastic and flexible, but not particularly resistant. The problem was that we could not apply the resin directly onto the object, as Waterer had done, since we needed either a base to contain the flow of the liquid resin or to use thickening agents which would alter the characteristics of the resin.
Furthermore, even when dyed, the film had an unfortunate, very plastic look.
Several tests were carried out aimed at reinforcing the resin film and at the same achieving a solid, workable material using intermediate or underlying layers of synthetic fabrics (Remay, Bondina, Cerex, etc.) and small, perfectly manageable pieces of fabric for the filling were obtained. Problems arose when we attempted to adapt these pieces to the gaps, since pockets and buckling occurred, the film adhered very poorly and there was no mechanical resistance whatsoever.

We then tried the traditional system of reinforcement with fabric, in this case synthetic, in the zone of the gap. Polyester fabrics (Remay, Bondina) were attached to the inside of the object with polyvinyl acetate and a small piece of dyed resin film was attached to them. The result was fairly good, since the fabric helped restore the skin's mechanical properties and the resin filled out the gaps visually. Nevertheless, due to the extent and location of material loss, the result was not entirely satisfactory.

We decided that if we could not achieve material similar to the original we could obtain an imitation. To do so a mould was made of the grainy surface of the original skin using dental silicone (Coltex fine). Once the silicone set, a positive impression was obtained in dyed acrylic resin (Pliantex). The outcome was considered definitive and it was decided to reintegrate all the gaps with small pieces of dyed resin film with this moulded surface. The pieces were glued to the synthetic fabric base with the same resin, and cut according to the desired shape. The fissures between the edges of the object and the synthetic skin implant were filled with the same dyed liquid resin.

Conclusions

The described technique of filling lacunae has been used for different leather and skin objects whenever we needed to imitate a special grain pattern of surface work, and we have obtained satisfactory results.

Acknowledgement

Museo Naval, Madrid.

References

1. SeIm, Rosemarie, 'The conservation of upholstery leather. An evaluation of materials and techniques'. *Conservation of leather in transport collections*. UKIC 1991, London, p. 15-22

2. Calnan, Christopher N., 'Conservation of leather upholstery on the 1894 Panhard-Levassor Motor car at the Science Museum, London'. *Conservation of leather in transport collections*. UKIC 1991, London, p. 31-35

3. Morrison, Lynn, 'Some suggested materials for the repair and reconstruction of archaeological leather'. *Conservation Today. UKIC 30th Anniversary Conference* 1988, London, p. 107-111

4. Collins, Catherine, 'Conservation techniques for ethnographic leather artifacts: Application to the Paul Kane Collection'. *The care and preservation of Ethnological materials.* Symposium Ottawa 86, C.C.I, p. 62-67

5. Herraez, M.I., 'Restauración de un casco de piel y fibra vegetal '. *II Congreso Conservación y Restauración de Bienes Culturales,* Sevilla 1992, p. 634-636

6. Waterer, J.W., 'A novel method for the conservation of fragile leather'. *Studies in Conservation*, 17, 1972, p. 126-130

Materials

- Ethyl alcohol
- 1 , 1 .1 -trichloroethane
- Mowilith DMC 2, polyvinyl acetate
- Pliantex, acrylic polymer
- Pliantine standard, lubricant
- Coltex Fine, elastomeric polysiloxane. Colténe AG
- Remay, non woven 100% polyester
- Bondina, non woven 100% polyester. 30 gr, 110 gr/m^2
- Cerex, non woven 100% nylon. 10 gr/m^2
- Dry ground, Winsor and Newton
- Maimeri colours.

Addresses of the authors

Aline Angus
The Leather Conservation Centre
34 Guildhall Road
GB-Northampton NN1 1EW

Thomas Bilson
24 Church Road
Piddington
UK-Northamptonshire, NN7 2DE

Céline Bonnot
ARC Nucléart, Centre d'Etudes Nucléaires de Grenoble
17 rue des Martyrs
F-38054 Grenoble Cedex 9

Jaap van der Burg
Projectmanager Deltaplan
National Museum of Ethnology
P.O. Box 212
NL-2300 AE Leiden

Claire Chahine
Centre de Recherches sur la Conservation des Documents Graphiques
36, rue Geoffroy-Saint Hilaire
F-75005 Paris

Laura M. Chiotasso
Vejle - Restauro Conservazione Cuoio Tessuti
Via P.A. Grammatico 52
I-00 144 Roma

Diana H. Dicus
Objects Contract Conservator
305 N. 17th Street Suite 315
Boise,
USA-Idaho 83702

Olaf Goubitz
Rijksdienst voor het Oudheidkundig Bodemonderzoek
Sectie Conservering Organische Artefacten
Kerkstraat 1
NL-3811 CV Amersfoort

Pieter B. Hallebeek
Netherlands Institute for Cultural Heritage (formerly the Central Research Laboratory for Objects of Art and Science)
Gabriël Metsustraat 8
NL-1071 EA Amsterdam

Ioannis A. Ioannidis
MEMED Consultants for the Leather Industry,
47 Souidias str., 106 76 Athens, Gr.

Salwa-Victoria Joram
Fachhochschule
Claudiusstraße 1
0-50678 Köln

Dorota Jutrzenka-Supryn
Nicolaus Copernicus University
Laboratory of Paper and Leather Conservation
P7-100 Torun

Marion Kite
Textiles/Organics Conservation
Victoria and Albert Museum
South Kensington
UK-London SW7 2RL

Eloy Koldeweij
Valeriusstraat 213-11
NL-1075 EX Amsterdam

Vassilis Kilikoglou
Nuclear Research Centre "DEMOCRITOS".
153 10 Ag. Paraskevi, Gr.

Vivi Lønborg Andersen
Arbejdermuseet, 1987
Romersgade 22
Facaden 1904
DK-1362 Kobenhavn K

Ekaterini Malea
Diastavrossi Rafinas
GR-19009 Rafina Attica

Mª Isabel Herráez Martín
Instituto de Conservación y Restauración de Bienes Culturales
Ministerio de Cultura
c/ Greco, 4. Ciudad Universitaria
E-28040 Madrid

Véronique Montembault
10 Grande Rue
F-89500 Egriselles de Bocage

Richard Moroz
Westfalisches Museumamt
Zentrale Restaurierungswerkstatt
Haus Lüttinghof
Lüttinghofallee 3
D-4650 Gelsenkirchen

Mariabianca Paris
Istituto Centrale per il Restauro
Piazza San Francesco di Paola 9
I-00184 Roma

Halina Rosa
Nicolaus Copernicus University
Laboratory of Paper and Leather Conservation
P7-100 Torun

Christine Rottier
Centre de Recherches sur la Conservation des Documents Graphiques
36, rue Geoffroy-Saint Hilaire
F-75005 Paris

Costantino Sarnelli
Vejle - Restauro Conservazione Cuoio Tessuti
Via P.A. Granimatico 52
I-00144 Roma

Anne Lisbeth Schmidt
Bevaringsafdelingen
Nationalmuseet i Brede
DK-2800 Lyngby

Andreas Schulze
Landesamt für Denkmalpflege Sachsen
Augustusstraße 2
D-01067 Dresden

Angeliki Stassinou
20 Asclipiou str., 106 80 Athens, Gr.

June Swann
28th Broadway
GB-Northampton NN1 4SF

Roy S. Thomson B.Sc., C.Chem., F.R.S.C., F.S.L.T.C.
Chief Executive
The Leather Conservation Centre
34 Guildhall Road
GB-Northampton, NN1 1EW

Ko van de Watering
Book restorer
Royal Library
P.O. Box 90 407
NL-2509 LK, The Hague

David Watkinson
senior lecturer,
Archaeological Conservation, School of History and Archaeology,
University of Wales Cardiff,
P0 BOX 909,
Cardiff CF1 1XU, Wales, U.K.

List of participants

Mrs. V. L. Andersen
Denmark

Mrs. A. Angus
UK

Mrs. M. Ch. Berardi
Italy

Mr. Th. Bilson
UK

Mrs. C. Bonnot
France

Mrs. R. Bonten
The Netherlands

Mr. J. van der Burg
The Netherlands

Mr. Ch. Calnan
UK

Mrs. C. Chahine
France

Mrs. L.M. Chiotasso
Italy

Mrs. D.H. Dicus
USA

Mr. M. Goldman
Canada

Mrs. J. Göpfrich
Germany

Mr. O. Goubitz
The Netherlands

Mr. P.B. Hallebeek
The Netherlands

Mr. T.S. Hayes
UK

Mrs. S.-V. Joram
Germany

Mrs. D. Jutrzenka - Supryn
Poland

Mrs. B. Kantzenbach
The Netherlands

Mrs. M. Kite
UK

Mr. E. Koldewey
The Netherlands

Mr. R. Kozlowski
Poland

Mrs. N. Krumperman
The Netherlands

Mr. G. Lee
UK

Mrs. E. Malea
Greece

Mrs. I. Herráez Martín
Spain

Mrs. W. Meeuws
The Netherlands

Mrs. S. Meijer
The Netherlands

Mr. R. Larsen
Denmark

Mrs. V. Montembault
France

Mr. R. Moroz
Germany

Mrs. E. Nijhoff Asser
The Netherlands

Mrs. M. Paris
Italy

Mrs. A. Peckstadt
Belgium

Mrs. E. Perova
Russia

Mrs. M. Polman
The Netherlands

Mr. C. Sarnelli
Italy

Mr. C. Schettini
Italy

Mrs. A.L. Schmidt
Denmark

Mr. W. Schmitzer
Germany

Mr. A. Schulze
Germany

Mrs. T. Seddon
UK

Mrs. M. Silveira
Italy

Mrs. I. Specht
The Netherlands

Mr. C. Stable
UK

Mr. M. Stolz
France

Mr. T. Sturge
UK

Mrs. J. Swann
UK

Mr. R. Thomson
UK

Mr. C. van de Watering
The Netherlands

Mrs. L. Watteeuw
Belgium

Mrs. B. Wills
UK

Mr. J. Wouters
Belgium

Mrs. M. Yusupova
Russia