2002 AIC PAINTINGS SPECIALTY GROUP POSTPRINTS

Miami, Florida June 6-11, 2002

The American Institute for Conservation of Historic and Artistic Works

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Compiled by Helen Mar Parkin

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TABLE OF CONTENTS

THE REMOVAL OF MULTIPLE LAYERS OF OVERPAINT WITHOUT THE USE OF TOXIC SOLVENTS

Kenneth B. Katz, Conservator of paintings[1]

This presentation discusses two methods of removing multiple layers of oil and acrylic paint over original designs. The methods were carried out at the Detroit Athletic Club during an overall restoration of the historic club, designed by Albert Kahn. The use of toxic solvents was proscribed because of the locations, time and requirements of the Athletic Club. The two following methods, water poulticing and strappo were used to accommodate the Athletic Club's requirements.

The water poultice treatment took place in the late summer and early fall of 1999, a year after the Detroit Athletic Club had begun a process of somewhat informed conservation and restoration of their entire historic building. The building, designed by Albert Kahn was modeled after the exterior of early renaissance palaces of Italy. The building was completed in the year 1915 and was called an architectural triumph, by no other than Kahn, to which he added the art features. In an article, which appeared in the Detroit News of 1915, Kahn described all his decorative surfaces with respect to his interior architecture and made a point to their importance in his overall scheme.

Our treatment was part of an overall treatment of the dining facilities known as The Grill Room, which is located on the first floor. Kahn described this room as being patterned on the rooms in the Fourteenth Century Palazzo Vincigliata, outside of Florence. Archival notations had indicated that the entry foyer and vaulted ceiling had been painted by the same decorative painter who had painted the upstairs dining room, A. Duncan Carse, who Kahn described as an artist with rare and unique skills. However, the style in the foyer did not appear to be the same as noted in the upstairs main dining room, which had been treated the previous summer. Further investigations revealed that The Grill Room had been completely restored in the nineteen fifties due to the unacceptable harsh and loud sound quality. Acoustic tiles had been placed over the original design and the original design repainted on the tiles. The club's intention was to reveal the original surfaces in the parts of the Grill that had not been destroyed and remove the acoustic tiles, which would then be replaced with a new plaster ceiling and painted reproductions. The entryway, which consisted of oak wainscoting, ending in a plaster wall, appeared to be the only remaining, undamaged surface that had been decoratively painted by Carse.

I was given the task to see if we could remove the overpaint; the stipulation being; the Athletic Club wanted to remain open and functioning during treatment. This provided a challenge. Previous tests made by a decorative painter using strong solvents appeared to be too intrusive to the public or damaged the original design. It appeared that traditional means of overpaint removal would not work. I attempted the Strappo technique that had been highly successful the summer before on the upstairs dining room, but it did not work. I then thought about a minor treatment that I had performed on the Diego Rivera Frescoes located at the Detroit Institute of Arts. I had been asked to remove a small area of oil restoration that was disfiguring. I had intended on using the fresco cleaning solutions that I had been exposed to in Italy, but not having the additives to make this water based solution, I remembered applying wet cotton on the overpaint, covering it with plastic and letting it sit for about maybe five minutes. The overpaint became soft and came off with a little help from a scalpel. I also remembered that during the summer of 1998, we had tried this water poultice system in the main dining room of the athletic club, but only got the paint to wrinkle. Those tests had been about 7 hours. This time I covered a section of the foyer wall painting with cotton and plastic and waited 24 and 48 hours respectively. To my delight, the 48 hours seemed to do the trick. The upper layers of overpaint became soft and wrinkled and were removable with a flat tipped spatula. Absolutely no damage occurred due to the exposure to water or mechanical removal. A table was set up; cotton was rolled out, cut to size and inundated with water. Using the paper backing, in which the

[1] Kenneth B. Katz, Conservator of Paintings, Conservation and Museum Services, 905 Henry Street, Detroit, MI 48201 313 963 5262 kenann81@aol.com

cotton is rolled, as a support, the poultice was placed against the wall, and covered in plastic and taped close. After waiting the 48 hours, the poultice was rolled off and the overpaint removed. It seemed that direct contact had to be made or the paint, although soft, would not come off as easily. For those areas that did not come off easily, a poultice was applied again for a couple of hours. The overpaint was removed from the two side walls. The rounded concave ceiling proved to be our next challenge since we had to have the wet cotton in direct contact with the overpaint. First, we cut one play cardboard to the size needed. We unrolled the cotton over plastic and wet the cotton. We then kind of wedged the cardboard in place between the two side walls, and used plastic tubes, cut to size to keep the matrix up. I soon realized that the amount of water dripping on the already cleaned walls was causing blanching. We then protected those walls. We waited 48 or so hours, in one case it was 56, and then peeled off the poultice and sloughed off the soft, wrinkled overpaint. After removal of all overpaint, losses were filled and inpainted with acrylics and watercolors, the areas of blanching were treated with a brush coat of Rohm & Haas Acryloid B72 in Exxon Chemical Company aromatic solvent 100 and diacetone alcohol 2:1, applied very early on a Sunday morning. The blanching was removed and a final spray of 5% Acryloid B 72 in xylene and Exxon solvent 100 was applied as protection. We have not had an opportunity to try this water poulticing technique since, but feel strongly that the unqualified success of this treatment should make this technique another option for architectural surfaces.

Water as a solvent for overpaint removal was also used the year before at the Detroit Athletic Club. We were given six weeks to remove three layers of overpaint on a ceiling that covered approximately 1000 square feet. This treatment took place in the Main Dining Room of the Detroit Athletic Club, which originally had a decorative painted ceiling. This ceiling was painted over in the nineteen fifties. As with The Grill Room, the presence of all the construction trades, who were also working in the room, proscribed the use of traditional strippers. In addition, the limited time available and the logistics of removing overpaint above your head made the use of such solvents impractical. We decided to try Strappo. Strappo, comes form the Italian word to tear and it's a procedure that is used to remove the final design layer of a fresco from its under layers. First, we did small tests, which were successful and eventually made the major commitment to do it all. It took us three days to remove all of the overpaint. We chose cheap cotton muslin bought at Minnesota Fabrics and brushed on a mixture of Elmer's Yellow Carpenter Glue and water 2:1 directly onto the overpaint and then brushed on a second mixture of glue and water 1:1 onto the muslin, which was then applied to the overpainted surface and squeegeed to remove the excess. Once dried, the matrix was pulled off taking the layers of overpaint. Once the overpaints were removed, the underlying varnish was removed with acetone and the restoration continued using traditional conservation methods where appropriate, and decorative painters where major losses had occurred. Again, the use of water as a non-toxic stripper allowed us to complete a great challenge. To date, we have used this method successfully on other architectural surfaces and have also used it to remove upper layers of overpaint on smooth coves of overpainted oil gilded frames. I have often given thought as to why the treatments worked as they did. At this point, I think that the water poultice treatment may have worked because the original oil based paints had cross-linked so thoroughly, compared to the later additions. This meant that the water molecules could penetrate the spaces among the molecular chains of later paint, but could not penetrate the older, more crosslinked original layers. Therefore, the upper layers swelled and were removable, while the lower layers held their ground. The reason why the overpaint cleaved so distinctly in the Main Dining room might be explained by the fact that the painters of the overpaint in the 1950's had not adequately prepared the surfaces, so that there was a layer of grime that provided a line of demarcation. Lucky for us.

Recently we have experimented with the Elmer's glue strappo technique in the removal of "radiator" paint from gilded frames. We have had great success in removing upper layer of overpaint, which allows us more control in the removal of the lower layers.

THOMAS EAKINS AND THE PURSUIT OF "TRUE TONES"

Nica Gutman, Associate Conservator for the Kress Collection Conservation Program
Mark Tucker, Senior Conservator of Paintings

In preparation for the Fall 2001 exhibition "Thomas Eakins: American Realist" at the Philadelphia Museum of Art, over 150 of his paintings were studied, not only as the products of a combination of specific artistic and technical concerns but also as products of a history of conservation interventions, namely cleanings.[1] Of particular concern was the original final effect Eakins strove to achieve and the role of color in that effect. Eakins's particular painting techniques and evidence of specific patterns of physical and visual alterations in a broad sampling of his paintings show that precise control of color and tone in Eakins's paintings was closer to the core of his artistic concerns than the present appearance many of his paintings now suggest. Changes to the surface of Eakins's paintings are largely the result of past restorations that began to take place a year after Eakins's death in 1916. Throughout the decades, attempts to reveal what were believed to be the true colors of Eakins were taken up time and again, and with each campaign, the visual and material connection with the original surface and effect of paintings became more tenuous. Study of the paintings themselves, gave us the opportunity to interpret the physical evidence of changes that have occurred and how they affect the accuracy and completeness with which the paintings represent Eakins's artistic inclinations, ideas and abilities. How we see Eakins reflected in his art depends critically on our knowing how his paintings would have looked as he knew them.

Through our examination of Eakins's writing and its correlation with technical and visual characteristics of his paintings, it became apparent that from his earliest paintings onward Eakins was committed to a particular way of painting in layers. His paintings can often seem like multi-layered workbooks in the study and control of color relationships and overall key. In many paintings, broad areas of color such as skies have passed through earlier stages, sometimes tonally and texturally unrelated to the final surface Eakins settled upon. Rarely did Eakins's final effect depend on directly applied, unmodified pure colors and high key. His technique is characterized by a direct, solid underpainting followed by successive modifying layers. He used such modifying layers not only for modeling but to adjust relativities of color and lower the overall key of his paintings. Often seen are very light-toned underpaintings, sometimes of jarring, brilliant color whose brightness was then attenuated with glazes or scumbles or sometimes neutralized with layers of darker or more subdued opaque color. After making his final color choices, we have found that Eakins often further reduced the brightness of his paintings with thin layers of black, brown or gray tone. These layers were either applied over broad passages or over the entire paint surface. We have observed a variety of such final surface toning layers ranging from what appear to be no more than sparsely pigmented varnish to more conventionally pigmented transparent brown or black glazes to thin transparent scumbles.[2] Eakins's use of such final toning layers has been traced to works from his early years as a student through every decade of his career. Progressive adjustment of color, in particular the lowering of color intensity and key, is a consistent and definitive feature of Eakins's painting process.

Numerous accounts by those who knew the early appearance of Eakins's paintings firsthand confirm that they were noticeably and intentionally subdued in contrast and color and low in key. Eakins's widow Susan, who best understood the effect Eakins strove to achieve, was deeply upset by the excessive contrast in a photograph of a painting that she claimed misrepresented Eakins's work saying, it "in no way represents a true description of the delicacy and quiet true tones of the picture."[3] Further, she stated that the painting had not darkened and that in a correct photographic rendering of the painting, "No matter how soft or dark in tone it may appear, the tones are true..."[4]

Nica Gutman , Associate Conservator for the Kress Collection Conservation Program, Conservation Center of the Institute of Fine Arts, New York University, New York, NY.
Mark Tucker, Senior Conservator of Paintings, Philadelphia Museum of Art, Philadelphia, PA.

As a mature artist, Eakins never publicly expressed his approach to color and nearly all that we know comes from letters and notes made early in his career. In these writings, Eakins concerns himself with a number of points that remain pertinent to the technique and appearance of his painting through the decades. His notes as a student in Spain (1869-70) at the Prado Museum show him responding rapturously to the technique he sees in the works of seventeenth-century Spanish masters. Eakins analyzes Velásquez's painting technique writing, "...perhaps he sought his color harmonies at several times painting over it, for the color is excessively thick... Finally, he rubbed over it when it was all completely dry, using tones already prepared..."[5] In speculating about this last stage of Velazquez's technique Eakins may well have been responding to the accumulation of dark varnish that would have covered this and so many other paintings at that time in the Prado.[6] Such varnish layers were often viewed as an integral part of the "patina" of old master paintings. Eakins's dark toning layers may have not only served a tone-adjusting function, but to some degree an historicizing one: an imitation of patina to associate his work with that of the old masters.

In the works of Velásquez and other old masters, Eakins sought, and found, affirmation of his belief in the superior potential of indirect, layered painting, stating that it is "the only [way], in my opinion, that can give delicacy and strength at the same time."[7] Eakins's particular layering process achieves a mutual reinforcement of these two expressive modes. He establishes strength in his work by painting solidly, quickly and as brightly as possible, thus establishing high key and emphatic contrasts at the outset. The objective of all subsequent layers and adjustments would then be to offset that strength with delicacy—ever finer gradations of modeling and contrasts, leading to an ultimate goal of refined total effect.

Artists who wished to represent nature objectively knew that the absolute tonal range of most subjects was beyond that of oil paints. Endpoints of the scale available to the painter are of course fixed by the absolute values of black and white pigment. With Eakins's particular technique he was able to extend this scale by compressing his value gradations into a narrower range and then shifting them towards the darker end of the value scale. This shift gave "headroom" for the sparingly disposed highlights, which he could then set very high above the picture's overall key. In many cases, the overall key of Eakins' s paintings was certainly toward the darker end of academic realism's range. Sometimes overall key could be radically low especially in his outdoor scenes (fig. 1).

For all Eakins's concern with refinement of color values we see in his writings that he worried intensely over a problem that was beyond his control: the effect of various colors and intensities of light on a painting. On A May Morning in the Park (Fairman Rogers Four-In-Hand), we see evidence of Eakins's response to higher than expected light where it was being exhibited. The painting's overall key was adjusted by a final, extremely thin black coating that was added after the painting was in its frame and on the wall (Figs. 2, 3). In Eakins's writing he reasons through many problems of illumination and finally concludes, stating, "One ought to know the place where a picture will be shown before it is begun."[8] Eakins found his own way, painting for the viewing conditions he preferred and considered as standard—the diffuse white daylight of a nineteenth century picture gallery or domestic interior. Eakins painted by daylight for his paintings to be viewed by daylight. His sensitivity to subtle differences in the quality of daylight indicate he would not have accepted the artificial illumination of the day (particularly gaslight) for either painting or critical viewing. The subdued-veiled looking aspect of the majority of Eakins's paintings was the product not only of his personal inclinations, artists he admired, and period academic standards, but also of his specific sensitivity to color.

The individuality of Eakins's vision of color and the layered, indirect painting technique that served this vision would have unforeseeable consequences for many of his paintings. In the period immediately following Eakins's death in 1916, some paintings were cleaned in preparation for the 1917 Thomas Eakins Memorial Exhibition at the Metropolitan Museum of Art (fig. 4). By this time specific tastes and theoretical criteria Eakins had addressed in paintings created twenty, thirty, forty or more years earlier were all but forgotten with the fading of the critical currency of academic realism. Foremost among these were the low key and "dark," "soft," "true" tones pointed out by Susan Eakins as fundamental to Eakins's intent. As paintings were cleaned in subsequent years, the absence of specific knowledge of his desired effect and of the painting techniques by which it was achieved led to frequent misinterpretation. The objective directness of academic realist paintings suggested to some an equal directness in execution. In those cases, Eakins's intentionally subdued paintings were mistakenly believed to have been originally lighter, and simply obscured by accumulated grime and darkened picture varnish. As a result, the primary aim of many earlier cleanings became the exposing of a lighter paint surface and what they thought were the "truer" bright colors. Susan Eakins's ongoing concern for the state of paintings that were not in her direct care is clearly expressed in a letter of 1937 in which she declares, "I confess I fear the so-called, expert restorer, if the effort is not understood irreparable damage may be done by the effort to lighten the colors, which destroy the tones."[9] For the painting of William Rush Carving His Allegorical Figure of the Schuylkill River (1876-77) she stated, "The picture is so delicate that attempts to lighten it would be disastrous."[10]

Accounts suggest that Eakins did apply a varnish over his final layers, likely mastic.[11] An artist with Eakins's formal training; however, was aware of the inevitability of future cleanings, making sure his final layers of painting could withstand the removal and replacement of such aged soft-resin varnish. A May Morning in the Park (Fairman Rogers Four-In-Hand) is one of the few paintings which has its overall toning layer nearly intact (Fig. 2). A cross-section sampled from the foliage in the upper right background illustrates Eakins's indirect layering technique. The foliage was initially painted with a bright yellow green oil paint. An interlayer varnish was applied over the initial lay-in and the area was then toned down with a darker green oil paint. The painting was further darkened with a dark toning layer which was applied overall, seen as the uppermost layer of the cross section (Figs. 5, 6). For his interlayer varnish, the forms of damage we see suggest that it is an easily soluble soft-resin. Eakins also occasionally mixed resinous mediums into his paint which have been seen incompletely blended. Technical analysis was carried out on the upper toning layer. It comprises carbon black pigment particles, yellow ochre, transparent browns and numerous wool fibers suspended in a transparent medium.[12] Analysis of the medium has confirmed that the toning layer is a copal/oil mixture made from an African copal.[13] The identification of copal in paintings through technical analysis has been difficult in the past due to the chemical reaction of the resin over time, which results in a loss of its characteristic components. With the recent development of a two-step pyrolysis-GCMS method with on-line thermally assisted methylation, markers of the resin even in small amounts can now be identified.[14] The phases of the analysis detected traces of diterpene compounds characteristic of an African copal, including eperuic and copalic acids (Fig. 7).[15] In addition, the ratio of the C8/C9 carboxylic acids seen in the first phase total ion chromatogram indicates heat bodied drying oil.[16] The application of such hard resins to resist the typical cleanings, was a precaution advocated in many artists' treatises of the time such as the 1830 treatise "De la peinture á l'huile" by J.F.L. Merimée. It is also quite possible that Eakins learned this practice from his teacher Jean Léon Gérôme who gave students his own recipe for a copal/oil final protective coating which he said would "give the solidity of flint."[17] With Eakins's interlayering of varnish and paint layers, the upper pigmented copal /oil layer not only served to tone down the painting but also to "seal off" its many layers.

To the naked eye, Eakins's uppermost layers of dark tone and glazes that modified color and key would have been indistinguishable from darkened picture varnish and accumulated grime. In early cleanings of Eakins's paintings; however, restorers' removal of only the more soluble uppermost picture varnish would not have brought about the expected increase in brightness or clarity of color. Unfortunately, further more aggressive efforts were often made to reveal what was believed to be Eakins's still-obscured color by removing his intentionally dark toning layers. Once these layers were finally broken through, underlying glazes, paint layers and intervarnish layers were also disturbed, exposing in places the lighter or brighter colors Eakins had used in earlier foundational stages of painting. Often cleaning continued in the hope of uncovering consistently purer colors. In some paintings Eakins had placed delicate highlights on top of his glazes or toning layers; such highlights unfortunately often came away with removal of the toning layers on which they rested. Through the years, attempts to reveal what were believed to be the "true" colors of Eakins were taken up time and again, and with each campaign, the visual and material connection with the original surface and effect of paintings became more tenuous.

Despite the disruption to Eakins's toning and upper paint layers, some evidence of the original layering and final surface usually remains. Patches and residues of once-continuous upper toning layers are often found in more protected recesses of the paint surface. Even when what remains are bare traces, evidence of their original presence is suggested by erosion or undercutting of the paint. One earlier restorer's report we encountered records a typical misinterpretation of an originally and intentionally dark surface layer on an Eakins painting: "Varnish dissolved and removed which however did not lighten the surface considerably. It appears that the paint film must have been 'oiled out' at one time before it was [lined] and varnished, which accounts for the darkening. Only a rather risky time-consuming treatment could correct this."[18] The restorer did however try to lighten the painting and subsequently records, "An attempt was made to remove the brown coating by cleaning with morpholine swelling repeatedly with copaiba balsam and toluene. Some was scraped with scalpel."[19] After which the restorer summed up, "Almost impossible to remove coating from original."[20] As unthinkable these measures seem now, they show how convinced some people were that Eakins's surfaces were wrongly obscured and needed to be revealed.

Comparison of a painting with archival photographs taken before various cleanings can give direct evidence of change and effects of cleaning. Defects in the tonal rendering of the early photographs call for caution in interpretation, but their comparison to the present state of paintings can give a comprehensive and direct idea of the effects of cleaning (Figs. 8, 9). It is important to acknowledge that a degree of change in Eakins paintings has occurred through aging, such as darkening and yellowing of mediums and some fading of specific pigments, but compared with the consequences of well-meaning but uninformed cleanings, aging is by far the lesser factor in changes to color relationships and key throughout Eakins's work. We have observed a wide range in the degree of alterations and broad trends from more aggressive cleanings. Light areas rendered inappropriately more so by removal of overlying tone may exhibit false or more abrupt modeling transitions, heightened contrasts, and area-to-area incongruities of key. In addition to distortion of color and overall key, some cleanings have had an unsettling influence on effects of paint texture and handling. Residues of once continuous toning layers remaining in the recesses of more textured paint can often create a heightened sense of assertiveness to the brushwork. Cases of more aggressive cleanings may exhibit disruptions of modeling and spatial representation and loss of delicate detail that can produce a false appearance of lack or inconsistency of finish (Figs. 10, 11).

Although we can discern trends of alteration, the situation is complicated. Such obvious damage that we have seen is really the exception. In most cases, it is only through close technical examination of each painting, along with comparison with archival documents and research of written accounts that we can even begin to gauge to what degree and in what way a given painting is altered. This study has given us new grounds for interpretation of the physical evidence of changes that have occurred and how they affect the accuracy and completeness with which the paintings now represent Eakins's artistic inclinations, ideas and abilities. With the information gathered, it has been possible in some case to reconcile some of the conflicts between the present state of paintings and what we could determine about their original appearance.[21] Continued close study of the paintings themselves—not only as products of a combination of specific artistic and material concerns but also as products of a history of interpretations and interventions—still affords some of the best possibilities for enrichment of our understanding of distinctive qualities of Eakins's artistic identity and achievement.

ACKNOWLEDGMENTS

The authors wish to thank Andrew Lins, Beth Price, Dr. Kenneth Sutherland, and Dr. Klaas Jan van den Berg for their work on the analysis of Eakins's materials. Our gratitude especially goes to all of the conservators who shared their thoughts and experiences with Eakins paintings. Also we would like to express our appreciation to our colleagues in the Conservation Department of the Philadelphia Museum of Art for their support throughout the project.

ENDNOTES

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[1] Research findings were published in depth in the exhibition catalog: Mark Tucker and Nica Gutman, "The Pursuit of 'True Tones'," *Thomas Eakins*, [Philadelphia Museum of Art] 2001, 353-365.

[2] The sparsely pigmented varnish found on a number of Eakins's paintings often contains studio detritus such as the occasional wood fiber, red and blue textile fibers, flecks of gold leaf and brush hairs.

[3] Susan Eakins to Charles H. Sawyer, March 16, 1934, Addison Gallery of American Art, Phillips Academy, Andover, Mass.

[4] Susan Eakins to Charles H. Sawyer, March 27, 1934, Addison Gallery of American Art, Phillips Academy, Andover, Mass.

[5] Thomas Eakins, Spanish Notebook, Pennsylvania Academy of the Fine Arts, Philadelphia, Charles Bregler's Thomas Eakins Collection, purchased with the partial support of the Pew Memorial Trust [hereafter Bregler Collection]; authors' translation from the original French.

[6] Eakins would have noticed the marked darkness of Velásquez's paintings in the diffuse daylight of the Prado's galleries. As Velásquez scholar Griddley McKim-Smith notes, "The overall tonality [of Velásquez's] paintings still seems dark when compared with other European paintings," even in late canvases with lighter beige grounds (private correspondence). In addition, Velásquez's paintings were almost certainly more obscured by darkened varnish in Eakins's day than they are now.

[7] Thomas Eakins, Spanish Notebook, Pennsylvania Academy of the Fine Arts, Philadelphia, Charles Bregler's Thomas Eakins Collection

[8] Ibid.

[9] Susan Eakins to Charles H. Sawyer, 1937, Addison Gallery of American Art, Phillips Academy, Andover, Mass.

[10] Susan Eakins to Fiske Kimball, January 21, 1932, Eakins Research Collection, Philadelphia Museum of Art, Philadelphia.

[11] Elizabeth La Rue Burton cited a letter from Susan Eakins as specifying only rectified turpentine, used sparingly, as the solvent for the safe removal of dull or discolored picture varnish from the surface of Eakins's paintings, and mastic in rectified turpentine as the picture varnish to be reapplied after cleaning (letter from Elizabeth La Rue Burton found on the inside of the backing of her portrait by Eakins in the Minneapolis Institute of Arts, dated November 30, 1935, copy in Eakins Research Collection.

[12] Pigments were identified using polarized light microscopy.

[13] Preliminary analysis was carried out by Beth Price and dr. Kenneth Sutherland at the Philadelphia Museum of Art. Micro-FTIR and GC-MS suggested the presence of natural resin and oil. A scraping of the layer was sent to dr. Klaas Jan van den Berg at the Netherlands Institute for Cultural Heritage (ICN), Amsterdam, for analysis by Py-GCMS which confirmed the presence of copal resin.

[14]For description of analytical technique, see Van den Berg, K.J., van der Horst J., Boon J.J., "Recognition of Copals in Aged Resin/Oil Paints and Varnishes," In Bridgeland, J. (ed.), Preprints of the 12th Annual Meeting of the ICOM Committee for Conservation. Paris: International Council of Museums, (1999) 855-861.

[15] The data is described in detail in the publication: "Analysis of copal resins in 19th century oil paints and resin/oil varnishes" (van den Berg et al, Art 2002: 7th International Conference on Non-destructive Testing and Microanalysis for the Diagnostics and Conservation of the Cultural and Environmental Heritage, June 2002, Antwerp, Belgium.)

[16] Ibid.

[17] Charles Moreau-Vauthier, *The Technique of Painting*, New York: G.P. Putnam's Sons; London; William Heinemann, 1917, p.139.

[18] Research records at the Conservation Department of the Philadelphia Museum of Art.

[19] Ibid.

[20] Ibid.

[21] Treatments were carried out on a number of paintings, most notably *The Pair-Oared Shell*, *Sailboats Racing on the Delaware*, *The Crucifixion*, *Mending the Net*, *The Agnew Clinic*, *Between Rounds*, and the Philadelphia Museum of Art and Ball State University paintings *Shad Fishing at Gloucester on the Delaware River*. The treatments of *Mending the Net*, *Sailboats Racing on the Delaware*, and *Between* Rounds were briefly illustrated in the lecture.

Fig. 1 The overall extremely low key of *Ships and Sailboats on the Delaware*, 1874 (Philadelphia Museum of Art), the middle painting, is evident in this 1944 installation photograph. The painting, with its overall dark gray tone, depicts in Eakins's own words, "a still August morning 11 o'clock."

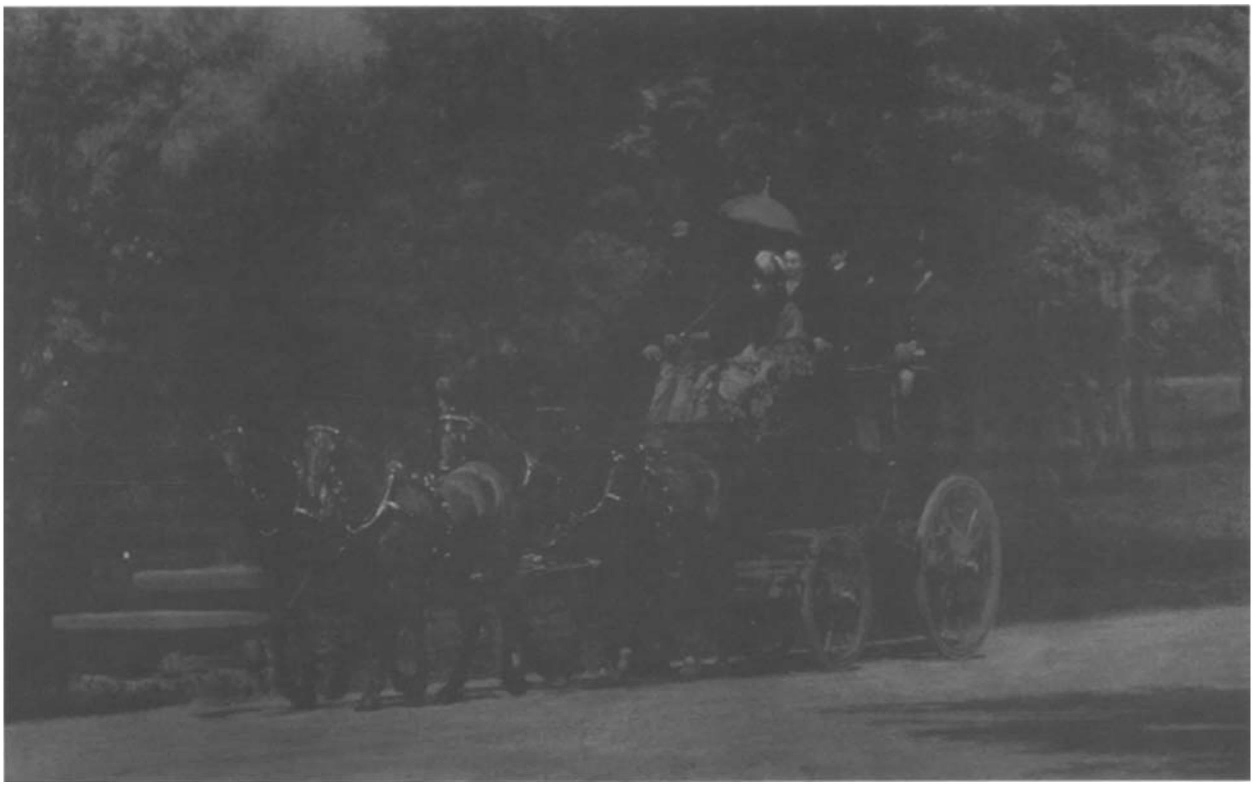


Fig. 2 Thomas Eakins, *A May Morning in the Park* (*The Fairman Rogers Four-in-Hand*), 1879-80, Philadelphia Museum of Art.

Fig. 3 Detail of right edge of A May Morning in the Park shows where the black surface coating does not extend onto the narrow margin of the painting covered by the frame.

Fig. 4 *Thomas Eakins Memorial Exhibition at the Metropolitan Museum of Art, New York, November 5- December 3, 1917.* The Metropolitan Museum of Art, New York.

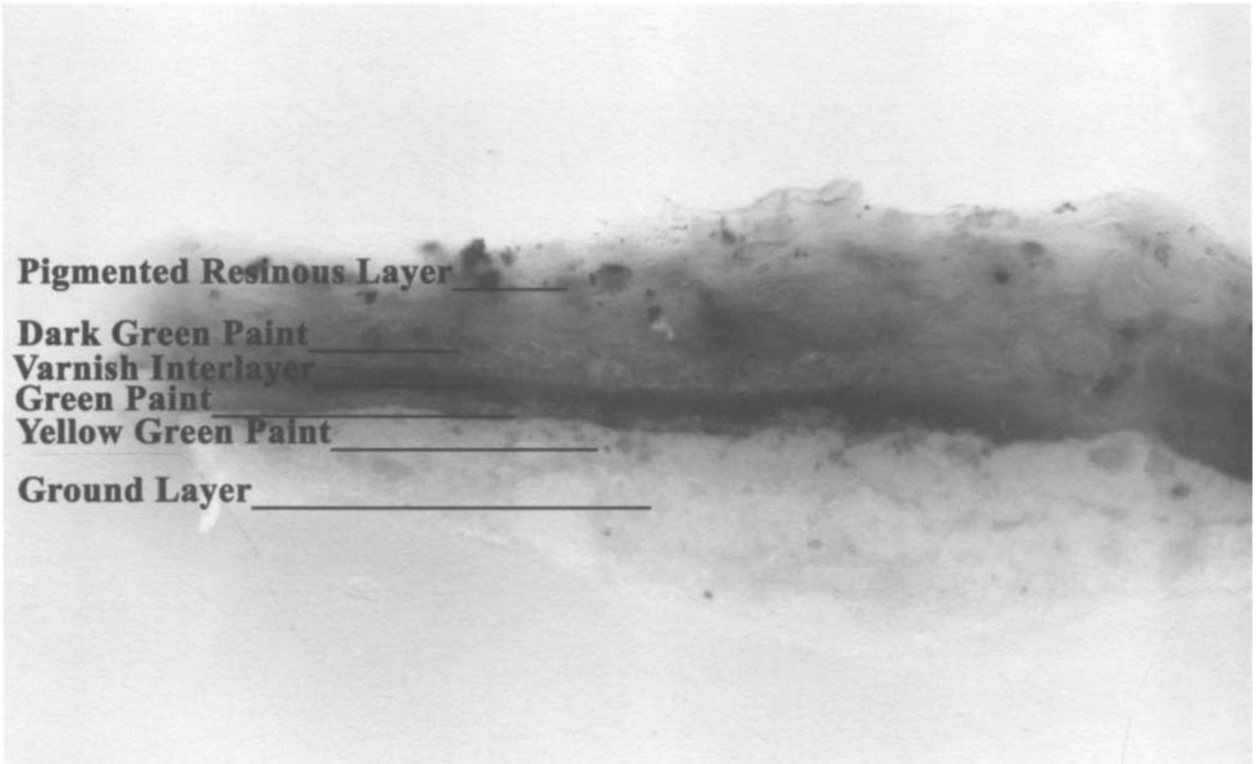


Fig. 5 Cross-section through the green foliage of the right background. Photographed under visible light at a magnification of 500x.

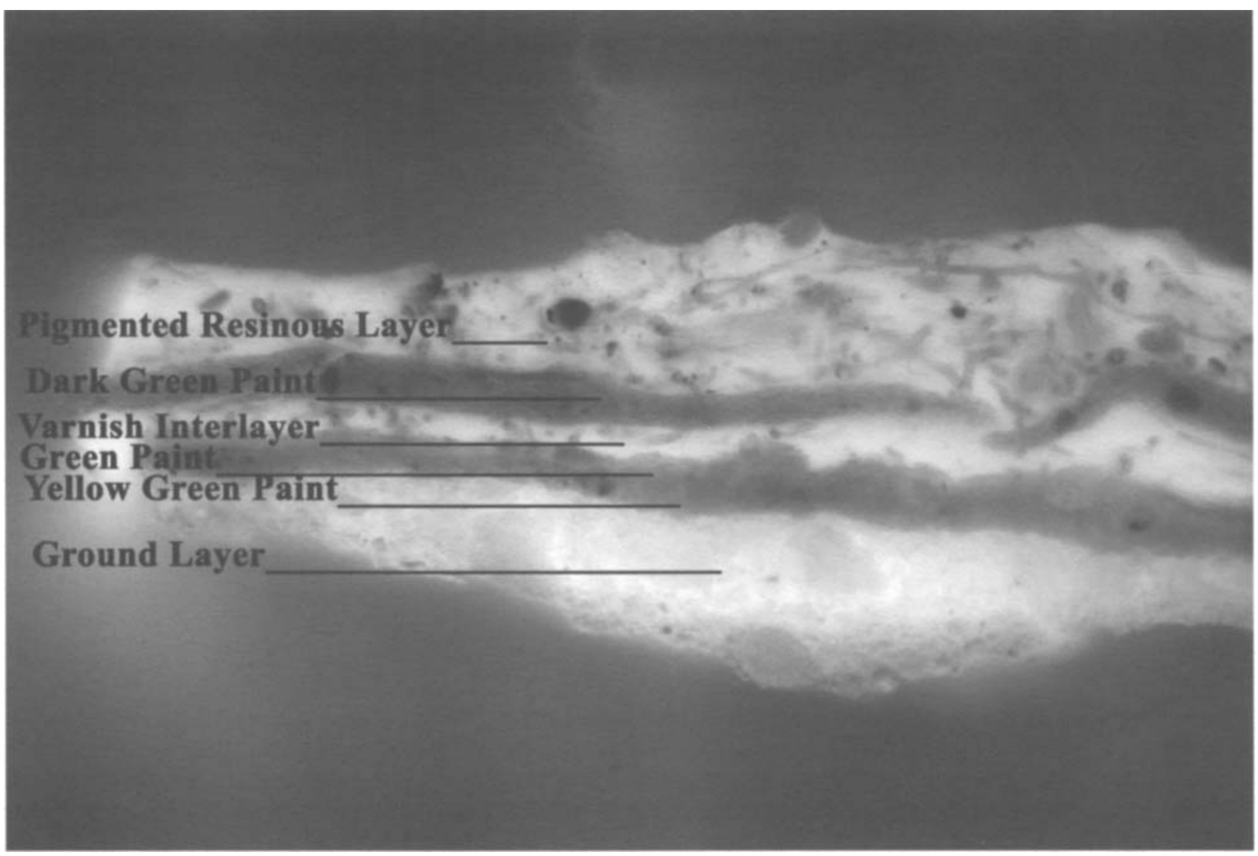


Fig. 6 Cross-section through the green foliage of the right background. Photographed under ultraviolet light at a magnification of 500x.

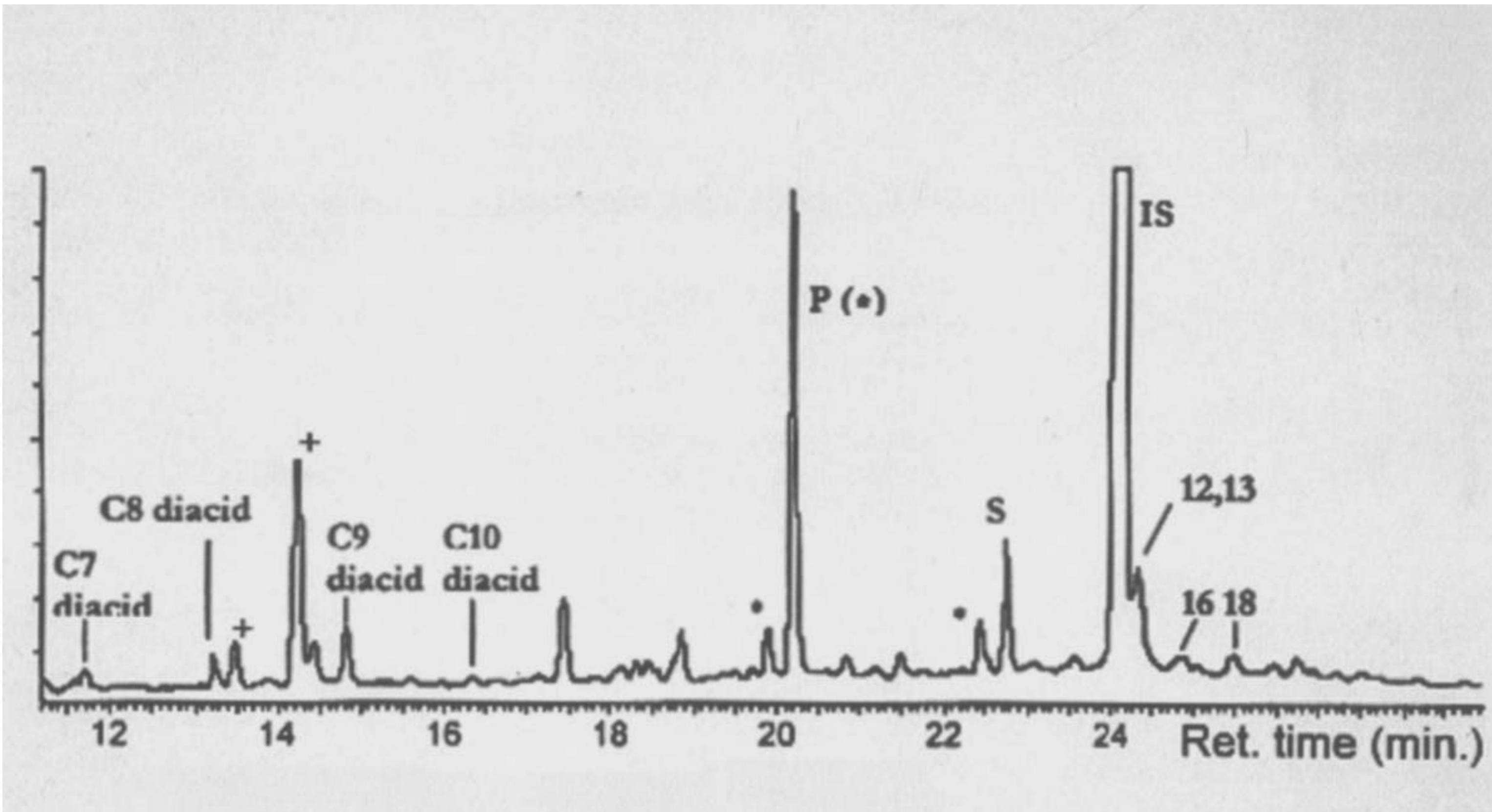


Fig. 7 Total Ion Chromatogram of the first phase of analysis of the upper layer of *A May Morning in the Park.*

Fig. 8 Photograph of *Salutat*, 1898, taken at the time of the 1899 Pennsylvania Academy of the Fine Arts 68th Annual Exhibition. Archives, Pennsylvania Academy of the Fine Arts, Philadelphia.

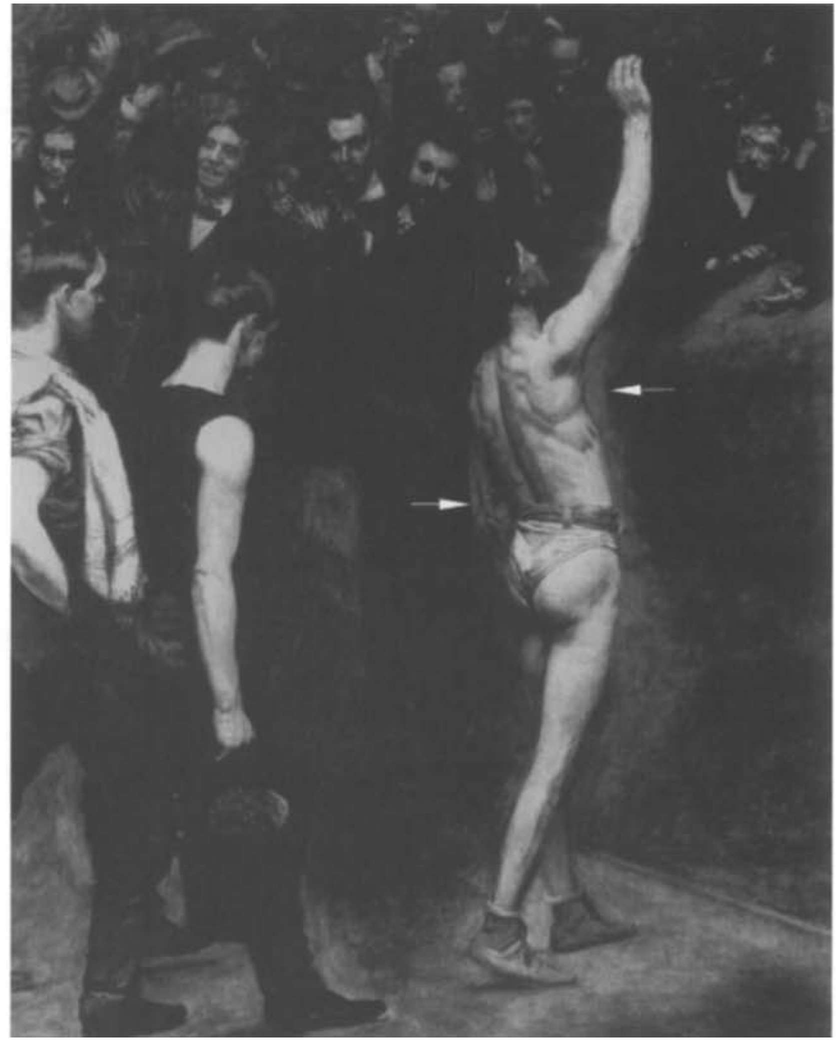


Fig. 9 Changes caused by disruption of upper paint layers in early cleanings are visible in comparison with figure 8. The arrows show the halo around the figure of the fighter caused by a cleaning that removed dark surface tone from the adjacent background.

Fig. 10 Detail of 1917 photograph of *Sailboats Racing on the Delaware*, 1874. The Metropolitan Museum of Art, New York.

Fig. 11 Detail of the same area of the painting photographed October 2000. As early as 1944, photographs show that details of rigging visible in the 1917 photograph had been removed in an attempt to lighten the tone of the sail.

THE CONSERVATION AND TECHNICAL STUDY OF THE CORONATION OF HEBE ATTRIBUTED TO PAOLO VERONESE

Catherine G. Rogers, Private Paintings Conservator*
Gianfranco Pocobene, Private Paintings Conservator**
Elizabeth Leto Fulton, Associate Conservator of Paintings ***

Within the past few years, the Isabella Stewart Gardner Museum has undertaken major conservation projects to preserve some of this country's finest art collections. One such large project has recently occurred in the Veronese Room, one of the most stunning galleries in the museum. The Veronese Room is located on the third floor of the Gardner Museum, and it is adorned with rare gilt and painted leather wall coverings primarily from seventeenth and eighteenth century Italy and the Netherlands. The reconstructed room and ceiling emulates the feeling of a Venetian room with a painted and gilded ceiling of the late fifteenth and early sixteenth centuries. It was commissioned to accommodate the ceiling decoration whose author gives the room its name. The *Coronation of Hebe*, executed by Paolo Veronese (1528-1588) and his studio, was originally painted in the 1580s for a ceiling at the Palazzo Della Torre in Udine, Italy where it remained into the eighteenth century when it was moved to Venice. The painting was eventually sold and made its way to France. On recommendation from her agent, Mrs. Gardner purchased the painting in 1899 from a dealer in Paris where the painting probably received its last major treatment.

Depicted in the work is the Roman goddess Hebe who is presented by Mercury to her parents, Jupiter and Juno, as she assumes her role of cup bearer to the gods. More than fifty figures fill the composition against a backdrop of sky and clouds. Although the perspective system common in Venetian ceiling painting intends that the painting be viewed from a forty-five degree angle, it is still unclear, even after some art historical debate, as to how the painting was originally mounted. To obtain this Venetian perspective properly, one must view the painting from the doorway of and from the adjacent gallery, the Titian Room.

The *Coronation of Hebe* painting project began with the examination of the painting in March 1999 in the Veronese Room. One day was spent on movable scaffolding examining the approximately thirteen foot square painting in situ attached to the eighteen foot ceiling. Solvent testing revealed an easily removable natural resin varnish. There was active flaking paint throughout the painting most likely encouraged by the slackness of the canvas on the stretcher which was further exacerbated by the weight of the paint film on a large canvas which was mounted horizontally facing the viewer. A treatment proposal was submitted during that month, but the necessary funds were not available until the following year. The project was to include setting down of flaking paint, grime and varnish removal and re-varnishing, in-painting, and possible re-stretching of the canvas. The time estimation was approximately 3-4 months for a crew of two-full time and two part-time conservators.

The conservators for the project were Catherine Rogers, Gianfranco Pocobene, and Elizabeth Leto Fulton. Conservation assistants Peggy Waldron and David Colombo, who work for conservators in the Boston area, joined them in the treatment of the painting. Alan Chong, Chief Curator and Anne Hawley, Director of the Isabella Stewart Gardner Museum were actively involved in many of the treatment decisions. The former Chief Conservator, Barbara Mangum, was the person most involved with initial planning stages for this project and was responsible for the fund-raising without which the project would not have taken place. Valentine Talland, Senior Objects Conservator and Kathy Francis, Senior Textiles Conservator, took over the role of acting heads in Conservation and continued to offer support and advice throughout the treatment.

* Conservator of Paintings and Murals, Post Office Box 1408, Charleston, SC 29402
** 193 Maple Street, Malden, MA 02148
*** Museum of Fine Arts, 465 Huntington Avenue, Boston, MA 02115

The treatment of the Veronese painting began on September 5, 2000. The removal of the painting from the ceiling involved numerous hands, three scaffoldings, and a ladder. Chris Aldrich, Chief Preparator, orchestrated the removal of the painting at the museum, and coordinated a crew of sixteen people. The handling crew was made up of conservation and curatorial staff from the Gardner and employees from the art transport company, Fine Arts Express (FAE). On the morning of the removal the group convened in the gallery to talk through the delicate and risky process of removal.

The process started with the removal of the moldings that framed the perimeter of the painting which were then passed down to the two lower tiers of handlers standing on the scaffolding and floor below. The painting was held into the ceiling plaster with eight-inch screws mounted through screw eyes that were attached around the tacking edge of the painting. The scaffoldings were adjacent to three sides of the painting leaving the ladder on the fourth side at the bottom edge of the painting. Once the painting was released from the ceiling on all sides, it was slowly angled down from the bottom edge on the ladder side where one handler could slowly walk down the ladder while the other handlers passed the painting down to the lower tiers of handlers on the scaffoldings. This method helped distribute the enormous weight so that no one person could lose their grip on the painting. Once it arrived at floor level, the handlers there held the bottom edge of the painting while the top was lifted into a vertical position.

Once the painting was vertical, the ladder was removed and a scaffolding tower on lockable wheels was placed behind the painting to act as an easel. The scaffolding had been modified by Chris Aldrich to include four support boards that extended from the base of the tower meant to support the painting off the floor along its bottom tacking edge. It was decided in the preliminary talks that the painting needed to be off the floor by at least a foot for the ease of working along the lower edge. The crew then raised the painting onto wooden support mounts. The weight of the painting was counter-balanced by weights attached to the lower level of the scaffolding. Outriggers were placed on the legs of the scaffolding to stabilize it, thereby keeping the tall painting balanced. The preparator then secured mounting boards at the top of the scaffolding to the painting's top edge. Both the upper and lower mounting boards had projecting wood edges to keep the painting from slipping forward.

All areas where the boards touched the painting were padded to protect the painting from abrasion. As the painting was attached to a wooden stretcher containing several cross-bars, these served as a place to which linen fabric strips were tied to secure the painting to the scaffolding. With the painting now on its "easel" with wheels, the conservators were able to move the painting as needed with ease, and the construction of the workspace began.

Since the painting was too large to remove from the room on its stretcher and too stiff to roll without damage, the decision had previously been made to build a workspace for the conservators in the Veronese Room. Contractors were brought into the museum to construct a public walkway with a Plexiglas viewing window. This allowed the conservators to have an environmentally isolated studio in which to treat the painting with solvents while providing the museum visitors with a viewing area to see the work in progress. The isolated workspace was also a necessary fire and safety precaution.

Many adjustments in the gallery/studio were necessary to make the room a safe working environment. An exhaust system was installed using a switch-operated fume extractor with an elephant trunk that extended to an external window, that could be turned on when needed. An electrical control panel was added to the room for additional electrical needs. A solvent storage container on a wooden dolly made movement around the studio space easier. Portable lights and exhaust systems on wheels were added to the space. Art work and furniture that could be removed from the room were put in storage and other larger pieces of furniture were stored over the walkway and covered with protective materials. The leather wall coverings, which had recently undergone a three-year treatment, were protected from accidental blows with sheets of acid-free board in the lower sections. The entire expanse of the four walls was covered with muslin as a dust cover and reflector of ambient light.

At this point, the conservators and staff assessed the condition of the painting. The painting measured 152" x 155". It was tacked to a wooden stretcher with mortise and tenon joins. There were two vertical crossbars, two horizontal crossbars, and fifteen of the sixteen keys were present. Although no documentation existed for previous treatments, it was apparent that the painting was disassembled for the transatlantic shipping. The evidence supporting this fact was that the stretcher had previously been marked with letters at each joint for ease of assembly. It was apparent that it had been previously lined to a secondary fabric of medium to heavy weight linen with a glue paste adhesive. The original tacking edges had been previously cut away, and at the perimeter of the painting and onto the lining fabric was a reddish-brown paint, which surrounded the painting. The painting was extremely slack on the stretcher, the canvas itself sagging some nine to ten inches from the stretcher when it hung from the ceiling. Once removed from the ceiling and place vertically on the easel for treatment, the canvas rippled along the lower half of the painting.

The ground and paint layers were generally in good condition overall. However, there were some areas of loose and lifting ground and paint layers throughout, but especially in the lower left and right corners in addition to the sky area. The flaking paint was consolidated with warm isinglass glue diluted in de-ionized water. The lifting paint was set down with a warm tacking iron through a silicone release Mylar sheet. Excess isinglass glue was cleared from the painting surface using cotton swabs and sponges moistened with de-ionized water. During this clearing process the surface grime was also removed from these as well as from all areas of the painting.

The removal of the discolored surface coatings began with small tests in various areas of the painting to check for sensitivity of the paint layers. During the testing process we were joined by two fellow colleagues, Jim Wright, Head of Paintings Conservation at the Museum of Fine Arts, Boston, and Marcia Steele, Paintings Conservator at the Cleveland Museum of Art. It became evident during the examination that the varnish layers were uneven over the surface of the painting. The blue sky and cloud areas were covered with a thinner varnish than the figures in the composition, possibly due to a selective cleaning performed in the past to brighten up the lighter and cooler colors of the sky and clouds. A solvent mixture of acetone and mineral spirits 135 (1:1 ratio) was used to dissolve the varnish layer, which was removed from the paint quite easily with cotton swabs.

During the varnish removal, it was observed that the entire background of sky and clouds in the painting were heavily over-painted. This occurred during the restoration of the painting in Paris in the last decade of the 19th century, which is mentioned in the French dealer's correspondence with Mrs. Gardner concerning the sale of the painting. Upon observing that a large portion of the painting was over-painted, solvent test were undertaken as well as paint sampling to verify the stratigraphy of original paint layers and to identify the over-paint layers and pigments used in the restoration. This scientific research was undertaken by Elizabeth Leto Fulton and Richard Newman, Conservation Scientist at the Museum of Fine Arts (MFA), Boston. The analytical work consisted of taking numerous cross-sections of ground and paint layers which were analyzed by electron microprobe analysis and polarized light microscopy conducted at the Gardner Museum, the Museum of Fine Arts Boston, and Harvard University.

While more analytical work could be conducted, for this project, specific areas were focused on to confirm the in suspicions aroused by the cleaning tests. The following information was arrived at through this study. The painting received at least two campaigns of major treatment before the 20th century, which were undocumented. The most recent major restoration was probably done in a French studio previous to Mrs. Gardner's purchase of the painting the late 19th century. Zinc white and artificial ultramarine blue were present in the over-paint layers from that restoration. Original paint layers contain lead white, smalt and natural ultramarine blue pigments that were typically used by Veronese and his studio, as well as by many 16th century painters. The ground layer in the painting was also typical for the 16th century Italian painters; calcium sulfate in an animal glue binder with a very thin upper layer of earth colored imprimatura.

In other samples from a restoration previous to the 19th century, smalt and natural ultramarine were also present. But unlike the original paint samples, they were usually found over a non-typical ground containing calcium carbonate as well as calcium sulfate with no imprimatura layer seen in the samples. Some samples of this type show lower layers of original blue pigments with degradation rings in the smalt, possibly explaining the motivation for restoration in an attempt to liven up a faded sky.

Baker Testing Service of Rockland, Massachusetts took x-radiographs on the painting with the intention of helping to explain the gross areas of over-paint. The conclusion of the x-radiographs was that the painting had numerous small losses, but no major paint loss or damage in the areas of x-radiography. This correlated with the visible examination we could observe under strong tungsten lights in the studio.

Numerous solvent-gel formulas were tested for the removal of the heavy over-paints that covered the painting, but these were found to be ineffective or too slow. Much of the late 19th century over-paint was thinned and removed with acetone and ethanol mixtures. More tenacious layers were softened and swelled with aqueous solutions of ammonium hydroxide at pH 9-10. The over-paint layers were then removed with acetone. In isolated areas, where highly tenacious layers predating the late 19th century restoration covered original paint, N,N-Dimethyl Formamide diluted 1:1 in acetone was used. In areas where the over-paint did not respond to solvents, a scalpel was used to mechanically remove the over-paint. In the figure of Venus this latter approach was abandoned as the figure was so badly damaged.

After the cleaning phase was completed, tests were made on the surface of the painting with different varnish mixtures to determine the varnish to be used on the painting. Five varnish mixtures were applied in vertical strips on the painting. The following mixtures were applied:

A. Acryloid B-72 ®, 15% in CycloSol ® 53.
B. Dammar 25%; Dammar resin 150 g.,Stoddard solvent 400 ml.,Xylenes 100 ml.and Tinuvin ® 292 3g.
C. ConservArt ® Gloss varnish Acrylic varnish F10 & B67
D. MS2A ®, 30% in Stoddard solvent with 2% Tinuvin ®
E. Reagalrez ® 1094; Reagalrez ® 1094 46 g.,Kraton ® G1650 4 g.,Tinuvin ® 292 1 g. and Mineral spirits 66/3 150 g.

The curator, Alan Chong, and the conservators discussed the selection of the varnish with the aid of these test areas. Acryloid B-72 ® (ethylmethacrylate methylacrylate copolymer) was chosen as the varnish for the painting as it adequately saturated the paint surfaces for inpainting. This resin is among the most stable and reversible materials used in conservation and in this case provided adequate saturation for in-painting. The painting was brushed varnished with Acryloid B-72, 15% in CycloSol ® 53. The varnishing was begun at the top of the painting and continued along the surface towards the bottom.

There were several small areas along old seam lines and one tear area in the upper right corner that needed filling. These areas were filled with Polyfix ® (calcium carbonate in PVOH binder). Numerous areas of old fill were retained as no adjustments were needed to be made to improve their appearance. All losses were toned with Windsor & Newton ® watercolors to match the red earth colored undertone of the painting.

The areas of loss and abrasion were in-painted with MSA Restoration Colors ® (manufactured by Golden Artist Colors, Inc., of New Berlin, N.Y.). Most of the in-painting consisted of a series of small stippling of color to bring up the area of damage as the uppermost canvas nubs had been abraded. The main exception to this approach was in the area of Venus's face and upper body. This had been previously over-painted due to underlying damage and no longer had the appearance of Veronese's style. The conservators along with the Director, Anne Hawley, and the Curator, Alan Chong, made the decision to rework the face in the style more appropriate to Veronese.

During the examination of the painting it was observed that the stretcher had bowed considerably since its installation on the ceiling at the Gardner Museum. The stretcher consisted of eight members with two vertical cross bars and two horizontal cross bars. One key was broken and one key was missing. The stretcher had mortise and tenon butt end joins. It appears that at some point in the 20th century, the stretcher had been reversed. There were one-inch wide wooden strips added to the perimeter of the stretcher with nails. The beveled side of the stretcher was found not on the canvas side as one would expect, but on the opposite side. This indicated the canvas had been stretched on the wrong side or, more likely, that the stretcher had been flipped over at some point during the 20th century, and the canvas re-stretched. Stretcher stencils and labels were also found on the inner side of the stretcher which confirmed that the stretcher had been reversed during its history at the museum. Aluminum tacks were also used for the stretching of the canvas onto the stretcher, which would indicate a mid-20th century intervention. There were 63 tacks along the upper edge, 61 tacks along the lower edge, 52 tacks along the right edge, and 57 tacks along the left edge. The canvas was detached from 32 tacks on the left edge. Screw eyes were located along the tacking edges and used in the previous installation of the painting. There were seven screw eyes located along the upper edge, four along the lower edge, three along the right edge, and five along the left edge. The screw eyes were bent from carrying the weight of the painting. The stretcher was badly bowed from the force of gravity and was no longer structurally sound to carry the weight of the lined painting. The mortise and tenon corner joins were especially weak.

The painting had been previously lined to a secondary linen fabric with a muslin cloth interleaf. The lining fabric did not have any seams but the muslin cloth interleaf was made up of several sections. The muslin was approximately 25 inches in width and was placed on the reverse of the painting with an overlap of approximately 1-inch. This muslin interleaf remained on the reverse of the painting during the linen canvas lining removal as it gave structural security to the painting and would have been difficult to remove. The adhesive used was a glue paste adhesive, which had deteriorated considerably. Tacking edges along the perimeter were no longer well attached as the canvas had torn away at the tacks. It was felt that the ceiling molding was the main support for securing the painting in the ceiling. Detachment between the painting and the lining fabric was also occurring along the perimeter and upon further examination, it was observed that the glue-paste adhesive had deteriorated to the point that the original painting canvas and lining canvas were easily pulled apart with little force.

The removal of the stretcher and lining canvas began by saving any information for the archival records in the museum. One stretcher label was removed and backed with Japanese tissue paper and wheat starch paste. It was then encapsulated in Mylar. The stencil label on the stretcher was photo-documented with 35mm color slides. Remnants of a French newspaper were attached to the perimeter of the painting from the previous lining procedure in France. These remnants were collected and recorded.

The removal of the stretcher and old lining canvas was begun with the preparation of the studio space for the structural work. The floor was carefully swept and mopped and layers of rosin paper followed by silicone release Mylar were used to protect the surface of the painting from direct contact with the floor. The painting was then placed face down on this surface and the lining fabric was cut from the tacking edges. Tacks were removed from the stretcher's tacking edges as the stretcher was to be used later in the lining process. The stretcher was photographed and then re-attached to the scaffolding easel. The lining canvas was removed by pulling the canvas in small strips in a horizontal direction. A scaffolding plank longer than the width of the painting was placed on end blocks several inches above the painting to provide a work station for the conservators at the center of the painting. Once the old lining fabric had been removed, the reverse was lightly sanded and vacuumed to remove any excess glue-paste adhesive. The muslin cloth interleaf that was found on the reverse of the canvas after the lining removal was left in place on the back of the painting.

The reverse of the painting was then rolled with warm BEVA 371 ® adhesive (an ethylene vinyl acetate based adhesive); Conservation Products. Co., P.O. Box 411, Chatham, N.J. 07928. Two applications of BEVA ® 371 adhesive were applied to the reverse of the canvas. Each coat was allowed to dry for a 24-hour period. A Polyester Taffetta (polyester fabric), style #738, lot #9792; Testfabrics, Inc., 415 Delaware Avenue, P.O. Box 26, West Pittston, PA. 18643, was selected as the new lining fabric for the painting. It was applied in four strips in along the horizontal direction of the painting. It was attached to the back of the painting by the means of a warm iron.

The second stage of the lining process was the attachment of a second layer of Polyester Taffetta fabric. With this attachment of fabric a cold lining procedure was undertaken with BEVA ® GEL as the adhesive. BEVA 371 was not used here for fear that the solvent might release the bond between the first lining fabric and the painting. Four strips of Polyester Taffetta were placed on the reverse the painting perpendicular to the first layer of polyester fabric. This provided lining support in both the horizontal and vertical directions. The lining fabrics were ironed through a linen cloth release sheet the following day so that the lining fabrics had a sound attachment to the reverse of the painting. To raise the painting from the floor after lining, the old stretcher was positioned over the lined painting. The lined painting was then temporarily attached to the stretcher with staples. The painting was placed on sawhorses, face down to check the condition of the lining and inspect the appearance of the drape of the canvas in its reinstallation position. It was found that there were several undulating planar distortions in the canvas when viewed with a raking light. The lined painting was warmed with tungsten lights during brief periods over the next several days and carefully monitored to encourage the relaxation of these planar distortions. The conservators found that the controlled heat relaxed the distortions considerably and that after re-installation in the ceiling the force of gravity would completely relax these distortions. It has been noted that two years after the painting was reinstalled in the ceiling most of the canvas distortions have disappeared.

During the course of the treatment of the *Coronation of Hebe* painting, conservators and the curator had initially decided to attach the lined painting to a solid support of aluminum honeycomb panel, which would be custom made for the painting. The conservators discussed the problems of installation of such a large painting with several colleagues to find the best solution for the painting installed in a ceiling. Some of the conservators believed that the attachment of the painting to a solid support was the best solution for a painting of this size installed for viewing in a ceiling. In all practicality, the painting cannot be moved or loaned and is to be housed in this position for the duration of the museum's existence. Given the previous problems of sagging from the stretcher support and the bowing of the wood members, a rigid auxiliary support was an ideal solution. Upon further discussions with the curator, it was decided to compromise the proposed attachment to the solid support with a re-stretching of the lined painting onto the solid support. The painting would sag of a few inches but would hang in the ceiling as a stretched painting. The most important aspect of retaining the aluminum solid support is that it will not warp with the weight of the lined painting during over time as the wooden stretcher had previously done. It was also felt that the solid support could be used in a future conservation treatment should it become necessary to actually mount the paint.

The honeycomb aluminum panel was custom made by ConservArt Associates, Inc., at 4823 Berryman Avenue, Culver City, California. It consisted of three sub-panels and edge mounts with pre-drilled holes. The center panel measured 5 feet by 13 feet and two side panels measured 4 feet by 13 feet. The panels are held together by female and male edge joins which fit together when one panel is slid into its mated panel. Small Allen screws were inserted in pre-drilled areas along the seam joins on the reverse of the panels to hold them together tightly. This solid support system incorporates right-angled aluminum mounting edges that are with pre-drilled and mounted to the tacking edges after the painting is re-attached. The mounting edges are then used to secure the painting to the ceiling.

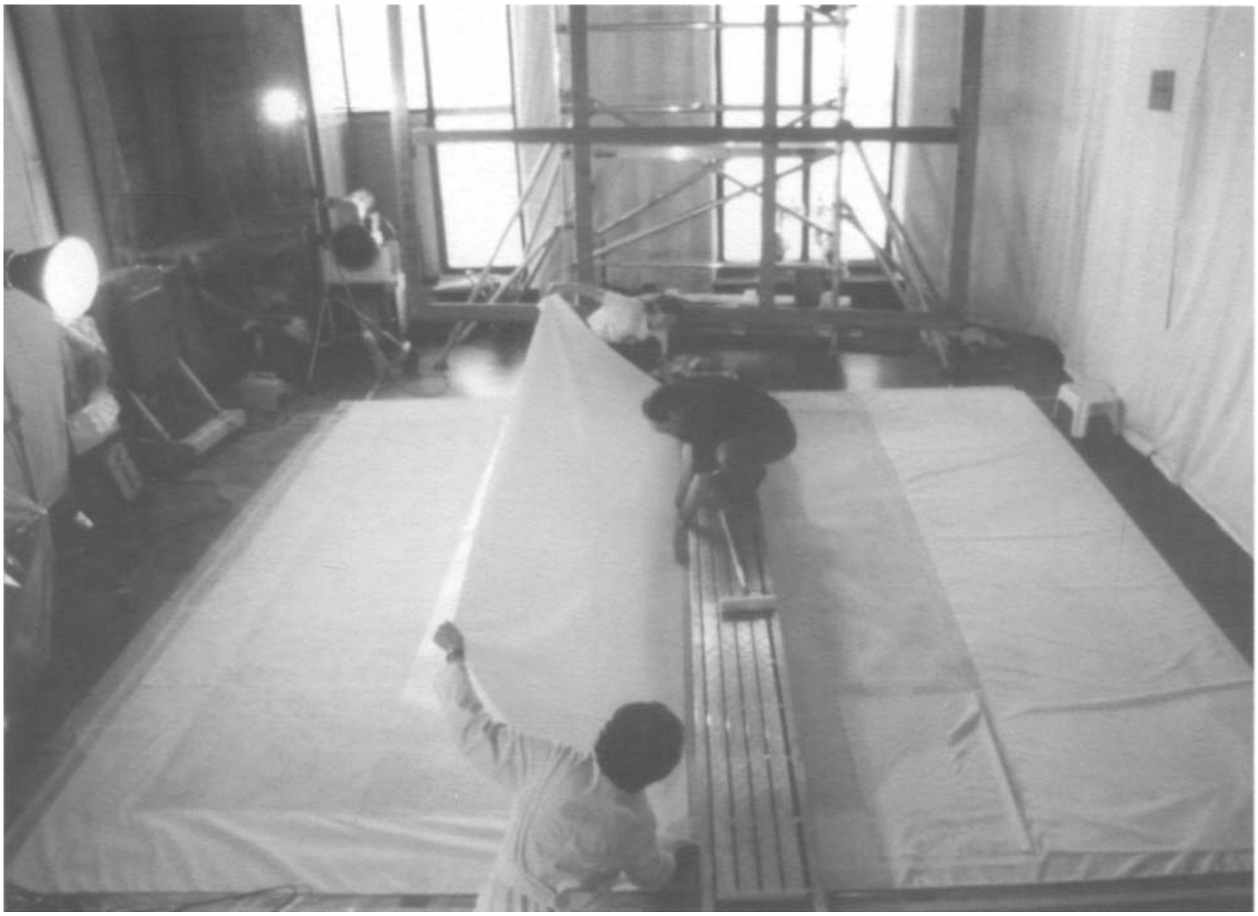
Several applications of BEVA ® 371 adhesive were rolled onto the perimeter of the panel and onto an outer band on the reverse of the panel (approximately 3-4 inches wide). The lined painting was placed face up on the panel, which was placed on sawhorses. The canvas was stretched to reduce the planar deformations and attached to the edges and reverse of the panel with the aid of a warm tacking iron. After the painting was stretched and attached to the solid support, the right angle aluminum mounting edges were attached with Hex bolts provided by panel manufacturer.

Two layers of Acryloid B-72 ® varnish (15% in CycloSol) were applied as a final spray to the painting. In dull passages a thin coat of ConservArt ® Gloss Varnish (1:1) in mineral spirits was sprayed to properly saturate the surface of the painting. This was followed by a final top coat of Acryloid B-72 ®.

During the week of April 8, 2001, the painting was successfully reinstalled in the ceiling of the Veronese Room at the Isabella Stewart Gardner Museum.

Overall of the *Coronation of Hebe* by Paolo Veronese and studio, Before Treatment

Overall of the *Coronation of Hebe* by Paolo Veronese and studio, After Treatment



Lining Process on the *Coronation of Hebe*

Coronation of Hebe **reinstalled in Veronese Room at the Gardner Museum**

MORE THOUGHTS ON AMERICAN IMPRESSIONISTS AND THE QUESTION OF VARNISHING

Lance Mayer and Gay Myers, Conservators of Paintings

(The authors are preparing for submission to the AIC *Journal* a longer version of their talk that will include the results of additional research and a number of illustrations. For this reason they are publishing here only an abstract of the talk that was presented in Miami.)

Ten years ago the authors gave a talk and published an article in the AIC *Journal* about the techniques of American Impressionist and Tonalist painters. Varnish and gloss are important aspects of these painters' techniques, and this talk presented additional findings and thoughts that relate specifically to the varnishing practices of American Impressionist painters.

We have found additional evidence, through written documentation and by studying the paintings themselves, that supports our opinion that some American Impressionists varnished their paintings, while others did not. Written sources show that at least some American painters saw matteness as an option by the late nineteenth century. There is also evidence that by the late nineteenth and early twentieth centuries, authors and artists who continue to recommend varnishing speak with more frequency about a thin varnish layer looking better than a heavy one.

While it can be difficult to determine a particular painter's varnishing preferences, we have found specific information about a number of painters. For instance, we now know of three inscriptions on paintings by Willard Metcalf in which the artist wrote that he did not want those paintings varnished. In the lengthiest inscription, Metcalf talks about the change in values that would occur if the painting were varnished, and he says that varnishing would "absolutely ruin" it.

Childe Hassam, on the other hand, varnished at least some of his paintings. We have previously reported written evidence that in 1919 he planned to varnish his flag paintings. Since that time we have found that a 1901 painting by Hassam shows retouching by the artist on top of a varnish (proving that it was varnished while still in the painter's hands). William Merritt Chase also made changes on top of a varnish layer on at least one of his Impressionist paintings from the 1880s.

Since written or other evidence is often lacking, it is the conservator who must make complex and sometimes subjective decisions about whether a particular painting would look better varnished or not. We use our study of paintings by Theodore Robinson as an example of this decision-making process. There is no first-hand evidence that Robinson did not want his paintings varnished, although there are many hints in that direction. His diary helps us to better understand his method vis-à-vis Monet, and Robinson wrote in his diary that a critic referred to American Impressionists as "'the adobe painters,' I suppose in allusion to chalky, dry painting." In addition, Robinson exhibited with Theodore Wendel (whose oil paintings were so matte that they were confused with pastels), and around 1918-20 another painter wrote that Robinson's paintings should not be varnished. We illustrated with slides the removal of varnishes that were applied at a later time to several paintings by Robinson, and discussed the differences in appearance between varnished and unvarnished paintings. We have come to believe that Robinson's paintings are often adversely changed by varnishing -- even if the varnish has not changed color -- because the saturation of differently-colored areas alters the relative values of the colors (as Metcalf had feared).

Lance Mayer & Gay Myers, Conservators, Lyman Allyn Art Museum, 625 Williams Street, New London, Connecticut 06320

Exploring Picasso's La Vie, An Interactive Experience

By Marcia C. Steele, Conservator of Paintings

Pablo Picasso, one of the most important artists of the 20th century, has been the subject of numerous publications and exhibitions. A recent exhibition (2001) explored the theme of the artist's studio in Picasso's work. Titled "Picasso, The Artist's Studio," it opened at the Wadsworth Athaneum and traveled to one other venue, The Cleveland Museum of Art.

According to Michael Fitzgerald, the author of the exhibition's catalogue, "Only Matisse rivaled Picasso's devotion to the subject of the studio." [1]Unlike some artists who isolated themselves in their workshops, Picasso used his studio as a social and intellectual center as well as a place for artistic creativity and experimentation. Throughout his career, his studio was a recurrent theme in his drawings and paintings. For example, one sketch of his studio in Paris from 1920 (fig. 1) depicts a corner jumbled with an array of carelessly placed portraits, frames and artist's utensils. Olga's portrait is seen sitting on the floor. The Sculptor, from 1931 (fig. 2) is of interest in that it combines a variety of techniques and materials. Picasso included sand in some areas, and most likely used commercial paint as well. He used pointillist-type dots in various areas and included a small abstract expressionist painting in the lower right.

The Cleveland Museum of Art owns one of Picasso's seminal masterpieces, which is among the earliest works set in the artist's studio. A Blue Period painting, La Vie (fig. 3) entered the collection in 1945. The Rhode Island School of Design had de-accessioned it and The Cleveland Museum of Art purchased it through The Seligman Gallery. Painted in 1903, La Vie has been the subject of art historical interpretation since its creation. While those interpretations are based on the finished image, a more comprehensive understanding can be derived from study of related works and--more importantly--alterations to the composition. For example, earlier studies (figs. 4 and 5) indicate that Picasso initially intended the male figure to represent himself standing between a naked woman and a canvas on an easel. This earlier idea can be confirmed through x-radiography (fig. 6) and infrared reflectography (fig. 7).

Furthermore, when the painting was first x-rayed in 1976, an entirely different composition--long believed to have been lost--was revealed. Oriented in a horizontal format, the x-ray can be compared to a sketch for Last Moments (figs. 8 and 9). The painting made from the sketch, which was exhibited in the 1900 World's Fair in Paris, was subsequently painted over. The x-radiograph clearly shows the lamp on the table and the open drawer of the bedside table in addition to the white collar and cuff of the standing priest.

When it became apparent that the Cleveland museum was willing to devote an entire gallery of the exhibition "Picasso, The Artist's Studio" to conservation research, the challenge was how to convey the rather complicated stories underlying Picasso's artistic process. In Picasso's own words, "A picture is not thought out and settled beforehand. While it is being done it changes as one's thoughts change." [2]The artist's working methods and thought processes for La Vie were presented in this final gallery through a variety of means, including the full x-ray of the painting on a light box, infrared images and details, and a computer interactive station. The aim of the latter was to provide a gallery experience where the visitor could use technology in the context of the exhibition, rather than seated in a kiosk or at their home computer through visiting a website. More importantly, we wanted to include investigations on other paintings by Picasso. Toward this end, we displayed another full-scale x-ray of Harlequin With Violin (fig. 10 and 11) which is also in the Cleveland collection. Here initial ideas in the areas of the head and arm of the figure are related to his drawings of jesters. In addition, we devoted another computer terminal to research on Picasso undertaken at other museums. The latter project, "Understanding Picasso Through Conservation" or "UPTC" offers a glimpse at the future potential of a Picasso research consortium. Presently, links to seven other research projects around the world are available. UPTC is still available through the Cleveland museum's website at http://www.clevelandart.org/exhibcef/PicassoAS/html/UPTC.html It encompasses examples of analysis by conservators and curators at other institutions and provides a central forum for the exchange for Picasso research. For example, one of the UPTC contributions focuses on a blue period painting from Los Angeles

Marcia Steele is the Conservator of Paintings at The Cleveland Museum of Art
11150 East Boulevard, Cleveland, OH 44106

Portrait of Sebastià Vidal Junyer where the painted woman is not seen in the x-ray, while a dog is visible in the lower left (fig 12). This raises the question of whether the female figure was added at a later stage, and beyond that whether Picasso actually painted her.

In the future, we hope to expand this information with contributions by other conservators and institutions and eventually publish the compiled research.

The computer interactive component of the exhibition centered on information about La Vie that was accessed with a click of a wireless mouse. The information technology department at the museum designed this project with the aim of targeting the various learning styles of museum visitors. To this end, it combined audio, video, computer animation, written text and navigation with the mouse.

The interactive contained four sections: Introduction, Stories, Explore, and Methods of Scientific Examination (fig. 13). Each of the thumbnail images on the front screen was captioned to indicate what would be discovered when the visitor clicked on it. Working with software developers Cognitive Applications based in Birmingham England, we used conservation, art historical research, and technical images of the painting to relate various aspects about the painting. The curator and conservator provided texts to be read along with some of the sections.

In the "Introduction," the interactive was explained as well as Picasso's life and artistic background.

The six items on the "Stories" section were created to help visitors understand the enigma of La Vie. In essence, it is a painting titled "Life" painted over a painting of a deathbed scene. In the final composition, the identity of one of the figures in La Vie was changed from Picasso's self-portrait to a that of Picasso's friend, another artist Carlos Casagemas who committed suicide. The Stories section aimed to integrate a moving or morphing image while explanatory text was being read in a timed segment. For example, the story of Last Moments--the earlier painting residing underneath La Vie--was explained while the present composition was spinning to a horizontal position and the x-radiograph was superimposed over it. The narrator then pointed out some compositional elements visible in the x-ray and finally compared the x-ray to the only known sketch for the underlying composition (see figs. 8 and 9). After the "story" was related through this mini-movie, it was possible for the visitor to use the mouse to morph back and forth between the x-radiograph and the painting by sliding the cursor underneath the image from side to side. Another story titled "The Birdman," used a detail of the infrared image (Fig.14) of the central lower area of the painting where a flying birdman is apparent. This creature was then shown in comparison to similar images in other works by Picasso.

The most popular section of the interactive was the "Explore" section, supporting the idea that the user might want to explore and discover different aspects of the painting on their own without any audible stories. Here the visitor could move the mouse around the image of the painting and either enlarge it, or look at the x-radiograph or infrared image of the corresponding area. In addition, within the Explore section, hot spots (fig. 15) of information were provided for those who wanted a destination for the cursor. There, a written text would pop up, explaining the image.

The final section of the interactive "Methods of Scientific Examination" included descriptions of various scientific methods used in analysis of La Vie: Microscopy, Sampling and Cross-sections, Scanning Electron Microscopy, X-radiography, Infrared Reflectography and Ultraviolet Illumination. These were accompanied by videos of members of the conservation staff carrying out each type of examination, as well as graphic illustrations of how each method works.

Different types of infrared examinations were especially useful for seeing various elements within the painting, such as an expression on a face, and comparing these to two drawings by Picasso. For example, the images from a Charged Coupling Device (CCD) camera, the Kodak DCS 460 IR camera, were more useful for seeing things which are part of the final image and were only partially obscured by Picasso, whereas the Inframetrics infrared camera was more useful for "seeing" deeper into the paint layers (see fig. 14). This confirms the usefulness of looking in different ranges within the infrared spectrum. The range for the Inframetrics camera was narrowed to between 1.5-1.75 microns through the use of a filter targeting that bandwidth. The Kodak DCS 460 had a filter to eliminate visible light and captured in the range between .7- 1 microns. Visiting experts helped capture these images. Bonnie Rimer, Mellon Fellow at the Chicago Art Institute, brought the Inframetrics camera and capturing system and did the mosaic of the infrared image. The Kodak camera was provided by Jim Wentzel, the photography supervisor at the Cuyahoga County Coroner's office, who uses it for looking at victims of gunshot wounds to determine muzzle-to-target distance.

During the exhibit, many visitors were captivated by the interactive and often went back to the actual painting to look more closely. Some reactions to the interactive found in the comment book provided at the end of the exhibition follow.
"Boy technology these days is wonderful"
"I really like the painting La Vie and all its secrets"
"What a great exhibit--we enjoyed the use of the interactive computer at the end. What a neat way to learn about the artistic process."
"I liked the movie thingy at the end of the exhibit. It was very interesting."
"The interactive exhibit at the end was wonderful--it's especially great to see examples of art in process, especially with works as complex as this."

The x-radiographs in particular seemed to really captivate people.
"I thought the x-rays were awesome-to see his eraser marks"
"The part of the exhibit explaining x-radiography was the best part...the only part worth the time. Thanks"

As with any project, there were some aspects that in retrospect could be reconsidered. In terms of the installation the sound within the gallery was a problem. Sometimes it was too loud or too soft. One solution may be to place speakers above the person rather than on the wall facing out. While the information technology department chose a reader on staff whose voice was "user-friendly" for reading the texts, some visitors felt it was a little too folksy and would have preferred a more intellectual tone. Some people were bashful about approaching computers and using a mouse in a gallery of a special exhibition. Moreover, people with little computer experience were having difficulty controlling the cursor and navigating around the different parts of the interactive unless someone was there to explain the various aspects of the interactive and demonstrate how to navigate through the individual sections. With this sort of aid, they were more intrigued and stayed much longer, indicating the program may have been too cumbersome for some visitors. Ultimately, there was something that intrigued most visitors in the conservation gallery. Sometimes it was simply seeing a full-scale x-radiograph on a light box. Since the subject of the artist's studio lent itself so perfectly to the type of information that conservators can provide, it was an ideal situation to give the public insight into conservation techniques. Working with Cleveland curator William Robinson, whose art historical research continues to advance our understanding of Picasso, this gallery gave the museum visitor a sense of how conservators and curators can work together to deepen our experience of an artist's work.

Endnotes

[1] Michael FitzGerald, Picasso, The Artist's Studio, exhibition catalog, 2001, p. 16.
[2] Hiro Clark, ed., Picasso In His Words, San Francisco, 1993, p. 12.

Figure 1. Picasso, The Artist's Studio in the Rue La Boétie, June 12, 1920, Pencil and charcoal on paper, 62.5 x 48 cm., Musée Picasso, Paris

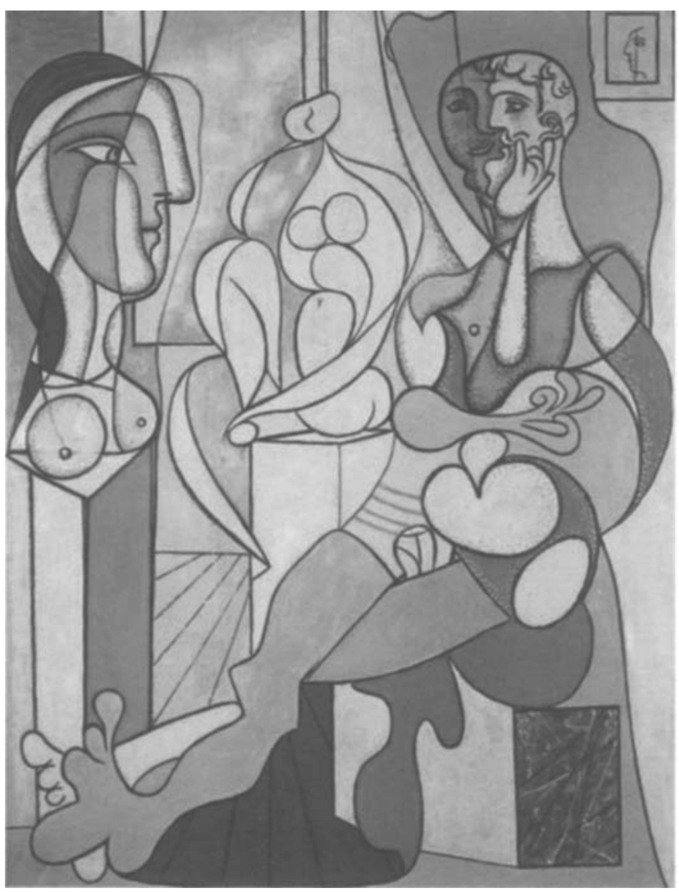


Figure 2. Picasso, The Sculptor, December 7,1931, 128 x 96 cm., Oil on plywood, Musée Picasso, Paris

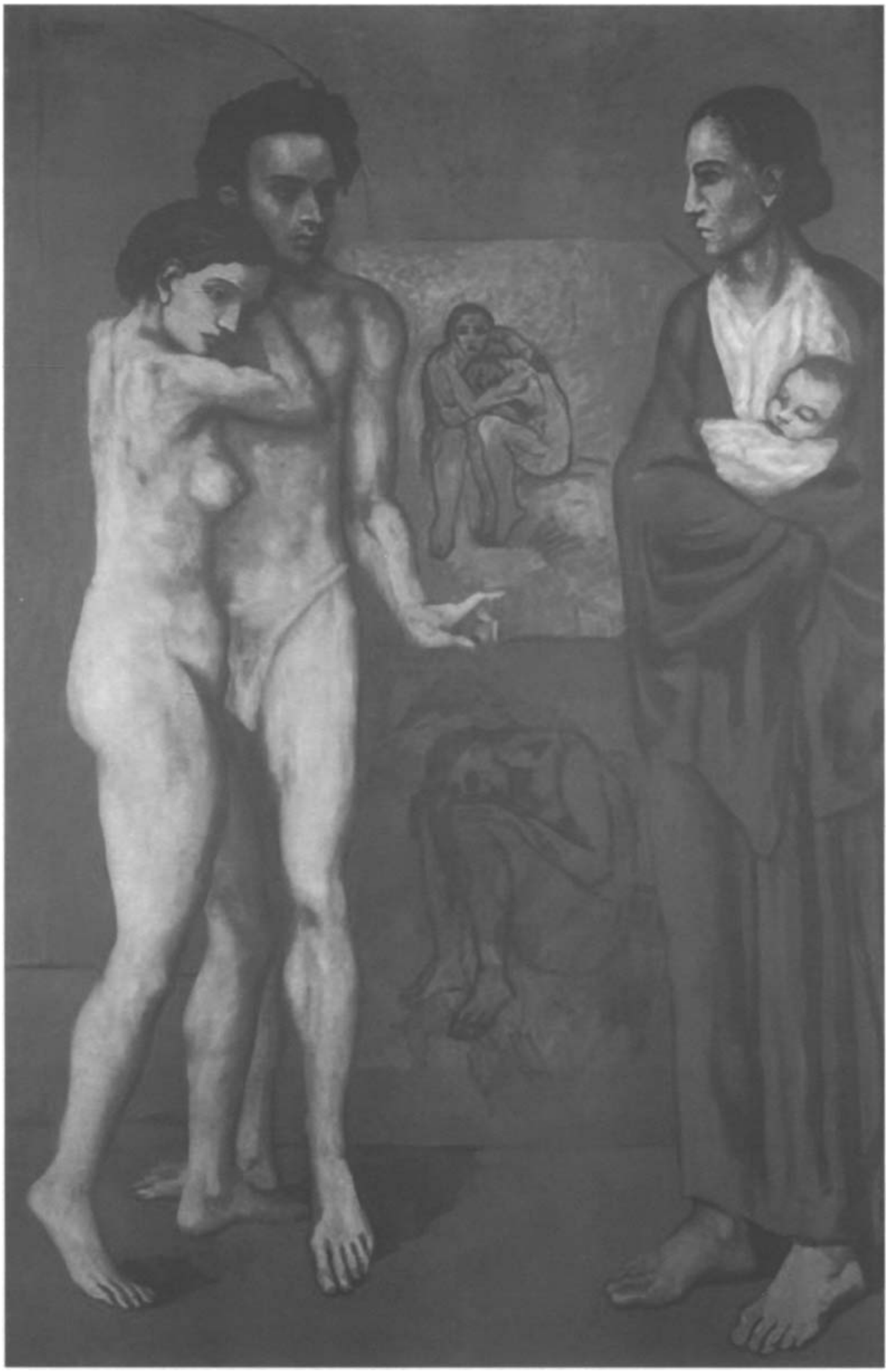


Figure 3. Picasso, La Vie, 1903, Oil on canvas, 196.5 x 129.2, The Cleveland Museum of Art, Cleveland, Ohio

Figure 4. Picasso, Preparatory Drawing for "La Vie", 1903, Conté crayon on paper, 15 x 10 cm., Musée Picasso, Barcelona

Figure 5. Picasso, Study for La Vie, dated "2 Mayo 1903", Ink on paper, 26.7 x 19.7 cm., private collection

Figure 6. X-Radiograph of Picasso's La Vie

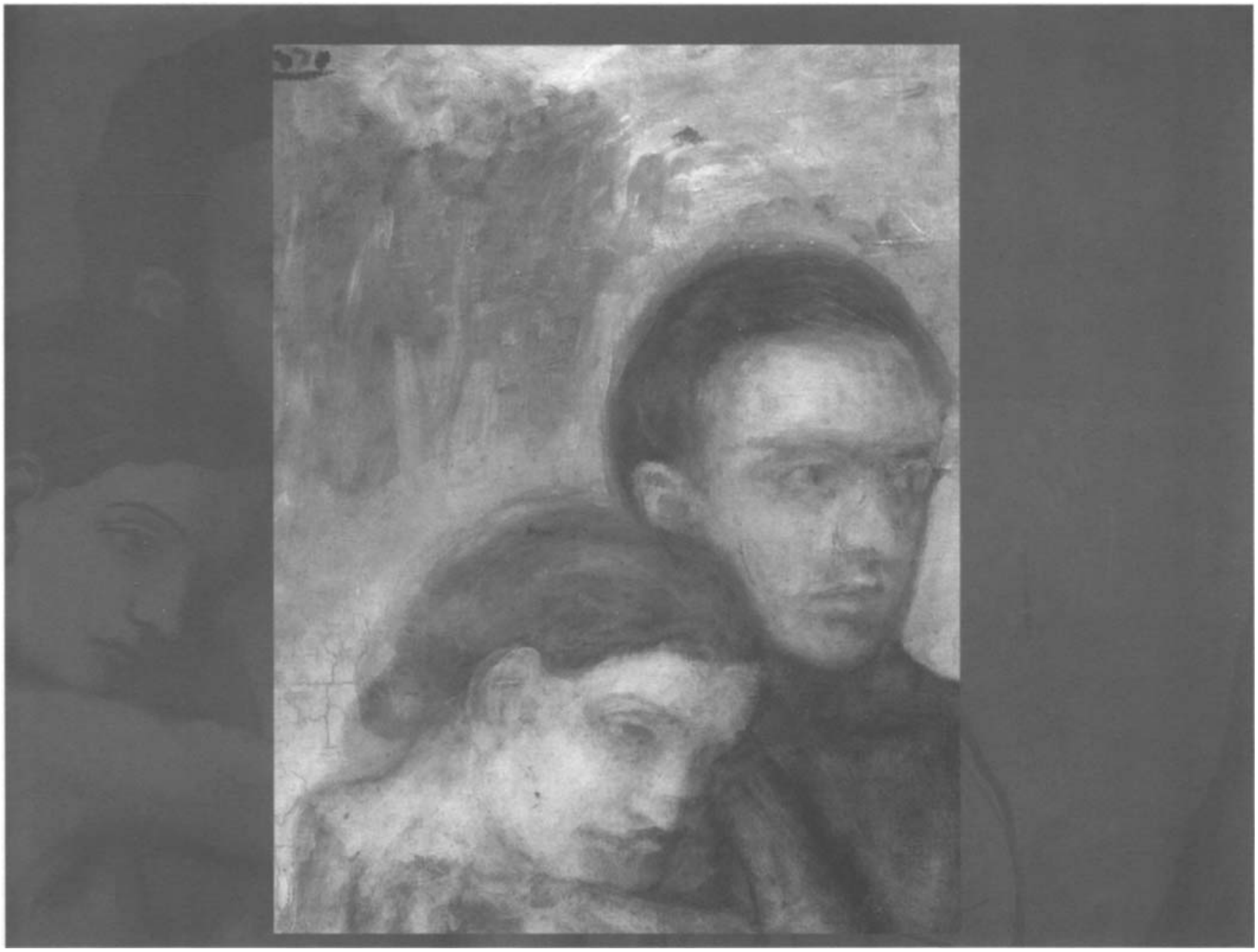


Figure 7. Detail of Infrared Reflectogram of Picasso's La Vie revealing Picasso initially intended to paint himself as the artist

Figure 8. Picasso, The Kiss of Death (Study for Last Moments) 1899-1900, Conté pencil on paper, 15.9 x 24.3 cm., Museu Picasso, Barcelona

Figure 9. X-radiograph of Picasso's La Vie oriented in a horizontal direction

Figure 10. Picasso, Harlequin with Violin, 1918, Oil on canvas, 142.2 x 100.3 cm., Cleveland Museum of Art, Cleveland, Ohio

Figure 11. X-Radiograph of Picasso's Harlequin with Violin with some changes outlined. These shapes are reminiscent of Picasso's drawings of jesters.

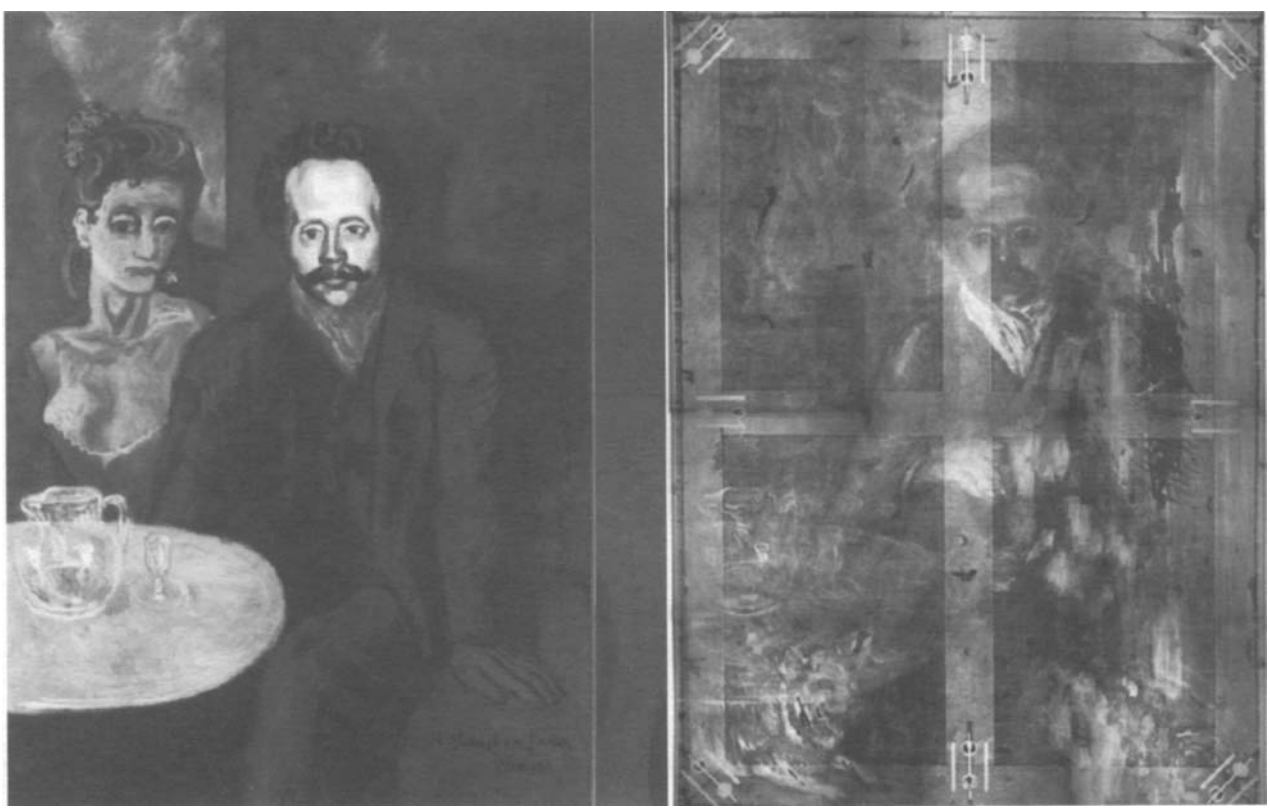


Figure 12. Picasso, Portrait of Sebastià Vidal Junyer, 1903, Oil on canvas, 125.5 x 91.5 cm., The Los Angeles County Museum of Art, and the X-radiograph of the picture

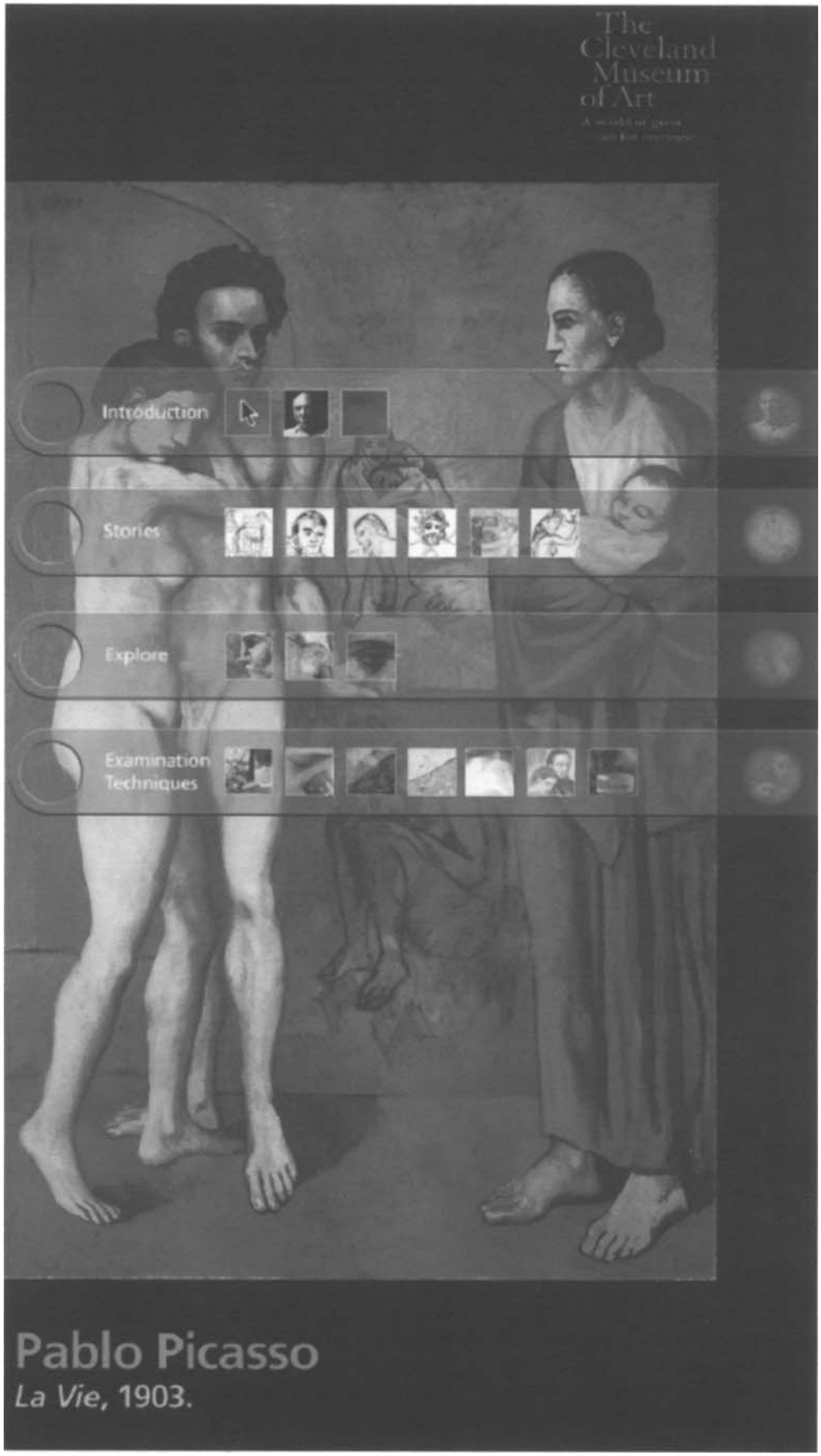


Figure 13. Frontscreen of the Picasso Interactive

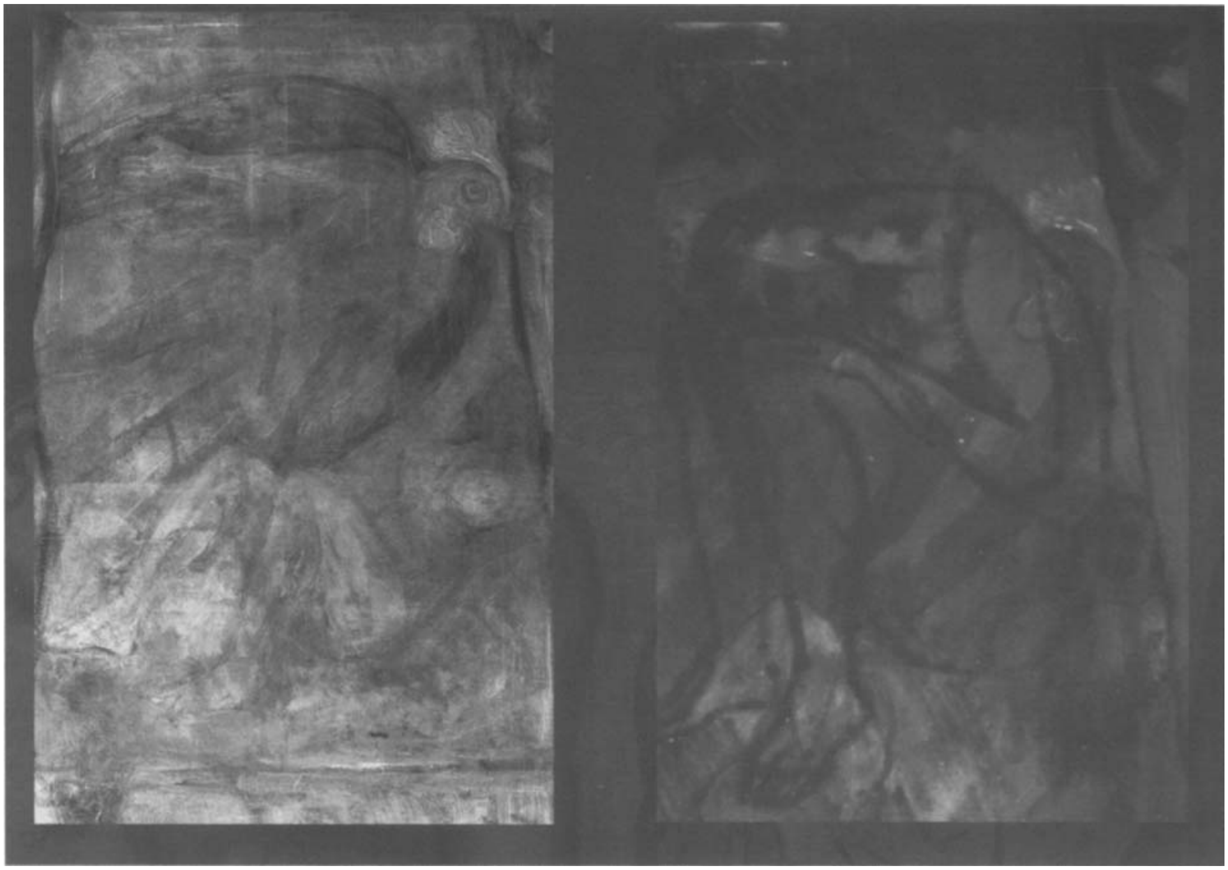


Figure 14. Infrared image of the detail of the birdman in La Vie with the FLIR Inframetrics camera on the left and the same area with a Kodak DCS 460 IR camera on the right

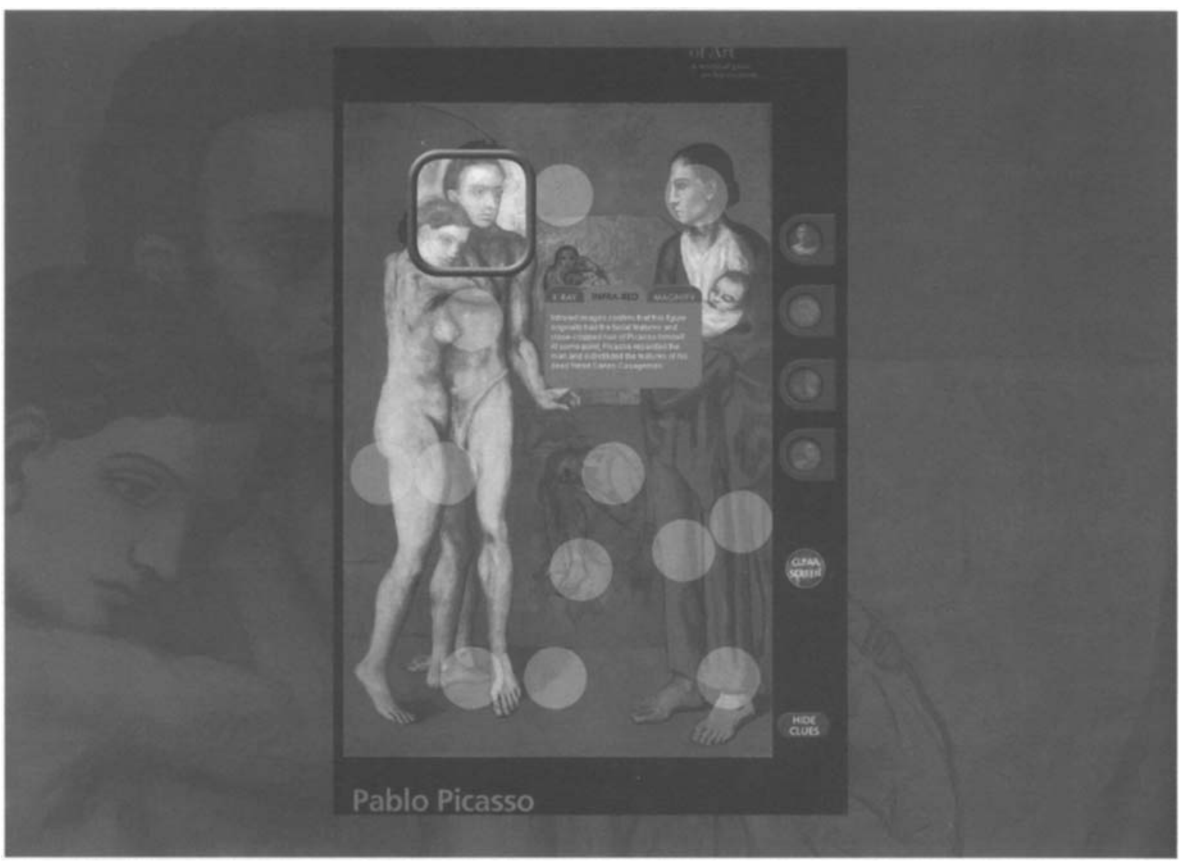


Figure 15. Frontscreen of the Explore section of the Picasso Interactive with hot spots of information illuminated

THE INFLUENCE OF NON-TRADITIONAL ART MATERIALS ON THE PAINTINGS OF PABLO PICASSO

Fotini Koussiaki*

Pablo Picasso (1881-1973) is arguably the most famous artist of the twentieth century. During his artistic career, which lasted more than 75 years, he constantly searched for new ways to represent or interpret reality creating thousands of works in a remarkable range of media. As a painter he explored many stylistic and technical approaches, varying his materials, his working methods and the quality of his paint surfaces from picture to picture. This variety makes him of particular interest, and a particular challenge for technical study.

An important aspect of Picasso's technical exploration as a painter is his use of non-traditional materials. This paper discusses the influence of non-traditional art materials on Picasso's work as a painter. By introducing painting materials that were commonly associated with other well-defined purposes, such as architectural or marine use (commonly, though not always accurately, identified as *Ripolin*[i]), and often in conjunction with artists' paints, he was able to achieve a range of colours and effects that would not have been possible with artists' oil paint alone.

This paper examines the links between style and content in Picasso's paintings and the materials that were chosen for their execution. Particular attention is paid to his use of non-traditional materials and emphasis is placed on the surface characteristics of his work, as these are often indicative of the materials employed. The information presented here derives from an extensive study of Picasso's painting techniques and materials undertaken by the author towards PhD. Although this study has involved the survey of many collections, the focus has been on works from the collection of Tate (London), which includes examples from all of his principal creative phases. A number of works from this collection were selected for extensive technical examination and scientific analysis using a range of techniques.

In addition to the scientific and technical aspects of the work, the study was augmented by significant information from documentary sources, most notably unpublished materials from the Picasso Archives, Paris. These reveal, among other things, that Picasso was aware of and interested in the quality of his materials and sensitive to paint defects. The holistic approach to the research, employing both documentary evidence and technical evidence from paintings, has enabled a more complete understanding of how Picasso's materials and working methods changed in the overall context of contemporary artistic and industrial developments.

It was during Picasso's Cubist period in 1912 when materials from the industrial world appear to have been first introduced on his canvas. At this time he was making an attempt to involve colour in his Cubist compositions, which until then, both Georges Braque and Picasso had found incompatible with the pictorial space they were introducing. The use of *Ripolin* marked this transition point. He first used it for the stencilled letters and figures in his paintings. Unlike artists' oil paints, *Ripolin* could produce a flat and glossy surface, completely free of brushstokes. Later Picasso would use this paint to assign the appropriate brightness and intrinsic gloss to a variety of items represented on his canvas (for example, playing cards, flags, clothes, posters, and labels). He created a powerful contrast between the enamel-like industrial paints and artist's tube colours. In a way he used paint of different qualities to mimic the effects achieved by collage. This approach worked particularly well with the stylistic objectives of Synthetic Cubism. Images were composed of clearly defined large, flat, coloured, textured and patterned planes.

Picasso knew well that, following the revolution of form represented by Cubism, he was breaking another link with conventional art by employing non-artists' materials. The introduction of these new paints has dual significance. On a practical level, it extended the range of colours and mainly the surfaces that could be achieved. On a conceptual level, at a time when fundamental ideas about painting were being challenged through Cubism, it represented another attack on tradition. Signifying the importance that Picasso gave to his use of industrial paints is his remark on recent pictures made with *Ripolin*: *'Perhaps we'll manage to disgust everybody, and we still won't have said it all'* (letter dated 17 June 1912, cited in Monod-Fontaine 1984, 168). Picasso eventually led art into a new direction, with an assemblage of methods from the industrial world.

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* Paintings Conservator, PhD student, Royal College of Art, London. 33 Fitzjames Ave., W14 0RR, London, UK

Picasso's focus was certainly on surface effect. Apparently the artist was conscious that particular paints had inherent visual characteristics that could be exploited for his purposes. Furthermore housepaints offered a range of matte and gloss finishes not available in artists' paints in the earlier twentieth century. Thereafter he either continued to use this technique and these materials to achieve such surface-effects or he manipulated his paint with driers and medium. Later, during discussions with his friends, he was adamant about the surface qualities he could achieve by his interplay with mixtures with *Ripolin Mat*. In 1952 he explained to Roland Penrose that nothing was a better basis than *Ripolin Mat* [sic] that he used mixed with ordinary oil colours, especially in the thirties. In 1968 Picasso gave Penrose a commercial card of the *Triton* paints, which is dated 1952 (unpublished documents in Penrose Archives, Edinburgh). This expresses Picasso's long faith to these paints. Both the *Ripolin* and the *Triton* products played an essential role in creating his messages and they could translate his intentions on the canvas during several periods of his career.

A note on materials and analysis

Wherever possible, a comprehensive range of examination, photographic and analytical techniques was employed. The detailed observation of the painted surface, including microscopic examination was particularly important. It is possible to infer much about the use of both artists' and non-artists' materials from surface appearance even where rigorous identification is more difficult.

Visual documentation: Principally the way of documenting the appearance and the condition of Picasso's works was visually. All the paintings from Tate's Collection have been photographed routinely in several regions of the spectrum. However macrophotographs through a microscope proved to be an particularly useful technique for studying the complex paintings' surface of Picasso's works. Optical magnifiers disclosed details of brushwork, the nature and texture of paints and other aspects of a painting's condition. Examination by microscope of small cracks and losses, especially those penetrating to the underlying ground or canvas revealed the artist's layering technique.

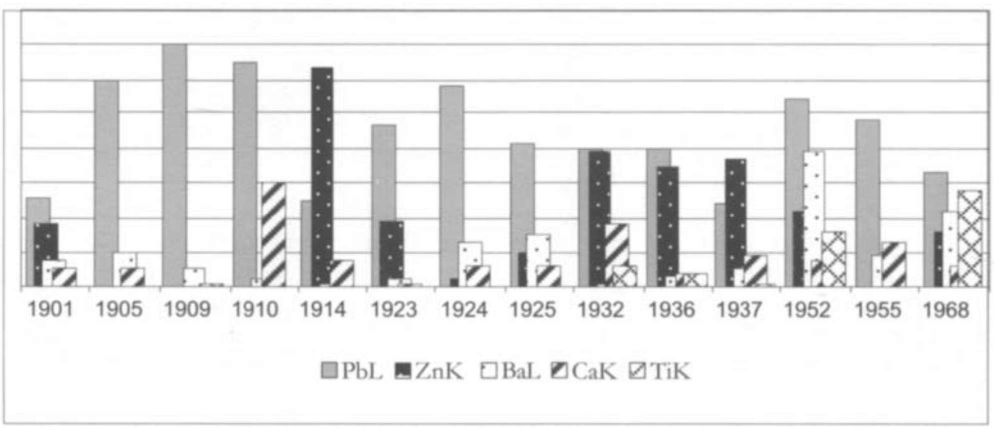
Instrumental Analysis: The difficulty in analysing twentieth century materials is due to several factors. Types of binders range from modern synthetic materials to complex natural products or mixtures of them. Pigments vary from fine particles of traditional metal-based or organic colours to synthetic organic and inorganic ones. The molecular structure of many of these is complicated itself; moreover they are present as complex mixtures. Analytical methodology for synthetic painting materials is not widely established yet, in contrast to the approaches for traditional pigments and mediums. However, the Conservation Science Section of Tate's Conservation Department is successfully developing analytical protocols for such materials. Because of their complexity, even in the freshly produced works, there isn't one technique, but a combination of techniques to answer a question.

The complementary nature of several analytical techniques for this specific characterization and identification of modern paints was illustrated through this research project. The identification of pigments and extenders was achieved by studying paint cross-sections and dispersions under polarized and ultraviolet fluorescence microscopy, microchemical colour reactions, scanning electron microscopy (SEM), energy dispersive x-ray analysis (EDX), and X-ray diffraction (XRD) analysis. Binding media are characterised by Fourier transform infrared microscopy (FTIR), pyrolysis-gas chromatography-mass spectrometry (PyGCMS) and thermally assisted hydrolysis and methylation THM-GCMS techniques.

A particular interest in this study was the possibility of distinguishing between artists' quality and non-artists' paints through medium analysis or quantitative inorganic analysis. However, differentiation through medium analysis is inherently problematic because drying oils were the principal binders in both artists' and non-artists' paints throughout the majority of Picasso's career. Only in his late period did alkyd resins become widely used in the housepaint market. To illustrate this, it is worth considering the composition of *Ripolin* paints. Past contact with *Ripolin* tells us about the series of good quality products provided at the beginning of the century which were described as analogous to good quality artists' paints (unpublished letter in Picasso Archives). Unfortunately the *Ripolin* archives have been destroyed. However the company was able to confirm that heat-bodied linseed oil was used in their housepaints before the 1950s, and later replaced by soya oil. Alkyds were incorporated into *Ripolin* paints only after 1955 (Picasso Archives). Picasso also made use of other commercial products, such as *Triton* paints. While there is no precise information available as yet on the composition of such commercial products, it is reasonable to say that alkyd became the most important binder in all oil-based household and industrial paints from the mid-50s.

In the samples from Picasso's paintings analysed, the presence of oil was often indicated by Fourier transform infrared spectroscopy (FTIR). Characteristic C-H stretching and carbonyl (C=O) peaks were still evident in spectra for samples from areas of paintings that had the appearance of housepaint and in which a high proportion of extender and white were found (as would be characteristic of a housepaint). Gas chromatography – mass spectrometry (GC-MS) indicated that Picasso mainly used colours bound in linseed and poppyseed oil, although sometimes heat bodied linseed oil was suspected, especially in paintings after 1930 (e.g. *Weeping Woman*, 1937). The fact that he was mixing his paints and even these results can not, however, confirm Picasso's use of house paint before his late period (his last twenty years). Even in samples from late works, where it was possible to identify oil-modified alkyd resins using pyrolysis-GC-MS, the proportions of oil to alkyd resin indicate that Picasso often mixed his alkyd housepaint with oil or other oil paint.

As medium analysis is of limited value in distinguishing between good quality non-artists' (no natural resins are involved) and artists' paints until the introduction of alkyds in the 1950's, attention turns to the inorganic components of the paint, and in particular to white pigments and extenders. These are important components in both artists' paints and house paints. The choice (and proportions) of these materials influences the appearance, surface characteristics, drying and mechanical properties of a paint, as does the medium. With developments in technology and the introduction of new materials, paint formulation became more sophisticated during the first half of the twentieth century. The materials used and their relative quantities would be manipulated by the manufacturer to achieve particular results (as well as for economic reasons). The differences in the materials used and the relative quantities employed therefore offer potential for distinguishing between artists' and non-artists' paints. Correlating surface appearance with composition can be useful in indicating the likely use of a non-artists' paint on a painting.



Graph shows results from X-ray quantitative microanalysis. Each bar represents the average percentage of elements present in various paints from one painting and calculated from the EDX spectra of the cross sections, after ZAF corrections.

To explore the potential of quantitative inorganic analysis of white pigments and extenders as a means of distinguishing artists' and non-artists' materials, X-ray quantitative microanalysis was performed on fifty samples from Picasso's paintings during scanning electron microscopy. This revealed the presence of significant amount of these pigments in the paint samples throughout the period represented by the works. The graph shows that both zinc white and lead white paints (with significant amount of extenders) were employed in the painting of 1901. Later lead white is present alone but in 1914 the surface characteristics of household paint seen on *Still Life* is partially due to the zinc-based paints (also medium manipulation). During the next periods, until the thirties, lead based paints show stronger presence but metallic soaps are frequently present. In the thirties and forties lead and zinc have an equal presence in paints while titanium appears with colours as well as white paint. In 1952 lithopone-based white paint was analysed alongside with titanium and lead based ones. And finally all different types can be found on the late period paintings (lead based, zinc based, lithopone based and titanium based paints). The percentages appearing on the graph were for the actual elements.
This graph shows that since Picasso started using house paints the presence of zinc increases and as soon as industrial/retail trade paint manufacture developed other types of paints (like lithopone and titanium paints), those appear on Picasso's work. It is worth considering that lead paints are always present and Picasso never stopped making use of his artists' paints.

The following paragraphs give a chronology of the surface appearance during the main periods in Picasso's oeuvre and the main findings in medium and extenders involved. Changes are frequently attributed to coexisting technological advances as Picasso regularly used industrial paints. In such a way, an attempt is made to reveal the combined role of the organic and inorganic components in his paints on the surface characteristics of a work.

A chronology

Picasso had already demonstrated his delicate brush-stroke during his formative years in Spain. Surfaces, then, were thinly and flimsy painted and he showed his technical skills in presenting opaque and transparent effects. In the first years of the century Picasso was in Paris and experimented with a rich variety of brush-stroke. He tried to work sometimes with delicate and sometimes with thickly applied paint in visible brushwork supplemented with the use of a palette knife, which give a dense opacity of matter (*Flowers* 1901, Tate, Z.I:61). During the Blue and Rose periods, tones were frequently thinned with diluent and some appeared nearly translucent. Picasso used a fine touch and presented a flatter surface but made the finishing strokes by crisp lead white highlights (*Girl in a Chemise* c.1905, Tate, Z.I:307). Until that point the young artist was interested in the different languages of art and he mocked the idiom of other artists and older styles. However, even if his later work (the early days in Paris prior to Cubism) betrays his admiration of Cézanne's art, Picasso was not influenced by his translucent work. The appearance characteristics of these paints are largely affected by the white pigments present. In the majority of analysed paints lead white ($2PbCO_3.Pb(OH)_2$) has been identified with linseed oil or mixtures of linseed and poppy oil (GC-MS); frequently with chalk and kaolin, which are the common tube extenders. Lead white-based paints from the tube generally form an elastic film and produce vivid surfaces when they dried while poppy oil was mixed in with linseed in order to prolong the life of the tube paint and because it tends to make buttery pastes (Mayer 1991, 188).

During the early periods, zinc white was also included as paint on Picasso's palette. It has a colder and flatter tone than lead white and painters at that time used to have both of them side-by-side on their palette because of their different handling and hiding properties. However according to analysis results from the available case studies, zinc was not identified during Picasso's Rose period and the early phases of Analytical Cubism when form was treated with opaque and sculptural built-up of earthy colours. For instance almost all paints on *Bust of a Woman* 1909 (Tate, Z.IIa:143) have a chalky surface and the mixture of lead white and barium sulphate ($BaSO_4$) was consistently identified. This pigment mixture is known as 'barium white' or reduced lead white (Crown 1968). However it was not found on the next available-for-analysis picture (*Seated Nude* 1909-10, Tate, Z.IIa:201) and in place of the thick crisp strokes, Picasso soon thinned out his lead based paints to create a lively surface touch and the illusion of a subject that faded out at the edges and corners of the canvas.

At least since 1914, the peak of Synthetic Cubism, and during the next periods, the twenties and the thirties, *poppy oil* is frequently found on its own when not in mixture with linseed oil. At that time Picasso brightened up his Cubist palette and large forms of pale and white colours were included. Manufacturers preferred poppy oil for their white paints because it yellowed less than linseed oil. At the same time these paints show less brushmarking and are softened by the flow of the thickly applied paint.

The *Ripolin* paint that Picasso started to use during Synthetic Cubism was a tool for him to manipulate the variation in surface sheen of his paintings. No pictorial effects were attempted; he only laboured on the contrast of surface textures. Moreover, during that time, he experimented by adding other compounds to his paints. GC-MS and THM-GCMS revealed irregularities that would indicate different components, such as animal fat. A sample taken from the *Fruit Dish, Bottle and Violin* 1914 (National Gallery London, Z.IIb:529) was analysed by GC-MS in 1995 at the National Gallery in London. The results tally the medium analysis of samples from the 'picture relief' *Still Life* 1914 (Tate, S.47), run by THM-GCMS at Tate in 2002. Both analyses for those different works indicated the presence of drying oil (probably linseed) admixed with 'animal tallow' or fat. It is well known that Picasso during that period experimented a lot with different materials. The animal fat may have originated from the found furniture pieces that consist the *Still Life* but its source is unclear for the *Bowl of Fruit, Violin and Bottle*[ii]. On the other hand, the surface characteristics of a thick and flat beige-coloured paint, possibly a house paint on the *Bowl of Fruit, Violin and Bottle* 1914, augments the heat-bodied oil finding (see above about heat bodied linseed oil in *Ripolin* paint).

Also in 1914, when Picasso used 'Ripolin' paint on his Cubist constructions, the relative amount of zinc in his paints appears high while possibly lead exists as a drier (SEM-EDX Quant) The characteristic qualities of zinc oxide pigment, like the hard paints and the fine texture they make, are effects regularly observed on Picasso's works during and after this period. Later, on his Neoclassical subjects (e.g. Seated Woman in a Chemise 1923, Tate, Z.V:3), zinc oxide was found alongside lead white and after 1925 it occurs in most of the colours with metallic soaps regularly being present (FTIR). When there is a mixture of zinc white in paints, the basic nature of zinc oxide leads to interaction with paints of high acid value (fatty-acid components of the drying oils) with consequent formation of zinc soaps[iii]. However, oxide of zinc is a slow and bad drier and therefore manufacturers added suitable driers to make zinc oxide paints dry fast (Cruickshank 1909, 50). According to Vanderwalker 'oil driers when properly made contain no gums or resins and do not dry to a hard film. As a rule oil driers made of both lead and manganese salts as an oleate are considered better than resinate driers and Japans' (1924, 101). Since with the turn of the twentieth century driers[iv] were based on metallic soaps infrared analysis of samples taken from Picasso's works frequently revealed them. These were identified by their characteristic absorption around the band of 1558 cm^{-1}. In general soaps (oleates, palmitates, stearates, naphthenates) of several elements (lead, zinc, manganese, barium, calcium, magnesium, aluminium, sodium) show characteristic absorption in 1500 to 1590 cm^{-1} region, which is due to the asymmetric vibrations of the COO^- groups in metal carboxylates (about reference spectra see FDM Electronic Handbook by Fiveash Data Management, Inc.). In theory such bands could indicate the presence of driers and distinguish industrial products from artists' paints. However, the reaction of pigments with their oil medium that leads to the formation of such soaps is likely in any artists' paints as well.

Nevertheless, when in 1955 Picasso talked to Penrose about housepaints, in particular *Ripolin Mat,* he explained that in the thirties he mixed it with ordinary oil paints because it dried fast and became very hard. Driers are typical additive materials to housepaints but usually occur in very low concentrations that range from 0.1 to 0.5 % by weight depending on the type of paint (levels in a traditional housepaint in Turner 1993, 159). When driers consist of metallic compounds their identification can theoretically be achieved with EDX analysis. However as they are usually only present in low concentrations, EDX requires long acquisition times to make identification likely, and little analytical identification has been possible apart from the aforementioned infrared indications about their soaps.

Picasso, on the other hand, often added driers to his paints while painting (evidently until the mid 1920s). Unpublished documents show that in 1922 Picasso's supplier *G. Guerard* in Paris had supplied him with both '*Ripolin* white paint' and a drier, '*siccatif De Harlem*', along with artists' paints in tubes and several sizes of canvas (Picasso Archives). Other evidence that Picasso used siccatives in earlier periods was found in a letter Picasso sent in 1912 to his art dealer Kahnweiler (sent from Céret on May 24, Monod-Fontaine 1984, 166). *Siccatif de Harlem* is a drier based on copal resin and was frequently used by academic painters of the late 19th century to speed the drying of oil colours; but also because it produced brilliant colours and hard films (Carlyle 2001). Picasso had this academic education and was supplied with it by *Lefranc*, later *Lefranc and Bourgeois*, which still produces it (Picasso Archives). However, even if literature and analytical indications were found, copal resin from the drier could hardly be identified by the available techniques.

In Picasso's correspondence in 1912 we find him referring to the paintings as *'the Ripolin enamel paintings, or Ripolin-like paintings'* and described them as the best ones (letter cited in part in Monod-Fontaine 1984, 169). This means that sometimes he actually worked with housepaints while at other times he probably just manipulated the medium of the paste paints in order to achieve similar surface characteristics to industrial products. Where he required paint of extra brilliance, he added media and driers. The thick and brilliant characteristics displayed on paints used for example for *The Three Dancers* 1925 (Tate, Z.V:426), indicated the use of a different from artists' paint. However, natural resins were not found and the use of driers was not confirmed (see above about concentrations). But without any doubt Picasso manipulated his media with extra oil. This painting marks a turning point in Picasso's oeuvre and stylistically the artist returns to the '*collage*-style painting'. Moreover the idea is that Picasso tries again to give texture to areas on his painting that is similar to his cubist period. The very rough texture of the top left blue area is due to the mixture he made of paint with large excess of gypsum forming uniform solid mass. Calcium sulphate or gypsum is used as an extender pigment in paint but the excessive quantity here shows that it was added by the artist (FTIR).

In the 1920s, in an attempt to demonstrate the body and the texture of his material Picasso frequently used to score it. Many works have opaque, brilliant and silky surfaces. On the other hand in parallel to his late Synthetic Cubism Picasso developed his neoclassical style. In the same studio that he executed his late Cubist works by flat and hard edged forms (e.g. *Three Musicians* 1921, MoMA, Z.IV:331), Picasso made a number of neoclassical subjects. However, it seems that he found the flat characteristics of the material available from the tin inappropriate for his neoclassical figures. On those he decided to explore the interplay of the thinned and the textured traditional tube paints (e.g. *Three Women at the Spring* 1921, MoMA, Z.IV:322; *Seated Woman in a Chemise* 1923). Colours from the tube were applied over layers made translucent by addition of diluent, probably turpentine and medium. This is reliable evidence of the relationship between Picasso's style and use of materials.

Later, on a painting made in Boisgeloup at 1932, the paints used were lead, zinc and titanium[v] based (*Nude in Red Armchair*, Tate, Z.VII:395). This is a period when Picasso made a number of large canvases for an exhibition using materials from large supplies. He used paints from the tins as well as tube paints containing the common extenders (chalk, kaolin, etc). Apparently on the examined case study, each of the paints used was different in quality: some contain lead titanate pigment, others titanated gypsum (titanium with calcium sulphate) or leaded zinc oxide or zinc paints with magnesium etc. In general the mixing of pigments, e.g. titanium with lead, titanium with gypsum, lead with zinc or lead with zinc and titanium was common practice in the paint industry to modify paint properties. For instance leaded zinc oxide was recommended for paints used in damp conditions and the desired proportions varied (Vanderwalker 1924, 114). The combined pigments were readymade by the manufacturer. Brindley notes that *'the brittle nature of the zinc is countered by the powdering action of the lead'* (ca. 1952, 220). However in oil, the hiding power of zinc oxide is not as great as that of titanium or lead whites and that resulted in zinc's replacement by titanium white, especially after 1945 when titanium white represented 80% of white pigment on the market (Brunnel 1978, 592). Thereafter titanium would be frequently identified on Picasso's works in both colour and white paints. Another finding, lead titanate, sometimes called Titanox L, is said to be commonly used in architectural finishes in Holland (Crown 1968, 36). The so-called 'extended titanium pigments' (mixtures found with barytes, calcium sulphate and chalk) were commonly used in the paint industry until the late 1950s.

The paintings in Antibes (painted in 1946), as was well-documented in photographs taken by Michel Sima, included 'marine' paints and mostly look transparent (documented also in Gilot and Lake 2000, 128-129). However, analysis done by LRMF showed linseed oil and a regular mixture of titanium and barium base (Giraudy 1982, 31-33). In a 1947 painting, the *Femme Assise dans un fauteuil* (private coll., Z.XV:39) which was analysed for the present study, the combination of titanium and barium was found in blue, purple, green and yellow paints. Those 'extended titanium pigments' were found containing quantities of precipitated barium, regularly in proportions 50:10 or 40:25 (quantitative EDX after ZAF corrections). This finding suggests similar paint to the Antibes's group and it can be related to one industrial paint manufacturer (Rioux and Lahanier in Giraudy 1982, 33). Unfortunately we are not familiar with the exact ingredients of the industrial/retail trade products from that time because reference samples have not been analysed, but this result may be a reflection of how extenders were added to titanium dioxide in order to make cheap paints. For certain, housepaints, like *Ripolin*, were oil-based products until the 50s; however in the first decades of the century commercial catalogues describe several types of *Ripolin* to be sold in France (household, motor, marine paints etc). Possibly these might have been manufactured using different materials. The company itself reported the use of heat-bodied oils (see above), which have levelling properties and dry to a smooth film, free from brush marks. However even if heat bodied linseed oil was not confirmed during the 1982 analysis by LRMF in any of the Antibes's works, it was found in many of the glossy and fluid paints from the *Dish of Pears* 1936 (Tate, Z.VIII:311) and the *Weeping Woman* 1937 (Tate, Z.IX:73).

Possibly heat bodied linseed oil is frequently present in Picasso's works until the mid 1950s, like a case study examined, the *Goat's Skull, Bottle and Candle* 1952. This painting, even if it is monochromatic (black and white), is characterised by the most heterogeneous paints. Different binders were analysed for several samples and each paint contains different white hiding pigment suggesting their diverse formulation. Pure lithopone white paint[vi] was found alongside zinc and titanium based paints (XRD results).

Lithopone was already found as a component in Picasso's samples as early as 1923, notably in colour paints with vermilion red, cadmium yellow, prussian blue, viridian and emerald pigments. It was cheaper than white lead (Kelly 1929, 121) and it appeared to arrive at its peak in the 1920s and 1930's. On the *Weeping Woman* 1937, lithopone was found in many cases, sometimes with cadmium pigments. In that case it can be a pigment that has been termed cadmium lithopone[vii] (or cadmopone) but a definite distinction was not made. However it is better to make it clear that if cadmopones had been positively confirmed to be present, then zinc sulfide or zinc oxide has been added as a lightener. On the other hand, it is worth mentioning that in the majority of the samples examined (not in *Goat's Skull* 1952), lithopone was always present in mixture with chalk, kaolin and other extenders (talc, gypsum).

In the 1950s, Picasso used housepaints along with *Talens* artists' products. He was in frequent contact with suppliers of industrial paints (*'La Boite a peintures' Dépositaire des Peintures et Vernis 'TRITON', Cannes*) as well as the actual companies (dated letter from *Triton*, Picasso Archives). Moreover he requested specific information to be given by their chemists (letter dated June 1954; Picasso Archives). At the same time that Picasso is documented working with several qualities of paints, we come across canvases that are depicted almost exclusively by standard artist's quality paints and exhibit the typical textured surface of tube paint. In *Studio* 1955 (Tate, Z.XVI:497) all paints were applied in thick single layers and almost all are lead based paints from the tube. Conversely, this was not the case with other contemporary works. For instance many synthetic organic pigments were found mixed in large amounts of white base on the *Nude in a Rocking chair* 1956 (The Art Gallery of New South Wales, Z.XVII:55). It is said that with the Studio series Picasso paid attribution to the 'old-master' Matisse; however around the same period he made important insights into other artists' masterworks as well. Hence the choice of his material for Tate's *Studio*, which is the last from the same series, has a significant meaning besides the practical justification: the traditional artist's paint from the tube was used for the illustration of the old-master's environment, the artist's studio.

In the *Nude Woman with Necklace* 1968 (Tate, Z.XXVII:331), different types of paints were distinguished by their different white hiding pigment base. Namely they were found to be either titanium or lead or zinc or lithopone based paints. Pigment analysis signified the presence of a range of synthetic inorganic and organic pigments; like the azo reds, PR3 (*toluidine red*) and PR9 (*permanent red*), the phthalocyanine blues and phthalocyanine greens. Those synthetic organic pigments have very high tinting strength and appreciable amounts of extender and white pigment, mainly lithopone was added in order to result lightfastness. Titanium white was found again in many of the samples. Sometimes it occurs in a typical titanium/zinc blend with chalk and in other cases paint is found exclusively pigmented by TiO_2 (pure titanium dioxide, XRD). It was not until the late 1950s that titanium industry took off and 'extended titanium pigments', meaning the mixtures of titanium pastes, became irrelevant.

By making use of industrial paints Picasso also used alkyds. Zinc oxide, which was found, is added to alkyds to reduce the yellowing by converting the colour bodies to white or colourless soaps[viii]. It may be converted into the sulfide upon exposure to industrial environment, and fortunately the change is not apparent, as zinc sulfide is also white pigment (Feller 1986, 174). For that reason, in the coloured pigment industry, lithopone and other zinc sulfide pigments are used intentionally to cheapen the coloured pigments used both for oil pastes and oil paints. The presence of zinc sulfide, as well as the other zinc formulations, was suggested from the available techniques but limited access to XRD analysis didn't permit further confirmation.

On the *Nude Woman with Necklace* 1968 alkyds were found mixed with oils and sometimes artists' paints were also applied straight from the tube. This confirms that Picasso regularly in his artistic life employed and mixed paints made for different purposes. As alkyds are completely intermixable with traditional oil paints, Picasso continued this practice just as he had when commercial paints were only oil based.

During his late period (last ten years), Picasso worked on the canvas by handling his brush anxious. Occasionally, glossy paints are rolling along the surface of his late paintings. Thick glossy paints, rich in medium, have been pushed and dabbed on the canvases. Their glossy richness sharply contrasts against a thinned down one. Such paints originally applied thickly tend to wrinkle because they dried quickly as solvent evaporated.

In most of his latest paintings Picasso commonly creates translucent top layers. Usually the layer of a diluted alkyd is very thin but strong in colour while an undiluted alkyd shines through since it is paler as a medium than linseed oil. Transparent films of colour and translucent scumbles were noticed during certain periods, basically those when Picasso made use of industrial paints because they are rich in medium. For instance the works executed in Antibes in 1946 and the big project *The War* and *The Peace* 1952 (Vallauris, Z.XIV.196, 197).

It is worth mentioning here that no other synthetic binding media, e.g. acrylic, polyvinyl acetate have been found in any of the analysed works and no previous research mentions use of such media. However scrutiny of photographs from the 50s showing him working in his studio (Quinn and Daix 1987, 295), reveals not only a tin of *Ripolin* Mat but also some aerosol paint cans on a table beside him (likely to be acrylic coating). He did not often use aerosols but once he was given one tin (unpublished letter sent to Picasso from Krylon®; Picasso Archives), he delightedly tried it out. He also kept until his death colour charts of fluorescent paints (also at the Picasso Archives; about their paint formula see Sloane 1970, 494-495).

Archives), he delightedly tried it out. He also kept until his death colour charts of fluorescent paints (also at the Picasso Archives; about their paint formula see Sloane 1970, 494-495).

Picasso's thorough method of dating paintings by giving the year, month as well as the day made us aware that many works were completed in one day. One can imagine the effort in applying paint and the fast physical action required by the artist. He applied paint in a direct manner, often using one or few layers.

In general during his late periods at Vallauris (1940s-1950s), at Vauvenargues (late 1950s), at Mougins (1960s), or for the Avignon series, Picasso mainly chose to work with house paints, largely for aesthetic reasons and for their handiness during application because of his age. The very different handling properties of these paints affect their appearance. He produced effects of substance and texture by allowing the paint to run and trickle freely, thickly applied in places, hastily spread elsewhere. Bleeding of colours laid side by side, paint drips and trickles are often found left on the surfaces; no subtle scales of tonal values but fluidity and smudged effects, overlapping of layers and interplay of transparencies are in use. The exercise with all these techniques, the colours and the unvarnished surfaces produced canvases lively in appearance supporting the idea of the accidental. To that end Picasso employed a range of plastic effects throughout his career, which respect the nature of the materials he used.

Conclusions

Picasso textured his paints by various means: matt and glossy, flat, thick, dry, impastos, thin, lean layers revealing the coarse texture of the canvas; passages of thick paint and scratches inscribed with pointed tools or spatulas. The texture of paintings' surface is the result of the materials used and the way in which they were manipulated. Picasso used industrial/retail trade paints alongside or mixed with his tube colours.

The surface characteristics of paints are due to a combination of factors like the type and amount of medium, the white hiding pigment involved as a base, the particle size of that white base, the extenders and the driers. Usually the artist is not aware of the medium, the white pigment base and certainly not about the extenders used by the manufacturer. However Picasso was conscious that particular paints had inherent visual characteristics that could be exploited for his purposes. Apparently he trusted his own experience about their handling properties and the surface appearance they were obtaining when dried but he would also ask for scientific information by paint chemists when possible. Here an attempt has been made through materials analysis to correlate the materials to Picasso's stylistic periods and the influence of the paints' organic and inorganic minute components on the properties of the dried paint and to the surface texture exhibited.

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IRUG, Infrared User Group Spectral Database.

LRMF, Laboratoire de Researche des Musées de France

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Endnotes

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[i] *Ripolin* is the trade name for a range of good quality house paints made by French manufacturer. The name comes from Dr Riep, the inventor of this paint.
[ii] Max Doerner noted that animal oil *has been used now and then in place of beeswax in oil colours* adding that *mutton tallow and beef tallow at one time were very undesirable* additions, used to thicken oil colours (Doerner 1935, 142) and probably to make paints slower-drying in order to prolong the storage. However their proportion in tube paints should have been quite small and hence they would not be easily identifiable.
[iii] The identification of zinc was achieved by EDX analysis and was confirmed as zinc oxide by ultraviolet microscopy because of its characteristic green fluorescence. Zinc soaps were identified by the combination of evidence: analysis by EDX, absence of green fluorescence in UV microscopy and characteristic absorption in the band of 1580cm^{-1} in FTIR.
[iv] A drier is a metal soap with an acid portion that confers solubility in the oil medium. Cobalt and manganese are primary driers working as catalysts, lead is a secondary drier but also synthetic acids are normally used.
[v] The first published occurrence of titanium dioxide white in Picasso's painting was from *The Rocking Chair* (Z.XIII:80) from 1943, analyzed by Raman microscopy (FitzHugh 1997, 340). However here titanium was found on the *Nude Woman in Red Armchair* from 1932.
[vi] Having a greater hiding power than zinc white (Feller 1986) and owing to its comparative cheapness, lithopone was widely used until the adoption of titanium dioxide as the prominent white pigment for so-called exterior paints (Pike 1994).
[vii] Cadmium pigments are co-precipitated with barium sulfate to produce the cadmopones (first patented in 1921 in the United States, Feller 1986, 89).
[viii] As alkyds age, coloured compounds formed by oxidation cause them to yellow. A small amount of fine particle size, highly reactive zinc oxide (about 5% to 10% of the total pigment) reduces the yellowing (Preuss 1974, 12).

INFRARED REFLECTOGRAPHY AT THE ART INSTITUTE OF CHICAGO

Bonnie Rimer, Andrew W. Mellon Fellow

Since its introduction in the 1960's by J.R.J. van Asperen de Boer, infrared reflectography has become a vital tool for the non-destructive examination of paintings. The vidicon systems used by van Asperen de Boer were tube cameras with lead sulfide detectors with a spectral sensitivity of around .75-2 microns (μ). An evaluation of these systems in the early 1990's by researchers at the National Gallery in Washington revealed the vidicon cameras, when compared with solid-state cameras had a lower signal to noise ratio, resolution, and spectral sensitivity. These findings resulted in solid-state cameras particularly those with platinum silicide detectors beginning to replace vidicons in many conservation studios.

In 1998 the Art Institute of Chicago purchased the Inframetrics® InfraCAM™, an infrared sensitive camera equipped with a platinum silicide solid-state detector. Since acquiring the camera, the conservation department has discovered that a high quality camera is only a small part of the equation. In any imaging system, the quality of your images is only as good as your weakest link. To achieve the best possible images attention needed to be turned to the set-up of the capture system, including; placement of the camera, lighting, and most importantly the capture board used to digitize the images. This paper describes the Art Institute's experiences with the Inframetrics InfraCAM and the solutions we've found for improving image quality and accuracy, from the placement of the lights to the selection of a capture board and finally our procedures for documenting and archiving images.

The Inframetrics InfraCAM weighs about 3 pounds and with viewfinder and battery pack is extremely portable, easily taken into the gallery for scanning (Fig. 1). It has a filter slot cut into the lens housing that allows you to add bandpass filters behind the lens (Fig. 2). The InfraCAM's platinum silicide detector has a spectral sensitivity of around 1.1-5.0 microns. The combination of an internal filter added to reduce noise and the CaFl lens reduces the spectral sensitivity of the camera to 1.1- 2.5 microns. By comparison, the Museum of Modern Art has had the internal filter removed from their InfraCAM, and using a germanium lens they are able to access the full spectral sensitivity of the detector.

Figure 1 Inframetrics InfraCAM shown with filters, close-up lenses and apertures.

Figure 2 Placing a filter into the filter slot.

Bonnie Rimer, Andrew W. Mellon Fellow, Painting Conservation
Art Institute of Chicago
111 S. Michigan Ave.
Chicago, IL 60603

The detector is made up of 65,536 discrete platinum silicide detectors arranged in a pattern of 256 by 256 elements. Each element appears as one point or resolution element in every image at a rate of 60 times a second. The camera is cooled by a miniature self-contained cryogenic cooling system that maintains the detector array at a constant operating temperature of 75°Kelvin.

The camera has two ports meant to output data. The main video out port located at the back of the camera outputs an RS-170 composite non-interlaced analog signal that has a voltage equivalent of 8-bits when digitized (Fig. 3a) A port at the top of the camera is referred to by Inframetrics as the extended dynamic range port, and we were told it was capable of 12 bit digital output (Fig. 3b).

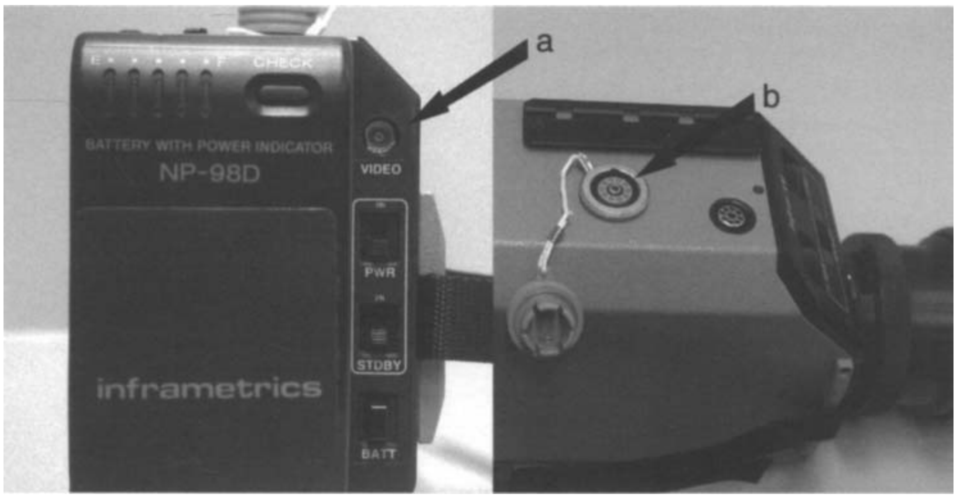

Figure 3a & b RS-170 video out. Extended dynamic range port.

Soon after receiving the camera it was discovered that it was not compatible with any of the capture boards currently being used by our colleagues. It did not sync with these boards, which resulted in a checkerboard interference pattern in the images. Inexpensive video cards used for portable captures and a board standard in our PowerMac worked, but the image quality was degraded.

The image degradation was noticed when we compared the image seen through the viewfinder on the InfraCAM with the image captured to the computer. A dotted line as seen through the viewfinder became a solid line when captured. In addition, Henry Lie at the Straus Center for Conservation noticed a difference in the histograms for images captured with inexpensive boards versus those captured with higher quality boards.[1] A histogram is a plot of the gray levels of pixels within a digital image (Fig. 4). The horizontal axis graphs brightness from 0-255 gray levels, and the vertical axis plots the number of pixels. Because all pixels must have some brightness value, the histogram represents the total number of pixels in the image. The histograms for the images captured with the cheaper boards show a loss of pixels indicating that information was lost (Figs. 5 & 6).

There may be several factors causing this loss of information. It may be related to the non-standard video signal output by the InfraCAM. This non-interlaced signal is generally preferred in scientific imaging systems such as high-performance cameras, Scanning electron microscopes and medical imaging equipment. However, most commercially available boards are unable to sync with the non-standard signal. The inexpensive video cards were more flexible but were still unable to correctly digitize the signal resulting in a loss of image quality due to inefficient and incorrect data collection.

Poorer quality Analog-to-Digital (A-D) converters used in inexpensive video cards and capture boards may also contribute to data loss. Manufacturers of inexpensive consumer boards often use "approximating" A-D converters, converting to approximately 7.5-bits versus a true 8-bits. In other words, the analog signal is digitized inaccurately and incompletely resulting in lower quality images.[2] In addition, capture boards, even high quality boards, are powered by the computer bus, which can be a significant source of noise. The benefit of using a high-end camera can be lost by connecting to a cheap board or exposing the signal to unnecessary noise produced by the computer's environment. Combined they can significantly degrade image quality.

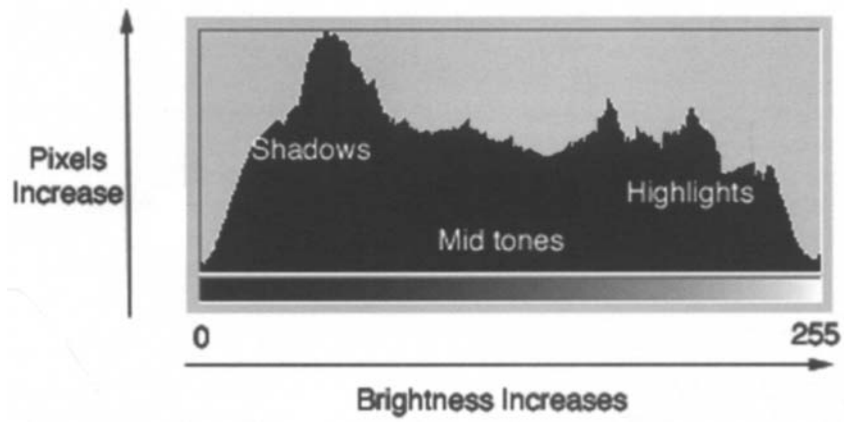

Figure 4 A histogram is a plot of the gray levels within a digital image.

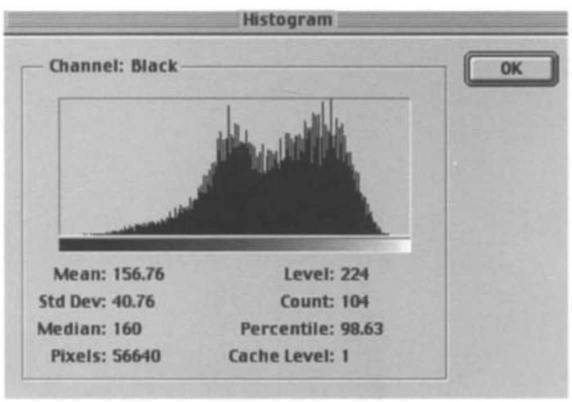

Figure 5 Histogram from image captured with InfraCAM and EPIX capture board.

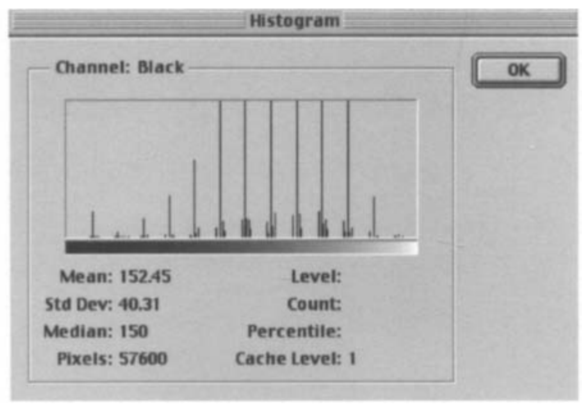

Figure 6 Histogram from image captured with InfraCAM and inexpensive video card.

Another problem is some of the boards only captured in an array of 640x480 pixels. Since the focal plane array of the InfraCAM was 256 square the capture boards were stretching the image to create the full 640x480 image. It does this by upsampling the image. In other words it duplicates existing pixels to fill the gaps between actual pixels in order to make the image a rectangle. The result is distortion and blurring of the images and stairstepping of lines. In order to return the image to the appropriate 256 square the computer must throw away pixels. It does this randomly resulting in a loss of information.

After lengthy and sometimes aggravating discussions with Inframetrics and a variety of capture board manufacturers, we were finally directed to the EPIX® corporation in Buffalo Grove Illinois. Martin Lopez, an engineer at EPIX, took the time to measure the signal coming from the camera and identified a capture board that would allow us to maximize the information extracted from the camera. Using an oscilliscope Martin determined the port at the top of the camera that many of us had initially thought was a digital output was not, and in fact had no data output at all. Instead this second port was found to contain a pixel clock which could be used to regulate the signal from the video port at the back of the camera.

Though we were disappointed to discover that this port was not digital, the discovery of the pixel clock was significant. Accessing the pixel clock would allow us to control how the analog signal was sampled. Without the pixel clock the signal is sampled randomly, and sampling may start at a different point each time. This can result in a loss of information. By using the pixel clock we were able to generate a 1:1 correspondence between the lighting intensity on the sensor and the gray levels of the stored digital image. In other words the digitized image contains pixels that exactly correspond to what is present in the detector. There is no further processing or interpolation by the board, so the software displays what the A-D converter gets. This reduces the loss of information caused by interpolation of some boards and software.[3] The result was visually obvious when looking at a series of black and white lines. Without the pixel clock a slight graying was evident between the lines; with the clock the resolution of the lines was clear and sharp.

The EPIX board we purchased is the Silicon Video MUX™ (SVMUX) capture board. It is only available for the PC platform. We determined early on that boards made for the Apple platform could not be used with the non-standard signal produced by the infraCAM. This was annoying since we were strictly a Mac-based lab, but we soon adapted to using the PC and found ways to work with both platforms.

The software used with the EPIX board also improved our imaging process. When capturing an overall reflectogram of a painting, images are captured in rows starting at the top left corner and moving from left to right and then down the painting. The EPIX software stores up to 18 images into temporary buffers. This allows us to capture an entire row relatively quickly, and then save the row automatically. The software automatically names each individual image sequentially and stores it in a designated folder. This is similar to batch processing of images in Adobe®PhotoShop®. Combining this feature with the grid system on our easel improved the efficiency of the capture process.

The easel used for capturing images was constructed by Kirk Vuillemot, our conservation technician. Kirk created grids for the x and y axes of the easel that consisted of numbered Plexiglas strips for use on the x axis and lettered magnetic strips on the y axis (Fig. 7 & 8). The size of the captures was determined using small grids ranging in size from 2-12 cm square each with a 1cm border (Fig. 9). Once the appropriate capturing distance was determined grids were held in front of the painting (Fig. 10). When a grid filled the camera's field of view it was chosen as the capture size for the individual images. Grids of a corresponding size were then chosen for the x and y axes on the easel. This allowed us to capture with approximately a 1cm overlap using the grids on the easel as guides. A script was written by EPIX that automatically saved the images with a letter indicating the row and number indicating the position within the row. Images were saved in the TIFF file format. This format was designed for use by most computer platforms, making the images easily shared between the different platforms.

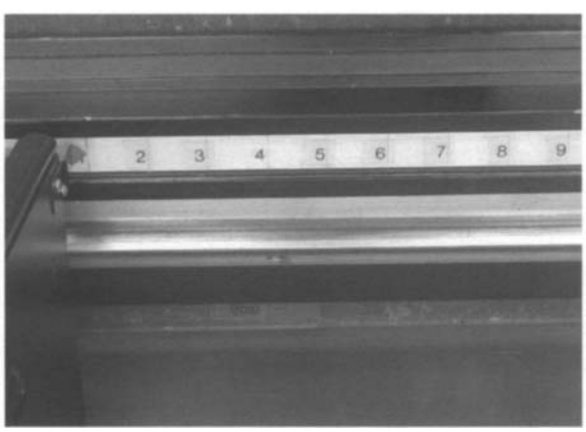

Figure 7 X-axis on capture easel.

Figure 8 Y-axis on capture easel.

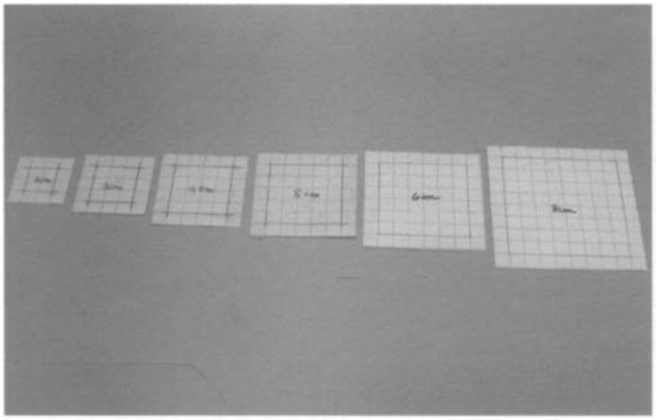

Figure 9 Capture grids.

Figure 10 Selecting capture grid.

In addition to improving the capturing procedure to increase efficiency, factors such as lighting and camera placement were reviewed to determine the best set-up to reduce distortions and uneven lighting. Unlike the vidicons the solid state cameras in general image more evenly. The improved optics of the infraCAM reduces distortion and the lighting inconsistencies seen with the vidicons, providing the object is evenly lit and in plane with the camera lens. We determined that by using two lights placed equidistant from the painting at a slight angle we were able to create an even wash of light over the painting's surface (Fig. 11). The extreme sensitivity of the camera requires that other light sources be extinguished to prevent interference with image quality. This includes the light emanating from the computer monitor. The monitor must be turned away from the painting or it will create a reflection that is picked up by the camera. Dramatic changes in the light levels caused by turning on additional lights midway through the capture can also result in changes in the image quality from row to row or image to image. Controlling the lighting reduces the possibility that this adjustment will occur; therefore the examination room is made off limits until the capture is completed.

Another useful feature of the EPIX software is the ability to retrieve a histogram for an image. A histogram will provide information about your set-up that may be difficult to judge through visual inspection of the image. When imaging an area on the painting that appears to have a good sampling of lights, darks and mid-tones, the histogram for that image should be broad covering the full range of 0-255 gray levels (Fig. 12a). If you move around the painting and your histogram shows clipping in any areas then you will need to adjust your gain and offset or lights until you reduce the clipping (Fig. 12b & c).

Figure 11 InfraCAM capture set-up in Art Institute examination room.

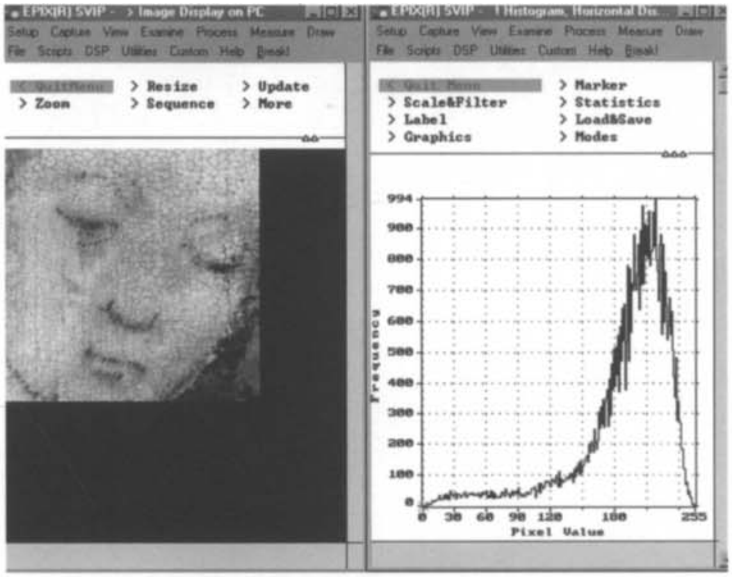

Figure 12a Example of image and histogram with even gray levels. (Histogram values stay between 0 & 255).

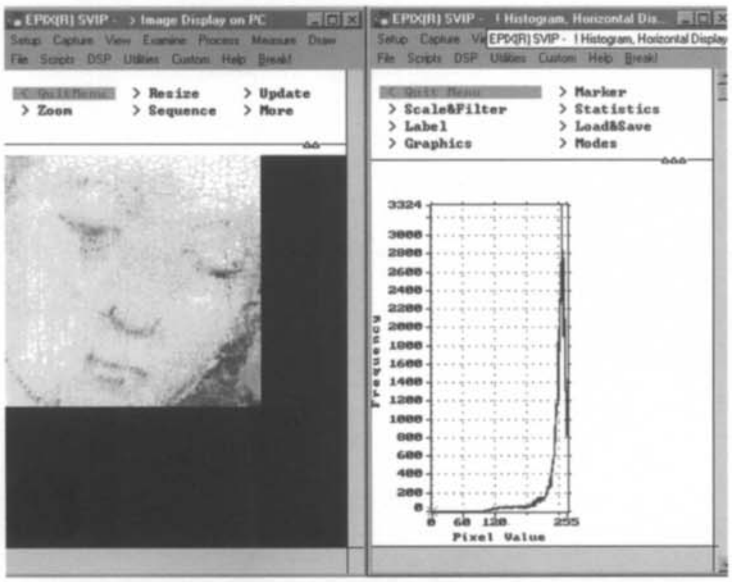

Figure 12b Example of image and histogram with clipping in lights. (Histogram runs off edge at right).

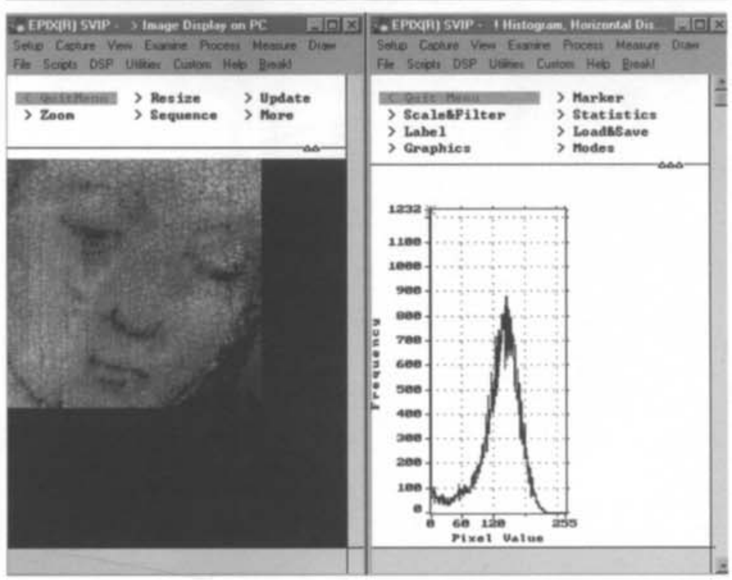

Figure 12c Example of image and histogram with clipping in darks. (Histogram runs off edge at left).

Distortion of the image is possible if the camera lens is not in plane with the face of the painting. This is difficult to avoid if the painting's support is warped, which is often the case with panel paintings. Increasing the depth of field by shutting down the aperture (normally f/2.0) may help to reduce this distortion. On the InfraCAM this is accomplished by adding small discs to the back of the lens that reduce the size of the aperture (Fig. 13). Illumination must be increased accordingly. We also use a level to assure the camera and tripod are level and an angle finder to assure the camera lens and painting are in plane across the vertical direction.

The choice of filter to be used is also crucial. Currently we have four bandpass filters ranging from 1.1-2.4μ (Fig. 14). When first examining a painting we have found that the 1.5-1.73μ filter is the most representative. Once we have a sense of the visibility of the underdrawing we will usually test the other filters to determine if we are seeing more or less with any of these filters. We have discovered that the 1.5-1.73 and 1.5-1.8μ filters sometimes show too much detail, overemphasizing things like cracks in the paint layer. Also, the 1.5-1.8μ filter appears to create a higher contrast image. High contrast images can make capturing an even overall reflectogram difficult. In general we do not use this filter unless we feel it alone retrieves line detail. Occasionally we will find that the 1.1-1.4μ filter shows the same amount of information but de-emphasizes the cracks so that they do not distract from the visibility of the underdrawing lines. Sometimes it is necessary to make more than one overall capture using different filters in order to have a clear comparison. For the painting by Paul Gaugin, *Portrait of a Woman with Still Life by Cézanne*, three overall reflectograms were made using the three main filters (Fig. 15). Each reflectogram showed slightly different information so we determined it would be useful to have all three reflectograms for comparison.

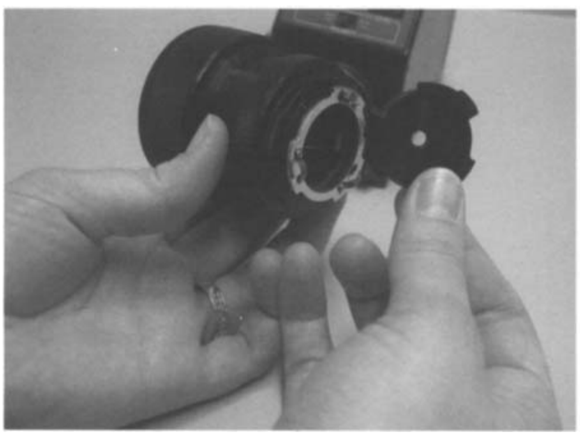

Figure 13 Adding disks to the back of lens to close aperture.

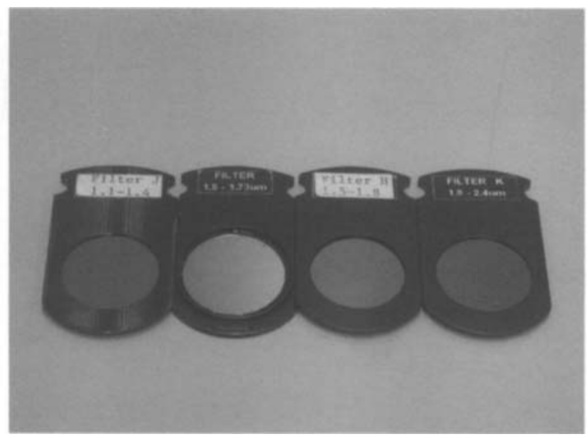

Figure 14 InfraCAM bandpass filters.

Figure 15 Paul Gaugin *Portrait of a Woman with Still Life by Cézanne* three overall reflectograms taken with 1.1-1.4 micron filter, 1.5-1.8 micron filter, and 1.9-2.4 micron filter respectively.

Finally, the distance of the camera to the painting dramatically effects the resolution of fine details. Figure 16 shows details of the head and hands of the infant from the painting *Virgin and Child with Young St. John the Baptist* attributed to the Workshop of Pontormo. One was taken at 36" from the painting and the other at 12". The separation in the drawing medium caused as it skips over palm and fingerprints in the ground are not readily visible in the detail taken at 36". In general we have found that the best imaging distance for the best resolution with this camera is at around 12" or 3-4 cm captures. For larger paintings this can mean hundreds of individual captures. In the case of this painting we determined that a detail of the child's head and hands would be sufficient to demonstrate the underdrawing medium so a detail was taken at 12". An overall reflectogram of the painting was taken at 36" which still gives us a sense of what areas are underdrawn and where there are deviations from the underdrawing to the paint layer.

We use Adobe PhotoShop to mosaic our source images. Corrections to variations in alignment and lighting from image to image are made at each join. We have experimented with automated stitching programs such as VIPS and Panvue but found that both created some blurring at seams and occasionally artifacts. We feel we have better control and obtain better overall results using PhotoShop.

To record our findings and capture procedure log sheets are created for each session whether or not images are captured. Our log system is based on the system used by Elizabeth Walmsley at the National Gallery of Art. Like the National Gallery we use FilemakePro® to document the set-up for each session.[4] This database program allows us to save information about the object being examined and how the infrared reflectograms for the object were captured. The information can be used for comparison with future captures or if we need to recapture an area using the same set-up. The database is kept on a central file server and hardcopy logs for each object are kept in a binder in the examination room for quick reference.

Images are also stored on the file server, which is maintained by our information services department. The server can be easily accessed by anyone on the network. Since our images are TIFF format they can be read by both Apple and PC platforms. Images are password protected to prevent them being destroyed or altered accidentally. The file server is backed up daily using DLS tapes.

We are experimenting with an image database program called Extensis® Portfolio™ that allows storage of individual composites in an image catalogue with other related images. The meta data for the image can be included in the Extensis catalogue. Theoretically the catalogue will make it easier for curators to access finished composites without having to search through all of our image files.

Printing is still an issue. We have purchased an Epson Stylus® Color 3000 large format inkjet printer that allows us to print images up to 16 x 23 inches. However, we have found that image quality is degraded in most prints likely due to some interpolation by the printer software. In general we encourage curators to work with the images on the computer and only use print copies for reference keeping in mind that the information on the print copy may be degraded.

We have established a portable capture system using a VisionX PCMCIA video card in a laptop and the Art Innovations CPS 100 portable easel and lights (Fig. 17). This system allows us to make captures at any location. However, the image quality is not as good with these video cards so we are not able to get the degree of quality as with our studio set-up. Also since in most cases we are not working in controlled conditions and usually have limited time it can be difficult to set-up with the same degree of precision.

Finally, copyrighting of images is important when infrared reflectograms are requested by colleagues for research purposes. Images are watermarked with "AIC" or with a copyright line imprinted on the image. Printed copies have a label adhered to the back with information about the object and the capture procedure, as well as a disclaimer indicating images are not to be reproduced without our express permission. Digital files are also imprinted with a copyright line or AIC watermark and a simple text file is included on the disk with copyright requirements.

Though we have made a lot of progress in understanding and improving our infrared imaging procedures, there is still room for improvement. As is the case with most conservation studios, we can not devote the time we would like to perfecting our system. Consultations with colleagues at other museums have been crucial to problem solving. In June of 2001 we co-hosted a two-day Infrared reflectography workshop with Marcia Steele and Len

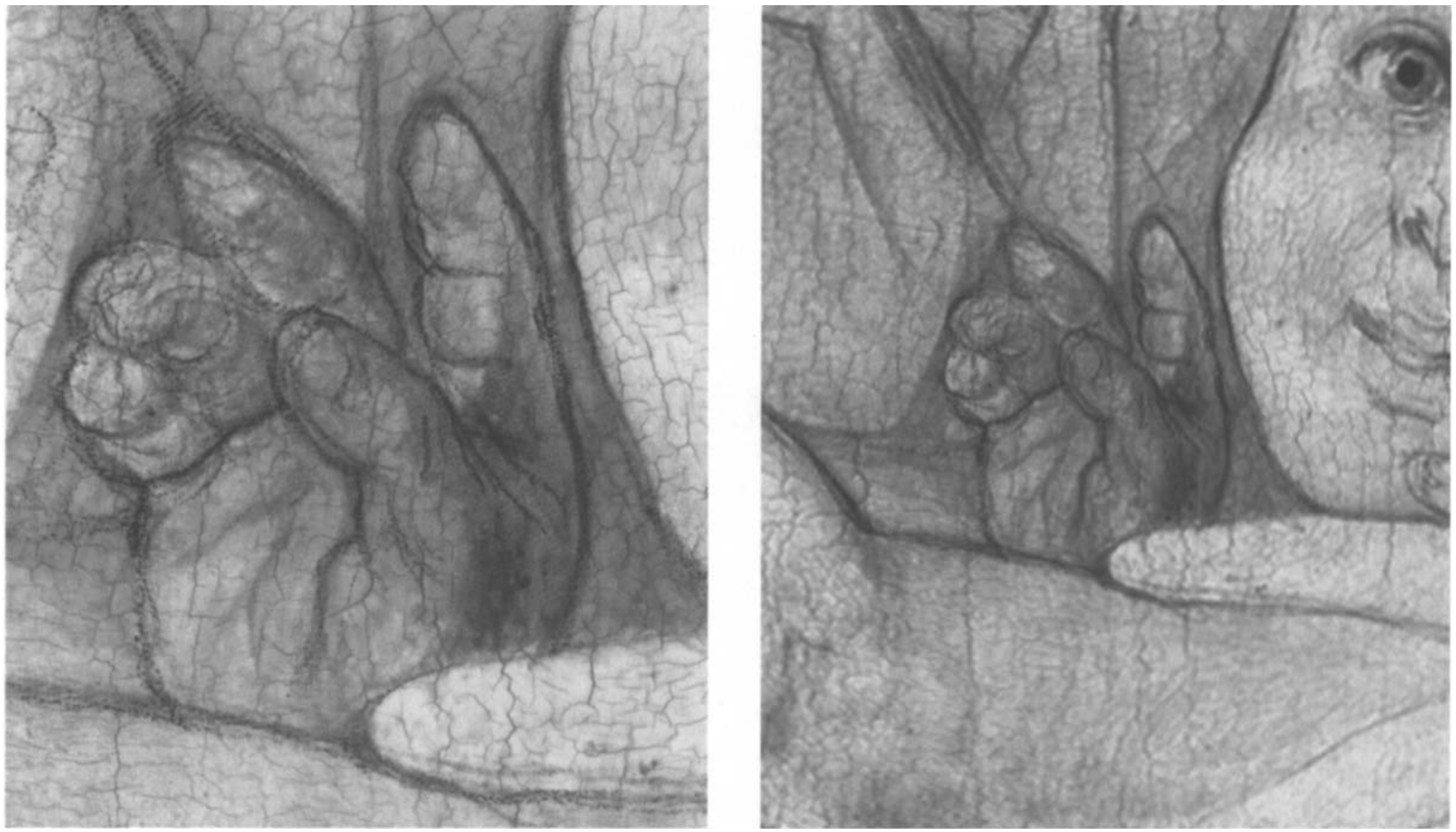

Figure 16 Workshop of Pontormo *Virgin and Child with St. John the Baptist* taken at 36" from painting and 12" from painting.

Steinbach of the Cleveland Museum of Art. We invited colleagues currently working with solid-state cameras and those who were in the process of purchasing solid-state cameras. The purpose of the workshop was to compare existing systems and discuss some of the issues surrounding these systems. We tested only solid state cameras. These included the Inframetrics InfraCAM, the Mitsubishi® M700, Art Innovations "ARTIST" and the PhaseOne® Light Phase® camera back.

Figure 17 InfraCAM portable capture system. Set-up in examination room and packed for transport.

Both the ARTIST and the PhaseOne image effectively in visible light and up to 1.1 μ in the near infrared. The ARTIST provides two infrared filters to further narrow the spectral band and it has the potential to image in ultraviolet. Both cameras showed good penetration of paint layers up to 1.1 μ and good resolution.

We found the Inframetrics and Mitsubishi cameras were very close in quality. In general the Inframetrics is more portable and easier to use, and when combined with the EPIX board provided better resolution. The Mitsubishi's images required sharpening and averaging to achieve the same quality. However with the Mitsubishi you do not need to be as close to capture the same detail, effectively reducing the number of images required for an overall reflectogram to half as many as required with the InfraCAM. Also the Mitsubishi has a digital port which when used should provide better images in the long run since it will eliminate many of the problems associated with capturing stills from an analog signal.

The opportunity to compare the different systems and discuss the results with our colleagues during the workshop was extremely valuable but we only scratched the surface in our brief two-day meeting. Future workshops focusing on the topic of the practical aspects of using these systems should be considered. The systems are endlessly complicated and since most of us are not optical engineers we are limited in our understanding. Sharing what we learn in our individual experiences will save us all time and perhaps lead to a standardization of the infrared imaging process. We found through our experiences with the InfraCAM that the more you know and understand about your system the better your end result.

I would like to thank the Andrew W. Mellon Foundation for supporting my fellowship and Frank Zuccari for supporting my work with the InfraCAM and for having faith in my ability to establish a working system and allowing me to explore and experiment until I found something that worked. I would like to thank my colleagues at the Art Institute of Chicago for their contributions, encouragement and patience especially Cynthia Kuniej Berry, Martha Wolffe and Kirk Vuillemot. I would also like to thank Jim Coddington, Henry Lie, Ron Spronk, Steve Pequiney (I-Cube, Inc.), Martin Lopez, John Delaney and Rhona MacBeth for sharing their knowledge of these systems and providing me with invaluable advice and training. And I would especially like to thank Elizabeth Walmsley who introduced me to infrared reflectography as a technician under her tutelage at the National Gallery. She has patiently suffered through eight years of my questions regarding every aspect of the system from turning on the camera to copyrighting images.

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AN INVESTIGATION INTO THE SOLVENT-INDUCED SWELLING RESPONSE OF LEACHED OIL PAINT FILMS.

Jo Willmore, Courtauld Institute of Art, London[1]

Abstract

Most oil paint films encountered in everyday conservation practice will have undergone a degree of leaching at some point in their treatment history. The process of leaching, which irreversibly alters the constitution of a paint film has long term implications for the response of the paint to the solvents commonly used in varnish removal. As part of a wider reassessment of the effects of solvents on artists' oil paint, this paper describes the swelling response of pre-leached oil paint films as a consequence of immersion in a range of organic solvents. A simple microscopical method using computer-based analysis was used to determine the lateral, in-plane swelling of the unsupported paint films during immersion in solvent. Results obtained for more than 45 common organic solvents are presented in this paper. Comparisons are made with the extant swelling data for both leached and virgin oil paint films. In addition to showing a lesser degree and rate of swelling upon immersion in solvents, the leached films of the current study are found to differ from the virgin films previously studied (Phenix, 2002) in terms of their greater range of response within the various solvent classes. They also exhibit a different pattern of swelling behaviour to the leached stand oil films tested by Stolow in the 1950's. The swelling properties of various solvent families are discussed, in conjunction with the implications of this new swelling data for the cleaning of oil-based paints.

Introduction

Despite the ongoing investigation of less hazardous alternatives, organic solvents remain the cornerstone of modern conservation practice; they not only play a key role in cleaning and varnishing but are also elemental to customary procedures of inpainting and consolidation. Their unquestionned position as the foremost chemical tool of the conservator, however, is not reflected by our, as yet, incomplete knowledge of solvent-paint interactions.

Of leaching and swelling, the two primary processes attendant upon the exposure of a paint film to an organic solvent, it is the former that has been the subject of more extensive and up-to-date research (Erhardt & Tsang 1990, White & Roy 1998, Tumosa et al 1999, Sutherland 2001). Conversely, solvent-induced swelling, closely associated with the process of leaching and arguably an issue of more palpable concern to a conservator engaged in the cleaning of paintings, has received relatively little attention since Nathan Stolow's pioneering studies in the mid 20th century. In this context, swelling is a result of the sorption of solvent by the organic binder phase of the paint. Depending on the extent to which it occurs, swelling can engender a temporarily softened state in the film, making it increasingly vulnerable to mechanical abrasion and loss of pigment. It is these immediately discernible dangers which make an understanding of the relative swelling potential of various solvent/paint combinations so critical to informed and safe cleaning practice.

This paper forms part of a wider study, still in progress, examining the swelling behaviour of artists' oil paint films with a view to improving the existing understanding of paint/solvent interactions (Phenix 2002). The present study concentrates specifically upon pre-leached oil paint and its chief objective is to establish the

[1] Jo Willmore, Student of Paintings Conservation
Courtauld Institute of Art, Somerset House, Strand,
London. WC2 0RN. UK

relative swelling power of a wide variety of organic solvents for paint films of this type. Results for the most widely used solvents will be presented graphically. The first part of this paper's 'results' section will compare the new data for pre-leached paint with that obtained for related 'virgin' paint films in a previous phase of the wider study. By using paint samples derived from the same stock as those previously tested and making extraction the sole experimental variable, it is possible to draw conclusions with regard to the specific effect of leaching on the potential swelling response of the paint films tested and to relate any observed differences in response to the characteristics peculiar to leached oil paint films. The second part of this paper's 'results' section will consider the new data in terms of its contribution to the ongoing reassessment of the existing model for describing paint solvation. Finally, the 'discussion' section will address the identification of any implications that this new swelling data may have for the cleaning of oil paint films.

Background

In the course of Nathan Stolow's mid 20th century research into the swelling and leaching of artist's oil paint, a number of significant discoveries were made with regard to the relationship between the solvent-extractable components and the swelling behaviour of oil paint films. Through his swelling experiments on both 'virgin' and 'pre-leached paint films, he was able to demonstrate that the processes of swelling and leaching operate concurrently during solvent sorption and that leaching, therefore, influences the pattern of swelling in oil paints. A key finding was that a paint film which has been completely pre-leached by long-term immersion in a polar solvent such as acetone, and subsequently dried and reimmersed in solvent, will show a swelling curve which is distinctly different from that obtained for a 'virgin' sample of the same paint. He found that a virgin paint sample swells more rapidly than one which has been pre-extracted, but that the swelling induced by the sorbed solvent is soon counteracted by the contraction resulting from the leaching of soluble matter in the virgin film. Conversely, a pre-extracted film will not display a peak in the swelling curve (since there are no remaining extractables to remove) but rather exhibit a smoothly rising curve of growth culminating in a maximum swelling equilibrium or plateau. Whilst Stolow found the ultimate degree of swelling to be of a similar order of magnitude for both virgin and extracted paints, it was shown to be lower in the latter case before absolute equilibrium was reached. Thus, it would be logical to expect 'virgin' paint films to show greater sensitivity to solvents than extracted films; the presence of the extractable mobile phase increasing considerably both the degree and rate of swelling.

More recently, preliminary experiments conducted as part of a wider study seeking to reassess the swelling data of Stolow and the model of paint/solvent interaction that it informs, showed similar relationships between the swelling responses of virgin and extracted paint films (Phenix 2002b). However, whilst several types of virgin paint films were extensively tested in the first phase of the study, specific experimentation on pre-extracted films was limited (acetone and ethanol were the only solvents tested). In the wake of this research, therefore, it remains critical to discover whether the overall pattern of swelling behaviour as a function of solvent type is similar for both virgin and extracted films.

The importance of conducting parallel swelling experiments upon virgin and pre-extracted films is twofold. Firstly, an important advantage of studying pre-leached films lies in the capacity for measuring swelling as a lone phenomenon, without the competing influence of leaching. This circumvents one of the major sources of variability in swelling measurements, simplifying the interpretation of results and allowing for improved discrimination of solvent effects. Secondly, there is good reason to expect that in their swelling response, pre-leached paint samples may indeed be more representative of the type of paint films usually encountered in solvent cleaning situations. During the course of their existence, paintings that are centuries old may be repeatedly subjected to the processes of cleaning and varnishing, leading in turn to an accelerated depletion of the paint binder's mobile phase. Furthermore, extraction of the mobile phase by cleaning solvents may, in itself, be an accelerated form of a process which occurs naturally; there is strong evidence to suggest that over long periods of time, oil paint films may become depleted of mobile low molecular weight components by natural processes of migration and evaporation (Tumosa et al.1999, Erhardt et al 1990, Sutherland 2001). However, this notion that pre-leached samples are more representative must be treated with a degree of caution as it is unlikely that the leaching experienced by paintings from conservation treatments, or indeed the loss of mobile components from the paint as a consequence of natural ageing processes, will be as 'exhaustive' in nature as the thorough leaching carried out on the test films of the present research.

A further reason for the current study of pre-extracted paint films lies in its potential contribution to the ongoing reappraisal of the existing model for paint/solvent interaction. One of the long-term goals of the larger study is to further develop the theoretical model of solvent/paint interaction used by conservators as a guide during everyday cleaning practice. As discussed in a previous paper (Phenix 1998) this involves a reassessment of both the Teas fractional solubility parameter interpretation of Hedley (1980) and its use of selected data from the swelling studies of Stolow (1957). The perceived limitation of the Teas chart in its current form concerns its definition of the 'peak swelling region' obtained using Stolow's swelling data set for paint films based on linseed stand oil. Recently reported findings have suggested that the response of stand oil paint films is different from that of other more commonly used binding oils and thus the 'peak swelling region' of the Teas chart may not be accurate in reflecting the sensitivity of artists' oil paints to solvents. By providing a source of swelling data for pre-extracted paint films with ordinary linseed oil to compare with Stolow's data set for pre-leached stand oil films, it may be possible to further clarify this apparent inconsistency.

Experimental Procedure

Sample Films

To ensure comparable results, the films used in the current investigation were derived from the remaining stock of one of the reference films previously studied in detail, namely paint type #16 (Phenix 2002b) These films were prepared in 1991 and consist of a mixture of yellow ochre and flake white pigment bound in linseed oil. For the purposes of the present study, virgin samples of paint #16 were extracted by immersion in acetone for 72hours, removed from the solvent and then left to dry naturally for 5 days. This extraction process was repeated twice, in order to remove as great a degree of soluble material as possible. The extracted samples were then left to dry out fully under ambient room conditions for a further 14 days. Weight change measurements of samples over the course of the three immersions indicated that the acetone-extractable fraction of paint#16 constituted 9% of the overall mass of the paint[2].

Test method

All experiments were conducted in a fume cupboard where the ambient temperature was approximately 23°c. The set-up was essentially the same as that previously reported (Phenix, 2002a) although the video camera used to record images of the swelling samples was here replaced by a digital camera (Nikon coolpix 990, 3.3megapixels). The camera was attached by means of a trinocular viewing head to a low-power stereo zoom microscope (objective range 1-4X). Small fragments(2-5mm²) of the unsupported paint samples were arranged, as shown by figure 1, on a sheet of microfibre filter paper within a semi-opaque glass basin situated on the microscope stage. The paint samples were covered by a custom-built glass slide, chromium printed with a calibration scale and two semi-circular shapes serving as internal standards to provide a safeguard against temporal variation in image constancy(see figure 1). The basin was viewed through the microscope at a magnification of 2.0X in transmitted light from the microscope's internal tungsten-halogen light source.

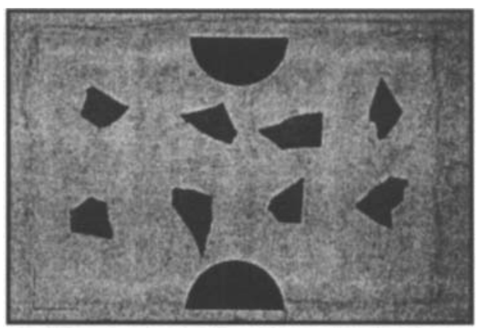


Figure 1. Image of swelling samples.

During experimentation, the test solvent (approx. 10ml) was run into the basin from a dropping funnel. As soon as the paint fragments were wetted, the first image was captured using the digital camera. Further images were captured at regular intervals over a time period ranging from 40-180 minutes, depending on the diffusion speed of the test solvent. Illumination and viewing conditions were kept as constant as possible; focus, magnification and light levels were not adjusted during the course of an experiment. Moreover, the lamp was only illuminated during image capture in order to restrict its thermal effect on the paint sample. Equally, where possible, the basin was covered to limit solvent evaporation and evaporative cooling of the samples.

Two computer software packages were used to process the experimental images. Images were adjusted for brightness and contrast using Adobe Photoshop V. 5.0. Calibration, thresholding and particle measurement was then carried out in Graftek Optilab V. 2.6.1. and an absolute area measurement recorded for each paint fragment in every image. These absolute values, measured at each time interval were then converted to % change in area

[2] For a more detailed characterisation of the #16 samples, including the results of organic chemical analysis by GC-MS, please refer to Phenix 2002b, p. 7

by calculation against the initial t=0 values. The resultant data was presented as plots of time vs. % change in area. The data from each of the individual paint fragments in a single experiment was also combined to produce a mean swelling curve[3].

Results

Table 1 (see Appendix) is a compilation of data on the maximum degree and rate of swelling attained by the pre-extracted #16 of the current experimentation generated by a wide range of organic solvents. Figure 2 illustrates, for a selection of the most commonly encountered cleaning solvents, these different rates and magnitudes of swelling for the extracted #16 paint films. For ease of comparison, representative swelling curves for the virgin #16 paint films from the previous study (data from Phenix 2002b) are reproduced in the adjacent figure 3.

A number of generic differences between the swelling response of the virgin and the extracted paint films are evident across the seven chemical classes of solvents tested. Most obvious is the disparity in extent and rate of swelling. The prevalent trend describes a lesser magnitude and rate of swelling for the extracted #16 films than for their virgin counterparts. On average, the extracted films take approximately 3 times as long as the virgin films to reach equilibrium swelling. This finding is consistent with the current understanding of the chemical and mechanical changes induced in a paint film by leaching. It is likely that the proportionally smaller organic content of an extracted film will serve to impede solvent penetration within the paint binder network.

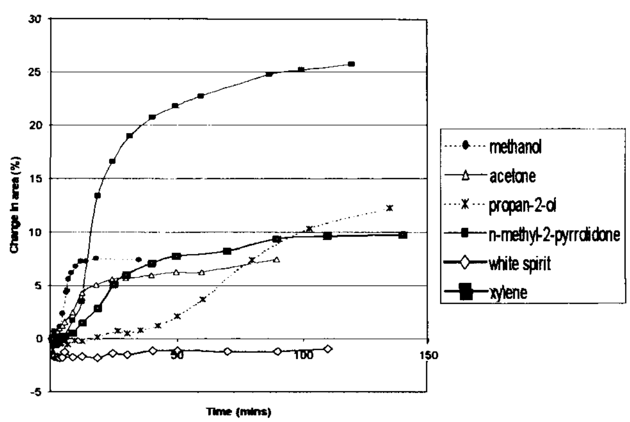


Figure 2. Swelling vs. time curves for pre-extracted #16 paint films in commonly used cleaning solvents.

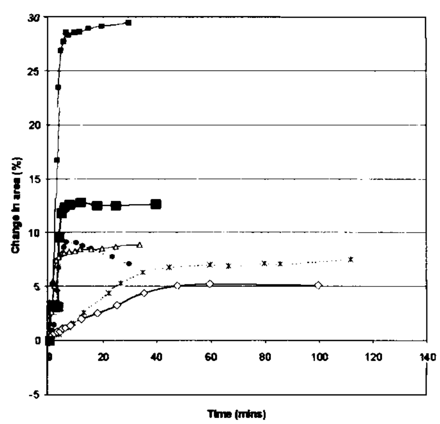


Figure 3. Swelling vs. time curves for virgin #16 paint films in commonly used cleaning solvents (data from Phenix 2002b).

Differences in the curve shape for the two sets of paint film can also be interpreted in terms of compositional changes associated with the leaching process. Mean swelling curves for a number of the solvents tested on the

[3] For a full discussion of experimental error and the validity of the test method as reported, please refer to Willmore 2002 pp.16-18

#16virgin paint films of the previous study show a distinct decline in sample size following an initial swelling peak. This pattern is presumed to represent the reductive effect of leaching in the previously unextracted films. It is not, therefore, surprising that such peaks and contractions are largely absent from the curves for the pre-extracted films tested in the present study, which in accordance with Stolow's findings, follow a gentler and smoother path toward equilibrium.

A further dissimilarity in response emerging from the comparison of swelling data for the #16 virgin and extracted test films concerns the breadth of the overall spread of maximum swelling values. The extracted films seem to display a more extreme stratification of the solvents with reference to their chemical and physical properties. This trend is particularly apparent in the results for the ester class of solvents.

The extracted films can be distinguished from their virgin counterparts by their pronounced grouping tendencies. In the case of the virgin oil paint films, the acyclic esters display a homogenous swelling response, as opposed to the molecular size-dependant behaviour characteristic of the extracted samples. Propyl propanoate, for example, is set apart from the shorter chain esters (ethyl propanoate and n-butylacetate) by its slower and lower powers of swelling for the extracted films. This comparatively profound influence of stereochemical factors upon the swelling responses of extracted films is, moreover, widely reflected by the considerably reduced levels of maximum swelling attained for these samples during immersion in solvents with large molar volumes. Increased film density in the extracted samples would account for this apparently superior discrimination between molecules of different sizes.

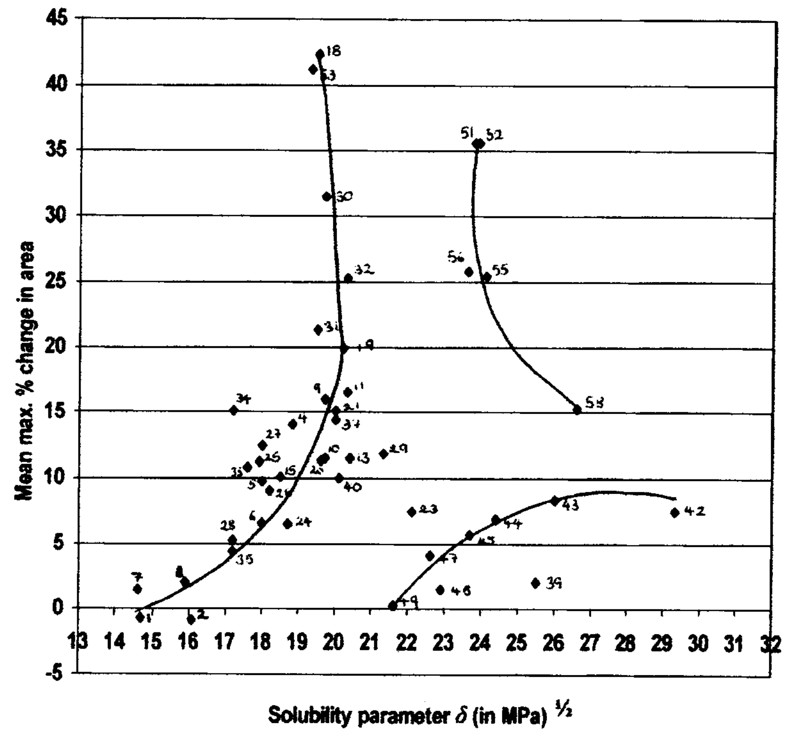
Data plotted as function of Hildebrand (δ)

Plotting the maximal swelling values of these extracted #16 films as a function of Hildebrand solubility parameter (δ)[4]is a useful way to identify the relative swelling potential of the different classes of solvents. In Figure 4, the swelling data of Table 1 is plotted against Hildebrand (δ). The simple alcohols can be seen to form a self-contained band of low to low-moderate swellers with comparatively high polarity values. The aliphatic hydrocarbons are revealed as similarly low swellers for these extracted films although, due to their non-polar nature, they are situated at the opposite end of the plot. Very high swelling propensities are evident in solvents with wide ranging δ values; the moderately polar cyclohexanone and chloroform are rivaled by the extremely (di)polar nitrogen-containing solvents and fluorinated alcohols.

[4] This is a measure of the overall magnitude of the intermolecular forces between molecules in a solvent or solute. In theory, the solvents which have the greatest swelling action on the dried linseed film will be those which possess a cohesive energy density virtually equal in magnitude to that of the polymeric film. Accordingly, the solubility parameter of a polymeric substance, such as dried linseed oil, can be defined by examining its swelling response in a range of solvents; its Hildebrand parameter (δ) will be approximately equivalent to that of the solvént causing the highest levels of swelling.

Figure 4.

Maximum swelling of pre-extracted #16 paint films as a function of Hildebrand solubility parameter (δ). See Table 1 for key to numbers representing solvents.



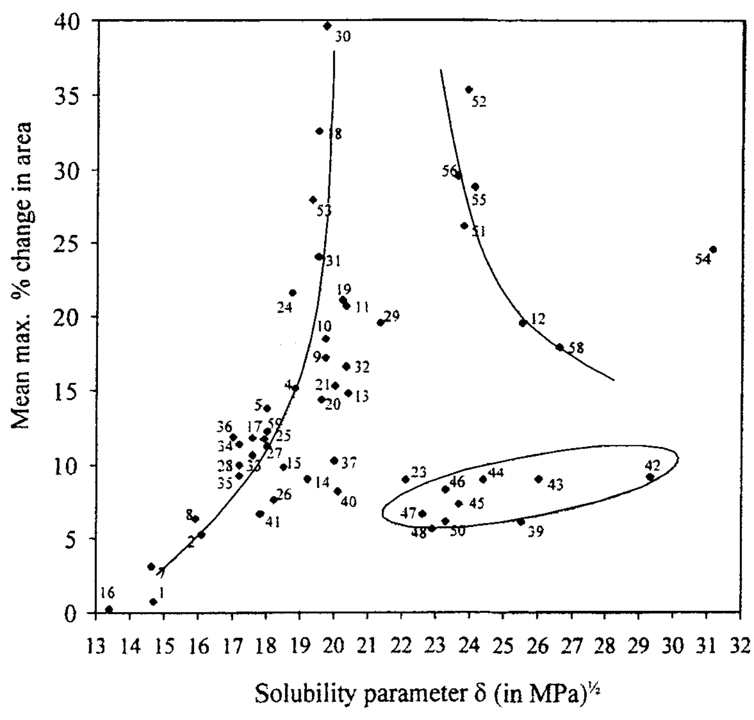


Figure 5.

Maximum swelling of virgin #16 paint films as a function of Hildebrand solubility parameter (δ). See Table 1 for key to numbers representing solvents. (Reproduced from Phenix 2002b).

Although, of a generally lower magnitude, the data for the #16extracted films mimics, almost exactly the pattern shown by the #16virgin data for the same plot. Figure 5 reproduces the plot for the virgin #16 films, as compiled by Phenix (2002b). On the whole, the similarity in pattern between the Hildebrand plots for the two types of

#16film is far greater than any correspondence between the scatter of data plotted for the #16 extracted films and for Stolow's leached stand oil films. For purposes of comparison, Figure 6 reproduces a plot of maximal swelling values for Stolow's young, leached lead white/ stand oil films as a function of Hildebrand δ[5].

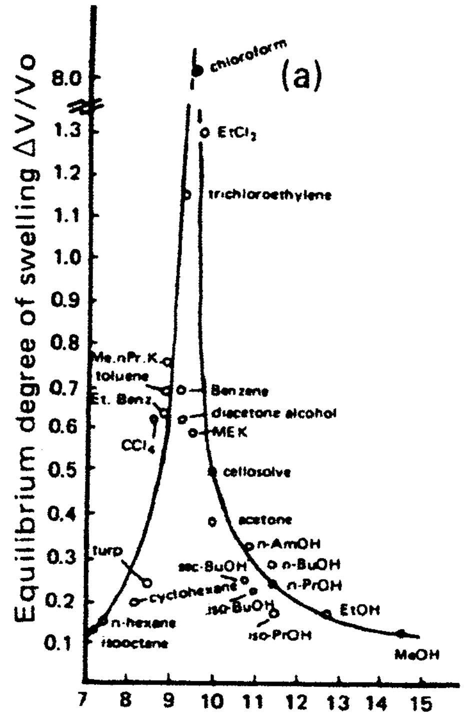


Figure 6. Maximum swelling of Stolow's leached lead white / stand oil films as a function of Hildebrand solubility parameter (δ). (From Feller, Stolow & Jones, 1959). The unlabelled x-axis in this plot should read (cal/cm³)½.

The most obvious discrepancy between these plots concerns the 'peak' of high swelling solvents, common to both. In the chart representing the #16 extracted samples (Figure 4), the peak encompasses a much wider range of δ values (approx. 18.5 to 24Mpa½) than that covered by the equivalent peak in Stolow's data (18 to 22.5Mpa½). Another difference between the patterns of response presented for the #16extracted films and Stolow's leached films, lies in the order of maximum swelling shown by the homologous series of simple alcohols. The smaller and more polar methanol and ethanol cause greater swelling than the larger alcohols of the series in the case of the #16 extracted films. The reverse is true for Stolow's findings. Such trends support the original supposition that stand oil films exhibit an essentially different pattern of swelling response to that shown by other types of linseed oil. As indicated by the preceding research, it appears that whilst the *degree* of maximum swelling can vary widely between paint films of differing ages and constitutions, variations in the actual *pattern* of swelling response are primarily related to the type of oil used as paint binder.

Discussion

Clearly, leaching does effect the response of a paint film to a solvent. The results reported here identify a generally lower magnitude of swelling and a slower rate of response in paint films which have previously undergone leaching Because the extracted films have a proportionally smaller organic phase than their virgin equivalents, there is accordingly less swellable material present in the film. The decrease in medium richness and the increase in film density incurred during leaching would also account for the slower rates of swelling displayed by the extracted #16 films by adversely affecting solvent penetration of the paint structure. In certain solvents, most notably the ethers, this retarded penetration is particularly marked, resulting in a brief period of

[5] It should be noted at the outset that comparisons between Stolow's measurements of volume change, and the dimensional change data produced in the present study, make the assumption that the two sets of results are comparable in their relative patterns of response. Whilst the two studies measure different parameters of swelling (i.e volume and area) which are likely to produce non-comparable absolute values, it is presumed that the proportional swelling effects of various solvents will remain consistent for both dimensions.)

total inactivity following immersion of the sample, prior to the commencement of any visible swelling. This trend might be of practical benefit to a conservator in allowing greater leeway in the duration of 'safe' exposure of paint film to cleaning solvent. Further to this, the spread of data for the extracted #16 films suggests that leached paint films are better at discriminating between different solvents, especially with regard to their molecular shape, size and perhaps even functionality.

Useful observations may also be drawn from the results in relation to popular cleaning liquids. Acetone, for example, was shown to possess only a low to moderate swelling potential for these pre-extracted films which, in combination with its fast evaporative qualities and intermediate polarity, would account for the effaciousness of this solvent in varnish removal. Equally, the coupling of strong polarity and low swelling witnessed by the current experimentation in solvents such as ethyl acetoacetate and butyrolactone, suggests a need for more thorough, practical investigation of the cleaning applications of these liquids, especially with regard to their potential use in binary mixtures. Furthermore, the low degrees of swelling measured for most of the simple aliphatic alcohols, also tends to validate their present role as staples of the conservator's cleaning toolbox.

In addition to any implications for safer varnish removal, the data gleaned from these swelling experiments might be positively harnessed in the service of solvent selection for overpaint dissolution. The stereotypical scenario of relatively old original paint covered by significantly younger oil overpaint allows for an exploitation of the age difference between the two in finding a suitably discriminating solvent. It can be postulated that the older original paint, with the increased presence of oxygenated functional groups in its binder phase, will have an amplified sensitivity to solvents at the polar end of the spectrum. Accordingly, the younger overpaint, more similar in character to the paint films of the present study, will be vulnerable to solvents with a wider range of polarity values. Thus, solvents such as cyclohexanone and chloroform[6] which possess moderately low polarity parameter (E_T^N) values and yet are capable of inducing extremely high levels of swelling in the young/mature films tested here would, in theory, be best qualified for removing overpaint without endangering the older original paint. The aromatic solvents may also be useful ingredients in overpaint removal formulations. Interestingly, n-methyl-2-pyrrolidone and dimethyl formamide, which are already used for this purpose, fall into the same bracket of low/moderate polarity coupled with intense swelling power for young paints.

Whilst attempting to identify implications for practical conservation, it is important to acknowledge the limitations inherent to the findings of this study in terms of their immediate relevance to genuine cleaning situations. Although the leached nature of the films tested here may arguably render them more representative of the older paintings most commonly encountered in conservation studios, they are still essentially young films (approximately 10 years) and, as such, their swelling response may differ from that of aged, oxidised paint films, especially to solvents at the more polar end of the spectrum. Furthermore, it must be recognised that swelling experiments of this nature are, in Ruhemann's words, " far removed...from the actual conditions prevailing during varnish removal"(1968) and that accordingly, there is a need for further related experimentation beyond the remit of this project.. In the future, we would seek to both explain the exact relationship between swelling

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[6] Although in practice, however, the narcotic properties of this solvent would make its use inadvisable.

and physical damage to paint films, and also, to investigate the comparative response to solvents exhibited by much older paint samples, before the results from this study can be placed in their proper context and any definitive information for conservators extrapolated.

Acknowledgements

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Appendix

Table 1. Values for maximal swelling of pre-extracted #16 paint films for a range of solvents

No.†	Solvent	Maximum % change	T½ (mins.)‡	No.†	Solvent	Maximum % change	T½ (mins) ‡
1	iso-octane	-0.7	-	32	diacetone alcohol	25.31	48
2	white spirit	-0.9	-	33	n-butyl acetate	10.8	27
4	toluene	14	10	34	ethyl propanoate	15.1	53
5	xylene	9.72	20	35	propyl propanoate	4.4*	36
6	ethyl benzene	6.55	35	37	ethyl benzoate	14.4	150
7	1,8-cineole	1.5*	105	38	methylcyclohexylacetate	5.6	70
8	di-n-butyl ether	2	65	39	butyrolactone	2*	68
9	dioxane	16*	18	40	ethyl acetoacetate	10*	62
10	anisole	11.5	15	42	methanol	7.52	4.5
11	2-ethoxyethanol	16.5	40	43	ethanol	8.26	21
13	methoxypropanol	11.5	45	44	propan-1-ol	6.75	48
15	ethoxypropylacetate	10.1	68	45	propan-2-ol	5.71	120
18	trichloromethane	42.35	3.5	47	butan-2-ol	4.14	105
19	dichloromethane	19.85	2	48	iso-butanol	1.53	80
20	trichloroethane	11.27	51	49	tert-butanol	0.3*	110
21	1,2-dichloroethane	15.07	9	51	benzyl alcohol	35.6*	49
23	acetone	7.5	11	52	trifluoroethanol	35.59*	30
24	butanone	6.5	8.75	53	hexafluorobutanol	41.18*	35
25	methyl iso-propyl ketone	11.25	24.5	55	dimethylformamide	25.4	10
26	pentan-2-one	9	19	56	n-methyl-2-pyrrolidone	25.8	18
27	pentan-3-one	12.5	15	58	dimethylsulphoxide	15.3	25
28	iso-butylmethyl ketone	5.3	37				
29	cyclopentanone	11.8	29				
30	cyclohexanone	31.5	6				
31	acetylacetone	21.3	1				

*Solvent had not reached equilibrium in the course of the experiment.

† Numbers given to solvents by Phenix (2002b)

‡ This is the time taken for the samples to reach half their maximum swelling value.

THE SWELLING OF ARTISTS' PAINTS BY ORGANIC SOLVENTS AND THE CLEANING OF PAINTINGS: RECENT PERSPECTIVES, FUTURE DIRECTIONS

Alan Phenix, Senior Lecturer, University of Northumbria, UK[1]

1. INTRODUCTION

It has long been recognized that swelling of the oil binder represents an important aspect of risk in the cleaning of paintings using organic solvents. If the paint is swollen to a significant degree it becomes softened and its capacity to bind pigment may be diminished, possibly to the point where the pigment is vulnerable to erosion, for example, by the mechanical action of the swab that is carrying the solvent and absorbing dissolved varnish. Safety in cleaning depends to a large degree on controlling the magnitude and rate of paint swelling.

Within the field of conservation, there had until lately been no studies of solvent-induced paint swelling since N. Stolow's pioneering work of the 1950s. Recently, however, the initial results of new studies into the solvent-induced swelling of artists' oil paints have been presented by the present author. A new method for measuring the in-plane swelling of unsupported paint films was described (Phenix, 2002a), plus the results of measurements on the swelling responses of two related oil paint films in various pure solvents and binary solvent mixtures containing ethanol (Phenix, 2002b). The two paint films tested in detail were composed of flake white and yellow ocher pigment bound in linseed oil: one (designated paint film #17) had been artificially aged by exposure to high intensity uv-filtered daylight, while the other (designated paint film #16) had the same original composition and environmental history, but had not been subjected to high intensity light exposure. Both films were regarded as reasonably typical, young-mature oil paint films, in that they were thoroughly dried/cured, yet were not severely deteriorated. The swelling results reported were for 'virgin' samples of these two paint films, in the sense that the test samples had not previous been treated with solvent. Results of further experiments to examine the swelling behavior of pre-extracted films of paint type #16 are described elsewhere in these proceedings in the paper by J. Willmore.

One issue discussed in detail in the previous papers was the role of swelling data in the theoretical models used by conservators to guide their practice in cleaning paintings. Particular attention was drawn to the Teas fractional solubility parameter interpretation of Hedley 1980 and its use of selected data presented by Stolow. (Feller, Stolow, and Jones 1971). The data set for paint films based on linseed stand oil that Hedley used in his Teas

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[1] Alan Phenix, Senior Lecturer, Conservation of Fine Art, University of Northumbria, Burt Hall, Newcastle upon Tyne NE1 8ST, UK.
(at the time of the AIC Miami conference, Alan Phenix was employed at the Institute for Archaeology, Art History and Conservation of the University of Oslo, Norway.)

chart treatment for defining the 'peak swelling region' (see Figure 1) was questioned regarding the extent to which it properly reflected the sensitivity of typical artists' oil paints to solvents of various kinds, especially those at the more polar end of the range. The previous publication of the new swelling data consciously avoided an attempt at an interpretation using the Teas Chart, due its intrinsic theoretical shortcomings that are now well established. (Phenix 1998) Although we still believe that the way ahead lies in more sophisticated analysis of swelling data in relation to a whole variety of descriptors of solvent behavior, from presentations of our recent work to practising conservators we have been persuaded that there is still some value and interest in a Teas Chart interpretation. Since the Teas chart approach is so widely adopted within paintings conservation as a graphic aid to solvent selection in cleaning, it is useful to interpret the new data in this format, not least to allow a direct comparison with the Hedley/Stolow 'peak swelling region' that has been so central to theoretical explanations of the cleaning process now for more than 20 years. One of the intentions, then, of our most recent work has been to develop further the theoretical model through a re-examination of the 'peak swelling region' for oil paints, in the hope of establishing a more realistic, reliable picture of the sensitivity of such paints to solvents during cleaning.

The range of solvents examined in the previous study (Phenix 2002b) was not originally selected with a Teas Chart analysis in mind. The solvents tested were chosen on the basis of other criteria: for specific properties in relation to a family of solvents, for relevance to cleaning practice, and so on. Although the body of data previously reported included more than 70 solvents and solvent mixtures, published Teas fractional solubility parameters were available only for a fraction of these. When the data was analyzed using the Teas Chart, it became apparent that coverage across the chart was incomplete and that several important areas were not represented by the existing data.

One of the principal aims, then, of this paper is to present the results of further swelling experiments that allow a more comprehensive analysis using the Teas Chart. The sample paint material used for these studies are one of the types tested previously, namely paint #16. Results are here reported for a further 25 or more solvents and solvent mixtures with the goal of establishing a substantial body of swelling data for this paint type sufficient to cover most of the principal areas of interest in the Teas solubility diagram.

2. EXPERIMENTAL

Sample Paint Films

The paint samples examined here come from the remaining stock of one of the reference films previously studied in detail, namely paint #16 (Phenix 2002b). This reference paint film was prepared in 1991. It is a 'virgin' paint film, in the sense that it has had no previous exposure to solvent. Paint #16 is 140μm thick and consists of a mixture of yellow ocher and flake white pigment bound in linseed oil. Instrumental chemical analysis by GC-MS of paints #16 and #17 characterised the nature of the organic binder phase and of solvent-extractable components as in the Appendix. [1]

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[1] This table, which was originally published in Phenix 2002b, is reproduced again here to correct a misprint that occurred in the original version.

Solvents

Based on the existence of Teas fractional solubility parameter data, solvent availability and health and safety considerations, a group of solvents was selected for further swelling experiments on paint type #16. After a first round of experiments with pure solvents, certain parts of the Teas solubility diagram still remained uncharted. The gaps were not entirely filled by the various ethanol/white spirit mixtures tested in the previous study. (Phenix 2002b) Accordingly, in order to ensure reasonably complete coverage of the Teas Chart, a second series of experiments was conducted using three sets of binary solvent mixtures in various proportions (butanone with white spirit, butanone with propan-2-ol and diacetone alcohol with white spirit) and one set of ternary mixtures comprising propan-2-ol, acetone and white spirit.

As in the first phase of this study, the experiments reported here used mostly new batches of general-purpose or analytical grade solvent. In a few specific cases - dipentene, diethyl benzene, 2-pyrrolidone, pyridine, morpholine, butanone, white spirit – quantities of solvent for the swelling experiments (only about 10ml per experiment) were obtained from existing opened stocks. The white spirit used was supplied by Fluka and contained 17% aromatics. All solvents were conditioned to the laboratory temperature for several days before use.

Experimental Method

The method used here for measuring the swelling of paint type #16 during immersion in solvents was essentially the same as that described previously (Phenix (2002a), though with a few minor refinements. (Willmore 2002) The CCD video camera used previously to capture images of samples during immersion in solvent was replaced by a still digital camera (Nikon Coolpix 990, 3.3 megapixels) that gave greater image quality and resolution. As before, the camera was attached by means of a special adapter to the trinocular viewing head of a low-power stereo zoom microscope. All experiments were conducted in a fume-cupboard or with other local vapour extraction equipment.

Quantitative image analysis to determine the change in the areas of paint samples during immersion in solvent was here done using different software to that reported previously. Rather than the Graftek Optilab 2.6.1 (which was available only for Macintosh), the image analysis in the present study was done on a PC platform using the software 'Image Processing Toolkit'. Essentially, this software consists of a series of plug-ins for Adobe Photoshop (version 5 and higher) that offer a variety of quantitative functions, including particle measurement. A series of comparability tests using identical raw image sets showed no significant differences in the results obtained with the 'Image Processing Toolkit' compared to Optilab 2.6.1.

3. SWELLING OF 'VIRGIN' PAINT TYPE 16: FURTHER RESULTS

Tables 1 and 2 show respectively a compilation of the results of this latest round of swelling experiments on paint type #16 using the selected pure solvents and solvent mixtures. The tables present the essential measured properties of $\Delta A\%_{max}$ (the mean maximum or equilibrium swelling expressed as percentage change in area from original dimensions), and t_ (the time taken to reach half the value of $\Delta A\%_{max}$), plus selected descriptors of solvent properties (Teas fractional solubility parameters, solubility parameter δ, Reichardt polarity E_T^N, and molar volume V_m). An outcome of the previously published study was the classification of solvents into five arbitrary categories according to their swelling powers on paint types #16 and #17, and according to their rates of swelling. The classifications of individual solvents and mixtures in the range tested here are also included in Tables 1 and 2.

Furthermore, the new data for pure solvents can be added to the plots we have already presented of $\Delta A\%_{max}$ against common polarity indicators, such as Reichardt polarity, E_T^N, or total solubility parameter, δ. (see Figures 2 and 3) While such plots are of some value in demonstrating very loose relationships between swelling power and solvent polarity, clear patterns do not emerge, and this outcome probably inevitable when trying to interpret the swelling data in terms of any single parameter of solvent power. Overall, the new data set does not significantly alter the general pattern established by the results of the first round of experiments. Most immediately noticeable are the very strong swelling powers of the two cyclic nitrogen-containing solvents, pyridine and morpholine. Also of note are the comparatively low swelling powers on paint type #16 of ethylbenzene (ΔA_{max} = 8.7%) and diethylbenzene (ΔA_{max} = 8.0%) in relation to xylene (ΔA_{max} = 13.7%) and toluene (ΔA_{max} = 15.1%).

4. TEAS CHART ANALYSIS OF SWELLING DATA FOR VIRGIN PAINT FILMS

The three-parameter Teas Chart does, however, allow for a more coherent visualization of the relationship between $\Delta A\%_{max}$ and the specific solubility properties of individual solvents than single parameters such as δ or E_T^N. The great advantage of the Teas system is that it permits the determination of solubility parameters for mixtures of solvents. Taking together the range of solvents and solvent mixtures previously published (Phenix 2002b) with the additional liquids that are reported here, values for the Teas fractional solubility parameters f_d, f_p, f_h can be determined from published sources for around 80 of the liquids we have now tested. Plotting these parameters on the triangular Teas diagram gives fairly good coverage across the key areas of the chart.

Using the five broad categories of ultimate swelling power we have defined previously on the basis of the $\Delta A\%_{max}$ values for paint #16, it is now possible to define zones on the Teas chart that correspond to solvents with potential to cause different degrees of swelling to this paint film. Figure 4 shows the zones of the Teas solubility chart corresponding to solvents and solvent mixtures that give maximum swelling values ($\Delta A\%_{max}$) greater than 6 - 12% (light shading: low-moderate swelling power), 12 – 18% (medium shading: high-moderate swelling power), and greater than 18% (dark shading: high and very high swelling power). In essence, this is a simple contour map of swelling power in relation to Teas solubility parameters.

It becomes apparent immediately that the area of special sensitivity of oil paints is appreciably more complex than the single zone of high swelling suggested by Hedley.(Hedley 1980) Solvents capable of causing significant degrees of swelling, for example those having

ΔA_{max} values of 12% or greater, are spread over a large part of the Teas chart covering a broad range of polarities, extending from the aromatic hydrocarbons and apolar mixtures of ethanol and white spirit having f_d values around 80, through the chlorinated solvents (f_d values ca. 60-70) to the strongly dipolar solvents such as the amides and cellosolves (f_d values ca. 40-50). The areas of low and low-moderate swelling ($\Delta A_{max} < 12\%$) correspond mostly to the aliphatic hydrocarbons, aliphatic acyclic ethers, aliphatic alcohols, aliphatic acyclic ketones and some of the esters.

Rather than the single zone of highly active solvents represented by the Hedley/Stolow 'peak swelling region', it can be seen now that high and very high swelling solvents and solvent mixtures lie in four quite distinct zones of the Teas chart:

(i) a zone, centred on f_d ca. 80, corresponding to relatively low polarity mixtures of white spirit with ethanol, butanone or diacetone alcohol;

(ii) a zone at intermediate polarity corresponding to morpholine, chlorinated solvents and some mixtures of white spirit with diacetone alcohol, and

(iii) a zone at higher polarity corresponding to the remaining nitrogen-containing solvents, cyclic ketones, DMSO, and

(iv) a zone corresponding to benzyl alcohol and the cellosolves (2-methoxyethanol and 2-ethoxyethanol).

Whether these four zones actually merge with each other at some places not yet covered by the experiments so far conducted is an open question that would require still further experiments to answer. It appears at least, however, that - with at least one exception that is described below - the areas of the Teas Chart between these four zones of high- and very high-swelling solvents are populated almost exclusively by solvents that are high-moderate in swelling power.

One of the more significant observations on the results as a whole is the finding that within the large zone of high-moderate swelling there is at least one 'hole' corresponding to solvents that cause just low-moderate swelling on the paint film tested. The main 'hole' arises from the fact that the aliphatic acyclic ketones - acetone, butanone, pentan-2-one, methyl *iso*-butylketone, etc. – populate the central area of the active part of the Teas chart, around f_d = 48-65, f_p 20-30, between the chlorinated solvents and some of the strongly dipolar nitrogen-containing solvents; yet the aliphatic acyclic ketones are just low-moderate swellers compared to the high- or high-moderate swelling solvents all around. In part, this anomaly reflects some of the limitations of the Teas fractional solubility parameter chart: solvents from families with quite different solubility properties, for example ketones and amides, are clustered close together in similar regions of the chart. Solvents having similar Teas solubility parameters can have very different swelling powers: compare, for example, acetone (f_d 47, f_p 32, f_h 21; ΔA_{max} = ca. 9%) with N-methyl-2-pyrrolidone (f_d 48, f_p 32, f_h 20; ΔA_{max} = ca. 30%). This kind of anomaly also occurs elsewhere on the chart: for example, the low-moderate sweller di-*iso*butylketone (f_d 67, f_p 16, f_h 17; ΔA_{max} = ca. 8%) lies in a region of the Teas chart mostly populated by quite strongly swelling chlorinated solvents. The contours of swelling will be very tightly packed in areas of the chart such as this. One contributor to this apparent anomaly is the loss of the <u>total</u> solubility parameter δ_t, which is an inevitable consequence of the Teas fractional parameter approach. This dimension, which would separate the somewhat more polar amides from the aliphatic ketones and esters, could be re-introduced following Michalski's 3-dimensional graphic approach, though even with this enhancement the visualisation of the swelling zones remains problematic.

It is conceivable that the 'ketones hole' shown in Figure 4 is actually somewhat broader than indicated here. Unfortunately, Teas solubility parameters for several of the ketone solvents tested in the present study are not available, meaning that important parts of the hole are not charted. Reassuringly, though, the observation of generally low swelling powers for the aliphatic acyclic ketones lends support to the use of these solvents (acetone, butanone, etc.) for the removal of aged varnish, since – like the lower alcohols – they combine moderately high polarity with low-moderate swelling power on oil paint. An interesting finding is that, while the aliphatic acyclic ketones are generally low-moderate swellers, the <u>cyclic</u> ketones are among the group of very active solvents on these oil paints, for reasons that are not fully clear at present.

In addition to the acylic ketones, there may be other groups of low-moderate swelling solvents that lie within the broad zone of high-moderate swellers, but the absence of published Teas solubility parameters precludes their plotting here. In particular, a number of esters have been identified as low-moderate swellers, and these might be expected to form a distinct cluster in the region around, for example, *n*-butyl acetate (solvent no. 33) and *iso*butyl *iso*butyrate (solvent no. 75).

5. FUTURE DIRECTIONS

It is hoped that the results presented here help in explaining some of the discrepancies that conservators inevitably encounter between the theoretical Hedley/Stolow model of solvent-cleaning and their own practical experiences. The main difference is the identification, now, of zones of strongly swelling solvents in the parts of the Teas chart occupied by polar solvents such as ether-alcohols and nitrogen-containing solvents. Many of the observations and conclusions of the Hedley/Stolow model remain essentially unaffected, but the improved description of oil paint-solvent interactions that the present Teas Chart analysis establishes should give the conservator a better framework for problem-solving in practical cleaning situations, as well as a better vocabulary for describing the respective activities of different solvents. Some potentially useful avenues have emerged that perhaps warrant further evaluation from a practical point of view. Along with the higher, branched-chain aliphatic alcohols like *sec*- and *iso*-butanol, the acyclic aliphatic ketones and esters may offer a combination of moderately high polarity and relatively low swelling power that the conservator can exploit usefully in certain situations, for example when dealing with highly solvent-sensitive paint. We know little about the solubility of aged varnishes in such solvents, and this is obviously complementary information that would be very useful. It might, now, be appropriate in solvent-cleaning studies to shift attention back to the varnish element of the cleaning process. Pioneering work in the past, for example by Feller, has shown evidence of a shift in polarity of varnish resins due to oxidative ageing, but a more complete picture of how the solubility regions of resins like dammar and mastic change over time, covering all parts of the Teas chart, would certainly be informative. (Feller, 1975)

The oil paint films studied so far, type #16 and its light-aged analogue type #17, have been characterized as 'young-mature' films in that they are thoroughly cured, though not yet obviously degraded. The relative youth of these films is, perhaps, reflected in the still marked sensitivity to hydrocarbon solvents, such as toluene and xylene, and various non-polar mixtures of white spirit and ethanol. Typical lead white-containing oil paint films of, say, 100 years old or more would not normally be expected to show such sensitivity to these non-polar solvents. On the basis of what is currently known of degradation processes of oil paints of this type, we might conjecture that paint films more severely aged than the ones tested here would show a contraction in the overall peak swelling region due to ageing. Specifically, one might hypothesise that solvents lying in zone (i) of the four distinct zones of maximal swelling described above become comparatively less active with continued ageing of the paint. There is some slight evidence for this development in a comparison of the swelling data for paint type #16 with that for the light aged analogue, type #17.

Given that the method used here for measuring paint swelling is a relatively low-sensitivity technique, we accept that there may be real limits to its reliability for quantifying solvent interactions with quite severely aged paints. It might be expected that the physical swelling of severely aged oil paints, as measured by change in dimension, is very much reduced compared to young paints, due to differences in internal chemistry and lower organic binder content. Dimension changes in very old paints due to swelling may actually be so small as to approach the limits of reliable detection; yet there may still be changes to the physical properties of the paint that are significant for pigment binding. In any event, an assumption has been made in the present study that the degree of swelling caused by a solvent is correlates directly with the vulnerability of the paint to mechanical abrasion, and it remains to demonstrate that this is indeed true. The most obvious way of doing this would be to examine the swelling phenomenon by a different approach, for example, by measuring changes in mechanical properties caused by solvent sorption, insofar as these might be indicative of the pigment binding power of the paint. Furthermore, since both oxidative and hydrolytic degradation processes in oil paints lead to the formation of polar, hydrophilic species, the influence of water and various aqueous environments on oil paint swelling is also a matter of considerable interest. Variation in the swelling of oil paint films in relation to pH of aqueous solutions is relevant to the cleaning of paintings with aqueous formulations. This line of investigation would lead again to some interesting convergence between studies of cleaning and studies of paint visco-elasticity in the context of flattening deformations in paintings.

Suppliers

Software:

The Image Processing Toolkit.
Reindeer Graphics Inc.
PO Box 2281
Asheville
North Carolina 28802-2281

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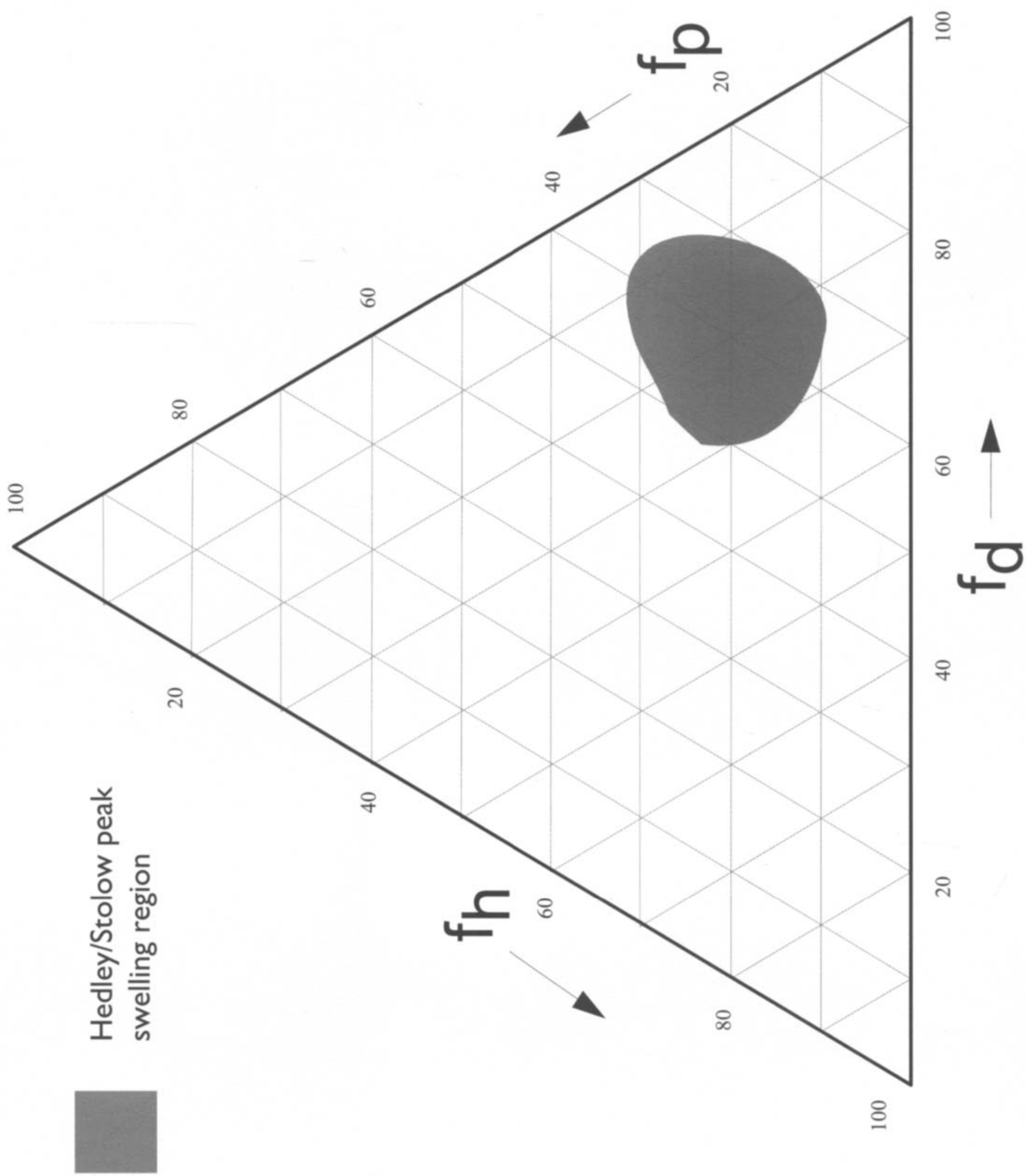


Figure 1. *Teas solubility diagram showing the 'peak swelling region' for oil films defined by Hedley 1980 based on selected data from Stolow (Feller, Stolow, and Jones 1971).*

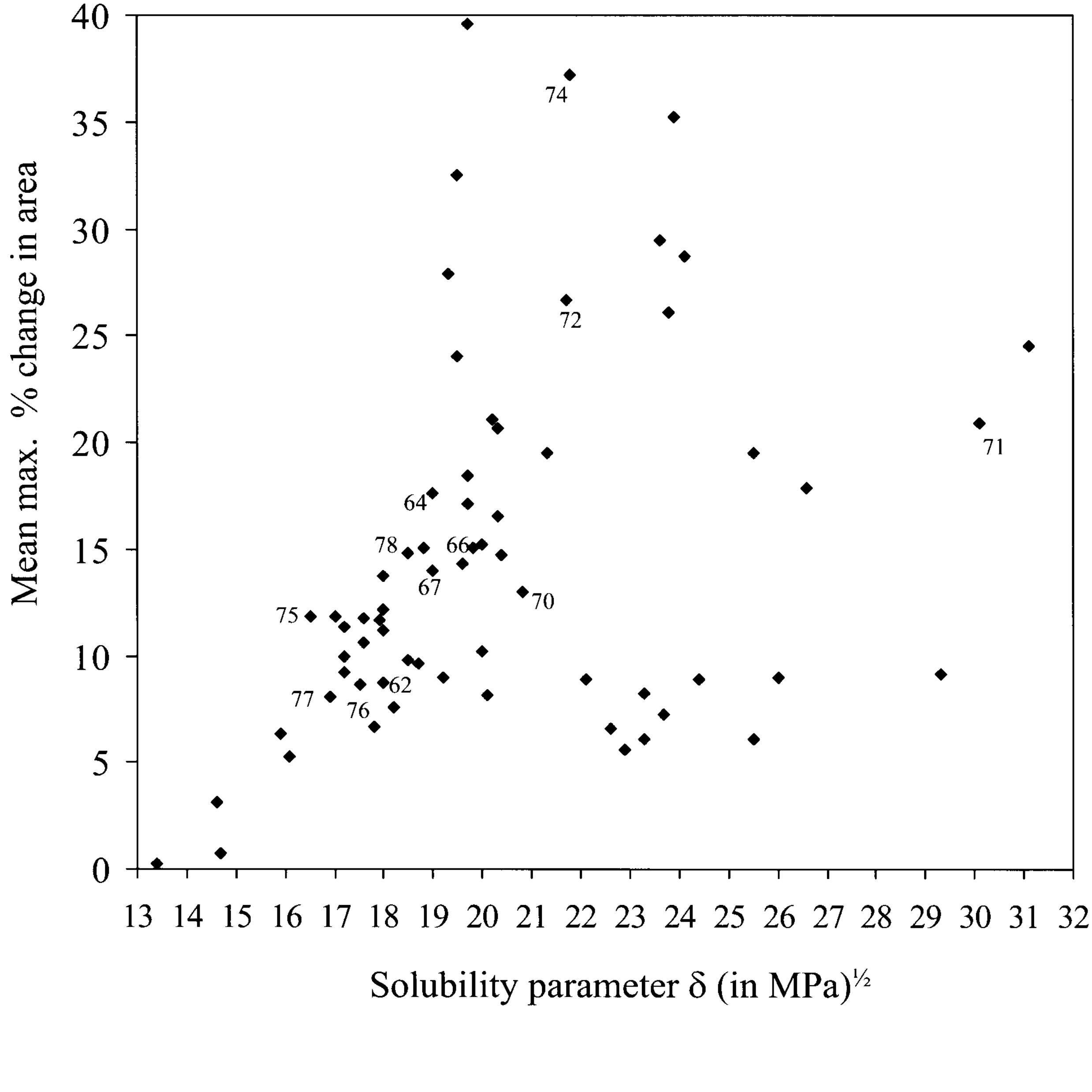


Figure 2. *Maximum Swelling of paint film #16 as a function of solvent solubility parameter δ. Numbers indicate solvents tested in the present study: un-numbered data points correspond to previously published data. (Phenix 2002b)*

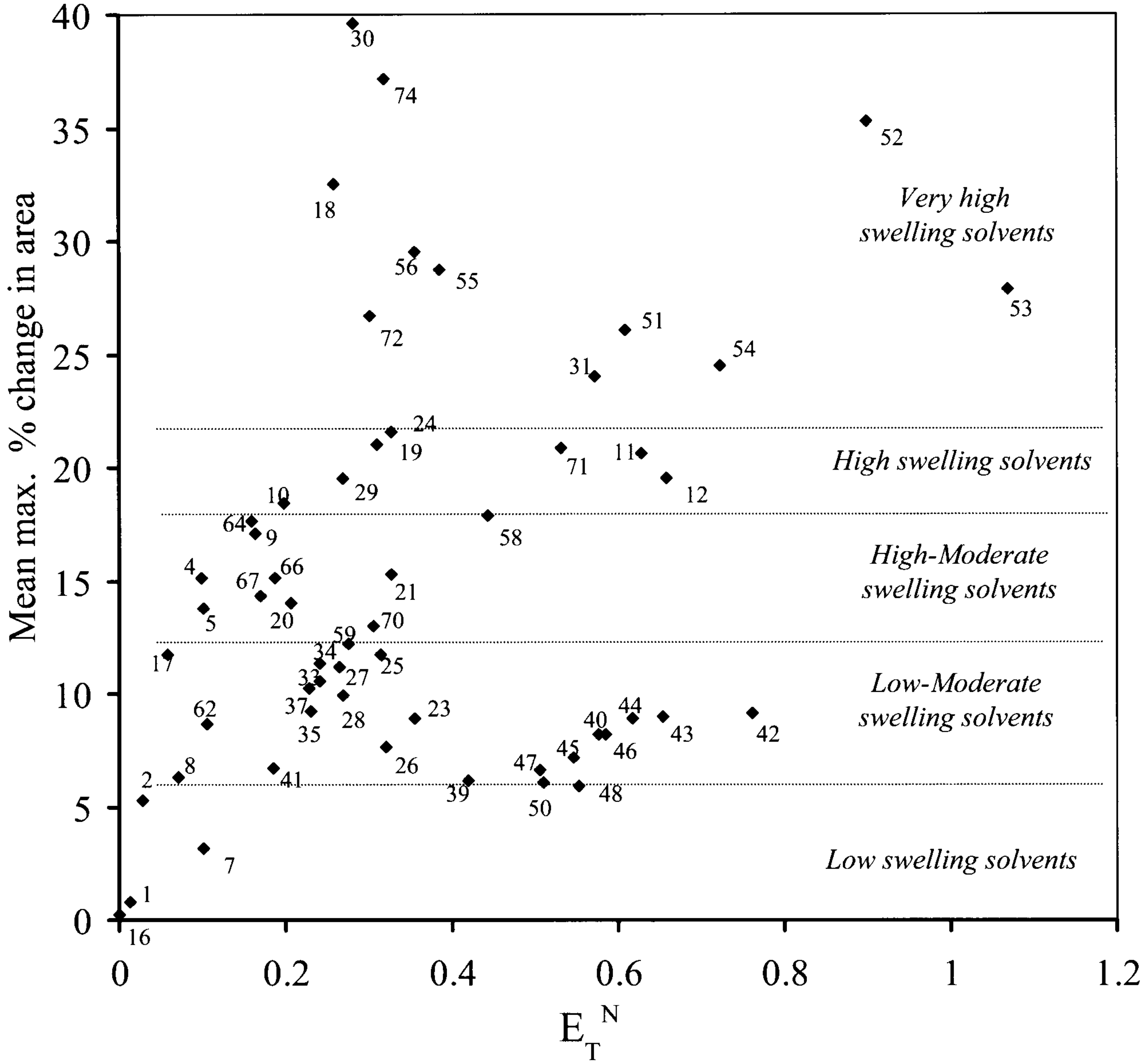


Figure 3. *Maximum Swelling of paint films #16 as a function of Reichardt solvent polarity parameter E_T^N. Numbers indicate both solvents tested in the present study and solvents examined previously. (Phenix 2002b)*

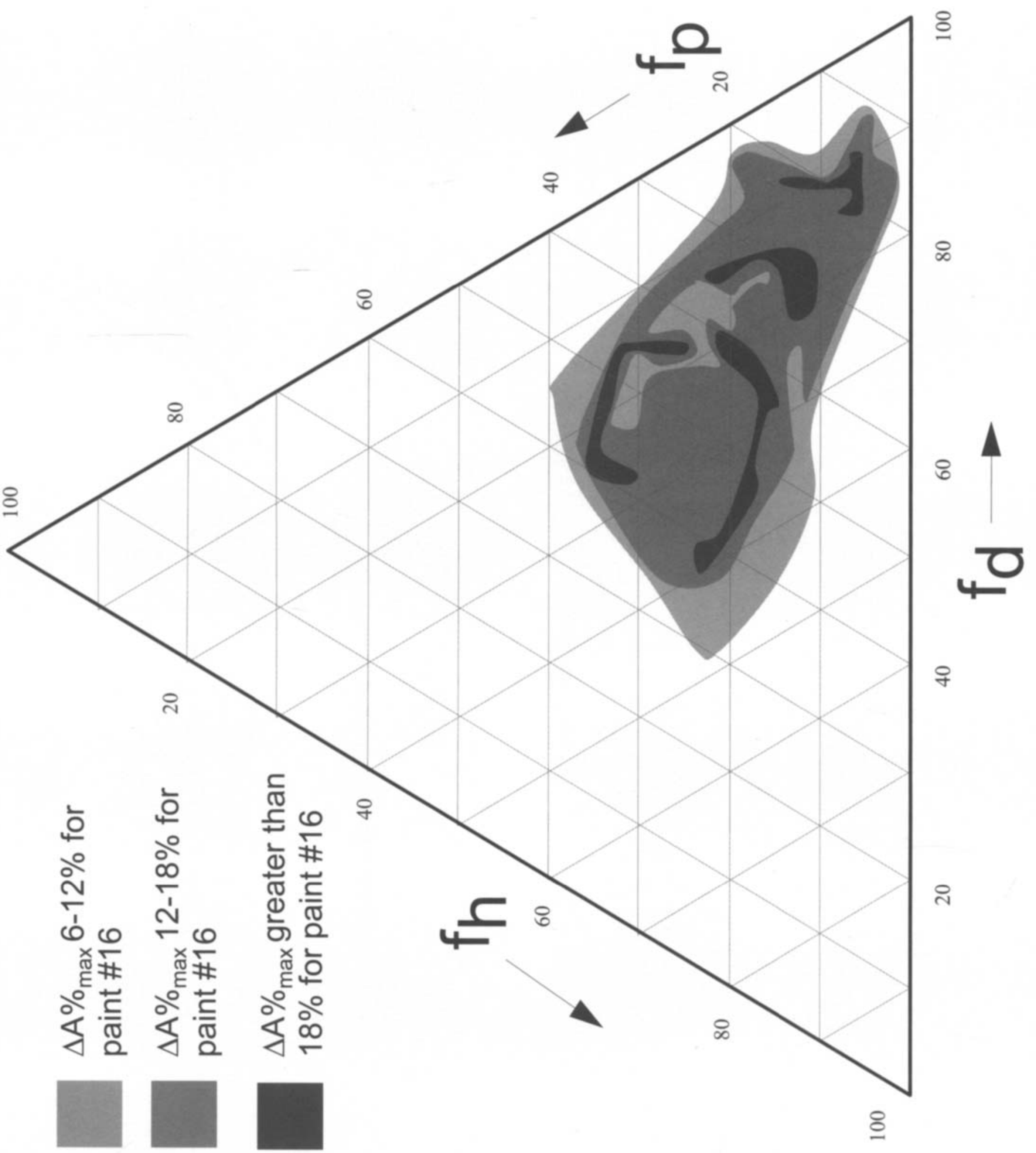


Figure 4. *Teas solubility diagram showing, for paint type #16, zones corresponding to different degrees of maximum swelling.*

Table 1

No.	Solvent (synonym)	Teas fractional solubility parameters (Note 1)			δ (Note 2)	Reichardt normalized polarity E_T^N (Note 3)	V_m cm^3/mol (Note 2)	$\Delta A\%_{max}$	Std. dev	Total no. of samples	$t_{1/2}$ (mins)	swelling power category	swelling rate category
		f_d	f_p	f_h									
61	dipentene	75	20	5	-	-	-	8.7	1.22	6	24	low-moderate	slow
62	ethyl benzene	87	3	10	18.0	0.105	123.1	8.7	0.87	6	4.5	low-moderate	fast
63	diethyl benzene	97	0	3	-	-	-	8.0	0.57	6	14	low-moderate	intermediate
64	trichloroethylene (trichloroethene)	68	12	20	19.0	0.160	90.0	17.6	1.55	6	1.5	high-moderate	very fast
65	chlorocyclohexane	70	21	9	-	-	-	12.8	1.42	6	11	high-moderate (borderline-)	intermediate
66	chlorobenzene	65	17	18	19.8	0.188	102.2	15.1	0.27	5	2.9	high-moderate	very fast
67	tetrahydrofuran	55	19	26	19.0	0.207	81.6	14.0	0.26	6	1.7	high-moderate	very fast
68	n-amyl acetate	60	12	28	17.3	-	148	15.5	1.34	6	7	high-moderate	fast
69	isophorone (3,5,5-trimethyl-2-cyclohexen-1-one)	51	25	24	19.9	-	150.5	13.7	1.97	6	22	high-moderate	slow
70	acetophenone (methyl phenyl ketone)	59	29	12	20.8	0.306	117.4	13.0	0.67	6	10	high-moderate	intermediate
71	2-pyrrolidone (butyrolactam)	41	36	23	30.1	0.531	76.9	>20.9 (Note 4)	2.02	5	>40 (Note 4)	high	slow
72	pyridine	56	26	18	21.7	0.302	80.9	26.7	2.14	6	<1	very high	very fast
73	ethyl lactate (ethyl 2-hydroxypropanoate)	44	21	35	21.7	-	115	14.7	1.21	6	30	high-moderate	slow
74	morpholine	57	15	28	21.8	0.318	87.5	37.2	2.4	7	2.5	very high	very fast
75	iso-butyl iso-butyrate	63	12	25	16.5	-	163	11.87	0.69	5	21	low-moderate (borderline+)	slow
76	methyl iso-amyl ketone (5-methylhexanone)	62	20	18	17.5	-	142.8	8.62	1.08	6	7	low-moderate	fast
77	di-iso-butyl ketone (2,6-dimethylheptan-4-one)	67	16	17	16.9	-	177.1	8.05	1.96	4	12	low-moderate	intermediate
78	mesityl oxide (4-methyl-3-penten-2-one)	55	24	21	18.5	-	115.6	14.82	1.01	6	6	high-moderate	fast

1. data from various sources: Gardon & Teas 1976, Banik & Krist 1984, Lorenz 1998.
2. data from Marcus 1999 and Hansen 2000
3. data from Marcus 1999
4. equilibrium swelling not fully reached at 100 mins. when experiment stopped.

Table 1. *Compilation of solvent properties and swelling data on paint type #16 for selected pure solvents.*

Table 2

No.	solvent	Teas fractional solubility parameters			$\Delta A\%_{max}$	Std. dev	s.e.m	Total no. of samples	$t_{1/2}$ (mins)	swelling power category	swelling rate category
		f_d	f_p	f_h			(Note 1)				
121	Butanone : white spirit 2:1	65.2	21.3	13.4	18.24	1.24		5	1.5	high (borderline-)	very fast
122	Butanone : white spirit 1:1	71.5	17	11.5	14.78	0.86		6	<1	high-moderate	very fast
123	Butanone : white spirit 1:2	77.5	12.7	9.6	18.79	2.0		6	2.2	high	very fast
124	Butanone : white spirit 1:3	80.75	10.5	8.75	10.93	1.05		6	3	low-moderate	very fast
125	Butanone : propan-2-ol 2:1	48	25.6	26.3	14.88	1.21		6	3.5	high-moderate	fast
126	Butanone : propan-2-ol 1:1	45.5	23.5	31.0	13.66	0.66		6	4.5	high-moderate	fast
127	Butanone : propan-2-ol 1:2	43	21.4	35.6	12.06	0.73		5	5.5	high-moderate (borderline-)	fast
130	diacetone alcohol : white spirit 4:1	54	20	26	16.26	0.55		5	26	high-moderate	slow
131	diacetone alcohol : white spirit 2:1	60	17.3	22.7	17.86	1.49		5	23	high-moderate (borderline+)	slow
132	diacetone alcohol : white spirit 3:2	63	16	21	15.9	1.08		5	31	high-moderate	slow
133	diacetone alcohol : white spirit 1:1	67.5	14	18.5	18.7	1.01		5	23	high	slow
134	diacetone alcohol : white spirit 2:3	72	12	16	18.02	-	0.67	10	24	high (borderline-)	slow
135	diacetone alcohol : white spirit 1:2	75	10.7	14.3	16.27	0.62		5	38	high-moderate	slow
136	diacetone alcohol : white spirit 2:7	79	9	12	15.68	1.55		4	34	high-moderate	slow
137	diacetone alcohol : white spirit 1:4	81	8	11	20.33	2.4		5	20	high	slow
140	propan-2-ol: acetone: white spirit 60 : 15 : 25	52.3	16	31.7	15.22	1.36		5	5.5	high-moderate	fast
141	propan-2-ol: acetone: white spirit 4 : 2 : 4	60.6	14.8	24.6	12.68	0.56		4	6.5	high-moderate	fast

1. Where multiple experiments were performed, variability in the measured results is reported as the standard error of the mean (s.e.m.)

Table 2. *Compilation of solvent properties and swelling data on paint type #16 for selected solvent mixtures.*

APPENDIX

Summary of GC/MS analysis on yellow ochre/lead white/ oil test paint types 16 and 17

	Palmitate: Stearate [(a)]	Azelate: Palmitate [(a)]	Oleate: Palmitate [(a)]	% Palmitic soluble. [(b)]	% Stearic soluble. [(b)]	% Azelaic soluble. [(b)]	% Oleic soluble. [(b)]
Sample 16: Yellow ochre/Flake White, unexposed control							
Fatty acid ratios	1.91	0.99	1.14				
extracted in ethanol				26.33	30.09	5.26	32.33
extracted in xylene				31.88	38.08	7.65	40.06
Sample 17: Yellow ochre/Flake White, light aged							
Fatty acid ratios	1.91	1.06	0.92				
extracted in ethanol				24.86	29.22	4.87	28.87
extracted in xylene				34.31	40.15	7.99	40.26

(a) *Results presented are means of analyses on two samples for each solvent/paint film combination. Internal standard: methyl tridecanoate. Derivatization method: TMTFTH [(m-trifluoromethylphenyl) trimethylammonium hydroxide]. The ratios palmitate:stearate, azelate:palmitate and oleate:palmitate refer to the relative proportion sof these fatty acids in the solid paint films, before extraction by solvent.*

(b) *% Palmitic sol, % Stearic sol., etc. refer to the proportions of palmitic, stearic, oleic, azelaic acids etc. extracted from the paint films respectively by ethanol and xylene. Results presented are means of analyses on two samples for each solvent/paint film combination.*

STRUCTURAL TREATMENT PHILOSOPHIES: PANEL DISCUSSION

Susan Blakney, Mark Bockrath, Paul Himmelstein, Rustin Levenson, Robert Proctor; moderated by Jay Krueger

Maintaining the structural integrity of paintings is central to our role as conservators, however approaches to the structural treatment of paintings vary widely. As we assess the condition of a painting and begin to make decisions regarding treatment, our individual background and training may nudge us in certain directions, financial or time considerations can be imposed on us, and a wide range of treatment or non-treatment options may present themselves. How do we determine an appropriate course of action when there are what seem to be myriad variables and rarely one way to address these issues?

Five experienced conservators were asked to participate in a round table discussion focusing on their personal philosophy and approach to the structural treatment of paintings. The conservators brought a wide range of training, experience and informed opinion to our discussion, and each spoke for approximately 10 minutes, leaving the better part of an hour for further discussion and fielding questions from the floor. The talks were not taped or prepared with written presentation in mind, so the following short abstracts merely reflect the range of topics that were discussed.

Jay Krueger, Senior Conservator of Modern Paintings
National Gallery of Art
Washington, DC 20565

THE EVOLUTION OF WESTLAKE CONSERVATORS' STRUCTURAL TREATMENTS

Susan Blakney, Chief Conservator

Westlake Conservators' special interest in linings began in 1975 when I returned from a 6-year apprenticeship in London with IIC Fellow William Fraser Lowe. Soon after building my first vacuum hot table, I visited Sheldon Keck to discuss how to avoid weave interference and to have him critique a recent wax resin lining I'd completed. His suggestions led me to begin experimenting with different interleafs, cushions and pressures. Reading Gustave Berger's articles about Beva in the early 1970s, and meeting with him at an AIC conference led us to begin visiting him to learn tips on Beva's use. In 1981, Canadian conservator Diane Falvey introduced us to V. R. Mehera's negative pressure cold linings and we began experimenting with his methods and acrylic emulsion adhesives. We decided to test and develop cold lining techniques in combination with researching existing industrial materials, to find alternatives for stable synthetic lining support materials. For 2 years we tested their application with a wide range of lining systems, with varied techniques and adhesives. In 1983, this research culminated in 2 presentations at the AIC conference; Diane Falvey's paper entitled, Cold Lining in Skaneateles, NY, and Margaret Sutton's and my poster session titled, A Sensual Lining Comparison. We displayed numerous samples of simulated linings, with a variety of commonly used fabrics and lining adhesives, compared to our discovered support materials with most of the common lining adhesives. We encouraged conservators to bend, initiate separation, consider overall stiffness of the laminate, adhesion of the materials in the laminate, peel strength, weave interference and ease of application.

Our research findings were subjective. We discovered four synthetic support materials, which we introduced to the field, that are among our favorites, in use today. We no longer use organic fibers such as linen or cotton due to their instability with humidity swings.

1. G10 is a translucent, chemically inert, phenolic resin plate, used for electronic circuitry boards. It is available in many gauges and is ideal as semi-rigid lining support. This lightweight, flexible material is stiff enough to combat bad planer distortion such as major tears and cupping. It is available in 3' x 4' or 4' x 8' sheets (we prefer the natural color) through plastic supply corporations such as AIN Plastics. It cuts easily with scissors, may be used to overcome poor stretcher design, may be passively used as a panel stretcher and has a myriad of alternate studio uses such as disposable pallets, cleaning hooks, mural separators, etc. As a semi-rigid lining support, we always incorporate a lightweight interleaf of fiberglass or polyester Tergal to stabilize the tacking margins and ease reversibility. Linings can be transparent with wax adhesive and translucent with Beva film.

2. Tergal is a sheer polyester curtain fabric from France, available 118" wide, in a variety of pale colors. It is useful as a strong, inert, minimal weave, interleaf. This material can be found in many curtain fabric stores.

3. Terytex is 100% polyester, straight weave multifilament, with the weight and texture of heavy cotton duck. It is available in two weights and two different widths of 41" and 80" wide. This is available through Madison Filtration of Skaneateles Falls, New York. For more information contact Sue Pennel at 1-800-637-6206.

4. Soft-Faced Monomesh is ideal for oversized paintings and murals. This amazing 30' wide fabric is a complex weave of monofilament acrylic and polyester threads, with a multifilament stuffer on one side. It is, however, no longer in production due to a company take over and changes in industrial demands. A comparable replacement fabric manufactured by the National Wire Fabric Company Inc. in Arkansas, is available in black or white, but without the multifilament stuffer. For information contact Mike McGuire at 1-800-643-1558. These fabrics are precisely woven and ideal for vacuum envelope linings. Their strength is suitable to support marouflage murals allowing the murals to be easily transported / stored rolled, and easily screwed to a wall in a removable installation, or strip-lined and stretched over an auxiliary support.

Susan Blakney, Chief Conservator, AIC and IIC Fellow
West Lake Conservators
P.O. Box 45 Skaneateles, NY 13152

See "The Successful Use Of Soft Faced Monomesh as the lining Support for a 14' x 17' Mural, 93, Paintings Specialty Group Post Prints."

Since opening our business in 1975, we have lined hundreds of paintings. We are a group practice with, at times, up to 5 paintings conservators. My partner and sister, Margaret Sutton, is our team's structural specialist. She does most of the linings and tear repairs. Today, Beva is typically our adhesive of choice in lining, unless presented with a heat sensitive work or a rough textured painting front and back which is better suited to cold lining. We still argue amongst ourselves whether to line or not, and my sister claims that, although she has been lining paintings for 27 years now, she always worries over each one. We sometimes use loose or camey linings, or create panel stretchers with G10 or Mylar. We attempt to use the original stretcher or strainer, if at all possible, and even save original tacks on a template for mock reuse. Using an upholstery conservation technique, tacking margins are often secured to the bars with Beva film making the degraded tacks more a visual artifact than a structural necessity. Tear repairs, if not lined, may be locally textile welded and stabilized with staggered adhesive coated threads. Treatment decisions are based upon the owner's projected goals and maintenance capabilities. Budget considerations often dictate a compromise to treatments, especially complete reversal of old deteriorated linings. I know I can stabilize insecurities and beef up the existing lining by infusing with more, and often a different, adhesive, but future reversals will become more complicated and time consuming.

We employ the following equipment to address a variety of structural problems with varied treatment capabilities, both locally and overall; Leister hot air tool, Mitka suction plate, vacuum hot tables (5' x 6' and 12' x 8'), negative pressure cold table, hot air guns, heated spatulas and a Maxwell table top suction platen/humidity chamber. This last year we have gone 'high-tech' by adding a 12 channel, Scanning Thermocouple Thermometer, made by Barnart, which connects to a laptop computer and accurately displays and records temperatures in the lining process. The alarm feature is particularly useful. A hand held IR heat sensor also helps us to measure various surface temperatures.

My experience and observations in treating paintings since 1969 have led me to the following conclusions. Structural weaknesses and surface deformations caused by cracks, cupping and tears may be temporarily corrected by heat and vapor treatments in conjunction with consolidation, but unless environmental maintenance conditions are ideal, will return unless stabilized by a lining. The lining must be done with materials that combine to be stiffer and stronger than the original's combined paint/ground/support layers. Once a tear in the canvas or a crack through the paint/ground alters the surface tension of the paint layer, lining is the simplest, hence, the most economical method of long-term stabilization. We often select minimal intervention with the client agreement that further treatment may be necessary if the condition worsens. I believe, however, once funds or a grant are dedicated for a treatment, it is unlikely a custodian will return to re-treat an object because they assume other priorities now take precedence. Budget, unfortunately more often than not, dictates treatments. For this reason we charge the same amount for lining as strip-lining.

Lining falls in and out of favor for a variety of reasons, often because it unnecessarily alters the original character of the painting. In my opinion, the success of the treatment relies on the expertise and sensitivity of the conservator to select appropriate adhesives, support materials and techniques, in conjunction with employing tools (as mentioned above) with a high degree of skill. Often, the artwork's material construction limits the success. Weave interference, Mylar slick, flattening of impasto, dimpling / craters of texture, glaze flattening and board-like appearance are all undesirable results of heavy handed treatments. A conservator must have a variety of choices and the knowledge to design a treatment suited for each painting's individual needs.

Susan Blakney, Chief Conservator, AIC and IIC Fellow
West Lake Conservators
P.O. Box 45 Skaneateles, NY 13152

HUMIDIFICATION/SUCTION TREATMENTS

Mark Bockrath, Paintings Conservator, Winterthur Museum

I first learned about humidification/suction treatments while working for Marion Mecklenburg's Washington Conservation Studio twenty years ago. At that time, Marion, and then Gerry Hedley and Stefan Michalski were involved in research that was to yield significant discoveries about how paintings respond to fluctuations in relative humidity, how and why their paint films crack, and what can be done to flatten distortions in fabric and paint.

The use of moisture in treatments to flatten paintings has a long history, with methods as various as the application of moist blotters and weight, local moistening and ironing, quick introduction of steam in traditional glue-paste linings, and humidification over longer periods of time in a closed chamber as per Mecklenburg's method. This latter method differs from other moisture treatments in several very important ways. No heat is used while the painting is being humidified, although heat used after humidification is very instrumental in flattening distorted paint and supports. Since the humidification is done at room temperatures over a period of 6 to 24 hours, the painting is not wetted with uncontrolled steam or direct contact with liquid water, thereby reducing the possibility of blanched paint films and tented paint cleavage, as well as the need for quick drying of the support with irons. Humidification in a chamber is done with a controlled elevated relative humidity of 80% or lower, and all layers of the painting slowly take up water vapor. Mecklenburg's research shows that it takes many hours for a paint film to absorb enough water to become flexible, and that at this point, it is easier to reduce cupping under suction without breaking the paint film. At this point lower temperatures and pressures can be used to effectively flatten distortions.

The stiffness, or Young's modulus E of the support fabric, glue size and paint film all vary with fluctuations in relative humidity. The glue size is extremely stiff at low RH and contributes a contractive force to the painting's structure. At high RH, the glue becomes very soft. The paint film is less dramatically stiff at low RH, but also continues to become more flexible as RH increases. A restrained fabric relaxes and becomes less stiff with increasing RH until about 80 to 85%, at which point the yarns of the fabric are so saturated with water that an irreversible change in the crimp of the fabric occurs, resulting in a dramatic rise in stiffness, and shrinking of the fabric that induces tenting of the paint film. Thus all layers of a painting relax with increasing RH until about 80 to 85%, at which point the fabric response takes over. At low RH, the glue size layer has the most dramatic effect on the composite.

This research serves as a sound theoretical basis for performing humidification/suction treatments. Utilizing the setting of 80% RH or slightly lower, we can safely relax the layers of the painting without inducing shrinkage.

I use humidification treatments primarily when distortions in the paint film like cupping or puckering from tension in paint films of uneven thickness cause the painting to go out of plane. If the distortions are from the fabric only, such as edge puckers from sparse tacking, draws from a slipped stretcher member or bulges from a blow to the support, I frequently use repeated applications of blotters and weights over a lightly moistened support to return it to plane, followed by restretching the support, with strip lining or stretcher modification treatments as needed.

I usually pre-flatten the painting with a humidification/suction treatment to make it easier to line. Humidification times for a painting of average thickness are typically 6 to 8 hours, and up to 24 hours for very thick paint films. If required, the humidification/suction treatment is followed by a lining with BEVA sheet film and polyester fabric on a vacuum hot-table. The lined painting is weighted under blotters overnight, or until restretched, as it takes several hours for the paint film to lose the moisture that it has imbibed.

Mark Bockrath, Paintings Conservator
Winterthur Museum, Winterthur, Delaware 19735

STRUCTURAL TREATMENT PHILOSOPHIES

Paul Himmelstein

As part of a panel discussion of the structural treatment of paintings, I presented a very brief summary of some of the treatments used at Appelbaum and Himmelstein.

We use slight moisture and pressure to reduce cupping and other planar distortions. This is usually carried out on the vacuum hot table, and the painting is kept under vacuum for several hours, giving the moisture a chance to evaporate. We line some paintings with a wax-resin adhesive when we feel that is required, especially if the painting is going back into a relatively uncontrolled environment. When paintings are on very deteriorated supports, such as paintings by John White Alexander on burlap, we sometimes mount the painting to an aluminum-faced aluminum honeycomb panel using a non-woven interleaf that has been sprayed with a polyvinyl acetate resin mixture. The resin mixture is then heat activated. This gives very light overall support, while allowing easy mechanical reversal of the treatment if that is desired in the future. The non-woven support acts as a cushion, reducing the possibility of weave enhancement.

When we have contemporary paintings that require restretching, but have tacking margins that are too narrow, in place of (or in addition to) an adhesive to attach new strips at the edges, we have sewn the strips, using a sewing machine. This gives better mechanical strength, especially on larger paintings, when shearing may tend to pull apart an adhesive bond.

Finally, I focussed on the decision-making process that one needs to use when deciding what treatment method is appropriate for a specific painting. A conservator should have a variety of treatment possibilities available, depending on the physical and aesthetic characteristics of a particular work, and the desired goals of treatment. One must always bear in mind the likely future destination of the work. Will it be housed in a museum with controlled temperature and humidity (RH), and will it be observed by a conservator at regular intervals? Will it be going into an historic house with no climate control and extensive fluctuations in temperature and RH, and where there will be no one to examine it for years at a time? Or will it be in a private collection, where there may be some environmental control, but where the painting may be lent to travelling exhibitions on a regular basis? The desire to preserve the material aspects of a painting that are not seen by viewers, such as stretchers, must be balanced against the physical preservation needs of the painting.

One way to balance priorities in designing a treatment is to make a list of various material and non-material aspects of the painting, and assign relative values to each. Such aspects include: its final appearance, retention of its original stretcher, visibility of the reverse of the original canvas (with or without an inscription), the ability of a casual museum visitor to view it without being distracted by condition problems, susceptibility to water damage, resistance to vandalism, etc. Based on the assigned values for this specific object, decisions can be made that produce the desired result. The choice of an appropriate structural treatment is not a simple one, and the conservator must be willing to allow the painting to guide the choice in each case.

Paul Himmelstein
Partner, Appelbaum and Himmelstein
444 Central Park West, New York, NY 10025

STRUCTURAL TREATMENT OF PAINTINGS: PAST, PRESENT, AND FUTURE

Rustin Levenson

I began my training at Harvard University's Fogg Art Museum in 1969. At that time, structural treatment focused on a single lining technique, wax-resin adhesive with a fabric faced aluminum panel for an auxiliary support. As a student, my job was to prepare the unwieldy mixture of wax resin, according to the Plenderleith formula that provided the optimum melting temperature and adhesion. I remember, with particular distaste, the gum elemi. The treatments were designed to infuse and adhere the paintings in one treatment, and generally did that job well. As a profession, conservation provides daily opportunities for learning. Over thirty plus years, we as a profession have learned that there are many subtleties to the concept of reversibility and that there is more than one approach to the structural treatment of paintings. Our studio has evolved and modified several techniques for responding to the particular needs of paintings. Some of the most fun was in the naming of the techniques.

Strip linings and Loose lining:

Strip linings are carried out when the fabric support of a painting is still in good state, but the tacking fold and margins have become fragile. Strip lining is often carried out in combination with a loose lining, to support and extend the life of the original canvas. We usually use BEVA film and Pecap for strip linings, but adhesives and supports can be substituted as dictated by the painting.

PIE CRUST STRIP LINING: This simple technique refers to strip lining paintings without flattening the tacking margins. A block is used to support the tacking margin as a strip lining is attached.

SHIRT-TAIL STRIP LINING: The strip lining is attached to the outside of the tacking margin. This is used if a painting with a secure tacking fold is to be remounted on a new or modified original stretcher and areas of the tacking margin are scant for stretching. If desired, the shirt-tail can be removed after the painting is mounted.

TRAMPOLINE LOOSE LINING: A concept we have not yet employed, the loose lining would have an elastic tacking margin and linen or synthetic fabric behind the painting. This was considered for loose lining large paintings to give the control of the tension to the original canvas.

Insert Linings:

We originally devised insert linings to support works in transit. Our first inserts were ethafoam (expanded polyethylene) cut to fit into the area between the stretcher bars and support the painting. The shaped block was adhered to a larger piece of foam-core. The ethafoam was often covered with fabric for added texture and then the whole unit was screwed to the stretcher. The advantages of insert lining are that the painting does not need to be removed from the stretcher and that the treatment is easily and completely reversible.

RUSTIN LEVENSON is a private conservator with studios in New York and Miami. She is the author of Seeing Through Paintings, Yale University Press, 2000.

PILLOW TOP INSERT: Because the ethafoam inserts could warp over time, especially on larger openings, we began using polyester batting for the shaped insert. Used for pillows and padding, this material comes in rolls of 3/4" and 1". The width can be easily modified. For mounting, the batting can be attached to foam-core, as above, or can be basted in place with a grid of fishline or strong thread.

CAMILININGS: These inserts, devised (and named) elsewhere, describe a piece of fabric placed behind the stretcher bars and attached to the back of the stretcher.

WHALEBONE CAMILINING: We use wood strips stapled or nailed against the inside edge of the stretcher to position the fabric evenly in proximity to the back of the painting.

<u>Linings:</u>

The range of adhesives, pressure systems, and auxiliary supports has expanded to give conservators a wide range of choices if a painting does need to be lined. If other supportive systems will not sustain a painting, then the conservator can tailor the lining treatment to the needs of the painting. The last lining we did in the Florida studio was with BEVA film with extra BEVA 371 on the tacking margins. The auxiliary support was linen, the pressure system a vacuum envelope.

My challenge for the symposium was to imagine the future of structural treatments. In speculating what the future might hold for conservators, I considered electrostatic systems with a charged substrate and an oppositely charged coating on the painting. Is there a successful way to tack line a painting? The Fieux material in the eighties seemed to be only useful for short term treatments, Plextol can bond too firmly if the heat is not controlled exactly. We know now that canvasses, old and new, are not static. How much adhesion and infusion is necessary to truly "stabilize" a fabric? To what extent do we want to "embalm" an original support? In the early seventies I had an opportunity to examine paintings in an exhibit "The Age of Louis XVI. Almost all of the paintings had been lined using a variety of adhesives. I found I could tell at a glance which adhesive had been used on each painting. Have other conservators, examining installations of similarly dated paintings had the same experience? New adhesives are being designed daily, let's keep our ears open.

STRUCTURAL TREATMENTS: CONSIDERING MINIMAL INTERVENTION

Robert Proctor, Painting Conservator

The following is an abridged transcript of Robert Proctor's introductory remarks to the Panel Discussion:

I hope my contribution will stimulate discussion on the philosophy of "minimal intervention" as it applies to the structural treatment of canvas paintings.

First, I would like to dispel the notion that this is a new approach. Certainly the concept of minimal intervention can be traced back at least twenty eight years to Mr. Percival-Prescott's call for a temporary halt to linings at *The Conference of Comparative Lining Techniques* held in Greenwich England in 1974. Indeed, it seems this concept may have originated with one of the pioneers of conservation, a German Restorer named Pecht who wrote in 1869, "It would be better to accept the damage to a painting as it exists rather than to disguise it, one should be satisfied with preserving the original as it exists and protect it from further bad influences". (1)

In discussing the structural treatments of canvas paintings in the context of minimal intervention, the desire to avoid linings is always stressed. Some may argue this desire is overemphasized and ignores the most important function of a painting, to look good hanging on a wall. Others may counter this with the argument that the parts of the painting that are not normally on view have both historical and aesthetic value, and that these elements can be as important as the signature and a testimony to the time and manner in which the painting was made.

It is not just an aesthetic and intellectual appreciation that guides such an approach, but an emotional response to the evidence of the hand of the painter. Seemingly inconsequential things such as the way the canvas is tacked to the stretcher can be truly fascinating and lead to a greater appreciation of the painting. Observations such as the systematic or haphazard way the tacks are spaced, neatly trimmed edges or the canvas being carelessly bunched up in the corners as well as things like brush cleanings on the reverse or fingerprints on the tacking margins can give useful insight to the artist's personality, temperament and intent.

Similar emotional reactions may result from evidence of past restorations. Personally, I favor the use of tacks when restretching a painting and the use of linen for edge linings (a.k.a.. strip linings). Replacement of stretchers with the expansion bolt variety on old paintings and white polyester sailcloth used for loose linings seem unsympathetic.

Rarely do I react negatively to the work of a restorer who has done too little whereas, I can get quite upset when one has done too much. What conservator is not thoroughly delighted when a painting comes to them unrestored or even unlined with small patches, or when they encounter one that has been beautifully and sensitively restored?

If we can transfer this sense of reverence and respect to our client they will be much more likely to take proper care for their paintings. It is my opinion this step will do much more for the preservation of a painting than making it bulletproof!

There is often the misconception that an approach favoring minimal intervention is the luxury of conservators employed by museums because the paintings are monitored and kept in a good environment. On the contrary, there may be more pressure from museums to intervene. While a private client might accept minor surface deformations or the appearance of age, these things are often unacceptable to many of those responsible for museum collections.

Whitten & Proctor Fine Art Conservation, 402 Byrne Street, Houston, Texas

Of course there are all kinds of circumstances which we work under, many of which inevitably lead to the lining of paintings, (sometimes more often than we would like) due to prevailing expectations or due to a real concern for the longevity of the painting.

I would like to dispel the notion (as many of us have experienced) that minimal intervention necessarily means minimal treatment. It often takes more time and care. In general, minimal intervention focuses on isolating the treatment to the area of damage.

Finally, I would like to end with the following analogy as food for thought: you can put a frog in formaldehyde and make it last indefinitely but, what kind of frog is it if it can no longer jump?

This presentation was followed by a brief slide presentation of a few successful examples where severe damages were treated locally where other approaches may have resulted in the overall treatment of the painting possibly including a lining.

1. D. Daley Hartin, "An Historical Introduction to Conservation", *Shared Responsibility, Proceedings of a Seminar for Curators and Conservators*, Ottawa, Canada: National Gallery of Canada, 1990, p 33.

CELEBRITY TIP TAWK

with Linda Richman

Austin Powers, **Sister Wendy Bennett**, and **Linda Richman** (aka Leslie Kruth, Debra Evans, and James Bernstein) appearing in *Celebrity Inpainting* at the November, 2000 WAAC Meeting, Nevada City, CA

This year's Paintings Specialty Group Studio Tips had a special twist to it. The theme was *Celebrity Tip Tawk*, modeled after the Saturday Night Live® satire *Coffee Talk*, with host Linda Richman (alias comedian Mike Myers). Colleagues were invited to assume the persona of a famous (or infamous) personality, presenting tips in costume and character before the Miami AIC PSG. Our 'celebs' came from great distances, even back from the dead, to be with the packed-to-capacity audience.

The celebrities and their tips were kept completely secret until show time, surprising the unsuspecting attendees. Based on the great turnout and response (shrieks of laughter), the session was immensely enjoyable. As the following pages illustrate, the Studio Tips were ingenious and informative as well.

Linda Richman, Hostess/Moderator	James Bernstein, Conservator of Paintings & Mixed Media, San Francisco, CA
Pee Wee Herman	Robert Proctor, Whitten & Proctor Fine Art Conservation, Houston, TX
Sister Wendy Beckett	Debra Evans, Fine Arts Museums of San Francisco San Francisco, CA
Bob Marley	Dean Yoder, Yoder Conservation, Cleveland, OH
Groucho Marx	Steven Prins, Steven Prins & Company, Santa Fe, NM
Audrey Hepburn	Charlotte Seifen, Fine Arts Museums of San Francisco, CA
Emily Latella	Judy Bischoff, National Parks Service, Harpers Ferry, WV
Miss Julie Andrews	Janice Schopfer, Fine Arts Museums of San Francisco, CA
Minnie Pearl	Carolyn Tomkiewicz, Brooklyn Museum of Art, Brooklyn, NY

STUDIO TIPS

James Bernstein, Conservator of Paintings and Mixed Media

Finger Held Reservoir Cups

A visit to the dentist is rarely delightful, but the trip may be enhanced appreciably when discovering a new item for studio use. Typically, during a semi-annual dental cleaning, the hygienist will dip a rotating cleaning brush into a tiny tub of polishing compound. The polishing mixture is dispensed from a small cup mounted on a ring that fits onto a finger. Thus, the compound is close at hand for repeated dips during a procedure. Not surprisingly, this small ring cup is great for holding filling putty, so that small amounts may be picked up with a spatula tip when filling losses on paintings or other artifacts. There are several varieties available that may be purchased from any dental supply, or may obtained from a dentist.

My favorite has a relatively large reservoir cup and is made entirely of lightweight stainless steel, clipping onto a finger. A smaller version uses disposable plastic cups that fit into a metal collar atop a metal ring (the dental polishing mixture comes prepackaged little cups). Another variation is a solid blue plastic spool, that resembles a chess piece. It has a cylindrical indentation in the top, serving as the putty reservoir. This dispenser is held in the gap between two fingers, secured by holding the fingers close together. This requires a bit more attention as the cup has to be consciously held, but has the advantage of being entirely plastic, with no metal parts to accidentally contact an art work surface. As with any other tub or tube fillers, it is important to keep the compound from drying out prematurely from exposure to air. When not in use, the dispenser top may be covered with aluminum foil or plastic wrap.

Sudio Items to be Found on eBay®

EBay®, "the world's online marketplace", has changed the way the world shops, and conservation is no exception. All sorts of wonderful objects and materials appear on eBay®, some very old, some brand new. Besides the possibility of obtaining items at bargain prices, the conservator has markets available that would not be otherwise, and remarkable, sometimes vary rare objects are to be found. Some of the items I have acquired on eBay® include antique ceramic palettes, wooden palettes, table top tracing easel, 19th Century paint boxes, new paint sets, small tools and instruments, brushes, pigments, Diederot engravings (pages such as the "Peinture" and Dessin" images from Diderot, Denis & Jean Le Rond D' Alembert. Encyclopédie, Ou Dictionnaire Raisonné Des Sciences, Des Arts Et Des Métiers...), images of artists in their studios, and "expendable" paintings, works on paper and photographs for treatment experimentation. One of my favorite recommendations is to search under "ivory", "piano", "keys", which should yield a number of sellers offering batches of 19th Century ivory piano keys. Contemporary ivory being contraband, antique ivory over 100 years old is the only source for this wonderfully dense, translucent bone material. The piano key tips are typically rectangular cuts approximately 1" x 2" and are thicker than the slender key body pieces, which measure about 1/2" wide by 4" long. The most obvious application is for replacement of lost inlay ivory on antique artifacts. I find the ivory filets make great conservation tools. Ivory is easily cut, sanded and polished to produce invaluable, task-specific spatulas, burnishers, scrapers, and needles.

James Bernstein, Conservator of Paintings and Mixed Media, 4353 24th Street, San Francisco, CA 94114

Ivory is an excellent material for the application and tooling of pigmented wax fills on oil paintings. The ivory will not cool and harden the wax immediately the way metal spatulas will. Also, the ivory is just the right firmness, not so hard as to mar, burnish or leave dark marks on paint (as steel spatulas do). Depending upon the lot offered on eBay and the quantity purchased, the pieces will end up costing between $0.50 and $1.50 each, a very nominal amount. My recommendation is to purchase a lot of 25 to 50 ivory pieces, so you will have stock on hand and will be able to share pieces with your conservation colleagues. Happy (eBay®) hunting! www.ebay.com

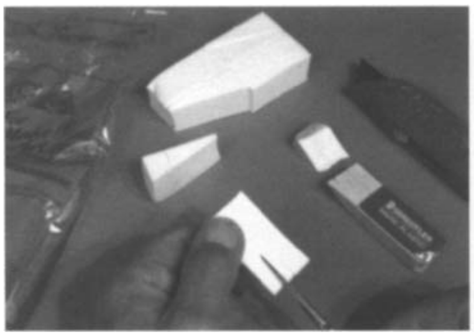
An Onsite Inpainting Pigment Kit

While on the trail for antiques, consider obtaining a compact luggage cosmetic case, the kind very popular for train travel in the 40's and 50's. I found an excellent leather-exterior case in top condition for $40. I was originally looking for an strong aluminum photo equipment case, but was not able to find one with the dimensions and cost I had in mind. The sturdy cosmetic case has been outfitted to become a first-rate onsite pigment kit. It is fitted with four layers of one inch thick ethafoam, cut to fit the contours of the case and designed to stack upon one another. Each layer of foam is drilled with a Forstner bit (producing flat-bottom wells) so that they will hold 40 glass vials (with screw caps) of pigments. All together, I am able to transport 160 different pigments and inerts, readily accessible for accurate color and sheen matching onsite.

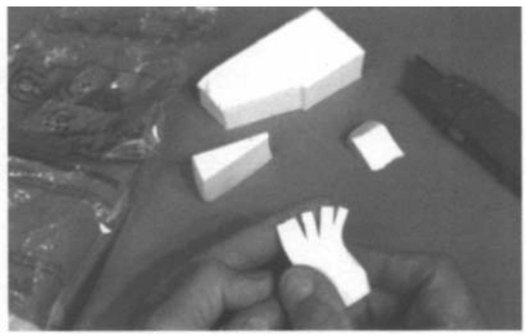
The pigment case peaks the curiosity of security guards at airports, who ask "What is in the jars?" Once inspected, I have always been allowed to keep the pigments with me in the passenger cabin. A major benefit of this is that it the case is compact and squat, and never needs to be tipped sideways in order to fit under a seat or in the overhead compartment. While some may ask, "Are 160 pigments really necessary?", I can't tell you how often a unique item in that case has saved the day. Without the correct pigment or matting agent, I would have never been able to make a successful match. Best of all, the dry pigments may be transported cleanly and safely, and are ready to be mixed with the medium of one's choice (resin, gum, wax, etc.). Have 'pigs', will travel!

Foam Cosmetic Sponges for Cleaning

Soft, white foam wedges, used for the application or adjustment of facial make-up base or rouge, may be found at every drugstore cosmetic counter. They come in different sizes, several to a package (12, 24, etc.) and are inexpensive. I have found these sponges to be wonderful cleaning aids for selected painting applications. They are particularly useful gently cleaning open, somewhat lean paint structures, particularly when there is a sooty soiling problem or one where there may be a greasy element (the old cleaning adage: like goes to like). As when using Magic-Rub® or other vinyl/rubbery eraser-like products, I am very concerned about the potential for irreversible abrasion.



cutting foam wedge



slits in foam

I cut erasers into wedge shapes similar to the foam wedges, so that the thicker, stiffer body of the wedge tapers to a thin, flexible tip. To soften the action of the foam or eraser wedges, I make tangential parallel cuts into the body of the wedge, coming in from the thin edge of the material. This turns the "eraser" into a brush-like instrument. The slits enable the foam/vinyl/rubber to slip past projecting features, softening the pressure and reducing the potential for abrasion of the paint. Whenever possible, if a painting structure allows, I keep the paint surface wet in the immediate region I am cleaning. This lubricates the action and reduces the potential for abrasion or burnishing.

Management of Inpaint Gloss / Sheen

Conservators often seek manufactured materials of the highest purity and uniformity for conservation formulations. One such material is fumed, sub-micron sized silica. While extremely pure, uniform and minute in particle size, used widely as matting agents in industrial paint production, super-fine silicas can be too effective, graying and robbing pigment intensity from paints. I feel larger sized silicas, more varied in size or configuration, are superior for the adjustment of retouch gloss and sheen. The larger particles stay more separate, effectively flatting the sheen without diminishing pigment strength. They are also less likely to become air born and aspirated, reducing (but not eliminating) the health hazard. There are countless silica products produced that may be helpful additions to our matting agent/film modifier arsenal. For starters, however, here are three silicas I am particularly fond of and recommend as indispensable:

• Ground Glass SP921 TF-200, 8 to 12 microns mean size (200 mesh). This lead-free silica is nicely sized, and very effective as a matting agent. Produced by Specialty Glass Inc., 305 Marlborough Street, Oldsmar, Florida 34677. Tel (813) 855-5779 Fax (813) 855-1584 Web site: http://www.sgiglass.com

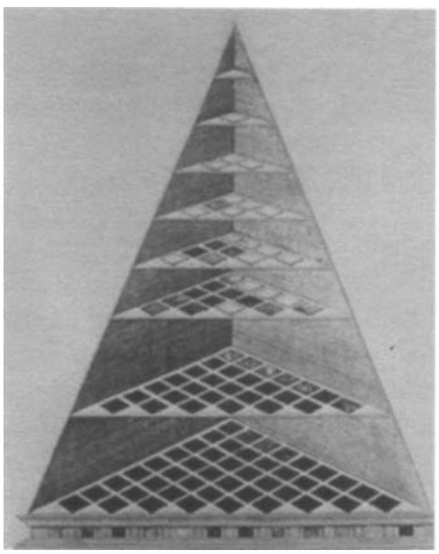
• Glass Beads, 0 to 50 microns. This is an extremely transparent silica mix with a wide range of particle sizes, dispersing light very effectively. It may be too "chunky" for certain paints, but the solid glass beads and the special distribution of the particles produces one of the cleanest matting results, with minimum loss of pigment intensity. Available from Kremer Pigments, 228 Elizabeth Street (at Prince), New York, NY 10012 Tel (800) 995-5501. Fax (212) 219-2395 Web site: http//:www.kremer-pigmente.com

• Glass Platelets, 15 microns. As the name suggests, these flat splintery particles of glass, sharper edged than most, quickly bring down gloss, producing a matte, toothy-surfaced paint. Different from many other matting agents, they can add a glistening effect to a paint surface. Available from Kremer Pigmente, Farbmühle, D-88317 Aichstetten/Allgäu Germany. Tel 07565-10 11 Fax 07565-16 06 Web site: http://www.kremer-pigmente.com Not imported by Kremer Pigments in New York City; Available, along with Glass Beads and other Kremer items, from Sinopia Pigments & Materials, 3385 22nd Street, San Francisco, CA 94110 Tel: (415) 824-3180 Fax (415) 824-3280 Web site: http://www.sinopia.com

I believe when you try the above silicas, they will knock you flat! (...sorry, I couldn't resist the pun.)

Pyramidal Stepped Pigment Block for Inpainting

I have been using a pyramidal stepped pigment block to hold my inpainting pigments for many years now. However, every few years, the block seems to grow, as I find more pigments I can't live without having at my fingertips. I confess, I have added yet another layer to the base of my pigment pyramid. If I keep this up, I may need to a step stool to reach the uppermost colors!



The pyramidal distribution is inspired by the color pyramid by Johann Henirich Lambert (from Lambert's *Farbenpyramid.* Berlin, 1772.) Lambert uses the pyramid as a conceptual model for his distribution of colors, tints and shades. Not only should an artist arrange his colors by chromatic relations; most importantly, the placement should acknowledge the different value relations of colors and pigments. The colors highest in value appear closest to the top peak of the pyramid; the colors deepest in value appear closest to the bottom. This approach makes total sense and is particularly apropos for the conser-vator who, every time he or she dips into a color, is not just making distinctions of color, but where colors fall in value (lightness and darkness), warmth and coolness, clean vs. dirty, etc.

Since there are relatively fewer pigments of very light value, and many deep value pigments, the pyramidal form with greater width and room for colors at the base, works very nicely. It is also the most stable of forms, assuring the block will not be knocked over. When inpainting, I keep my taboret to my right and I have designed my block for right-handed access as well. All vials face either to the front or to the left.

Years ago, I made pigment blocks from basswood. Now I use ethafoam, which is lightweight, easy to tool, flexible, and cushions/grips the vials nicely. Blocks are fabricated by cutting rectangles of stock using a knife, table saw or band saw, depending upon the availability. The overall dimensions of the block are determined by the number of vials to be held and the dimensions of the taboret or table upon which the pyramid is to sit. It is desirable that each row of the block be stepped, so that rows to the rear are progressively higher. Remember that the pigments all need to be within easy visibility and reach.
Blocks may be made from a single thick slab of stock, cut and stepped on a band or table saw (not particularly safe or practical); or preferably by stacking and adhering 1" thick sections of ethafoam, one upon each other. Most of the cutting and drilling should take place PRIOR to gluing and assembly of the blocks. Holes slightly smaller in diameter than the pigment vials are drilled 7/8" deep into the foam using a Forstner bit (available from quality hardware stores or woodworking suppliers) and a drill press. This guarantees uniformly vertical holes with cleanly drilled sides and flat bottoms. A 1-inch wide drill bit works for foam; 1-1/16 inch wide bit may be needed when drilling wooden

blocks. Holes are evenly spaced at close intervals, allowing sufficient space for fingers to get in and unscrew the caps, and for vial labels to be readable.

Foam layers may be adhered together using a hot melt glue gun or a spray contact adhesive suitable for foam. Once assembled, the bright white block may be spray-painted to a neutral, middle-value warm gray tone (Ace Hardware Rust Stopper Enamel, Medium Gray #17076).

The block is then ready to be fitted with glass vials of pigment. The vials are short form glass vials w/ black screw cap (28 x 57mm 15 ml 4 drams), sold in packs of 72 or more from Fisher Scientific, Cat # 03-339-21J Tel (800)766-7000; or VWR Scientific, Cat. # 66012-022 Tel (800) 932-5000.

Pyramidal pigment block on work cart

Identifying Labels need to be adhered to the vials, keeping labels towards the top, so information is readable and not hidden by the foam block. 3/4" high labels are secured to the vials with clear tape to protect labeling from staining or getting lost. Label information should include: Pigment Name; Pigment Number/other Designation; Source/Date of batch. Label information should be stacked vertically (kept compactly in the center), as it is difficult to read information or to see pigment color if labels wrap around the vials. Screw cap tops must be clearly labeled as well. Placing the wrong cap on a color is a sure way to contaminate the pigment reserve.

When filling the vials with pigment, I like to fill the vials completely, with the pigment close to the top. To remove a small amount when working, I wet the inpainting brush with diluent and gently touch the tip to the pigment. A small cluster of powder immediately clings to the brush, ready for transfer to the inpainting palette. Of course, it is important not to touch the lips of the vials with wet brushes; repeated contact will produce caking of color around the mouths of the containers.

Obviously, a working pigment block cannot hold all of the pigments ever needed for every inpainting job. I have made individual blocks for specific color or pigment classes. For instance, I have blocks containing good representations of: whites and inerts; blacks; yellow earths; red earths; brown iron oxides; cadmiums; blues; greens; yellows; oranges/reds; organic lake pigments (azos, quinacridones, etc.); violets; and neutral, low-tinting strength dusting/patination pigments, pearlescent mica "metallics"; Day-glo® pigments; etc.

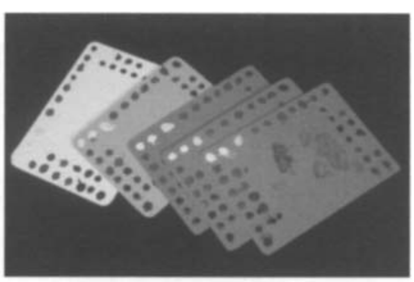
These pigment blocks become works in progress, easily cut, reconfigured and expanded as need (and the discovery of wonderful new pigments) arises.

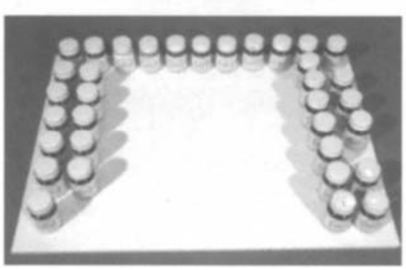
Gamblin® Conservation Colors Palettes

Most conservators have known about the Gamblin® Conservation Colors for some time. Many conservators, however, have not had the opportunity to try these wonderful inpainting colors. The Gamblin®'s are aldehyde resin paints comprised of Laropal® A-81, mineral spirits and artist pigments. Laropal® A-81is a small molecular weight resin produced by BASF ®. It has excellent wetting and leveling properties, and remains resoluble in organic solvents. The Gamblin® Conservation Colors are to be recommended for a number of reasons. In almost every instance, a beautiful pigment choice has been made in the selection of pigments for the series of thirty-five colors. Acknowledging the needs of the conservator, the pigments are of high quality and permanence, there are quite a few transparent glazing colors, and a number of modern, high-performance pigments have been included as well. The pigment-to-vehicle ratio is ideal, with the paints heavily loaded with pigment and very little extending (which would dilute pigment intensity). Packed in glass jars, the pigment will settle from the vehicle over time; prior to use, the colors should be stirred thoroughly to insure proper consistency.

As with any inpainting situation, when using the colors it is always good to start lean, building gloss only towards the topmost applications. This is particularly true for the Gamblin® Colors, since Laropal A-81 builds gloss very rapidly and introduction of the medium must be done judiciously. Also, because of the ready re-solubility of the colors, the choice of inpainting diluent is critical. Gamblin® offers a Technical Data sheet, with some suggestions of solvent mixtures for these paints. These may need to be modified to achieve satisfactory working properties in various studio environments. One solvent that is very effective for zeroing in on the solubility center of this and other inpainting resins is 1-Methoxy-2-Propanol. The addition of 10 to 15% of this solvent to an inpainting mix will do wonders for getting the colors to flow and brush off nicely. Most essential, with whatever solvent mix is being used, is that the inpainting solvent mix should not be overly "strong" in solvent strength or "slow" in evaporation rate. Inpainting low molecular weight resin colors, such as the Gamblin® Colors, requires getting on and off quickly, so as not to disturb or re-dissolve previous inpaint applications. And of course, changing the diluent frequently makes a world of difference, keeping the colors clean and preventing the paints from getting too slippery (from buildup of re-dissolved medium in the diluent).

For colleagues who have not acquired the Gambin® Conservation Colors, possibly concerned about the expenditure for a complete set, I recommend getting together with a number of colleagues to purchase a set collectively, that may then be divided and shared. When preparing an inpainting palette, don't make just one palette. It is very time consuming opening tubes or jar lids, stirring settled colors, applying paints, and cleaning the spatula after each color. Instead, make 10, 15 or 20 palettes at one time. My favored palette surface is an acrylic sheeting palette of neutral value, against which the distinct coloration of the paints read well (as opposed to conventional white palettes that blind the eye and make subtle color differentiation difficult). Cyro® Industries produces 1/8 inch thick Acrylite® acrylic sheeting in a wide variety of tones, that may be cut into rectangles or other shapes/sizes as desired. Manufactured in 4 foot by 8 foot sheets by Cyro Industries, cut-to size rectangles are available from TAP Plastics (or other acrylic sheeting supplier) for approximately $8.10/square foot. Amongst the most neutral colors are Medium Gray (Acrylite® 107-0) or Light Gray (Acrylite® 1119-0; any sharp corners or edges are easily sanded and smoothed. Before placing paints onto the palettes, design a paint distribution arrangement that makes chromatic sense, taking into account the relative value of each color.





Draw up a legend (it helps to have a reminder of what color is where!) and print copies for reference and to accompany each palette. Following your distribution legend, place a dab of each color in the same respective location on every palette. For colors such as Titanium white and "Ivory" black, it is desirable to keep them at opposite ends of the palette; two dabs of these particular colors are extremely useful.

When all solvent has left the dabs (this may take a week or two), store the palettes individually in polyethylene zipper-lock bags. Now when a fresh palette is needed for a particular job, there are full color spectrum palettes ready to go. And no matter which palette is picked up, the colors will be found in the same familiar locations!

Technical data inquiries and purchases of the Gamblin® Conservation Colors may be made at Gamblin Artists Colors, PO Box 625, Portland, OR 97207 Tel (503) 235-1945 Fax (503) 235-1946 Web site: www.gamblincolors.com

A new addition to the roster of low molecular weight resin inpainting paints are the recently introduced Maimeri® Restauro® Ketonic Resin Colors. The original Restauro® Varnish Colours, a line of mastic resin paints, remains available. Now, a series of more readily resoluble ketone resin binder paints is being manufactured by Maimeri®. The initial list of 20 tube colors is limited to exclusively traditional ones (very few modern or recent pigments), but additional colors to flesh out the line are hopefully planned for the future. Technical information and sales sources may be obtained from the United States distributor Savoir-Faire, PO Box 2021, Sausalito, CA 94966 Tel (800) 332-4660 Fax 884-8091; or from Maimeri® online: http://www.mameri.it/FineArts/colorprod.asp?mnu=0502

REMOVING VARNISH FROM HANDS

Robert Proctor, Paintings Conservator

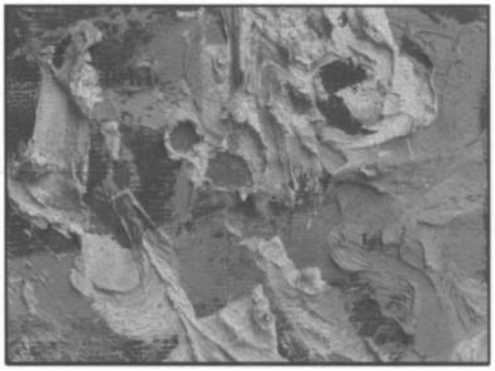
To remove varnish from your hands, try rubbing on a liberal amount of hand cream before washing with soap and water. If normal hand cream fails, try Noxzema®.

Robert Proctor, Whitten & Proctor Fine Art Conservation, 402 Byrne Street, Houston, TX

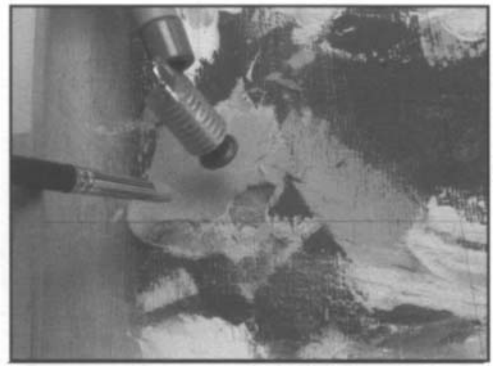
STUDIO TIPS SESSION

CONSOLIDATION OF AN EXTREMELY FRIABLE PAINT LAYER ON A JOAN MITCHELL PAINTING WITH *BEVA®371* AND *COLOUR SHAPERS©*

Dean Yoder, Paintings Conservator



Detail of eruptions in paint layer.



Warming with radiant heat tool after introduction of *Beva®371*.

A unique approach was taken recently to consolidate an extremely friable paint layer on a Joan Mitchell painting. Joan Mitchell had added a silica sand-type of material that over time had caused the paint layer to rupture and explode away from the underlying paint, leaving volcanic-like craters. This phenomenon had occurred mostly in a large expanse of very thickly applied, granular yellow paint. The crumbling paint layer in some areas resembled pollen and had become so insecure that it would become attached to a brush loaded with a diluted adhesive.

The treatment consisted of lying the painting flat, placing a thread grid work over the surface of the painting in order to keep track the progress of the consolidation, then introducing drops of warmed, dilute adhesive (*Beva®371* in naphtha, 1:5) into the crumbling paint. A day or two later the consolidation was repeated. After another day or two, the paint layer was pressed back into place using *Colour Shapers®* while the surface was being warmed with an *Englebrecht* radiant heat tool. *Colour Shapers®* ***(Royal Sovereign, Ltd., UK)*** are commercially available brushes frequently used in ceramics that come in a wide variety of shapes, sizes and degrees of firmness. They are made of a solid, heat-resistant, flexible silicone material which does not stick to extremely sticky surfaces, even warmed sticky *Beva®371*.

The *Shapers* allowed the consolidated paint to be gently coaxed and gradually set down to the pre-eruption state without any paint particles sticking to them, avoiding many of the complications that a conservator would normally expect.

Setting down paint with a *Colour Shaper®*.

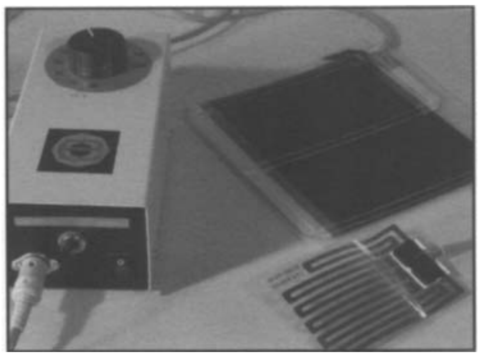
Yoder Conservation, Inc., 12707 Larchmere Blvd. Cleveland, OH 44120

NEW ATTACHMENTS FOR THE ENGLEBRECHT CONTROL UNIT

Dean Yoder, Paintings Conservator

New 1and 2mm thick heated foils that plug directly into the *Englebrecht* control unit have become available to conservators. These flexible foils can be used to gently warm surfaces and are thin enough to fit behind a stretcher bar.

Heated syringes and syringe jackets have been also been recently developed to deliver warmed adhesives with pinpoint control. For more information about both the foils and syringes, please contact Olaf Unsoeld at 718.802.1659.



Englebrecht power unit with two foils.

Yoder Conservation, Inc., 12702 Larchmere Blvd. Cleveland, OH 44120

STUDIO TIPS

Presented by James Bernstein for Steven Prins*

1) **Universal Benchtop Temperature Controller**. This little box can be used to control the temperature of a wide variety of heating instruments in the studio. It senses temperature through a thermocouple (the little plug on the right), compares it to your set point, and regulates output to a 120V outlet (the big black plug on the left) to control whatever heating device is plugged into it. The set point and process temperature are displayed, along with other operating information, on the LCD panel in the center of the control module. It not only controls temperature to within a degree under most circumstances, it can even learn the heating curve of the element plugged into it. It is even capable of fuzzy logic! Apparently its only limitation is spelling. It insists on spelling 'learn' "LeRN"! Note: the heating instrument must be a simple resistant element. The controller will not work properly with heating instruments that have other temperature regulators built into them, such as adjustable tacking irons and hot plates.

Here it is illustrated with a tacking iron attached to it (CLE Design Ltd., London, Model XS, 115V, 25 W). We are pretty low-tech, so for these kinds of applications we simply tape the thermocouple to the tip of the tacking iron. This is OK for the range of temperature we use. Used in conjunction with a 120V solid-state relay, this little device can accurately control the temperature of your hot table as well! (Fig. 1)

Cole-Parmer (cat #U-89810-04). I chose this model because I am familiar with and like the sensitivity and temperature range of the T-type thermocouple (-350° - 750°F). The processor is made by Love Controls, Chicago, IL. Because I was already familiar with their products I was able to specify a particular Love controller that provides not only fuzzy logic, self-tuning, and profile learning, but incorporates ramp and soak processing as well (special quote #809170151: $528.33 in 1998).

2) **Kapton heating element**, illustrated connected to the Universal Temperature Controller. This is a very thin, flexible, Mylar-like material with a metal foil heating element inside. With it you can create a miniature hot-table. I often use it in conjunction with a suction platen, such as those made by Rob Proctor. But simply used with weights it is great for alleviating deformations in canvases, etc. (fig. 2)

WATLOW, St. Louis, MO. Kapton heating elements are available in various shapes and sizes, and can be custom made. They are also available form **Cole-Parmer** (see cat #U-36060-00 to U-3060-50, and #U36067-00/10), although local distributors of WATLOW products are often less expensive.

3) **Stretcher Scribing Assistant**: This is one of four little box corners made to assist in sizing and scribing new stretchers. (Fig. 3) They are attached to the original stretcher in all four corners, as shown. (Fig. 4) The new stretcher is laid into the 'box'. Both stretchers are face down. The new stretcher is keyed out until it fills the corners. The corners of the new stretcher are then fixed with braces. We just use Masonite triangles. (Fig. 5) The new stretcher can then be scribed, either with a hand plane or with an electric router. (Fig. 6)

4) **Solid Brass Tack Hammer**. Since Stanley stopped making the venerable old 54-602, this has become my favorite tack hammer. The solid brass head is very sturdy and has a good weight. The steel striking tips are extremely durable. And although it is not split like most tack hammers we are familiar with, the smaller of the two tips is magnetized. The angled configuration of the head makes accidents less likely and fits well into tight spaces, such as keying out canvases. (Fig. 7)

C. S. Osborne & Co., an upholsterers' tool company and is available through **Woodworker's Supply**, Albuquerque, NM, a national catalogue company (cat #936-003).

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* Steven Prins, Conservator of Paintings & Owner, Steven Prins & Company, 1570 Pacheco, Suite A-W5, Santa Fe, NM, 87505, 505 983-2528

5) **Staple/Tack Puller**. This is another very useful tool from **Osborne**. It's sharp, beveled, bifurcated tip gets under staples readily and pulls them out cleanly. The width of the shaft fits most commercial staples. The finely tooled notch is good for pulling tacks, too. (Fig. 8) Also available from **Woodworker's Supply** (#936-038).

6) **Economical Microscope Floor Stand**. Faced with the need to mend a tear in a large canvas, we improvised this economic floor stand for a binocular microscope: a tabletop boom stand attached to a workshop trestle. This has the advantage over a pole type stand of creating an entire workstation in front of the canvas. The small platform clamped to the trestle provides a place to put tools and equipment as well as a place for the user to rest their arms. This is very important ergonomically when faced with a long work session, and is greatly appreciated in short order. The design also allows for greater flexibility and mobility for general microscope use. The stand can be rolled to any table or easel for use on objects vertical or horizontal. It has proven to be so useful that I plan to make a permanent, use-specific stand as soon as possible. (Figs. 9 & 10)

7) **Wild M3, 10x Binocular Microscope**. The microscope in use on the stand is a Wild M3 fixed-magnification, binocular microscope. It is an incredible piece of equipment, with a very bright field and a remarkably long focal length. The field is so bright that one can often use it without any additional light source. And the long focal length provides plenty of workspace between the lens and the canvas. The tabletop boom stand illustrated here is made by **Diagnostic Instruments**. The fiber optic set up has a segmented articulated bifurcated light path. The 3200°K light source is by **LUMINA**. Microscope and accessories are available from **Micro-Optics, Fresh Meadows, NY**.

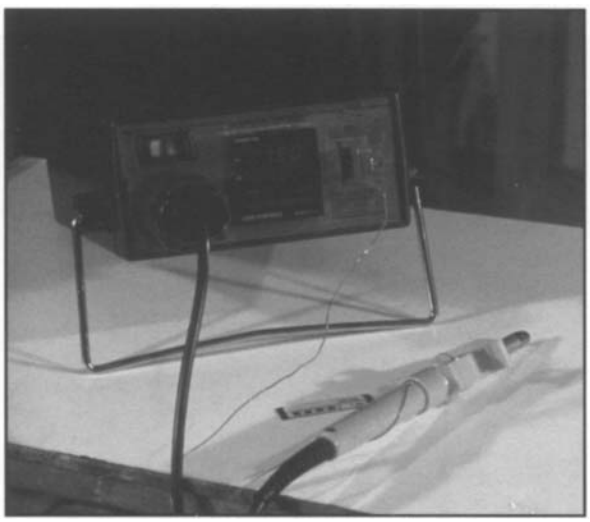


Fig. 1 C-P Benchtop Temperature Controller with CLE tacking iron.

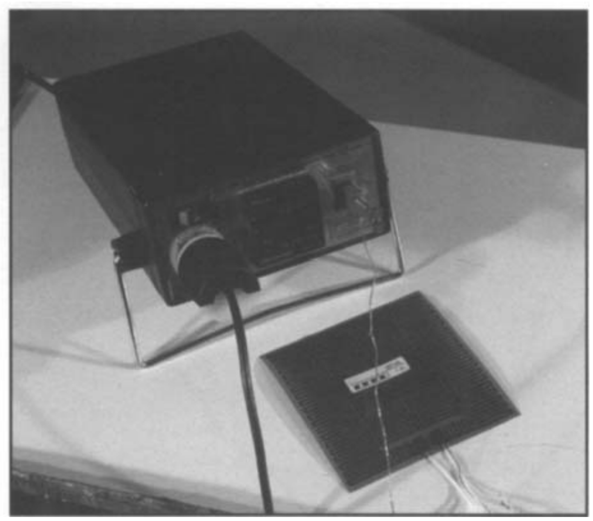


Fig. 2 C-P Benchtop Temperature Controller with Kapton heating element.

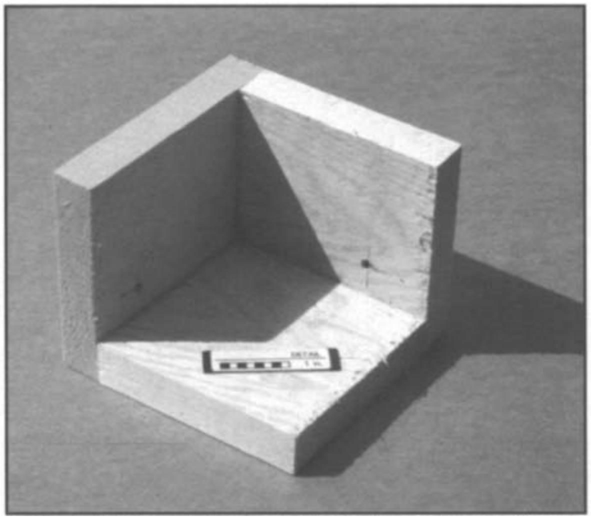


Fig. 3 Wooden corner brace for sizing and scribing new stretchers.

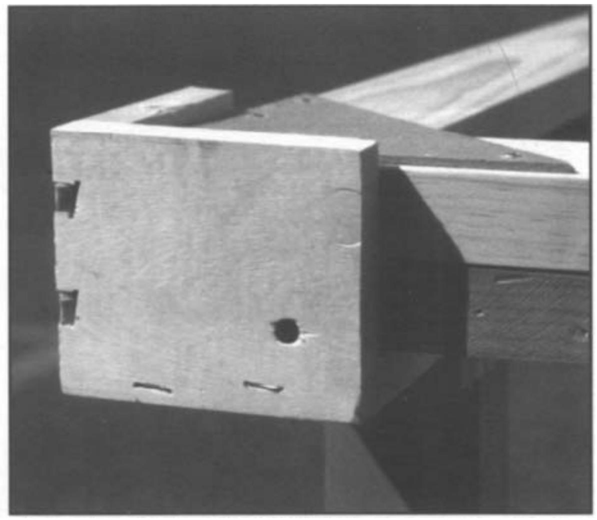


Fig. 4 Corner brace secured to original stretcher with new stretcher laid into 'box'.

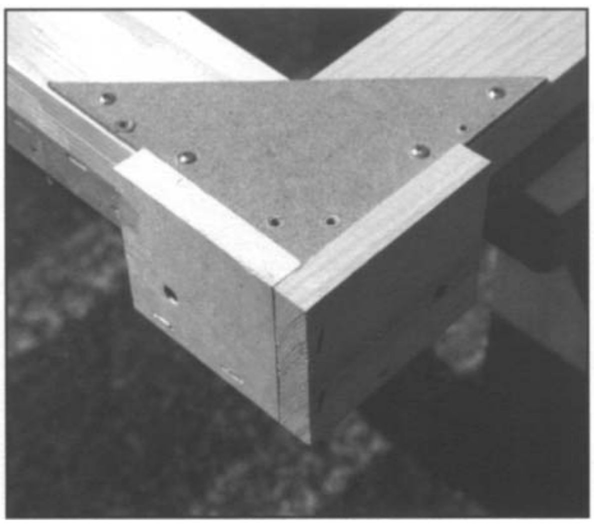


Fig. 5 New stretcher keyed out into corner brace secured with a hardboard triangle

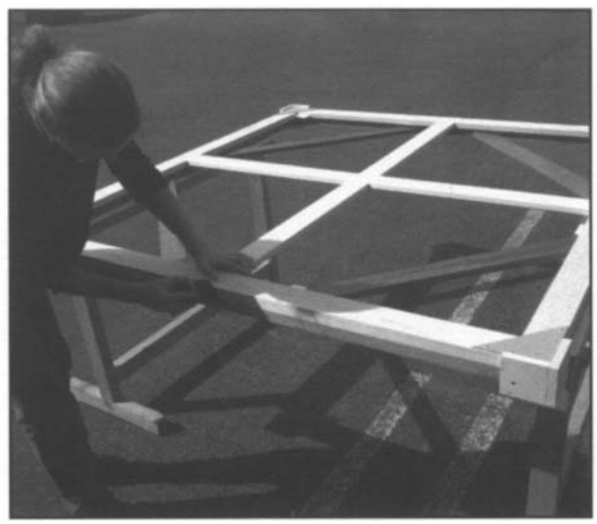


Fig. 6 Scribing the new stretcher with a hand plane.

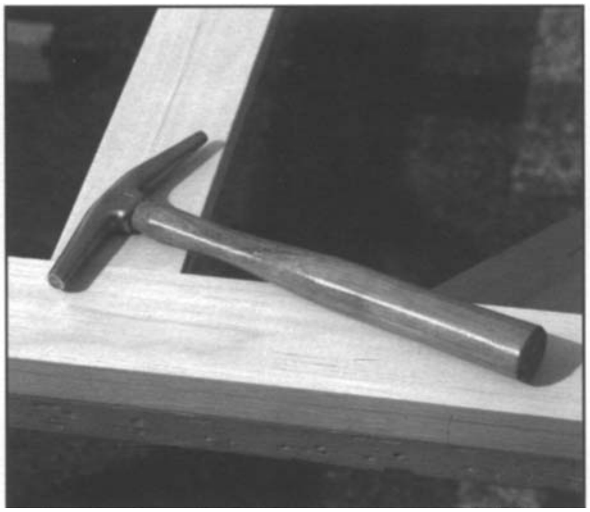


Fig. 7 Solid brass tack hammer from Osborne.

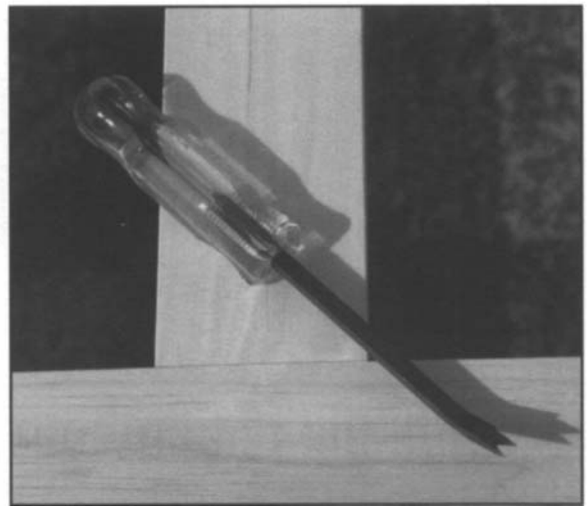


Fig.8 Tack puller, also from Osborne.

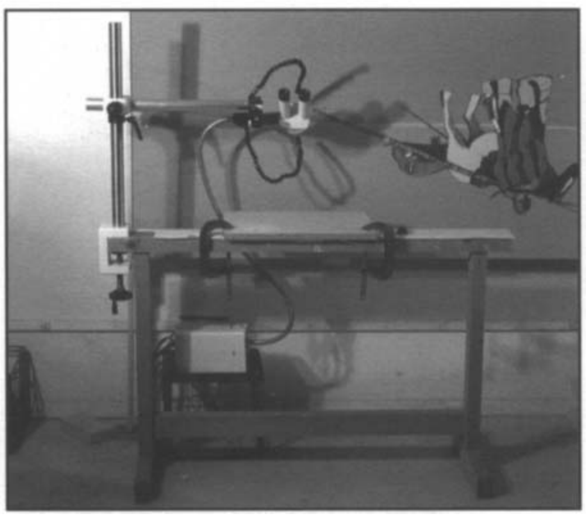


Fig. 9 Economic adaptation of a sawhorse/trestle for use as a vertical microscope stand.

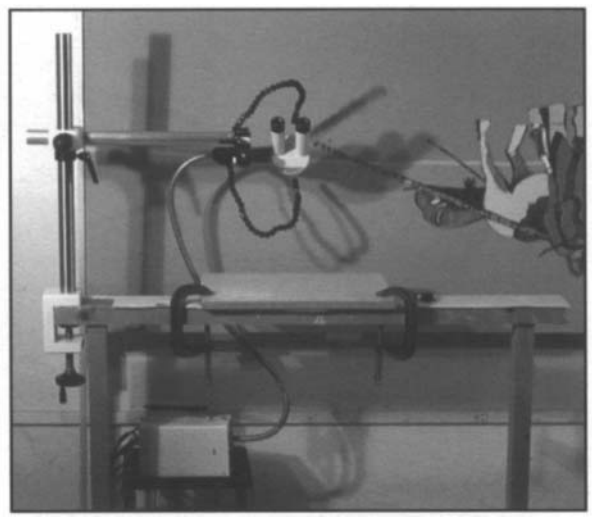


Fig.10 Detail of Wild M3 binocular microscope mounted to sawhorse/trestle with work platform.

STUDIO TIPS

Carolyn Tomkiewicz

Surface Texturing:

Whether using conventional gesso/glue putty, BEVA® gesso-p or wax-resin/pigment fill mixtures, surface texturing can be carried out with various types of mold-making materials. Care must be always taken that the paint surface is neither friable nor otherwise sensitive when considering casting a mold. If possible, the paint layer should be isolated with a working varnish prior to casting with the mold-making material.

The casting can be used to impress a texture into a thermoplastic final inpainting layer, such as PVA-AYAB mixed with dry pigments. This is particularly useful when attempts at surface texturing a fill are either unsuccessful or are obliterated by subsequent inpainting. The latter prompted a series of tests to transfer surface texture to the inpainting layer.

Two types of casting material were tested for transferring a surface texture to PVA-AYAB inpainting: **Reprosil®**, hydrophilic vinyl polysiloxane, and **ELASTOSIL® M1470/T40**, kneadable, heat-conductive, two-component silicone rubber.

Example: A twill weave support fabric appeared very visible through the paint layer on a 19th c. portrait undergoing treatment. When a twill insert and thin gesso application were inpainted, the twill texture was mostly obscured. Beginning again was not an option. The PVA-AYAB inpainting was augmented with additional resin to even the surface before heat-transferring the surface texture from the mold-casting to the thermoplastic inpainting layer.

Testing for transfer of texture to PVA-AYAB showed that the thermoplastic characteristic of this resin responded to both of the above-mentioned mold-making materials: **Reprosil®** or **ELASTOSIL® M1470/T40**. Though the latter is a thermal-conductive material, the former also transferred sufficient heat through the thin layer (ca. 1/16" thickness) that was cast. In both instances the transfer of surface texture was successful. Other thermoplastic inpainting materials could be tested.

Procedure:

1. The painting surface is isolated with a working resin (if possible).
2. The mold-making material is evenly spread out onto 5 mil Mylar® while avoiding bubble inclusions, placed material-side-down onto the surface to be cast, smoothed lightly with a brayer and weighted for even casting. The area of the painting is supported below during casting and texture transfer.
3. The casting is placed onto the thermoplastic inpainting material and the texture transferred by heat-sealing with a heat spatula followed by weighting until cool.

Recommendation: Test all materials prior to use for familiarization with workability and curing times.

Supply Sources:

Reprosil®, Type 1, very high viscosity, heavy body
DENTSPLY Caulk, DENTSPLY International Inc., Milford, DE 19963; call for local distribution, 1-800-532-2855.
[New York City: Becker/Parkin Dental Supply (212) 216-0700]
ELASTOSIL® M1470/T40, kneadable, pasty, stiff (Catalyst T40 is available in red paste or clear liquid)
Kremer Pigments, Inc., 228 Elizabeth Street, New York, NY 10012, (212) 219-2394.
Manufacturer: Wacker-Chemie GmbH, Hanns-Seidel-Platz 4 D 8177.
Mowilith® 20, Polyvinyl Acetate, (substitute for **PVA-AYAB**), medium for retouching
Hoechst Celanese, route 202-206 North, Somerville, NJ 08876, (201) 231-3654.

Carolyn Tomkiewicz, Brooklyn Museum of Art, 200 Eastern Parkway, Brooklyn, NY 11238
tel.: (718) 501-6274 e-mail: carolyn.tomkiewicz@brooklynmuseum.org

Other useful silicone casting products:

ELASTOSIL® M4370A / M4370B

Example: A method was sought for dealing with extensive lifting scattered throughout the entire surface of a late 19th century American portrait. Treatment within a vacuum envelope would provide needed pressure during heat-sealing of an applied thermoplastic adhesive. After removal from the stretcher, the reverse was built up with Archivart® Tycore® to the upper edge of the tacking margins so that these not be flattened during treatment. The thermal-conductive silicone material was poured onto 1 mil Mylar® onto the reverse of the painting (thickly enough to ensure curing - see package instruction). Heat application was administered with infrared bulbs at a controlled distance from the front. Consolidation could be assisted by local pressure with the hand and cotton wads from the surface. The silicone acted to trap needed heat and simultaneously warm from below. The painting could then be left in the vacuum envelope to cool allowing the adhesive to set under vacuum pressure.

Sylgard™ 184

Because this two-component silicone is liquid, Sylgard™ 184 is poured into the middle of a pre-molded dam of heavy body Reprosil®. It is poured out thinly (approximately 1/16 inch) so that the cured film readily transfers sufficient heat to the material to be textured. This clear silicone allows for visible adjustments during the texture transferring procedure.

Note: A translucent material (paste) from Wacker-Chemie GmbH is on order and will be tested. Similar working properties to other paste mold-making materials are expected with the advantage of visibility through the material to align the mold with the adjacent surface texture to achieve seamless continuation.

Sylgard™ 184 was tested in transferring texture to BEVA® gesso-p. For greater flexibility and receptivity to texturing, BEVA® gesso-p can be augmented with up to 30% by weight additional BEVA® 371.

Tests were carried out in transferring texture with heat:

1. canvas fabric impression transferred into a fill mix composed of 4 parts BEVA® gesso-p + 1 part BEVA® 371 (left)
2. silicone mold texture transferred into a fill mix composed of 4 parts BEVA® gesso-p + 2 parts BEVA® 371 (right)

Note: The second sample showed greater ease of texture transfer.

BEVA® gesso-p (diluted in aromatic solvent) can be used in situations where shallow fills are needed and/or in situations where water-sensitivity is encountered (clean-up with iso-octane or petroleum benzine). The material is useful due to its thermoplastic nature, not only in the transfer of texture using silicone molds but also in modeling with the Engelbrecht Minor welding needle or other fine heat tools such as the Willard 1EM heat spatula with "micro tips".

Supply Sources:

ELASTOSIL® M4370A / M4370B liquid, iron oxide-pigmented base, clear liquid catalyst, thermal-conductive;
TAYCHEM INDUSTRIES, Ltd. East Coast distributor of Wacker-Chemie GmbH products; (866) 794-0004.
Sylgard™ 184, medium-viscosity liquid;
DOW CORNING CORPORATION Midland, Michigan 48686; call for local distribution: (989) 496-4000.
BEVA® 371 solution, film, and gesso;
Conservator's Products Co., 5 Corey Road, Flanders, N.J. 07836, (973) 927-4855.
Tycore®, acid-free, lignin-free and buffered mounting panel with honeycomb core;
Archivart®, A Division of Heller & Usdan, Inc., (800) 804-8428.

Re-tensioning

Raking light images:

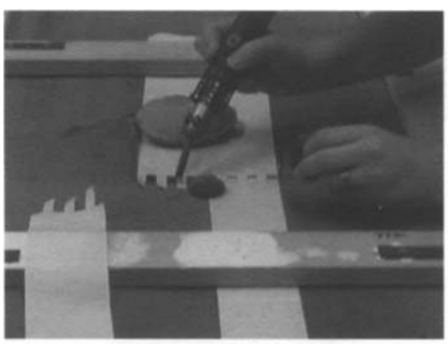
front, before treatment

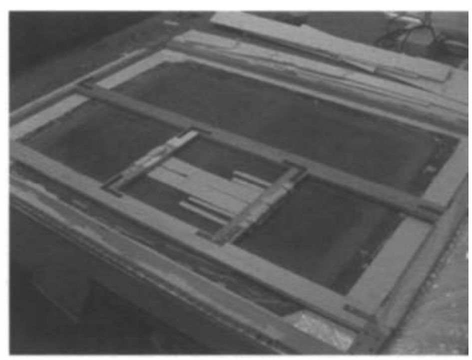
front, after local tear repair, re-tensioning, edge lining and re-stretching over loose lining

Example: Wood, Ogden, Road to Quettehout, Acc.# 13.1073

Tears were addressed according to methods recommended by Professor Winfried Heiber, University of Dresden School of Fine Arts, Germany. Treatment was carried out at BMA.[1]

Closing space that had developed at the tear site over time after initial damage was carried out by pulling together with an instrument constructed to simulate the functioning of Der Trecker.[2]





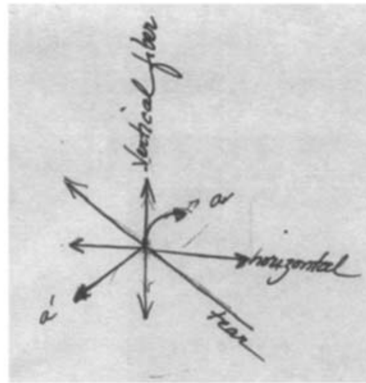
The painting was placed in a "Dutch Method" strainer and the RH slowly increased in a chamber and monitored to relax the deformed canvas. The entire painting was kept taut while setting up a sub-structure to accommodate the gradual closing of the gap over several weeks by pulling and re-pinning fabric attached to either side of the tear with BEVA® 371 film. Overlapping and welding broken fibers was carried out with Heiber's sturgeon glue : wheat starch paste adhesive mixture as recommended in Die Rissverklebung [3]. The mended tear was held in plane with the Re-tensioning[4] method suggested by Tomkiewicz.

1 Project carried out at BMA by Winstone Wells Sellin, 4th-year graduate student, Conservation Center of the Institute of Fine Arts, New York University .

2 Petra Demuth and Winfried Heiber, Der Trecker, Restauro, issue 5, 2000, pp. 344-347.

3 Winfried Heiber, Die Rissverklebung, Zeitschrift für Kunsttechnologie und Konservierung, no. 10, issue 1, 1996, pp. 117-146.

4 Carolyn Tomkiewicz, Re-tensioning, AIC annual meeting, St. Louis, MO, 1999 (AIC PSG Postprints).



Re-tensioning fibers perpendicular to tear orientation

diagonally oriented tear with forces a, a_

The tip of a warp fiber from linen similar to the original is coated with Jade 403 and while still liquid heat-sealed to one side of the tear. The remainder of the fiber is coated with Jade 403 delivered on a fine brush; the fiber is pulled across the tear to the opposite side and heat-sealed to maintain tension and prevent lifting out of plane. The addition of fibers is continued along the repaired tear. The length of the individually added fibers is varied and staggered to distribute stresses.

Jade 403 set up quickly upon driving out moisture and showed strength of attachment as pulling and heat-setting to a stronger area of canvas was undertaken. Other adhesives did not prove as easy to use during heat-sealing. The Heiber mixture did not seem to afford the same shear strength (empirical testing) when used to attach fibers superficially, as carried out here. Jade R was not available at the time of testing, thus was not included in this series of tests. If readily reversible, Jade R may be preferable. Jade 403 can be mechanically removed. BEVA® 371, Paraloid® B-72 adhesives were tested as well as carriers of Japanese tissue and Hollytex instead of linen fibers; these materials have found good use in other cases of re-tensioning tears in canvas supports containing residues of various materials from previous treatments.

It was reasoned that the vector of force that may cause a tear to lift forward out of plane needs to be countered by an equal force against that vector, as in the case of diagonal tear orientation. In all cases the re-tensioning fibers are added perpendicular to the tear direction. Re-tensioning is recommended in all cases where bridging is considered to reinforce local tear repair as well as prior to lining where lining can not be avoided due to deteriorated fabric. The painting presented here is edge-lined and stretched over a loose lining. A Tycore® insert attached to the backing board limits movement and affords additional protection. Treatment was completed in May of 2002. It remains taut and in plane and shows no signs of weakness at the site of the repair.

Raking light: Planar deformation has not recurred one year after re-tensioning.

Note: It is encouraging to have monitored numerous cases of local tear repair and re-tensioning that have maintained planar stability over the past 10 years; cases in which "strong" lining or "heavy" patching were reversed and replaced by the method described in these notes.

The recommended procedure aims at re-constructing lost forces where possible rather than constraining a structure under forces against which it reacts.

ODE TO HAZY SKIES:
"REDISCOVERING" COLORED PENCILS

Charlotte Seifen Ameringer, Paintings Conservator

From time to time the conservator is called upon to don the cap of explorer and seek innovative solutions for specific treatment conditions. Such was the case several years ago while treating a painting that a previous restorer had attempted, unsuccessfully, to devarnish. The result was a skinned area in the sky of the painting -- a wonderfully atmospheric moonlit seascape. In the area of solvent abrasion pale, misty veils of the atmosphere gave way to dark monochromatic underpainting. While one choice might have been to inpaint the area of abrasion using any of a number of familiar inpainting media, an alternate approach was sought. Fortunately, resourceful colleagues had already discovered the perfect solution.

Searching through my notes and files I chanced upon a paper by Bettina Jessell and Mary Whitson, presented at the 1992 AIC meeting, in which they discussed the use of colored pencils as an aid to inpainting[1]. In the paper, the authors describe using colored pencils to reconstruct abraded or overcleaned paint layers. Intrigued, I armed myself with a large box of Caran d'Ache Supracolor II® pencils and soon became a steadfast fan. The advantages of the colored pencils (well enumerated by Jessell and Whitson) that enticed me were: the ease of complete reversibility, the fact that the pencils added virtually no mass allowing the texture and characteristics of the original paint to remain unchanged, and (as Jessell and Whitson express elegantly) the pencils provide an alternative to 'burdening' a painting with extensive overpaint in situations where this may be felt somewhat unappealing, e.g. damaged or compromised original paint films.

The colored pencils have been invaluable in subsequent conservation treatments, notably a painting with areas of dark, intractable oil overpaint that could not safely be removed, and a Hudson River School painting with extensive ground staining. In both cases, inpainting was carried out using a combination of traditional inpainting media and colored pencils.

The Colored Pencil Society of America website (www.cpsa.org) contains both product research and lightfastness information. It is important to point out that several of the pencils should be removed from the set as their lightfastness rating does not meet conservation standards.

For further information on the use of colored pencils, I refer the reader to the original article by Jessell and Whitson. I would simply like to remind colleagues that colored pencils can be a useful addition to our conservation repertoire.

[1]Jessell, B. and M. Whitson. 1992. An Aid to Inpainting, *1992 AIC Paintings Specialty Group Postprints*, Buffalo, NY. June 5, 1992. 26-34.

Paintings Conservation, The Fine Arts Museums of San Francisco
Interim deYoung Museum, 245A South Spruce Ave., South San Francisco, CA 94080

SOME OF MY FAVORITE THINGS

Julie Andrews

The use of watercolor for inpainting is considered a standard practice in paper conservation. Hopefully paintings conservators can infer an appropriate use from this description. Watercolor by itself even from the best set of Schmincke pan colors has certain limitations. One can encounter difficulty achieving the proper sheen or in some cases a very particular tone. There are also the occasional accidents when you unfortunately push a color beyond an appropriate match. It is sometimes possible to alter the tone of the inpainted fill without the necessity of redoing the repair with the addition of a dry pigment to the toned fill. Call them tricks, but these interventions can in some cases be not only effective but also time efficient. Tone alone is not the only requirement for a good repair. Preparation of the paper's surface to achieve a good transition from the original paper support to the fill paper can make the difference between a beautiful cosmetic compensation and a noticeable repair. But this tip is focused on the tone and sheen of the inpainting color.

The surface sheen of an inpainting medium can be altered with the addition of other materials (such as various methyl celluloses, chalks or other fillers) to dull the finish or opacify the color. But a simple and often quick correction for color can be achieved with the application a tiny bit of pastel to the surface of your watercolor-toned loss. For example, Japanese prints are artworks with printed media that often requires a dusting of dry pigment to better achieve both the sheen and tone of the surround. Pastel pencils can facilitate the toning of matte surfaces, opaque gouache and tempera paints, some printing inks, minor surfaces abrasion on paper or media, and areas of compensation where wet inpainting media are inappropriate.

Standard soft pastel can be used to adjust the sheen of a fill by applying the pigment with cotton swabs, stumps or brushes. This method of applying the pastel can be awkward and somewhat imprecise. The loosely bound pastel pigment can also impart a dusty appearance due to the light scattering or refractive properties of the media. A slightly denser and better-bound pastel is available in a pencil format. We are using both Stabilo CarbOthello pencils made by Schwan and the newest addition to our palette, Faber-Castell Pitt Pastel pencils. We have been very satisfied with the results. Together, these pencils sets, being very similar in composition, provide broad diversity of color.

Some of the advantages of these pencils over stick pastels are: They can be sharpened for precise placement of color. Most of the colors allow surfacing of a watercolor-toned area without the problem of imparting a chalky surface sheen seen most noticeably in strong raking light. The binder for these pastel pencils provides good working properties - soft enough to allow ease of application without the problems presented by loosely bound pastel sticks yet hard enough to allow for accurate deposition and blending of color. Because of these working properties, the pencils can be used to cosmetically mask distracting loss or stains in pastel drawings. They can also be very effective in dry toning paper fills or minor surface abrasions with or without pre-toning with watercolor.

<u>Sharpening</u> - These pencils can be difficult to sharpen as the points break easily in conventional pencil sharpeners. We have had good success using the Dahle Pencil Sharpener or scalpels. However, the ease of sharpening can vary as individual pencils have their own particular structural stability.
<u>Applicators</u> – We have used various methods for applying the color, depending on the desired results and/or the friable characteristics of the media being color corrected. One can choose to use: traditional stumps, color shapers, Holbein pastel brushes (or regular brushes cut short and flat), cosmetic sponges or absorbent points (tiny twists of paper available in fine, medium, coarse, and extra-coarse) used for root canals, available through dental surgical catalogs.

A source for Stabilo CarbOthello pastel pencils; Faber-Castell Pitt Pastels; Holbein pastel brushes; Colour shapers and The Dahle Sharpener is: Dakota Art Pastels: PO Box 2258, 416 Gates Street, Mt. Vernon, WA 98273 1-888-345-0067, E-mail: pastels@fidalgo.net. Absorbent points are manufactured by Endoco, Inc., 1835 Park Avenue, Memphis, TN 38104

Janice Schopfer, Conservator of Works of Art on Paper
Fine Arts Museums of San Francisco, Legion of Honor
Lincoln Park, 100 34th Ave., San Francisco, CA 94121

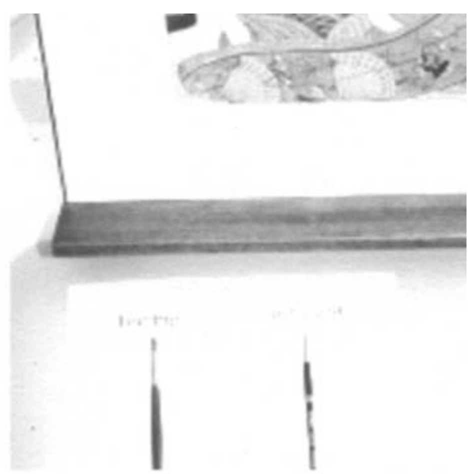
A FEW HUMBLE INPAINTING TIPS

Sister Wendy

While my schedule did not permit my attendance, the following tips were offered via slides:

The Italian Art Store has an astonishing deal on a metal box of 48 Schmincke half pan watercolors. This set would usually cost well over $300 and all but one of the 48 colors are lightfast! Contact www.italianstore.com, 1-800-643-6440. The set is product H74448, $185.00.

Be your palette in watercolors or resin paint, paint out a swatch card to keep with your colors. Paint the colors right over the edge of the card so that the paint color can be put directly next to the color you are preparing to inpaint. This is how the card is used to find a good base color for inpainting a small loss on a Japanese print.



You should use a very fine, very dry sable brush to achieve just the right amount of control. Using a brush that is too big is a common mistake that is actually a mortal sin. Changing to a smaller brush will successfully cure many conservators' inpainting difficulties. Depending on the maker, the brush size will change, but typically a range from 1 down to 000 will be needed.