



Painting Conservation Catalog

Volume III: Inpainting

The Paintings Specialty Group
of the American Institute for Conservation

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Catherine A. Metzger, Compiler
January 2011

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I.

Statement of Purpose

This third volume of the *Painting Conservation Catalog* is designed to give the working painting conservator a compendium of methods and materials currently in use for inpainting losses in painted surfaces within a context of historical approaches and current ethical philosophy. Each chapter was written by an individual contributor and was vetted for content by an eight-member editorial board, including seven practicing painting conservators and a conservation scientist, to ensure accuracy and completeness of approach. It is not the purpose of this volume to advocate one method or set of materials over another, but to present to readers what is currently considered a responsible approach for making paintings legible.

II.

Compensation Goals/ Philosophical Issues

A. HISTORICAL BACKGROUND

1. Approaches to the Reintegration of Paint Loss: Theory and Practice in the Conservation of Easel Paintings

a) Introduction

The inextricable links between materials and meaning in a work of art have ensured that issues of retouching have retained a prominent place in the theory and practice of paintings conservation throughout its history. Damage to the paint layer can result in a change or devaluation of the aesthetic, spiritual, historical, or cultural meaning of the work. Consequently, the method used to reintegrate paint losses, or the decision not to reintegrate them, strongly affects how the painting is understood and appreciated. A comprehensive knowledge of the underlying rationales that guide conservators in a particular approach is, therefore, very important.

For certain approaches, specifically Italian visible retouching techniques, comprehensive theoretical frameworks have been developed. This includes the writings of Cesare Brandi (2000) and Umberto Baldini (2001, 1997). Imitative retouching, on the other hand, is based on a longstanding tradition that is guided by practical principles rather than an explicit theoretical foundation. It is, therefore, necessary to consider discussions of the relative merits of and justifications for specific approaches to loss compensation that are dispersed in conference proceedings (Association of British Picture Restorers 2000; ARAAFU 2002; Garland 2003; Leavengood 1994; Meiss 1963) and published case studies of important conservation treatments, particularly those where significant areas have been reconstructed (Dunkerton 2003; Wallert, Tauber, and Murphy 2001)

or where instead large losses have not been reintegrated (De Bruyn Kops 1975, Seymour 1972).

Three important international conferences merit special mention, as their associated publications reflect contemporary discourse at key moments in the history of conservation, and, indeed, are cited frequently throughout this review. The “International Conference for the Study of Scientific Methods for the Examination and Preservation of Works of Art” was held in Rome in 1930 and is considered to be a seminal event in the establishment of the modern discipline of conservation (Clavir 1998, Von der Goltz 1996). Although the meeting was not specifically devoted to issues of retouching, the subject held a central place in the discussions, indicating that it was a critical issue in conservation at the time. The findings of the conference were disseminated in documents and articles (Ruhemann 1931, Van Gelder 1931) and eventually edited into a handbook, *Manuel de la Conservation et Restauration des Tableaux* (1939), followed by the English edition, *Manual on the Conservation of Paintings* (1940). The text was intended as a guide for curators responsible for overseeing conservation work in museums. It was compiled by an international committee of experts, which included conservators Helmut Ruhemann and George Stout, and is valuable as an expression of international opinion at the time.

In 1961, the “Twentieth International Congress of the History of Art,” held in New York, dedicated a session to the philosophical and practical issues of loss compensation: “The Aesthetic and Historical Aspects of the Presentation of Damaged Pictures” (Bomford and Leonard 2004, Meiss 1963). The principal speakers were museum director Philip Hendy and art historians Richard Offner and Cesare Brandi, who expressed widely divergent views about loss compensation, advocating for complete reintegration, no reintegration, and visible reintegration, respectively. Other participants included art historian Millard Meiss and curator Charles Seymour, conservators Sheldon Keck and George Stout, and conservation scientist Paul Coremans.

The third important conference was the symposium “Early Italian Paintings: Approaches to Conservation,” hosted by Yale University in 2002. This meeting focused on the restoration history and treatment of the collection of Early Italian paintings at Yale University Art Gallery, but broader issues of retouching philosophy were also discussed. The proceedings comprise papers by an international group of conservators, art historians, museum curators, and conservation scientists (Garland 2003). Of particular note are the contributions of Italian art historians and conservators whose papers on the history and development of Italian retouching methods provide an unprecedented level of access and understanding for the non-Italian reader.

Several important publications provide critical assessments and historical overviews of retouching approaches. These works, however, are not intended to be comprehensive literature reviews (Bomford 1994, Daly Hartin 1990) and often focus on restorations carried out in specific historical periods (Partridge 2003, 2006) or on a single retouching approach, for instance Italian visible retouching techniques (Olsson 2003; Ramsey 2000;

Reifsnnyder 2003; Schädler-Saub 1986, 1999a, 1999b). Despite the crucial impact that retouching has on the appearance and understanding of the artwork, a comprehensive review and contextualization of theory and practice is lacking in the English language literature. This review aims to address the most important contributions on the subject. It should be noted, however, that, despite the impossibility of considering retouching theory in isolation from its practical application, the more technical aspects of the methods and materials are outside the scope of the paper. Similarly, philosophical issues specific to the restoration of modern and contemporary paintings are not separately explored.

b) Complete Reintegration

A loss in the paint layer represents a negative alteration that diminishes the value of a work of art, whether aesthetic, devotional, or commercial. Complete reintegration, also referred to as “imitative” or “mimetic” retouching, aims to reconstruct the missing parts of the image by emulating the appearance of the original painting as closely as possible. Complete reintegration is the traditional approach to loss compensation in easel paintings conservation. It was used in the earliest restorations carried out by artist-restorers, and continues to be applied to the majority of paintings in public and private collections. Alternatives to complete reintegration were rare until the 1930s and 1940s. Nonetheless, there is a long history of discussion on approaches to reintegration, from both philosophical and practical perspectives, and the issues involved have played a pivotal role in the evolution of modern conservation theory. The first part of this section deals with the practice of complete reintegration from a historical perspective, covering approaches and commentaries on restorations carried out before the early decades of the 20th century. The second part focuses on modern conservation and current practices of imitative reintegration.

(1) Historical Overview of Complete Reintegration

Pioneering works on the history of restoration and conservation by art historian Alessandro Conti (2007, 2002, 1981) and art historian and conservator Roger Marijnissen (1967) draw upon documentary sources to provide a survey of approaches to restoration over the centuries. The examples discussed range from the renovations carried out by Renaissance painters to repair and update devotional images, to restorations in the 18th and 19th centuries that reveal a growing respect for the artist’s original work and avoidance of general overpainting. This latter tendency did not preclude the occurrence of more extensive, “aesthetic” reintegrations, which were undertaken for both museums and private collectors, indicating that different approaches to restoration have always been practiced concurrently. Of particular interest in the writings reviewed by Conti and Marijnissen are cases that reflect attitudes that seem to anticipate 20th-century standards, such as the intentional use of an easily removable, water-soluble retouching medium by artist-restorer Carlo Maratta in the late 17th-century resto-

ration of Raphael's frescoes in the *Psyche Loggia* of the Villa Farnesina. The Getty Conservation Institute (GCI) publication *Issues in the Conservation of Paintings* includes excerpts of several important historical texts from the 19th century and earlier that provide rare documentation and criticism of early restorations, as well as viewpoints on retouching expressed in 19th-century restoration manuals (Bomford and Leonard 2004).

Condemnation of excessive and poorly executed restorations did lead to calls for no reintegration, as well as proposals for stricter retouching practices, well before the 20th century (Conti 2002; Darrow 2000, 2002; Levi 1988; Marijnissen 1967; Partridge 2006; Tranquilli 1996). Already in the early 19th century the restorer Pietro Edwards recommended that retouching be limited strictly to areas of loss, and stressed the importance of the stability and removability of the retouching material (Conti 2002; Darrow 2000, 2002; Marijnissen 1967; Tranquilli 1996). In 1877 Giovanni Battista Cavalcaselle, art historian and arts administrator for the Italian State, issued a document outlining guidelines for restoration in which he advocated minimal intervention in retouching. In certain cases of fresco restoration, neutral watercolour toning of losses was carried out under his supervision (Conti 2002, Levi 1988, Partridge 2006). Instances of an approach to retouching more in line with modern standards, however, were relatively isolated and a disconnection between theory and widescale practice persisted. Restorers frequently resorted to overpainting, which could be associated with harsh cleanings that damaged or removed original paint, or with deliberate attempts to falsify the condition of the work or alter the original composition (Dwyer Modestini 2003, Marijnissen 1967).

More recent studies on the history of restoration explore how the aesthetic values and cultural expectations of the time have influenced the retouching and reworking of images (Anderson 1994; Braham 1975; Gould 1974; Hoeniger 2005, 1995; Sitwell and Staniforth 1998). Art historian Cathleen Hoeniger's research into early renovations of Tuscan devotional and civic painting discusses the religious and social motivations for the reworking of these images. For example, works were often rejuvenated through retouching to ensure their continuing efficacy or to update them for new generations of worshippers (Hoeniger 1995). Restoration work commissioned by Sir Charles Eastlake, first Director of the National Gallery in London, has been the subject of much critical attention. These restorations sometimes involved the repainting of areas to correct perceived deficiencies in the image, or retouching to alter the image for reasons of propriety so that it would be acceptable to the 19th-century viewer (Anderson 1994, Braham 1975, Conti 2002, Gould 1974, Partridge 2006).

(2) Imitative Reintegration and the Establishment of Principles for Conservation

The 1930 Rome Conference occurred at a time when conservation was establishing itself as a professional discipline, and the manual that was compiled by an international committee following the meeting represents an early attempt to formulate internationally accepted guidelines for practice (*Manual on the Conservation of Paintings* 1997). The opening pages, devoted to general principles for the conservation of paintings, focus largely on issues of retouching rather than varnish removal or structural treatment, indicating that it was considered to be a central concern. These principles, which serve to distinguish modern imitative retouching approaches from the deceptive practices of the past, include limiting the retouching to the areas of loss (inpainting rather than overpainting), ensuring that the materials used remain easily removable, and thoroughly documenting the treatment. It was also stressed that, prior to treatment, the conservator should gather as much information as possible about the work of art and how it has changed over time, consulting with curators and art historians for their perspective.

While significant attention was given to visible retouching techniques current at the time, the principles formulated at the Rome Conference allowed for a range of practical solutions, including complete reintegration. The aim of complete reintegration, however, was no longer to achieve a pristine finish in the restored work. Greater consideration was given to the impact of the loss on the painting and some signs of age and alteration came to be accepted. Alternatives to imitative reintegration were considered when the loss was extensive or occurred in an important part of the composition, or when there was insufficient information about the missing areas to inform a reconstruction. With the organization of the conservation profession over the following decades, these principles came to be codified through the drafting of professional codes of ethics (Murray Pease Report 1964, Murray Pease Report/Code of Ethics for Art Conservators 1968) and were further promoted in newly-established formalized training programs and texts on the theory and practice of restoration (Brandi 1963, Ruhemann 1968).

It is perhaps because imitative retouching has been the traditional approach to loss compensation, and because its development has been more practical than philosophical, that there has been no perceived need to articulate a theory of complete reintegration. Although complete reintegration continued to be widely practiced in the first half of the 20th century, there was not much published defense or theoretical discussion of this approach at the time (*Manual on the Conservation of Paintings* 1997, Stout 1941). However, the emergence of visible retouching techniques and philosophies of non-intervention in the 1940s and 1950s no doubt compelled a response from proponents of complete reintegration. These alternative approaches were, in part, a critical reaction against the excesses

and empiricism of some 19th-century restorations, but they also reflected philosophies about the impact of paint loss and the function of the restoration that differed from that of supporters of modern imitative reintegration (Baldini 2001, 1997; Brandi 2000, Seymour 1972). The attention received by the published theories supporting these alternative approaches seems to have prompted the need for a defense of complete reintegration. This occurred in 1961 at the New York Congress, which provided a venue for discussion of the relative merits of the different approaches. Philip Hendy, Director of the National Gallery in London, made the case for complete reintegration. He felt that presenting a work of art in a damaged state was antithetical not only to the artist's intention but to the very essence of the work of art, and argued for restitution of the unity of the image through imitative reintegration (Hendy 1963). Hendy also expressed concerns over how members of the public would respond to the display of unrestored works. His intention was not to conceal the true state of the painting; in fact, he suggested that this information be made available separate from the artwork, in a collection catalog, for example. Hendy had implemented this approach in the 1930s when he wrote the catalog for the Isabella Stewart Gardner Museum, Boston (Hendy 1931). Subsequent commentators have raised similar arguments for complete reintegration (Dwyer Modestini 2003). Ruhemann, who practiced imitative retouching in most cases, was open to alternatives. He expressed concerns, however, about the distracting effect of both unrestored losses and poorly executed visible retouching (Ruhemann 1968).

c) No Reintegration

Where no reintegration of losses is carried out, it may be part of a systematic policy that is related to an extreme minimalist view of restoration, but more often it is considered for specific cases such as paintings with extensive paint loss that would require inventive reconstruction, or where damages are deemed to carry some historical or cultural significance. Since the work is presented without any pictorial restoration, the appearance of the painting depends entirely upon the condition of the original materials.

There is a long history of commentary on the negative effects of retouching, as well as proposals that paint losses should be left exposed, particularly in Italy (Bomford 1994, Bomford and Leonard 2004, Ciatti 2003, Offner 1963, Partridge 2006, Schädler-Saub 1986). This point of view is often expressed in the context of criticism of a specific restoration where it is judged that a work of art is diminished by poor-quality additions. For example, Giorgio Vasari's disapproval of the restoration of a fresco painting by Luca Signorelli in the Church of San Francesco in Volterra led him to suggest that, "it would be better, sometimes, to keep the things made by excellent men half-damaged than to have them retouched by someone of lesser skill" (Conti 2002, 58). Writing in the 19th century, Cavalcaselle argued that it was better to have "a painting deteriorated or missing in some part, than a painting finished or refreshed by the restorer that ends up being neither old nor modern work" (Paolucci 1986, 15). The prominent Italian art historian

Roberto Longhi, in his critique of restoration practices in Italy in the early 20th century, stated that it was preferable to leave the losses exposed, “so the eye...can set them aside without effort, and restore, but only ‘mentally’...that which is missing” (Longhi 1940, 124).

(1) **Early Italian Paintings and the “Archaeological” Approach**

A non-interventive approach is often described as “archaeological” because the object can appear like a ruin or fragment, and because it often involves the removal of subsequent restorations in a kind of “excavation” aimed at retrieving the original image. As a methodology, the archaeological approach is most closely associated with the treatment of Early Italian paintings in the decades around the mid-20th century. During this period it was applied to paintings in important collections in Italy (Ciatti 1990), France (Mognetti 2003), and the United States (Aronson 2003, Hoeniger 1999, Seymour 1972). With the aim of revealing the original image, later restorations and additions were systematically removed, regardless of their aesthetic or historical significance, and the paintings were presented with no, or in some cases minimal, reintegration.

Perhaps the most well-known and discussed application of this purist approach involves the collection of Early Italian paintings in the Yale University Art Gallery. Between 1951 and 1972, conservator Andrew Petryn and his colleagues undertook a conservation campaign, under the direction of curator Charles Seymour, which involved about one hundred and fifty paintings in the collection (Aronson 2003). In the majority of cases, following the removal of previous restorations, a philosophy of no retouching was employed, and paint losses and abrasions, which in many cases were substantial, were left exposed. Seymour described the conservation program at the 1961 New York Congress (Seymour 1963, 176–178), and in a 1972 exhibition catalog, which documented the most important treatments (Seymour 1972). Seymour stressed the recovery of the original image, which had been obscured by restoration, invoking concepts of “truth” and “authenticity.” Offner, a specialist in the history of Early Italian painting, supported the conservation program at Yale. At the New York Congress, he argued that “the rejection of all but its original elements is the first and the final condition of an adequate restoration of a painting” (1963, 159).¹

The purist philosophy was driven in part by a desire to distinguish between the work of the original artist and later additions, an important requirement for connoisseurship and art historical study. Extensive restorations had long been considered an obstruction to the study of the work, posing an impediment to attribution and authentication (Partridge 2006). Some advocated for exposure of the actual state of the painting from an aesthetic perspective; that is, the original painting was felt to be best appreciated without the imposition of restoration, even if the work was in a highly damaged condition (Offner 1963; Partridge 2006; Seymour 1972, 1963).

Hoeniger notes that the function and reception of Early Italian paintings, combined with the condition in which many have survived (often fragmented, decontextualized, and badly damaged) has meant that they have often been subjected to heavy or multiple restorations (1995). The frequent presence of reworkings, extensive retouching, and overpaint on these works caused some commentators to draw a parallel between complete pictorial reintegration and falsification, as has been discussed by Hoeniger (1999) and Catalano (1998). Offner, for example, argued that “any addition whatever introduces irrelevant matter and serves to instill a false impression in anyone who sees the restored work...easy removal fails to justify it either on moral or aesthetic grounds” (Offner 1963, 157). Similarly, Meiss insisted that “mere knowledge of what is authentic and what is added is not sufficient. The two, in my experience, inevitably merge. The original is polluted by the fake” (1963, 165).

The correlation between restoration and forgery in the treatment of Early Italian paintings was, in fact, not entirely philosophical. With the critical reevaluation of paintings from this period in the late 19th and early 20th centuries, there emerged a new appreciation for these works on the part of foreign tourists and art collectors. This created a heavy market demand for genuine paintings, as well as a flourishing industry around the restoration and forgery of trecento and quattrocento works (Mazzoni 2001). This resulted in heavy restorations of seriously degraded original works — sometimes to deceive potential buyers, sometimes at their request — as well as the production of outright fakes (Joni 2004, Mazzoni 2001). In some cases, the line between a heavy restoration and a forgery can be ambiguous (Muir and Khandekar 2006). With the prevalence of unscrupulous restorations of Early Italian paintings in the early decades of the 20th century, perhaps a systematic policy of nonintervention for works in public collections seemed to provide the only guarantee of an unadulterated presentation of the damaged artwork.

The conservation campaign at Yale has been widely criticized for its strict adherence to a methodology that failed to recognize the unique requirements and histories of individual works (Aronson 2003, Christiansen 2003, Hoeniger 1999, Walden 1985). With the implementation of principles for retouching, as well as the possibilities offered by visible techniques, there is no longer much support for an archaeological approach to restoration. Quite separate from a purist ideology, however, is the rejection of retouching in specific cases where the damages are considered to be historically or culturally meaningful (Bergeon 1990, De Bruyn Kops 1975, Mognetti 2003, Muir 2007). Ségolène Bergeon has referred to this as a *patine d'utilisation* (1990, 194–98) that reflects the history and function of the work.

d) Visible Retouching

Visible, or differentiated, retouching techniques aim to reintegrate the image by reducing the visual impact of the loss while ensuring that the restoration is clearly recognizable as such. This approach is often seen as a compromise solution because it reaches something of a middle ground between imitative retouching and nonintervention, namely aesthetic reintegration of the damaged image in a way that neither competes with the original nor conceals all evidence of the actual condition and history of the work.

Examples of visible retouching are known from well before the 20th century. For example, it is documented that Carlo Maratta used a hatched (*tratteggio*) technique in his restoration of Raphael's *Psyche Loggia* in the late 17th century (Hoeniger 2005, Varoli-Piazza 2002). Conti mentions the use of pointillist techniques in the 1800s (2001). In the early part of the 20th century, there was a considerable amount of experimentation with alternative retouching approaches. In 1914, the German restorer Victor Bauer-Bolton argued that retouching should be clearly identifiable and proposed a method whereby the loss was filled and retouched at a slightly lower level than the original painting (2004). Significantly, he also recognized that the retouching approach largely depended on whether the painting was considered primarily as a work of art, a historical document, or a commercial object.

In 1922, Professor Max Doerner described the use of a hatched retouching technique (1922). As early as the 1920s, visible techniques were used at the Fogg Art Museum (Cambridge, Massachusetts), under the direction of Edward Waldo Forbes (Bewer 2002, Contreras de Berenfeld 2003, Mongan 1971). At the 1930 Rome Conference, Ruhemann, a practitioner of complete reintegration in most instances (Jessel 1976, Ruhemann 1968) supported the use of visible retouching in cases where losses were extensive and central to the composition (Ruhemann 1931). He subsequently described seventeen visible retouching methods in *The Cleaning of Paintings: Problems and Potentialities* (1968). Ruhemann's recommendation that imitative retouching should be visually distinguishable from the original paint, however, was not always easily translated into practice. As MacBeth and Spronk (1997) have reported, it was Ruhemann's expressed intention to avoid too pristine a finish in his 1932–33 treatment of Rogier van der Weyden's *Saint Luke Drawing the Virgin* from the Museum of Fine Arts, Boston. Nevertheless, his retouching was brought to a high degree of finish, including recreating the craquelure of the original paint in some areas.

(1) Cesare Brandi and the Istituto Centrale del Restauro

Visible reintegration did not achieve a true methodological status until the mid-1940s when the practice of *tratteggio* was developed by Cesare Brandi, director of the Istituto Centrale del Restauro (ICR) in Rome. Brandi formulated a theory of restoration that guided a number of important conservation projects and was influential in the training of conservators from Italy and abroad. He developed

his theoretical framework in a number of articles and lectures between the 1940s and 1960s. In 1963, a collection of these papers was compiled as *Teoria del Restauro* (1963). His impact on Italian conservation policy is evidenced by the 1972 *Carta del Restauro* (1963). This official document, which was largely based on Brandi's theoretical ideas, has had considerable influence on the conservation of cultural heritage in Italy.

Brandi conceived the work of art as an entity possessing both an artistic and a historical dimension. It was, therefore, necessary that the reintegration should aim to reestablish the aesthetic aspect, its "potential unity," while respecting the traces of the artwork's passage through time. Brandi used the ideas of Gestalt psychology to describe the impact of the lacuna on the perception of the work as a whole. He argued that the loss was not only a disturbing factor because it represented a gap in the image but because it could assert itself as a form within the composition. A principal function of restoration was, therefore, to reduce the dominance of the loss in order to allow the viewer to concentrate on the image. He advocated strict limits for retouching to prevent it from descending into invention or excess and argued that the retouching should always be recognizable under close viewing. Brandi arrived at *tratteggio* through experimentation with other visible retouching techniques, which ultimately proved to be unsatisfactory (Brandi 1954, Contreras de Berenfeld 2003).

Tratteggio consists of the application of many vertical strokes of various colors that are gradually built up to approximate the appearance of the original from a normal viewing distance, while remaining discernible under closer examination. Depending on the assessment of the impact of the loss, *tratteggio* could be used to reconstruct the missing forms of the composition or as a general toning of the lost areas. The technique was intended to provide a precise formula that would mitigate subjective influences and personal idiosyncrasies in the execution of the retouching.

Brandi's philosophical ideas were further explored by Paul Philippot, a Belgian art historian and teacher, whose ideas on retouching were elucidated in two important papers coauthored with his father, the conservator Albert Philippot (Philippot and Philippot 1959, 1960). Issues of reintegration were also discussed in the chapter "Problems of Presentation" in *Conservation of Wall Paintings*, which Philippot coauthored with Paolo Mora and Laura Mora (1984). The practical aspects of *tratteggio* were developed by the Moras, who were early students of Brandi, and conservators at the ICR. This chapter gives a detailed explanation of the technique. *Tratteggio* was developed in direct response to the profound damage sustained by Italy's artistic heritage during the Second World War. It was first applied to the frescoes by Lorenzo da Viterbo in the Mazzatosta Chapel of Santa Maria della Verità in Viterbo (Brandi 1996) and those by Andrea Mantegna in the Ovetari Chapel in the Church of the Eremitani in Padua (Brandi 1954),

which were both heavily damaged in bombings. The approach was soon after applied to panel paintings (Bonsanti 2003).

(2) Influence of Brandi Outside of Italy

Brandi's practical solution to loss compensation has been adopted in many European institutions and training programs, and his philosophical framework continues to guide the work of paintings conservation (Bergeon 1990; Masschelein-Kleiner 1989–91; Mognetti 2003, 1996; Philippot and Philippot 1959, 1960). However, with few exceptions (Lignelli 2003, 1997), *tratteggio* has not had a strong influence in English-speaking countries. It has been argued that Italian retouching methodology came to be seen as a more ethical approach to loss compensation (Meiss 1963) and many conservators experimented with the hatched techniques in the 1960s and 1970s (Bomford 1994, Olsson 2003). One of the main criticisms, however, is that, when poorly executed, visible retouching can become distracting and draw attention to itself (Bomford 1994). It has also been argued that the technique is only aesthetically suitable for use on frescoes or early panel paintings that do not rely on illusions of volume and three-dimensionality (Ruhemann 1968). Problematic interpretations and poor comprehension of Brandi's theory, particularly with respect to the application of *tratteggio*, have been noted (Bomford 1994, Conti 2001, Philippot 2000).

The impact of Brandi's theoretical writings in English-speaking countries has been debated. In the preface to the first full English translation of *Teoria del Restauro*, it is suggested that his texts have been inaccessible both because of the lack of English translations and because of their philosophical density (Brandi 2005). Salvador Muñoz Viñas, who characterizes Brandi's theory as outdated (2002), describes *Teoria del Restauro* as an "unnecessarily obscure text" (2005, 6).

Although the first full English translation did not appear until 2005, it is important to note that Brandi's thought was actually disseminated, at least in part, much earlier. Brandi's 1951 article on the restoration activities of the ICR, which included discussion of the reconstruction of the fragmented Ovetari Chapel frescoes, contained an English language translation (1954). A few years later, he provided the entry on "Restoration and Conservation" in the *Encyclopedia of World Art* published in 1966, where he discussed the historical development of the concept of conservation and touched upon many of his theoretical principles. The topic of the session devoted to the "Aesthetic and Historical Aspects of the Presentation of Damaged Pictures" at the 1961 New York Congress, where Brandi presented a paper (1963), is significant and Catalano suggests that the subject matter is related to an awareness of Brandian thought at the time (1998). Laurence Kanter, on the other hand, contends that Brandi has been overlooked in America and the United Kingdom because of acrimonious professional relationships between Brandi and important English and American historians of Italian art (including Offner and Meiss), a group that had significant influence on

the development of conservation practices in Europe and America. He argues that Brandi's presentation at the New York Congress, which was translated and summarized by Paul Coremans at the meeting, was largely disregarded (Kanter 2007).

Excerpts from *Teoria del Restauro* were translated in the 1996 GCI publication *Historical and Philosophical Issues in the Conservation of Cultural Heritage* (Stanley Price, Talley, and Melucco Vaccaro 1996). These excerpts are accompanied by useful contextualizing essays. In one essay, Alessandra Melucco Vaccaro argues that "nearly all contemporary methods can be traced more or less consistently and more or less consciously" to *Teoria del Restauro* and the precepts of Brandi (1996, 328). Recent conferences and symposia celebrating the centenary of Brandi's birth highlight the enduring relevance of Brandian philosophy, especially in English-speaking countries (ARAFU 2002, Contreras de Berenfeld 2003, Garland 2003, Kanter 2007).

(3) Alternatives to *Tratteggio*: Umberto Baldini

The philosophical approach developed by Umberto Baldini in the 1970s and 1980s has guided the restoration of numerous artworks in state-owned collections in Florence and surrounding areas. Baldini served as the head of the Florentine Restoration Laboratories and then as Superintendent of the Opificio delle Pietre Dure. His theory of restoration owes much to Brandi's *Teoria del Restauro*. However, he considered *tratteggio* to be unsatisfactory, largely due to misinterpretations of Brandi's theoretical framework (2001). Baldini developed his theory of "methodological unity" based on principles of optics and perception, and introduced two new visible retouching methods: *astrazione cromatica* (chromatic abstraction) and *selezione cromatica* (chromatic selection) (Baldini 2001, 1997). Like Brandi, Baldini's philosophical writings can be challenging to read; only short excerpts are available in English (Bomford and Leonard 2004; Stanley Price, Talley, and Melucco Vaccaro 1996). The practical aspects of *astrazione cromatica* and *selezione cromatica* were developed by conservator Ornella Casazza, who provided a lengthy, written description of their application with illustrated examples (1999).

The practical application of these techniques depends on a critical assessment of the loss and its impact on the painting. If the loss is limited and can be reintegrated without invention, *selezione cromatica* may be used. This involves the build up of individual strokes of various colors selected from a limited palette, applied using a hatching technique. The overall color of the retouching is based on that of the adjacent original paint and results from the optical mixing of the colors of the individual strokes. This method differs from Brandi's *tratteggio* in that the brushwork is not restricted to a vertical orientation, but rather follows the directionality of the original forms. When the loss is significant and cannot be reintegrated without invention or without overpowering the remains of the

original, then *astrazione cromatica* is employed. In this case, the hatched brush-strokes do not reconstruct forms, and the color of the retouching is derived from the overall chromatic character of the painting. The abstraction is intended to create a “neutral link” between the passages of well-preserved original paint (Baldini 2001, 1997; Ciatti 2003).

Astrazione cromatica was first used on Cimabue’s *Crucifixion* from the Santa Croce Museum, which had endured serious damage and paint loss in the 1966 Florence flood (Baldini and Casazza, 1983). Due to the large losses that interrupt, most significantly, the face and body of Christ, it was felt that reconstruction of the missing compositional areas was unjustified. To some extent, the color of the retouching is based on the adjacent paint, and in this sense, the application begins to approach *selezione*. The restoration, in fact, was carried out before Baldini’s theory of restoration was fully articulated and the reintegration of the *Crucifixion* should be seen as a first realization of the approach. According to Baldini, the restoration was designed to reestablish the *Crucifixion* as a work of art, while ensuring that the restoration “has no independent action” on it (Baldini and Casazza 1983, 49–50). Others have questioned whether the restoration was successful in its aims (Conti 2001, Marijnissen and Kockaert 1995, Talley 1996, Walden 1985). The method, however, continues to be refined, and modifications and new developments of the techniques proposed by both Brandi and Baldini are evident in recent Italian restorations (Ciatti 2003).

e) Conclusions

The literature on retouching falls at the intersection of theory and practice. Because of the multiplicity of values that works of art can possess and the challenges of reconciling the work’s original appearance with changes that have occurred over time, retouching represents an ongoing dilemma for the paintings conservator. The fact that this aspect of conservation has been debated for centuries attests to the impossibility of imposing any kind of dogmatic solution. Whether a damaged painting is presented in a fragmentary state or is restored to a relatively high degree of finish depends on a combination of factors whose relative weight may change over time. Many different factors can influence restoration choices, and articulated theories are not always straightforward to implement. In current practice, different approaches to loss compensation can be manipulated to give a range of degrees of finish, and conservators tend to adopt more flexible approaches than were evident around the mid-20th century when methodologies were more rigidly applied.

Current trends in conservation research, which show a greater interest in the subjective, culturally contingent factors that shape conservation theory and practice, have stressed the importance of an awareness of the historical and philosophical foundations of the profession (Avrami, Mason, and de la Torre 2000; de la Torre 2002; Muñoz Viñas 2005, 2002; Stanley Price, Talley, and Melucci Vaccaro 1996; Villers 2004). Knowledge of the most significant and fundamental sources in specific areas, such as the theory

of retouching, can contribute to a more comprehensive understanding of the contexts of past treatments, as well as offering direction in the complex task of conservation decision-making.

Author's note: This paper, titled “Approaches to the Reintegration of Paint Loss: Theory and Practice in the Conservation of Easel Paintings,” originally appeared in *Reviews in Conservation*, 10 (2009), pp. 19–28.

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ENDNOTE

¹ Contreras de Berenfeld (2003) notes that earlier, in the 1930s, Offner had a more tolerant attitude toward some examples of visible retouching.

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2. Retouching Paintings in Europe from the 15th through the 19th Centuries: Debates, Controversies, and Methods

a) Introduction

Loss compensation in paintings has generated discussion in Europe for centuries. This paper will attempt to provide an overview of debates surrounding loss compensation and show where possible the materials and techniques used, or at least recommended, for retouching. In my research, I have been helped by some extremely useful literature, especially Alessandro Conti's *Storia del Restauro* published in 1988 as well as more recent studies by Andrew McClellan, Jaynie Anderson, Cornelia Wagner, and Elizabeth Darrow, to name just a few scholars, on specific moments in the history of conservation.

Retouching has been criticized in art historical writing as far back as Giorgio Vasari. In his biography of Luca Signorelli, Vasari discussed a painting where the head of the Christ Child had been damaged and was repainted about fifty years later by Sodoma. Vasari was not particularly impressed with Sodoma's work, writing,

At Volterra, he [Signorelli] painted a fresco over the altar of a confraternity in the church of San Francesco representing the Circumcision of Our Lord which is considered beautiful and a marvel, although the Child has suffered from the humidity, and the restoration by Il Sodoma is much less beautiful than the original. In truth, it would sometimes be better to keep works done by excellent men in a semi-damaged state than to have them retouched by some one less skilled.¹

Vasari's implication, of course, was that genius could not be reproduced. This sentiment against retouching would be restated periodically in the art historical literature.² At the same time, there were other authors (often restorers) who, in the 18th century, began to evaluate the specific complexities of loss compensation.

This paper will examine the historical criteria for successful retouching. It will look at the beginnings of retouching in the style of the original artist in the Renaissance, the occasional use of reversible retouching materials in the 17th and 18th centuries, and the search for stable materials in the 18th and 19th centuries. By the end of the 18th century, specific training and skills were suggested for inpainting, including the knowledge of old master techniques and chemistry. In the 19th century, a "less is more" principle was articulated, an apparent response to a purist aesthetic that suggested leaving losses visible.

b) Retouching in the Style of the Original Artist

Retouching in the style of the artist seems to have begun surprisingly early. For example, in Simone Martini's *Guidoriccio da Fogliano* fresco in Siena (1320s), a large area of the

castle of Montemassi was damaged and recreated in the original style either seventy-five or one hundred and fifty years after the fresco was painted.³ This practice, of course, was quite unusual at this date. More commonly, damaged and even undamaged paintings were renovated in a contemporary style to ensure the work's continuing vitality. A Christ Child was added about one hundred years later to a Bernardo Daddi triptych of the 1330s (J. Paul Getty Museum) representing a Madonna with saints. Art historians speculate that the piece was commissioned for a funerary chapel and that the Madonna was gesturing toward a sarcophagus, interceding for the soul of the deceased. At some point the painting was probably moved, the interceding gesture no longer made sense, and the Child was added.

Despite "overpaint-to-update" practices, certainly by the late Renaissance there are examples of faithful reconstructions of the original composition. A famous case is Andrea del Sarto's *Madonna of the Harpies* (1517). The painting was damaged in the Florence flood of 1557, and approximately the bottom fifth of the paint layer was destroyed. The painting was considered to be a work of genius and was reconstructed in a manner close to the pre-damaged state.

c) Reversible Retouching

Although intense preoccupation with reversible retouching seems to have begun in the 20th century, there were 18th-century documents concerning the importance of reversibility, among them the well-known discussions of Carlo Maratta's projects. Carlo Maratta (1625–1713), an important Roman painter, was responsible for a number of restoration projects in Rome, including Raphael's *Stanze* in the Vatican and *Psyche Loggia* at the Farnesina Palace. Being such major works, the *Stanze* and the *Loggia* have been restored and re-restored many times, and it is difficult to perceive what of Maratta's work is still extant. The *Psyche Loggia* project (1693–4), however, was particularly well documented by contemporary and near contemporary writers. It was a complicated intervention involving frescoing areas in the vaults left unfinished by Raphael and undertaking structural work to deal with the consequences of the Loggia having been open to the elements. Also, according to Maratta's biographers, when Maratta retouched Raphael's frescoes, he used pastels bound in gum arabic so that his work could be easily removed if a more worthy restorer were found.⁴ There is another story of Maratta being asked by Pope Innocent XI to add a veil to Guido Reni's *Madonna del Cucito* fresco in the Quirinal (1609–11). The pope thought the Madonna's neckline was too low. Maratta added the veil, but with pastel so that he would not be irrevocably changing the work of another artist.⁵ Nothing remains of Maratta's 17th-century reversible pastel retouching as far as I know. However, a restoration campaign of the 1980s in Anne of Austria's apartment in the Louvre discovered a very late 18th-century pastel modification in a fresco (painted about 1655) by Giovanni Francesco Romanelli. When the frescoes were restored in 1799 during the French Revolution, the allegory of Faith was changed to an allegory of Victory with the chalice and cross hidden by a pastel fasces and laurel crown.⁶

About one hundred years after Maratta, the Venetian Pietro Edwards (1744–1821) became a tremendously important figure in the history of restoration. He was Director of the Paintings Academy in Venice and Director of Restoration for pictures belonging to the state. Edwards and his team were responsible for restoring over 700 paintings. He wrote a number of proposals and papers on caring for paintings, including *Restoration of the Public Pictures Approved by a Decree of the Senate on September 3, 1778: Articles for the Restoration of These Pictures Proposed by Professor Pietro Edwards* and *Preliminary Dissertation on the Care and Custodianship for Instituting the Possible Preservation and the Best Maintenance of the Public Pictures* (1786). Edwards' recommendations sound incredibly contemporary and included requests for condition reports. He was concerned about environmental effects on paintings, training for restorers, supervision and accountability, and removing old restoration that compromised paintings.⁷ Pietro Edwards felt that retouching should be reversible. In his rules outlining restorers' responsibilities, he wrote, "They may not use on pictures materials which cannot be removed. Instead, everything they use shall be removable from the art whenever it is necessary."⁸ For this reason, he directed that the Venetian paintings be retouched with dry pigments ground in a resin, probably mastic, and he seems to have prohibited insoluble retouching in oil.⁹ In his *Proposal for a School for the Restoration of Paintings* (written after 1819), Edwards even suggested that students be required to copy "head-dresses, wings, feathers, and foliage" of various painters using varnish colors.¹⁰

d) The Search for Stable Materials

While both Maratta and Edwards were influential figures and their concerns were known and discussed, reversibility was not the major concern in the 18th and 19th centuries. Instead, the real preoccupation in historical inpainting discussions was stability. Worries about inpainting darkening or lightening go back at least as far as Filippo Baldinucci's 1681 *Vocabulario*, a dictionary of art terms. Under the heading "restaurare" or "to restore," he wrote, "Many people think that the best pictures should not be retouched even by someone who is skilled since it becomes possible to recognize over time a restoration however small..."¹¹

The actual search for stable materials seems to have begun in the mid-18th century. Antoine-Joseph Pernety (1972) in his art dictionary of 1757 recommended either tempera or wax retouching as highly stable. Under the heading "repeindre" or "to repaint" he wrote,

Many people repaint damaged sections of pictures with the intention of repairing them, but it is very difficult to ensure that the new colors do not create stains...Oil will darken and create marks. One could repaint with tempera to avoid this problem...You can also read in the works of Messrs. de Caylus and Majault on painting in encaustic and wax, page 131, that colors prepared in wax work much better than oil colors to restore old paintings. M. le Lorain, a painter of the Academy, has tried this with singular success. He

*has repaired old paintings so that it is almost impossible to find the repaired and repainted areas.*¹²

My favorite example in the quest for stability comes from France during the Revolution. As with Pietro Edward's Venetian period, this nearly contemporary moment in France is fascinating for the history of restoration. The state was finding itself responsible for a huge number of art works as a result of the confiscation of aristocratic and Church property and Napoleon's looting. The Parisian art and museum communities had to justify to a very skeptical Europe their ability to care for all this confiscated material. To respond, numerous museum commissions were appointed, including commissions on restoration. Among the appointees were a number of important restorers, chemists, and painters including the painter David.¹³ One of the committee members was Jean-Baptiste Pierre Le Brun (1748–1813), who was an art dealer, painter, critic, and husband of the painter Vigée-Lebrun. In 1794, demonstrating a true Enlightenment faith in chemistry, Le Brun invited French chemists to invent a new medium for retouching that would not discolor. Le Brun was on the committee charged with designing an examination for restorers. He thought that retouching should be judged six months after it had been executed to see if the colors had shifted and added, "This leads me to invite chemists, in order to pursue perfection in Art, to discover a way to ally dry pigments with a liquid that would replace oil, without oil's disadvantages which include rising to the surface and distorting colors by absorbing their brilliance."¹⁴

The search for stability led, in fact, to an increasing concern over retouching in oils. The early 19th-century art press praised Pietro Palmaroli (1778–1828), an Italian restorer working in Dresden, for using watercolor on Raphael's *Sistine Madonna*. His campaign was compared to an 18th-century effort where the retouching in oil had significantly darkened.¹⁵ We also find oil retouching cautioned against in restoration literature, a new genre that first appeared in the 19th century. The first books exclusively devoted to the restoration of paintings were detailed handbooks with bibliographies, discussions of stable pigments, precise descriptions of inpainting methods and materials, and multiple approaches to particular inpainting problems. The writers did recommend oil retouching since they felt oil paint was easy to manipulate, but they were deeply concerned about colors shifting.

When oil retouching was recommended, it was with caveats. Christian Köster (1784–1851), a German painter and restorer, wrote the first book on the restoration of paintings, *Ueber Restauration alter Oelgemälde*, in three small volumes published between 1827 and 1830. Köster believed that you could use oil safely if you used only the purest materials and retouched over absorbent chalk fills.¹⁶ Ulisse Forni (c.1820–1867), the official restorer for the Florentine museums, published the *Manuale del Pittore Restauratore* in 1866. He was completely against the use of oils on tempera paintings, but felt that they were the easiest to use on large losses in oil paintings.¹⁷

Whenever oils were recommended, furthermore, authors gave alternative materials and methods. Köster wrote that retouching with tempera and pigments ground in mastic

were both possible substitutes.¹⁸ Henry Mogford recommended retouching in oil in his 1851 *Hand-book for the Preservation of Pictures; Containing Practical Instructions for Cleaning, Lining, Repairing, and Restoring Oil Paintings*. He added, however, that

It has been suggested that the use of body colours with a water medium would be the safest to prevent the change of colours in the repairs. It might perhaps answer in the bright painted skies in landscape, water, and so forth, but it requires great artistic skill to manage its exact tone: there is no question of it being unchangeable, and this seems its only advantage. There is another method adopted in the restoration of damages, which consists of the use of powder colors with copal varnish, or varnish megilp.¹⁹

Finally, Giovanni Secco Suardo (1798–1873), a northern Italian restorer and professional rival of Forni's, wrote *Il Restauratore dei Dipinti* (1866–73). He described age testing a variety of drying oils, trying to find one that would not yellow. Since he did not succeed, he devised a drained oil inpainting system with a mastic/copal mixture as the medium. Secco Suardo felt that this system was very stable and wrote of it being unchanged on paintings he had treated twenty years previously. He acknowledged, however, that some of his colleagues did not approve of even drained oils. If one encountered this type of objection, Secco Suardo recommended tempera underpainting with only very thin drained oil glazes on top.²⁰

e) Specific Training for Retouching

As is surely becoming clear, by the end of the 18th century, restoration was emerging as a distinct profession. For example, the Danish painter Jens Peter Möller was sent in 1810 by the Royal Danish Academy of Fine Arts to study restoration for three years at the Louvre in preparation for becoming the first official restorer for the Royal Paintings Collection.²¹ One of the results of professionalism was that specific training and skills became required for inpainting. Although a restorer was, of course, still expected to be a good painter, new requirements demanded a range of virtues, from patience, to humility, to subordination of the ego to the work of art. More important, though, Pietro Edwards and the Louvre commissions considered knowledge of old master techniques essential.²² Jean-Michel Picault, a restorer and one of the commissioners, wrote, for example, that

The restorer's art and the painter's art are in no way similar...a painter who can produce a masterpiece, will ruin masterpieces by another artist in trying to restore them...The most famous painter will substitute his style for Raphael's...and the result of his retouching will be the creation of a monstrous work which will surely cause the painting to lose value...Successful restoration requires a specific course of preliminary study...The restorer, who studies every master and school is not prepared to be, and should not be prepared to be, like a painter with his own style. He has sacrificed his own ideas to submit to the ideas of another; he no longer exists for himself.²³

This relationship between understanding old master techniques and successful inpainting was refined in the 19th-century literature. Köster's book contained sections specifically on retouching tempera painting,²⁴ and in this context he included a long chapter on tempera technique by guest author Jakob Schlesinger, a restorer of early tempera paintings. The back of Köster's book even contained an advertisement for a translation of Cennino Cennini's book. Köster's approach was taken much further by Simon Horsini Déon (1812–1882), a restorer at the Musées Nationaux in Paris. The last section of his book, *De la Conservation et de la Restauration des Tableaux* (1851), was an overview of the techniques of European painting by school, country, and period with commentary on particular restoration problems and the best methods of approaching them.²⁵

Recommendations for studying chemistry began a bit later, in the 1820s. By the time Forni was writing in the 1860s, he recommended not only books on the chemistry of artists' materials (i.e., G. A. Chaptal's *La Chimica Applicata alle Arti*, 1820), but also technical publications such as the *Complete Handbook for the Color Manufacturer and Varnish Maker* (1850 and 1862).²⁶

f) Development of a "Less Is More" Principle

Despite (or perhaps because of) increasing professionalism, the 19th century was also the period of major restoration controversies. The most famous were the cleaning controversies at the Louvre and the National Gallery in London. Another contested area, however, was retouching, and conscious decisions were made to leave losses visible. Works of art were increasingly valued as historical documents, in part due to the rise of archaeology and the creation of national museums. Already in an 1830s restoration campaign of an Amico Aspertini fresco in Lucca, the local arts commission instructed the restorer to leave large lacunae visible if these areas could not be reconstructed accurately.²⁷ In the 1870s, the art historian Giovanni Battista Cavalcaselle (1819–1897) was responsible for restorations of art works belonging to the Italian State, and he consistently wanted structural stabilization only. In work on the Giotto frescoes at Assisi only neutral toning was allowed.²⁸ His 1877 regulations for restoration work undertaken by the State declared, "It does not matter if you recognize a restoration, in fact, you should be able to recognize it, since what is necessary is respect for the original work at least for works belonging to the State. A lie, even a beautiful lie, must be avoided. Scholars should be able to recognize in a restored picture what is original and what is new."²⁹ Around the same time and in a similar vein, the chemist Max von Pettenkofer (1818–1901) in a quest for a "scientific restoration" also wrote against retouching, saying that, "Whoever would treat a collection of documents — such as our picture galleries should be in the future for the history of art — in such a way that even the most trained and acute eye cannot recognize what is authentic and what is imitation, deserves prison or the galleys because they would be guilty of forging documents."³⁰

In response to writing and directives against retouching, the formulation of a "less is more" principle began to emerge. The authors of the 19th-century instruction books repeated this again and again. Köster wrote, "Retouching is the last step. The less work

necessary, the better. And if nothing is necessary, do nothing.” Horsin Déon stated, “The best restoration is that obtained by a light, transparent touch which allows the master to appear wherever original still exists.” Forni concurred, writing, “The best restoration is obtained from economic work which leaves intact all the original parts.”³¹ Finally, the director of the Louvre wrote an article on restoration at the museum in the 1860s and clearly stated reasons to avoid excessive retouching: “Our mission is to show the masters as they are, to honor them with their strengths and weaknesses...discreetly filling losses created by flaking paint without spreading color over the edges of the damage, this is all that restoration allows.”³²

g) Conclusion

There is a long history of paintings restoration in Europe. There is also a long history of discussions, both philosophical and practical, on approaches to restoration. We often think of retouching from the past as being sloppy, heavy handed, and unsympathetic to the painting, making wholesale changes for reasons of taste and marketability. In fact, there are many examples of this type of work, but this is not the whole story. I hope I have shown that there were sensitive approaches to retouching and sophisticated discussions about retouching. I think this knowledge provides a certain depth and perspective to our own work as conservators.

Author’s note: This article, “Retouching Paintings in Europe from the 15th through the 19th Centuries: Debates, Controversies, and Methods,” originally appeared in AIC Paintings Specialty Group Postprints, Vol. 16, 2003, pp. 13–23.

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ENDNOTES

- ¹ G. Vasari, *The Lives of the Artists*. Trans. Julia Conaway Bondanella and Peter Bondanella (Oxford: Oxford University Press, 1991), 269. The painting, actually on panel, is now in the National Gallery, London. Recent x-rays have shown that under the Christ Child attributed to Sodoma are two earlier versions painted by Signorelli. See T. Henry and L. Kanter, *Luca Signorelli: The Complete Paintings* (New York: Rizzoli, 2002), 175–6.
- ² One of Bottari's speakers quotes Vasari on Signorelli, Sodoma, and retouching, p. 242. The antiquarian Luigi Crespi wrote in the mid-18th century, "It is better to see an old painting consumed and ravaged by time because at least the little that you see is pure and chaste... (è preferibile vedere un antico dipinto, dal tempo consunto e corroso, poiché almeno quel poco che vede, vergine il vede ed illibato, che da mano oltre il dovere coraggiosa (per non dire di più) ritoccato e compito, discordante veggendolo, crudo e disformato)." G. Bottari, *Lettere pittoriche*, 1754–73, quoted in M. G. Vaccari, *Restauro a Firenze nel Settecento: Tra Teoria e Prassi. Kermes* (1989), Vol. 2, No. 4, 39–44. Filippo Baldinucci wrote in *Notizie de' Professori del Disegno* (revised 1767 ed.) that Guido Reni "grew furious when he heard that any painter had dared to touch paintings by the old masters, even if torn and ruined; this was something that he would never undertake. (Dava nelle furie quando sentiva che alcun pittore avesse ardito di toccare pitture di antichi maestri, tutto che lacere e guaste; cosa che egli non volle mai fare)." Quoted in U. Forni, 1866. *Mannuale del Pittore Restauratore*. (Florence: Successori le Monnier), 9.
- ³ A. Conti, *Storia del restauro o della conservazione delle Opera d'Arte* (Milan: Electa, 1988), 12, and G. Ragionieri, *Simone o non Simone* (Florence: La Casa Usher, 1985), 26.
- ⁴ G. P. Bellori's *Vita di Carlo Maratta* (1731) discussed the painter's use of pastels in the 1693–94 restoration campaign: "with a little lapis and pastel he perfectly restored the contours and the color (con un poco di lapis e di pastel è perfettamente ristorato i contorni ed il colore). According to the writers of the *Encyclopédie*, Maratta did this so that his retouching could be removed if a more worthy restorer were found:

Carlo Maratta having been chosen the first painter in Rome and working on the ceiling of the Farnese Palace, on which Raphael had depicted the story of Psyche, wanted to retouch only in pastel so that, he said, if one day someone was found who was more worthy than myself to link his brush with that of Raphael, he could erase my work and substitute his own. (Carle Maratte ayant été choisi comme le premier peintre de Rome, pour mettre la main au plafond du palais Farnese, sur lequel Raphaël a représenté l'histoire de Psyché, il n'y voulut rien retoucher qu'au pastel, afin, dit-il, que s'il se trouve un jour quelqu'un plus digne que moi d'associer son pinceau avec celui de Raphaël, il puisse effacer mon ouvrage pour y substituer le sien).

Jaucourt. 1795. *Ecole Romaine (Peinture)*; Maratte, (Carle). In *Encyclopédie Raisonné des Sciences, des Arts, et des Métiers*, eds. Diderot and d'Alambert, Neufchastel. Vol. 5, 330.

- ⁵ Bellori wrote in 1695 that Maratta was

embarrassed, needing on the one hand to obey the pope and on the other not having the impudence to erase even one line of such a great man...He came up with a subtlety to obey the pontiff and to leave the work intact. He took chalk pastels ground in gum and with them painted in such a manner that it would remain durable a veil over the breast of the Virgin as the pope wanted; and whenever some one wanted to remove it with a sponge, the original color would return (confuso, dovendo da un canto ubbidire il papa, dall'altro non avendo ardire di por mano e cancellare né meno un tratto di sì gran uomo,... pensò ad una finezza d'ubbidire al pontefice e lasciar l'opera intatta. Pigliati dunque colori di pastelli di terre macinate a gomma, con essi dipinse il velo sopra il petto della Vergine come voleva il papa, in modo che rimane durabile; e quando si voglia torre con la sponga, ritorna il color di prima). Quoted in Conti, p. 108.

Bottari gives these words to Maratta in his *Dialoghi*:

Maybe with so sacred an authority [a text by St. Cyprian] I would have been able to stop the pope and induced him to relieve me of doing this thing which worried me for a month; however, without telling the pope anything concerning what I had decided to do, I made that bit of veil with chalk pastels ground in gum so that it could be removed at any time (forse con un autorità così veneranda avrei fermato il Papa, e indottolo a dispensarmi a far cosa, che mi tenne un mese strubato; benchè senza dirgli niente di come avea pensato di fare, condussi quell poco di velo con pastelli di terra, macinati a gomma, sicchè si può tor via ogni volta, che un vuole), 245.

- ⁶ S. Bergeon, "Quelques aspects historiques à propos de restaurer ou dérestaurer les peintures murales." In *Les Anciennes Restaurations en Peinture Murale* (Paris: International Institute for Conservation of Historic and Artistic Works/Section Française, 1993).
- ⁷ Articles in *Ristaurazione delle Pubbliche Pitture Assentita col Decreto del Sento li 3 Settembre 1778*. Quoted in Conti pp. 164–6, 346. Also, Wolfgang Goethe discussed Edwards' studio at SS. Giovanni and Paolo, writing,
- The institute has the advantage that all the experimental findings made in this art [of paintings restoration] are collected and preserved. The methods and technique of restoring each particular picture are very different, according to the various masters and the condition of the painting itself...The condition of every picture is first of all examined and assessed before it is decided what to do with it.*
- Goethe, W. 1790. "Early Paintings and Recent Restorations in Venice." In *Goethe on Art*, ed. J. Gage (Berkeley: University of California Press, 1980), 124–9, 128.
- ⁸ Article XIV of the rules set down for the restoration of the paintings belonging to the Venetian State: "Finalmente s'imegnano di non usare sui quadri ingredienti che non si possano più levare, ma ogni cosa necessariamente adoperata sarà amovibile da quelli dell'arte ogni qual volta si voglia." From *Ristaurazione delle Pubbliche Pitture Assentita col Decreto del Sento li 3 Settembre 1778*. Quoted in Conti, 165.
- ⁹ Pietro Edwards wrote specifications for the restorer Antonio Florian for the 1816 work on Titian's *Assumption of the Virgin*. He stated, "The above mentioned restorations shall be made upon a ground of gesso, tempered with weak *colla di ritagli* and the parts to be repainted, as well as the indispensable reparation of portions of the old colour, shall be executed with varnish, the use of oil being absolutely excluded..." The bill of expenses accompanying the contract indicated that the prescribed varnish in this case was mastic. Contract transcribed by M. Merrifield, *Original Treatises on the Art of Painting*, reprint of 1849 edition (Dover, New York, 1967), 876.
- ¹⁰ Conti, 187.
- ¹¹ "Direbbesi restaurare, o resarcire, o ridurre a bene essere, il raccomandare che si fa qualche volta alcuna piccola parte di pittura anche d'eccellente Maestro che in alcun luogo fusse scrostata o altrimenti guasta, perché riesce facile a maestra mano; e alla pittura non pare che altro si tolga che quel difetto, che, quantunque piccolo, par che le dia molta disgrazia e discredito. Molti però, non del tutto imperito dell'Arte, sono stati di parere che l'ottimo pittore né punto né poco si ritocchino, anche da chi si sia, perché, essendo assai difficile che o poco o molto, o subito o in tempo, non si riconosca la restaurazione per piccola che sia, è schietta va sempre accompagnata con gran discredito." F. Baldinucci, *Vocabulario Toscano dell'Arte del Disegno* (Florence, 1681).
- ¹² "Bien des gens se mêlent de repeindre les endroits endommagés des tableaux, dans le dessein de les réparer; mais rien si difficile à exécuter de manière que la nouvelle couleur ne fasse pas des taches. On est obligé de salir les couleurs que l'on couche, pour trouver le vrai ton de l'ancienne; l'huile que l'on emploie noircit et produit ces taches. Il faudroit repeindre à détrempe, pour ne pas s'exposer à cet inconvénient; ce seroit le moyen le plus sûr, si la détrempe pouvoit s'unir intimement avec la peinture à huile. On lit dans l'Ouvrage de Messieurs de Caylus et Majault sur la peinture à l'encaustique e à la cire, page 131, que les couleurs préparées pour la peinture à la cire, conviendroient beaucoup mieux que les couleurs à l'huile pour restaurer les vieux tableaux. M. le Lorrain, peintre de l'Académie, l'a essayé avec un succès singulier. Il a repassé des vieux tableaux de cette manière, de façon qu'il est presque impossible de retrouver les endroits réparés et repeints." A-J. Pernety, *Dictionnaire Portatif de Peinture, Sculpture et Gravure: Avec un Traité Pratique des Différentes Manières de Peindre*, reprint of 1757 edition (Geneva: Minkoff Reprint, 1972), 499.
- ¹³ The early committee work defining the proper care and restoration of paintings did not stave off controversy. In 1797, a painter/politician named Anthelme Marin accused the Louvre of storing paintings in stairwells and humid rooms and of damaging paintings through incompetent restoration. The Directory ordered an official inquiry and appointed a committee of 31 artists and experts to examine Marin's charges. The report was an official government publication: *Musée Central des Arts: Pièces Relatives à l'Administration de cet Établissement*. Two years later rumors again circulated of misconduct at the Louvre, and the administration responded by appointing four experts from the National Institute to supervise the restoration of Raphael's *Foligno Madonna*. The structural work was done by François-Toussaint Hacquin and the cleaning and retouching by Mathias Roeser. The supervising experts were the painters François André Vincent and Nicolas-Antoine Taunay and the chemists Claude-Louis Berthollet and Louis-Bernard Guyton de Morveau. See A. McClellan, "Raphael's *Foligno Madonna* at the Louvre in 1800: Restoration and Reaction at the Dawn of the Museum Age." *Art Journal* (1995) 54(2): 80–5.

- ¹⁴ “Ceci me porte à inviter les chimistes, pour la perfection de l’art, à faire en sorte de découvrir le moyen d’allier la poudre des couleurs avec un liquide qui remplace l’huile, sans avoir les mêmes inconvénients, qui sont de pousser à la superficie et de dénaturer les couleurs en absorbant leur éclat.” G. Émile-Mâle, 1956. “Jean-Baptiste-Pierre Le Brun (1748–1813): Son Rôle dans l’Histoire de la Restauration des Tableaux du Louvre.” In *Paris et Ile-de-France, Mémoires* 6:371–417, 402.
- ¹⁵ C. Wagner, *Arbeitsweisen und Anschauungen in der Gemälderestaurierung um 1800*. (Munich: Callwey, 1988), 28.
- ¹⁶ C. Köster, *Über restauration alter Oelgemälde* (Heidelberg: Christian Friedrich Winter, 1827–30) Vol. 1, 27–8 and Vol. 3, 16–17.
- ¹⁷ Forni, 88–9 and 143–5.
- ¹⁸ Köster, Vol. 3, 17–18.
- ¹⁹ H. Mogford, *Handbook for the Preservation of Pictures: Containing Practical Instruction for Cleaning, Lining, Repairing, and Restoring Oil Paintings* (London: Winsor and Newton, 1851), 63–4.
- ²⁰ G. Secco Suardo, *Il Restauratore dei Dipinti*, written between 1866–73 (Milan: Ulrico Hoepli, 1918), 500, 536.
- ²¹ M. Scharff, “Insight into Early Nineteenth-Century Painting Conservation in Denmark.” In eds. A. Roy and P. Smith, *Tradition and Innovation, Advances in Conservation, Contributions to the Melbourne Congress 10–14 October 2000* (London: IIC, 2000).
- ²² Edward’s thoughts on this subject are recorded in *Progetto per una Scuola di Restuaro* written after 1819. See Conti, 187.
- ²³ Picault was criticizing the idea that painters only were capable of directing the national museum. The text in French is as follows:
- Observe, au contraire, ledit Picault, que l’art de peindre et celui de restaurer ne se ressemblent en rien; que le peintre qui peut produire un chef-d’oeuvre, gâtera les chefs-d’oeuvre d’un autre, en voulant les restaurer; que dans un tableau malade et défectueux, le plus célèbre peintre substituera sa manière à la manière de Raphaël, des Carrache et de Titien; qu’il ne résultera de sa retouche qu’un assemblage monstrueux dont l’effet assuré sera de déprécier le tableau...que pour restaurer avec succès, il faut une étude particulière de preparation première, d’opération aussi utile qu’indispensable, de même qu’une habitude consommée des manières et préparations des maîtres de chaque école qu’il s’agit de retrouver, si elles sont perdues, et de conserver, si elles ne sont qu’altérées, et rendre, en un mot, jusqu’aux nuances les plus légères qui caractérisent, et chaque école et chaque maître...le restaurateur qui étudie tous les maîtres et toutes les écoles ne s’est point fait, et n’a point dû se faire comme le peintre, une manière à part. Il a fait le sacrifice de ses propres idées pour se plier aux idées d’un autre; il n’a plus d’existence à lui...*
- J-M. Picault, *Observations de Picault, Artiste Restaurateur des Tableaux à Ses Concitoyens sur les Tableaux de la République* (Paris: Imprimerie de H.J. Jansen, 1793), 37–8.
- ²⁴ Köster reminded restorers to take into account tempera’s delicateness of color, fineness of brushstrokes, and undermodeling of flesh tones, adding, “In truth tempera painting has reached such a degree of delicacy that whoever sees it must be astonished if he only knows oil painting” (Wirklich hatte die a tempera Malerei einen Grad der Feinheit und Delicatesse erreicht, worüber derjenige erstaunen muss, welchem von jeher nur die Oelmalerei im Sinne gelegen). Vol. 2, 18.
- ²⁵ For example, early Italian paintings tended to be in good condition since they were executed with sound techniques and often remained at the site for which they were commissioned. The problems encountered were usually problems with the supports or the paint layer covered with centuries of dirt, 145–6. S. Horsin-Déon, *De la Conservation et de la Restauration des Tableaux*. (Paris: Chez Hector Bossange, 1851), 127–214.
- ²⁶ Forni himself wrote a long section on pigments, describing production, properties, stability, and notable uses by certain artists, 285–427.
- ²⁷ Conti, 246.
- ²⁸ D. Levi, *Cavalcaselle, il Pionere della Conservazione dell’Arte Italiana* (Turin: G. Einaudi, 1988), 337–9, 347.

²⁹ “Poco importa che si conosca il restauro, che anzi lo si dovrebbe conoscere, ma quello che è necessario si è che sia rispettato l'originale della pittura almeno nelle opere appartenenti allo Stato. La bugia, anco detto con bel garbo deve essere tolta di mezzo. Lo studioso potrà conoscere da un dipinto restaurato a questa maniera quello che è originale da quello che è nuovo...” Levi, 350-1.

³⁰ From *Über Ölfarbe* 1870, quoted in H. Althöfer, *La Questione del Ritocco nel Restauro Pittorico*. Italian translation of 1974 German text (Padua: Il Prato, 2002), 20-1.

³¹ “Die malerische Herstellung macht allemal den Beschluss. Je weniger Einwirkung dabei nötig ist, desto besser, wo keine nötig ist, bleibt sie hinweg” (Köster, Vol. 3, p. 24). “La meilleure des restaurations est celle qui est obtenue par un travail léger et transparent qui laisse le maître apparaître partout où il existe encore” (Horsin-Deon, 116). “Il restauro migliore è quello ottenuto da un lavoro economico, che lascia intiere tutte le parte dell'originale” (Forni, 153).

³² “Notre mission, encore une fois, est de montrer les maîtres tels qu'ils sont, de les vénérer avec leurs qualités et leurs défauts... Retoucher en quelque sorte avec une aiguille les trous qui feraient une tache insupportable, combler discrètement les lacunes occasionnées par la chute des écailles sans étaler la couleur sur les bords de la cicatrice, voilà toute que la restauration promise.” F. Villot, “Restauration des Tableaux du Louvre.” In *Annuaire des Artistes et des Amateurs*. (Paris: Jules Renouard, 1860), 265–274, 271.

3. Tradition of Retouching Practices in America

Retouching, compensation, or inpainting as a professional practice did not fully take root in America until well into the 19th century. Prior to that, there are 18th- and early 19th-century references to restoration by artists and teachers who restored, retouched, or repainted works, but they did not distinguish themselves solely as professional conservators or restorers until later.¹ Even then, the practice seems to have been on an individual basis. Several known itinerant professionals were contracted by various new museums as they sprung up around the United States in the mid- to late 1900s. The practice of conservation in America, or more specifically in this case of retouching or inpainting, was intrinsically tied to Europe.

a) Late 18th Century and First Half of the 19th Century

Charles Willson Peale and other artists of the 19th century treated their own pictures, often attempting to correct problems with defective materials. For instance, Peale makes mention of paints that have faded and are too cool.² Benjamin West, Thomas Cole, John Trumbull, and Rembrandt Peale all seemed to be addressing severe paint cracking, possibly from the use of asphaltum. References indicate that artists were overpainting these areas in an effort to obscure the problematic traction crackle.

In 1806, Benjamin West retouched some of his earlier paintings, apparently because of problems with cracking. On one of these paintings, West's retouching and his second inscription clearly go over and into a pattern of wide traction crackle, indicating that concealing the disfiguring crackle was the likely motivation for the retouching.³ In the late 1820s, both Thomas Cole and John Trumbull were doing the same and for the same apparent reason.⁴

Between 1835 and 1840, Rembrandt Peale mentions having retouched his paintings three or four times during tours of the country.⁵ In an early mention of inpainting as we know it, around 1849–52, he stated in his *Notes of the Painting Room*,

I witnessed the mode practiced by a distinguished Professor at Florence repairing the Paintings belonging to the National Gallery. After cleaning the picture, the Cracks were neatly filled up with putty. When this was dry, the white lines were coloured by mixing the Colours, which were in impalpable powder & of suitable tints, with Copal Varnish — a little difficult to use but preferable to oil paints, which grow darker; with this varnish little or no change takes place.⁶

Hudson River School artist William Rickerby Miller used a mastic and gum-water mixture.⁷ Rembrandt Peale chose a copal varnish medium for inpainting.⁸ Both Miller and Peale criticized the use of oil paint for inpainting because it stained and darkened over time.

In another passage from *Notes of the Painting Room* (1849–52), Rembrandt Peale implies that repairing a painting involves improving it:

A good artist may submit to be employed to repair a bad picture, which comes from his hands with beauties that were not conceived by the Original Painter; not only in the retouching of forms, painting out defective parts, but with the magic results of toning & glazing. I have thus seen the celebrated Wertmuller repairing & improving (if I may venture the opinion), a damaged Wouvermans belonging to Wm. Hamilton of the Woodlands; and I think, in my own experience, I have several times been similarly successful.⁹

b) Second Half of the 19th Century

Frederick Church was documented as having retouched his paintings. In 1885, he was contacted by William Wilson Corcoran¹⁰ that his *Niagara* (1857) had vertical streaks through the sky; he responded that the “obnoxious” streaks were the result of the Winsor and Newton canvas where they used sugar of lead (lead acetate drier) to speed the drying of the ground layer. He said that the Winsor and Newton “Roman” canvas had these problems and that many years before he had repainted the sky of *Niagara* to cover streaks. He recommended taking the painting to Mr. Oliver in New York City to repair.¹¹

But a restorer had more respect for artists’ intent. George Howorth, a restorer and dealer working in the Boston area, wrote a book in 1859 titled *Restoration of Oil Paintings: With a Few Practical Hints to the Owners of Pictures*. Howorth complained that other painting conservators “daub, either leaving a picture with hideous patches of new paint, or proceeding, step by step, in the vain attempt to secure something like uniformity until they have actually covered up the last square inch of the original handiwork.”¹² In contrast, he did not “paint over an old picture for the purpose of restoring it, unless it be in places where the original paint is gone.” Howorth and his son John are known to have treated a number of pictures belonging to James Jackson Jarves, the New England-born collector, whose collection became the foundation of Yale University’s early Italian painting collection. In a broadside, dated 1867, an endorser praises Howorth for being a “scientific man, aware of the latest developments in the restoration of paintings.”¹³

Jarves’ collection of early Italian paintings was purchased by Yale University and became the first important collection of early Italian paintings in America. Jarves himself apparently restored some of these works, as did a Greek restorer, Georgio Mignati, although details are sketchy.¹⁴ He also weighs in on the debate over cleaning and retouching practice. In his 1861 book *Art Studies*, Jarves criticizes restorers of the day in this way: “Inadequate to replace the delicate work he has rubbed off, the restorer, to harmonize the whole and make it look fresh and new, passes his own brush over the entire picture, and thus finally obscures whatever of technical originality there might have still been perceived after the cleaning...Each restoration displaces more of the original, and replaces it by the restorer” and “[t]he true occupation of the restorer is to put the work given to him in a condition as near as possible to its original state, carefully abstain-

ing from obliterating the legitimate marks of age, and limiting himself to just what is sufficient for the actual conservation of the picture.”¹⁵ By 1869, Jarves had softened his criticisms of 1861 by stating that the issues he had discussed were “more applicable to past than to present” and that “systems for a reform, founded on true artistic principles, [were] everywhere beginning.”¹⁶

In 1869, Jarves published *Art Thoughts*, in which he described three modes of restoring pictures: “First, the only sensible one of such local repairs as are necessary to confine it to its original canvas or panel, or to transfer it bodily to a new one, leaving the age of the picture to speak for itself, and every drag of the artist’s brush intact.” The second was “the foolish mode of wholly repainting the original surface in various ways, the worst of which is by stippling, to the utter loss of those conditions of the painting which were a guarantee of its authenticity, and replacing them by the rarely better and almost invariably worse treatment of another hand.” And the third, “the dishonest method of restoration, done with the sole intent of deception. The original picture in this instance is either of no merit or it has been entirely ruined, with but few touches of a bare outline remaining. In the former event the intention is to make the work of an inferior hand or an old copy appear to be a veritable original of a great master, and, in the latter, to pass off the wreck of a fine picture for a perfect, intact one.”¹⁷

In 1878, Jarves wrote an article that appeared in the *New York Times*, in which he expressed an understanding of both sides of the debate over restoration; those who valued the early Italian paintings as aesthetic, whole objects, and those who viewed them as artifacts “best appreciated stripped of the accretions of time, dirt, varnish, and repainting.”¹⁸ He clearly understood both sides of the debate, advocating restraint in the face of works that had achieved “harmony with age, repaints and discolored varnish”¹⁹ and yet he knew that every museum had paintings that would benefit from the removal of dirt and retouching, even if those paintings were to suffer an aesthetic loss from the process.²⁰ Jarves was aware of the professional practice of restoration, advocating the use of “varnish colors, because it would be easy to remove.”²¹

c) First Half of the 20th Century

While the debate over retouching continued, the 20th century saw the beginning of organized discussions about the conservation field in general and, more specifically, about inpainting. Some artists continued to feel they alone were qualified to effectively retouch works of art, leaving structural work and other stabilization to the restorer or craftsmen. The Fogg Art Museum at Harvard University was the first center for discussion of many conservation issues, including retouching. *Technical Studies in the Field of Fine Arts* was published by Harvard University, from 1932–42, serving as a forum for these and other discussions. Other important voices and practitioners emerged, both in the United States and abroad, as the century developed.

Starting in 1908, the New York City Business Directory listed Stephen Pichetto “as a restorer with an establishment on East 28th Street.”²² Pichetto worked as a consultant

to the Metropolitan Museum of Art as well as the National Gallery in Washington, but he maintained a successful private practice, with clients as distinguished as Mellon, Lehman, Heinemann, Dale, Walters, Warburg, Lewisohn, and Guggenheim. He was also connected with Joseph Duveen, but most notable was his association with the collectors Samuel and Rush Kress, with whom he had a relationship for more than twenty years (until his death in 1949), advising them and treating many works in their collection.²³ Pichetto and his studio, in which he employed at least three other restorers, were exceedingly influential in the art world of the time. “Declaring that he ‘did not want to camouflage the damaged portions rather to retouch the missing portions with local color,’ Pichetto relied heavily on his three inpainters whose method was to apply colors in Winsor and Newton watercolors or in egg tempera, coat with French varnish (shellac), and glaze with dry colors in dammar varnish. Inpainting palettes included only seven colors, and varnish was done with dammar.”²⁴

In 1914, Henry Ward Ranger, an American Tonalist painter, said,

*The mechanical part of the work, such as relining, transferring, removing varnishes, &c., should be done by one who has thorough knowledge of, and continual practice in, these processes. Such a man soon becomes more adept in the art than opportunity permits the painter to be. But, such parts of the work which call for a higher artistic sense, such as reglazing, retouching, etc., should be done only under the supervision of the best available artist of the school to which the picture is closest related. I am confident that no artist would withhold his services from such a worthy cause.*²⁵

In other words, it was acceptable to leave structural work to another professional, but any retouching required an artist.

The artist Abbott Handerson Thayer had the most negative appraisal of retouching. In 1916, painting at the Freer, he left two decisive inscriptions on paintings: “This picture is never to be retouched — not one pin-point.”²⁶

Harry Augustus Hammond Smith — who was a restorer for the Metropolitan Museum of Art, Chicago Art Institute, Cleveland Museum of Art, Minneapolis Art Institute, Worcester Art Museum, the New York Historical Society, the Frick Collection, the Morgan Library, Harvard, and the Yale University Art Gallery — apparently treated twenty-seven paintings in the Jarves Collection in the summer of 1915. He was reputed to be the “first man in this country to raise the work of restoring paintings to an art in itself, second only to that of the original genius.”²⁷ Handwritten condition/treatment notes on Yale’s collection indicate insight and sensitivity of the work. He clearly treated paintings in a thoughtful, restrained manner, confining his retouching to scratches and minor losses where possible. He makes reference to “spots on the draperies and in the background which required retouching.”²⁸ But where there was tremendous loss (Yale’s Botticelli), he clearly felt the need to retouch more extensively to restore aesthetic integrity. He wrote:

The color had apparently been intentionally scraped off from the old ground, the remains of this color showing that it had been done with a sharp pointed instrument of some kind....The original drawing, the outlines, could be seen on the priming of the panel under a white ground and these where distinguishable were followed in restoring the hands. The darker shadow in the child's left arm was also damaged by these same scratches. The sky was also much damaged on the right side requiring much retouching.²⁹

Little conservation work was done to the Yale Collection between 1916 and 1949, except specific projects carried out by itinerant restorers.

In early 20th-century Italy, Cesare Brandi, the first director of the *Istituto Centrale del Restauro*, founded in Rome in 1939, codified a philosophy that retouching should attempt to integrate the work of art as a whole, but remain visible when viewed from near: "Restoration must aim to reestablish the potential unity of the work of art, as long as this is possible without producing an artistic or historical forgery and without erasing every trace of the passage of time left on the work of art."³⁰ His ideas gave rise to modern theories of restoration. Paul Philippot, the former director of the International Centre for the Study of the Preservation and the Restoration of Cultural Property (ICCROM) in Rome, an art historian by training and an influential member of the conservation community with a comprehensive vision of conservation issues, made Brandi's *Teoria del Restauro* accessible to professionals outside Italy. While conservators were developing and espousing theories and practices, it was the 1950s that saw the development of the profession as a distinct tradition in the United States, not merely an appendage to art criticism and the like.³¹

Paolo and Laura Mora, the most notable specialists in the philosophy and techniques of Cesare Brandi, described it as follows:

Tratteggio is a system of small vertical lines averaging one centimeter in length. The first lines, which indicate the basic tone of the retouching, are placed at irregular intervals equal to the width of one line. Next, these intervals are filled with a different color, and then with a third color, in order to reconstitute the required tone and modeling by means of the juxtaposition and superposition of colors which are as pure as possible. Each line in itself should be of weak intensity, the desired intensity of the whole being obtained by the superposition of glazes of transparent lines rather than by strength of color, which would cause the retouching to lack the vibration indispensable for a good integration.³²

The Department for Technical Studies at the Fogg Art Museum, Harvard University, was founded by Edward Waldo Forbes in 1928. He, along with George L. Stout, Rutherford J. Gettens, and Alan Burroughs, as well as others, developed general conservation standards, new methods of treatment, and the theoretical foundations for treatments.³³ R. Arcadius Lyon, painting restorer at the Fogg, introduced visible inpainting

techniques in the United States. In the mid-1930s, Forbes states that all compensation should be noticeable. In areas of loss, he imitated the original tone and modeling with hatch strokes similar to those nearby. Because the tone was so accurately matched, the result was something one would not notice at first glance, but because the strokes were less fine and had less subtle transitions, the restored areas could easily be noticed by the observant viewer.^{34,35}

Lyon discusses a concern related to wax lining that points to the use of watercolor for retouching: “The use of wax for lining presents another difficulty for the restorer, should he desire to retouch some of the wax infiltrated areas with water color. There is a grave danger of the peeling off of the retouchings, even if one has been successful in obtaining a seemingly good adhesion for the colors over wax.”³⁶ Lyon also discusses the use of UV light as an aid to restorers to determine the extent of retouching, often when they are so skillfully done as to be nearly invisible to the eye in normal light.³⁷

Maximilian Toch in his 1931 treatise, *Paints, Painting and Restoration*, distinguishes repainting from inpainting per se by writing,

*It has been conceded by those who know, that no painting must ever be repainted but that the restoration should be confined to the removal of extraneous substances which have collected on the surface and after this has been done, the picture is varnished. Yet there are noteworthy exceptions to this practice, such as pictures which have suffered from fire, pictures that have been neglected to such an extent that the paint film has dried and fallen off in places, and these must be restored by repainting the damaged parts. Under circumstances like this the restorer is warranted in filling in these bad spots and restoring the picture back to its artistic condition. But the average painting, which has not been partially destroyed or damaged, must under no circumstances be repainted, otherwise the work of the master is altered and interfered with.*³⁸

By the 1930s and early 1940s, the debate was fully articulating itself. George Stout, who represented the United States at the International Conference on the Examination and Conservation of Works of Art³⁹ described four procedures for resolving damages on paintings:

One way, and much the easiest, is to do nothing at all. The painting, though it may be much changed by overpaint, is left alone and untouched. A second way is to remove from the original paint any crust of darkened varnish or overpaint that would cloud or hide it and to stop there, the blemishes left to appear as they may. A third is to put into blemished areas tones that do not make so sharp a contrast as the losses themselves with what is adjacent. A fourth is to renovate the whole thing, to make a new painting out of an old one. In this procedure signs of age are covered over, dents and cracks are

*filled, and the original paint serves merely as a kind of tonal reference for the new coatings that are laid on it.*⁴⁰

Stout believed that the first and fourth choices do not give the public a fair chance to see the painting itself. In this context, he refers to the eminent art historian, Max Friedländer:

*What shall the restorer do about the sadly fragmentary condition which he has, of course, not produced, but which he has brought to light? If he does nothing, he runs the risk of being accused of damaging the work and diminishing its value. Dare he replace what is lost by filling in and repairing?... The work of art is a document for the scholar, a source of pleasure for the amateur and an object of value to the owner. That the scholar will answer with a sharp "No" there can be no doubt. In his eyes, every restoration that goes beyond cleaning, preserving and uncovering is a piece of counterfeiting—whether successful or not...He wants to see as much as has been preserved of whatever the artist created...The connoisseur judges from a less firm point of view...He...fears that faulty spots, holes, conspicuous defects and disturbances of the continuity may spoil his enjoyment of it. In this dilemma, [he can] probably recognize the right of the restorer to fill in and repair, providing that he works in the spirit of the old master and is able to recreate what is no longer there. The task is technically, and from the point of style, unsolvable. Memling worked with certain pigments and materials; the restorer with others. And even if the restorer could proceed with exactly the same technique as Memling, he would still not be in a position to repair what is preserved of the original because time has been at work on it since Memling. That which is made is never exactly like that which has grown.*⁴¹

George Stout goes on to explore what works well, using the second and third outlined procedures. He acknowledges that the issues of compensation are complex in nature and vary with the size and scope of the loss. He suggests that smaller losses, though great in number, may be less disturbing than larger losses, which interrupt the overall visual effect of the work. Stout, working with Alfred Jakstas and consulting with Morton Bradley,⁴² describes various losses and their impact on surrounding originals. He also comments that solutions might be differently appropriate, depending on the setting (public or private) for the work of art.

In 1942, Helmut Ruhemann put forth a procedure for examination of works of art and made this observation: "Experience has shown at least one advantage of retouching."⁴³ He said this in the context of one's interest in truly understanding the technique of the artist, feeling that the technique of retouching should align with the technique of the artist and the period in which the work was painted. Once the use of ultraviolet light came into common practice for detecting retouching, Ruhemann felt that what had been viewed as an unethical practice of invisible retouching could no longer be viewed as such. He was explicit in his description of his materials and techniques: "The sur-

face [of the fill] should be slightly lower than that of the surrounding paint to allow for the thickness of the inpainting...Inpainting medium should look and behave like the original medium, but must not darken with age.”⁴⁴ He appears to have used tempera for retouching⁴⁵ and practiced invisible retouching, citing three important attributes necessary to successful imitation of artistic technique:

1. Luminosity: imitation of the surface to reflect light, as if holding it within.
2. Cool transitions: light paint over dark paint, the “turbid medium effect.”
3. Texture: on every painting, depending on the direction of brushstrokes and viscosity of each paint layer.⁴⁶

The word *inpainting* is used for the first time in an American source by Richard Buck and George Stout.⁴⁷ They define it as “compensation of losses with no new paint put over that which is old and original.”⁴⁸ *Inpainting* is distinguished from *overpainting*, which goes “beyond mere compensation in areas of loss”; overpaint may have a “great deal of free invention.”⁴⁹ Buck and Stout discuss how poor execution of the inpainting, even when confined to losses, can obscure the beauty and fine handling of the original. Buck and Stout believe that the critical question in the discussion of retouching is whether the present condition of a work of art reflects the artist’s intent, or whether his idea has been “marred or destroyed.” This has to do with distinctions to be found between paint put on by the artist and that of the restorer.⁵⁰

William Suhr — who was conservator at the Detroit Institute of Art from 1927 until 1945, who worked simultaneously at the Frick Collection in New York from 1935 to 1977, and who was conservator to many other museums and private clients⁵¹ in the 1940s—took photographs after cleaning and prior to retouching. He wrote, “Restorations should preserve the original and attenuate losses in a manner that will permit the observer’s eye to pass over gaps in the paint without distress. It is difficult to define techniques to achieve this end. Each undertaking requires a different method and ultimately success will depend upon the craftsman, his native ability, his experience and, especially his understanding of and sympathy for the style and quality of the original.”⁵²

Mario Modestini earned an international reputation for, among other things, exquisite, imitative retouching. His career spanned more than seventy years and the records of his complete or full restorations became part of the individual paintings and institutional records.⁵³ Modestini employed “a logical process of perfect retouching, always respecting the original,” showing that one “can recover the original detail without invention, falsification or overpainting.”⁵⁴ “In 1948, the Samuel H. Kress Foundation in New York called on Mario Modestini to conserve its vast collection of Old Masters.”⁵⁵

d) **Second Half of the 20th Century**

The second half of the century brought with it tremendous development in the field of conservation and the training of professional conservators. Discussions about retouching were in the forefront of concern. Conferences that probed research into materi-

als, philosophies, and techniques were exceedingly important, as controversy was also ubiquitous.

At Yale University, mid-century brought the inception of a campaign of restoration, using “clear, philosophical guidelines”⁵⁶ that dictated honest presentation, without the encumbrance of repaints. Working with Andrew Petryn (a graduate of the Yale School of Art who trained briefly in restoration at the Fogg, the Boston Museum of Fine Arts, and the Metropolitan Museum of Art), Charles Seymour Jr. directed a campaign of “modern” conservation practice. In 1952, the Yale Art Gallery mounted a small exhibition of thirteen recently restored works. A small, accompanying catalog titled *Rediscovered Italian Paintings* was published, and the *New Haven Register*, the local newspaper, reported that many aids of science were employed during the project. Each painting was x-rayed and then subjected to ultraviolet and infrared light to determine original paint, the extent of past damage, and the necessary steps for restoration. Retouches done after revarnishing were meant to be visible and reversible.⁵⁷ After the 1952 exhibition, the project continued under Seymour’s direction, but the philosophy continued to evolve. When Antonio Pollaiuolo’s *Hercules and Deianira* was sent for conservation to the Museum of Fine Arts in Boston, it was returned cleaned and retouched, supposedly according to the 1951 model, but in actuality, three separate systems of retouching were employed: invisible retouching on Nessus’s arm, a system of crosshatching on a band of loss in the center, and simple toning and speckling on a larger loss. No treatment record is extant, but in 1961 Seymour spoke at the Princeton sponsored symposium, “The Aesthetic and Historical Aspects of the Presentation of Damaged Pictures,” where he explained his restoration policy, presenting four pictures from Yale and describing the method aimed at doing the minimum needed to preserve the visual unity of the artwork.⁵⁸ Sheldon Keck, long-time painting conservator at the Brooklyn Museum who was subsequently director of the New York University’s conservation training program, sharply criticized Seymour for his views. But the campaign continued until 1971, shortly after the publication of a catalog of the collection. Many of the paintings were, in the end, left unretouched.

In 1959, Modestini, in collaboration with the National Gallery of Art and Dr. Robert Feller, began testing synthetic retouching media. PVAc AYAB was chosen as the best; Modestini felt that its low glass transition temperature indicated greater longevity.⁵⁹ He had devised a system for manipulating plastic and, after performing a series of natural aging tests, he was fairly confident that it would stand the test of time. “In fact, this restoration technique has not altered in over fifty years...and its effects are still easily reversible.”⁶⁰

Shortly after a fire at the Museum of Modern Art, in 1958, a conservation department was established. Jean Volkmer was the first staff conservator. “Our philosophy has been influenced by the people who trained us. Sheldon and Caroline were influenced, in turn by Alfred Barr, who was then the Director [of MOMA] and one of the founders and great scholars of modern art. Alfred was very adamant about having paintings look to the eye as the artist intended. He did not believe in leaving fillings that are unpainted,

nor did he like the idea of crosshatching.”⁶¹ Volkmer went on to describe her choice of materials: “The one difference, of course, is that we never use the same medium of the artist, with possibly one exception, and that would be pastel...For paintings, we use our own pigments ground in methacrylate or in poly (vinyl acetate). Recently, we’ve also used Magna (Bocour), a commercial paint of pigments ground in methacrylate. It sometimes gets pretty impossible to duplicate colors, and we sometimes modify [by] dry color. But in no instance have we ever resorted to using oils. Anyone looking at our pictures under ultraviolet would detect the inpainting.”⁶²

The pivotal 1961 conference, sponsored by Princeton University, gathered other art historians as well as conservators, including Sheldon Keck, Philip Hendy, Richard Offner, and George Stout. A wide spectrum of ideas on the ethics of “deceptive” inpainting, practical matters involved in exposing losses, and so on was presented.

Philip Hendy, Director of the National Gallery in London, promoted vigorous training in the methods of artists and techniques of past traditions. He recognized the importance of the professional restorer as “essential to all historians of the art of painting.”⁶³ He continued by saying, “If we are going to have retouching at all, we must have it most of the time; and those who do it must go through all that rigorous training in the exact matching of tints and textures, which is needed for good restoration...We have to consider the context of every work of art, the purpose which it is serving, the nature of the public concerned with the result...I am going to postulate as a first principle in this question of retouchings that the public should be told at least in broad terms where they are, how extensive they are, and why, if it is not obvious in the context, they are necessary.”⁶⁴ He went on to say, “No retouching must be allowed to overlap any original paint surface...the past practice which had only one end in view: to cover up the fact that the picture was damaged. This led to much overpainting of original paint...It is not only overpainting, of course, which has to be removed...The excessive overpainting in the past led to a reaction in the opposite direction, first manifested, as far as I know, in the twenties: that it is unethical to do any retouching at all...But there are many possibilities between the two extremes..., ultimately advocating bringing the picture to the point where it can be appreciated as a whole.”⁶⁵ Hendy remarked, “Much of the more conscientious retouching of the past has been done with an oil and varnish medium (with varying proportions of each) and this has usually darkened seriously with time. It has to be removed and the retouching done again in some medium less subject to change. In other words, the picture has to be cleaned, and cleaned completely, so that the new retouchings may be matched exactly to the original paint. This is still by no means universal practice.”⁶⁶

At the same conference, noted art historian Richard Offner countered the argument for any retouching as follows:

The chief reason for the problem is to be sought in the universal greed for completeness...But the work of art will suffer even more if the missing part is replaced. Generally, the replacement is without specific artistic intention

and performs no positive artistic function other than that of covering up unsightly lower layers of a painting, or simply that of making it appear that the mutilation was not there. In most instances the restorer feels under obligation to supply the missing parts by guessing what was previously represented where the gaps now occur...Any restoration, therefore, that introduces paint or shape within its boundaries, even if the restoration be limited to the missing portions alone, must prove intolerable...Repainting adds the factor of personality — and possibly of intention — extraneous to the original work. Not the least objection to such additions is the resulting dissonance of color, since the pigment of the restoration is generally of a chemical composition different from that of the preserved portions, and its color tends in time to drift away from that of the preserved color.⁶⁷

Millard Meiss, a protégé of Offner and noted scholar, then rendered his opinion, coming around a bit and referring to the work of George Stout, Cesare Brandi, and A. and P. Philippot, but suggesting that further investigation and discussion are needed.⁶⁸ He stated, “The unreconstructed lacunae remain, of course, obtrusive, ugly shapes. Indeed, they *must*, I believe, retain a considerable degree of discreteness; otherwise, in the process of perception, they will merge with the surviving original areas and contaminate our response...It is obviously desirable to reduce the obtrusiveness of lacunae and their emergence as figures, but it is still more desirable to avoid their absorption in the image...Treatment of a loss in any given case should seek as recessive a surface as is consistent with the maintenance of its independence from the surviving areas at normal viewpoints. Its very un-assimilability is a measure of the integrity of the original. A damaged painting does not offer a good and a bad alternative; only a better and a worse.”⁶⁹

At the same conference, Paul Coremans, noted Director of the Royal Institute for the Study and Conservation of Belgium’s Artistic Heritage, outlined a thorough, five-pronged approach with guidelines addressing the issues:

- A. Precautions to Be Taken Beforehand
- B. Aesthetic versus Historical Aspect
- C. Aesthetic Aspect and Formal Reconstruction
- D. Impermanence and Vulnerability of Reconstruction
- E. Possible Deductions and Suggestions⁷⁰

Under A: Coremans encouraged differentiation between the original and later additions as clearly and completely as possible. He felt that a distinction also had to be made between the original state and the actual state of a painting, the actual state being the original state but somewhat altered, patinated by time, with a definitive determination of the exact chronology of any additions. Under B: Coremans acknowledged art historians whose first consideration in regard to an old painting is its significance and importance as a *historical witness*, mainly concerned with the knowledge and the teaching of objec-

tive truth. For them, according to Coremans, the painting should be shown in its actual state without attempting a reconstruction that can be arbitrary: later additions should be removed and the picture should be exhibited with all its mutilations and losses. For many others — the creative artists and numerous gallery directors, for instance — the painting remains, above all, a *work of art*. As a consequence, Coremans asserts, the aesthetic beauty and plastic unity must be reconstructed.⁷¹ Under C: Coremans defined the work of art as a unity of parts, a totality that cannot be broken. Reconstruction is an act of restoring formal continuity and aesthetic structure.⁷² Under D: Coremans spoke of the fashion of a period for a certain solution, in contrast to what may be deemed appropriate later on. Here, he clearly advocated the concept of reversibility. Finally, and not surprisingly, Coremans concludes by underscoring the need for a complete scientific understanding of a work of art, as well as complete documentation, whatever the chosen course of treatment.⁷³

Sheldon Keck's remarks at the conference were particularly significant. "Works of art, although constructed of matter, are imbued by the artist with an immaterial content variously ascribed as aesthetic, emotional, intellectual, or spiritual. They have, therefore, both objective structure and subjective significance...The completeness of the visual communication between artist and spectator depends also on the totality of the painting as originally designed by the artist. Damage or alteration of the physical structure modifies the character of its communication."⁷⁴ Keck further justifies retouching, alongside the work of the art historian:

Whether or not compensation for losses is made, as well as manner and extent of the compensation, depends on the present or possible future use to which a painting is being put. The kind of compensation depends on the technique and style of the painting, the relative size of the losses and their position in the design...The restorer who removes later accretions or compensates for losses, like the art historian, makes a critical comment on the painting. The restorer's comment is directly on the painting. As critical comment, cleaning and compensation are more subjective than objective, more an art than a science. No two restorers would produce exactly the same result.⁷⁵

Keck's remarks on the practice of ethical inpainting, later incorporated into the AIC Code of Ethics and Guidelines for Practice, are particularly significant, stressing the importance of reversibility and documentation:

What seems abundantly clear to me as a conservator is that the extent and kind of compensation depends on the requirements of the individual painting, its style, technique, type of damage, and present use. A wide variety of compensation is available. He who makes compensation, conscious of his responsibility and limitations, must not only keep it to a minimum but allow for its future removal. A photographic record of the painting's actual state before compensation is essential.⁷⁶

Sue Sack, who was trained by Sheldon and Caroline Keck at the Brooklyn Museum, said the conservators at the museum operated on the premise of the “aesthetic whole.” The inpainting could show close up, but one needs the aesthetic experience. They would inpaint areas of bad traction crackle and then would stand back to judge how far to go. They would inpaint in a lot of light and, given that gallery conditions had less light, they would satisfy the principle of the viable aesthetic whole. Reversibility was always a premise. Sack related Keck’s vision that general toning that might be acceptable on a fresco was not so on an easel painting. More is required when the work is to be viewed at eye level.⁷⁷ Sack said they worked with a lot of living artists and curators. In correspondence with Caroline Keck, she said that the publications of Julius Held were very influential in the conservation world. He published a book in 1963 titled *Alteration and Mutilation of Works of Art*. Sack said that for inpainting, they would use pigments ground in dammar or other media (PVAc AYAA, AYAB, or AYAF). They would build two or three layers of retouching, rather than underpainting, sandwiching layers with appropriate resins. Magna Colours were not preferred. The palette was considered limited and the texture “stringy.”⁷⁸

John Brealey was Chairman of Painting Conservation at the Metropolitan Museum of Art for fourteen years, from 1975 until 1989. His effect on attitudes and practices in the United States was transformative for more than a generation of painting conservators. According to Stephen Kornhauser, who worked with Brealey from 1980 to 1982, “John seemed to relate inpainting to the picture rather than just color matching. He forced you to look at the whole painting, as well as the losses. You were pulling the picture together rather than filling holes with paint. He believed that inpainting was ruled by forms even more than color and that once the forms were completed [matched] your eye could be tricked even if your color was slightly off. Both with cleaning and inpainting he’d say that the picture would tell you what to do.”⁷⁹ Kornhauser went on to describe materials used:

We used extruded oils and a titanium white ground in dammar/turps and a little egg yolk [to give a crisp line]. We underpainted in watercolor, gouache and at times even egg tempera [compacted with a burnisher at times]. With gouache, we’d underpaint lighter and cooler and thinly glaze with the oil colors. For the most part we stayed away from synthetics though we varnished with Winton Picture and Retouch Varnishes. Though we worked with oil colors, he [Brealey] said there were times that you might have to use synthetics. He liked the oil colors and natural resins because he said you couldn’t get the richness and handling in synthetics that you needed for old master paintings.⁸⁰

The 1976 AIC Conference in Dearborn, Michigan, included an important panel discussion on inpainting. Among those presenting were Peter Michaels, Elisabeth Packard, Lawrence Majewski, Robert Feller, Ursus Dix, Bettina Jessell, Mary Lou White, and Louis Pomerantz. Elisabeth Packard said,

Before synthetic resins began to become available in the 1930s, inpainting mediums, used separately and in combination, included egg tempera, watercolor gouache, gums, glues and casein; beeswax and natural resins such as mastic, dammar and even shellac. The most popular, of course, were drying oils, linseed, poppy seed and walnut. More enlightened restorers chose aqueous mediums or mixtures which would enable the retouchings to be easily removed. Then, as now, much depended on the skill and judgment of the conservator. Although overpainting was prevalent, the report of the 1930 Rome conference indicates that museum conservators like Helmut Ruhemann recognized the importance of preserving the integrity of the original.⁸¹

Lawrence Majewski described stability tests that he performed on certain inpainting media, through rapid aging. Pigments were painted on Masonite™ panels on lead white and linseed oil grounds. These “paintings” were damaged and then given to nine conservators to fill and inpaint, recording their treatments. These were then exposed to changes in relative humidity and UV light. Changes in varnishes as well as the inpainting were reported.⁸²

Robert Feller spoke of the problem of whitening of retouches. Mario Modestini and his associates Henry Hecht and Claudio Rigossi prepared test panels using retouching systems with “dammar varnish, egg tempera, dammar and egg tempera and poly (vinyl-acetate) AYAB mixed with several colored pigments and three whites: white lead, zinc white and titanium white...Results pinpointed dammar and zinc white as being particularly prone to whitening...The exposure tests also clearly demonstrated the superiority of the polyvinyl-acetate retouching system that has been used by a number of conservators for more than two decades.”⁸³

Ursus Dix described the practice of inpainting with egg tempera, standard in many conservation studios in the 1950s. He detailed the recipe and technique:

Pigment, dry or ground in water, or reliable egg temper colours in tubes
 (Neisch, Dresden — unfortunately no longer available)
 Egg yolk
 Water
 Shellsol 715, or comparable mineral spirit

Other egg tempera recipes include drying oils or varnish solutions (dammar, MS2A, n-butyl methacrylate).⁸⁴ Bettina Jessell presented Helmut Ruhemann’s inpainting techniques, listing specific materials and sources.⁸⁵ Mary Lou White described *tratteggio*: Brandi’s theory, materials used, sources and techniques.⁸⁶ Finally, Louis Pomerantz outlined his working methods:

1. Voids are filled with zinc white and other dry pigments (to match closely surrounding color areas), mixed with Elvace #1874 (Dupont) acetate copolymer emulsion.

2. Varnish is applied to entire painting by brush, with Soluvar Gloss/Matte (Permanent Pigment Co.) acrylic resin varnish in mineral thinner solvent.
3. Inpainting is executed with Magna (Bocour) methacrylate resin paint suspended in mineral spirits, placed in aluminum weighing dishes and allowed to dry. Xylene is then used as a diluent. (Magna uses Rohm and Haas Resin F10).
4. Isolating varnish for inpainting is Magna Varnish (Bocour), acrylic in alcohol, applied by brush locally, or as a continuous coating over the entire surface if necessary. (Magna Varnish is Rohm and Haas resin XR31).
5. Final varnish of Soluvar is brushed on.⁸⁷

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ENDNOTES

¹ Courtesy of Gay Myers: Early advertisement for restoration in the *New York Gazette and Weekly Mercury*, May 8, 1769, ad for William Williams, who will undertake general painting, and "He cleans, repairs and varnishes any old pictures of value"; Williams also advertises that he teaches art. Quoted in William Kelby, *Notes on American Artists: 1754–1820* (New York: New York Historical Society, 1922), 7.

² Courtesy of Gay Myers: According to Miller, many of Peale's early portraits were repainted because they faded and there was a "shallowness" in the flesh tints. C. W. Peale later wrote of works of this period: "The shadows [are] too cold, almost black, having used no red in my shading except lake. The fading of the lake left the black predominant in the middle tints and deep shades ... Had I used vermilion or light red, how much better these paintings would have been." See Lillian B. Miller, *The Selected Papers of Charles Willson Peale and His Family, Vol. 1* (New Haven and London: Yale University Press), 103–04.

³ Courtesy of Gay Myers: Paintings by West that are signed and dated twice include scenes from *Hamlet* and *King Lear*. See Helmut von Erffa and Allen Staley, *The Paintings of Benjamin West* (New Haven and London: Yale University Press, 1986) nos. 207 and 210, both of which are signed, "Retouched 1806," as is *The Battle of La Hogue*. The retouching of the two Shakespeare scenes can be documented to the time that they were in the collection of Robert Fulton, shortly before they were sent to America: "Mr. West has been retouching my pictures; they are charming." See H. W. Dickinson, *Robert Fulton, Engineer and Artist, His Life and Works*, (London: John Lane, 1913), 200. See also Rembrandt Peale, *Misc. papers*, American Philosophical Society: "[West's] Picture of Lear in the Tempest, after being many years varnished, he glazed with Asphaltum, Lake & Blue, & retouched it previous to Fulton's bringing it to America. Our dry atmosphere by contracting these thick glazings & retouches, which were on a soft varnish, has nearly destroyed it, the cracks being more than the eighth of an inch wide." We (Mayer and Myers) treated the scene from *Hamlet* (now in the Cincinnati Art Museum) and believe that Peale was probably wrong: West's retouching and his second signature clearly go over the wide cracks, indicating that concealing the disfiguring crackle was the likely motivation for retouching it, rather than the cracks having been caused by the retouching. Note that West wasn't *inpainting* but was generally "going over" the painting with his retouching. Farington was critical of West's retouching his paintings years after they were painted, saying that he did them "injury." See Robert C. Alberts, *Benjamin West, A Biography* (Boston:

Houghton Mifflin Company, 1978), 383. But West, in a letter to the Royal Academy in 1803, justified the practice, saying that when he signed and dated a painting a second time, he considered it “a new picture” (B. West to the Members of Council of the Royal Academy, April 16, 1803, Historical Society of Pennsylvania, AAA roll P23, frame 225). See also Alberts (1978), 280–85.

- ⁴ Courtesy of Gay Myers: Claire Barry’s article on Cole. Claire M. Barry, “Technical Note: ‘Painting in Imagination’: The Creation of The Garden of Eden by Thomas Cole,” in Franklin Kelly, *Thomas Cole’s Paintings of Eden* (Fort Worth: Amon Carter Museum, 1994), 55–66. Barry describes traction crackle in *Garden of Eden* (now in Amon Carter) and other paintings (especially in dark darks and greens), which she attributes to media containing oil varnish or asphaltum or to under-dried underlayers (p. 56); she also mentions the possibility of him varnishing his paintings too soon; the cave area was overpainted, probably because of serious traction crackle (Cole scraped out the area and painted the cave, possibly late in the process) (p. 56).

John Trumbull retouching his own works because of crackle: In 1829 Thomas Sully visits Trumbull in New York where Trumbull is restoring his paintings of Montgomery and Warren: he coated the backs with wax, “and afterwards carefully filled up with paint all the spaces occasioned by the cracks on the paintings.” Trumbull also showed Sully a copy of Correggio’s St. Catherine he did 40 years before and it was in excellent condition, due to the fact it was painted with simple materials. (Sully, *Hints* (Yale Ms.) (AAA NYPL Papers Roll N18, frame 125).

- ⁵ Courtesy of Gay Myers: in 1840, Rembrandt Peale requested space for “unrolling, retouching and exhibiting” the painting. Documents from 1846 and 1847 suggest even more retouching had been done by that time. See L. Mayer and G. Myers, “The Court of Death Through Conservators’ Eyes,” *Bulletin of the Detroit Institute of Arts*, vol. 701, no. 1–2 (1996), 8.
- ⁶ Courtesy of Gay Myers: Manuscript is in Historical Society of Pennsylvania, p. 47 (Hevner’s pagination).
- ⁷ William Rickarby Miller, *Hints and Recipes Pertaining to Painting in Oil and Water-Colours and the General Practice of Art*. June 1862. Owned by the New York Historical Society. Microfilmed by the Archives of American Art [reel number 801], 264.
- ⁸ R. Peale, *Notes of the Painting Room*, 44.
- ⁹ *Ibid.*, 178.
- ¹⁰ William Wilson Corcoran was banker, financier, friend, and patron of many 19th-century artists, including Albert Bierstadt, George Inness, Frederick Church, and Thomas Doughty. The Corcoran Gallery of Art was founded in 1859 to house his private collection. From the Corcoran Gallery of Art website, c. 2008.
- ¹¹ Courtesy of Gay Myers: Joyce Zucker, “From the Ground Up: The Ground in 19th-Century American Pictures,” *Journal of AIC*, vol. 38 (Spring 1999): 11.
- ¹² G. Howorth, *Restoration of Oil Paintings: With a Few Practical Hints to the Owners of Pictures* (Boston: Press of George C. Rand and Avery, 1859), 6.
- ¹³ Howorth Broadside (in YUAG archives), A letter on its verso from John Howorth to Luther Armand Jones, 1867.
- ¹⁴ Mark Aronson, “The Conservation History of the Early Italian Paintings at Yale.” In Patricia Sherwin Garland, ed., *Early Italian Paintings: Approaches to Conservation* (Yale University Art Gallery, 2002), 32.
- ¹⁵ James Jackson Jarves, *Art Studies: The Old Masters of Italy* (New York: Derby and Jackson, 1861), 49.
- ¹⁶ Mark Aronson, “The Conservation History of the Early Italian Paintings at Yale.” In Patricia Sherwin Garland, ed., *Early Italian Paintings: Approaches to Conservation* (Yale University Art Gallery, 2002), 32.
- ¹⁷ *Ibid.*, 32–34, as it originally appeared in Jarves. *Art Studies*, 348.
- ¹⁸ *Ibid.*, 34, as it originally appeared in Jarves. “Art Mysteries Unveiled: Cleaning Old Master Pictures,” *New York Times*, April 14, 1878, 10, col. 3.
- ¹⁹ *Ibid.*
- ²⁰ *Ibid.*
- ²¹ *Ibid.*

- ²² Ann Hoenigswald, Historical Papers. "Stephen Pichette, Conservator of the Kress Collection. 1927–49, 30–41.
- ²³ *Ibid.*, 32.
- ²⁴ *Ibid.*, 16–17. Internal quotation: New York University radio broadcast, October 22, 1944.
- ²⁵ Courtesy of Gay Meyers. Ranger quoted in Ralcy Husted Bell, *Art-Talks with Ranger* (New York and London: G.P. Putnam's Sons, 1914), 122
- ²⁶ Courtesy of Gay Myers: Abbott Thayer Monadnock April 1916. For in-depth discussion of Thayer's views against restoration, see Nelson C. White, *Abbott H. Thayer: Painter and Naturalist*. (Hartford, CT: Connecticut Printers, Incorporated, 1951), 243–252, as well as his 1920 essay from *Studio International*, "Restoration: The Doom of Pictures and Sculptures" (March 1920), 13–17, reprinted in *The Arts*, August/September 1921, after his death, p. 10–14.
- ²⁷ The Sun, obituary, HUAM archive, Edward W. Forbes, "Teaching Materials" file, H. A. Hammond Smith.
- ²⁸ H. A. Hammond Smith, Record, condition/treatment notes in the conservation department of the Yale University Art Gallery, p. 58.
- ²⁹ H. A. Hammond Smith, p.58.
- ³⁰ Cesare Brandi, *Theory of Restoration*, I, Reading 22, 231.
- Giorgio Bonsanti's article "Theory, Methodology, and Practical Applications — Painting Conservation in Italy in the Twentieth Century," in *Early Italian Paintings: Approaches to Conservation*, 2002, p. 82, refers to the origins of Brandi's theories as the embodiment of earlier Italian concepts and theories, among them those of Pietro Edwards, an eighteenth-century painter of English origin, who came to Venice and was charged with setting up a team of artists to conserve the so-called public pictures. Bonsanti credits Edwards with being among the first to exemplify modern principles of conservation. For more on Pietro Edwards, see Wendy Partridge's essay in this volume and Alessandro Conti's book *History of the Restoration and Conservation of Works of Art* recently translated into English by Helen Glanville. In the United States, Elizabeth Darrow wrote her thesis on Pietro Edwards, and she has a paper in British museum Occasional Papers no. 145,2001. *Past Practice-Future Prospects*.
- ³¹ A. M. Vaccaro, "The Emergence of Modern Conservation Theory," Introduction to Part III. In *History and Philosophical Issues in the Conservation of Cultural Heritage* (Getty Conservation Institute, 1945), 204–205.
- ³² Giorgio Bonsanti's article, "Theory, Methodology, and Practical Applications — Painting Conservation in Italy in the Twentieth Century." In Patricia Sherwin Garland, ed., *Early Italian Paintings: Approaches to Conservation* (Yale University Art Gallery, 2002), 91.
- ³³ Ron Spronk, "Early History of Conservation and Technical Studies at the Fogg Art Museum: Four Pioneers," *Harvard Art Museums Review* 6 (1996), no.1, Iff. Also referenced in *North American Graduate Programs in the Conservation of Cultural Property*, 1999, 22.
- ³⁴ Courtesy of Wendy Samet: Elizabeth H. Jones, "Edward Waldo Forbes: Herald of Conservation," *Edward Waldo Forbes: Yankee Visionary*, 99–146.
- ³⁵ Another type of nondeceptive inpainting possibly done by Lyon is illustrated on page 129 of Volume 8 of *Technical Studies*, July 1939–April 1940. It is vertical hatching — similar to *tratteggio*.
- ³⁶ R. Arcadius Lyon, "Comments on Relining," *Technical Studies*, Vol. II (1933–34): 221.
- ³⁷ *Ibid.*, 154–155.
- ³⁸ Maximilian Toch, *Paints, Painting and Restoration* (New York: D. Van Nostrand Co., 1931), 60–61.
- ³⁹ Irene Bruckle and Christopher Tahk, eds. *North American Graduate Programs in the Conservation of Cultural Property, Histories/Alumni* (Buffalo, NY: Petit Printing Co., 1999), 24.
- ⁴⁰ George Stout, "Treatment of Blemished Paintings," *Technical Studies*, Vol. X, Oct. 1941, No. 2.
- ⁴¹ *Ibid.*, October 1941, Stout's footnote: Max. J. Friedlaender, *Genuine and Counterfeit*, Carl von Honstett and Lenore Pelham, trans. (New York: A. and C. Boni, 1930), 27–30.

- ⁴² Ibid., “Treatment of Blemished Paintings,” 107–112.
- ⁴³ Helmut Ruhemann, “A Tentative Scheme for Analysis of Painting Technique,” *Technical Studies*, Vol. X (April 1942): 75.
- ⁴⁴ Ibid., 3.
- ⁴⁵ Ibid. As described by Bettina Jessell, adding wax for elasticity and ox gall for breaking the surface tension.
- ⁴⁶ Bettina Jessell, *Journal of AIC*, Vol. 17, No. 1 (Fall 1977): 1–8.
- ⁴⁷ Courtesy of Wendy Samet: Richard D. Buck and George L. Stout, “Original and Later Paint in Pictures,” *Technical Studies*, Vol. 8, No. 3 (Jan. 1940): 122–150.
- ⁴⁸ Ibid., 129.
- ⁴⁹ Ibid., 125.
- ⁵⁰ Ibid., 123.
- ⁵¹ OAC, Getty Research Institute, William Suhr papers, collection 870697 (online description).
- ⁵² William Suhr, “The Restoration of the Merode Altarpiece,” *Metropolitan Museum of Art Bulletin, New Series*, Vol. 16, No. 4 (Dec. 1957): 140–142.
- ⁵³ Dianne Modestini, “Approaches to Retouching and Restoration: Imitative Retouching.” In Patricia Sherwin Garland, ed., *Early Italian Paintings: Approaches to Conservation* (Yale University Art Gallery, 2002), 208–209.
- ⁵⁴ Ibid., 211.
- ⁵⁵ Gustav Berger, “Inpainting Using PVA Medium.” In J. S. Mills and P. Smith, eds., *Cleaning, Retouching and Coatings, Preprints of the Contributions to the Brussels Congress, 3–7 September 1990*, IIC, London, p. 150.
- ⁵⁶ Charles Seymour, “The New Conservation Program for Italian Paintings,” *Bulletin of the Art Gallery Associates* 19, No. 1 (January 1951).
- ⁵⁷ Aronson, 42.
- ⁵⁸ Ibid., as it originally appeared in Charles Seymour, “The Aesthetic and Historical Aspects of the Presentation of Damaged Pictures,” Vol. 4, *Problems of the 19th & 20th Centuries, Studies in Western Art* (Princeton University Press, 1963), discussion section pp. 176–78.
- ⁵⁹ Ibid., 150.
- ⁶⁰ Dianne Dwyer Modestini, “Approaches to Retouching and Restoration: Imitative Retouching.” In Patricia Sherwin Garland, ed., *Early Italian Paintings: Approaches to Conservation* (Yale University Art Gallery, 2002), 208–209.⁶¹
- ⁶¹ Jean Volkmer, FAIC interview by Lyn Reiter, November 4, 1977, 13.
- ⁶² Ibid.
- ⁶³ Philip Hendy, “In the Presentation of Damaged Pictures,” 1961 Princeton sponsored conference papers reprinted, p. 141.
- ⁶⁴ Ibid., 142–143.
- ⁶⁵ Ibid., 145.
- ⁶⁶ Ibid., 143.
- ⁶⁷ Ibid., 156–157.
- ⁶⁸ Ibid., 164.
- ⁶⁹ Ibid., 166.
- ⁷⁰ Ibid., 166–167.

⁷¹ Ibid., 167.

⁷² Ibid., 168.

⁷³ Ibid., 169.

⁷⁴ Ibid., 170.

⁷⁵ Ibid., 173.

⁷⁶ Ibid., 175.

⁷⁷ Personal interview with Sue Sack, spring 2008.

⁷⁸ Ibid.

⁷⁹ From an interview with Stephen Kornhauser, Chief Conservator at the Wadsworth Atheneum. He was a Mellon Fellow at the MMA under John Brealey, 1980–82.

⁸⁰ Ibid.

⁸¹ Elisabeth Packard, “Changing Approaches and Materials in Inpainting,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 124.

⁸² Lawrence Majewski, “Results of Rapid Age Testing on Various Inpainting Media,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 125.

⁸³ Robert Feller, “Exposure Tests on Traditional and Polyvinylacetate Retouching Systems and Characterization of Certain Modern Proprietary Painting Media,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 126.

⁸⁴ Ursus Dix, “Inpainting with Egg Tempera,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 127.

⁸⁵ Bettina Jessell, “Helmut Ruhemann’s Inpainting Techniques,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, pp. 129–132. A version of this presentation later appeared in the *Journal of AIC*, Vol. 17, No. 1 (Fall 1977): 1–8.

⁸⁶ Mary Lou White, “Rigattino: An Alternate Method of Inpainting,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 133.

⁸⁷ Louis Pomerantz, “Inpainting with Bocour Paints,” AIC Preprints, Fourth Annual Meeting, Dearborn, Michigan, 1976, p. 134.

4. Italian Differentiated Inpainting Techniques: A Review

a) Introduction

In early 20th-century Italy, new approaches to art restoration were influenced by several social, political, and cultural factors. One important new restoration approach concerned reintegrating paint losses in a way that could be differentiated from the original paint surface. Differentiated methods of inpainting developed in Italy were largely based on the philosophies of Cesare Brandi (1906–1988). The Roman restorers Paola and Laura Mora were among the first to bring Brandi's theories of restoration to practice and developed the technique of loss compensation called *tratteggio* in the 1940s and 1950s. Later, in Florence, Umberto Baldini and Ornella Casazza created derivations of *tratteggio* called *astrazione cromatica* and *selezione cromatica*. Today, many practitioners of differentiated inpainting have expanded their techniques and their choice of materials to customize their approach as necessary.

b) Background

Several factors set the stage for new approaches to the reintegration of paint losses in Italy. The development of art history as a field of study in the late 19th and early 20th centuries, and the growing connoisseurship of early Italian art, enabled historians to become increasingly aware and critical of past heavy-handed restorations. These restorations often included reworking that confused or completely concealed the artist's intent. Both the strong interest in the study of early Italian art and the drive to keep restoration distinguishable from the hand of the artist were generally consistent with aspects of the social and political environment of Italy in the 1920s and 1930s. The post-World War I environment was fueled by strong nationalism as well as what painting conservator Joan Marie Reifsnnyder describes as “a new Italian consciousness, aware of its tradition and resolute in its civil mission” (2003, 25). With its push to establish order and unity after the war, the Nationalist regime in Italy imposed moral and ethical standards on public and private life (Reifsnnyder 2003, 29). It was within this environment that Cesare Brandi's philosophies on art restoration were formed.

c) Cesare Brandi

In 1939, Cesare Brandi became the founding director of the state run *Istituto Centrale del Restauro*, which established the first formal state restoration school in the country. The standardized restoration training the school provided was analogous to the rigorous standardization being employed in Italian political, educational, and cultural spheres (Reifsnnyder 2003, 29–30). Brandi strongly believed that everyone should have the opportunity to have direct contact with art and stressed that civilization has a “moral obligation” to save works of art for future generations. Brandi's philosophies concurred

with ideas formed in Italy in the late 19th and early 20th centuries that began to favor minimal intervention and respect for the object as a historical document. From this framework, Brandi began to develop and expand principles to guide the restoration of artworks.

From the 1940s to 1960s, Brandi wrote essays on the restoration of artworks, which were published in his 1963 *Teoria del Restauro*. Stressing the need for balance between the aesthetic and historic aspects of a work of art, he wrote, “Restoration must aim to re-establish the potential unity of the work of art as long as this is possible without producing an artistic or historical forgery, and without erasing every passage of time left on the work of art” (1996, 231). He believed that any integration must be differentiated from the original, but not be disruptive to the potential unity of the piece. Therefore, at the general distance from which the work of art will be viewed, the integration should be invisible, but it should be immediately recognizable at a closer distance. He felt that the previous use of a single neutral tone in the paint losses was not sufficient at reestablishing pictorial aesthetic unity, as it visually would not seem to rest on the same plane as the image.¹ Besides the use of a single neutral tone in losses, sometimes mottled with dots of slightly darker color, other early approaches included a technique called “simplified chromatic volumetric completion” (Ciatti 2002, 195),² graphic reconstructions (Ciatti 2002, 194) and otherwise imitative approaches made differentiable by such methods as a network of lines over the surface or keeping areas of retouching at a lower level than the original paint.

d) The Moras

Laura and Paolo Mora worked closely with Brandi’s philosophical requirements of reintegration and developed the technique of *tratteggio* in the 1940s and 1950s. The Moras, with Paul Philippot, wrote, “Reconstruction in *tratteggio* consists in transposing the modeling and drawing of a painting into a system of hatchings based on the principle of the division of tones” (1984, 309). *Tratteggio* is meant to be used for reintegration of losses with a neatly defined outline. Traditionally, hatchings in watercolor are applied on a smooth white fill that is level with the original surface. The following are excerpts from the Mora’s book with Philippot, *Conservation of Wall Paintings*:

Tratteggio is a system of small vertical lines averaging one centimeter in length. The first lines, which indicate the basic tone of the retouching, are placed at regular intervals equal to the width of one line. Next, these intervals are filled with a different color, and then again with a third color in order to reconstitute the required tone and modeling by means of the juxtaposition and the superposition of colors which are as pure as possible. Each line in itself should be weak in intensity, the desired intensity of the whole being obtained by the superposition of glazes of transparent lines rather than by strength of color, which would cause the retouching to lack the vibration indispensable for a good integration.

In order to obtain neat hatchings, without discontinuity and without the formation of drops at the bottom, the following procedure is recommended:

1. The brush must be sufficiently loaded to trace a full line without letting any paint run. To achieve this, as soon as the color has been taken, the brush should be wiped over an absorbent material such as slightly wet cotton wool, which has been fixed to the bottom right-hand corner of the palette. This operation controls the load of the brush by discharging it if necessary and, by its spiral movement, gives the brush the perfect point it had lost while preparing the tone on the palette.
2. It must be pointed out that the use of a mahlstick is essential. It allows the correct movement of the hand which, while the upper part of the forearm remains still, must cause the point of the brush to trace an arc intercepting the picture plane along the length of the line, so that the line begins at the top and ends at the bottom in a very sharp point. (309–310)

In *Conservation of Wall Paintings*, the Moras describe various types of losses that are distinguished by size, location, and depth: the wear of patina; the wear of the pigment layer; the complete losses of pigment layer that are limited in surface area and capable of being reconstructed; the complete losses of pigment layer that should not be reconstructed due to their extent and/or localization; and the losses of considerable extent that nonetheless should be reconstructed (because of architectural significance). They advise first treating minor disturbances such as wear in patina and wear in pigment layer so that larger losses may be better assessed. They recommend reintegrating wear in the pigment layer with localized glazes (*velaturas*) in watercolor slightly lighter and cooler than the original for the purpose of distinguishing the restoration. Although this publication was written for wall paintings, many of the principles and techniques have been applied to easel paintings as well.

The Moras state that the reconstruction of missing parts ceases to be justified when the design becomes hypothetical, and when a loss exceeds a certain size or when smaller losses are too numerous. Their general guideline for non-reintegratable losses is when they constitute more than 20 percent of the original or when losses are located in important areas of the design, such as facial features. They suggest that other methods of identifiable retouching may be preferable to reduce the disturbance caused by these losses. For unreconstructable losses in wall murals, they recommend imitating the underlying *arriccio* layer by filling losses to the same level of the original *arriccio* using materials of the same color and texture. However, sometimes a non-reintegratable loss was left as found with panel or canvas exposed (Ramsey 2003, 11).

e) Florence

Different approaches to inpainting arose in Florence, although they are also based on Brandi's theories. Florentine restorers Umberto Baldini and Ornella Casazza developed the reintegration techniques called *astrazione cromatica* (chromatic abstraction) and

selezione cromatica (chromatic selection). These were described in Umberto Baldini's *La Teoria del Restauro e Unita di Metodologia*, which was published in two volumes in 1978 and 1981. *Astrazione cromatica* is used for large losses located in important areas of the painting to diminish the visual disturbance of the lacunae without reconstructing form. *Selezione cromatica* is used for smaller losses, where the reintegration of design is straightforward. Often both types are used on the same painting as dictated by the types of losses. For each, the fills are made level with the original surface and then inpainted with pure watercolors.

The lines of *astrazione cromatica* are applied in a crosshatching manner as opposed to the hatching manner of *tratteggio*. Marco Ciatti explains, "This layer is applied in a four-color scheme derived from the additive synthesis of colors (yellow, red, green, and black), carefully graded to attain the mean chromatic value of the entire painting" (Ciatti 2002, 197). Baldini and Casazza (1983) describe the process:

The first hatching will be complete in itself. It will cover all of the white of the preceding gesso, and will leave a nearly vertical course. The second hatching will be — since it crosses the first — applied lightly horizontally (this hatching will not be held to the form of small stiff segments, but will flow with free and spontaneous gestures of the hand) separated from the first, which will only overlap on the connecting point of the segment. The third and fourth hatchings will logically bring out the other colours, other patterns, and other interweavings, which mix in the eye and bring out a color tone which originates from an analysis of the colors occurring in the picture. (46)

This objective approach, intended as a "neutral link" (Baldini and Casazza 1983, 43), uses equal amounts of the same chosen colors in each area of loss of a painting. This technique was used on artworks damaged in the 1966 Florence flood and was a standardized approach that could be taught quickly. An example of this technique can be seen on the Cimabue *Crucifixion* in the Sante Croce Chapel.

The lines of *selezione cromatica* are applied parallel to each other as in *tratteggio* but, unlike *tratteggio*, they can change direction to follow adjacent forms. The colors are chosen as in *tratteggio*, by optical mixing of colors in the vicinity of loss. This approach allows for a greater variety of effect. Marco Ciatti noted that this technique, in combination with *astrazione cromatica*, can be seen in the Master of Citta di Castello's *Maestà* in the Pinacoteca Civica of Castello (2002, 198).

f) More Recent Developments

Today, *tratteggio* is often used as a blanket term to cover all types of discernable Italian reintegration and is colloquially referred to as *rigatino* by conservators (Ciatti 2002, 197; Lignelli 1997, 97). Some conservators are moving away from fixed theories of the past and incorporating updated versions of *rigatino*, such as varying size and thickness of the juxtaposed vertical strokes in response to loss size and location, slanting the line to increase visual texture, and employing direct color matches through the use of mixed

colors (Lignelli 1998). Other options include using textured fills as well as using resin-based paints either glazed on top of a flat base tone of watercolors or gouache, or used as the exclusive colorant. Sometimes mimetic and differentiated approaches are combined (Olsson 2003).³ Examples of *rigatino* by conservator Teresa Lignelli can be seen on the Philadelphia Museum of Art's Pietro Lorenzetti, *Enthroned Virgin and Child with Kneeling Donor* (see Lignelli 2002, 185; Lignelli 1997, 102). Another approach, more closely related to *selezione cromatica*, can be seen in areas of restoration in the grass in Sandro Botticelli's *Coronation of the Virgin* in the Uffizi (see Ciatti 2002, 201).

These expanded allowances lend more flexibility and greater variation of effect. Painting conservator Nina Olsson observes, "The plurality of choices before historians and restorers today also bespeaks an attitude that allows for varied conditions, historical stratifications, and diverse locations and purposes for the viewing of paintings" (Olsson 2003, 10). *Rigatino* can be successfully used on paintings from other time periods and originating geographic locations, but it is best on panel paintings and is the least successful on paintings with textured canvas supports (Lignelli 1998). As always, restoration choices are made on a case-by-case basis, and certain factors, such as the rarity of the work and context of loss location, play a part in the choice of approach and material (Ciatti 2002; 202, 206).

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ENDNOTES

¹ Brandi's students, the Moras, would write, "No tone can ever be neutral within the image/loss context, since it inevitably situates itself on a given plane and at a given depth." Paolo Mora, Laura Mora, and Paul Philippot, *Conservation of Wall Paintings* (London: Butterworths, 1984), 312.

² Ciatti uses this term when describing an early 1930s restoration by Vermeheren, who was "summarily indicating the volumes without defining the details."

³ Olsson refers to a recent restoration on parts of Duccio's *Maestà* in the Museo dell'Opera, Siena.

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B. INDIVIDUAL TECHNIQUES

1. Bettina Jessell

a) Introduction

The methods Bettina Jessell used were very close to what she learned from Helmut Ruhemann during the time she spent working with him. She did not change her techniques to any great extent, except for the fact that the painting materials were different and that naturally wrought some changes in her methods. But overall, she was still guided by the idea that it is the conservator's duty to restore, to the greatest extent possible, the quality of the painting. She believed that the best way to achieve that end was to study the technique of the painter and to match reconstructions of losses to the layer structure created by the painter (Jessell 1977). A conservator must try to restore the way the painter did his painting. If you understand what the painter is working toward, it suddenly becomes easier to inpaint and to match the painter's colors and technique. It takes some time to come to understand just how the painter achieved his results, Jessell noted, but it is time well spent.

According to Jessell, any discussion of inpainting must consider the state of a painting before that process begins. Many factors, unrelated to choice of materials or actual techniques, contribute to whether or not an inpainting job is successful. The success of inpainting is dependent on the structural integrity of a painting and the quality of the surface. Lacunae in the canvas and other structural problems that interrupt the continuity of the painting's surface must be successfully dealt with before attempting to inpaint. If necessary, the painting must be lined, mounted on a new stretcher, and keyed-out. If the existing stretcher is in acceptable condition, it may be retained.

b) Surface Preparation

Although contending with structural concerns is important, Jessell strongly emphasized the need to thoroughly remove a discolored varnish — because only by cleaning a painting completely can a conservator see the painter's intended colors. And it is based on knowledge of the painter's colors, combined with an acknowledgment of changes in the colors potentially wrought by time, that a conservator attempts to match colors. Jessell pointed out that cleaning must be done very conscientiously. Too often paintings are not cleaned completely; many conservators are understandably frightened at the prospect of cleaning a painting thoroughly. But unless one does clean thoroughly, one never approaches the painter's original intention. The wrong colors are simply perpetuated.

The preparation of the surface wherever there may be losses is as important as conscientious cleaning. After applying a preliminary layer of Ketone Resin N varnish, Jessell used an English product called Brummer Stopping to fill losses. She found this mixture of calcium carbonate, glue size, and gelatin better than any acrylic filler she tried. After

the filler dried, she shellacked the actual filled area, let the shellac dry, and wiped away the excess fill material spread by the balsa wood. She tried to match the texture of the canvas and paint layer as closely as possible while doing the fill. The texture of thickly painted passages could be matched in this way.

Jessell explained, however, that because the fill material was rather brittle once it dried, it was not suitable for building up any significant impasto. If the surrounding area was one of moderate to high impasto, she built up the impasto with alternating layers of the inpainting medium and localized isolating varnish, allowing each layer to dry before applying the next, and finishing with a layer of varnish. She found this a tedious method, but a successful one.

c) Choice of Pigments

Once the conservator is satisfied with the surface, inpainting can begin. Choice of inpainting pigments and media affects not only the immediate success of inpainting, but also the long-term success of the job. The use of materials closest to those the artist used is appealing, but the reality is that the materials used by the artist often prove unsuited to the different needs of the conservator — most critically, the need for stability. A compromise must be made.

In keeping with the methods of the old painters, Jessell used ground pigments. She found that there were about thirty different pigments that were useful, but she might only use four or five, in addition to ivory or bone black and titanium white, on any given painting (Jessell 1977). Many of the pigments are the same ones used by the old masters. Others are modern equivalents to pigments that are a great deal more permanent than the pigments they have replaced.

Opaque Pigments	Semi-Opaque Pigments	Translucent Pigments
titanium white	cadmium yellow	Indian yellow
Venetian red	cadmium red	viridian
vermillion	cadmium red deep	cobalt blue
yellow ochre	light red	alizarin crimson
Indian red	ultramarine	bone black
raw umber	Naples yellow	
burnt umber	cobalt violet	
Prussian blue ¹	raw sienna	
ivory black	cobalt blue	
cadmium orange	Monastral blue	
Winsor blue	burnt sienna	
chromium oxide		
NGL opaque green		

The type of palette the conservator uses is also important. Jessell had a fairly coarse ground glass palette and little containers for each pigment, and she had all the pigments in a row around the glass palette. The ground glass ensured that the powdered pigments were thoroughly ground into the paint. Jessell found that if you mixed the powdered pigments into the medium, the result was smoother on the ground glass palette than it would be if you were to use an ordinary glass palette or a metal palette. She mixed her paint with the same brush she used to inpaint.

d) **Choice of Medium**

The choice of inpainting medium is one of the most interesting, and historically problematic, decisions to make. With each medium, the inpainting technique changes in terms of how the paint is applied and how the colors are matched. The conservator must take into account how the paint adheres to the surface of the painting, the extent to which the medium is covering or translucent, and the extent to which colors change as the medium dries and the painting is varnished. Jessell used Paraloid® B-72 for oil paintings and used xylene as a thinner. She found that Paraloid B-72 was the best medium for imitating the translucency of oil paintings (Jessell 1977). She still used egg tempera, which she made herself from yoke and white with wax and ox gall, on tempera paintings (Jessell 1977). The wax added elasticity, and the ox gall served as a wetting agent.

When she first began to work in conservation, with Ruhemann in the summer of 1938, most commercial conservators inpainted with oil paint. Tempera was the other option, but many saw it as difficult to use and very slow. The problem with oil is that it begins to oxidize immediately, and the effect of the discoloration, at first negligible, compounds with the passage of time. Jessell explained that you will still see paintings with brown patches, and you will know that this is where the painting was inpainted because the oil has gone brown.

Because oil inpainting discolors, Jessell and Ruhemann used to use tempera for inpainting oil paintings, because no other available medium was stable. Working in tempera is a time-consuming and difficult process. It takes three or four times as long to inpaint in tempera as it does to inpaint in oil. It is slow because you first fill the loss, then put the ground layer on, and then test it with mineral spirits — because mineral spirits will change the color the way varnish will. And then, if the color is not right, you change it until it matches the ground color exactly. The actual inpainting is a similar process often involving two or more attempts to get the color just right. You put the paint on, allow it to dry, burnish it, try it, see that it is the wrong color, and begin again.

Early Italian tempera paintings on panel are constructed differently and thus require a different inpainting technique. The painter first covered the panel with a white gesso ground and a preliminary layer of terra verte. The modeling was then applied, in thin streaks of paint. Tempera paint is very covering, so all the layers must be visible to achieve subtle transitions. Following the painter's technique, the conservator reconstructs losses using the same layer structure (Jessell 1977).

Inpainting exclusively in tempera was an extremely slow process, but before acrylics were invented, there was no acceptable alternative. During the last six months that Jessell worked with Ruhemann, in the winter and spring of 1939 and 1940, they began using acrylics on an experimental basis. They were excited because acrylics enabled them to work with greater speed. The problem, of course, was that acrylics are not always sufficiently covering, particularly on old master paintings, to easily obscure the filler or ground. Quite often, paintings are reluctant to accept the acrylic layer because it is rather translucent; it nearly always requires two or three layers. The conservator must try it out to see whether it's likely to match. Regardless, it's much quicker to inpaint in acrylics than to inpaint in oil or tempera. And, thus far, acrylics seem to last a long time. A painting inpainted twenty years ago still tends to look acceptable. With acrylic, colors change to some extent, but they do not change nearly as much as they do with oil paint.

Jessell found that there are a number of other good inpainting media, that it's a personal choice, very much determined by the painting one is working on. Jessell used, on occasion, Maimeri paints. She also used watercolors, particularly to execute fine, raised brushstrokes in early paintings, although watercolor darkens significantly when varnished (Jessell 1977). And she used colored pencils as an aid to inpainting, particularly in areas where overpaint would be too heavy or where a fine line is required (Jessell 1992). Still, she generally used permanent powdered pigments, ground into tempera or Paraloid B-72. She believed that to be the most satisfactory way of achieving a good result. There are, of course, commercially prepared tempera paints available — Plaka® colors come to mind — which are covering and behave like tempera, although they are not the true tempera.

e) **Color Matching**

One of the basic skills that a conservator must master is the ability to match the colors used by the painter. Matching the actual colors is not the difficult task. The essential challenge, according to Jessell, is that the painter's colors have aged and the conservator must match the aged and oxidized paint, while knowing that his colors will also change with time, however slightly. Oil paintings, because of the oxidation problem, present the greater challenge. Oxidation affects the whole aspect of a painting. Modern oil paintings look so much more striking than older paintings because oxidation has only just begun. However much you clean a 17th-, 18th-, or 19th-century painting, it will always be browner than the painter meant it to be. That is where tempera gains because tempera does not oxidize. Tempera paintings look very much as they did when they were painted.

Any color can be matched, and that includes the discoloration caused by the oxidation of oil paint. To match the oxidizing of the painter's colors, you have to add a touch of red and a touch of green to every color you use; Jessell preferred to use burnt sienna and viridian (Jessell 1977). The addition of burnt sienna and viridian approximates the brown cast caused by the oxidation of the oil in the original paint, allowing for the fact that the colors that the painter originally applied have gone brown. Jessell usually began

an inpainting session by mixing a small patch of viridian and burnt sienna on her palette, from which she drew small amounts as she mixed colors.

The other technique she found that ensured a good result and, more important, was central to her approach to inpainting is the concept of matching the layers of inpainting to the layers that the painter used (Jessell 1977). She found that this is really the only way to achieve the correct degree of luminosity, preserve the transitions, and match the texture seen in the original. Every painter uses different techniques to create the visual experience he intends. An understanding of those techniques as well as an appreciation for the visual experience intended by the painter are essential to successful inpainting. In the absence of technical analysis, she suggested that conservators inspect the edges of losses, abraded areas, and the edges of a painting under strong magnification to gain an understanding of the layers used and build up their inpainting in layers the way the painter did. This may seem to be a more cumbersome method than simply attempting to match a color directly, but Jessell said it was by far the most successful way of getting an acceptable result.

After applying a layer of varnish, Jessell applied a coat of Renaissance wax with a velvet cloth (Jessell 1977). The Renaissance wax enhances the varnish surface, making it smoother and more even. The wax also protects the varnish layer, providing a final barrier to humidity and friction and making the varnish less friable. Renaissance wax is an English product — the British Museum invented it, but it is now known all over the world as a good final polish.

Jessell noted that inpainting is still the biggest challenge of conservation and, therefore, the greatest pleasure. Structural work answers the physical preservation needs of a painting, but it is through inpainting that the conservator attempts to preserve the vision of the painter and bring back the quality of the painting.

Author's note: The content of this article is based on interviews that the author conducted with Bettina Jessell.

Laura Rivers

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ENDNOTE

¹ Although Prussian blue is a rather translucent pigment, its unusual tinting strength makes it highly covering.

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2. Perry Huston: A Different Way of Using PVAc Colors

a) Introduction

In my first year of graduate study with Caroline and Sheldon Keck at Cooperstown in 1971, I learned to inpaint using dry pigments ground in poly (vinyl acetate) AYAC (Union Carbide) and remember vividly Mr. Keck's lecture on the "turbid medium effect." Because of the way that light is scattered by the tiny pigment particles in a scumble (which is semi-opaque), the resulting color appears warm or cool depending on whether the paint is applied over a light color or a dark color, in the same way that hazy smoke appears brownish in front of a white building but bluish against a dark hillside. When I began working with Perry Huston in 1980, I was exposed to a greatly expanded version of this concept, one in which warm and cool colors, as well as translucent and transparent ones, are juxtaposed on the palette and used to create special effects. Perry's palette, which was developed from a system James Roth was using in the 1950s at the Nelson Art Gallery in Kansas City, Missouri, uses PVAc-AYAC, but the same principles may be applied to any medium.

Palette Layout					
chrome oxide green warm opaque	cobalt blue special	ultramarine blue warm opaque	phthalo blue cold opaque	Prussian blue cold transparent	indigo blue special
vermilion red deep warm opaque	red earth warm opaque	Indian red cold opaque	alizarin crimson cold transparent	burnt sienna warm transparent special	burnt umber warm transp.
cad. yellow light warm opaque	cad. yellow medium warm opaque	aureolin yellow warm transparent	viridian green transp., special	cad. orange warm opaque	golden ochre warm transp.
titanium white transparent	lead white opaque	bone black warm	ivory black cool	raw umber special	raw sienna warm opaque

b) Palette Layout

The palette consists of twenty-four colors laid out in four rows of six, as indicated above. It began with many of the colors thought to be used traditionally, including the earth pigments, blacks, and whites, and was modified by additional light-stable colors. Modern or unusual colors were not included, since they were used only occasionally, but a few "special" colors — those which could not be matched with anything else — were included. The colors are arranged on the palette, in some cases, according to whether they are warm/cool or transparent/opaque relative to each other.

In looking at the layout of the palette, certain patterns emerge. While the colors are arranged generally by family (e.g., blues, reds, yellows), they are also set up in warm/cold or transparent/opaque pairs or sets. For example, the ultramarine/phthalo/Prussian blue group on the top row moves from warm opaque at the left to cold transparent at

the right. In the case of the four reds in the middle, the opaque reds are located on the left — one warm and one cold — and the transparent reds on the right — one cold and one warm, depending on the scumble or glaze required. Aureolin yellow is included as a warm transparent (although the modern version is not as transparent as the old) next to the cadmium yellows, which are warm and opaque. Earth pigments that are not strong reds are clustered near the lower right, with golden ochre and raw sienna, both warm, placed together because one is transparent and the other opaque.

c) Inpainting Technique

Perry mixes his colors on a glass palette over a white blotter. He looks at an area to be compensated in terms of whether the color needed is warm or cool in relation to the surrounding paint. He begins by inpainting all the tiny blemishes surrounding the loss, then applies the closest matching color to the loss itself. In the case of a large lacuna, he first breaks up the area into small sections around the edges, then finishes the center. Slight adjustments in hue, value, and intensity are made by applying thin, opaque scumbles or transparent glazes to modify the initial color applied and match it to the surrounding paint. Color may be modified by adding either the complement — to diminish intensity — or a little white, black, or raw umber — to reduce hue and adjust value. Inpainting on dark fills causes the prepared color to appear cooler than intended, so some adjustment with a small amount of warm color is necessary. Once this correction has been made, however, the technique becomes second nature. One solution to this problem would be to mix the colors on a dark palette, as suggested to me several years ago by Tom Caley. Either way, the multilayered system of thinly applied warm/cool and translucent/transparent colors works quite well in achieving an accurate match, far better than would a single layer of uniform color. Because it involves scumbles and glazes, it uses very little paint and thereby avoids the problem of cold flow sometimes associated with PVAc colors. Intermediate and final sprays of varnish (usually Paraloid B-72) may be applied over the inpainting until the correct color and gloss are achieved. The difference in solubility between the varnish and inpainting medium allows adjustment of the inpainting without disturbing the varnish. As an alternative to intermediate sprays, a small amount of medium may be added to the inpainting to bring up the gloss (particularly for earth colors like golden ochre and raw sienna, which dry light).

d) Palette Box Design

Jim Roth's original palette consisted of a block of wood into which were drilled twenty-four wells, each about one inch deep. Into each well was set a small, one inch-diameter ceramic crucible (made by Coors Brewing Company, of the following dimensions: height 1"; diameter at top 1 1/4"; diameter at bottom 5/8"; the number 04 is impressed onto the side of the crucible) held in place with a drop of molten microcrystalline wax at the bottom. The crucibles were filled with pigments ground in the medium to a creamy consistency. To keep the paint moist, the box was set on a glass surface and covered with an open-bottom wood box with a glass top. Cork was used to seal the upper box

against the glass. Perry refined this design by making the box out of cast aluminum. The detachable top was replaced with a hinged aluminum and glass lid, attached with small brass hinges on one side and held closed on the other with a window lock. To ensure a tight fit, a bead of silicone caulking material was pressed into a narrow groove along the 1/2"-wide inner edge of the lid. When this surface was pressed down against the corresponding smooth edge of the base, it created an airtight seal, which prevented the colors from drying out. It was occasionally necessary to add diluent and stir the paints to keep them creamy for use and avoid wear and tear on the brushes.

Authors' note: The content of this article is based on the author's many years of experience working with Perry Huston.

Helen Mar Parkin

Submitted January 2007

3. Helmut Ruhemann

a) Introduction

Early in the chapter on the technique and ethics of retouching in *The Cleaning of Paintings*, Ruhemann covers the fundamental rules of the process. Ruhemann did not believe that every damage should be repaired; retouching should be kept to the minimum necessary to restore the artist's intent. Restoration should never go so far as to make a painting look brand new. New paint should not cover even the slightest bit of old, lest any remaining part of the artist's work be obscured (Ruhemann 1968, 241–242). Above all, Ruhemann advocated imitating the original buildup of layers using knowledge gained from a thorough examination of the painting and a strong understanding of the painter's methods.

Ruhemann was not dogmatic on the subject of the particular technique of retouching that should be practiced; he mentions more than seventeen approaches to the compensation of losses in *The Cleaning of Paintings*. Despite the merits he saw in some forms of carefully executed visible retouching, Ruhemann clearly felt that, where appropriate, complete reconstruction was better suited to the goal of restoring coherence to a damaged work and that any ethical objections to matched retouching had given way with the introduction of UV light as a means of differentiating new from old paint (Jessell 1977, 1; Jessell, personal communication, 2000). Matched retouching is the end result of the method he chose to describe in detail in the *The Cleaning of Paintings*.

Yet Ruhemann did not advocate perfectly matched retouching for every damage, allowing that total reconstruction of such essential parts of a picture as hands and heads should never be attempted on a museum-quality painting (Ruhemann, 241–242). He instead emphasized the importance of using inpainting techniques appropriate to the painting in question and to the techniques employed by the artist or school of painting (Jessell 1977, 1). The complete program for matched retouching, which Ruhemann describes in *The Cleaning of Paintings*, depends on careful examination of the painter's techniques, and specifically the very layers with which the painter constructed the painting.

b) Choice of Medium and Palette

The choice of medium was not a topic on which Ruhemann gave a definite recommendation. He rejected oil as a retouching medium because of its propensity to oxidize, choosing instead to work in tempera at a time when many professional restorers worked almost exclusively in oil or oil-resin. Tempera required more experience, more time, and more patience, but Ruhemann believed it was the medium that most closely met the restorer's needs. He was, however, interested in acrylics, discussing MS2A resin color and Paraloid B-72 in *The Cleaning of Paintings* (Ruhemann, 245, 254). Bettina Jessell, a former student, remembers working with acrylics, on an experimental basis, during the

last six months she worked with Ruhemann, in 1942. She remembers that Ruhemann was fairly impressed with acrylics and that he felt they had great advantages, most significantly that they did not darken with age and required a less demanding application process than tempera (Jessell 2000).

Ruhemann used a palette composed of approximately twenty pigments. He preferred to rely on the pigments used by the old masters, and felt that a few effects could not be achieved without the old pigments (Ruhemann, 247). In general though, Ruhemann believed that the modern, more stable replacements for many of the old pigments were often equivalent or superior and that original hues could be matched using the newer pigments (Ruhemann, 247).

After the preliminary varnish, Ruhemann would begin to reconstruct missing areas in monochrome brown undermodeling. He considered monochrome undermodeling to be an essential step in the process, irrespective of whether undermodeling was present in the original (Ruhemann, 252). He executed the undermodeling in resin paint, thinned varnish containing a little stand oil, or in a very lean oil paint, using burnt sienna, raw sienna, and black pigments.

Taking this step had a number of significant advantages. Undermodeling enabled the restorer to work out the design thoroughly before applying the color. Drawing in the design brought the painting closer to being whole by minimizing the disruption caused by the losses, making it easier for the restorer to envision the final result. Undermodeling also provided the initial, essential layer necessary to achieve the desired hues after the addition of subsequent layers; Ruhemann mentioned that certain grays and the hues of some skies could not be achieved without undermodeling. Contours were made “almost automatic” by the application of undermodeling. Retouching worn areas and light cracks with the brown undermodeling paint could lessen the disruption caused by those problems without the addition of subsequent layers. In some areas, undermodeling could be all that was required to restore coherence to a painting — the restorer need not go further. Ruhemann was of the opinion that once the undermodeling was finished, the painting would look almost complete in a black and white photograph (Ruhemann, 252).

In the case of paintings with large losses, undermodeling might not be sufficient to restore coherence to the painting and further reconstruction might be required. Ruhemann was emphatic in his belief that a model passage on which to base a reconstruction should, if at all possible, be found within the painting being restored. Alternatively, a painting by the same master might provide an acceptable model. The restorer should work from nature only if no other acceptable source was available. Ruhemann believed that reconstruction from memory was “rarely satisfactory” (Ruhemann, 253).

Following the painter’s layers, Ruhemann would apply one or more layers of opaque or semi-opaque tempera body paint. He built impasto up gradually, allowing previous layers to dry at least to some extent before applying the next layer. It was important that

this layer be as completely modeled as possible. In part, the undermodeling contributed to the development of cool middle tones in the appropriate areas when subsequent layers were placed over areas of darker undermodeling. After the application of the body color, the painting should look more or less complete. However, the areas where there were formerly losses appeared lighter and cooler than the surrounding areas (Ruhemann, 253).

Ruhemann would then burnish the retouchings to avoid the absorption of the varnish into the tempera paint and then apply a thin layer of varnish to the retouched areas. The next step would be to apply very thin, light glazes to the retouched areas, using watercolor or wax in MS2B. Ruhemann suggested using lighter pigments or adding kaolin to lighten the glazing. He mentioned using Davy's grey in preference to black and, instead of brown or yellow, light red and cobalt or cerulean blues (Ruhemann 254). Finally, Ruhemann would varnish the matte spots, applying a varnish layer of normal thickness.

Author's note: In addition to the references cited, the content of this article is based on accounts from his student and trainee, Bettina Jessell.

Laura Rivers

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C. CONTEMPORARY CONSERVATION PROFESSION MATERIALS AND PRACTICES

1. Documentation of Original Condition Prior to Compensation

a) Introduction

The purpose of this special record is to provide a reference image for documenting the extent to which losses, damages, and other factors that detract from the visual integrity of the painted design are compensated by the conservator, this compensation being made by the addition of materials to the artwork. For the record to be complete, it also requires making an after-treatment image for comparative purposes. In addition, it may serve as a record of the extent and appearance of remaining original surface, even if compensation for loss is not to be carried out.

The recommendation for making this record goes back to the early history of 20th-century conservation. It is seen, for example, in the International Museums Office 1939 *Manual on the Conservation of Paintings*; because this publication reflected already accepted attitudes at the time, the importance and need for this record was clearly realized early on in the history of modern conservation. The *Manual* expressed the recommendation as follows: “Photographs should be taken of the different stages of the cleaning operations, but the most valuable record will be a photograph of the picture completely stripped” (182). And, “Whatever method [of retouching] may be adopted..., the various systems of recording will always furnish the necessary data for ascertaining the condition of a painting before and after stripping and before retouching and additions” (109).

The *Murray Pease Report* (1963), which served as the *Standards of Practice and Professional Relationships for Conservators* for the IIC-AG and, until 1993, for the AIC, required the creation of a “Photograph in ‘actual state’ without compensation” (Section IV, C, 2, b). In a conceptual sense, the term “actual state,” still commonly used today to describe the subject of the pre-compensation photograph, was never well defined. The introduction to *Commentary 23* (approved Oct 1997) in the *AIC Commentaries to the Guidelines for Practice*, however, now provides some clarity to this ambiguity, as follows: “The baseline for determining the nature and extent of loss is the point at which the cultural property was generally accepted as completed, although compensation need not return the cultural property to this state. The original completed state (what the artist/maker actually did) takes precedence over the artist’s/maker’s original intent in guiding the nature and extent of compensation for loss.”

Thus, it is the extent to which the remaining “original completed state” is revealed that is to be documented. In most cases, the making of this record serves to fulfill all the listed

rationales in *Commentary 27, Documentation of Treatment*, and augments the precepts in *Guideline for Practice 23* that compensation “be detectable by common examination methods,” and that it “not falsely modify the known aesthetic, conceptual, and physical characteristics of the cultural property.”

While the written record and diagrams are important adjuncts to this record, documentation here must be photographic and should indicate as clearly as possible the condition of the remaining original surface and the areas of the painting that are to be compensated. In some cases, this may require special photographic techniques, filling or varnishing prior to photography, or other measures. Some suggestions follow.

b) General Recommendations for Photographic Documentation Prior to Compensation

(1) Relevant Information

The relevant information required in *Commentary 24* section B *must* be included in the photograph:

- Unique identifier (e.g., accession #)
- Date of the photograph

(2) Additional Referents and Information

In addition, as listed under “Recommended Practices” in *Commentary 27*, it is *highly* recommended that additional referents and information be included, not only in this photograph, but also in all like photographs of the paintings made throughout the examination and treatment process. These include:

- Gray scales: A gray scale is an essential referent to ensure color neutrality as well as uniformity of exposure and contrast among comparative images. It should be included in documentation photographs whenever possible. The *AIC Guide to Digital Photography and Conservation Documentation* (Frey et al. 2008) should be consulted for a discussion of gray scale reference targets and their use.
- Size scale
- Light direction indicator
- Other clarifiers, such as:
 - Stage of treatment label
 - Label indicating that lacunae have been filled prior to photography, or that varnish has been applied
 - Label indicating special illumination (e.g., UVA)

Note: In digital photographs, it is good practice to document in the image file's metadata any special measures taken to enhance or clarify the pre-compensation photograph. Such measures (discussed below) might include varnishing or filling prior to photography, transmitted light photography, or UVA-induced visible fluorescence photography. For the latter, any camera filtration used should also be recorded.

(3) Varnishing

The process of varnish or overpaint removal often leaves residues or other disturbances on the surface that create visual anomalies (variations in sheen, saturation, etc.) that do not reflect the true character of the remaining original, and indeed may confuse the record with respect to the photographic image of the remaining design. On paintings that are to be varnished again, it is advantageous to apply a saturating varnish to the surface before making the pre-compensation photograph. The photograph should be labeled to indicate this has been done.

c) Suggestions for Clarifying the Visibility of Areas to Be Compensated

(1) Detail Photographs

If areas to be compensated are small and localized, so that they would be difficult to discern in the overall pre-compensation photograph of the painting, detail photographs of the area should also be made. Similarly, areas of abrasion that are to be compensated are often best documented through detail photographs. Detail photographs should be made of the same areas after compensation for the most complete record.

(2) Filling

If losses in the painting are too small to be discerned easily in the overall photograph of the painting (especially in areas where the exposed support is similar in tone to the surrounding paint), it may be advisable to fill the losses prior to photography to provide enhanced contrast. The pre-compensation photographs should be clearly labeled to indicate that this has been done. Obviously, this method requires that the fills contrast well with the surrounding original (e.g., untoned gesso fills).

(3) Fluorescence Photographs

Pre-compensation and after-compensation fluorescence photographs of the painting under long-wave ultraviolet (UVA) irradiation can often provide an excellent record of the extent of compensation. This pair of photographs would be made in addition to the standard pre-compensation and after-treatment photo-

graphs. See the *AIC Guide to Digital Photography and Conservation Documentation* (2008) for information on the making of fluorescence photographs.

(4) Transmitted Light Photographs

Generalized pinpoint losses in canvas paintings can often be clearly recorded with transmitted illumination in combination with low-level front illumination.

(5) Annotation

Graphic annotations can serve as useful adjuncts to clarify areas to be compensated and are easily added to digital photographs.

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2. The Ethics of Inpainting

If my grandfather had an axe and he gave it to my father, and my father replaced the handle, and he gave it to me, and I replaced the head, is it still my grandfather's axe?... For me it's still my grandfather's axe...There's a constant battle between conserving the idea and conserving the object.¹

— Damien Hirst

a) Introduction

Previous generations had widely differing views regarding the ethical principles of inpainting damaged pictures, but their willingness to openly debate these issues has ultimately facilitated a positive result — general agreement on several key points among conservation professionals today. Reinforced by the foundation and credibility of graduate training programs in the United States and abroad; by an abundance of international symposia, conferences, and workshops; and by the publication of peer-reviewed journals focusing on conservation treatment techniques, scientific analysis, and technical art history, this consensus can be defined as follows:

- Minimal intervention with a focus on preservation
- Strong respect for the conceptual “artist’s intent”
- Objectives that account for the viewer’s response — aesthetically and educationally.

This essay will attempt to articulate the complex issues that the conservator must address to integrate and balance these three objectives into inpainting practices. Subtle boundaries within the ethical discussion, such as unity and authenticity that complement the more tangible policies like reversibility, will be explored in the context of historical views and modern perspectives.

One such historical view is found in the early 19th-century treatises on the conservation of paintings and works of art on paper written by German doctor, pharmacist, and chemist F.G.H. Lucanus. Lucanus (1793–1872) wrote for collectors who traditionally cared for their own collections, recommending that unless they were artists themselves, they seek out a restorer who was qualified to do the work (Lucanus 1828, 41). Prior to this time, books on restoration tended to contain tips and recipes haphazardly presented, whereas Lucanus was among the first to address the ethics of inpainting through the systematic presentation of methods and materials. His ethical justification for retouching incorporated the concept of visual unity when restoring a damaged picture without resorting to artistic additions or overpainting:

After doing everything necessary to remove the defects without damaging the essential substance, then you will have the pleasure of preserving the paint-

ing with all its colors and glazes, and you would simply re-varnish the surface. However, if there are losses, even if they are filled with paint or putty, if the contours are unclear, whole passages of paint are missing, or even single glazes abraded or faded, then the harmony of a painting is disturbed and a new element of the conservation takes place: you must retouch. (129–130)

b) Reversibility

Lucanus is probably best known, however, for introducing dammar in 1829 to artists as a preferred varnish, not only for its desirable visual properties but also because of its relative ease of reversibility (Wagner 1988, 19). Although Lucanus did not refer explicitly to the reversibility of inpainting materials, it can be inferred from his comments on varnish removal that he was conscious of the value in protecting artists' original materials: "It is not very likely that you will have to remove dammar coatings. However, if removal does become necessary it is very easy to execute it with a mixture of poppy seed oil and turpentine. The painting will not be damaged" (153). Lucanus's final bit of advice for preserving the paint film was to attach a note to the painting's reverse about the varnish type along with instructions for removing it, a further indication of his concern for the potential liabilities of reversing previous treatments (154).

Reversibility is a core conservation principle that is especially important with regard to inpainting for at least two reasons. First, the deterioration of the conservation materials relative to those of the original can eventually result in a visual discrepancy, causing the inpainting to become a distraction and no longer serve its intended function. Second, because a degree of interpretation takes place during execution, inpainting is subject to becoming stylistically irrelevant, and a future generation may deem it necessary to reinterpret the painting for its own time. Consequently, the conservator needs to consider the stability and permanence of the methods and materials used for inpainting, which are highly dependent on what materials are available at the time of treatment. Each generation is challenged with making the best use of currently available materials, developing new materials, and finding new uses for existing materials.

Based on the results of scientific testing and personal experience, conservators aim to predict the degree to which inpainting materials can be removed once applied to a painting. At the same time, each painting's unique characteristics, such as material composition, age, use, condition, and treatment history, call for individualized treatment solutions. For example, an inpainting medium that can be applied to an oil painting and successfully removed some years later might be an inappropriate choice for use with an acrylic painting due to the different solubility parameters of the paint films. The manner in which a material is used can potentially affect its reversibility, such as when a conservator modifies a proprietary inpainting material by adding dry pigments or another resin to alter its working properties. This practice could have an impact on the treatment's stability as well.

Insoluble inpainting materials, such as egg tempera, that are applied only to filled losses are technically acceptable within reversibility parameters because they can be removed mechanically. But this practice is less desirable because of the high risk of permanently covering the adjacent original paint margins by unintentionally encroaching onto them. Watercolors and gouache, on the other hand, are considered to be reliably reversible and lend themselves particularly well to early stages of inpainting when used to tone white fills, or later over a varnish layer for subtle glazing effects. Yet, even if a material has been professionally tested and deemed to be chemically resoluble over time, history has demonstrated that there are no guarantees with regard to aging properties. For example, Paraloid® B-67, once considered to be an appropriate synthetic resin for use with paintings, is no longer a preferred option as it can become increasingly insoluble over time. Environmental conditions to which the painting is subjected can also affect reversibility, especially if the restored painting is not within a climate- and light-controlled environment.

Although inpainting treatments of past centuries were commonly executed using materials closely matched to the original, such as oil paint retouching on an oil painting, subsequent conservators tended to replace oil with their favorite conservation-grade alternative and employed it in all cases. With a wider set of options now available, conservators have moved away from the formulaic use of a single inpainting material and have embraced a more humanistic approach when making treatment decisions. Consideration for the painting's overall harmony and legibility has been incorporated into the material selection process, yet only professionally accepted materials remain as options. Therefore, the conservator is faced with the ethical dilemma of accomplishing the aesthetic goals of the treatment while also optimizing the materials with respect to stability and reversibility. The success of the treatment depends on the conservator's ability to make compromises that reach a balance between preserving the physical nature of the work and maintaining its artistic integrity.

While varnish is perhaps the obvious and more debatable example of appearance versus reversibility, inpainting materials are also scrutinized and ultimately chosen to best suit the period of the painting, with the underlying prevailing factors being color stability and reversibility. For paintings where the retouching is isolated from the original by a varnish layer, it is important to remember that the solubilities of the varnish and inpainting materials are closely linked — we may consider an inpainting material to be reversible but usually not without the general assumption that it can be removed only during a future cleaning. Therefore, the reversibility of the inpainting essentially depends on the reversibility of the surface coating(s), in that inpainting is rarely removed without disturbing the varnish or overall patina.

Two private companies, Gamblin Artist's Oil Color and Golden Artist Colors, have recently begun to manufacture conservation-grade materials to meet conservators' needs for reversible inpainting materials that have desirable working properties. Oregon-based Robert Gamblin claims that Gamblin Conservation Colors are “stable, revers-

ible, and suitable for use with a wide array of painting styles and techniques.” Gamblin Conservation Colors are made with a low-molecular weight resin and pigments that lead to a “lightfast, permanent material with enhanced working and aging properties” (www.conservationcolors.com). Similarly, New York-based Golden Artist Colors has developed several conservation products, including MSA Colors, an alternative to Gamblin’s Conservation Colors. Golden asserts the reversible properties of their paints:

GOLDEN MSA Colors are produced with a mineral spirit-borne acrylic resin system. They dry quickly to form very durable films with excellent chemical resistance to acids/alkalis, water, and ultraviolet rays. All of the pigments in GOLDEN Acrylics are chosen for the greatest clarity and permanency within each chemical class. MSA Colors remain soluble in mineral spirits, making them ideal for easy removal without disturbing the layers of paint underneath. For this reason, they are beneficial in art conservation for inpainting techniques. (www.goldenpaints.com)

The availability of suitable inpainting materials from these and other proprietary sources is surely an advantage to conservators — not only does it make treatment materials more accessible and expeditious, but also with more options, a conservator has a greater chance for a successful restoration and an ethical treatment to coincide. While companies like Gamblin and Golden have formulated and tested their own products, many conservators have opted to fabricate their own paints using various conservation grade resins and dry pigments.

c) **Justification for Inpainting**

After the conservator has answered the primary question regarding which materials are available and appropriate for a particular inpainting treatment, two additional fundamental questions must be answered: is the inpainting justified and if so, to what degree should it compensate for damage? Answers to these questions are essential when developing an inpainting treatment plan and have been the source of contentious debate over the years. Inpainting is not usually required to preserve a painting’s structural integrity, and a painting could, in a narrow sense, be conserved without the addition of any color. Inpainting is warranted and necessary, however, because the need for a painting to continue to exist as a complete visual document and accurate record of an artist’s work is essential to the painting’s ability to deliver its aesthetic message to the viewer.

Whether to inpaint, and if so, to what degree may be decided by a team of conservator and curator if the painting is part of a museum collection, by the conservator and owner if the painting belongs to a private collection, or even by the conservator and the artist. For practical reasons, it is sometimes the conservator alone who makes these decisions; however, particularly in the case of a badly damaged work where controversial decisions need to be made, a conservator who seeks out other opinions ensures a more prudent and principled approach. Depending on the extent of damage, the compensation questions for an individual painting may differ, and differ yet again when considerations such

as location, type, and size of losses are taken into account. Almost always, compensation decisions are influenced by the environment in which the painting will ultimately be seen because the role of the painting as a viewable artwork will dictate varying degrees of unity and authenticity arrived at through treatment. Consequently, for the treatment to remain faithful to the artist's original intention but relevant to its current and future audiences, the extent of inpainting and the rationalization behind it must be clearly defined for each treatment.

A painting has a dual purpose that directly affects how it is experienced by the viewer. Sheldon Keck (1910–1993), who was a founding member of two conservation graduate programs — the Conservation Center, Institute of Fine Arts/New York University and the Art Conservation Program, Buffalo State College (formerly the Cooperstown Graduate Program) — gave serious and careful thought to this idea. First, a painting expresses the artistic concepts of its creator and exists as an aesthetic object. Second, a painting serves as a social historic entity because it is evidence of the moment and place of its creation. The purpose of a work of art is also connected to its places of exhibition and may change over time: “When it is first created its dominant importance is in the use to which it is put, but as time passes, its historic significance tends to overshadow its original intent and sometimes its aesthetic function” (Keck 1963, 171). The degree to which the historical significance exceeds the aesthetic value of a painting depends on who is making the evaluation. Everyone, including the artist, historian, curator, director, collector, and layman, perceives a painting differently because each has a different viewpoint, motivation, and purpose. The conservator must reflect on the function each individual assumes and consider the context in which the painting will be viewed after it is restored.

d) Authenticity versus Unity

When assessing the degree of compensation achieved through inpainting, the conservator must debate the value of retaining a level of authenticity versus the consideration for unity. Authenticity signifies the disclosure of the true and current condition of the work to the viewer, a treatment's faithfulness to the original condition of the painting and to what remains of the artist's hand. Unity, as a major principle of aesthetics, prompts questions interrelated with authenticity about how much damage should remain visible and how much intervention is necessary and acceptable. For example, how much can a viewer tolerate missing parts of figures or an interruption of a fluid brush stroke? How does a conservator approach an abraded face that no longer engages the viewer or demonstrates the competence of the artist? Does the risk to the distinctiveness of the artist and the individuality of the work brought about by the interference of a conservator's inpainting outweigh the need to restore the continuity of the composition for presentation to the viewer? The answers to these questions are subjective, as all pictures change differentially, and even with written accounts or photographs, it is impossible to know exactly what a painting looked like when the artist set down the brush for the final time. However, inpainting must not be considered an invention of an uninformed practitioner

that leads to an illusion of completeness at the cost of authenticity (Offner 1963, 156). Instead, inpainting should be viewed as a means of reestablishing the visual communication between the artist and the viewer, a communication that depends on the totality of the painting as originally conceived by the artist and leads to a more authentic, and therefore more gratifying, viewer experience (Keck 1963, 170).

Authenticity in restoration has been debated within the artistic community by artists, art historians, and conservators. French artist Eugène Delacroix (1798–1863) kept thoughtful diaries and notebooks that were compiled into a journal, first in 1893 and later edited in 1932 by M. André Joubin, the accepted authority on the artist's writings. In many journal entries, Delacroix commented on discrepancies between the artist's intent, authenticity, and the current condition of paintings in collections he visited. He especially noted the issue of pictures darkening over time, most often when describing paintings by Peter Paul Rubens:

...When we copy a Titian or a Rembrandt we believe that we are keeping the same relationship between lights and shadows as the master's, but actually we are piously reproducing the work of time, or rather its ravages. The great artists would be most painfully surprised if they could see the smoke-blackened daubs that the pictures which they originally painted have become. The background of Rubens' Descent from the Cross, for example, must always have a very dark sky, although one which the artist could imagine when he represented the scene, but it has now become so dark that one cannot distinguish a single detail. (238)

Delacroix recognized that paintings change over time and that the viewer must adjust his impression accordingly to understand what was actually intended by the artist. However, he had very little tolerance for changes made by a restorer whose goal was to compensate for those changes and expressed that a painting's authenticity was lost after restoration:

We are sometimes astonished that nothing remains of the painting of antiquity...We should be even less surprised at their destruction if we reflected that most of the pictures produced since the Renaissance — that is to say, comparatively recently — are already unrecognizable, and that a great number have already perished from a thousand different causes...Clumsy restorations only finish the work of destruction. Many people imagine that they do a great deal for paintings when they have them restored. They appear to think that pictures are like houses that can be repaired and still remain houses, like all those other things, in fact, which time destroys, but which we contrive to preserve for our use by constantly repairing and re-plastering. Women who know how to make-up can sometimes disguise their wrinkles so as to appear younger than they really are, but a picture is something totally different. Each so-called restoration is an injury far more to be regretted than the ravages of time, for the result is not a restored picture, but a different

picture by the hand of the miserable dauber who substitutes himself for the author of the original who has disappeared under his retouching. (238–239)

As an artist of the 19th century, Delacroix likely observed excessively overcleaned paintings and restorations that embraced unrestrained repainting that today would be deemed unacceptable according to current ethical inpainting practices.

Art historians have also expressed their concerns. For example, German-born scholar of Netherlandish art Max Friedländer (1867–1958) commented on restoration in his writings, defending restorations that involved varnish removal, structural stabilization, and consolidation. However, he had a more extreme attitude regarding loss compensation:

The activity of the restorer becomes highly problematical the moment there presents itself the question of making up for deficiencies — that is, of filling gaps or revivifying passages which have been rubbed...The historian, to whom the work of art is a record, opposes, from his standpoint, with full justification, that kind of restoration which goes beyond preserving and exposing. He demands to see clearly what is left of the original, but wishes it also not to be concealed from him that something of the original is missing. It is precisely the successful reintegration that is distasteful to him: the unsuccessful one he, of course, detects easily and can make allowance for. (1996, 333)

Because the term authenticity carries an authoritative connotation that an object is what it is claimed to be, there is also the implication that restoration changes the true identity of the work and therefore its very legitimacy. Friedländer writes further to say that art market value was the main reason damaged pictures were restored despite resistance from more purist scholars. (1996, 333)

Richard Offner (1889–1965), an Austrian-born authority on Italian art and cofounder of the Institute of Fine Arts at New York University, had a similar attitude to Friedländer and argued as late as 1963 that restoration was in direct conflict with the authenticity of damaged pictures:

Any restoration...that introduces paint or shape within its boundaries, even if the restoration be limited to the missing portions alone, must prove intolerable. The plea, generally advanced by the apologists of restoration, that a work may be repainted in tempera or watercolor which can be cleared away or renewed when desired, neglects the transparent truth that any addition whatever introduces irrelevant matter and serves to instill a false impression in anyone who sees the restored work. The longer the repainting endures, the more it misleads. Whether a restoration deludes the eye or disfigures a work, the fact that it is susceptible of easy removal fails to justify it either on moral or aesthetic grounds. Repainting adds the factor of personality — and possibly of intention — extraneous to the original work. (1963, 157)

Offner suggested that the moment a restorer changes the present state of a work, it no longer exists as the natural development and evolution of the artist's hand (157). These opinions imply that as the true connoisseur, the art historian would be expected to overcome the disconnected image and be impressed by the authenticity of the work despite any damage it endured.

In contrast, art historian Cesare Brandi (Italian, 1906–1988) was in favor of at least minimal retouching and reintegration, as he acknowledged that sacrificing unity for authenticity does not serve the painting or the viewer. In 1939, Brandi was appointed president of Italy's first training institute and school for restorers, the Istituto Centrale del Restauro in Rome, where he served until 1960. He is well known for developing conservation theories that informed the *tratteggio* style of inpainting based on the principles of nonimitative retouching, a nascent version of which was practiced in the early 1930s at the Fogg Art Museum (Contreras de Berenfeld 2008, 185).² *Tratteggio* was designed specifically to allow the viewer to distinguish retouching from the original while also attempting to resolve the authenticity dilemma. When considering the impact of damages on a painting, Brandi wrote:

A lacuna in regard to a work of art is an interruption of the figurative pattern...The lacuna, in fact, will have a shape and color that are not relevant to the figurative aspect of the represented image; it is inserted into the work of art as a foreign body...The image is more than just mutilated, it is also devalued in the sense that what was born as a figure is now reduced to mere background. (1996, 341)

In this statement, Brandi justifies the need for retouching as a primary means for maintaining the fundamental nature of a work of art. The secondary purpose of *tratteggio* was to retain a level of authenticity within the treatment by “prevent[ing]...any personal expression of the restorer...so that the intervention is structurally unmistakable as a critical interpretation” (Mora, Mora, and Philippot 1996, 351). According to Brandi's theory, unity is restored to the extent that the viewer perceives a continuous image when standing at a normal viewing distance. The unified picture is closer to the original intention of the artist while authenticity is preserved by limiting the degree to which inpainting makes the damage imperceptible.

Keith Christiansen, chairman of European paintings at the Metropolitan Museum of Art, demonstrated in a 2002 symposium on early Italian paintings at Yale University how a painting can lose its narrative function if it cannot transmit its message through a legible composition. Christiansen used Leonardo da Vinci's fresco, *Last Supper*, as a prime example of how a lack of completeness can influence the interpretation of a work of art: “...I fear what we see are no more than fragments of disconnected moments — some preliminary, some half way to the completed image, but all of them compromised by deterioration and damage. Were we to have only the remnants of the mural as it is now, would it be possible to deduce Leonardo's intentions? I doubt it” (2003, 76). Christiansen suggested that early descriptions of the work and photographs of its

condition in the past should be used to help evaluate the artist's objective. Whether the readability of *Last Supper* in particular can be veritably retrieved is beyond the scope of this discussion, but it is important to note that Christiansen's comments justify the act of inpainting while also reinforcing the importance of documenting treatments for future reference.

In addition to art historians and curators, an international group of conservators addressed the challenges of maintaining authenticity while achieving unity throughout a conservation treatment. Working in Belgium, Albert Philippot (1899–1974) and his art historian/archaeologist son Paul (b. 1925), who served as director of ICCROM in the 1970s, developed a model in 1959 for treating paintings that was structured around the concepts of balance and unity: "A work of art as such is not composed of individual parts but constitutes, as an image, a whole endowed with its own unity, realized in the continuity of the form — a unity therefore essentially different from that of the things represented. Any discontinuity, any interruption inevitably disturbs the reading of this rhythm" (1996, 335).

Treatments were based on forming an idea about the original appearance of the painting, and the method was informed by the knowledge of the evolution of materials and the ability to differentiate between actual damage and patina (Modestini 2005, 33). The Philippots addressed authenticity as well by qualifying loss compensation in two ways. First, they described how inpainting must be executed with critical interpretation of the paint layer, a high level of technical execution, and a practical cultivation of the visual imagination that is derived intuitively from the picture so that the conservator's own personality is suppressed as much as possible (336). Second, they considered the principle of strictly limiting the retouching to within the losses as a sacred one (336–337). Authenticity was achieved without sacrificing unity because the retouching was considered to be an informed reintegration of a damaged painting that could be changed in the future if the interpretation was deemed inappropriate.

Some years later, Paul Philippot collaborated with Rome-based conservators Paolo Mora (1921–1998) and Laura Mora (b. 1923)³ to coauthor an article that stated the following principle: because a work of art is created by an individual at a distinct moment in time, it is unique and cannot be reproduced — to attempt to do so would change not only its character but also its meaning (Mora, Mora, and Philippot 1996, 343). The conservator's role is to preserve that character and meaning through skilled and ethical treatments. The authors pointed out that multiple losses had the potential for overwhelming a painting to the extent that the image would become secondary to it, thus making it impossible for the viewer to experience the work of art in a meaningful way (343). And because the appearance of a work of art is directly related to the artist's intent, the condition of the work will affect the comprehension of that intention by the viewer. Consequently, if damage to a painting affects its appearance to the point where it can no longer be understood, then inpainting is necessary to preserve the illusion created by the artist. A conservator who is respectful of a painting's artistic and histori-

cal authenticity is justified in attempting to minimize the discontinuity of form because “from an aesthetic viewpoint, the work of art is characterized by the unity of the form as a whole. The image created by the artist differs from the object which is its physical support in that it is not equal to the sum of its parts and is therefore not divisible” (345). However, if the damage across a painting is so great that the unique quality of the work is at risk, a conservator must be limited to the practical extent that he or she does not make suppositions that would compromise the genuineness of the work. The painting’s uniqueness should be respected, and a conservator should make judgments that are guided by conscience, refraining from invention to the point that a treatment becomes a falsification.

Former Metropolitan Museum of Art conservator John Brealey (British, 1925–2002) articulated a humanistic approach to conservation, where decisions and judgments on cleaning and compensation were made through “an educated ability to look at works of art intelligently and sympathetically in order that the entire significance of the work is understood, both intellectually and emotionally” (Talley 1992, 46). According to Brealey, treatments should be guided by the visual interpretation of a painting and should try to resolve how the artist’s intention has been affected by the painting’s poor condition. While unity is the primary goal in this case, authenticity is also retained by incorporating scholarship that relates to a painting’s origin and context. This is accomplished by studying other works by the same artist; understanding work by the artist’s contemporaries, rivals, and imitators; gaining experience with the painting methods and materials used during the artist’s lifetime; and being familiar with the aesthetic, religious, political, and social ideas that were then current (Tomkins 1987, 45).⁴ After reflecting on this research, an informed, successful treatment from a humanist’s perspective depends on the recovery of tonal harmony, internal structure, and a painting’s convincingness as an illusion via technically derived methods of preserving and restoring art (44).

Mark Leonard, former head of paintings conservation at the J. Paul Getty Museum, elaborated on this approach in a personal reflection on paintings conservation. He wrote, “Allowing myself to be guided by the works of art enabled me to engage in restoration treatments that ultimately brought the individual paintings to a state where the artist’s voice could have its fullest expression through the physical reality of the work of art” (2003, 42). The most important part of this statement is “the physical reality of the work of art” because it signifies the acknowledgment of limits in a restoration treatment. There are limits to the extent of repair that can be reached, there are limits to the acceptable materials that can be used to treat the picture, and there are limits to how well an artist’s intention can be understood in a subsequent point in time as well as from an aged and damaged picture. These boundaries are created by the imperative of preservation that comes first in any ethical code in conservation and are guided by a goal in which a restoration allows for a viewer to experience the full impact of the painting as a work of art without commenting on the extent of the damage.

e) Viable Approaches

Imitative retouching is a practical solution to the philosophical questions discussed above. Also referred to as invisible or mimetic, imitative retouching aims to reproduce the hue, tone, texture, and reflective properties of the adjacent original paint such that the disruption caused by the damage is imperceptible and the illusion is restored to the picture. Directed by the information remaining of the original to either side of the damage, the conservator aims to reintegrate the loss so that it is indistinguishable from the original. New York-based paintings conservator Dianne Dwyer Modestini⁵ presented her views on this topic at the 2002 Yale symposium on the conservation of early Italian paintings:

Imitative retouching is not just cosmetic, but part of an aesthetic, some might say humanistic, approach to restoration. It has philosophical roots in Berenson's concept of tactile values: "Painting is an art which aims at giving an abiding impression of artistic reality with only two dimensions...I must have the illusion of being able to touch a figure, I must have the illusion of varying muscular sensations inside my palm and fingers corresponding to the various projections of this figure before I should take it for real and let it affect me lastingly," he wrote. Paintings that do not satisfy this illusion of the third dimension cannot communicate tactile sensations and so are difficult and confusing to most lay viewers. (2003, 209)

This approach is primarily favored when the painting is in a convincingly good state and only a minimal amount of interpretation is required.

When the treatment involves a picture with extensive paint loss and insufficient information to guide the conservator in his or her inpainting decisions, three basic compromises are available. First, based on art historical knowledge and an awareness of the aging properties of the original materials, and in consultation with other interested parties, the conservator can conceive an imitative reconstruction by making comparisons with similar works in a good state of preservation or historical photographs of the work. However, such a solution can be controversial and should be implemented only in response to an extreme situation where other options are impractical. If the painting is to be displayed in a museum or other public place, wall text should be included to inform the viewer of its compromised condition. Likewise, full disclosure of the extent of restoration, which can be accomplished with conservation documentation, should be obligatory when a picture is available to the marketplace.

If an approach that involves extensive reconstruction means going beyond what is deemed reasonable or desirable by the conservator, curator, art historian, owner, or other interested party, then a second option would be to use a type of discernible inpainting, also referred to as differentiated or evidenced inpainting. The purpose of discernible inpainting is to reconstruct the damages in such a way as to subdue the distracting effects of the losses when viewed from a normal viewing distance, but making them readily visible on close inspection. The *tratteggio* technique is eminently suitable in such cases.

The third alternative is another form of discernible retouching in which losses are toned with a neutral color to subdue the distractions caused by the damages. This allows the conservator to present the work in a respectful manner while also acknowledging its fragmentary state. The value of displaying a work in such a poor state of preservation should be widely debated before this type of treatment is undertaken.

In the case where a painting's condition varies extensively from one area to another, choosing between the two markedly different inpainting philosophies — imitative or discernible — might be difficult. The conservator would want to optimize the well-preserved areas without going beyond the ethical boundaries in the damaged areas. This may lead to a solution where both approaches are used within the same picture. This option, which is particularly well suited to large-scale works such as wall paintings, would signal to the viewer the painting's fragmentary state but also allow for the appreciation of the intact passages of the picture.

Although seemingly apart in their philosophies, conservators who prefer imitative and those who use discernible approaches to inpainting are, in practice, often less polarized than one might imagine. For the conservator who subscribes to discernible inpainting, the level of perceptibility tends to diminish as the level of preservation increases; the smaller and better preserved the picture, the less apparent is the retouching. Often for the imitative practitioner, the larger the loss and the smoother the surface texture, the more visible the retouching is to the connoisseur. Both philosophies can be ethically employed depending on the condition of the painting, the context in which the restored picture is re-presented to the viewer, and the sensitivity and skill of the conservator.

Sensitivity is especially important when a conservator is faced with the ethical challenge of determining whether a treatment requires retouching that may cover over original paint in order to achieve the objectives of the treatment. In light of the misguided and extensively overpainted treatments that conservators frequently inherit, controversy has surrounded the issue of whether and to what extent one should compensate for areas of abrasion, missing glazes, fugitive and discolored pigments, and tonal shifts in dark versus light passages over time. Consequently, when damage to a paint film goes beyond discrete losses, the ethical guidelines for inpainting become more complex. A conservator may be compelled to use thin glazes to restore three-dimensionality to a forehead or soften highlights on a nose to retrieve a portrait's tonal balance, for example. It is also not uncommon either for a conservator to use scumbling as a means for tonally lifting remnants of darkened varnish or embedded bits of grime that are trapped in the interstices of a flattened canvas weave.

Conservators and others from past centuries frequently commented on limiting retouching to discrete losses, and, as it is related to the principle of reversibility, a *staying-within-the-lines* approach is widely accepted as an ideal ethical practice. Only a few were willing to acknowledge the practical necessity of scumbling and glazing. For example, Lucanus's 1832 treatise explicitly addressed the subject of replacing the worn glazes of a painting:

Glazes form the skin of a painting. For this reason, the glazes are exposed to all occurrences. Furthermore, they are sensitive to all solvents that are used to remove varnish as they are applied over or in the varnish coating. If there are small breaks in the glazing then it is appropriate to complete them. In cases where all the glazes are missing, overglazing would disfigure the picture and take away everything that remains from its authenticity. If you are not quite sure if a painting had any original glazes then you should not do any glazing. (132)

This example of wrestling with the thorny and sometimes agonizing decision to retouch on top of original paint recognizes certain limits but also the instances when glazing can be warranted and successful.

Helmut Ruhemann (German, 1891–1973) recorded practical solutions to loss compensation in his book that reflected on nearly 40 years of working with the collection at the National Gallery London. He believed that “retouching should be kept to the minimum necessary to restore the coherence in composition and the characters of a damaged painting” and that “no new paint must be allowed to cover the smallest part of well-preserved original” (1968, 241). Ruhemann carefully chose the phrase “well-preserved original” to allow for exceptions to that rule: when a painting’s surface has “no fundamental loss of paint but only an ill-defined wearing of the original surface, ‘stippling-in’ is required”(242). Ruhemann also acknowledged that each picture may require a different level of inpainting, admitted to using different inpainting solutions within the same picture if necessary, respected the principle of reversibility, and recognized the value in presenting a picture that is aesthetically pleasing to its audience: “On the whole, once everything has been done to assure the preservation of a painting, its successful existence depends on its presentation. It will fail in its destiny to the extent to which the master’s intention is marred by losses or accretions. The initial meaning will not only be obscured but often distorted” (257). While Ruhemann’s practical approaches to cleaning paintings have been challenged, his writing on the subject of inpainting was balanced and respectful, based on connoisseurship that could be applied to many treatments today.

National Gallery London conservator Larry Keith’s recent treatment of Aelbert Cuyp’s *Large Dort* presents us with an excellent example of a well-reasoned approach to retouching. After the cleaning phase of the treatment, Keith was presented with a discrepancy in the spatial resolution between parts of the foreground and the middle ground that disrupted the reading of the picture. Guided by information obtained through technical analysis, he determined that much of the foreground paint had experienced a color change due to blanching. Scientists then conducted extensive analyses to determine the actual cause of the blanching, which helped to clarify which areas were meant to appear gray-green and which were not. Keith’s remaining questions regarding the artist’s intent were resolved by making visual comparisons with other Cuyps known to be in a good state of preservation. Strengthened by a complete understanding of the painting’s con-

dition, the conservator was justified in addressing the damage by selectively toning the blanched paint “to present a more coherent and properly functioning spatial recession... The intent was to aid the spatial illusion not through reconstructing the colours of the unaltered paints, but through re-establishing tonal relationships that functioned well enough to allow the viewer to appreciate some measure of the picture’s original splendor” (Spring and Keith, 2009, 82).

In his 1996 essay, conservator in private practice Steven W. Dykstra illustrated how a conservator might deliberate over whether to apply retouching on top of original paint by highlighting the example of a pentiment. The author pointed out that a pentiment likely was not intended by the artist to be part of a work, as it is the result of natural aging of the paint film, but that it could be visually acceptable and of interest to viewers because it provides insight into the artist’s thought process. On the other hand, in instances where a pentiment interferes with the legibility of a picture, it could be perceived as a disfigurement and is therefore something to be concealed with retouching (1996, 206). Dykstra used a similar line of reasoning to demonstrate how to deal with other unintentional features of a picture, such as a discolored pigment or a glaze that has faded:

Tradition and practicality seem to determine how this approach is applied. Traditionally in older artworks, some varieties of deterioration are commonly accepted despite their deviation from the artist’s original conception while other instances of decay within the same work are not. In baroque painting, especially landscapes, there is a tendency to concede the appearance of brown paints that we know were originally green, but the pale transparent hues of paints once tinted with fugitive red lakes immediately suggest color reinforcement. In practice, the desire to keep compensation to a minimum tends to allow only the most efficient efforts to unveil aspects of the artist’s intent. In the baroque paintings, there is compelling economy of treatment in a decision to touch up red accents and leave browned [ones] alone. (207)

At first glance, the decision to retouch one area over another may appear to be arbitrary — why replace the red lake glazes but not return the brown landscape to green? But Dykstra came to a logical conclusion about which areas should be retouched by understanding the practical constraints of the paint layer and applying the ethical guideline of minimal treatment. In the conservator’s judgment, too much opaque overpaint would be required to return the brown landscape to green, but the red glaze could be applied transparently and delicately, allowing the artist’s original brushwork to remain legible beneath it. Ultimately, the conservator must concede to making compromises in such cases.

The rationale for retouching on top of original paint could also originate from a conservator’s desire to postpone a painting’s next varnish removal; applying some retouching above an existing varnish layer to extend the life of the previous treatment can momentarily preclude exposing the painting to the rigors of cleaning. Further challenges may

be introduced when a conservator devises a treatment for a previously restored picture where there is good reason for retaining those restorations and incorporating them into the current treatment. One example is a picture that was restored or reworked by the artist himself sometime after it was completed, and the later additions that are now discolored no longer serve their intended purpose. In some cases, the historical importance of these alterations could outweigh the impulse to remove them, and the conservator must consider whether to implement glazing as a means for achieving more acceptable transitions between original paint and later additions.

Finally, a conservator's approach should not be based on a fundamentalist notion in which aesthetic quality — a primary value of a work of art — is ignored in favor of strict technical rules, for to do so would lead to failure. Keith Christiansen (2003) thoughtfully articulated this concept when he reflected on the conservation history of Yale University's Jarves Collection:

The tragedy of the Jarves Collection...resulted from zealously pursuing a methodology: a methodology that sacrificed concern for the appearance of a work of art to its documentary value. Moreover, it confused such moral terms as honesty and truth with the complex histories of works of art and the ambiguities they present both to those who, as a matter of course, oppose modern restoration practices, and those who are committed interventionists.
(72)

Christiansen recognized that a conservator's work is subjective because of taste, sensitivity, scholarship, and training, but that subjectivity is a positive factor because it leads to an "improved" picture rather than simply a "truthful" picture (81). Thus, if a conservator is concerned with the aesthetic value of a picture and the notion of artist's intent, some degree of glazing or covering of original material must be acceptable in certain cases, with the understanding that the method of application is consistent with the ethical imperatives of reversibility and documentation.

It is essential that conservators delineate ethical principles in order to maintain the integrity of paintings, artists, and themselves as professionals. The *AIC Code of Ethics and Guidelines for Practice* devotes only one short paragraph to the topic of compensation, and it offers no specifics with regard to inpainting. Indeed, it lumps together filling and inpainting under the umbrella term *compensation* without consideration for the distinctions between the ethical questions each may present. Treatment Section 23 "Compensation for Loss" of the *Guidelines for Practice* states:

Any intervention to compensate for loss should be documented in treatment records and reports and should be detectable by common examination methods. Such compensation should be reversible and should not falsely modify the known aesthetic, conceptual, and physical characteristics of the cultural property, especially by removing or obscuring original material.

Because this statement is meant to serve all conservation professionals, AIC has encouraged the specialty groups to provide additional guidance with a higher level of detail to its practitioners. The purpose of this essay is not to present a step-by-step, instruction manual-type methodology for the conservator to follow, but rather to persuade him or her to adopt a well thought-out and philosophical approach that can be modified to suit each individual painting.

While the principle of reversibility is established and widely accepted as a fundamental statute of any retouching treatment, the concepts of authenticity and unity must also be considered to justify the relative degree to which a painting should be retouched. Scholarship and scientific analysis can further rationalize and validate a retouching decision for a particular painting. The aesthetic, cultural, historical, and educational value of a painting determine the context in which a painting is restored, and each of these must be factored into treatment decisions. Because that context varies for each particular work of art, no definitive approach is capable of delivering an ethical justification for inpainting in every case. However, if the current generation of conservators continues to assess the influential judgments of the past and reflect on how its restorations will be evaluated in the future, the ethics of inpainting will likely continue to be revised as the objectives of restoration treatments and the interpretation of artworks change over time.

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ENDNOTES

- ¹ Ann Temkin, *Contemporary Voices: Works from the UBS Collection* (New York: The Museum of Modern Art, 2005), 64.
- ² Contreras de Berenfeld tells the story of Brandi's early experience with non-imitative retouching, demonstrating that the origins of *tratteggio* were the result of a fascinating American-Italian exchange in the years leading up to World War II.
- ³ The philosophy and techniques espoused by the Moras are discussed in this volume in greater detail in "Italian Differentiated Inpainting Techniques: A Review" by Pamela Betts.
- ⁴ Quotation refers to a conversation between John Brealey and the interviewer, Calvin Tomkins.
- ⁵ Modestini is Adjunct Professor of paintings conservation, Institute of Fine Arts, New York University, and consultant to the Samuel H. Kress Foundation.

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3. Ethics Glossary: A Reference for Inpainting-Related Concepts

Artist's Intent: The concept of artist's intent generally refers to how the artist wanted the work to be seen at completion and sometimes includes projections as to how it should be seen in the future (Hedley 1993, 154). The primary layer of intent consists of measurable, material things — the choice and preparation of media; size, shape, and order of brush-strokes; idiosyncrasies of drawing, modeling, and line — that make up a particular artist's distinctive artistic style (Dykstra 1996, 215).¹ The secondary layer goes beyond the technical characteristics of a painting; the psychological insights, social and intellectual purposes, and aesthetic effects (215).

Compensation: Reconstruction of missing design (Ruhemann 1968, 61). The act of making up for, offsetting, or counterbalancing (*Webster's II New Riverside University Dictionary*).

- **Approximate compensation:** Putting into [lacunae] paint that comes near to matching that of the original which is adjacent and in this paint some tone variations may be introduced (Stout 1941, 103).
- **Remote compensation:** Putting into the lacunae paint of a flat, neutral tone, said to be without drawing (Stout 1941, 103).

Glaze: A transparent or semi-transparent paint layer, applied either directly over the ground or over an underpaint to modify the color of the ground or underpaint. With the use of appropriate glazes, the tonal range of a color can be extended to give a greater contrast between highlights and shadows. Since the glaze is transparent, the color of the underpaint or ground, which is generally lighter, plays a part in the final optical effect.

The term *glaze* is often used imprecisely to mean any thinly applied paint layer, particularly the final finishing touches to a painting. However, these can include combinations of pigments and media that are normally opaque or semi-opaque: it is simply the thinness of application that allows the underlying layers to contribute to the optical effect. Properly, thin layers of opaque color applied to modify the underlying colors should be called *scumbles*.

Glazes are usually made by combining pigments and paint media that have similar or identical refractive indices: that is, they transmit light to a similar or equal degree so the light is not bent or refracted at the interface between the medium and the pigment particle. Media such as egg tempera, glue distemper, casein, gouache, and some paints based on synthetic resins have refractive indices that are lower than those of any artists' pigments: therefore they cannot be used to make truly transparent glazes. At best, the paint layers can only be translucent. Drying oils, however, have higher refractive indices, approaching those of certain pigments. Their refractive indices can be raised further by the addition of natural resins, usually those used in varnish making — for example, copal, sandarac, pine resins, mastic, and dammar.

Pigments that form transparent or semi-transparent glazes when combined with drying oils fall into three groups. The first contains pigments with refractive indices close to those of drying oils. They include several blue pigments (e.g., natural and artificial ultramarine, smalt, and Prussian blue), but they are not completely transparent because their refractive indices are still slightly higher than those of the oil-based media. The second, and perhaps most important, group comprises the red and yellow lake pigments. The red and yellow dyestuffs from which they are made do not themselves have low refractive indices, but when they are to be used as transparent lakes they are precipitated on to colorless substrates of low refractive index, traditionally alum (hydrated alumina) or chalk (calcium carbonate). The third group consists of pigments that are wholly or partially soluble in the paint medium. Since there is no longer any interface between pigment and medium to refract and scatter the light, the refractive index of the pigment is irrelevant. This group includes copper resinate (verdigris dissolved in an oil-resin medium), such colored resins as gamboge and dragon's-blood, and the various bituminous brown pigments (*Grove Art Online*).

The term *glaze* denotes a thin layer of transparent or semi-transparent color laid over another underlying color. The transparent colors used in glazes have low refractive indices (e.g., lake, ultramarine, copper resinate, Prussian blue). The careful building up of final colors by using layers of glazes was common from the 15th to the 19th centuries until the more widespread availability of stronger, industrially produced paints (*The Concise Oxford Dictionary of Art Terms*).

Inpainting: Term used in the conservation of paintings or objects for the toning or imitative matching of an area of paint loss, without obscuring any original paint (*Grove Art Online*). Applying new paint on areas where original paint has been lost or abraded (CCI 1994, 6). This term first appears in American conservation literature in 1935 in an article by George Stout and more specifically refers to the act of adding color within the confines of a discrete loss or abraded area. Stout defines the “placement of new paint in the lacunae of the old film” as “painting in (‘inpainting’)” (Stout 1935, 210).

- ***Cosmetic inpainting:*** Ornamental rather than functional; having little or no significance; superficial (*Webster's II New Riverside University Dictionary*). Wholesale repainting with resulting personal interpretation, often deliberate falsification, designed to upgrade attributions and conceal the ruins (Modestini 2003, 209–210).
- ***Deceptive inpainting:*** Intended or tending to mislead, dupe, delude, fool, hoodwink, misrepresent, trick (*Webster's II New Riverside University Dictionary*).
- ***Differentiated inpainting:*** Constituted or showing a distinctive difference in or between; distinguished; discriminated (*Webster's II New Riverside University Dictionary*).
- ***Evidenced inpainting:*** Present and plainly visible; conspicuous (*Webster's II New Riverside University Dictionary*).

- **Imitative inpainting:** Imitative retouching aims to reproduce the hue, tone, texture, and reflective properties of the adjacent original paint such that the disruption caused by the damage is imperceptible and the illusion is restored to the picture. Tending to duplicate exactly, copy the appearance of, reproduce or mimic (*Webster's II New Riverside University Dictionary*).
- **Invisible inpainting:** Not easily detected or noticed; imperceptible (*Webster's II New Riverside University Dictionary*).
- **Mimetic inpainting:** Using imitative means of representation (*Webster's II New Riverside University Dictionary*).
- **Neutral inpainting:** A type of visible inpainting consisting of a plain color — a so-called “neutral” tone — chosen to blend unobtrusively with the overall tone of the painting (*The Oxford Companion to Western Art*).

Lacuna: [Latin: gap] Completely blank area on a painting or painted object or manuscript, resulting from any form of damage. On paintings, the cause may be the gradual decay and loss of adhesion of the paint layers, allowing flakes of paint to become detached. Accidental damage can give rise to larger lacunae (*Grove Art Online*). The plural form is lacunae or lacunas; the adjectival form is lacuna.

Loss: Impairment of structural unity. Among these are fractures, splits, or checks, punctures, tears, and corrosion (Stout 1935, 205). Scars or actual lacunae in the paint film. The latter ordinarily fall into one of three types: abrasion or skinning, the superficial wearing or rubbing away of the paint; flaking, the separation and loss of small portions of the film above the level of the ground and without a total loss of color; and scaling, the separation and loss of large parts of the film, usually islands, which leave the ground exposed (Stout 1935, 210).

Losses may be divided into five different types:

1. Wear of the patina...due either to abrasion or to the loss of minute flakes of paint beneath which a part of the pigment layer or at least the original rendering remains.
2. Wear of the pigment layer.
3. Complete losses of the pigment layer...limited in surface area and capable of being reconstructed.
4. Complete losses of the pigment layer...which, because of their extent and/or localization, should not be reconstructed.
5. Losses of considerable extent, which should nevertheless be reconstructed because of their architectural significance (Mora, Mora, and Philippot 1996, 348).

Overpainting: Paint not applied by the artist that covers original paint and that is often an excessive and unnecessary alteration to the image; overpaint hides areas of abrasion, or

is used to reinforce the image or make changes to it (CCI, 7). Covering old paint with new (Stout 1935, 210).

Pentiment: [*pentimento*; Italian: repentance]. Visible evidence of an alteration to a painting or drawing that suggests a change of mind on the part of the artist. In particular, it refers to previous workings...revealed by the change in the refractive index of oil paint that occurs as it ages: thin layers of paint that were originally opaque may become semi-transparent. For example, in Titian's group portrait of the *Vendramin Family* (c. 1543–47; London, N.G.), the figure of a young, bearded man on the far left was moved inward. The head of the figure in the original position is now evident as a ghostly image on a patch of sky. The term is also used to refer to such effects where they do not necessarily imply a deviation from the original intention. For example, in Pieter de Hooch's *Interior* (London, N.G.), the checkered floor is visible beneath a maid's dress, confirming that the figure was added after the floor was painted. This may have been necessary, given the precise geometric pattern of the floor and the perspective involved. *Pentimenti* suggest that painters refined and altered compositions as they worked, and, for this reason, they are often cited as evidence of authenticity; similarly, they are less likely to appear in copies. The term is also used to describe the hesitant preliminary workings that show beneath some drawings (*Grove Art Online*).

Reintegration: Filling in the loss and inpainting the missing area to create the illusion of the original complete image and reintegrate the area of loss into the visual image of the whole (Caple 2000, 119). Careful retouching of gaps (integration) (Ruhemann 1968, 61).

- **Functional reintegration:** Where the area is restored to make the object stable (Caple 2000, 119).
- **Background reintegration:** Where the filled area is given a color and texture to blend with the base or background color and texture of the object; this makes it less visible but does not suggest any decorative scheme, often because information on the exact nature of the original decorative scheme is not available (119).
- **Similar reintegration:** The filled area is pigmented to give a crude approximation to what was originally present, although no detail is included and exact coloration is deliberately not achieved (119).
- **Exact reintegration:** The filled area is restored to its original appearance with all elements of the design included and correctly colored; as for all restoration, "exact" reintegration must still be detectable on close examination to avoid faking and deception; to undertake this level of reintegration, there must be clear and detailed information about the design and pigmentation originally present in the area of loss (120).

Restoration: "The practice of treating pictures or other works of art to aid in their conservation or to bring them nearer to their original condition" (Stout 1935, 203). Filling in missing areas; the "painting" or "retouching" of the filled areas or of those parts of the surface of the object where the original decoration or painted layer has been lost (*Grove Art Online*).

- **Fragmentary restoration:** Conserving the original material by cleaning, stripping, or removing overpaint, but not by retouching, filling losses, or making reconstructions; the painting is left in a fragmentary state (von der Goltz 1999, 202).
- **Documentary restoration:** After cleaning, losses and holes are filled to restore the two-dimensional surface of the painting, but they are kept visible by retouching them in a neutral gray; alternative to fragmentary with greater concern for the spectator (202).
- **Complementary restoration:** Treatment is to “complete” the painting and achieve the original effect created by the artist without any creative acts by the restorer; the artist’s intent is the guiding principle (202).

Retouching: The act or process of adding new fine lines, strokes, or tinges of color for correction or improvement (*Webster’s II New Riverside University Dictionary*). A traditional term that has been used synonymously with *inpainting*; inpainting is more precise because retouching can also imply *overpainting* so that original paint is covered (CCI 1994, 8). Coloring a defective area of a painting (Nicolaus 1999, 257).

Scumble: A thin layer of opaque or semi-transparent paint, applied on top of another layer without completely hiding it. It is effectively the opposite of a glaze and gives a broken and hazy effect, toning down the brilliance of the underlying color (*Grove Art Online*). Essentially, the partial application of one layer over another. In painting, a thin layer of opaque or semi-opaque color applied over an area of an oil painting without completely obscuring the underpainting (*The Concise Oxford Dictionary of Art Terms*).

Tratteggio: Transposing the modeling and drawing of a painting into a system of hatchings based on the principle of the division of tones...A system of small vertical lines averaging one centimeter in length. The first lines, which indicate the basic tone of the retouching, are placed at regular intervals equal to the width of one line. Next, these intervals are filled with a different color, and then again with a third color, to reconstitute the required tone and modeling by means of the juxtaposition and superposition of colors that are as pure as possible. Each line in itself should be weak in intensity, the desired intensity of the whole being obtained by the superposition of glazes of transparent lines rather than by strength of color, which would cause the retouching to lack the vibration indispensable for a good integration (Mora, Mora, and Philippot 1996, 351–353).

In different centers in Italy, where visible methods of restoration are perhaps most widely applied, several techniques have been developed and their methods and philosophies codified. In the simplest of these, the restoration can be recognized by the use of regular and equal sized vertical brushstrokes, called in Italian *tratteggio* or *rigatini*. Areas of damage may be reconstructed and the colors of the original matched, but the brushstrokes always remain consistent in their direction (*Grove Art Online*).

- **Chromatic selection (*selezione cromatica*):** A variant of the *tratteggio* developed in Florence...The brushstrokes are allowed to follow the direction of the form of the

area being restored, for instance the sweep of a drapery fold, or can be applied vertically and diagonally to form an interlaced mesh of brushstrokes...The colors for the restoration are chosen from the three primary and three secondary colors and mixed optically by the juxtaposition and interlacing of stippled dots of color, as in the Pointilist color theories employed by, for example, Georges Seurat. It is argued that, while remaining readily detectable, the technique produces a vibrant effect suited to the intense palette of medieval and Italian Renaissance paintings (*Grove Art Online*).

- **Chromatic abstraction (*astrazione cromatica*):** Similar optical principles as chromatic selection...also of Florentine origin. This method is employed when the losses are too large to suggest the forms and colors that may have been present and is intended to supply a more satisfactory solution than the so-called “neutral” restorations. The strokes, which are not directional, are painted with the three primary colors and black, the proportions of the colors determined by (or “abstracted” from) the colors of the areas surrounding the loss. If, for example, the loss is principally in an area of blue drapery but also extends into areas of red and green, a preponderance of blue strokes may be applied, but the presence of some red and yellow (suggesting green) strokes will in theory make the restoration visually compatible with the red and green areas as well (*Grove Art Online*).

Authors' note: The authors compiled this reference for inpainting-related concepts from non-exhaustive research to clarify terms used in the literature, many of which can be found in the authors' preceding submission, “The Ethics of Inpainting.”

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ENDNOTE

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- ¹ The thought-provoking article of Washington, D.C. private conservator Dykstra presents eleven different interpretations of the term *artist's intent* that challenge us on clarity when we use the term.

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———, s.v. *cosmetic*

———, s.v. *deceptive*

———, s.v. *differentiated*

———, s.v. *evidenced*

———, s.v. *imitative*

———, s.v. *invisible*

———, s.v. *mimetic*

III.

Inpainting Binders and Media

A. HAND-MIXED

1. Aqueous Binding Media

a) Egg Tempera

(1) Principal Name

Egg Tempera

The term *tempera* is derived from the Italian verb *temperare*, which translates into English as “to moderate, control, or temper.” The English verb “to temper” is defined as “to dilute or soften by the addition of something else (to temper justice with mercy).”

The word connotes that the pigments are tempered by the medium. This could, of course, refer to any paint, but is primarily used to mean a water-born, natural medium, usually egg.

(2) Other Names

Dawson Carr and Mark Leonard define tempera as a water-based paint that can include both egg tempera and glue tempera; they note that glue tempera is sometimes called distemper or *Tüchlein* (1992, 66). Rutherford J. Gettens and George L. Stout also include casein and gum as kinds of tempera (1966, 69).

Herbert Lank sometimes uses the term *egg tempera emulsion paint* as well as *egg tempera paint* and *tempera paint*.

(3) History of Use

(a) Industrial (Artistic)

Eggs have been used as artists' materials since ancient times. Pliny describes the use of egg as a paint medium (Gettens and Stout 1966, 70).

Eggs have two major components: the white (also called albumen) and the yellow or yolk; they can be used both separately and together. For easel paintings, they have most commonly been used separately, the yolk as a paint medium and the white as a varnish.

The preparation of glair from egg white is described in the *De Clarea* manuscript, a 12th-century copy of a text from the first half of the 11th century (Woudhuysen-Keller 1994, 92). Cennino Cennini writes of the use of egg white for gilding (1933, 79–80) and for painting on parchment (100). Egg white has also been used as a varnish (Woudhuysen-Keller 1994, 91).

Cennini also mentions whole egg tempera, combining the yolk and the white. These are suggested for painting on walls and can either be made of a whole beaten egg or with the addition of natural latex from the fig tree (51, 121–122). To do this, he describes adding clippings from fig shoots to the whole egg and beating the mixture. The laticifer tissue of the common fig, or *Ficus carica*, secretes latex, a thick, white complex emulsion of resins (terpenoids and phenolic compounds), proteins, acids, carbohydrates, tannins, alkaloids, and minerals (Langenheim 2003, 49). Presumably this would assist the adhesion of the tempera to the wall; Cennini notes that this is particularly useful for preparing plastered walls for oil paint (58).

Cennini described the technique of painting in egg tempera, writing in the early 15th century but describing traditions established at least 100 years before. His paint medium for use on a wooden panel prepared with a gesso ground uses only the egg yolk.

Although more Italian than Northern egg tempera paintings survive, egg was used throughout Europe. Surviving English examples include the late 14th-century Wilton Diptych (Gordon 1993, 80).

As the use of drying oils as a paint medium increased in the early 15th century, egg tempera began to be less common. It was rarely used by European artists after the mid-16th century.

In the 20th century, there was renewed interest in egg tempera, which was used by such artists as Andrew Wyeth. Mark Rothko added egg to his oil paints for the Rothko Chapel (Mancusi-Ungaro, 2001).

(b) Conservation

i. History

According to Mary Kempster, “In the 19th century, there was an upsurge of interest in the techniques of the ‘old masters’ and particularly in all forms of tempera painting, which ultimately encouraged the Nazarene and Pre-Raphaelite movements. It appears that tempera was first

introduced in Germany as a retouching medium at this time. Christian Köster, painter and restorer with the Boisserée Collection and the Royal Berlin Museum, published a treatise entitled 'On the Restoration of Old Oil Paintings' in 1827. In this he described retouching on a white ground or on tempera underlayers with lean oil colours. The tempera was made from egg yolk and mixed with a little vinegar as a preservative. This technique was continued by Jakob Schlesinger, who worked with Köster at the Royal Berlin Museum. This method of retouching, however, was not without its critics. Jakob Roux, a painter and university professor in Heidelberg, wrote that egg yolk on its own, as a medium, would not have enough adhesion and suggested the addition of wax. These were the rather experimental beginnings of egg tempera retouching" (Kempski 2000).

The main tradition of egg tempera retouching thus derives from Germany. However, egg tempera retouching has also been used by conservators trained in non-Germanic traditions. It was often used by Mario Modestini and his studio in the 1950s on paintings in the Samuel H. Kress Collection. Egg tempera and egg tempera with dammar were evaluated (along with dammar alone and PVAc-AYAB) for use as inpainting media by Modestini and Gustav Berger in 1959–60 (Berger 1990, 151). Many practitioners in Europe, and to a lesser extent in the United States, continue to use egg tempera today.

As of this writing, egg tempera retouching is primarily associated with the Hamilton Kerr Institute, the conservation training program in the United Kingdom, and with restorations in continental Europe. Students are taught the method that is used on most paintings treated at the Institute (McClure 1988, 6).

The institute's first director, Herbert Lank, has described his method of using egg tempera for retouching, which he learned from Helmut Ruhemann, with whom he apprenticed beginning in 1946 (1990). Ruhemann was the head of paintings conservation at the National Gallery in London from 1934 to 1972.

According to Kempfski, "Ruhemann brought the tempera retouching technique from Germany to England at the beginning of the [20th] century. [He] had spent four years at the Kaiser Friedrich Museum, Berlin...Ruhemann gained most of this conservation knowledge from his colleague, William Suhr, who also worked in Berlin and who ultimately became chief restorer at the Detroit Museum of Art. It is most likely that Ruhemann learnt the technique of tempera retouching from him" (45). Ruhemann was originally trained as an artist at the Academies of Art at Karlsruhe and Munich as well as with Max Liebermann,

and in Paris with Maurice Denis (Ruhemann 1982, 31). Sebastian Isepp, a contemporary of Ruhemann's and chief restorer at the Kunsthistorisches Museum in Vienna, also used egg tempera for retouching (Kempfski 2000, 45).

ii. Advantages

Egg tempera retouching exploits the characteristics of the medium to create quite convincing reconstructions of losses. Knut Nicolaus sees several advantages to the technique. "Egg tempera retouchings are among those that alter the least. Using egg tempera, one can closely emulate both the coloration and the characteristic structures of an old paint layer. In my opinion, egg tempera retouching is superior to the other techniques available today for retouching Old Masters. It yellows only slightly, is easy to structure, and in overall appearance looks like an old painting" (1998, 278).

Before the development of synthetic resins, restorers' other options for inpainting media were resins (mastic and dammar), oils, waxes, and gums. Ruhemann was particularly disturbed by discolored retouching (as well as oxidized varnishes). "I found that the copious retouching on many Kaiser Friedrich Museum pictures had been done with ordinary oil paint and had turned into dark blotches, often encroaching on original paint. They were not obvious to the layman because they were concealed by the useful brown umber veil of tinted varnish" (1982, 43). Meanwhile, "watercolors bleached and broke up the varnish film, causing the retouched areas to 'blanch' and become white" (Berger 1990, 150). When zinc white was used with dammar, a reaction yielded zinc dammarate, also creating a blanched effect.

Egg tempera avoids these problems because, after the protein in the egg denatures, there is very little further chemical or physical alteration in the paint film and its appearance. The pigment is essentially locked within a stable matrix.

The insolubility of egg after denaturing means that it can be easily and cleanly layered and is thus ideal for recreating the layering structure of a painting. This can be more difficult with resins or watercolor; upper layers may re-dissolve underlayers.

The relatively low refractive index of egg (1.346) means that as a paint, it is relatively opaque. The retouching can consist of multiple thin layers and still not be thick and "blobby."

Egg tempera is a water-based medium that does not expose the conservator to solvents that may cause health problems.

iii. Disadvantages

Preparation of egg tempera materials is more time-consuming than using manufactured media. It takes time to prepare the materials, carry out the retouching, and master the technique. As it is a self-made paint and thus involves working with unbound pigments, the potential for exposure to heavy metals may be greater.

The main drawback to the technique is also one of its greatest advantages: insolubility. If used over areas of original paint, the technique violates a fundamental criterion of modern conservation—reversibility.

(4) Source

(a) **Physical:** Poultry

(b) **Origin and manufacture:** Poultry

(c) **Manufacturers and vendors:** Poultry farmers

(5) Chemical and Physical Properties

(a) Chemical classification

The yolk and the white of eggs have different, but related compositions. “Egg yolk is an emulsion consisting of droplets of fatty material suspended and emulsified in a matrix of egg proteins in water” (Bomford et al. 1989, 28). Egg white is a mixture of proteins in water, with almost no fatty material. The proteinaceous part of each consists of a number of different proteins belonging to the albumin class. (Albumin should not be confused with *albumen*, a term used to refer to egg white.) These proteins serve as the truly binding part of the medium.

(b) Chemical formula/structure

Fresh egg yolk is approximately half water; the remaining half contains roughly twice as many fatty compounds as proteins (Davidson 2002). Specific proteins found in egg yolk include

- phosphovitin (MW c. 21,000), a composite protein;
- α - and β -lipovitellins, lipoproteins containing phospholipids;
- α -, β -, and γ -livetins (Mills and White 1987, 88).

Egg yolk contains several emulsifiers, including cholesterol and lecithin (Peterson 1998, 117). “The lecithin is a fatty substance to which has been given the empirical formula $C_{42}H_{84}NPO_9$, but it differs from most fats in containing nitrogen and phosphorus and in being very hygroscopic” (Gettens

and Stout 1966, 20). Yolk also contains trace amounts of phosphorous, manganese, iron, iodine, copper, calcium, and zinc.

The yellow color of the yolk comes from plant pigments known as xanthophylls contained in components of the hens' feed, such as yellow corn, alfalfa meal, and marigold petals. These plant pigments are considered to be relatively stable, even when cooked (www.aeb.org). Cennini writes that the yolks of country eggs are redder than those of town eggs (1933, 94). Presumably this is caused by a different diet.

Egg white consists of four alternating layers of thick and thin albumen. Fresh egg white is nearly 90 percent water, the remaining 10 percent being mostly protein. Specific proteins found in egg white include

- ovalbumin (MW c. 45,000), a glycoprotein (i.e., a protein linked to a carbohydrate) (50 percent of the protein in egg white)
- conalbumin (MW c. 85,000), a glycoprotein (15 percent)
- lysozyme (MW c. 17,000), the only non-glycoprotein in egg white (Mills and White 1987, 87)

Egg white also contains niacin, riboflavin, chlorine, magnesium, potassium, sodium, and sulfur.

According to the American Egg Board, "Albumen is more opalescent than truly white. The cloudy appearance comes from carbon dioxide. As the egg ages, carbon dioxide escapes, so the albumen of older eggs is more transparent than that of fresher eggs" (www.aeb.org).

(c) Solubility

According to Mills and White, "The albumins are readily soluble in water and belong to a class known as *globular proteins*. These are held in a tight ball conformation by internal hydrogen-bonding between adjacent amino acid clusters in such a way that the more polar, hydrophilic groups line the outer surface of the ball and the hydrophobic groups are folded away within. However, these albumins quickly 'denature' under the effects of heat and certain reagents, by which it is meant that they become insoluble (as when an egg is boiled.) What happens is that the internal hydrogen bonds rupture and the molecular structure opens up and adopts an open chain-like structure, the overall hydrophilic properties being lost" (1987, 87). Thus, after denaturing, egg proteins are no longer soluble in water.

(6) Preparation and Formulation (Preparing the Medium)

(a) Typical application methods

Numerous variations on making and using egg tempera exist. For this entry, the following method described by Herbert Lank—the Lank recipe—will be presented as the basic version:

The whole egg, except the shell and chalaza (the fibrous strings that hold the yolk sac in position within the shell), is used. The egg is broken into a clean beaker, taking care not to break the yolk. Any fertilized egg, showing a blood spot, is discarded. The chalaza is removed with fine tweezers. The yolk and white are tipped into a bottle, which is then stoppered and shaken vigorously to mix the yolk and egg white together. Unlike in egg tempera painting, the albumen content of the white plays an essential role in the use of egg tempera as a retouching medium.

The egg in the bottle is an emulsion with a high water content. It is now diluted further by the gradual addition of purified water. The water content of every egg is not identical. The addition of up to a maximum of 60 percent water may be required. An excess of water will destroy the emulsion, allowing the constituents to separate and making the medium unusable.

After the addition of the water, the stoppered bottle is again shaken. Foam should not be allowed to form on the surface, as this can hinder the grinding of pigments into the medium. The emulsion will separate out if an excess of water is added. It is therefore advisable to add only the amount of water required to attain a workable viscosity for the medium. (1990, 156)

This whole egg recipe would have a higher protein-to-fat ratio than the egg yolk tempera described by Cennini. This would change the “feel” of the paint, making it less greasy and may alter the refractive index of the medium.

There are numerous variations on the steps of preparation and ingredients of the medium. This author was taught by Renate Woudhuysen-Keller to whip the white separately, in accordance with the way glair is prepared. According to Woudhuysen-Keller, “Rolf E. Straub describes the characteristics of egg white varnish thusly: ‘Egg white has a cordlike macromolecular structure, which has to be broken up by beating’” (1994, 92). According to Kempfski, “Whipping egg white causes denaturation even before dehydration” (2000, 47). The white is beaten to a stiff peak. Separately, as much water in equal volume to the yolk is added to the yolk and lightly blended with a fork. The yolk is then added to the white, and the mixture is allowed to stand in a tall narrow container. The usable medium will collect at the bottom.

Once the medium is prepared, dry pigments are combined with it to create the paint. Lank states that “any permanent pigment can be used for tempera retouching” (1990, 156). As he uses tempera for body paint, the opaque pigments predominate. Doerner warns that “pigments containing sulfur, such as cadmium, vermilion, and artificial ultramarine, when used with an egg emulsion, may decompose by combining with the nitrogen and sulphur compounds in the egg to form hydrogen sulfide” (Doerner 1984, 215).

The pigments must be ground into the medium, not simply mixed with an inpainting brush. This can be done, in small amounts, on the inpainting palette with a muller. A glass rod, polished to a flat, angled surface on one end, works well for this. Lank notes that “the less dense, transparent pigments are harder to grind into the medium” (1990).

The ratio of medium to pigment is very important. The high pigment ratio that can be achieved with egg tempera is one of the reasons it is effective at mimicking the look of old oil paint. However, too little medium gives a powdery paint, whereas too much can lead to flaking. Different pigments require different amounts of medium; for example, earth pigments usually require more than heavy metal pigments. In addition, as the water content in the egg medium will vary, the ratio must be determined empirically. One can start with roughly equal proportions of medium to pigment. A good test is to paint out a small stroke on the palette, allow it to dry, judge its gloss, and rub lightly with a finger to test its durability.

Once the paint is made, it cannot be allowed to dry on the palette, as it cannot be re-dissolved. Gradual additions of water should be ground in over time.

(b) Additives

Knut Nicolaus describes a variation that adds beeswax to the medium to ensure reversibility:

1. To make up the paint, first break a chicken egg, and separate the yolk from the white.
2. Dissolve some bleached beeswax in white spirit, measuring it in the rough proportion of 1:3 to form a wax paste.
3. With a spatula, mix the egg yolk with a pea-sized quantity of the wax paste.
4. Put the egg yolk and wax mixture into a glass, then add the egg white, seal the container, and shake the glass thoroughly.
5. Dilute the mixture with the same quantity of distilled water and a drop of vinegar as a preserve. (1998, 279)

Nicolaus also suggests adding a surfactant such as ox-gall to help the paint adhere to the fill.

David Bull employs the yolk of the egg (separated from the white) with a few drops of toluene as a preservative.

Other modern recipes for egg tempera paint, which may at times have been used for inpainting, may be more or less complicated. To his yolk-only medium, Thompson recommends adding “two or three drops of vinegar or 3 percent acetic acid as a preservative and to make the medium less greasy” (Thompson 1936, 96). Doerner advises against adding vinegar or phenol because they may cause discoloration of the pigments, but suggests adding a drop of oil of cloves or a small amount of alcohol (Doerner 1984, 215).

(c) **Storage/shelf life**

The egg medium should be refrigerated when not in use. Even with refrigeration, it will only remain fresh for a few days. One suggestion is not to cover the container too tightly, to prevent buildup of sulfur.

(7) **Handling Characteristics**

(a) **Appearance**

The aim of egg tempera retouching is to recreate the layering structure of the painting. This is considered to give the most convincing appearance and be convincing over a long period of time. “A clean and unobtrusive retouching is achieved, which, should the upper glazing layer become more transparent, will nevertheless be found acceptable” (Lank 1990, 157).

Because it is an emulsion, the paint will undergo several changes in tonality. Lank describes these steps:

1. Changes between the wet mix on the palette and the newly applied paint
2. A darkening of the paint when dry
3. A slight drop in tonality after burnishing
4. A marked enhancement of the colors and a drop in tonality when the paint is saturated with white spirit or varnished (Lank 1990, 157)

“Once the tempera retouching has been lightly burnished and thinly varnished, it should generally be very slightly lighter and cooler in tonality than the original paint. This allows for a final glazing layer, which will turn the tempera retouching slightly darker and warmer, finally matching the surrounding original paint” (Lank 1990, 157).

(b) Application

As a rule, egg tempera use should be restricted to filled loss areas, as it will become insoluble. As the retouching will later be burnished, soft fills such as wax are not suitable. In general, because of its insolubility and because it is difficult to apply in pinpoint areas, egg tempera is not used on unfilled areas, such as abrasion. The fill should be sealed and the painting varnished; the varnish will also aid in future removal of the tempera inpainting.

In Lank's procedure, first the fill is toned with a glaze of resin tinted with transparent pigments, such as raw sienna and black; the aim is to imitate a laying-in tone or an aged ground. "Care must be taken to keep the resinous medium to a minimum, as the tempera layer would not be easy to apply on top of a thick resinous surface. This layer should be allowed to dry. Subsequent solvent evaporation can otherwise cause fissures in the tempera paint" (Lank 1990, 156). At the Hamilton Kerr Institute, this resin is usually MS2A, which is also used as the varnish. Nicolaus suggests a natural resin varnish (1998, 280).

As described above, egg tempera is used in conjunction with a resin-based glazing medium. This is used as both the first and last layer, between which the egg tempera is sandwiched, and can be used alone on areas of abrasion. The difference in solubility between the resin and the egg is exploited to keep the layers crisp. It should be noted that the resinous medium is seen as being the "weak link" in the inpainting, the part that may lead to later color shifts that may make the inpainting more visible. Therefore, it is generally used sparingly.

The paint is applied by brush. It can be allowed to dry naturally (by evaporation and denaturing) or, as Lank suggests, be dried with a small hand-held hair dryer. Once dry, it is burnished lightly with an agate burnisher. (Nicolaus describes, instead, "polishing the surface lightly with a silk cloth" (1998, 280). It is then thinly varnished. Some practitioners burnish and varnish after each layer of paint is applied, others only after the final layer.

(c) Modifications for special applications and effects ("Tricks of the Trade")

Many practitioners apply egg tempera directly onto the fill, without a resin layer between. In this practice, the egg tempera can only be used for discrete paint losses, and not to replace missing glazes.

(8) Aging Characteristics**(a) Chemical process**

"The first stage in the drying of egg tempera paint is therefore the evaporation of the water, followed by the denaturing of the egg proteins to a hard

waterproof film...The egg fats are largely non-drying in character and, in part at least, survive little changed, perhaps serving to plasticize the paint” (Bomford et al. 1989, 28).

(b) Resultant chemical and/or physical alterations

The egg itself is more than 75 percent water; more water may have been added while making the medium, and dry pigment has been added. It is difficult to say what the final water content of the paint may be. Nevertheless, as it dries, the paint loses volume and tension is created in the layer, which may make it brittle and somewhat porous (Woudhuysen-Keller 1994, 92).

(c) Impact on appearance, solubility, and removability

The whole-egg medium matrix surrounding the pigment particles is almost equal proportions of denatured protein and non-drying lipids. Thus, in theory, it would be more easily removable than pure egg white varnish. In addition, the inpainting has been sandwiched in between two layers of soluble varnish.

(d) Attraction and retention of dirt and grime

Egg tempera retouching should be sealed with varnish to protect it from dirt and grime.

Jean Dommermuth

Submitted October 2006

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b) Aquazol

(1) Principal Name

Aquazol[®]

(2) Other Names

Poly(2-ethyl-2-oxazoline) (PEOX)

(3) History of Use

(a) Industrial

In 1977, the Dow Chemical Company was issued the first in a series of patents for a new polymer, poly(2-ethyl-2-oxazoline), or PEOX (Chamberlin 1977). This tertiary amide polymeric material was found to exhibit some unusual physical and chemical properties (such as solubility with relatively low viscosities in water, thermal and mechanical stability, etc.), suggesting a variety of possible industrial uses. The first comprehensive review of the physical and chemical properties of PEOX was published by Chiu and co-workers (Chiu, Thill, and Fairchok 1986). Among other properties, its refractive index was found to be the same as glass (1.520). PEOX is miscible with a number of common polymeric materials, often giving blends with single glass transition temperatures, and therefore is potentially useful for enhancing the adhesion of various polymer blends to a wider range of substrate materials. PEOX's glass transition temperature of 55°C,¹ in combination with its water solubility, suggested possible uses, such as in biodegradable heat-seal packaging adhesives.

In the early 1990s, Dow licensed production of the polymer to Polymer Chemistry Innovations, which is producing it on a limited scale under the trade name Aquazol, in molecular weight ranges of 5,000 g/mol; 50,000 g/mol; 200,000 g/mol; and 500,000 g/mol and labeled as Aquazol 5, 50, 200, and 500 respectively. Aquazol has found uses as a hot-melt adhesive and in some pressure-sensitive adhesives. It has gained acceptance as a greenware binder because of its clean burnout and nonionic nature. Aquazol has been approved by the FDA as an indirect food additive (adhesive).

(b) Conservation

In the early 1990s, Richard Wolbers became interested in the potential of Aquazol for certain conservation applications, specifically noting that because Aquazol's refractive index is virtually the same as glass, it might be useful as a consolidant for flaking reverse glass paintings. In 1994, a paper authored by Richard C. Wolbers, Mary McGinn, and Deborah Duerbeck, titled "Poly(2-ethyl-2-oxazoline): A New Conservation Consolidant," was

presented at the symposium “Painted Wood: History and Conservation” in Williamsburg, Virginia. The paper outlined the polymer’s physical and chemical properties, as well as the results of aging and other tests conducted by the authors. Case studies illustrating the use of Aquazol 50 and/or 500 as a paint-to-wood consolidant were presented, and its potential for other conservation uses—such as replacement gilding or as a binder for water-based inpainting—were suggested.

At the 1995 Paintings Specialty Group presentations (at the 23rd Annual Meeting of AIC in St. Paul, Minnesota), Mark Lewis presented a paper he coauthored with Richard Wolbers titled, “Evaluation of the Suitability of Poly(2-ethyl-2-oxazoline) as a Potential Retouching Medium for Easel Paintings.” The paper covered a continuation of the earlier testing of Aquazol by Wolbers, McGinn, and Duerbeck, focusing more specifically on its light aging characteristics when used as a pigment binder.

Soon thereafter, other formal presentations to the conservation profession began including various uses of Aquazol as an inpainting medium. For example, at the 1996 Annual Meeting of the Western Association for Art Conservation in Las Vegas, Nevada, Chris Stavroudis presented a paper that included his use of pigmented Aquazol 50 bulked with fumed silica for the reversible inpainting of a Jasper Johns encaustic painting.

Aquazol is currently used in conservation for a wide range of treatment procedures in addition to its use as an inpainting medium, including, but not limited to, consolidation of matte or friable paint, treatment of flaking or lifting paint layers, treatment of gilding, as an adhesive, as a component of fill materials, and as an isolating layer or barrier film (see Arslanoglu 2004).

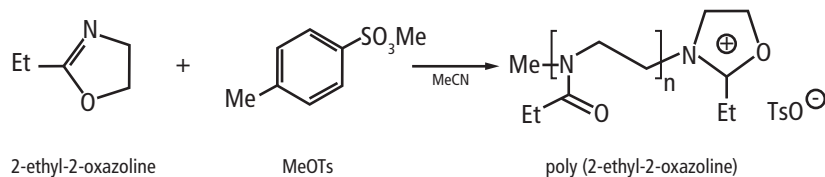
(4) Source

(a) Physical

Solid, colorless to light yellow, translucent crystalline granules or pellets. The solid forms of the four molecular weight grades in current production: 5,000; 50,000; 200,000; and 500,000 g/mol; each has a slightly different appearance.

(b) Origins and manufacture

The synthetic polymer is prepared by a cationic ring-opening polymerization of the monomer 2-ethyl-2-oxazoline (CAS Number: 10431-98-8), with methyl tosylate as an initiator.



According to the Materials Safety Data Sheet for Aquazol, the percentage of unpolymerized monomer remaining in the final product is <0.1%. However, according to quoted information from Richard Wolbers (McGinn 2009), he has found that methyl tosylate (or methyl-p-toluenesulfonate) from most suppliers (such as Shanghai Aladdin Chemical Company) comes as a 97% grade, which varies in color from white to pale yellow to brown, and that the discoloration of some Aquazol batches and solutions is due to the residual initiator rather than to any deterioration of the Aquazol polymer itself.

(c) Manufacturers and vendors

Dow Chemical Company licensed production of Poly(2-ethyl-2-oxazoline) to Polymer Chemistry Innovations, Inc. in the early 1990s. Polymer Chemistry Innovations³ produces the polymer under the trade name Aquazol. Distributors supplying retail quantities of Aquazol to the conservation community are listed at the end of this chapter.

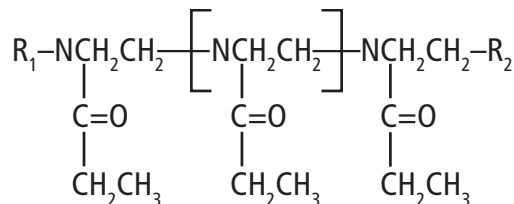
(5) Chemical and Physical Properties

(a) Chemical classification

Tertiary amide polymer resin
CAS Number: 25805-17-8

(b) Chemical formula/structure

Poly(2-ethyl-2-oxazoline), also known as PEOX.



(c) Solubility

Aquazol is soluble in water, readily soluble in alcohols such as ethanol and methanol and in ketones such as acetone and methyl ethyl ketone, as well

as in methylene chloride and propylene glycol. Aquazol is slightly soluble in toluene and n-pentane.

The manufacturer's Technical Information Sheet states that Aquazol's pH in aqueous solutions is neutral and that it is stable in weak acids and bases (but strong acids or bases will hydrolyze the amide group).

The manufacturer's literature also indicates that, as might be expected, the lower molecular weight grades are more flexible and water soluble compared to the higher molecular weight products, which have more "strength."

Aquazol solutions in solvent mixtures (for example, of water with acetone or with alcohols such as ethanol or isopropanol) have been used in various conservation treatments (see Arslanoglu 2004).

From the Manufacturer's Technical Information:	
n-Pentane	P
Toluene	P
Methyl ethyl ketone	S
Methylene chloride	S
Acetone	S
Propylene glycol	S
Ethanol	S
Methanol	S
Water	S

P = solubility of 2% or less by weight

S = solubility of 25% or more by weight

From Chiu, Thill, and Fairchok (1986):	
Toluene	p
Ethanol	S
Acetone	S
Isopropanol	N
Arcosolv PM/1-Methoxy-2-propanol	N
Shell Cyclo Sol 100/Shell Cyclo Sol 53	N
Shell Odorless Mineral Spirits/Shell Sol 71	N
Stoddard solvent/Shell Sol 340 HT	N
Shell Mineral Spirits 145	N
Petroleum Benzine	N
Turpentine	N
Xylenes	N

P = solubility of 2% or less by weight
 S = solubility of 25% or more by weight
 N = not tested

More extensive and precise solubility testing of Aquazol 50, 200, and 500 was done as a graduate student project at the Buffalo State College Art Conservation Program by Dawn Rogala (class of 2006), under the direction of Professor James Hamm. The solubility of Aquazol 200 was subsequently plotted in Teas Chart format at the BSC Art Conservation Program by students in the 2009 class, under the direction of Professor Gregory Dale Smith.

(d) **T_g (glass transition temperature)**

In 1986, Chiu, Thill, and Fairchok reported a T_g value for PEOX of 550C [~1250F]. Technical information for Aquazol provided by the present manufacturer states, "Glass Temperature: 69–710C (amorphous)" [~154–1590F]. As noted above, at 50% RH and 740F, Aquazol achieves an equilibrium moisture content of ~5–8% by weight. This moisture content acts as a plasticizer and apparently lowers the T_g closer to the 550C figure. Like most polymers, the glass transition temperatures of the lower molecular weight (MW) Aquazols exhibit lower T_gs than the higher MWs. The lower MW Aquazols are also more water soluble and hydrophilic, which have a slightly greater effect on lowering their glass transition temperatures.

(e) **Molecular weights**

The polymer is presently produced by Polymer Chemistry Innovations in four molecular weight ranges: Aquazol 5 (5,000); Aquazol 50 (50,000); Aquazol 200 (200,000); and Aquazol 500 (500,000). These are weight average molecular weights (g/mol), with a polydispersity range of 3–4. Polymer

Chemistry Innovations has also custom-made some other molecular weights and forms of Aquazol (such as low molecular weight copolymers) for specific industrial purposes.

(f) Refractive index

$n_D = 1.520 + 0.001$ (Chiu, Thill, and Fairchok 1986; Polymer Chemistry Innovations' Technical Information Sheet 2001). Note that this is similar to the refractive index for common glass of ~ 1.529 .

(g) Brittleness and flexibility

Aquazol's water solubility makes its flexibility and other strength characteristics subject to ambient relative humidity conditions, but even at very low RH values it exhibits Young's modulus⁴ characteristics for an extremely plastic material. Yield stresses and strains do decrease slightly at low percentage RH levels, but even at 8% RH, Aquazol 500 has an elongation to break (*eB*) of 380% (Wolbers, McGinn, and Duerbeck 1994). By comparison, hide glue has an elongation to break of only 2–3% at 8% RH. According to the manufacturer's data, Aquazol in granular form at 50% RH and 74°F achieves and maintains an equilibrium moisture content of $\sim 6\%$ by weight (in about 10 days). According to Richard Wolbers, this moisture content will act as a plasticizer even after the rest of the original carrier solvent or solvents have evaporated (phone conversation, June 2002).

RH	% Elongation to Yield	Yield Stress (kg/m)	% Elongation to Break	Breaking Stress (kg/m)
8%	44.62	380	53.57	
33%	25	40.17	450	43.10
73%	50	17.85	550	26.78

Tensile strength data for Aquazol 500 conditioned at various RHs (Wolbers, McGinn, and Duerbeck 1994)

(h) Specific gravity/density

The product's MSDS sheet gives a value of 1.14 (water = 1).

(6) Preparation and Formulation

(a) Typical application methods

Paints can be prepared using the various molecular weight grades of Aquazol as a binder in a range of solvents or solvent combinations (including water), as well as with a very wide range of solution and pigment concentrations, creating an extensive spectrum of possible paint characteristics. In-painting formulations using Aquazol can be tailored to visually imitate many types of painted surfaces, from matte to glossy and from thin glazes to thick pastes.

Julie Arslanoglu (2004) conducted an overview of responses to a survey about how conservators are using Aquazol. In the section on Aquazol as an inpainting medium, the following typical formulations are discussed: Most commonly, concentrated stock solutions of Aquazol 50 or 200 in water are diluted as necessary and then mixed with dry pigments, or added to water-colors or gouache tube colors. Aqueous stock solutions are usually made up quite thick initially (and later diluted as needed for use) for each of the molecular weights of Aquazol at approximately the following concentrations:

- ~67% wt./vol. for Aquazol 50
- ~33% wt./vol. for Aquazol 200
- ~18–20% wt./vol. for Aquazol 500

More concentrated aqueous solutions than those above, as well as blends of the different molecular weights, have also been used for inpainting particular types of surfaces, for example, a 40–50% solution of equal parts Aquazol 200 and Aquazol 500 (used for inpainting gouache and enamel paint on paper).

Aquazol has also been used as an inpainting medium in solutions of alcohol (usually ethanol or isopropanol), acetone, and in mixtures of water:alcohol and water:acetone, such as in the following examples:

- 10% Aquazol 200 in ethanol (faster drying than in water).
- 10% Aquazol 200 in 95% water and 5% ethanol (reduces surface tension).
- Aquazol 50 in 1:1 or in 80:20 water:ethanol (applied with a nebulizer to imitate very chalky gouache).

Diluting Aquazol with a mixture of 10–40% acetone in water (which Jim Bernstein refers to as “water extra dry”) reduces surface tension as well as modifying characteristics such as drying time and final surface sheen.

(b) Additives

No specific additives are required to use Aquazol as an inpainting medium. However, Aquazol is compatible with a wide variety of possible additives to modify its working properties or other desired characteristics. Adding a small amount of a secondary solvent to a solution of Aquazol can improve its handling properties over those in just the primary solvent alone. For example:

- Adding some ethanol or acetone to a water-based solution will reduce surface tension and viscosity, thus improving wetting and flow. A very

small amount of Kodak Photo-Flo® can also be added to aqueous solutions to improve wetting (reduce “beading up”) on some surfaces.

- Adding some aliphatic solvent, such as naphtha, to a primarily alcohol-based solution might be used to extend the working time, and reduce the overall polarity of the carrier solvent mixture, if necessary.

Aquazol is compatible with many polymers, including PVAc and wax. It can be bulked with fumed silica or clay for gap filling or as a substitute for traditional bole or gesso (see below under “Modifications for special applications and effects/Tricks of the Trade”).

(c) Storage/shelf life

Given the general stability of Aquazol, the manufacturer considers the shelf life to be essentially infinite. The manufacturer’s Technical Information Sheet states that Aquazol has a “Degradation Onset of > 380oC (TGA in air),” indicating stability under normal conditions. However, the product must be kept tightly sealed because it will absorb ambient moisture and a variety of other volatile materials in the immediate environment. Aquazol in granular form kept at 50% RH and 74oF achieves an equilibrium moisture content of ~5% water by weight.

The survey and subsequent article by Julie Arslanoglu (2004) concerning the use of Aquazol in conservation practice includes some additional information related to Aquazol’s shelf life. Aquazol’s synthetic PEOX polymer does not support mold growth in either aqueous or other solvent solutions, and solutions have been stored for many years without evidence of mold growth, as long as the containers remain uncontaminated by other sources. Some conservators have observed cold flow (i.e., gradual “slumping” in the container) of the lower molecular weight grades (Aquazol 50 and sometimes Aquazol 200) in their studios over time under typical storage conditions.

As mentioned above, the polymerization initiator, methyl tosylate (or methyl-p-toluenesulfonate), presently used in the manufacture of Aquazol, is supplied as a 97% grade, which varies in color from white to pale yellow to brown. According to Richard Wolbers, any perceived discoloration of Aquazol batches and solutions is due to this residual catalyst rather than to any deterioration of the Aquazol polymer itself.

(7) Handling Characteristics

(a) Appearance

Aquazol is supplied as translucent, colorless to light yellow granules or pellets. Yellowish or brownish color variations have been observed in some batches of Aquazol resin (Arslanoglu 2004), but the manufacturer consid-

ers these to be within the specification limits for the product (which is not designed for use as a conservation material). The mixing of yellowish or brownish Aquazol solutions with light inpainting colors may have an undesired effect on their appearance.

The lower molecular weight grades of Aquazol (i.e., Aquazol 50) tend to wet pigments better than the higher molecular weight grades.

Solutions or mixtures using the higher molecular weight Aquazol 500 have a tendency toward drying with a glossy sheen (which can be either an advantage or disadvantage, depending on the final results desired). Films of Aquazol 500 are flexible, but can form a skin that may be prone to peeling, scaling, or scratching.

The absorbency of the surface being inpainted to the solution of Aquazol being used needs to be taken into account, so that the support does not draw off too much of the carrier solvent(s) or binder. The Aquazol paint should be viscous enough so that the inpainting remains appropriately saturated.

(b) Application

Since Aquazol-based inpainting formulations can be created in a wide array of pigment/binder ratios, viscosities, and dilutions, ranging from water-thin glazes to stiff opaque pastes, a similarly broad range of appropriate application techniques can potentially be employed, including brush, spray, palette knife, roller, nebulizer, syringe, etc.

Some typical formulations used by conservators are discussed above under Preparation and Formulation, “Typical Application Methods.”

Conservators responding to Julie Arslanoglu’s survey described the Aquazol-based paints they used as having characteristics like a fuller-bodied opaque gouache, with sheen, or as having an “oil paint consistency.” In practical terms, a 10% solution in deionized water of any of the available molecular weights produces a working solution of dissolved Aquazol resin having more or less familiar viscosities, binding characteristics, and film forming properties.

A 10–15% solution of Aquazol 50 or Aquazol 200 in water can be sprayed or airbrushed, because even relatively concentrated aqueous solutions of the higher molecular weight grades of Aquazol generally have much lower viscosities at similar concentrations than many other water-soluble polymers.

Drying time will vary depending on ambient humidity and temperature levels, but can be modified by the use of carrier solvents, or combinations of solvents, having different evaporation rates—for example, combining various amounts of ethanol or acetone with aqueous solutions.

**(c) Modifications for special applications and effects
("Tricks of the Trade")**

Julie Arslanoglu's article contains a great deal of information and examples of how conservators have used Aquazol in a variety of specific applications (2004).

- Aquazol can be used for reversible inpainting of surfaces with high wax content (or other particular solvent sensitivities)—for example, Chris Stavroudis' use of watercolor in Aquazol 50 bulked with fumed silica for inpainting of a Jasper Johns encaustic painting (1996); and Carolyn Tomkiewicz's use of Aquazol 200 mixed with watercolors for inpainting losses in a contemporary oil painting having a high wax content in the original paint (1999) (20 grams of Aquazol 50 in 30 grams of water, bulked with fumed Silica makes a translucent solution with a wax-like appearance).
- Aquazol can be useful for safely inpainting acrylic paintings, since it does not fuse to, swell, or solubilize the original paint the way typical solvent-based inpainting resins might.
- Jim Bernstein has observed that the different molecular weight grades of Aquazol, when mixed with the same pigment, often exhibit characteristics of binding media having different effective refractive indices. It appears that the difference in molecular size of the different weight grades optically saturates the pigment in different ways or to different extents (the lower molecular weight grades saturating the pigments more than the higher molecular weight grades). The variations in final appearance can be quite dramatic, akin to differences in saturation that the pigment might exhibit in oil versus aqueous media. This characteristic of Aquazol can be exploited—with pigments such as raw umber or ultramarine, for example—to render similar pigment to binder ratios either pale and light or dark and saturated in appearance.
- The addition of 20% Aquazol 500 to a watercolor palette improves the glaze quality of the paint. The paint remains transparent and reversible, but it can be particularly useful for glazing abraded paint surfaces.
- Inpainting with Aquazol in water can be done over the top of or in between other solvent-based inpainting or varnish layers, with much less tendency to disrupt the underlying layer(s). For example, inpainting using Aquazol in water was layered with Regalrez in Shellsol to inpaint scratches in multiple layers of acrylic emulsion glazes.
- Aquazol films cast from solutions containing water will probably retain about 5% moisture content by weight within the dried polymer matrix, apparently even in a fairly low humidity environment. The retained

water acts as a plasticizer and lowers somewhat the effective glass transition temperature of the dried Aquazol. The lower molecular weight grades of Aquazol may be slightly more hygroscopic and/or have their physical properties more affected by the retained moisture content. Wolbers makes use of this in applications where the strength of higher molecular weight is desired along with added plasticity. For example, he might add 10% water to a solution of Aquazol 500 in isopropyl alcohol for this reason (personal communication, June 2002).

- The surface to be inpainted can be pre-desiccated by blowing air on it. The inpainting dries more quickly, with a richer color that does not have the same tendency to blanch, as might be the case if one was just using a faster evaporating solvent.
- Aquazol 500 has been used as a substitute for hide glue in making gesso putty, and in bole for conservation gilding. The gesso putty made with Aquazol has a number of qualities that differ from traditional gesso; for example, it can be tooled with heat, but it is more plastic-like and is not really carvable. Furniture conservator Chris Shelton developed a method of using bole made with 10–20% Aquazol 500 in alcohol for gilding. It dries quickly and is burnishable. It is compatible with traditional water gilding in that it is hygroscopic, but delivered and reversible in solvents other than water.

(8) Aging Characteristics

(a) Chemical process

The 1994 paper by Wolbers, McGinn, and Duerbeck (1998) outlined the results of various accelerated aging tests the authors had conducted on poly(2-ethyl-2-oxazoline). Films of Aquazol cast from 20% solutions in deionized water were exposed to accelerated light aging in a Weatherometer for the equivalent of approximately 24 years of natural aging under normal museum conditions (i.e., exposure under light sources that produce irradiances in UV wavelengths of 75 mW/m² or less). Properties of unaged and artificially light aged samples were compared using a variety of test methods, including Size Exclusion Chromatography (SEC) (to determine molecular weights); pH measurements (to determine initial pH and whether aging produced any ionizable functional groups on the polymers); Thermogravimetric Analysis (TGA)/Differential Thermal Analysis (DTA) (to determine heat stability); resolubilization rates of cast films in various solvents; viscosity measurements (to determine molecular weight /polymer size changes); Infrared Spectroscopy (FTIR) (to determine whether oxidation or delamination, etc., had resulted in any gross chemical changes after light aging); color measurements; and Tensile Strength Tests.

The light aging tests on cast films of Aquazol 50 and 500 showed virtually no changes in color, FTIR spectra, pH of solutions, or resolubility after aging. The polymer also appeared to be thermally very stable.

Drops in molecular weight after light aging of Aquazol were suggested by both lowered solution viscosities and by shifts in SEC elution times.

(b) Resultant chemical and/or physical alterations

Controlled test results seem to indicate that decreases in molecular weight, rather than cross-linking or any gross chemical alterations, are the main result of artificial light aging in the Aquazol polymer.⁵ Although chain scission is preferable to cross-linking, especially in terms of reversibility in conservation applications, some eventual loss of particular mechanical properties related to polymer size might gradually occur in some situations.

(c) Impact on appearance, solubility, and removability

No yellowing, discoloration, or other significant changes in appearance were indicated by accelerated light aging tests of cast films (equivalent to 24 years of standard museum lighting exposure) conducted by Wolbers, McGinn, and Duerbeck.⁶

Resolubility testing of Aquazol 50 and 500 after artificial light aging (also conducted by Wolbers, McGinn, and Duerbeck) revealed that aged films remained essentially resoluble in the same solvents they were soluble in initially.

Mark Lewis and Richard Wolbers evaluated the potential for changes in resolubility of the Aquazol polymer mixed with pigments after accelerated light aging (equivalent to ~30 years of museum light level exposure) using FTIR spectra and SEC determinations of molecular weight (Lewis 1995). When resolubilized in plain water, experimental results with some samples suggested that metallic ions associated with several of the tested pigments may form typical organometallic complexes with the polymer. Adding a small amount of the chelating agent EDTA to the resolubilizing water (to de-complex possible pigment-binder interactions) eliminated the initially observed apparent increases in molecular weight of the Aquazol binder/pigment combinations after artificial aging. Based on these findings, adding ~1/2% EDTA, ammonium citrate, or a similar chelating agent to water being used to remove Aquazol-based inpainting may increase the ease of resolubility of the inpainting in water.

(d) Attraction and retention of dirt and grime

According to the manufacturer's Technical Information Sheet, PEOX's glass transition temperature is 69–71°C (~154–159°F). Since this second order T_g is well above any normal room temperature range, dried Aquazol films

should not tend to attract or retain dirt and grime due to cold flow or thermal softening at room temperature. (By way of reference, Aquazol's Tg of 69–71°C is in the same range as Dammar resin [67–75°C]).

The Tg for Paraloid® B-72 is 40°C (104°F)]. Because Aquazol films are water soluble and hygroscopic, however, their softness and vulnerability to imbibing foreign particles will certainly increase under conditions of high ambient relative humidity. Aquazol in granular form kept at 50% RH and 74°F achieves an equilibrium moisture content of ~5% by weight in about 2 weeks. Even at very low RH values, Aquazol is an extremely plastic material.

(e) Theoretical lifetime

As noted above, testing by Wolbers, McGinn, and Duerbeck revealed that cast films of Aquazol 50 and 500 did not discolor and remained essentially resoluble in the same solvents they were soluble in initially after an accelerated aging exposure equivalent to 24 years of standard museum lighting. The polymer also appeared to be thermally very stable and showed virtually no changes in IR spectra or pH of solutions after that amount of accelerated aging. Aquazol's sensitivity to relative humidity might shorten its effective useful lifetime in excessively damp, humid, or unstable RH environments.

Some conservators have voiced concerns about the potential for cold flow (“creep”) of the lower molecular weight grades of Aquazol (mostly Aquazol 50), based on observations of slumping of the raw material form in the container, as supplied. However, Richard Wolbers theorizes that when Aquazol is mixed with pigments for inpainting, a stiffer and more mechanically stable matrix may be formed that would reduce the potential for such “creep” in practice.

(9) Health and Safety

- (a) Aquazol has been reviewed in accordance with section 311 and 312 of SARA Title III (the Superfund Amendments and Reauthorization Act)⁷ and found not to be in any hazard class.
- (b) No adverse health effects are known or expected for eye, skin, ingestion, or inhalation exposure, although use of standard protective procedures (appropriate gloves, goggles, dust respirator, etc.) is always advisable. Chronic exposure information is not available. Aquazol has been approved by the FDA as an indirect food additive. The MSDS toxicological information states, “Oral LD50 (rat): 3980 mg/Kg.”

(c) Decomposition begins at 300°C, which may generate toxic fumes, including nitrogen oxides, carbon monoxide, and carbon dioxide. Auto-ignition temperature is >400°C.

(10) **Disposal**

Dispose of in a manner consistent with federal, state, and local regulations. As of 4/15/2002, Aquazol is not regulated for transport under DOT, IMO, or IAAO regulations. Ecological information is not available.

Mark van Gelder

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ENDNOTES

- ¹ The Tg for PEOX was reported by Chiu et al., and subsequently referenced by others, as 550C. The present manufacturer's technical data give a Tg value for Aquazol of 69–710C [~154 -1590F]. The manufacturer's information graphs indicate that at 50% RH and 740F, Aquazol achieves an equilibrium moisture content of ~5% by weight and that the addition of ~5% water will drop the Tg of Aquazol from ~700C into the ~550C range. However, they suggest that the earlier reported value may also be related to imposed laboratory conditions that prevented the samples from achieving normal, post-polymerization equilibrium.
- ² Chemical Abstracts Service (a division of the American Chemical Society) Registry Number for the monomer.
- ³ Polymer Chemistry Innovations Incorporated, 4231 South Fremont Avenue, Tucson, Arizona 85714; Phone (520) 746-8446, Fax (520) 746-8876.
- ⁴ Young's Modulus is also referred to as the Modulus of Elasticity in Tension. This is a measure of a material's strength and elasticity; specifically, the deformation produced in the material by a given amount of applied force. The ratio of stress force to strain elongation (i.e., the amount that a particular material stretches when it is pulled on) can be represented as the slope of a graphed line. The percentage of the material's original length that it stretches before breaking is a useful measure of its comparative brittleness.
- ⁵ The observed drop from an initial size of about 300,000 daltons to around 50,000 daltons in the light aged samples of Aquazol 500 could indicate the occurrence of chain scission at a frequency of 1:600 monomer units.
- ⁶ No positive increases were measured in the "b" coordinate value of the L*a*b* notation used⁶.
- ⁷ Superfund Amendments and Reauthorization Act of 1986, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), pertaining to any hazardous substances for which a facility must maintain a MSDS under the OSHA Hazard Communication Standard.

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VENDORS

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2. Wax

a) Hand-Mixed Pigmented Wax

The use of wax as a surface coating has been extensively researched by Carole Abercaugh in Volume I of the *Painting Conservation Catalog: Varnishes and Surface Coatings* (1997, 201–209). A great deal of information specific to the use of hand-mixed wax is identical to that found in that publication and will not be repeated here. The reader is invited to refer to this volume for supplemental information.

This segment will focus on the use of synthetic waxes, which are the most commonly used waxes for inpainting.

(1) Principal Name

Beeswax, paraffin, carnauba, microcrystalline wax, Multiwax, Be Square, Petro-nuba-C, Polywax, Victory Wax, polyethylene wax, Bareco wax, Bareco polywax, petrolatum wax, Cosmolloid, mineral wax

(2) History of Use

(a) Industrial

In addition to being used extensively in coatings and polishes, synthetic wax is used in an array of industries. Microcrystalline, for example, is used to generate such products as candles, adhesives, corrugated board, cosmetics, and castings. It is also found in the tire and rubber industries, where it is combined with paraffin to create products with greater flexibility, melting point, and opacity.

Microcrystalline wax is essential in the production of petrolatum. Different grades of petrolatum are produced by incorporating oil with wax. The properties of petrolatum are determined by the congealing point (ASTM test D938) and needle penetration depth (ASTM test D1321) of the chosen wax. In an effort to become more environmentally friendly, a hybrid petrolatum is now produced using renewable resources such as vegetable oils and waxes.

(b) Conservation

In the early days of Richard Buck at Oberlin (at the Intermuseum Conservation Association), the conservators used crayons as a “quick and easy” method for temporary inpainting of paintings they saw on inspection trips. This eventually led to the idea of manufacturing “crayons” using dry pigments and selected waxes (personal communication from Martin J. Radecki, who worked with Buck in Oberlin).

Microcrystalline and polyethylene waxes are the most commonly used type of wax for inpainting. The wide variety of hardness, molecular weight, color, and refractive index makes wax a versatile material.

In addition to being used as a matting agent in varnishes and as a surface coating, it is also used as a filling and inpainting material. Combined with resin or other grades of waxes and pigments, wax mixtures can be used for filling and inpainting in one single step.

The very low shrinkage coefficient of microcrystalline wax offers advantages in the treatment of large losses and long mechanical cracks, often present in modern paintings. The opacity, tinting capacity, and handling qualities also offer many advantages in the treatment of shallow losses. Wax is also used in the treatment of panel paintings and paintings that have been wax-lined.

The high melting point of polyethylene waxes restricts their use. However, combined with softer waxes, they increase the hardness of mixtures. This can be especially useful for the treatment of works in high traffic areas, such as public art, or when a very durable coating is required, as in the case of an outdoor work.

(3) **Source**

(a) **Physical**

Synthetic wax is available in granules, pellets, beads, slabs, or liquid bulk.

(b) **Origin and manufacture**

Microcrystalline wax was invented in the late 1930s by Baker Petrolite, Barnsdale, Oklahoma. (See Abercaugh 1997 for fabrication process.)

Refining process, i.e. odor removal, bleaching, etc.

Microcrystalline waxes are divided into three categories or types:

Type 1: Laminating; Type 2: Coatings; and Type 3: Hardening.

Grade	Melting point	Needle penetration (dmm*)	Properties	Applications
Type 1 Laminating	130–170°F 54.4–76.7°C	20–40 dmm	Flexible, Tacky	Packaging Adhesives Cosmetics Rubber Candles
Type 2 Coatings	170–185°F 76.7–85°C	15–25 dmm	Harder, low tackiness	Adhesives Packaging Chewing gum Inks Plastics Rubber
Type 3 Hardening	185–200°F 85–93.3°C	5–12 dmm	Very hard, higher viscosity	Adhesives Inks Chewing gum Candles Specialty

*digital multimeter

Source: The International Group, Inc. (see www.igiwax.com/microcrystallinewax)

The standards used in the production of microcrystalline wax are the congealing point (ASTM D938), needle penetration depth (ASTM D1321), color (ASTM D6045), and viscosity (ASTM D445).

(c) Manufacturers and vendors

- Manufacturers:
 - Bareco® Products (<http://barecowax.lookchem.com>): STARWAX™, VICTORY™, ULTRAFLEX™, BE SQUARE™ (joined Baker Petrolite under the banner of Baker Hugues)
 - The International Group, Inc. (www.igiwax.com)
 - Crompton Witco
- Retailers:
 - Talas (<http://talasonline.com>)
 - Conservation Support Systems (www.silcom.com/~css)
 - Museum Services Corporation (www.museumservicescorporation.com)

(4) Chemical and Physical Properties

(See Abercaugh 1997 for additional information.)

Wax	Origin	Color	Characteristics	Composition	Melt Temperature	Hardness (Penetration)	Char	Usage	Source	RI
Beeswax	Insect Natural and bleached	Pale Amber or Ivory Deep brown to light taffy white (A)	Amorphous, slightly tacky (A)		147 F / 64 C 62–65 C (A)	15–20 (A)	Slab Bead [®]	Convenient for low melting temp. Crystallizes		1.440–1.445
Be Square™ 175 amber (T, C)	Synthetic (T, C)	Amber (T, C)			175–180 F (T) 182–183 F	16–19 (T) 17				
Be Square™ 175 black	Synthetic	Black		MW 500 to 800	175 F / 83 C 182 F/83 C	17	Slab		Bareco [®] - Baker Hughes Inc.	
Be Square™ 185	Synthetic	Pale amber		MW 500 to 800	195 F /91 C	10	Bead		Bareco [®] - Baker Hughes Inc.	
Be Square™ 195	Synthetic	White		MW 500 to 800	199 F/93 C	6	Bead		Bareco [®] - Baker Hughes In.	
Carnauba	Natural Palm (A)	Amber Pale yellow to greenish brown(A)	Very hard, brittle, not tacky, lustrous (A)		180–187 F/83 C 181 F/83 C (C) 83–86 (A)	7 1–3 at 25 (A)	Flakes	Use sparingly. Makes wax mixtures brittle		1.4540
Cosmolloid H80	Synthetic	White		High MW purified hydrocarbon wax	166–176 F/ (T)		Slab	Used extensively in Europe	Astor Corp.	
Multiwax [®] X-145A	Synthetic	Light amber White-yellow (T)		High MW purified hydrocarbon wax	155 F/68 C 150–160 (T)	40 35–45 (T)	Slab		Crompton Witco [®]	
Multiwax [®] W-445	Synthetic	White		High MW purified hydrocarbon wax	175F/ 79 C 170–180 F/ C (T) 170 F/ C (M)	40 28 25–35 (T)	Slab		Crompton Witco [®]	
Multiwax [®] W-835	Synthetic	White	Very soft and sticky	High MW purified hydrocarbon wax	170 F/77 C 171–178 F/ C (T) 175 F/ C (M)	70 60–80 (T)	Slab		Crompton Witco [®]	
Paraffin	Synthetic (Petroleum)	White	Soft to hard, solid, coarse, fibrous crystals, oily to dry (A)	High MW purified hydrocarbon wax	F/45–75 C 44.5–74 (A)	6–40 (A)	Slab			
Petronuba-C	Synthetic	Light amber	Hard, with low melting temp.	Synthetic Carnauba	199 F/93 C	7	Bead Flake [®]			
Polywax [®] 500	Synthetic	White		Ethylene polymer MW 500	187 F/85 C	7	Bead		Bareco™ - (Bareco polyethylene wax is now sold under the name Polywax [®])	
Polywax [®] 2000	Synthetic	White		Ethylene polymer MW 500	259 F/126 C 257 F/ C (M)	7 1	Bead	Small % can be added to regular microcrystalline wax to prolong life of outdoor coatings	Bareco™ (Bareco polyethylene wax is now sold under the name Polywax [®])	
Victory™	Synthetic	White		High MW purified hydrocarbon wax	175 F/79 C 171–178 F/ C (T)	26 26–29 T)	Slab		Bareco™	
Victory™ Brown		Brown							Bareco [®]	
ES692, Brown (C)	Synthetic (C)	Brown (C)	Darker and cleaner than Victory™ (C)		175 F/79 C (C)	26 (C)	Slab (C)			

Source: This chart is provided courtesy of James Bernstein, Inpainting Workshop, May 2008.

T: Talas C: Conservation Support Systems M: Museum Services Corporation A: Carole Abercaugh, citing from *Encyclopedia of Polymers Science and Engineering*, Vol.17, 792–93 (John Wiley and Sons, 1989).

(5) Preparation and Formulation

(a) Typical application methods

The waxes are selected depending on the nature of treatment. Some waxes can be softened with the simple action of mixing on a palette or in a hand. Others will require the use of a heat source, ranging from a mug warmer to a small hotplate.

The waxes are first mixed together to achieve a uniform mixture. The pigments can then be mixed directly into the wax or in a compatible solvent prior to being incorporated in the wax to obtain a uniform result. Solvents are used to increase malleability and working time.

The wax can be custom-tinted for a specific project or prepared beforehand in a range of colors. It can be rolled in the shape of crayons or in small squares. Caution must be taken not to exceed the melting temperature of the wax. Overheating can cause the wax to become granular. The wax can be softened or melted in a variety of ways, such as directly in your hand, on a piece of Mylar, in disposable aluminum pans, or in round metal containers. Some containers can be used for melting and storage at the same time.

(b) Additives

A few drops of slow evaporating solvent can be added to increase drying time.

(c) Storage/shelf life

Waxes should be stored in a cool, dry, dust-free environment. Thus stored, the shelf life is nearly infinite.

(6) Handling Characteristics

(a) Application

- Unstable cracks
- Large losses where traditional fills might crack
- Shallow losses
- Transparent surfaces

(b) Modifications for special applications and effects (“Tricks of the Trade”)

Custom-made crayons are useful for inpainting unstable cracks, i.e., long running mechanical cracks in modern paintings. Pigments are ground into a soft wax such as Microcrystalline X-145A on a heated slab and then rolled into the shape of crayons. A few drops of slow evaporating aliphatic solvent

can be added to increase the softness of the crayon. The color of the crayons can be customized to each project. The wax can be mixed on a palette and warmed slightly in your hand before being pressed into the crack. Excess wax can be removed with a dry cotton swab or cloth. The topography of the wax fill can be adjusted to match the surrounding original by burnishing, texturing, or altering the surface (Chris Stavroudis, personal communication July 1, 2008).

Tjanting tools (needles) are used to apply the wax in very fine lines. This rudimentary tool consists of a handle onto which is attached a circular hollow tube-like reservoir that tapers to a needle spout. The hot wax is poured into the reservoir. The tip of the tool is held down to start the flow of the wax and held back to stop it. It is available in different sizes (see www.dickblick.com).

Agate and silicone tip brushes can be used to burnish and texture the surface of the wax fills.

Pros and Cons of Microcrystalline Wax:	
Pros	Cons
Readily available	Certain waxes have a low Tg, can attract dirt, and should be varnished
Affordable	Color correction with another inpainting medium might be restrictive because of solubility
Chemically inert, long shelf life	Soluble in many solvents found in varnishes
Useful to fill shallow losses	Hard to wet with water and ethanol
Imparts low sheen	Does not provide a high gloss
Can be buffed to increase gloss	Cannot be emulsified
Reversible with mild solvents	
Does not shrink	
Easy to texture	
Compatible with silicone molds to reproduce fine surface topography	
Available in a variety of hardnesses	
Can be used as a fill and inpainting material at once	
Can be easily pigmented with dry pigments	
Easily portable and usable for in situ treatment (crayons, palette)	
Does not require the use of solvent	
Chemically inert	
Can be softened with the addition of mild solvents	
Some waxes produce a hard and non-sticky surface	
Odorless	
Higher melting point (54–95°C)	

(7) Aging Characteristics

For base resin, see Abercauph, 1997.

(8) Health and Safety

For base resin, see Abercauph, 1997.

Waxes are nontoxic materials. Precautions are advised when heating any waxes as serious burns may be inflicted by molten wax. Face and hand protection should be used when handling hot waxes. Burns should be flushed immediately with cold water. Adequate ventilation must be maintained to remove any fumes from solvents added to waxes. All waxes are flammable and must be kept away from furnaces, flames, etc.

Chantal Bernicky

Submitted November 2008

3. Solvent-Based Resins

a) Hand Mixing Pigments in Solvent-Based Binding Media

Following is the procedure for milling paint.

(1) Milling Paint in Quantity

- Prepare an area for messy work, preferably in the vicinity of a wet sink. Cover table surfaces with disposable paper.
- Wear protective gloves, a particle respirator, and either an apron or smock.
- Know the toxicity, tinting strength, and medium absorption characteristics of the pigment to be ground.
- Place a mound of pigment in the center of a clean plate of $\frac{1}{4}$ " or thicker non-etched glass. Make a depression in the core of the mound and add diluent, gradually wetting the pigment to a wet, yogurt-like consistency. Mix slowly with a spatula and avoid lifting the pigment powder in the air.
- Smooth and separate pigment clumps with a glass muller, grinding with lateral "figure eight" movements. There is no need to press downward while milling.
- When the slurry thickens, add diluent as needed. Do not work too wet, causing the pigment slurry to spatter.
- Periodically scrape material from the outer edges of the batch and off the muller edges and place it back into the center of the color.
- Once sufficient dispersion is achieved, add binder, working the medium into the color. Allow the diluent to evaporate some and the paint to thicken.
- When the paint appears to be of the proper consistency, test a small amount of the mixture, brushing it onto a piece of board. Allow it to dry completely. Determine whether the pigment-to-binder ratio is balanced, too lean, or too rich. Adjust as needed.

(2) Milling Paint on the Palette in Small Amounts

- Place a small mound of pigment on the palette. Make a depression in the center and use a dropper or brush to drip diluent onto it.
- Using a small spatula or a piece of a glass rod that has been fire-burnished to a smooth finish, mix to a yogurt-like consistency.

- Add binder in diluent and continue mixing, picking up the paint ridges at the edges and moving them to the center. These movements are small, so a small round area of paint is made.
- Try brushing the paint; add pigment or binder to achieve the desired consistency and gloss.

James Bernstein

Submitted February 2008

b) Hand-Mixed Natural Resin Varnish

(1) Principal Name

Varnish Colors

(2) Other Names

Varnish paints, resin colors, resin paints

(3) History of Use

(a) Artistic

Varnish colors can be dated in the literature on painting technique to the mid-18th century. Robert Dossie mentioned mixing pigments with varnish without the addition of oil in his *Handmaid to the Arts* from 1758 and noted that “(this) art has been greatly improved and extended within these few years...” (Dossie 1758, 138). Although he referred to shellac as the preferred vehicle for painting largely due to its durability, he stated that mastic with gum anime dissolved in spirit of turpentine could be used for whites and light colors, which would discolor when mixed with the harder resin (Dossie, 179–80).

The influential manual on painting, gilding, and varnishing by Jean Felix Watin, which was first published in 1772, includes two recipes for varnish as a medium without the addition of oil. The first recipe is based on mastic and sandarac in equal parts and produced a medium noted to saturate colors well and dry quickly. The second, of mastic and turpentine, is said to dry more slowly but could be handled more easily and achieve a greater quality in effect (Watin 1776, 56–7).

Carlyle notes several recommendations in 19th-century artist’s manuals to reduce or eliminate the amount of oil in painting by replacing it with resins. Speed of execution due to its faster drying nature as well as less of a tendency to crack were two of the advantages that some writers noted of painting with varnish instead of oil (Carlyle 2001, 123–4).

(b) Conservation

Perhaps the earliest mention of varnish colors used for restoration was by Pietro Edwards, the Director of Restoration of the Public Pictures for Venice from 1778 until 1819. As mentioned by Partridge in the historical overview of retouching materials in this volume (see section II.A.2), the reversibility of restoration materials was of primary importance to Edwards. This concern led him to require varnish colors to be used in the restoration of oil paintings—a directive evidenced by the oft-quoted contract for the restora-

tion of Titian's *Assumption of the Virgin*, which specified that "the parts to be repainted...shall be executed with varnish, the use of oil being absolutely excluded" (Merrifield 1967, 876).

The tendency of oil retouching to darken was cited by some authors as a reason to choose varnish colors. The British manual titled *Advice to Proprietors on the Care of Valuable Pictures Painted in Oil with Instructions for Preserving, Cleaning, and Restoring Them When Damaged or Decayed* from 1835 notes that "...in restoring colours accidentally removed, it should be done with a vehicle of simple varnish, because of the change in tint which takes place after drying in oil" (Anonymous 1835, 19). However, other restorers like Giovanni Bedotti believed resin led to rapid darkening of retouches. In his manual on the restoration of paintings from 1837, he noted that even though varnish colors were widely used in Italy, he followed the opinion more prevalent in France in favor of retouching in oil (Köster 2001, 162).

In 1855, the Spanish artist and restorer Vincente Polero y Toledo recommended that colors for retouching be ground in mastic. He noted the difficulties in handling such a quick drying paint and recommended that the brush be constantly rewet with turpentine (Polero y Toledo 1855, 72).

Ulisse Forni's manual from 1866 discusses dammar varnish as a medium for restoration because it could be easily removed without damage to the painting. Although mastic could be substituted, he believed that dammar is superior and noted that it does not yellow or crack (Forni 1866, 151–2). The following year in his own restoration manual, Giovanni Secco-Suardo recognized the tendency for drained oils to discolor and wrote that the majority of (Italian) restorers used pigments mixed with turpentine and tempered with varnish.

At the end of the 19th century, the French painter Oscar Edmond Ris-Paquot mentioned in his book on restoration that varnish was a good medium for small repairs because it changes very little and is quite solid. However, he felt that it was not practicable for large losses because varnish colors dry too fast (Ris-Paquot 1890, 42).

In the early 20th century, Max Doerner stated his preference for retouching in mastic or dammar varnish colors because they could be easily removed without damage to the painting. In addition, he noted their "transparency and saturated effect most closely approach the appearance of oil color," but they do not discolor to the same degree (Doerner 1984, 407).

In her review of retouching materials in the 1970s, Emile-Mâle wrote that "The use of varnish paint goes right back to the late 18th century...It has always had its fans, though nowadays many of them have replaced natural resin with a synthetic product" (Emile-Mâle 1976, 102). Varnish colors con-

tinue to be used today, primarily in European countries with a long tradition of their use, such as Italy, Germany, and Spain.

(4) Source

Dammar

(a) Physical

Light blond rounded lumps of resin of varying sizes. Dammar crystals tend to have a chalky surface and become transparent/translucent when wet-up. Debris such as dirt and plant material is often found trapped in the resin.

(b) Origins and manufacture

Dammar comes from the Dipterocarpus family of angiosperm trees found from India through Southeast Asia. The resin available in the United States and Europe originates primarily from Malaysia and Indonesia. The trunk of the tree is cut with incisions, and the exuded resin forms tears that are gathered after drying.

(c) Manufacturers and vendors

Dammar is a common material used in oil painting and varnishing and can be purchased both in crystal form and as a varnish dissolved in solvent. Dammar crystals can be purchased from Kremer Pigments, Talas, Conservation Resources, Conservation Support Systems, among other vendors. Dammar varnish is made by a number of manufacturers of painting materials, including Winsor & Newton. It is typically dissolved in turpentine.

Mastic

(a) Physical

Small light to medium honey-colored rounded “tears.” Bits of debris and dirt are sometimes trapped in the crystals.

(b) Origins and manufacture

Mastic comes from the *Pistacia lentiscus* evergreen shrub found throughout the Mediterranean. The highest quality resin has traditionally come from Chios. Mastic tears are produced by incisions cut into the tree and the tears collected after drying.

(c) Manufacturers and vendors

Mastic is not as widely commercially available as dammar. It is generally sold in crystal form. The dry resin can be purchased through Kremer Pigments, Conservation Support Systems, and other vendors. Maimeri and Kremer Pigments both make a premade varnish dissolved in turpentine.

(5) Chemical and Physical Properties

Dammar

(a) Chemical classification

Triterpenoid resin

(b) Chemical formula/structure

Dammar is a complex mixture of triterpenoids and a lesser amount of polymeric material of which the exact components and percentages can vary. The tetracyclic dammarane skeleton series comprises the largest portion of the resin but also present are pentacyclic oleanane, ursane, and hopane derivatives (Mills and White 1994, 107; van der Doelen 1999, 17–19, 169).

(c) Solubility

Initially soluble in turpentine, xylene. As the resin ages, more polar solvents are required for its removal.

(d) Tg

Approximately 39°C

Mastic

(a) Chemical classification

Triterpenoid resin

(b) Chemical formula/structure

Mastic is a complex mixture of compounds including triterpenoids of the tetracyclic euphane and dammarane skeleton type as well as the pentacyclic oleanane skeleton type. Two bicyclic triterpenoids have been identified in analysis as well (Mills and White 1994, 107–8; van der Doelen 1999, 20–22, 169).

(c) Solubility

Initially soluble in ethanol, acetone, turpentine.

(d) Tg

Approximately 35°C

(6) Preparation and Formulation

(a) Typical preparation

The following procedure is used at the Opificio delle Pietre Dure in Florence, Italy (Irma Passeri, personal communication, 2006): One part mastic resin is dissolved into three parts turpentine. The solvent is then allowed

to evaporate until the medium reaches a honey-like consistency. Pigments are prepared by grinding on glass with water and a little ethanol, left to dry, and then stored in containers. The varnish is mixed into a small amount of pigment with a spatula to form a smooth paste. Some colors require more medium than others, but care is taken not to add too much varnish, which would render them too transparent. The varnish colors are set out on a palette, and the solvent is allowed to evaporate off. Xylene and, more recently, ethyl lactate (ethyl 2-hydroxypropionate) with a little isopropanol added to speed drying are used as diluents.

(b) Additives

In the past, Canadian balsam has been added to the medium to help the paint form a paste. However, it has fallen out of favor at the Opificio because it becomes too hard and reduces the solubility of the varnish colors.

(c) Storage/shelf life

A palette of varnish colors does not have a finite shelf life and will remain resolvable indefinitely. Because the paints are fairly soft, the palette should be covered when not in use to avoid dust.

(7) Handling Characteristics

(a) Application

In Florence, varnish colors are applied in a *tratteggio* technique on a base of watercolor or tempera that has been applied in a flat tone. They can be layered but care must be taken with the amount of diluent used because the underlying strokes can be disturbed.

(b) Appearance

Due to their transparency and refractive index, varnish colors can be used to great advantage to simulate an aged oil paint as well as a patina.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

More medium or diluent can be added to the mixed colors to adjust their opacity. Maimeri colors enriched with more varnish medium are sometimes used if specific colors are needed that are not available as dry pigments.

(8) Aging Characteristics

(a) Chemical process

The precise mechanisms of the aging of mastic and dammar films are complex due to the number of compounds that compose these resins. The aging process is based on autoxidative free radical chain reactions primarily initi-

ated by exposure to ultraviolet light. After the primary autoxidation reactions, thermal processes lead to secondary degradation reactions (de la Rie 1988, 66).

(b) Resultant chemical and/or physical alterations

The aging process leads to an increase in molecular weight, the formation of polar degradation products, and the formation of yellow and fluorescent products.

(c) Impact on appearance, solubility, and removability

The increase in polar degradation products in an aged resin results in the need for more polar solvents to be used in its removal. The formation of yellow chromophores can lead to significant yellowing of the medium over time. Other autoxidative reactions can lead to brittleness, hazing, and loss of gloss.

(d) Attraction and retention of dirt and grime

Dammar and mastic resin paints do not seem to preferentially attract or retain dirt and grime.

(e) Theoretical lifetime

When used in thin layers and in dark passages, the inpainting should last as long as the varnish in a typical restoration.

(9) Health and Safety

Mastic and dammar dry resins do not present a health hazard. The dust from dammar resin can be a respiratory irritant in high concentrations. The MSDS should be followed for the solvents used to dissolve the resin.

(10) Disposal

There are no special precautions to take if all the solvent has evaporated.

Elise Effmann

Submitted July 2006

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c) Hand-Mixed Acrylics

Although most acrylic resins that are used by painting conservators as varnishes have also been employed as inpainting media, Paraloid® B-72 is the acrylic resin that is most commonly used for inpainting. Therefore, this section has been written based on the author's knowledge of and experience with B-72. For information regarding principal names, history of use, source, chemical and physical properties, aging characteristics, health and safety factors, and disposal, see Volume 1 of the *Painting Conservation Catalog: Varnishes and Surface Coatings* and go to www.conservationwiki.com/index.php?title=Chapter_V_Polymeric_Varnishes#B._ACRYLIC_RESIN_VARNISHES.

(1) Preparation and Formulation

(a) Typical application methods

Paraloid B-72 can be ground with dry pigments for use as an inpainting medium. A typical stock solution is 20 percent B-72 solids (weight/volume) in either xylenes or propylene glycol monomethyl ether (methoxy proxitol) (Arcosolv PM®). The pigments should be ground into this mixture so that each pigment particle is fully dispersed and coated with medium. This can be accomplished either directly on the palette with a small spatula or in larger batches using a mortar and pestle. The paint can be diluted with the solvent used in the preparation of the stock solution to create a more matte appearance. To increase glossiness, more stock solution can be added or a stock solution with a higher concentration of resin can be used.

(b) Additives

Additives are not commonly used because the level of glossiness can be modified by adjusting the type and amount of diluent used.

(c) Storage/shelf life

Paraloid B-72 is a Class A material, as rated by the standards established by Robert L. Feller (1978). This means it remains stable for perhaps 200 years if stored and used in a museum environment.

(2) Handling Characteristics

(a) Appearance

Paraloid B-72 has a tendency to have a fairly matte, unsaturated appearance. This can be adjusted by adding more medium or by using a medium with a higher concentration of resin. It can have a grayish cast, especially when mixed with dark pigments.

**(b) Modifications for special applications and effects
("Tricks of the Trade")**

- It is important to saturate the pigments fully to avoid graying and muddiness. Dark pigments will require more medium.
- High chroma pigments can be used to help compensate for Paraloid B-72's tendency toward grayness.
- Keep pigments, brushes, and medium clean to aid in achieving the darkest darks and whitest whites.
- To prevent muddiness, it is often beneficial to build up numerous transparent layers to create opacity.

Jim Bernstein recommends the following three diluent solutions:

1. To create a more matte finish:

Heptane	70 ml
Toluene	30 ml

2. For a slow evaporating diluent:

Petroleum Benzine	45 ml
Isopropanol	30 ml
1-Methoxy, 2-Propanol	10 ml
Shellsol 15	15 ml
Acetone	20 drops
Benzyl Alcohol	5 drops

3. For normal evaporation:

Petroleum Benzine	70 ml
Xylenes	30 ml
Acetone	25 drops
Benzyl Alcohol	5 drops

Bernstein points out that the presence of xylene assists in staying close to the solubility center of most conservation resin paints, and he cautions users not to use a lot of xylenes when inpainting over resolvable low molecular weight varnish.

Joanna Dunn

Submitted February 2010

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d) Hand-Mixed Poly (vinyl acetate) Resins

Poly (vinyl acetate) (PVAc) resins have been employed in artists' paint since the 1930s (Clark and Ives 1935). Restorers have also employed them for inpainting. PVAc resins have been in use both to formulate paints in the studio and in ready prepared form from colormen. Their main use in conservation has been in the formulation of a medium by dissolving the resin. Progressive thinning of the solution with ethylene glycol monoethyl ether or cellosolve acetate results in a versatile vehicle capable of a wide range of matte and gloss finishes. Alternatively, the solution may be thinned with alcohol with a few drops of ethylene glycol to increase drying time. Cohesive, adhesive paints may be formulated with a medium containing less than 5 percent solids, although 10 percent is required to imitate oil paints. The refractive index of PVAc (c. 1.46-7) requires it to be glazed with resins of higher RI to imitate richly bound oil paints.

In many respects, poly (vinyl acetate) works and appears like whole egg tempera, although it may not hold textures as easily as egg. Compared with many of the resins we use in conservation, the lower molecular weight PVAc's are notoriously low in Tg and creep, which may be an issue for some environments or applications. PVAc's of varying sizes may be mixed to achieve the wetting properties and firmness desired. For more information on poly (vinyl acetate) resins, see Gettens and Stout's *Painting Materials: A Short Encyclopedia* (Dover Publications 1942); the table in *UNESCO, The Conservation of Cultural Property* (UNESCO 1968, 311–312); *Mastering Inpainting Workshop Manual* by James Bernstein and Debra Evans; and the chapter on PVAc in Volume I of the *Painting Conservation Catalog: Varnishes and Surface Coatings* (Painting Specialty Group 1998), available at www.conservation-wiki.com/index.php?title=Chapter_V_-_Polymeric_Varnishes.

One of the most commonly employed PVAc resins in inpainting today is Mowilith® 20, which closely approximates the molecular weight and properties of Palmer Cement®, or Vinylite AYAB®, formerly a favorite for inpainting formulations. Mixing 1 part AYAA® with 1 part AYAC® can also result in a similar molecular weight resin. The author is familiar with the use of Mowilith 20.

(1) Principal Name

Mowilith 20

(2) Other Names

Lascaux Medium for Retouching®, Berger's PVA Inpainting Medium®

(3) History of Use

(a) Industrial

See the varnish volume of the PSG catalog.

(b) Conservation

Mowilith was adopted for use by several conservators as a substitute for PVAc AYAB® after production of that resin, also sold as Palmer Cement, was discontinued.

(4) Source**(a) Physical**

Mowilith is available as a translucent resin or dissolved in a solvent (e.g., Ethanol/Acetone or methyl proxitol).

(b) Origins and manufacture

See the varnish volume of the PSG Catalog.

(c) Manufacturers and vendors

Lascaux Medium for Retouching, Talas Berger's PVA Inpainting Medium, Kremer Mowilith 20.

(5) Chemical and Physical Properties**(a) Chemical classification**

Vinyl Acetate

For its chemical formula and structure, solubility, and Tg, see the varnish volume of the PSG Catalog.

(6) Preparation and Formulation**(a) Typical application methods**

Mowilith is generally prepared as a solution in either ethanol, a mixture of ethanol and acetone, ethanol with cellosolve or cellosolve acetate, or in propylene glycol monomethyl ether (Arcosolv®). The solutions are generally made to be of a viscosity resembling the paint to be emulated in the retouching. Typical formulations range from 8 percent to 30 percent solids. The solubilized resin is mixed with dry pigments, often directly on the palette. Additional resin or diluent can be added to the dried colors to achieve the desired level of gloss. At the 1990 IIC conference in Brussels, Gustav Berger discussed the use of PVAc as an inpainting material, with a reference to substituting Mowilith for PVAc AYAB (Berger 1990).

(b) Additives

Because the gloss and handling properties are readily manipulated by the type and amount of diluent utilized, additives are not commonly used.

(c) Storage/shelf life

Experimental tests of PVAc have shown it to be a very stable (Class A) material. Mowilith will fuse into a solid block, which must be shattered into smaller pieces to make it dissolve more quickly in the diluent.

(7) Handling Characteristics

(a) Appearance

Depending on the ratio of solvent to resin, Mowilith can have characteristics ranging from a matte scumble to a rich resinous glaze. Altering the amount of pigment in the mix can result in effects from opaque films to sparse dispersions.

(b) Application

The most common application method is with small inpainting brushes. The medium can also be thinned with solvent and applied as a spray coat to seal underlayers.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

If Mowilith is diluted in pure propylene glycol monomethyl ether, it can be manipulated for a longer time, allowing blending and glazing effects. The use of ethyl alcohol as the solvent makes it dry more quickly and allows the conservator to keep the color more matte and each brushstroke distinct. Jim Bernstein recommends the following solvent mixture:

Ethanol	95 ml
Diacetone Alcohol	5 ml
Acetone	15 drops
Benzyl Alcohol	5 drops

Gustav Berger’s publication describes various handling characteristics to achieve specific ends, such as final glazes, cracks, and the creation of patina using watercolor or varnish colors over the PVAc (1990).

Catherine A. Metzger

Submitted May 2004

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B. PROPRIETARY

1. Aqueous Binding Media

The author for this chapter on watercolors uses the Schmincke® line of products and thus has written the entry based on experience and knowledge of Schmincke. Although there are numerous manufacturers of watercolors, as the material properties of watercolors will remain consistently those of pigments mixed in water-soluble vegetable gum, the entry stands *pars pro toto* for all watercolors. It should be noted that each product line will have differing pigments, pigment-to-gum ratios, and lightfastness, etc.; practitioners should acquaint themselves with the variant handling of the manufacturer's line before investing in a complete set of paints. In addition to researching each manufacturer's information, other sources may also be useful. One such online source is *Handprint* (www.handprint.com), a single artist's site based on his personal tests, observations, and biases solely as a user of watercolors.

a) Watercolors (Plant Gum)

(1) **Principal Name**

Schmincke watercolors

(2) **Other Names**

Schmincke Horadam® Aquarell, Horadam® Watercolors, Schmincke Akademie® Aquarell

(3) **History of Use**

(a) **Industrial/Artistic**

Founded in 1881 by two chemist-colormen, H. Schmincke and J. Horadam, the Schmincke factory originally produced natural-resin oil colors for artists. Josef Horadam developed the watercolor line of products and received his first Prussian patent in 1892 for "Horadam Patent-Aquarellfarben." Although Schmincke does not specify its research methods, the company states that it continues to research and develop artists' materials, striving for the highest standards of quality and service, including consumer outreach through its Internet site (www.schmincke.de/startseite.html?L=1).

(b) **Conservation**

Pigments in a gum binder have long been available to artists, the earliest restorers, and modern conservators. By way of documenting the use of watercolors in the early eras of modern conservation, Morton Bradley in his *Treatment of Pictures* (1950) noted, "A water emulsion of poly (vinyl acetate)

may be added to water-color paints for use over a resin coating.” The 1987 completion of the conservation treatment of Diego Rivera’s *Detroit Industry* included the decision to use watercolors for inpainting due to the compatibility with the original surface, ease of removability, and lack of toxicity (Heller 1988, 93). Depending on the surface to be inpainted, watercolors are most often used alone or as a preparatory layer for glazes or other inpainting media (Gordon 2000, 62). With this great range of versatility, watercolor has proven to be a useful tool in conservation.

(4) Source

(a) Physical

Schmincke watercolors are available in ready-to-use 5ml, 12ml, and 15ml tubes, or in half or full pans.

(b) Origins and manufacture

Schmincke follows a traditional liquid pouring of watercolors in pans, which is carried out sequentially four times using special machinery. Company literature states that after each layer, the pans are placed in drying chambers to dry at constant temperature for 2–6 weeks, requiring a total production time of 3–5 months for a single pan. This unique process enables the company to use the same formula for both pan and tube colors—and enables the user to fill pans with tube colors when necessary. Schmincke watercolors conform to ASTM D-4236 (Schmincke n.d.), which is a mandatory U.S. health labeling standard (Gottsegen, personal communication, 2009).

(c) Manufacturers and vendors

Schmincke watercolors, Horadam Aquarell, Horadam watercolors, and Schmincke Akademie Aquarell are manufactured by H. Schmincke & Co. and are distributed by artists’ supply stores. [Although the ASTM International’s subcommittee on artist’s materials recommends using brands that conform with ASTM D-5067—the *Standard Specification for Artists’ Transparent Watercolors* (Gottsegen 2009)—it cannot be confirmed, as of this writing, whether the manufacturer Schmincke conforms to this ASTM standard.]

(5) Chemical and Physical Properties

(a) Chemical classification

Pigments are bound in a non-crystalline plant-based gum. The plant gum is composed of salts of organic acids built of sugar units with Ca, Mg, and K (Gettens and Stout 1966, 29).

(b) Chemical formula/structure

Kordofan gum arabic with pigments, extenders, additives, and water. The listed pH values for the watercolors are pH 5–6.5 at 50% concentration and 20°C.

Shades 223, 224, 225, 226, 227, 228, 347, 348, 349, and 350 contain Cadmium pigments. Shades 487, 488, 499, 509, 510, 533, and 535 contain Cobalt pigments. Shades 209, 212, 530, 536, 221, and 229 contain Nickel pigments (Schmincke 2001). It is known that different pigments require different amounts of gum to function well (Cohn 1977, 36) so exact formulas vary, but Schmincke watercolors are known for having a high pigment-to-binder ratio.

(c) Solubility

Soluble in water and miscible in all proportions.

(d) Tg

Not available

(e) Pigment and content labeling

Names of individual colors in the Schmincke Horadam (and other manufacturers') watercolor lines are often not indicative of the pigments or mixture of pigments used in individual watercolor paints. Minimally, the manufacturer should provide the Pigment Index information for the colors present (e.g., PY 154 or PG 36). The conservator should obtain the technical product literature available from the manufacturer for the most complete listing of watercolors available by a manufacturer, the actual pigments or mixture of pigments present in each color, and some indication of lightfastness (LF) rating (with the caveat that a paint seller is in the business of selling paints, so almost all pigments are going to have a somewhat acceptable LF rating, according to the maker).

The conservator should know the content and permanence of each color used in the palette. The manufacturer naming may be misleading. For instance, Schmincke provides a color #786, Charcoal Grey. Referral to the product literature indicates that the paint contains no charcoal; it is, in fact, Lamp Black PBK 7. The paint is fine for the conservator to use if he or she understands that it is Lamp Black, but it will not produce any of the special effects that a true Charcoal Black will provide.

Also, the manufacturer may provide some colors for artist interest, but not all pigments will be suitable for conservation use.

Watercolor White Pigment Caveat

Conservation scientist Robert Feller established as early as 1955 that re-touchings containing Zinc White (Zinc Oxide PW 4) deteriorated prematurely, causing chalking (whitening/break-up) of inpaints in resin paints (PVAcs, Methacrylates, etc.). If watercolor underpainting is subsequently glazed with resin colors and resin varnish (as it often is in traditional easel painting restoration) and zinc oxide is present in the underpainting, this bodes poorly for the stability of underlying glazes. Chinese White (Zinc Oxide White), although present in many watercolor paint sets, should *never* be used when resin glazing or varnish is to follow. Zinc White may be considered for use if applied as a standalone application where the white color is not to be mixed with other colors or coated (Bernstein, personal communication, 2010). For further information on Zinc Oxide, refer to *Artists' Pigments: A Handbook of Their History and Characteristics*, Volume 1 (Feller 1986, 169).

(6) Preparation and Formulation**(a) Typical application methods**

Application is most typically by a wet to damp brush (although airbrush has been used).

(b) Additives

Schmincke watercolors contain ox gall, glycerin, sugar syrup, and dextrin. According to Dr. Müller, a representative of H. Schmincke & Co., they do *not* contain paraformaldehyde (personal communication, 2004), an ingredient in some watercolor preservatives that may be of concern, as noted by Rossol (1990, 177).

(c) Storage/shelf life

The shelf life of tubes is three years; for pans, more than five years.

(7) Handling Characteristics**(a) Appearance**

The form is pasty, the color depends on ingredients used but is uniform, the odor is slightly aromatic, and the flow properties are excellent. In addition to rating colors for lightfastness (stars) [that does not correlate with ASTM D-5067 (Gottsegen 2009)], Schmincke also rates colors for glazing/opacity properties (squares) and for staining properties (triangles)—symbols noted on package labels—along with color index number and color name.

(b) Application

Application techniques vary from washes to layering, from the vertical hatch strokes of *tratteggio* (*rigatino*) to the contour interweaving of colors (*cromatica astrazione* or *cromatica selezione*) to pointillist style.

Traditionally, watercolor is a fundamentally *transparent* medium, used to achieve transparent effects. The thin applications of color are made luminous by the bouncing of light off the underlying white paper or chalk/gesso. While some pigments in watercolor are opaque, there are limitations of watercolor imitating full-bodied, pigment-rich paints, such as acrylic dispersion colors or silkscreen printing inks. For these, pigments in Aquazol® or gouache may offer more of the body and the desired, densely pigmented look of certain paint structures (Bernstein 2010).

(c) Modifications for special applications and effects (“Tricks of the Trade”)

- i. Addition of gum arabic to increase transparency (Ryan 2001).
- ii. Addition of Aquapasto®, a Winsor and Newton tube formulation of gum arabic thickened with silica, to mimic texture/brushwork. Aquapasto and gum arabic solutions, in general, darken with age and so should be used with caution. Addition of gum arabic or Photo-flo® to aid in adhesion to nonabsorbent surfaces (Bernstein 2010; Elyse Klein, personal communication, 2004).
- iii. Especially good for adding fine cracks on top of PVAc or MSA in painting, adding a bit of “dirt,” quieting abrasions before varnishing (Joyce Hill Stoner, personal communication, 2004).
- iv. For transparent glaze effects, seal watercolor base with varnish then use diluted Maimeri® or Gamblin Conservation Colors (pigments in Laropal® A81) as a glaze (Bernstein 2010; Heller, personal communication, 2004).
- v. Add small amounts of either gum arabic or calcium carbonate for gloss and matte respectively. Use only as much water as necessary to keep paint workable and for less value distortion upon drying (Peter Malarkey, personal communication, 2004).
- vi. Silicates, available in many shapes and sizes, are among the clearest particles (glass-like) and are better matting agents than calcium carbonate (chalk), which imparts milky whiteness/turbidity to colors (Bernstein 2010). Note that caution should be taken when considering

the use of silicates as free silica may be present and pose a health risk (Rossol 1990, 148).

- vii. Use “Water Extra-Dry” (adding some acetone to water) to speed drying and provide greater control of paint application. This also aids in reducing surface tension and pigment dispersion (especially when organic-origin or “greasy” pigments, such as Lamp Black, are present) for improved paint mixtures, particularly when bits of dry pigment are added to proprietary watercolors.

Starting-point formulas are¹:

Deionized Water	70 ml
Acetone	30 ml

or

Deionized Water	60 ml
Acetone	40 ml

The exact percentage of acetone to water will depend on:

- The artwork under consideration;
- The application requirements;
- The ambient temperature and humidity;
- The size of the brush being used.

Alternately, adding ethanol to water (“Waternol”) may also break down surface tension and improve wetting. Formulas are as follows:

Deionized Water	75 ml
Ethanol	25 ml

or

To break down surface tension, improve wetting, and reduce the amount of water being used, the formula below is suggested. It also lowers viscosity and improves handling of paint binders such as Aquazol that may be unwieldy in water alone.

Deionized Water	50 ml
Ethanol	50 ml (Bernstein 2010).

- viii. Use of gum arabic as a medium for grinding watercolors: The conservator may prepare custom watercolor paints for his or her use for access to the fullest range of pigments, producing paints of maximum purity and intensity and in colors not readily or otherwise available commercially. As a cautionary point on gum arabic preparation and usage, do *not* use traditional ox gall as a wetting agent or certain proprietary gum arabic mediums containing acetic acid as both are pH 5 or below. As

preparing gum from dry tears of the resin is very time consuming and difficult (requiring extensive filtration), use only the finest grade prepared gum arabic solution (e.g., Winsor and Newton). Bernstein recommends grinding the pigment in water with some acetone first, then slowly adding the gum arabic solution. Test the paint swatch, allowing it to dry to determine the correct pigment-to-medium ratio.

Bernstein provides the following formula as a starting point:

Winsor and Newton Gum Arabic	96 ml
Glycerin	4 ml
Honey:water (1:3)	5 drops
Golden® Universal dispersant (of 10% GUD diluted in water)	1-2 drops
Aquazol® 50 solution (from 35 gms Aquazol in 65 ml H ₂ O) (Bernstein 2010)	2-5 drops

- ix. Add trace amounts of Titanium Orange (Chrome Orange Titanate), ochre, or cadmium orange to warm light-value colors and to counteract “cold” white, especially when covering dark spots (Bernstein 2010, Mohr 2004).
- x. Watercolor with the admixture of a small amount of Lascaux 498HV® will make the watercolor more resistant to water but will still allow it to be easily removed with water or saliva and a bit of pressure on the swab. Aquazol 200® has also been mixed with watercolor to inpaint a loss on a contemporary oil painting with a high wax content, providing a good gloss match (Tomkiewicz, personal communication, 2004; 1999).
- xi. When using watercolor for transparent toning or inpainting on porous modern paint structures (exposed canvas, Color Field Acrylic paintings, etc.): Watercolor should never be used directly on open canvas or porous structures where intractability and irreversibility may be an issue. Watercolors are known to become increasingly insoluble with age; if used directly, they may travel into a painting structure, producing permanent staining and optical alteration of adjacent original paint or support. Exposed canvas, paper, or other cellulosic supports—often disrupted and made more porous due to physical deterioration or damage—need to be relaxed and re-swollen with gradual humidification. The temporarily plasticized fibers/threads/wood particles may then be coaxed, realigned, and brought back into plane to simulate the original or former topography.

Once all fiber manipulation has taken place, a dilute adhesive may be introduced, if appropriate, to consolidate the region. To counteract excessive porosity in a region of disruption and repair, the application of a dilute isolating size is recommended before applying any color.

One of the most benign and effective cellulose isolators prior to inpainting with watercolors is a thin, continuous application of sodium carboxymethylcellulose ether (gum) size. Depending on the artwork and isolation requirements, the conservator may select one or a mixture made from the following stock solutions:

Methocel A4C (mw 41,000 viscosity 400 cps) 3.5% in H₂O

Methocel A15C (mw 63,000 viscosity 1500 cps) 2.5% in H₂O

Methocel A4M (mw 86,000 viscosity 4000 cps) 2.5% in H₂O

Stock solutions need to be diluted with additional water for application. The lower viscosity grades offer greater flow; the higher viscosity grades are more unwieldy to apply but offer more skin-like isolation.

- xii. Use of increased air flow or increased warm air flow may aid in applying and working with watercolor: Under typical studio conditions, watercolor paints in water take a few minutes to dry. This can be problematic, as the exact final color of the dried paint may only be observed a few minutes later, slowing down the inpainting process. Drying may be accelerated if freshly applied watercolor retouchings are gently blow-dried with a small portable hair dryer (with the heat setting turned off). If more rapid drying is required and the artwork allows it, blow-drying from a distance with the blower set to mild heat may be employed. In some instances, it is beneficial to “pre-dry” an artwork structure before inpainting with watercolor. The blow dryer may be directed to a place on a stretched canvas (e.g., Color Field painting) to “pre-desiccate” the porous canvas structure. After preparing the canvas in this manner, tiny bits of watercolor in “Water Extra Dry,” applied with a tiny brush, may be applied to the desiccated surface and the color may be placed with little or no wicking or traveling (Bernstein 2010).
- xiii. Making watercolors more viscous, controllable, resolvable, or plastic: Watercolors in water by themselves are very fluid and difficult to control. A tiny trace of gum from a sodium carboxymethylcellulose solution (e.g., Methocel® A4C) may be introduced into the watercolor. This will extend and distribute the pigment particles farther apart, making the paint more viscous, less intense, and less staining—in essence, more controllable. Color and design may be built up with successive

applications of paint, each containing less cellulose gum. The cellulose gum also aids in reversibility, enabling future re-swelling and clearing away of aged watercolor retouchings with water (Bernstein 2010).

- xiv. In addition to sable rounds and other brushes traditionally used for watercolor painting, the conservator should become acquainted with “Spotters.” Spotters or retouchers are a squatter version of the pointed round sable brush. The shorter hair length and rapid tapering to a point make them very effective in some inpainting instances. The squat brush form prevents the hairs from flopping (as may happen with longer-haired rounds) and there is less of a belly on the brush, so amounts of paint delivered to the tip may be more controllable. They are particularly effective for slippery surfaces or “spotting” activity, where the color is applied head-on as a dot, rather than laid linearly as a stroke. One consistently excellent version of the spotter is the Winsor and Newton Series 7 Miniature Kolinsky sable® watercolor brush, available in a variety of sizes (Bernstein 2010).

(8) Aging Characteristics

(a) Chemical process

Lightfastness tests are conducted on finished colors; colors are rated with a five-star system correlated to the blue wool standard (blue scale 3–3.5 = 1 star least lightfast/less than 20-year lifetime; 3.5–5 = 2 stars limited lightfastness; 5–6 = 3 stars lightfast; 7 = 4 stars good lightfastness 100+ year-lifetime; 8 = 5 stars extremely lightfast). [It should be noted that although the blue wool scale is still commonly used, it might be inaccurate according to the two major lightfastness-testing companies: Atlas Materials Testing and Q-Lab (Gottsegen 2009)].

(b) Resultant chemical and/or physical alterations

Fading for fugitive to limited lightfast colors with (extended) exposure to light.

(c) Impact on appearance, solubility, and removability

Fading of some colors possible, some colors may stain, colors generally remain soluble in water.

(d) Attraction and retention of dirt and grime

Information not available.

(e) Theoretical lifetime

This depends on particular pigments' lightfastness, e.g., a color with five stars has a theoretical lifetime of between 150 and 200 years under "museum conditions" (Müller, personal communication, 2004).

(9) Health and Safety

(See varnish chapter for base resin)

- Flash point: not applicable
- Slight irritant to eyes
- Non-sensitizing
- Moderately/partially biodegradable
- Use general protective and hygiene measures (do not eat, drink, or smoke while using; avoid contact with eyes).

First-aid

- Eye contact: rinse thoroughly with water, seek medical advice if symptoms persist.
- Skin contact: clean with soap and water.
- Inhalation: remove from exposure.
- Ingestion: in case of problems, seek medical advice and show package label.

Hazards

The shades containing Cadmium, Cobalt, or Nickel pigments contain chemicals known to the state of California to cause cancer by means of inhalation (Schmincke 2001).

(10) Disposal

Do not discharge into waterways; retain and dispose of contaminated wash water. Classified as nondangerous goods, the product does not require hazard warning labels in accordance with EC directives. Empty packages may be recycled (Schmincke 2001).

Victoria Ryan

Submitted December 2004

ENDNOTE

- ¹ Information on formulas comes from “Diluents, Fillers, Binders, and Coatings” by James Bernstein, excerpted from James Bernstein and Debra Evans’ *Mastering Inpainting Workshop Manual* (June 2010 edition, San Francisco, California). This is a combination of original and compiled information provided as an education resource to participants of Mastering Inpainting or Mastering Fills workshops.

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b) Gouache

(1) Principal Name

Gouache is a term for opaque watercolors. It therefore describes a visual effect rather than a separate class of materials. Opacity is achieved through adding a higher proportion of pigment than is used in watercolors and sometimes by the addition of an inert substance, such as blanc fixe (CaCO₃), that gives the colors opacity (Gottsegen 1993, 204). Gouache is gum-bound and remains water-soluble when dry.

(2) Other Names

The term *gouache* is French, but it derives from the Italian word *guazzo*, meaning muddy pool or bog, or perhaps *guazza*, meaning dew or moisture. There is no equivalent English term, “apart from the commercially tainted ‘poster colour’ (which tends in fact to be made of inferior ingredients)” (Lamb 1970, 78). Gouache may be designated as “Designers,” “Fine Artists,” or “Student or Beginner grade.” Designer gouaches are tubes of color, available in a wide range of colors, which are consistent pre-mixed combinations of several different pigments for use where permanence may not be mandatory. In fact, many of the bright colors have “been observed to fade completely in less than a year of exposure to sunlight (Gottsegen, 206). “Fine Artist” gouaches come in a more limited range of colors, and the tubes may contain only a single pigment. Student or beginner grade gouache is of more variable quality than these other types, and it may contain inferior pigments, binding agents, and other additives. Products called “Acrylic Gouache” are not true gouache. Although it is matte like gouache, it does not remain water soluble when dry, and the binder is an acrylic resin rather than a gum.

(3) History of Use

(a) As an artist’s material

Since gouache is essentially watercolor with the addition of opaque inerts, its history of use is not easy to separate from that of its more transparent cousin. Theophilus, writing in the 12th century, describes the use of gum binders, and there is evidence that it was a common medium in ancient classical painting (Gettens and Stout 1966, 29). It became the dominant pigment binder in Europe during the 14th century, since it was better able than the previously used glair to saturate certain pigments, especially dark blues (Thompson 1956, 56). The use of exclusively opaque watercolors did not develop until the late 18th century in Europe (Kuhn 1986, 69), although gouache was used for Indian miniature painting before that date. Gouache became increasingly popular in the 19th century due to advances in color

chemistry that allowed the development of new opaque inorganic pigments in a much wider range of colors (Cohn 1977, 54).

(b) First conservation use

While the tradition of using watercolor or gouache for restoration may predate the 20th century, its use in previous centuries cannot be confirmed, since pre-20th-century sources describing restorations in aqueous media do not specify whether that medium is tempera, watercolor, gouache, or glair. As late as 1914, an essay by a restorer working in Germany and Latvia described the use of water-based retouching with varnish glazes over it (Bauer-Bolton 2004, 367), but it is unclear what the specific medium is. In 1939, an official museum publication in France—*Manuel de la Conservation et de la Restauration des Peintures*—recommended tempera paint or pigments mixed with rabbit skin glue as the lower layer in a two-part inpainting system (Office International des Musées 1939, 185), so it is clear that gouache was not the primary aqueous medium in conservation use at the time. However, once gouache became widely available in tubes, during the 1930s, it might have begun to replace handmade tempera and glue colors due to its convenience.

Currently, gouache is a common component in two-part systems of inpainting in which the gouache forms a base layer that is modified by an upper glaze layer. This system, especially popular in Europe, has been taught for many years at the Belgian conservation program at l’Institut Royal du Patrimoine Artistique (IRPA) (Goetghebeur 1990, 4) and is in use in Germany (Tomkiewicz, personal communication). In the United States, Mark Leonard described its use as an inpainting material on an Italian Renaissance painting at the 2003 Yale Symposium “Early Italian Paintings: Approaches to Conservation” (Leonard, 228), and it was used by Tiarna Doherty in the treatment of an Oudry painting in 2007 (GCI n.d.).

(4) Source

(a) Physical

As in transparent watercolor, the historic binder for gouache was cherry gum or gum arabic (also called gum acacia), an exudate of the acacia tree, but neither is a precise term. Cherry gum also included the gums of the apricot, almond, peach, and plum trees. Modern gouache is bound with gum arabic, most commonly derived from the Senegalese acacia (Lamb 1970, 80).

(b) Present-day vendors

In 2009, at least 12 companies offer gouache paints, usually in 15–20 ml metal tubes, although they are sometimes available in pans or bottles. The claims listed below for these paints are extracted from promotional materi-

als and have not been lab tested (for independent information on stability, see “Aging Characteristics” below). Since gouache is more compatible with titanium than zinc (Chinese) white, the companies that carry titanium are noted below.

- **Daler-Rowney “Designer’s Gouache”:** Available in 87 colors, milled “up to 9 times.” In business since 1783, the company caters to fine artists. The opacifier is calcium carbonate. The company offers both Chinese and Titanium white. The color chart available on their website lists the color index number (but no chemical name of the pigments), four levels of lightfastness, and a cursory opacity rating. (UK)
- **Da Vinci:** A small company whose high-quality colors all conform to the stringent ASTM D5724 standard. The technical sheet on their website identifies all colors by pigment name, CI name, and CI number and gives a lightfastness rating. The company offers titanium white only (no zinc). (USA)
- **Holbein Artists’ Gouache:** 90 colors, no opacifiers added. (They also offer an “Acryla” gouache series, which is resin bound and therefore not a true gouache.) They provide a color chart with three levels of lightfastness and the pigment name. They offer zinc white and permanent white, which is titanium dioxide. Their paints adhere to the stringent ASTM D5724 standard (see “Aging Characteristics” below). (Japan)
- **M. Graham Gouache** (artists’ gouache): This small company catering to fine artists makes 38 gouache colors, mostly based on a single pigment. The binders are gum arabic and honey (added as a plasticizer), which they claim create a smoother finish. No fillers or opacifiers are added. Their website includes a color chart with three levels of lightfast ratings, four levels of opacity ratings, and listings of the chemical name of the pigment and color index number for each pigment. They do not offer zinc white as a gouache pigment (probably because of its instability in gouache); both their Chinese white and titanium white are made with titanium dioxide. (USA)
- **Schmincke Horadam** (artists’ gouache): No opacifiers added. They offer three grades of gouache; the highest grade for fine artists is available in 48 colors; all but eight are pure pigment (no mixtures). The other grades are designer’s gouache (60 colors) and Academie, a beginner’s grade with 18 colors. They publish their own MSDS and color chart. They claim that all their colors except for madder lake deep (color #12354) meet the ASTM D5724 standard. They offer a permanence rating chart that they claim is more rigorous than the ASTM standard. They use a different opacity rating than the ASTM standard because

their definition of opacity is not the same as the ASTM's (Mueller, PSG Listserv post). They offer titanium and zinc white. (Germany)

- **LeFranc et Bourgeois (Designer's Gouache):** Linel gouache, 40 colors. (France)
- **Maimeri:** 54 colors. The company offers both titanium and zinc white and supplies a rating chart with two levels of lightfastness and opacity. (Italy)
- **Winsor and Newton "Designer's Gouache":** No opacifiers added, available in 84 colors. They offer extensive technical information about their gouache. Their color charts identify colors by specific pigment name, color index name, and color index number. They assess four levels of lightfastness and also indicate relative opacity, as well as which paints will granulate, stain, or bleed. They offer titanium white and zinc white, but do not recommend titanium white for mixing with other pigments. They suggest using only AA- or A-rated colors if permanence is important. (UK)
- **Reeves:** Reeves lists sets of 12–24 tube colors on their website, but no materials information is included. (UK)
- **Savoir Faire:** The company markets "French School Gouache," but no materials information is included. They also offer Lascaux "Acrylic gouache," which is not true gouache. (USA)
- **Royal Talens extra fine gouache:** 60 colors, available in tubes or bottles, two whites offered (no pigment names given), lightfastness chart on website. (Holland)

(5) Chemical and Physical Properties

See watercolor entry (III.B.1.a).

(6) Preparation and Formulation

(a) Commercial manufacture

Commercial manufacture of gouache began in the 19th century, with the production of a limited range of colors, including lead white, red lead, chrome yellow, copper oxide green, Naples yellow, and cobalt blue (Cohn 1977, note 9, 79). In 1841, the old-fashioned pan was replaced by metal tubes and by 1851, Winsor and Newton had created "moist watercolors" of thicker consistency that could be stored in tubes. This led to the addition of extra gum binder to these paints, since they were often applied more thickly and would otherwise crack or look too chalky (Cohn 1977, 57).

Poster color appeared after World War I. Further improvements led Winsor and Newton to introduce their line of gouache in 1937 (Winsor and Newton). At present, there are at least twelve companies making it. It is prepared by the same method as watercolor, but it is made more opaque by the addition of greater amounts of pigment or sometimes by the addition of opacifiers. Modern commercial preparations of gouache usually include gum arabic, wheat starch (dextrin), preservatives, thickeners, plasticizers, and wetting agents (Gottsegen 1993, 204). Plasticizers may include hydromel or sugar water, and glycerine may be added to keep the paint moist (Mayer, as quoted in Schenck 1994, 17). Opacity is generally achieved by the addition of precipitated chalk, although some higher-quality gouache manufacturers claim that no white is added to boost covering power and that the opacity is due purely to the amount of pigment present in the binder. Cheaper grades may use lithopone (zinc sulfide with barium sulfate and titanium dioxide) as the opacifier (Gettens and Stout 1966, 125). In general, gouache is bound with a slightly higher proportion of gum than watercolors, and its pigments may be less finely ground (Gottsegen 1993, 204). Its solubility is the same as that of watercolor; it remains water soluble once dry.

(b) Pre-commercial formulation

Before commercial manufacture, gouache was made in the same way as watercolor (see watercolor entry in this catalog, section III.B.1.a.), with the addition of opaque white.

(7) Handling Characteristics

(a) Appearance

When dry, gouache appears as a matte opaque layer with little or no impasto. Unlike watercolor, it dries lighter than its color when wet. This is because the chalk additive is translucent when wet but opaque white when dry (Gottsegen 1993, 206); conversely, it darkens appreciably when varnished. It must be also due to the relatively greater amount of pigment in proportion to medium because the higher-grade gouaches do not add opacifiers.

(b) Application

Gouache can be applied with the sable brushes used for watercolors, with stiffer bristle brushes if applied more thickly, with a pen, or by airbrush.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

- Gloss may be adjusted by adding more gum binder.
- Evenness of tone can be increased by adding glycerine (Schenck 1994, 17).

- If using gouache in an airbrush where it will be thinned with water, adherence to the substrate can be increased by adding more gum arabic (www.winsornewton.com).
- To create more texture, manufacturers suggest mixing gouache with Aquapasto medium or other acrylic texture gels, but these materials have not been tested for stability.
- A combination of 70/30 deionized water/acetone aids pigment dispersion for better paint blending, reduces wicking, and speeds drying. This mixture can also be used at 60/40 (Bernstein 2008).
- A mixture of 3/1 or 1/1 water/ethanol can be used with gouache to break surface tension, improving wetting (Bernstein 2008). Oxgall or Photo-Flo (Kodak) can also be used for the same purpose.
- Gouache is sometimes used as the lower layer in a two-layer system of inpainting because, since it is opaque and therefore reflects light, it covers well even in thin layers (Kuhn 1986, 69). Therefore, one can more rapidly achieve an opaque underlayer than is possible with various synthetic resin-bound inpainting materials. This can be especially helpful when losses are large. However, when dry, gouache appears more even in tone than when saturated with a varnish or overlying glazes, so care should be taken to get this layer even before applying the overlying glazes. Evenness of tone can be increased by not adding too much water and by selecting those colors rated as most opaque (for example, Schmincke rates its pigments at four levels of opacity). Tones selected should be slightly lighter, cooler, and more intense than the original (Leonard 2003, 228). Gouache has been described as being appropriate for Early Italian pictures because of the “clean, precise, clarity” of its color (Leonard, 228). It has been used as an underlayer with a thin layer of varnish applied after inpainting and a final surface glaze of Gamblin or Maimeri Ketonic Colors (Rosser, Tomkiewicz, Scarpini PSG Listserv posts), where it is reported to be unchanged in tone after 20 years (Cox PSG Listserv post). In a series of Paintings Specialty Group List posts from Jan. 15–18, 2009, most conservators preferred Schmincke Horadam gouache to Winsor and Newton gouache due to greater opacity (Craddock) and less tendency to peel (Scarpini, Tomkiewicz). Jim Bernstein suggests that the peeling in Winsor and Newton gouache may be due to their greater addition of humectants (Tomkiewicz). Other posters reported good results using Holbein gouache (Rosser, Fredericks). The Calligraphy series from Schmincke Horadam was suggested as good for inpainting modern pictures (Craddock).

(d) Advantages

- Gouache works especially well in inpainting early Italian Renaissance paintings, where it can imitate the tempera paint of the original works. After the gouache is laid down, its tone and gloss can be modified by overlying glazes in a synthetic resin or natural resin medium.
- It remains soluble and thus can easily be removed.
- Old gouache retouching remains in place during varnish removal, provided there is no isolating varnish layer beneath it. Therefore, inpainted areas may not need to be redone, or they may need simply to be adjusted with glazes.

(e) Disadvantages

- Because gouache dries lighter than its saturated color, this needs to be taken into account when applying the overlying glaze. Correct color matching can be improved by rolling mineral spirits over the gouache layer to check for its color accuracy when wet up (Cox, Rosser, PSG Listserv posts).
- If one doesn't achieve the correct color in the gouache layer, it is difficult to modify it by painting over it with more gouache because one easily can pick up the already applied layer.
- Gouache is opaque and therefore is not suitable for all applications.
- It sometimes doesn't adhere well to the underlying surface, causing the gouache to bead up. This problem can be solved by adding a few drops of a surfactant, such as oxgall or Photo-Flo, to your water.
- Gouache is not always compatible with an extremely absorbent fill since the gouache binder may be absorbed by the substrate, causing cracking.
- Not all pigments work well in gouache. For example, zinc white (Chinese white), the main watercolor white pigment, can turn gray in gouache medium if mixed with Prussian blue, and it does not photograph in its true value (Lamb 1970, 81). This graying has been documented in practice by Carolyn Tomkiewicz (PSG Listserv post). Zinc white is also much less opaque than titanium white. Lithopone, an inferior zinc pigment used in student grades, has a history of darkening when exposed to strong light (Lamb 1970, 81). Some conservators who have had difficulty finding titanium white gouache have mixed Utrecht watercolor titanium white with their gouache colors to achieve a more stable tint (Rosser PSG Listserv post).

- The pigments brown madder, bistre, VanDyke brown, chrome yellow, and Hooker's green are not lightfast in gouache, nor are the violet colors.

(8) Aging Characteristics

(a) Chemical/physical alterations

i. Lightfastness

Questions about the stability of gouache are actually questions about the stability of its pigments, since the gouache medium is not protective against degradation by light. Since some gouache colors are not lightfast, it is important to select colors that are rated as permanent. However, evaluating lightfastness is somewhat complex, since many companies have their own rating systems that are different from the current ASTM standard. The current best standard for permanence is the "ASTM D5724 Specification for Gouache Paints." This is a voluntary standard. Some manufacturers state on their labels that their gouache conforms to ASTM standard D4236, which is the mandatory standard for labeling of chronic health hazards, and it is not a permanence rating. As of this writing, two gouache companies, DaVinci and Holbein, comply with the D5724 standard. This does not mean that other companies' products are less permanent, but only that they don't use the ASTM permanence standard as their yardstick.

For example, Schmincke Horadam states that all its colors meet the ASTM D5724 standard except the color madder lake deep (color # 12354). They supply their own MSDS, their color chart rates colors for both permanence and opacity, and they feel their permanence ratings are more stringent than the ASTM standard. Winsor and Newton also provides a permanence rating and recommends using only AA- or A-rated paints if permanence is important. In the face of so many different standards, a useful rule of thumb might be that the higher-quality gouache manufacturers are more concerned with permanence, and if a company produces permanence charts and other details of testing in their promotional literature, their pigments will be more stable than companies offering no information at all. Note also that some of the names of the gouache colors may not actually reflect the true pigment composition of that color (for example, "ultramarine blue" may not actually be made with the pigment ultramarine). Therefore, the permanence rating is a better way to judge stability than simply relying on the color's name on the tube. Another source to consult for the stability of individual colors is *The Wilcox Guide to the Best Watercolor Paints* by Michael Wilcox.

ii. **Pigment interactions**

Zinc white has been found to become chalky and to discolor in gouache, so most of the makers of high-grade gouache offer a titanium-based white in addition to zinc white. The DaVinci Paint Company offers only titanium white, and M. Graham Company's two whites, Chinese White and Titanium White, are both made with titanium only.

(b) **Shelf life**

Gouache theoretically remains permanently usable in the tubes if well sealed and not exposed to the air. Paints will not change color, but after many years they may become hard in the tubes.

(c) **Removability**

Gouache remains soluble in water even after drying.

(d) **Attraction of dirt and grime**

Gouache has not been reported to attract dirt and grime.

(9) **Health and Safety**

(a) **Storage**

Gouache is stable under normal conditions. It should not be exposed to excessive heat for long periods of time. Winsor and Newton lists its gouache as pH 6- and its boiling point at above 100°C. Gouache may coagulate at freezing temperatures (M. Graham and Co. Material Safety Data Sheet).

(b) **Handling**

No special equipment is required. There are no inhalation health risks under normal use. Ingestion may cause irritation to the gastrointestinal system. Avoid prolonged skin contact; wash with soap and water to remove.

Carol Christensen

Submitted January 2009

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GOUACHE VENDORS

Daler-Rowney

2 Corporate Dr.
Cranbury, NJ 08512-9584
www.daler-rowney.com
Phone: (609) 655-5252
Fax: (609) 655-5852

DaVinci Paint Company

11 Goodyear St.
Irvine, CA 92618
www.davincipaints.com
Phone: (800) 553-8755
Fax: (949) 859-4766
E-mail: dvp@davincipaints.com

Holbein

www.holbeinhk.com

H. Schmincke and Co.

GmbH & Co. KG
Otto-Hahn Str. 2 D40699
Erkath, Germany
www.schmincke.de

Lefranc et Bourgeois

www.lefranc-bourgeois.com

Maimeri

www.maimeri.it
E-mail: maimeri.info@maimerispa.it

M. Graham and Company

P.O. Box 215
West Linn, OR 97065-0215
www.mgraham.com
Phone/Fax: (503) 656-6761

Reeves, Oasis Art and Craft Products Ltd.

Goldthorn Rd.
Kidderminster, Worcestershire, DY 117 JN, UK
www.reeves-art.com
Phone: +44 0 1562-744522
Fax: +44 0 1562-823181
E-mail: enquiry@reeves-art.co.uk

Royal-Talens Company

P.O. Box 4
7300 AA Apeldom, Netherlands
www.talens.com
E-mail: info@talens.com

Savoir-Faire

40 Leyeroni Court
Novato, CA 94949
www.savoirfaire.com
Phone: (415) 884-8090
E-mail: Productinfo@savoirfaire.com

Winsor and Newton

In the United States, 11 Constitution Ave., Piscataway, NJ 08854
www.winsornewton.com
Phone: (800) 445-4278

c) Plaka (Casein Paint)

(1) Principal Name

Casein tempera, casein emulsion, casein colour, Plaka®, Shiva®

(2) Other Names

Milk paint, farmer paint, badigeon, casein lime paint, casein fresco, casein gesso

(3) History of Use

(a) Industrial

From ancient times, casein, a derivative of milk, has been one of the earliest paint binders and adhesives known. It is probable that casein was used in the cave paintings of southwest France and northeast Spain in 20,000 to 15,000 BCE. Cattle and goats were domesticated for milk, among other uses, in Turkey and other Near East sites from 10,000 to 6,600 BCE (Browne 2002, 157).

From Gettens and Stout we know that “it has served extensively as a binding medium for cold-water house paints and, to a limited extent, for pictorial painting, both as a binding medium and in the preparation of grounds. Craftsmen of ancient Egypt, Greece, Rome, and China are considered to have used casein” (Gettens and Stout 1966, 8). Hermann Kühn reported in 1966 that he found proteins in samples of Hellenistic wall paintings from Bulgaria, indicating the presence of a casein and lime binder (Browne, 135). In ancient Rome, we know from Pliny the Elder’s *Historia Naturalis* that “... the Romans were familiar with various binders which could be used on a dry rendering, e.g., animal glue, gum, egg, honey and milk...” (Browne, 157). Ancient Hebrew texts mention the use of curd (casein) in house painting and decoration (Gettens and Stout, 8).

Casein or pot cheese was used as an adhesive by woodworkers in the ancient Middle East (Browne, 134). Without doubt, it was a joining adhesive in the cabinet work of the Middle Ages (Gettens and Stout, 8). The preparation and use of casein were described as far back as the 12th century by Theophilus Presbyter (Werner 1951, 5). Michelangelo is said to have used a combination of sour milk, oil, and pigments to produce highlight effects on walls (Gettens and Stout, 8). Lime casein was used in many well-preserved 18th-century ceiling paintings in upper Bavaria and Tyrolean peasant houses. They were painted either into still moist fresco plaster or into a lime wash. Many wall and ceiling paintings of that time are these so-called “casein frescoes” (Doerner 1962, 299).

Commercial preparation of casein paints began around 1900 (CAMEO). Tempera painting, using either egg or casein as a binder, surfaced in the 1920s in the United States, where artists had adopted its use from British and German painters who already had a strong tradition of casein decorative painting from the previous century. Casein paint was imported from Germany to the United States as early as 1928 (Werner 1951, 5). Ralph Mayer concurs, noting in his handbook that tubes of commercially prepared tempera were highly developed in Germany, where all types were made (Browne, 154). According to the artist A. R. Katz, who rediscovered casein in 1927, the artist Ramon Shiva was already using casein in the United States and pioneered in originating a new line of colors that were soon to be sold in art stores everywhere (Dulac 1969, 66). In 1933, Shiva began to produce "... a high grade commercial version [of casein glue and paint], using an emulsion composed of casein glue plus a very small amount of linseed oil..." (Browne, 155). According to their website, the Pelikan company of Germany introduced their first line of Plaka casein colors to the market in 1934.

In the 1930s, Daniel Thompson's *The Practice of Tempera Painting* and a translation of Max Doerner's *The Materials of the Artist* were very influential to a generation of American artists exploring the rediscovery of medieval and Renaissance techniques of tempera and fresco painting. The revival of casein painting took hold roughly from 1930 through 1950 (Boyle 2002, 15). For many WPA projects executed from 1935 until 1943, artists used egg and casein tempera in studies for murals because these media were durable, permanent, fast drying, and resulted in a "look" that approximated fresco (Boyle, 41). Dispersions of synthetic polymer emulsions replaced casein as a paint medium in the early 1950s in the United States (Crook and Learner 2000, 27) because they possessed most of the advantages and none of the drawbacks of casein.

(b) Conservation

The casein paint used in conservation is sold under the trade name Plaka. It is commercially manufactured by the German company Pelikan. It is currently the only casein paint reported for use as an inpainting medium, for underpainting of fills, and as a toned fill material. Perhaps because of its long tradition as a paint binder and adhesive in cabinetmaking in Europe, Plaka casein colors are currently used more commonly by European painting conservators than by their North American counterparts.

(4) Source

(a) Physical

Commercially manufactured artists' grade casein paint is sold in tubes or small jars ready to be diluted with water for application.

(b) Origin and manufacture

In general, we know from Gettens and Stout that the binder “casein is prepared from skimmed milk by heating it at 34.5° to 35°C and adding hydrochloric acid till the mixture reaches a pH of 4.8. It is then allowed to settle and, after separation from the supernatant liquid, is washed with hydrochloric acid, also with a pH of 4.8. Casein so prepared is technically pure, and is a snow white, slightly hygroscopic powder...” (Gettens and Stout, 7). To make a casein paint, the casein powder is mixed with water and alkalis forming a colloidal solution (Mayer 1981, 380) to which the pigments are added. For best quality results, the alkalis of choice would be ammonium compounds such as ammonium carbonate (Gettens and Stout, 8). Commercial caseins are often prepared with potash or soda. In traditional paints used for wall paintings, the alkali’s source would have been slaked lime when the desired product was a coarser casein paint. Some commercial preparations, such as Shiva, add a small amount of linseed oil in their preparation, perhaps to enhance its flexibility and emulsifying properties.

(c) Manufacturers and vendors

Plaka is produced in Germany by the company Pelikan and can be found through various suppliers of art materials in North America. The manufacturers of Shiva, Grumbacher, and Permanent Pigments have also been making casein colors (Browne, 154), but their use as an inpainting medium by conservators has not been reported.

(5) Chemical and Physical Properties**(a) Chemical classification**

The significant ingredient of Plaka colors is casein, which is an organic compound belonging to the class of proteins, grouped with one of the more complex subdivisions, the phosphoproteins. It consists of carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorus. Like all proteins, it is amphoteric, i.e., it functions both as an acid and a base. It has, however, decided acid properties and exists in milk as calcium caseinate (Gettens and Stout, 7), a salt of calcium.

(b) Chemical formula/structure

The definition of casein, according to Wikipedia, states:

Casein consists of a fairly high number of proline peptides which do not interact. There are no disulfide bridges. As a result, it has relatively little secondary structure or tertiary structure. Because of this, it cannot denature. It is relatively hydrophobic, making it poorly soluble in water. It is found in milk as a suspension of particles called casein micelles, which show some resemblance with surfactant-type micellae

in a sense that the hydrophilic parts reside at the surface. The caseins in the micelles are held together by calcium ions and hydrophobic interactions.

(c) Solubility

Casein paint, which is considered a tempera, is an aqueous paint system made by dispersing pigments in an emulsion. As an emulsion, tempera always contains a mixture of aqueous and non-aqueous binders (Browne, 98). When initially working with wet casein paint, it is soluble in water. It remains partially soluble shortly after and is not waterproof until fully cured. However, in certain types of thinner applications, it may be removable with warm water.

(d) Tg

At room temperature, the dried paint film is brittle and is not recommended for inpainting on stretched canvas or on other flexible supports.

(6) Preparation and Formulation

(a) Typical application methods

Plaka is removed from the small jars in which it is sold using a microspatula or other suitable tool, and transferred onto a palette for mixing. Before application, it is recommended that the paint brush be loaded with water and the colors be mixed thoroughly and thinned to the desired consistency.

(b) Additives

Although Plaka colors are available in a variety of hues, dry pigments can be added to widen the spectrum of colors as needed.

(c) Storage/shelf life

It has been observed by conservators that 5- to 10-year-old Plaka colors whose water content has evaporated, leaving a thickened paste paint, can be thinned successfully with water, provided they are not completely hardened. For best results, jars should be stored with the caps screwed on tightly in closed plastic bags. Completely hardened paints cannot be reconstituted for use.

According to Gettens and Stout writing in 1942, it was generally difficult to keep casein in tubes without the paint hardening and crumbling (9). Glycerine may be added in some commercial preparations to keep the paint moist (Gettens and Stout, 9). However, this additive could make them more susceptible to mold growth. Sheila Ross, a Shiva employee, stated in an article in 1975 that the early tubes of Shiva casein paints had an uncertain shelf life caused by hardening or separation of the pigment and binder, but that by the

1930s those problems had been resolved (Browne, 155). Certain casein paints, such as those used by decorative wall and theater set painters, have a limited shelf life in larger quantities and can putrefy. This leads one to believe that Plaka may have preservatives or small amounts of linseed oil in it.

(7) Handling Characteristics

(a) Appearance

Plaka colors are opaque colors, water-soluble while wet, which behave very much like egg tempera or gouache colors. They have more body than either paint and enough for slight impasto techniques. However, thicker applications are not recommended since they will crack and may not dry properly. Casein paints are smooth and more workable than acrylics. As they have a very strong covering power, they maintain their opacity in thin applications. Similar to a gouache, they dry to a slightly lighter shade and darken considerably when varnished. In very dilute applications, they can appear as watercolors without the brilliance. They are completely matte when dried and can be buffed with a dry cotton swab to a dull sheen, making them very suitable for conservation of murals and fresco-like surfaces.

(b) Application

Plaka colors are completely water-soluble when taken from the jar. However, they dry quickly on the palette and can sometimes be reconstituted when color mixing during the same inpainting session. They also dry quickly upon application to the fill surface. As a result, they are best suited for shorter strokes executed in thinner applications.

(c) Modifications for special applications and effects ("Tricks of the Trade")

Although casein is reported to be irreversible and therefore unacceptable as an inpainting medium, several conservators describe Plaka colors' unique properties as useful for certain types of inpainting, underpainting, and texturing of fills. They are ideal for inpainting techniques using pointillist and short hatch-strokes as they dry very quickly. Some conservators have reported Plaka to be particularly helpful on fresco projects. During a recent treatment of a fresco in the United States, the Italian fresco conservator Giovanni Cabras suggested that some fresco conservators in his native country prefer using Plaka because its body and sheen upon drying are more aesthetically compatible to the surface of a fresco than any other inpainting medium (Leto-Fulton 2000). Cabras and his colleagues also believe that when used in dilute concentrations, it can be removed easily and is ideal for toning back pinpoint losses in frescoes by diluting it very thinly as a watercolor.

Also in this context for larger filled losses, one can carefully integrate the whiteness of the fill by slowly adding small, light-handed touches of a neutral beige color rather than color matching. This allows the original paint to be the protagonist of color so that the inpainted fill doesn't become heavy. The technique is similar to working with watercolor: one would use the lightness of the non-original *intonaco* fills for the lighter colors. Only when there are darker areas to be inpainted would a little white be added to the palette for the needed opacity (Leto-Fulton 2000). Other American conservators feel that Plaka colors are difficult to color match when using mixtures containing white because of their color shift upon drying. However, compensation for this shift can be made when mixing the color on the palette.

Some conservators have reported the use of casein for underpainting and texturing fills followed by a more traditional, reversible inpainting palette. Since Plaka has some body and dries insoluble in water or solvents, it is useful for building up texture on a smooth fill, provided the fill material is removable, thereby isolating the Plaka in reversible adjacent layers.

London conservator Valentine Walsh reports that she has used Plaka as a fill material for small losses in copper panels since it remains in place when any excess is cleared with warm water or carved away with a scalpel. She notes that it can be applied very thinly and can be easily matched to any ground color. It should be applied very carefully, only in the loss and not over surrounding original paint layers since it may not be reversible.

Walsh has also used Plaka for retouching small losses on frames and other gilding. In this case, the conservator matched the bole color or general tonality of the gilding. Plaka comes in a variety of colors, including metallic colors, although no conservators reported their use.

(8) Aging Characteristics

(a) Chemical process

In casein paint, calcium and similar multivalent alkalis create cross-links, forming an insoluble product (Horie 1987, 144). Certain commercial formulations contain small amounts of linseed oil, which oxidizes and polymerizes, forming cross-links. This further contributes to the paint's insolubility over time (for more details, see section III.B.2.a on drained oils as an inpainting medium).

(b) Resultant chemical and/or physical alterations

Casein paint generally becomes a hard and brittle film upon aging and therefore is not recommended for use on flexible substrates such as stretched canvas. It is better suited for conservation of wall paintings and fragments thereof that have been mounted to rigid supports.

(c) Impact on appearance, solubility, and removability

Because of the unpredictability on the issue of insolubility, it is generally recommended that inpainting with Plaka be limited to areas of fills. Theoretically, casein reacts as a weak acid; when fully cured, it is insoluble in water, alcohol, and other neutral organic solvents and is soluble in the carbonates and hydroxides of the alkali and alkaline earth metals and in ammonia (Gettens and Stout, 7). Although theoretically casein colors become waterproof within 24 hours of initial application, some conservators observe solubility using light moisture for much longer. Plaka colors used in very dilute concentrations can be easily removed (Leto-Fulton 2000). The addition of glycerine for flexibility in some commercial preparations keeps the paint moist, but destroys the insolubility of casein in water (Gettens and Stout, 9). Although casein paints are chemically miscible with resins and oils, it is not recommended because they can darken considerably and become even harder to remove.

(d) Attraction and retention of dirt and grime

Casein paints are matte when dried and, depending on the atmosphere in which the paintings are housed, will retain dirt and grime more readily than traditional varnished inpainting materials. Surfaces of dried paint that have been buffed with a dry cotton swab producing a dull sheen will mitigate the ability for retention of atmospheric dirt.

(e) Theoretical lifetime

In a good environment that is well-suited for most paintings collections (generally speaking, 68°-72°F +/- 2° and 45%-55% RH), casein inpainting should be able to withstand the aging process with no appreciable visual shift or loss of structural integrity.

(9) Health and Safety

Casein can support mold growth if applied in thicker layers if glycerine is present in the formulation (Gettens and Stout, 9) or if casein paints are applied in damp environments (Horie, 144).

(10) Disposal

There are no specific standards for disposal of the medium in Plaka, although certain colors may contain heavy metal-containing pigments requiring specific guidelines for their disposal.

Lisa Leto-Fulton

Submitted June 2008

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d) Inks

(1) Principal Name

Higgins Waterproof; FW Waterproof Drawing Ink; Luma Brilliant Concentrated Watercolors; Winsor & Newton Ink; Pelikan Drawing Ink, Waterproof

(2) History of Use

(a) Industrial

Since antiquity.

(b) Conservation

The author has used inks since 1985. It is not known how long they have been in use for inpainting.

(3) Source

(a) Physical

There are different sources, depending on color.

(b) Manufacturers and vendors

Higgins: Sanford, Bellwood IL (Newell Company)

FW: Steig Products

Luma: Daler-Rowney, Jamesburg, NJ

Winsor & Newton: London HA3 5RH England

Pelikan: D-3000, Hanover 1, Germany

(4) Preparation and Formulation

(a) Typical application methods

As packaged by manufacturer.

(b) Additives

As supplied by manufacturer.

(c) Storage/shelf life

Depends on brand and storage methods. The tighter the seal after opening, the longer the inks remain liquid and viable for use.

(5) Handling Characteristics

[*Note:* The inks are used as a *base coat* before subsequent retouching. Inks provide a good initial color for further inpainting because they penetrate the fill

material without adding another distinct layer, and there are no discreet pigment particles to affect the texture of the retouching.]

(a) Appearance

Straight from the bottle, the inks can be quite intense. This quality can be a benefit or a hindrance depending on the color to be matched. Also, the inks can appear shiny depending on the manufacturer and the inclusion of shellac. The sheen disappears with the application of the subsequent retouching layer.

(b) Application

First the loss is filled with white gesso and textured to match the surrounding area. The inks then are applied in a manner similar to watercolor painting, i.e., the white ground may be used as a factor in the color mixture. Inks may be mixed together in simple, limited combinations to achieve colors other than those directly obtainable from the bottles. Too much mixing results in a muddy color.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

For a light color, the ink may be diluted with water. For dark colors, the ink may be used directly from the bottle, followed by a thin glaze or scumble to achieve the final match. In general, if the desired color cannot be matched with the ink, it is better to keep the inks a little lighter and cooler.

Preparatory ink applications are especially useful for inpainting surfaces with little to no impasto, such as 14th- to 16th-century panels where the paint layer is extremely thin but the color is intense. This method works especially well with blacks when India ink is followed with a warm glaze.

Inks used as a base coat can speed up the total inpainting process. As a preparatory step, their application suggests the final appearance of the painting while still leaving room for modification. The ink layer can be transparent or opaque, depending on the individual painting and desired effect. For example, if the ground or ground color is part of the final effect, the inks may be applied transparently, as in a watercolor. For a richer, more intense color, an opaque application may be preferable. Typically, inks are applied prior to the application of the isolating varnish, for varnish may block the penetration of the ink into the fill. Varnish may be applied around the edges of the loss/fill prior to ink application as a precaution. The author has never had a problem with ink stains at the edges of the loss.

Inks also may be used late in the inpainting process, such as in the reconstruction of rigging in a ship or to reproduce fine cracks.

Typically, a brush is used for the application of inks. Brush size depends on the size of the loss and what is meant to be reconstructed.

(6) Aging Characteristics

(a) Impact on appearance, solubility, and removability

Inks can be easily removed with moisture and the fill material.

(b) Attraction and retention of dirt and grime

The inks are an underlayer and not susceptible to dirt and grime.

(c) Theoretical lifetime

Changes have not been detected through glazes and scumbles in the subsequent retouching layer. Lightfastness or changing of color has not been detected in 25 years.

(7) Health and Safety

Inks are very safe to use.

Eric Gordon

Submitted April 2004

2. Oil

a) Drained Oil

(1) Principal Name

Drained oil, extracted oil, leached oil; variant: oil-resin color

(2) History of Use

(a) Artistic

In the 19th century, some artists' manuals advised placing oil paint onto blotter paper or another absorbent surface as a method to draw out the excess oil often encountered in commercially produced paints. This procedure is written about at least as early as 1858 in A. Ducrot's *La peinture à l'huile et au pastel apprises sans maître*, in which unsized paper or wood is recommended for this purpose (Ackroyd 1999, 38). In 1881, in *A Course of Lessons in Landscape Painting in Oils*, Alfred Grace remarked that too much oil would lead to "the dead, muddy, leathery look in your painting which is so disagreeable" and went on to propose extracting the excess oil on blotting paper (Carlyle 2001, 152). Philip Gilbert Hamerton, in his 1882 book titled *The Graphic Arts*, noted that a fellow artist "...like Sir Frederic Leighton...objects to oily colours, and extracts superfluous oil by squeezing the pigment upon blotting-paper" (Carlyle 161). The chemist Sir Arthur H. Church in *The Chemistry of Paints and Painting* also recommended the practice and further stated that a clean block of Plaster of Paris was the best surface for drawing excess oil out of the paint (Church 1890, 46). In 1891, the academic painter Jehan George Vibert, remarking on the common belief that too much oil led to darkening, wrote that "many artists, convinced of this excess, have adopted the custom of leaving their colours some minutes on blotting paper before using them" (Vibert 1892, 75).

In addition to minimizing certain perceived defects, the technique of oil extraction was also used to modify the paint's handling properties and appearance. By the late 19th century, particularly with the advent of Impressionism, many artists used this method to obtain paint that was leaner, more easily impasted, and dried faster (Callen 2000, 101). When asked why he put his paints onto blotting paper, Claude Monet responded that he believed there was too much oil in commercial paints and that he was interested in achieving a more matte surface (Salomon 1971, 24). Edgar Degas was known to draw out excess oil before diluting with turpentine to produce matte washes of paint in a technique called *peinture à l'essence* (Bomford 1999, 25–27; Fletcher and DeSantis 1989, 257). Pierre Puvis de Chavanne as well was observed by a former student to drain his oils on blotter paper to create

his fresco-like surfaces (Baudoüin 1935, 302; Hensick, Olivier, and Pocabene 1997, 64).

(b) Conservation

When using oil paint for retouching, extracting excess medium is a logical attempt to address the disadvantages of oil paint while still retaining the advantages. In the late 19th century, Giovanni Secco-Suardo remarked on the practice in his manual *Il Restauratore dei Dipinti* that some restorers extracted oil on absorbent paper and diluted the paints with turpentine as a way to prevent the darkening and deadening of the colors after drying. Although this practice helped to some degree, he noted that the discoloration would still occur over time. For this reason, he said that the majority of restorers used pigments mixed with turpentine and tempered with varnish (Secco-Suardo 1918, 498–99).

In the 20th century, drained oils have been included in overviews of restoration materials techniques, such as those of Emile-Mâle (1976, 102) and Nicolaus (1999, 274), often with the caveat that they are known to discolor over time. Although drained oils have largely fallen out of use in favor of more stable alternatives, their facile handling properties and rich saturation have ensured their continued usage by some conservators today, both in America and abroad.

(3) Source

(a) Physical

Commercially produced artists' grade oil paint sold in tubes.

(b) Origins and manufacture

The colors are typically high-quality paints consisting of finely divided pigments bound with linseed and/or safflower oils. Safflower oil¹ tends to dry more slowly but yellows less than linseed oil and is frequently the medium of lighter colors and white.

(c) Manufacturers and vendors

Winsor & Newton and Schmincke are two companies with a reputation for a high degree of purity and consistency of materials.

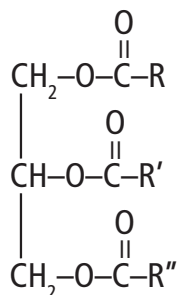
(4) Chemical and Physical Properties

(a) Chemical classification

Drying oils, such as linseed and safflower oil, consist primarily of triglycerides, which are the esters of glycerol with fatty acids. A high proportion of fatty acids in the triglycerides must be unsaturated to provide sufficient

reactivity to allow for the oxidation and polymerization processes required for drying. The triglycerides in drying oils typically consist of polyunsaturated linoleic and linolenic acids, in combination with other species including oleic, palmitic, and stearic acids.

(b) **Chemical formula/structure**



R, R', R'' = fatty acid chains

Fatty acids found in linseed oil:

Linoleic	$\text{HOOC}(\text{CH}_2)_7\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_4\text{CH}_3$
Linolenic	$\text{HOOC}(\text{CH}_2)_7(\text{CH}=\text{CHCH}_2)_3\text{CH}_3$
Oleic	$\text{HOOC}(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_3$
Palmitic	$\text{HOOC}(\text{CH}_2)_{14}\text{CH}_3$
Stearic	$\text{HOOC}(\text{CH}_2)_{16}\text{CH}_3$

(c) **Solubility**

The solubility of drying oil decreases over time as the cross-linkage of triglyceride molecules occurs. Solubility in alcohols and acetone is increased by the addition of dammar or mastic varnish to the medium.

(5) **Preparation and Formulation**

(a) **Typical preparation methods**

Oil paint is squeezed out from the tube onto blotter or filter paper and allowed to sit for several days to pull out excess oil. Even after a few hours, a ring of oil will be noticeable on the paper. Turpentine and xylene are both possible diluents.

(b) **Additives**

Natural or synthetic resin varnishes are typically added to increase the gloss and solubility.

(c) Storage/shelf life

Oil paints will dry out in their tubes over time. Once squeezed onto a blotter palette, a skin will form after several days. This can be pierced to access fresh paint.

(6) Handling Characteristics**(a) Appearance**

Saturated colors and deep blacks are possible due to the fine dispersion of the pigments in commercial artists' oil paints and the refractive index of the medium. The fine particle size also contributes to a high degree of transparency that is particularly conducive to glazing. When used in the final stage in a layered retouching system, drained oils can convincingly imitate the patina of an aged oil paint. Drained oils are not a stable inpainting material. When used thickly and opaquely or in light areas, a noticeable color shift will occur over time.

(b) Application

Due to their transparency and saturation, drained oils are most commonly used as a final thin glaze over another lighter and more opaque underlayer. Usually the underpaint is water-based like gouache or tempera, although other retouching media, such as pigments in poly (vinyl acetate) or Paraloid® B-72, could be used as well. Drained oils are known for being easy to work with because they dry more slowly and have more fluid handling properties than water-based and synthetic retouching materials. Some practitioners use the medium directly, without a base layer.

(7) Aging Characteristics**(a) Chemical process**

The initial oxidation and polymerization that converts the liquid paint into a solid film is a complex process resulting from a series of free radical chain reactions. In addition to reactions that result in cross-linking of triglyceride molecules, other oxidation and hydrolysis reactions occur, which result in low-molecular weight degradation products.

(b) Resultant chemical and/or physical alterations

Drying oils yellow over time due to the accumulation of chromophores as part of the aging process. This yellowing contributes to the color shift often observed in oil paints. Because the extraction of oil on blotter paper only removes excess medium, drained oils are still oil paints and will polymerize and yellow.

(c) Impact on appearance, solubility, and removability

Drained oils are reversible when isolated from the painting surface by varnish or another retouching medium. Solubility is further increased when a resin varnish is added to the paint. Discoloration, however, is a significant issue in considering the use of drained oils. Essentially, there are two main views about their use in conservation. Some conservators believe that the inherent instability of the medium and the availability of more stable alternatives are reasons enough to preclude their use in any restoration. Numerous instances can be cited where the injudicious application of oil retouching has resulted in noticeable alterations.

Other conservators note that when drained oils are used sparingly and mixed with varnish for use as thin glazes in dark and/or richly saturated areas, the resulting discoloration observed is comparable to a natural resin varnish. In conversations with some museum conservators who have paintings in their collections that have been restored using this technique in moderation, many note that there actually has been little if any noticeable alteration after twenty years.

(d) Attraction and retention of dirt and grime

There is no evidence that drained oils preferentially attract dirt or hold grime.

(e) Theoretical lifetime

When used sparingly as a glaze over a stable underpaint, the retouching should last as long as the natural resin varnish.

(8) Health and Safety

Refer to the Paintings Specialty Group's *Painting Conservation Catalog, Volume 1: Varnishes and Surface Coatings* (1998) for added resin (see www.conservationwiki.com/index.php).

There are no specific health and safety concerns with linseed or safflower oil. The general concerns about hazardous pigments and solvents apply.

(9) Disposal

There are no specific regulations on disposal.

Elise Effmann

Submitted February 2010

ENDNOTE

¹ Safflower oil is the more common oil (as opposed to walnut) added to commercially made oils. The Winsor and Newton website notes that "most of our whites are milled with safflower oil." Of course, walnut is the historic oil used for light colors, but I think it is more expensive and has been replaced by safflower in modern day manufacturing.

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3. Solvent-Based Resins

a) Low Molecular Weight (LMW) Resins

(1) Maimeri Restauro Varnish Colours

(a) Principal name

Maimeri Restauro Varnish Colours

(b) Other names

Maimeri, Varnish colors

(c) History of use

i. Industrial

Maimeri Restauro Varnish Colours were developed expressly for use by conservators and restorers. (The author is not aware of any documented use by artists, although there is some discussion of experimentation with the Varnish Colours on various artist message boards.)

ii. Conservation

Maimeri Restauro Varnish Colours were introduced in c. 1950 by the Maimeri Gruppo in Italy (Maimeri, personal communication, 2008). Developed exclusively as conservation/restoration paints, they were likely developed as a commercial (ready-made) alternative for drained oil paints and “hand-mixed” resin/varnish colors, which at the time were the most commonly used media for retouching. The use of the Varnish Colours spread quickly from Italy to conservators and museums in other countries. The Istituto Centrale del Restauro appears to have been key in promulgating the use of the Maimeri Varnish Colours.

(d) Source

i. Physical

Maimeri Restauro Varnish Colours are currently available as 20ml tubes in a range of 33 colors.

ii. Origins and manufacture

Maimeri Restauro Varnish Colors are a proprietary product manufactured by Maimeri Gruppo of Milano, Italy. Maimeri was founded in 1923 by Italian Impressionist painter Gianni Maimeri. The Restauro line was developed in c. 1950 specifically for the restoration/conservation profession.

iii. **Manufacturers and vendors**

Maimeri Restauro Varnish Colors are manufactured exclusively by the Maimeri Gruppo of Milano, Italy. They were officially introduced in the United States in 1981 by the Charvoz-Carsen Corporation (no longer in business) in partnership with Maimeri Gruppo. However, numerous museums and conservators had already been using the Varnish Colours for some time, and several U.S. art supply stores already carried them. They are currently available from a number of conservation suppliers and art stores.

(e) **Chemical and physical properties**

i. **Chemical classification**

Proprietary mixture containing primarily a natural resin (mastic), pigment, and solvent.

ii. **Chemical formula/structure**

According to Maimeri Gruppo, the Varnish Colors are a mixture of “pure, authentic, lightfast pigments mixed with mastic resin and refined hydrocarbon solvents” with the mastic coming “exclusively from the Island of Chios” (Maimeri website). Analyses conducted at the Canadian Conservation Institute (CCI) in 1989 (Williams 1989) and at the National Gallery of Art, Washington, D.C. in 2000 (de la Rie et al. 2000) both confirm the presence of gum mastic. Mastic is a triterpenoid resin derived from the sap of a tree, *Pistacia Lentiscus*; it has a varied and complex composition based on a structure composed of six isoprene units (see the Paintings Specialty Group’s *Painting Conservation Catalog, Volume 1: Varnishes and Surface Coatings*). The 1989 analysis conducted at CCI revealed that the solvent was likely α -pinene (a purer form of oil of turpentine). However, a 2000 Safety Data Sheet (the European equivalent of MSDS) states that the solvent mixture contains Petroleum Naphtha (CAS # 64742-82-1, a hydrosulfurized heavy naphtha aliphatic solvent) and Solvesso 100® (CAS # 64742-95-6, a 97 percent aromatic solvent composed primarily of C9-10 dialkyl and trialkyl-benzenes). Based on these findings, it seems likely that the solvent mixture has changed over time.

It is important to note that several Maimeri colors are actually composed of a mixture of pigments, i.e., Naples Yellow consists of a mixture of zinc oxide, an arylide yellow, and synthetic iron oxide; Titanium White is actually a mixture of titanium dioxide and zinc oxide. Currently the label on each tube lists both the pigment name and the Color Index Name (2 letters and several numbers) of all individual pigments contained within that color. (Older tubes may not have this informa-

tion; it is provided on the Maimeri website.) In addition, synthetic pigments have replaced some of the pigments initially used, i.e., Madder Lake Deep—a rose madder—has been replaced by Permanent Madder Deep—an anthraquinone lake. (*Note:* The CI name, PR83, for the anthraquinone lake designates a natural anthraquinone, which is only marginally more lightfast than madder). Several of the pigments used have mixed or poor lightfast ratings. These include Permanent Carmine (ASTM IV); Permanent Madder Deep (ASTM IV for one pigment); Green Lake (WG V for one pigment); Brown Madder (ASTM IV for one pigment); and Vandyke Brown (ASTM V for one pigment) (ASTM rating as given in Wilcox 2000).

iii. Solubility

The Varnish Colors are initially soluble in a range of solvents including low aromatic mineral spirits, xylenes, toluene, isopropanol, 1-methoxy 2-propanol (e.g., Arcosolv® PM), and various mixtures of solvents. (A small degree of polarity or small fraction of aromatics is needed for full solubility.)

iv. Tg

While the Tg of these proprietary paints has not been provided by the manufacturer, the Tg of mastic is -34.7°C (see volume I of the PSG catalog, *Varnishes and Surface Coatings*). The Tg of Maimeri Restauro Varnish Colors may be expected to be similar.

(f) Preparation and formulation

i. Typical application methods

Maimeri may be used alone or, as is more common, applied over an initial layer of inpainting (often opaque and lighter/cooler), such as watercolor, tempera, or gouache. Current practice at the Istituto Centrale per il Restauro (ICR) is to first tone the fill with watercolors, apply a spray varnish, and then do final toning with the Varnish Colours (Graziosi 2008). Several of the colors are quite transparent. Each tube carries a symbol on its label designating the transparency of that color. The fine grind, good dispersion, and transparency of the Varnish Colours make them particularly well-suited for glazing and building up layers of glaze.

ii. Additives

The 1989 analysis at CCI found the presence of various stabilizers: aluminum soaps, silica, clay, and wax (Williams 1989). A 2003 study also found the addition of calcium carbonate, an extender, in some of the colors (Szmit-Naud 2003).

iii. Storage/shelf life

Tubes of paint should be stored in a cool, dry area. Because the colors are in aluminum tubes, there is no specific need to store them in the dark. Shelf life will depend on how often the tubes are opened and how tightly they are resealed.

(g) Handling characteristics**i. Appearance**

Upon drying, the colors have a semi-gloss appearance. One significant advantage of the Varnish Colors is that there is no color change from wet to dry. The gloss of individual colors varies such that there is no consistent level of gloss within the set of colors (Szmit-Naud 2003). The Varnish Colours can be valuable when trying to match dark, transparent aged oil films.

ii. Application

The colors are generally applied using a small inpainting brush in small dots or strokes. Faster evaporating solvents will produce a slightly more matte appearance. Adding additional mastic resin will produce more glossy colors.

iii. Modifications for special applications and effects ("Tricks of the Trade")

The colors can be mixed with additional resin to create very transparent glazes.

(h) Aging characteristics**i. Chemical process**

Two considerations determine the aging characteristics of Maimeri Restauro Varnish Colours: the aging of the mastic resin and the long-term stability of the pigments. The aging of mastic resin is a complex autoxidation process. Basically, it proceeds quickly via radical chain reactions that proceed both in light and dark environments, resulting in yellowing and a loss of transparency (van der Doelen 1999). Feller et al. noted that mastic dissolved in turpentine and spread into a film begins to oxidize rapidly (1985). Pigments age via photodegradation processes most often resulting in fading and/or in some cases darkening or chromatic changes.

ii. Resultant chemical and/or physical alterations

(see below)

iii. Impact on appearance, solubility, and removability

Only a few studies have looked specifically at the long-term aging of Maimeri Restauro Varnish Colours. All found that there are significant changes to the appearance, solubility, and removability of the Varnish Colours—in some cases after only 405 hours of accelerated aging, which corresponds to only a few years under typical museum lighting conditions (de la Rie et al. 2000).

Most of the Varnish Colours tested exhibited color changes during artificial aging primarily due to degradation of the resin. Ultramarine and ivory black underwent significant color changes: the ultramarine increased in both lightness and chroma, with a shift from reddish blue to a greenish blue; ivory black decreased in lightness. With more prolonged aging, many other colors also showed changes: the yellow ochre increased in lightness and decreased in chroma, with a slight shift from a reddish yellow towards a more greenish yellow; the alizarin decreased in lightness. Viridian showed a decrease in lightness and an increase in chroma. Titanium white shifted toward the yellow. Only the cadmium yellow demonstrated some color stability (de la Rie et al. 2000). Cerulean blue, ultramarine, yellow ochre, and green earth were found to be only moderately light-fast, while the alizarin reds (Permanent Carmine and Permanent Madder Deep) border on low stability (Szmit-Naud 2003).

One of the primary concerns in using Maimeri varnish colours is the yellowing of the colors over time, due to aging of the mastic resin. A number of conservators report using only the darker colors, where discoloration is thought to be less problematic. However, as shown in testing by de la Rie et al., darker colors may lighten. Artificial aging in both light and dark conditions produced chromatic alterations in the Varnish Colours tested (Graziosi 2008). The lighter Varnish Colours, in particular the white, showed marked yellowing. Those paints that contain high binder absorption pigments, such as black, browns, and other earth pigments, showed a more marked tendency to change (Szmit-Naud 2003).

After artificial aging, thin films of the Varnish Colours became extremely matte, and many had fine cracks and were flaking (de la Rie et al. 2000). Isolating the Varnish Colours with an acrylic varnish helps to stabilize changes in gloss. The inclusion of zinc oxide in the Titanium White has an unfavorable effect on aging, resulting in degradation and interlayer chalking, visible as whitening of retouching layers containing some white (Szmit-Naud 2003).

Maimeri Restauro Colours rapidly become insoluble in non-polar solvents. Interestingly, this effect was diminished in ivory black. In addition, the Varnish Colours were the only retouching paints tested that also changed solubility in the dark (de la Rie et al. 2000). Varnishing with an acrylic was found to positively impact the solvent removability of the Varnish Colours (Szmit-Naud 2003).

iv. **Attraction and retention of dirt and grime**

Similar to mastic.

v. **Theoretical lifetime**

Similar to that of natural resin varnishes, the degree and onset of perceptible yellowing and degradation will vary depending on environmental conditions, etc. (not a Feller Class A material).

(i) **Health and safety**

Mastic resin presents no acute health hazards. However, the solvents used both in manufacture of the paints and during inpainting may pose health risks. Use with adequate ventilation and avoid contact with skin and eyes. Keep away from heat and flame.

(j) **Disposal**

Dispose of in accordance with local regulations.

(2) **Maimeri Restauro Ketonic Resin Colours**

(a) **Principal name**

Maimeri Restauro Ketonic Resin Colours

(b) **Other names**

Maimeri Ketone Colors

(c) **History of Use**

i. **Industrial**

Not applicable. Maimeri Restauro Ketonic Resin Colours were developed expressly for use by conservators and restorers.

ii. **Conservation**

Maimeri Restauro Ketonic Resin Colours were introduced in c. 1998 by the Maimeri Gruppo in Italy (Maimeri, personal communication, 2008). According to Maimeri, this new line of colors, developed exclusively as conservation/restoration paints, was introduced in response to “recent demands of scientific research into the conservation of works of

art” for use with modern synthetic varnishes (see www.maimeri.it/index_en.asp). Some have suggested that they may have been developed partially in response to the discontinuation of the Lefranc & Bourgeois/Charbonnel colors (Hamm, personal communication, 2008).

(d) Source

i. Physical

Maimeri Restauro Ketonic Resin Colours are available as 40ml tubes in a range of 20 colors.

ii. Origins and manufacture

Maimeri Restauro Ketonic Resin Colours are a proprietary product manufactured by Maimeri Gruppo of Milano, Italy. Maimeri was founded in 1923 by Italian Impressionist painter Gianni Maimeri. The Restauro Ketonic Colours line was developed in c.1998 specifically for the restoration/conservation profession.

iii. Manufacturers and vendors

Maimeri Restauro Ketonic Resin Colours are manufactured exclusively by the Maimeri Gruppo of Milano, Italy. They are currently available from a number of conservation suppliers and art supply stores.

(e) Chemical and physical properties

i. Chemical classification

A proprietary mixture containing primarily a ketone resin (polycyclohexanone), pigment, and solvent.

ii. Chemical formula/structure

According to Maimeri Gruppo, the Varnish Colours are a mixture of “lightfast tested pigments with ketonic resin and selected hydrocarbon solvents” (Maimeri website). Maimeri states that the resin used is not a Laropal ketone (Maimeri, personal communication, 2008). Analysis conducted at the Museum of Fine Arts, Boston, in 2008 confirmed the resin to be a polycyclohexanone with additional absorption bands that probably correspond to plasticizers and/or other additives (Derrick 2008). According to Maimeri’s head chemist, the Ketonic Resin Colours are made with a Cyclohexanone condensation product (Reifsnyder, personal communication, 2008). The 2003 Safety Data Sheet (the European equivalent of MSDS) states that the solvent mixture contains Naphtha Petroleum (CAS # 64742-82-1, a white spirit) and 1,2,4 Trimethylbenzene (CAS # 95-63-6, an aromatic isolated from the C₉ hydrocarbon fraction).

As with the Varnish Colours, each tube's label gives both the pigment name and Color Index number (two letters and several numbers) of all the pigments the color contains. (This information is also available on the Maimeri website.) Several colors contain a mix of pigments, i.e., Payne's Grey is composed of bone black and ultramarine. Also, as with the Varnish Colours, Titanium White contains a mixture of titanium dioxide and zinc oxide.

iii. **Solubility**

The Ketonic Colours are initially soluble in a wide range of solvents including petroleum benzine, white spirits, xylenes, isopropanol, 1-methoxy 2 propanol, and mixtures of solvents. They will become slightly less soluble over time in non-polar solvents. Maimeri states that the Ketonic and Varnish colors can be mixed and thinned using the same solvents.

iv. **Tg**

While the precise Tg of these proprietary paints is not provided by the manufacturer, the Tg of Laropal K80 (a polycyclohexanone) has been given as 42°C (Maines and de la Rie 2005). The Tg of Maimeri Restau-ro Ketonic Colours may be expected to be similar.

(f) **Preparation and formulation**

i. **Typical application methods**

Maimeri is usually used alone, particularly on modern/contemporary and unvarnished works. However, it may be used in combination with an initial underlying layer of inpainting, such as watercolor, gouache, etc. Most of the colors have good opacity.

ii. **Additives**

No additives are substantiated, although the brittle nature of the resin suggests that plasticizers may have been added to counteract brittleness. Preliminary analysis found absorption bands that probably correspond to plasticizers or other types of additives (Derrick 2008).

iii. **Storage/shelf life**

Tubes of paint should be stored in a cool, dry area. Because the colors are in aluminum tubes, there is no specific need to store them in the dark. Shelf life will depend on how often the tubes are opened and how tightly they are resealed.

(g) Handling characteristics**i. Appearance**

Upon drying, the colors have a matte appearance. There is little color change from wet to dry.

ii. Application

The Ketonic Resin Colours are generally applied using a small inpainting brush in small dots or strokes. Faster evaporating solvents will produce a more matte appearance. Adding additional resin will increase gloss and produce more transparent colors.

iii. Modifications for special applications and effects (“Tricks of the Trade”)

The Ketonic Colours can be mixed with Maimeri Varnish Colours. They can also be used in conjunction with Gamblin Conservation Colors.

(h) Aging characteristics**i. Chemical process**

The chief path of degradation of polycyclohexanone resin is photochemically initiated autoxidation. There is no induction period, i.e., aging starts immediately (de la Rie and Shedrinsky 1989).

ii. Resultant chemical and/or physical alterations

(see below)

iii. Impact on appearance, solubility, and removability

Very few aging studies have looked at the Maimeri Ketonic Colours. One study did find chromatic alteration of the Ultramarine Blue Ketonic Colour in dark aging and chromatic alteration of the Titanium White and Ultramarine Blue colors in light aging. In addition, changes in solubility are observed for the Ketonic Colours tested (Graziosi 2008). Ketone resin films are hard and brittle. Ketone resins yellow less quickly than natural resins. Although they are initially more stable than natural resin films, autoxidation results in a rapid change in solubility, resulting in the need for more polar solvent mixtures for removal. Ketone resins are prone to yellowing in the absence of light, have a tendency to bloom and/or haze, and develop matte areas due to microscopic wrinkling (de la Rie and Shedrinsky 1989).

iv. Attraction and retention of dirt and grime

Ketonic Colours are not excessively prone to attract dirt or grime.

v. **Theoretical lifetime**

Similar to that of a polycyclohexanone varnish (not a Feller Class A material).

(i) **Health and safety**

Ketone resin presents minimal health hazards; however, contact with skin and eyes may cause irritation. The solvents used in the manufacture of the paints and during inpainting may pose health risks; use with adequate ventilation and avoid contact with skin and eyes. Keep away from heat and flame.

(j) **Disposal**

Dispose of in accordance with local regulations.

Charlotte Seifen Ameringer

Submitted October 2008

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(3) Robert Gamblin Conservation Colors

(a) Development and formulation

Robert Gamblin Conservation Colors are a commercially prepared palette of 44 pigments ground in a urea-aldehyde resin. During the 1990s, a collaboration among conservation scientists, conservators, and a commercial artists' materials manufacturer produced an inpainting material that was designed to exhibit photochemical stability, lightfastness, and reversibility. It would also have working properties suitable for use with a wide array of painting styles and techniques. In addition, the low molecular weight resin would require *mild* solvents, making the paints safe to use.

Development of the product was detailed in a paper written by Mark Leonard, Jill Whitten, Robert Gamblin, and E. René de la Rie delivered at the IIC conference in Melbourne (Leonard et al. 2000). The collaborative team determined to develop an inpainting material that exploited the superior pigment wetting qualities of low molecular weight resins and the consistent pigment dispersion produced by industrial milling. The absence of a commercially available inpainting product that incorporated recent resin research prompted inquiries in search of a specialized paint manufacturer. By 1994, Gamblin Artists Colors Co. had agreed to produce a new inpainting material that would utilize a new low molecular weight (LMW) resin and commercially prepared pigments.

Data generated at the National Gallery of Art in Washington D.C. suggested that aldehyde resins manufactured by BASF showed good working qualities and exhibited photochemical stability. The aldehyde LMW resins exhibited more desirable paint medium qualities than other hydrocarbon LMW resins (e.g., Arkon® P-90, Regalrez® 1094) that were already being used for varnishes because their slight polarity permitted better pigment wetting. The resins' high refractive index would produce good color saturation. An aldehyde resin, Laropal® A-81, was identified as a readily available suitable resin. Twenty colors, selected for trial using results from a survey of conservators' inpainting practices, were manufactured by Gamblin and distributed to conservators for use and evaluation.

Gamblin Artists Colors Co. began supplying a palette of 36 colors using Laropal A-81 binder and three-roll milling in May 2000. In July 2009, 10 new colors were introduced, bringing the palette up to 44 colors. (Two new colors were substitutions: Manganese Blue replaced the original Manganese Blue Hue, and Transparent Earth Orange replaced the original Mars Yellow. In addition, the original Transparent Mars Red was renamed Transparent Earth Brown.) In 2010, Gamblin acquired an electric muller that permits cost-effective production of paint in very small quantities. Specialized, rare,

and hazardous colors (e.g., lead white, vermilion, and azurite) can be mixed into the Laropal A-81 resin to make custom inpainting colors. About 25–50g of conservator-supplied, powdered dry pigment is needed to manufacture a single jar. Robert Gamblin Conservation Colors are dissolved in a petroleum distillate mixture and are supplied in 15 ml jars. The medium for the colors, Galdehyde Resin Solution, is Laropal A-81 resin in petroleum distillate solution and is supplied in 4 fluid ounce bottles.

All pigments “are rated lightfastness I (excellent lightfastness)” (Leonard et al. 2000, 112), with light-stable modern substitutes used for fugitive colors such as Indian Yellow, Alizarin Crimson, and Brown Madder (Leonard et al. 2000). Gamblin’s Color Chart lists the Color Index name for each pigment. No additives are present except in modern organic pigments that contain “alumina hydrate to properly adjust tinting strength for better working properties” (www.conservationcolors.com).

The Gamblin Conservation Colors performed well in aging tests. They retained their original film gloss, except for titanium white, which became more matte. Aged paint films appeared as “smooth uniform surfaces with no signs of cracking or flaking” (de la Rie et al. 2000, 57).

Aging tests carried out on a small test palette of seven colors milled with Laropal A-81 medium without the addition of a hindered amine light stabilizer (HALS) found that the colors’ solvent removability performance was comparable to the behavior of other synthetic resin inpainting media (e.g., Paraloid B-72, LeFranc & Bourgeois “Charbonnel Restoration Colours,” Bocour “Magna” and Golden “Polyvinyl Acetate Conservation Paint” (de la Rie et al. 2000). Additional tests on a preliminary light-stabilized palette showed that the color quality in some (e.g., Indian yellow, cobalt blue, and ultramarine blue) was substantially light stabilized when HALS inhibitor (Tinuvin 292, Ciba 1%) was added whereas other colors (yellow ochre, burnt umber, raw umber, raw sienna, permanent alizarin, and Indian red) showed only slight improvement. Other colors (chrome oxide green, viridian, titanium white, ivory black, burnt sienna, cadmium yellow light and medium, and cadmium red light and medium) showed no change. Likewise, the HALS (Tinuvin 292, Ciba 1%) additive improved solvent removability of some paint film colors (cadmium yellow light) but had no effect on others (titanium white and ultramarine blue). These findings led investigators to conclude that “Laropal A-81 paints appear stable enough to be used without the addition of a stabilizer such as Tinuvin 292” (de la Rie et al., 58). The study further noted that the accelerated aging tests had been carried out in an environment that simulated daylight through window glass without ultraviolet filters. The paints could be expected to perform better in circumstances that included ultraviolet filtration (de la Rie et al.).

(b) Handling characteristics**i. Appearance**

Robert Gamblin Conservation Colors have “handling and optical properties comparable to those of natural resin paints and are particularly suitable for use in glazes and where relatively high colour saturation is required” (de la Rie et al., 51). The desire in formulating these products was to “enhance working properties while maintaining the permanence of the materials” (Leonard et al., 111).

The paints, supplied in 15 ml jars, are intentionally lean and dry matte. Most conservators who initially tested the colors responded positively to survey questions and found them easy to learn to use. The paints were noted as having “good covering power, versatility in the achievement of a variety of effects, little change in colour upon drying, usefulness for both glazing and scumbling and ease in *editing* with a silk cloth” (Leonard et al., 113). The few negative responses appeared to emanate from professionals who had mastered inpainting with conservator-made retouching materials.

In practice, this author has found that Gamblin Colors can become glossy when additional unaltered Galdehyde Resin Solution is used. The glossy inpainting can also have some perceived thickness where the retouching appears too high. This can be remedied by limiting the quantity of or diluting the supplied Galdehyde Resin Solution. Alternately, custom-made solution made with a few beads of Laropal A-81 in isopropanol can be used as added medium (Whitten, personal communication, November 26, 2008).

The palette includes a number of transparent and semi-transparent colors. Four transparent earth colors—Transparent Earth Brown, Transparent Earth Orange, Transparent Earth Red, and Transparent Earth Yellow—and Greenish Umber are especially useful for inpainting traditional oil paintings. Rich glazes are readily produced using these colors. Lamp black, so often useful to create saturated dark colors, was added in 2009.

Jim Bernstein likes to lay out the colors as shown in the following table.:

Gamblin Conservation Color Palette in Aldehyde Resin Laropal A-81(BASF®)										James Bernstein 2007
Titanium White	Titanium White	Indian Yellow	Hansa Yellow Medium	Cadmium Yellow Light	Cadmium Yellow Medium	Cadmium Orange	Cadmium Red Medium-Light	Cadmium Red Medium	Quinacridone Red	Alizarin Permanent
Extender White (Chalk)		Chrome Titanate Orange					Yellow Ochre	Raw Sienna	Venetian Red	Dioxazine Purple
Manganese Blue Hue (Phthalo)	Chromium Oxide Green								Indian Red	Cobalt Violet
Cobalt Blue	Cobalt Green								Transparent Earth Yellow	Transparent Earth Orange
Prussian Blue	Viridian Green								Brown Madder Alizarin Permanent	Transparent Earth Red
Phthalo Blue	Phthalo Green								Burnt Sienna	Transparent Brown (Charbonnel) Lefranc-Bourgeois
Ultramarine Blue									Burnt Umber	Raw Umber
									"Ivory" (Bone) Black	Spinel Black

ii. Application

The use of Gamblin colors for a variety of inpainting projects is described by Jill Dunkerton in her article titled “Retouching with Gamblin Conservation Colours” in *Mixing and Matching: Approaches to Retouching Paintings* (2010, 92–100). As explained in the clear text and shown in the illuminating images, the colors have proved useful for inpainting both tempera and oil paintings on panel and on canvas. The colors’ fine quality permits their use for inpainting while employing binocular magnification. Specific pigment mixtures that Dunkerton finds especially useful are included in the article. Dunkerton practices strict “palette hygiene”; she maintains a separate palette exclusively for “translucent glazing” colors (Dunkerton, 94).

Robert Gamblin Conservation Colors can be used straight from the jar as supplied to produce a smooth matte surface. In practice, the paints used straight from the jar are gummy and difficult to handle (Whitten, personal conversation, November 26, 2008). More commonly, conservators remove the paints from the jar and allow them to dry out before re-dissolving them for use.

The pigment particle size is consistent, resulting in even color application with a high degree of saturation. The colors shift slightly on drying but change almost imperceptibly when used with additional medium or varnish.

Diluents: When the test panels were sent for evaluation in 1997, conservators were habitually using more polar and aromatic solvents than

needed. Laropal A-81 requires a hydrocarbon solvent that is 35–40% aromatic or an oxygenated solvent such as alcohol or acetone. Mineral spirits mixtures that contain 35–40% aromatics can be used. Isopropanol is a good solvent that is less toxic to the user. A dilute (1:4) mixture of isopropanol in mineral spirits (15% aromatic) that lengthens working time can be useful. Arcosolv—also known as methyl proxitol, 1-methoxy-2-propanol, propylene glycol monomethyl ether—can be used but is polar and swells resins. Arcosolv has an evaporation rate similar to xylene but gives the sense of more working time due to its resin-swelling capacity. Slower evaporating mixtures increase the likelihood of re-dissolving underlying inpaint, so faster evaporating mixtures are useful when working on top of a layer of retouching.

iii. **Modifications for special applications and effects (“Tricks of the Trade”)**

Because these paints contain a resin that was designed to handle like natural resins, special effects and techniques, such as rubbing with powdered resin and polishing with a silk cloth, can be achieved.

The finely ground and evenly dispersed pigments produce very consistent brushstrokes. Fine details, such as eyelashes, ship rigging, and single brushstrokes, can be accomplished using Gamblin Conservation Colors. A fast evaporating solvent such as acetone is useful for these purposes as it avoids disturbing the inpainting underneath. Inpainting done in this manner produces an unblended or *dry brush* appearance. An acetone diluent can be used to create very fine brushstrokes that are also very matte.

Blending inpainting can be accomplished when Arcosolv is used as the solvent. Although Arcosolv evaporates quickly, it swells Laropal A-81 resin, giving the sense of more working time. However, using Arcosolv can also increase the likelihood of disturbing a lower layer of inpainting.

The addition of a few grains of powdered pigment can alter the texture to mimic the appearance of coarse or hand-ground colors. Added dry pigment can also be used to make the inpaint leaner and more matte.

iv. **Tips on Use**

Packaging: The supplied pigment and resin separate in their jars. For ease of use, the paints should be kept soft by adding a few drops of solvent (acetone or isopropanol) to the jars. According to Whitten, “Gloss matching and tinting strength are improved if you do not stir the paints. Use a swab stick to reach in and pull out the pigment paste and leave the resin in the jar. A small vial of resin and diluent can be placed

on your palette for matching the gloss as you work. The colors are more useful on matte surfaces if the resin is not stirred in” (personal communication, November 26, 2008).

Some colors, especially cadmiums, dry out and may fall off a palette. To avoid losing paint cakes, place a drop or two of the resin solution underneath the color that has been withdrawn from the jar.

Diluents: The supplied resin solution (Galdehyde Resin Solution) initially resists the Arcosolv but is easily blended with a little extra mixing.

Manipulation of solvents for use on top of other layers follows the same paradigms as for other inpainting media. To avoid disturbing a lower layer of dammar, Paraloid B-72, Regalrez® 1094, or Laropal A-81 varnishes, isopropanol is an appropriate solvent.

(c) Health and safety

There are no special warnings for the dry resin, which has no travel restrictions and no flash point. Health and safety recommendations for the resin itself can be accessed at www.basf.com/resins.

- Health: Exposure and first aid procedures should be determined by the solvent(s) used.
- Disposal: The paints should be allowed to dry out prior to disposal. Pigment content of some colors may determine special disposal requirements.

Sian Jones

Submitted June 2010

Note: the color chart included with this volume is a photographic reproduction of paint-outs. It was executed and provided by Gamblin Conservation Colors.

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Leonard, M., J. Whitten, R. Gamblin, and E. René de la Rie, 2000. Development of a new material for inpainting. *Tradition and innovation: Advances in conservation, Contributions to the Melbourne Congress*, 111–113. London: International Institute for Conservation of Historic and Artistic Works.

ADDITIONAL RESOURCES CONSULTED

www.basf.com/resins

www.conservationcolors.com

www.gamblincolors.com

www.mfa.org/cameo

VENDORS

Gamblin Artists Colors Co.

P.O. Box 15009
Portland, OR 97293
www.conservationcolors.com

Also available:

In Europe:

Stuart R. Stevenson

68 Clerkenwell Road
London, England EC1M 5QA
www.stuartstevenson.co.uk

C.T.S. France

26 Passage Thiere
Paris, France
Phone: 01 43 55 60 44

Kremer Pigmente GmbH & Co. KG

Hauptstr. 41 – 47
DE-88317 Aichstetten
www.kremer-pigmente.de

In North America:

Talas

20 West 20th Street
New York, NY 10001
www.talasonline.com

Preservation Supply Services

427 Ashley Street
Coquitlam, BC V3K 4B2
www.preservationsupplyservices.com

b) Polymeric Resins: Golden PVA

(1) Principal Name

Golden PVA Colors™

(2) Other Names

Often referred to as PVA paints or, more correctly, as PVAc (to distinguish the poly (vinyl acetate) medium from polyvinyl alcohols).

(3) History of Use

(a) Industrial

While there is extensive use of PVAc resins in industry as early as 1930, Golden PVA Colors are specifically formulated for use by conservators and have no industrial or fine-arts related uses. (See Varnish catalog for base resin history of use.)

(b) Conservation

Golden PVA Colors were formulated and marketed by Golden Artist Colors, Inc. in 1999 in response to conservators' expressed need to have a commercially available PVAc-based inpainting medium. Prior to 1999, PVAc paints for inpainting were hand-made by conservators.

(4) Source

(a) Physical

Golden PVA Colors come in 1 oz. containers and are pre-mixed with ethanol,¹ PVAc resin, and one of 29 pigments.

(b) Origins and manufacture

Golden PVA Colors are available in 29 colors in addition to extender resin (see the paint-outs included with this volume). All colors are single pigments mixed with a very high pigment-to-resin ratio into PVAc resin dissolved in ethanol and mulled to a viscous consistency. Golden Artist Colors, Inc. has a long history of working with conservators and artists and is willing to make additional colors or paints upon request.

(c) Manufacturers and vendors

Golden PVA Colors are a proprietary product manufactured exclusively by Golden Artist Colors, Inc. in New Berlin, New York. Vendors include most suppliers of conservation materials, including Talas, Conservation Resources, and Kremer.

(5) Chemical and Physical Properties²

(a) Chemical classification

Base resin is 100 percent poly (vinyl acetate), thermoplastic solution polymer. Solution is a 1:1 ratio of AYAA and AYAC, dissolved in ethanol.

(b) Chemical formula/structure

(See varnish catalog for a more thorough description of base resin.) AYAA, and AYAC PVAc used in Golden PVA Colors are formed by free radical polymerization of vinyl acetate monomers. Resins are sold to paint manufacturers already polymerized in small beads that can be resolubilized in alcohols and mixed with pigments. The Golden Artist Colors, Inc. acquires PVAc resins from a variety of industrial sources; however, the average molecular weight of resins is 83,000 atomic mass units (amu) for AYAA and 12,800 amu for AYAC.

(c) Solubility

PVAc resins are soluble in ethanol, and paint films remain soluble in ethanol after drying. Golden PVA Colors are also soluble in methanol, glycol ethers, ketones, and acetates. Golden PVA Colors are insoluble in glycols, hydrocarbons, propanol and higher alcohols, and water.

(d) T_g

ACAA softens at 97°C, AYAC at 71°C; the T_g of paint is approximately 84°C, depending on the pigment-to-binder ratio.

(6) Preparation and Formulation

(a) Typical application methods

Paints are manufactured and distributed in 1 oz. (30ml) jars. Paint is a viscous liquid in the jars. However, small amounts are usually taken from the storage containers and placed on a glass or ceramic palette to dry. Working with wet paints directly from storage jars is very difficult and often results in a thick, stringy, and difficult-to-match paint, therefore indirect application is recommended. A thin wash/layering application is generally most effective. Multiple layers can be built up quickly when rapidly drying solvents are used. It is possible, however, to resolubilize and pick up lower layers when building up colors, so isolating with varnish can often be useful.

(b) Additives

Golden PVA Colors are composed of only PVAc resin, pure single pigments, and ethanol. Once dried on a palette, the paints can be easily resolubilized.

(c) Storage/shelf life

Paint in jars can dry out if stored for a long time, but are easily resolubilized through the addition of ethanol. No special storage is necessary for jars or dry palettes.

(7) Handling Characteristics**(a) Appearance**

Paint from the storage jar is a thick, viscous, intensely colored material. When dried on a palette, the paint is extremely hard and may appear somewhat matte to very glossy, depending on the colorant. The refractive index of base resin is 1.4665 (at 20°C), making it somewhat similar to other acrylics and somewhat dissimilar to aged linseed oil. Depending on the amount of medium and solvent used, Golden PVA Colors dry to a matte through glossy appearance, although they tend toward the glossy end of the spectrum. Paint diluted with fast-evaporating solvents will often appear matte, while slow-evaporating solvents will result in a glossier sheen. Additional medium can be mixed with the paint to bring up a matte area of inpainting to the sheen of surrounding glossy paint without having to add additional varnish to the surface. Alternatively, paint from storage jars can be drained on a piece of FomeCor or absorbent board to achieve a very matte effect. The nature of the resin means that dark colors such as black or brown can often appear somewhat grey, dull, or milky in contrast to oil paint; however, according to Laura Hartman, the addition of Kremer dyes and/or dry pigments can create a more saturated appearance to these colors (personal communication, 2009).

(b) Application

Paint dissolved in ethanol dries very quickly, making Golden PVA Colors good for delicate, thin layers of application. Working time can be extended by using slower evaporating solvents or solvent mixtures. The dried paint film is generally very durable, with excellent resistance to acids/alkalis, water, and ultraviolet rays. Film formation requires a minimum temperature of 9°C; however, dried films can withstand freezing temperatures. Use of clean solvent seems to be more essential with Golden PVA Colors than with other inpainting choices, as the paint seems inclined to “cloud” easily. Meticulously clean solvent and judicious use of white seems to prevent this problem.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

Golden PVA Colors are very versatile and either can be thinned with solvent and mixed with additional medium for glazing effects or used at a thicker consistency to reproduce brushstrokes or trails of paint. The viscous nature

of PVAc allows it to accept additives such as microballoons, ground glass, or additional pigments easily. It is an excellent choice for areas of inpainting requiring texture and bulk. One of the strengths of PVAc is that it is soluble in solvents completely different than those required for MSA colors and most varnishes. This property allows conservators to interlayer different inpainting systems without picking up previous layers. In addition, if conservators are unhappy with a session of inpainting, they can often remove the layer of PVAc media from a varnished or MSA inpainted passage without disturbing the lower paint or varnish (Brian Baade, personal communication, 2009). Golden PVA Colors' greatest limitation is that a highly saturated black is difficult to match as it often appears cloudy or milky by comparison to the surrounding paint. The Quinacridone Gold color can be mixed with or layered over inpainting to give the appearance of an aged oil paint.

(8) Aging Characteristics

(a) Chemical process

PVAc resins are among the most stable available to conservators. Combined with high-quality, light-stable pigments, Golden PVA Colors should be expected to have very few visible or chemical changes. The base PVAc resin has shown little tendency to cross-link over time or in the presence of atmospheric pollutants, and chemical changes appear relatively minor.

(b) Resultant chemical and/or physical alterations

PVAc can lose the appearance of saturation over time. However, given the high pigment-to-binder ratios in Golden PVA Colors and the usual thin layers of application, loss of saturation should be of less concern than the “graying” associated with some varnishes or surface coatings.

(c) Impact on appearance, solubility, and removability

PVAc paints remain soluble throughout their lifetime, with few reports of reversibility problems associated with aging. If original paint is vulnerable to ethanol and inpainting still needs to be removed, toluene has also been reported to remove dried and aged PVAc films with success and less “stress” to the original paint (Joyce Hill Stoner, personal communication, 2009). A list of lightfastness, permanence, and opacity/transparency values for each color is available from the manufacturer.

(d) Attraction and retention of dirt and grime

PVAc resins can remain somewhat tacky and soft, particularly in the presence of high temperatures and humidity. Golden PVA Colors are often applied under a final varnish coat of another material, so the attraction and retention of dirt and grime is much less problematic under these circum-

stances. Even in the presence of high temperatures and humidity however, retention of dirt and grime on thinly applied areas of inpainting is only a minor concern.

(e) Theoretical lifetime

PVAc is a Class A material, so aging will be determined by the presence and behavior of any additives and the lightfastness of the pigments; however, inpainting is generally expected to age at a different rate than the original painting, regardless of inpainting material chosen.

(9) Health and Safety

Golden PVA Colors are generally a very safe inpainting option for conservators. PVAc resin has few known health risks and, depending on the solvent used, provides a system that can be used in a public space with minimal ventilation. According to the MSDS that accompanies the paints, "Vapor may cause drowsiness and irritation of the respiratory tract. May cause nasal discomfort and discharge, coughing, possible chest pain." As with any inpainting system, some pigments carry special handling/safety warnings.

(10) Disposal

Brushes and palettes can be cleaned up using ethanol on paper towels or cotton. When the ethanol evaporates, the towels can be thrown in the regular trash, or if the pigments contain heavy metals such as cadmium, placed in marked containers for special pick-up. Empty containers of paint may be left to evaporate and dry in a fume hood and then placed in the regular trash if they contain nontoxic pigments, or marked for special disposal if they contain toxic pigments.

Tatiana Ausema

Submitted July 2009

ENDNOTES

¹ Pure ethanol will not dissolve PVAc; some water is also required. However, since ethanol is hygroscopic, most opened containers of ethanol will contain enough water to dissolve PVAc.

² Physical and chemical data (average molecular weight, solubility, and Tg) for Golden PVA paints have been provided by Golden Artist Colors, Inc. and are published in a technical leaflet available on the manufacturer's website.

4. Acrylics

a) Bocour Magna

(1) Principal Name

Bocour Magna

(2) Other Names

“An acrylic resin formulated for artist’s use” [on tube].

(3) History of Use

(a) Industrial

Bocour Magna was developed by the American paint makers Leonard Bocour and Sam Golden in the late 1940s and marketed as “the first new painting medium in 500 years.” Bocour and Golden kept the pigment concentration in Magna deliberately high, so that the paint could be thinned with considerable amounts of solvent and still produce a saturated, intense color.

Roy Lichtenstein used it almost exclusively. It was also used by Kenneth Noland, Morris Louis, and others. A Robert Motherwell painting at the Metropolitan Museum of Art has the lettering “painted with Bocour Magna, do not clean with turpentine.” The artists liked its solubility in turpentine, its tinting strength, and the fact that it could be mixed with oil paints (Crook and Learner 2000, 25–27).

(b) Conservation

The author has been using Magna for inpainting since 1969. She first made a palette of it on a plate of glass to use during a summer work project in Colonial Williamsburg. According to Robert Feller, it is a “true lacquer” paint, meaning it will always go back into solution and never polymerize. The author’s oldest Magna palette is still soluble in xylene.

Louis Pomerantz made a presentation on the use of Magna as his preferred inpainting medium in 1976 at AIC Dearborn in a panel organized by Peter Michaels (1976, 134).

(4) Source

(a) Physical

Bocour and Golden purchased the resin from Rohm and Haas (Crook and Learner 2000, 24–25).

(b) Origins and manufacture

Bocour made Magna beginning in the late 1940s. Bocour later sold Bocour Artist Colors, Inc. to Zipatone of Chicago, but they ceased making Magna paint in the early 1990s. Golden Artist Colors now produces a mineral spirit-borne acrylic paint called MSA Color, which is said to be similar to the original Magna, according to Crook and Learner, but Magna requires at least some xylene to go into solution, and MSA generally does not.

(c) Manufacturers and vendors

It is no longer available; it used to be sold by Arthur Brown in New York City. Many people have stockpiled it.

(5) Chemical and Physical Properties**(a) Chemical classification**

Acrylic resin

(b) Chemical formula/structure

The Conservation & Art Material Encyclopedia Online (CAMEO) notes, “A brand name for a series of acrylic paints prepared from pigments dispersed in n-butyl methacrylate resins and diluted with turpentine, mineral spirits, xylenes, and toluene. The paints dry rapidly to a hard, matte, nonyellowing film.”

(c) Solubility

Magna is soluble in xylenes and toluene, and it is said to be soluble in turpentine. Some colors are slowly soluble in petroleum benzene.

(d) Tg

The Tg was unavailable at the time this volume was published.

(6) Preparation and Formulation**(a) Typical application methods**

The author squeezes it from the tube out into a porcelain or glass palette. A dropper can be used to drip xylene onto it to soften it. It can be mixed on a temporary palette of foam board.

(b) Additives

To increase gloss, add Paraloid® B-72 to the paints on the palette. This is generally needed for the dark colors but not for the lights. It can be drained on palettes of foam board to make it more matte.

(c) Storage/shelf life

The author's 1969 paints are still good. The tubes dry up but can be cut open and xylenes dropped onto them to make them usable.

(7) Handling Characteristics**(a) Appearance**

Bocour Magna paints are not as glossy as PVAc or Gamblin colors. They are useful for inpainting tempera paintings because they dry matte. Bocour Magna paints are transparent, which can make it difficult to build up opacity. It is best to use them to glaze other media, applied more opaquely if opacity is required.

(b) Application/modifications for special applications and effects ("Tricks of the Trade")

As mentioned, Bocour Magna paints can be drained on foam board palettes to make them more matte. Paraloid B-72 in xylenes can be added to make them glossier.

The paint is readily soluble in itself so it must be applied in dots or tiny stripes that are allowed to dry before subsequent layers are added. It cannot be applied wet on wet. They are good for glazing on top of watercolor or tempera underpainting. They are readily portable, and the author has never found them to vary over the years.

Jim Bernstein recommends the following three diluent solutions:

1. To create a more matte finish:

Heptane	70 ml
Toluene	30 ml

2. For a slow evaporating diluent:

Petroleum Benzine	45 ml
Isopropanol	30 ml
1-Methoxy, 2-Propanol	10 ml
Shellsol 15	15 ml
Acetone	20 drops
Benzyl Alcohol	5 drops

3. For normal evaporation:

Petroleum Benzine	70 ml
Xylenes	30 ml
Acetone	25 drops
Benzyl Alcohol	5 drops

Bernstein points out that the presence of xylene assists in staying close to the solubility center of most conservation resin paints, and he cautions users not to use a lot of xylenes when inpainting over resolvable low molecular weight varnish.

(8) Aging Characteristics

(a) Chemical process

Dr. Feller said in 1970 that they do not polymerize or oxidize, etc., and remain soluble (personal communication, 1970). This appears to be true.

(b) Resultant chemical and/or physical alterations

Bocour Magna inpainting on paintings treated 25 years ago by the author has not shown changes.

(c) Impact on appearance, solubility, and removability

Very satisfactory.

(d) Attraction and retention of dirt and grime

A painting the author treated 25 years ago was returned because it had been subjected to life with a heavy smoker. The Magna retouches absorbed more of the nicotine yellow than the surrounding Paraloid B-72 varnish and had preferentially discolored. It was all readily removable and replaceable.

(e) Theoretical lifetime

The author has witnessed 40 years of Bocour Magna holding up well in normal conditions.

(9) Health and Safety

(see varnish chapter for base resin)

The main problem with Magna is that it requires xylene as the solvent.

(10) Disposal

As with other paint materials, follow local and federal disposal guidelines.

Joyce Hill Stoner

Submitted October 2003

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b) Charbonnel

(1) Principal Name

Charbonnel restoration colors

(2) Other Names

LeFranc and Bourgeois restoration colors; Charbonnel Colori per il restauro

(3) History of Use

Charbonnel, originally LeFranc and Bourgeois, were intended from their creation for use in conservation/restoration. This line of paints was developed by LeFranc and Bourgeois in 1983 for painting restorers who wished to avoid the natural resins used in Maimeri formulation. The product was transferred to Charbonnel, which manufactured it until the late 1990s, after which it ceased being made.

(4) Source

(a) Physical

The manufacturer states that the paints are composed of pigments ground in acrylic and ketone resin binder, but analytical tests did not detect a significant ketone component (see below.)

(b) Origins and manufacture

The Lefranc and Bourgeois literature states:

This medium...contains as much ketonic resin as acrylic resin (butyl methacrylate), dispersed in a heavy mineral spirit. The inclusion of ketonic resin allows for a high pigment content in these colors (mostly around 30% but sometimes up to 60% pigment)...the pigments used in this range are all used in our ranges of Artists' Colors...The mineral pigments are basically oxides (Titanium, Zinc, Iron, Cobalt, Chrome), Cadmium selenides and sulfo-selenides, Cobalt aluminate and complex silicate of sodium and aluminum with sulfur. The organic pigments are essentially copper phthalocynine, azo and stable diazo, nickel azo, naphthol, quinacridone, thioindigo and alizarin. (Lefranc & Bourgeois, undated product information sheet)

Colors for use in restoration; transferred to Charbonnel; discontinued.

(c) Manufacturers and vendors

Not manufactured at present; still available from some conservation specialty vendors.

(5) Chemical and Physical Properties**(a) Chemical classification**

Acrylic resin paint

(b) Chemical formula/structure

Infrared spectra and nuclear magnetic resonance spectra performed by Dr. Crandall of Indiana University in 1984, together with reference spectra of B-67, identified polymethacrylate as the major component. The spectra generated did not show a significant influence of ketonic resin, if it is present. Dr. Feller ran tests the same year with similar results.

(c) Solubility

Tests were carried out at Indiana University in 1984 with three sets of paint-outs: one set was placed in dry heat at 70°C for 54 days; another was placed face-up in a north-facing window; and a third was kept as a control in a dry drawer. Some of the dry-heat-aged colors became less readily soluble in petroleum benzine and heptane, with these solvents causing blanching. Solubility in VM&P Naphtha was slightly reduced, but xylene and toluene remained effective solutes and did not cause blanching. The daylight-exposed samples showed no changes in solubility.

(d) Tg

The resin is assumed to have a Tg similar to the Tg of B-67, 50°C, although paint-outs at 70°C for 45 days did not deform, presumably due to the presence of pigment stiffening the paint.

(6) Preparation and Formulation**(a) Typical application methods**

The vendors of these colors suggest in their catalogs that solubility in alcohol makes them ideal for inpainting. However, the relatively high polarity of alcohol makes it, in fact, a poor inpainting choice. Although the colors dissolve slowly in alcohol, the methacrylate binder is more soluble in aromatics or, when fresh, mineral spirits. To inpaint with these colors after they have dried out, mineral spirits with aromatics added are required. If the inpainter wishes to avoid the aromatic solvents, mineral spirit mixtures with 25 percent acetone work well.

Jim Bernstein likes the following solvent mixture:

Petroleum Benzine	70 ml
Xylenes	30 ml
Acetone	25 drops
Benzyl Alcohol	5 drops

He adds that the presence of xylene assists in staying close to the solubility center of most conservation resin paints. He notes, however, that conservators should avoid using too much xylene when inpainting on top of resoluble low molecular weight (LMW) varnish (e.g., Regalrez® 1094.)

(b) Additives

The authors do not use additives.

(c) Storage/shelf life

When the Charbonnel retouching colors are stored at room temperature in their tubes with the tops tightly secured, they have a long shelf life. Although they dry out slowly in these conditions, tubes can last 25 years or longer showing only a moderate loss in working properties. If the colors do dry out, they can be reconstituted in mineral spirit mixtures containing either aromatics or acetone.

(7) Handling Characteristics

(a) Appearance

When the colors are first squeezed from their tubes, they have the paste-like consistency of any tube paint. When initially applied they appear glossy, but as the diluent evaporates, they dry quite matte. After the colors dry and are brought to the gloss of the surrounding paint by applying varnish, the re-saturated color is usually slightly darker than the initially applied color.

(b) Application

The Charbonnel retouching colors work like most other inpainting colors, in that they are usually applied with small brushes in a diluted form. They can be squeezed from the tubes in small dabs onto a palette and mixed by taking a little from each. When applied to the painting, they can be opaque or translucent depending on the pigments in the mixture or the thickness of application. Additional acrylic medium can be added to increase translucency and gloss.

To build up layers, either to make the application more opaque or to mimic the layer structure of the painting, an application of retouch can be varnished with a thin layer of PVAc in ethanol. This PVAc layer prevents the layer below from becoming disrupted by newer applications on top as long as its diluent is predominately aliphatic.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

Used straight from the tube and only slightly diluted, the colors have enough body to be helpful in hand texturing fills. They are particularly useful in ap-

plying a canvas texture to the narrow fills of a tear. A problem often encountered with texturing by hand is that the texture turns out too high. Because the Charbonnel texture shrinks appreciably on drying, this tendency is often overcome.

(8) Aging Characteristics

(a) Chemical process

Due to the inclusion of pigments, the cross-linking properties of the butyl methacrylate are mitigated (Dr. Feller, personal communication, 1984) and the paints should remain stable for a very long period (sufficient for use as an inpainting material).

(b) Resultant chemical and/or physical alterations

In the twenty-five years since their introduction, no adverse chemical or physical alterations due to aging have been reported.

(c) Impact on appearance, solubility, and removability

A slight matte appearance can develop over time if the paints are used straight from the tube, without added medium, and are not varnished or coated following use. The acrylic resin Paraloid® B-67 will yellow slightly with age, so it is possible these paints may also show a very slight yellowing.

(d) Attraction and retention of dirt and grime

If the inpainted areas are not coated with varnish or some other resin, they may attract airborne grime due to the relative softness of the butyl methacrylate medium and the slightly rough surface.

(e) Theoretical lifetime

More than 50 years.

(9) Health and Safety

See Varnish volume of the PSG Catalog for base resins.

(10) Disposal

As with any paints, the material is best disposed of as a dry film, after the solvent has evaporated.

**Catherine A. Metzger and
Michael Swicklik**

Submitted January 2010

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Lefranc & Bourgeois. Undated product information sheet.

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VENDOR

Lefranc & Bourgeois

357 Cottage Street

P.O. Box 2484

Springfield, MA

c) Golden MSA Conservation Paints

(1) Principal Name

Mineral Spirit Acrylic® Conservation Paints

(2) Other Names

MSA paints, MSA Colors, Mineral Spirit Acrylics. The term Magna® has also been used to refer to MSA Conservation paints. Although similar in formula, Magna was produced by a different (but related) manufacturer (Bocour Artist Colors, Inc.) and is described elsewhere in this volume.

(3) History of Use

(a) Industrial

MSA colors are produced exclusively for conservators and artists, however, the poly *n*-butyl methacrylate binder is used industrially (see Rohm & Haas product literature for more details).

(b) Conservation

MSA Conservation Paints were first introduced to the art materials market by Golden Artist Colors, Inc. in the early 1980s as a custom product. They were reintroduced to the conservation field in 1994 as the successor of Magna colors after conservators suggested that they could be useful to the field.

(4) Source

(a) Physical

MSA Conservation Paints are composed of poly *n*-butyl methacrylate binder, pigments, and a thickener/rheology modifier (see “Chemical Classification,” below, for more details). The manufacturer provides 57 colors; in addition, custom colors are available upon request (see “Appearance,” below, for an example). The paints are sold in both one- and four-ounce glass jars with metal twist-off lids.

(b) Origins and manufacture

MSA Conservation Paints are manufactured exclusively by:

Golden Artist Colors, Inc.

188 Bell Road

New Berlin, NY 13411

Phone: (607) 847-6154

Toll Free: (800) 959-6543

Fax: (607) 847-6767

www.goldenpaints.com

The acrylic binder is manufactured by:

Rohm & Haas Company, a subsidiary of Dow Chemical Company

100 Independence Mall West
Philadelphia, PA 19106-2399
Phone: (215) 592-3000
Fax: (215) 592-3377
www.rohmhaas.com

The thickeners/rheology modifier, called Thixcin® R, is manufactured by:

Elementis Specialties, Inc.

P.O. Box 700
Wyckoffs Mill Road
Hightstown, NJ 08520
Phone: (609) 443-2000
Fax: (609) 443-2422/2201
www.elementis-specialties.com

(c) Manufacturers and vendors

Golden MSA Conservation Paints are distributed by:

Conservation Support Systems

Santa Barbara, California
www.silcom.com/~css

New York Central

www.nycentralart.com

Talas

New York
http://talasonline.com

The Italian Art Store

Morristown, New Jersey
www.italianartstore.bizland.com/store

(5) Chemical and Physical Properties

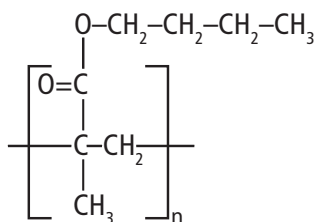
(a) Chemical classification

The poly *n*-butyl methacrylate binder is supplied by Rohm and Haas Company as 40% solids in 54% mineral spirits (Stoddard Solvent, which is typically 15–20% aromatic) and 6% Aromatic 150 (high flash aromatic naphtha, type II, aromatic 150, which is typically 98% aromatic). The residual acrylic monomers from the polymerization of the binder comprise < 1.0 wt. %. Initiators and chain transfer agents are also added, but the polymer manufacturer did not report further information.

The paint manufacturer adds pigments (see list of pigments under Chemical Process, below) and a thickener/rheology modifier, which is an organic derivative of castor oil (trihydroxystearin) called Thixcin® R, by Elementis Specialties, Inc. No ultraviolet radiation stabilizers, preservatives, or freeze-thaw stabilizers are added by the manufacturer. Since the introduction of MSA paints, no changes have been made to the formulation that affect the application/solubility characteristics.

(b) Chemical formula/structure

Please note that the chemical formula for Thixcin, the main additive in the Golden MSA Conservation paints, is proprietary and could not be obtained for this paper. The chemical structure of Poly n-butyl methacrylate follows:



poly (n-butyl methacrylate)

(c) Solubility

The manufacturer recommends using mineral spirits (but not “odorless” or “low odor”) to thin the paints and resolubilize them after drying (Golden MSA Conservation Paints). However, conservators have found that a solvent with a higher percentage of aromatics (from 10% to 50%) is often needed to re-solubilize them after they are dry and to attain a fluid consistency that flows from the brush easily. Stoner (personal communication, 2008) suggests 80% petroleum benzene and 20% xylenes. Pollak (personal communication, 2008) uses a xylene/benzene mixture, with small amounts of benzyl alcohol and acetone added.

The manufacturer also reports that artists have found that lower layers of MSA paints are sometimes resolubilized under subsequent applications of the paint, during the process of creating a painting. This is undesirable because it inhibits the creative process for the artist. In an ongoing study by the manufacturer concerning the resolubility of certain colors of MSA paints, younger paint films (24 hours old on glass substrates) are slightly more quickly resoluble in Stoddard solvent than older paint films (3–12 years old on laminated cardstock). However, the study also shows that the paint films are even more quickly resoluble in solvents with higher aromatic

content than in Stoddard solvent alone. The solvents included in the test are (1:3) Stoddard:xylenes; (1:1) Stoddard:xylenes; and xylenes, neat (Golden Artist Colors, personal communication, 2006). Details of the study can be obtained from the manufacturer.

As a remedy for unintended resolubilization of lower layers by upper layers, the manufacturer recommends that artists apply their product, the water-based Golden Polymer Varnish, in between layers to act as an isolation layer (Golden MSA 2010). At the time of this research, however, no conservators had reported using this technique.

(d) **T_g**

The glass transition temperature of the poly n-butyl methacrylate binder is 20°C.

(6) **Preparation and Formulation**

(a) **Typical application methods**

Conservators typically remove a small portion of paint from the glass jar packaging, as supplied by the manufacturer, and place it onto a palette. If the paints are not used immediately, they are left to dry on the palette and are resolubilized when needed. Conservators typically apply the paint by brush, but it can also be sprayed (see Application/Modifications for Special Applications and Effects, below, for more information).

(b) **Additives**

See Chemical Classification, above.

(c) **Storage/shelf life**

The manufacturer recommends that the consumer avoid freezing the product. The paint should be applied at temperatures above the Minimum Film Formation Temperature of 48°F/9°C.

The manufacturer does not foresee a limit to the shelf life of the product. Conservators have observed that the solvent can evaporate over time, but that the binder and pigment remain blended and do not separate. The manufacturer recommends keeping the lids on tight to help retain the solvent. It was the empirical observation of one of the authors that different colors dry out in the manufacturer's packaging faster than other colors. Stored together in an air-tight box, the following colors exhibited varying degrees of solvent retention (although it was acknowledged that some jars were probably more tightly sealed than others and that the purchase dates of each color may have varied):

Quantity of Solvent (Empirical Observation)	Names of Colors in Jars
Retaining the most solvent	titanium white and titanium buff, mars black, dioxazine purple, quinacridone crimson, raw sienna, cadmium orange, yellow medium, and red medium, and cerulean blue
Slightly dry	yellow ochre, burnt sienna, ultramarine blue, cobalt green, and permanent green light
Drier	raw umber and cadmium yellow light
Driest	bone black

(7) Handling Characteristics

(a) Appearance

The MSA paints have a matte to satin appearance when applied thin and a satin sheen when applied with a higher impasto. All colors are slightly glossier when wet than when dry. The various colors have different opacities in accordance with the characteristics of each specific pigment, as they would in oil paint. It should also be noted that the materials and texture of the infilling and isolation layer to which the paints are applied may also affect their appearance.

When fresh from the jar, some colors are stringy, although they become workable with the proper solvent, whereas other colors are buttery and can be directly shaped into impasto. Conservators have found that the pigments are finely ground, contributing to the smooth, even consistency when diluted with solvent.

Dried MSA paints are slightly glossier than other inpainting materials, such as Magna and Lefranc & Bourgeois Charbonnel colors, but are still selected by many of the conservators surveyed for this paper for their good match to matte and unvarnished modern paintings, where they do not require gloss adjustment or varnish on top. However, a recent study by Sims et al. (2009), in which a wide variety of inpainting media were tested specifically for matching acrylic emulsion paintings, suggested that achieving a perfect match to acrylic emulsions with solvent-borne acrylics is difficult, although perhaps can be achieved with more experience in using the medium. Sims et al. (2009) also noted that the paints are translucent when thinned and were not opaque enough to cover a mark in their test paintings, but suggested that this translucency may be useful in other applications.

One of the authors recently purchased custom colors to match specific areas in a modern painting. In this case, the manufacturer matched the colors of the painting through the use of colorimeter readings. Drawdowns were sent before the finished product to confirm the color match. Using the paint wet from the jars was possible, as they had a more buttery consistency. Used this way they dried to a slightly higher gloss than when applied thin, although

likely to a comparable level as would be seen with the buildup of multiple thin layers.

**(b) Application/modifications for special applications and effects
("Tricks of the Trade")**

Increasing gloss

The surface sheen of MSA paints can be increased with the addition of varnishes while in the wet state, such as Paraloid® B-72 (Stoner, personal communication, 2008); Paraloid™ B-67 (Pollak 2008); or Winsor & Newton matte or gloss varnish.

Adding varnishes on top of dry MSA paints, either locally or over the entire painting, will also increase gloss. Some conservators find that varnishing is not always necessary, although dammar, Regalrez®, MS2A and Golden MSA Varnishes can be sprayed over the surface. Stoner (personal communication, 2008) notes that a thin layer of MS2A is an option and localized application with silk or an inpainting brush can achieve a gloss appropriate for 17th- or 19th-century paintings, although perhaps a glossier inpainting medium should be chosen to begin with for these types of paintings. Pollak (2008) has locally brushed on Paraloid B-72 and B-67. Both Pollak (2008) and van Gelder (personal communication, 2008) have sprayed on 10% concentrations of Paraloid B-72, overall. Conservators have also brushed and sprayed Regalrez overall in 10–15% concentrations.

Matting

The gloss of the MSA paints can be reduced by draining colors on a Fomcore® palette (Stoner 2008). In fact, Stoner (2008) stressed that, "It's not so much whether they are thickly or thinly applied but how you drain and dilute them before applying." Pollak (2008) has added fumed silica for matting. It was noted by van Gelder (2008) that the more the paints are diluted with solvent, the less glossy they will appear upon drying.

Spray application

The manufacturer suggests that artists can apply MSA paints by spraying. They suggest that the paints be blended with Golden MSA Varnish in 10% increments to attain the desired color intensity and then diluted with an equal amount of mineral spirits. They recommend using airbrushes without "O-rings" that could react with solvents (Golden MSA Conservation Paints). MacDowell (personal communication, 2009) reported having applied the MSA colors to ceramics by spraying with an airbrush and then sealing with a clear coating for durability.

Adjusting working properties and translucency

Stoner (2008) notes that acrylic gels can also be used over or under the MSA paints for other desired effects. The manufacturer recommends blending MSA paints with Golden MSA Gels and MSA varnishes to adjust consistency and translucence (Golden MSA Conservation Paints).

(8) Aging Characteristics**(a) Chemical process**

Over the last 50 years, there has been a significant amount of research on the poly *n*-butyl methacrylate binder of the MSA paints, and ongoing research continues to advance our understanding on this material. Epley (1997) provided a summary of the information available to that date. The research suggests that the resin does have a slight tendency to cross-link and become insoluble, especially under accelerated aging. It is not currently known how the addition of pigments and additives may affect these processes.

(b) Resultant chemical and/or physical alterations

Under natural and light-aging, Sims et al. (2009) noted a darkening and cooling of the color of Golden MSA Quinacridone Red and a lack of change in the Titanium White. These were the only two colors noted in the study.

The manufacturer has tested the lightfastness of the MSA paints under extreme conditions, while under glass and under direct exposure to outdoor conditions. The lightfastness of the various colors ranges from excellent to fair (a change of zero to eight units on the CE 1976 $L^*a^*b^*$ color difference scale), with the exception of Cadmium Yellow Primrose, which was poor (a change of over 20 units). The following is a table of the results (Golden MSA 2010):

MSA Colors - Lightfastness Results			
Antraquinone Blue	4.3	Mars Black	0.26
Bone Black	1.1	Mars Yellow	0.66
Burnt Sienna	0.26	Naphthamide Maroon	3.3
Burnt Umber	0.6	Naphthol Red Light	3.1
Burnt Umber Light	0.97	Naphthol Red Medium	5.7
Carbon Black	0.53	Nickel Azo Yellow	3.2
Cerulean Blue	0.37	Phthalo Blue G/S	1.4
Chrome Oxide Green	0.28	Phthalo Blue R/S	1.5
Cadmium Orange	7.3/.112	Phthalo Green B/S	0.74
Cadmium Red Dark	3/.37	Phthalo Green Y/S	0.72
Cadmium Red Light	5.6/.33	Pyrrrole Red	0.55
Cadmium Red Med	4.5/.37	Quin. Burnt Orange	2.6
Cadmium Yellow Dark	NA/.35	Quin. Crimson	1.9
Cadmium Yellow Light	13.5/.39	Quin. Gold	2.6
Cadmium Yellow Med	11.1/.21	Quin. Red	2.7
Cad Yellow Primrose	20.3/.4	Quin. Red Light	1.5
Cobalt Blue	0.36	Quin. Violet	2.1
Cobalt Green	0.42	Raw Sienna	0.34
Cobalt Titanate Green	0.67	Raw Umber	0.47
Cobalt Turquoise	1.27	Red Oxide	0.44
Diarylide Yellow	1.3	Titanate Yellow	0.38
Dioxazine Purple	5.3	Ultramarine Blue	1.7
Green Gold	2.9	Vat Orange	1.4
Graphite Gray	0.61	Violet Oxide	0.53
Hansa Yellow Med	6.2	Yellow Ochre	0.54
Hansa Yellow Light	2.25	Yellow Oxide	0.75

Testing followed the protocol of ASTM Test Methods for Lightfastness of Pigments Used in Artists' Paints (D 4303), Test Method A. Samples are reduced to tints of 40% reflectance and exposed in southern Florida outdoors, under glass, at a 45° angle facing the equator. Exposure duration is 3–4 months, for a total radiation dose of 1260 MJ/m². Samples were measured before and after exposure (specular reflection excluded). In accordance with the CE 1976 L^{*}a^{*}b^{*} color difference equation, color change is stated in terms of total color difference units ΔE^* . Changes of up to 4 units are considered excellent to very good, 4–8 units are very good to fair. As a point of reference, a true Alizarin Crimson tested at the same time had a color change of 17.46 units.

Cadmium pigments are not lightfast under the extremely humid conditions of outdoor exposure testing. They have been found to have excellent light-

fastness when tested under conditions of accelerated exposure with relative humidity controlled to normal levels (50–60%). The second figures (e.g., 7.3/.112) in the table for the cadmium colors represent changes measured after 400 hours of UVA-351 fluorescent lamp, simulated daylight exposure.

Disclaimer: The above information is based on research and testing done by Golden Artist Colors, Inc., and is provided as a basis for understanding the potential uses of the products mentioned. Due to the numerous variables in methods, materials, and conditions of producing art, Golden Artist Colors, Inc. cannot be sure the product will be right for you. Therefore, we urge product users to test each application to ensure all individual project requirements are met. While we believe the above information is accurate, *we make no express or implied warranties of merchantability or fitness for a particular purpose*, and we shall in no event be liable for any damages (indirect, consequential, or otherwise) that may occur as a result of a product application.

(c) **Impact on appearance, solubility, and removability**

- i. **Appearance:** The color changes in the paints, when tested for light-fastness, as reported by the manufacturer, may not be perceptible to the human eye. However, as stated in the section on Chemical Process above, the poly *n*-butyl methacrylate resin alone has been shown to crosslink and become insoluble upon accelerated aging; the paint with added pigment and other additives was not tested for solubility and reversibility. Sims et al (2009) also noted that the color shift in the MSA Quinacridone Red was very slight.
- ii. **Solubility:** As Feller (1971) and others have noted, aging processes do not necessarily inhibit later removal until they have reached a very advanced state. According to Feller (1971), while solubility will be affected, swelling and removal should be possible up to the point that the film has become 90% insoluble. Sims et al. (2009) noted that the light-aged samples in their study took longer to solubilize than the naturally aged samples and perhaps this is a result of polymerization upon aging.
- iii. **Removability:** None of the conservators surveyed for this entry reported having to reverse aged MSA paints inpainting. Anecdotal evidence from multiple sources suggests that Magna®, which was also a homopolymer of pnBMA, remains very easy to reverse at this time.

(d) Attraction and retention of dirt and grime

In general, it has been suggested that the relatively low glass transition temperature, molecular weight, and minimum film formation temperatures can cause a solvent-borne acrylic film to remain tacky at room temperature and attract and retain dirt (Epley 1997; Feller 1977; Harren 1977; Lamb 1982; Lodge 1988). However, compared with acrylic emulsions, it remains harder and will be less likely to absorb dirt over time. Another factor is that a high pigment load could produce an uneven surface, offering minute places for dirt to lodge.

The development and retention of static charge has long been suggested as another possible drawback, but has only recently been tested: Abbott and Smith (2009) showed that MSAs tend to hold a charge at low RH for longer than many other paint mediums, although these charges were found to dissipate after a few hours at most.

Pollak (2008) noted that the dried MSA paints on palettes do not seem to absorb dirt. One of the authors' observations of thickly applied Magna on paintings dating from the late 1950s showed no current absorption of dirt by the surface. Stoner (2008) reported finding that the 20-year-old Magna inpainting (a product similar to Golden MSA Conservation Paints) on a painting in a home with smokers had preferentially absorbed grime, but was readily removed.

(e) Theoretical lifetime

The theoretical lifetime for Golden MSA paints has not been tested. However, paintings created with Magna, a similar product, by artists such as Morris Louis (American, 1912–1962) and Roy Lichtenstein (American, 1923–1997) have been examined by conservators over the years. Ausema (personal communication, 2010) reports that, based on observational study of color field paintings employing Magna, the paint appears to have excellent color fastness and that the binder is very stable even when heavily diluted.

(9) Health and Safety

See the manufacturer's Materials Safety Data Sheet on Golden MSA Conservation Paints for further details.

(10) Disposal

Disposal of MSA paints primarily pertains to heavy metal-containing proprietary materials. Refer to the disposal rules of the region in which the paints are used.

**Elizabeth Jablonski
and Matthew Skopek**

Submitted December 2003

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FOR FURTHER READING

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d) Acryloid® B-72 Resin-Based Inpainting Material

Conservators began using Acryloid B-72 as an inpainting medium almost as soon as the resin became available to them in the 1960s and 1970s (Ackroyd 2010, 58). The hand-ground paints had the same drawbacks as did any hand-made paint. Eventually, conservators sought inpainting colors that offered evenly dispersed pigments in the chemically stable resins they had been using. The production of Acryloid B-72 Color Chips was announced to conservators in 1993. The colors were not made specifically for conservators but came from another application (an urban legend via Scott Blair of Conservation Support Systems suggests that the colors were made for pinball machines). Over ten years later, in 2006, the German company Kremer Pigments, Inc. began making Kremer Retouching Colors specifically for conservators using pigments commercially ground in B-72. This product was a logical addition to Kremer's offerings, as B-72 had been a more widely used retouching medium in Britain and other parts of Europe. Kremer had been carrying B-72 since 1980 and considered it the most important acrylic resin for "...retouching paint in conservation" (www.kremerpigments.com).

Acryloid B-72 Color Chips

(1) Development and Formulation

Acryloid B-72 Color Chips were an early introduction into the commercially prepared inpainting color palettes, but they are not widely embraced by paintings conservators as there have been very few references to the colors in conservation literature. The chips may see more use for conservators of wooden artifacts. The supplier reports that they are popular in Europe where they are used as a filling material as well as for toning or inpainting.

Their production was announced in the January 1993 issue of the *WAAC Newsletter* in the Technical Exchange pages. According to the announcement:

Quaker Color in Quakertown, Pennsylvania (215/536-3520) makes pigment dispersions. They currently grind about 30 different pigments (from Ciba Geigy, etc.) in Acryloid B-72 using a differential roll mill, aiming for a 7–8 grind (Hegmen gage) or about 6.4 microns. This is much finer than pigments can be ground dry. These pigment dispersions are sold as dry chips of pigment in varying percentages of B-72. They are soluble in acetone; however, a few drops of toluene will dissolve them more completely, producing transparencies without flecks of pigment. (1993, 3)

The sole supplier of Acryloid B-72 Color Chips—Conservation Support Systems—explains that

Acryloid B-72 color chips are made by the dissolving of Acryloid B-72 resin in toluene and then color blended with the finest lightfast pigments on a

three roll mill. Once the color is fully blended, the solvent is then evaporated from the processed mixture. The resulting dry material is then crushed, producing color chips that vary in texture from a very coarse powder to chips approx. 1/8"-1/4" in size. Acryloid B-72 color chips have a pigment concentration of approximately 32–38% with the balance being Acryloid B-72 resin (a small percentage of 1–2% of toluene may be present). They are great for inpainting, as a solid colored filling material, making colored marking solutions and much more... (www.silcom.com/~css)

The Color Chip palette includes 23 colors, which utilize natural pigment for some colors and organic colorants for others. Conservation Support Systems, the supplier, lists them on its website (www.silcom.com/~css). In 2009, the supplier reported that the color chips were becoming increasingly difficult to get from their supplier, who was demanding larger quantity minimum orders for repackaging (personal communication, July 21, 2009).

(2) Handling Characteristics

(a) Appearance

The Color Chips dissolve into very fine pigment dispersions. The paints have high tinting strengths to produce highly chromatic pure colors. The fine colorant particle size enables thin, transparent washes of color. The large molecule size and relatively low refractive index of the Acryloid B-72 (~1.489) contributes to the perception of poor saturation in the dark colors. However, the stability of the resin promises clear, bright whites and light colors that are unlikely to discolor. The red palette needs supplementing with true reds, such as the cadmium pigments. The transparent colors (e.g., Thioindigoid Red) are useful glazing materials. The blue palette lacks a cerulean color, and the two green colors offered are phthalocyanine greens, which are difficult to use without significant manipulation. The palette may be more useful for modern and contemporary paintings.

(b) Application

The Color Chips are easiest to use when a small amount of chips (of a single color) are placed in a storage palette that has pans or wells. The chips can be softened with solvent in the well where they will become workable and then dry out again to become a “cake” of color. They could probably be effectively used as pure colors placed straight on a working palette, but the dry “chip” form needs anchoring on the palette with a little solvent, or solvent and medium. Several colors of dry chips can be dissolved and mixed together for cakes of custom colors.

The paints dry to a satin gloss finish when used without additional medium. Some color shift is apparent when varnish is applied over them, but if the

color is matched when wet, it will match again, after varnishing. The surface gloss is especially easy to match when a final application of Acryloid B-72 varnish is used.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

The paints can be manipulated in the same manner as other inpainting media. Fast evaporating solvents permit crisp touches of color over another color. Slower evaporating solvents can allow for some blending. Additional medium will make the colors glossier but only as glossy as Acryloid B-72 itself. Additional dry pigment can create a very matte and dry appearance. If the added dry pigment is coarsely ground, the resulting paint will also appear rough textured. (I don't know about creating impasto with it, but am looking for others who may use it in this manner.)

The Acryloid B-72 Color Chip palette has quite a wide range of transparent synthetic colors that enhance the use of refining inpainting with glazes.

(3) Health and Safety

The paints carry the same warnings as their components. The chosen solvent determines the paint's handling and disposal requirements. Some pigments that are inherently toxic carry additional warnings.

CSS Restoration Colors

(1) Development and Formulation

These are tube colors that contain approximately 30–32% pigment content in approximately 12–20% resin solution. They are also supplied by Conservation Support Systems. The CSS Restoration Color palette has exactly the same 23 colors as Acryloid B-72 Color Chips because they are actually the same base material that has been redissolved into a paste and inserted into tubes. Although still listed in Conservation Support Systems' catalog, inventory in early 2010 was small. Low demand had not warranted replacement of inventory and the effort associated with their production (Scott Blair, Conservation Support Systems, personal communication).

Kremer Retouching Colors for Conservators

(1) Development and Formulation

In 2006, Kremer Pigments acquired a grinding mill for mixing commercially ground paints. The company produced concentrated pigment paste colors, or “semi-dry pastes,” using historic pigments ground in 50% solids B-72 resin dissolved in toluene. The colors are normally supplied in 3ml glass jars with snap

caps. Larger quantities are available upon request. The colors are marketed in two palette groupings. The colors come in a wooden box that holds the jars upright.

The two palette groupings have 27 colors each, 17 of which are repeated in both palettes. A total of 37 colors ground in B-72 are made. Most colors are the historic pigments that conservators are familiar with. The majority of the pigments are natural, except for a few historic substitutes, e.g., madder lake. The listings for many of the colors include pigment particle sizes or ranges. The palette range includes traditionally opaque and transparent offerings.

(2) Handling Characteristics

The colors can be used straight from the jar by adding a few drops of solvent to the glass. Small amounts of the paste colors can also be removed from the jar, allowed to dry on a palette, and then redissolved for use. The manufacturer recommends acetone, toluene, and Shell Sol A as good solvents when using the colors for inpainting. To redissolve the colors in their jars, acetone, ethyl acetate, Shell Sol A, toluene, or xylene can be used.

The paints can be used as stand-alone inpainting, as a foundation layer, or as glazes. Because the colors have been machine ground, the paste is smooth and consistent, with good hiding power. Many effects can be mimicked by altering the amounts of pigment, solvent, and medium used. Little medium and a fast evaporating solvent such as acetone can produce fine dry brushwork. Additional medium can be mixed with the finely ground pigment to thin it for use as a transparent glaze. Careful choice of solvents can help prevent disturbing lower layers of B-72 inpaint. A local isolating layer of a different varnish that is more polar can also be helpful to achieve manipulations to the upper layers without disturbing those below.

(3) Health and Safety

The solvents used with B-72 carry health and safety warnings. Kremer's website provides links to the PDF Material Safety Data Sheets for acetone, toluene, and Shell Sol A. The solvents used should determine health and safety guidelines. Many historic pigments, especially those that contain lead, mercury, and chromium, carry their own hazards. Before disposal, the paints should be allowed to dry out and be removed according to local regulations.

Sian Jones

Submitted March 2010

REFERENCES

P. Ackroyd. 2010. Retouching media at the National Gallery, London since the nineteenth century. In *Mixing and matching: Approaches to retouching paintings*, eds. R. Ellison, P. Smithen, and R. Turnbull, 58. London: Archetype Publications.

WAAC. 1993. *Newsletter*, vol. 5, no.1 (Jan.), p.3.

VENDORS

Conservation Support Systems

(800) 482-6299

www.silcom.com/~css

Kremer Pigments

247 West 29th Street

New York, NY 10001

(212) 219-2394

www.kremerpigments.com

5. Synthetic Resin Emulsions

a) Flashe (PVAc)

(1) Principal Name

Lefranc and Bourgeois Flashe Vinyl Colors

(2) Other Names

None

(3) History of Use

(a) Industrial/Artistic

Dominique Rogers writes (personal communication, March 3, 2004) that her experience working with Flashe as a ghost for the Op artist Victor Vasarely gave her some valuable insights into the medium: “All of his studio paintings were made with Flashe (Lefranc and Bourgeois) on canvas or cardboard. Good points: the colors, as long as you follow the star system and do not use color with less than 3 stars, have shown a good lightfastness. They are easy to mix, and I have not found anything else that gives such a flat, uniform, matte surface. Bad point: the surface created is fragile to the touch or even the breath.”

According to the Lefranc and Bourgeois website:

The FLASHE range, distributed since 1954, is one of the first modern painting materials to give artists other means than oil painting to express themselves. Its optical characteristics allow the effects of old tempera paints and primitive painting grounds to be reproduced. Matte and velvety, opaque.

FLASHE colours are diluted in water and become indelible when dry.

FLASHE colours are applied using brushes, paint guns, or sponges.

FLASHE is a multi-purpose product with many uses: Preparing grounds for using oil or acrylic paints, creation of canvas paintings, theatre sets, advertising decors, thumbnail sketches, or trompe l'œil drawings.

For these many techniques, FLASHE has a palette of 84 colors (35 new colors since 2007) that can all be mixed together. FLASHE is available in 60ml tubes (40 shades), 125ml glass jars (77 shades), 400ml glass jars (49 shades), and, on request only, 5kg pails (40 shades).

(<http://loisirs.lefranc-bourgeois.com>)

(b) Conservation

Flashe colors were initially used in objects conservation, often on modern sculpture. Gerri Ann Strickler, Object Conservator at the Williamstown Art Conservation Center, is recorded as having used them as retouching medium on two Calder mobiles in 1983 (Julie Wolfe, Getty Museum, personal communication, January 26, 2004). In addition, Object Conservator Wolfe used them on modern sculpture while employed at the Guggenheim Museum (Wolfe 2004). Flashe colors are currently being used on the Vermont Museum and Gallery Association Painted Theater Curtain Project for retouching. They closely emulate the matte appearance of the original distemper (estimate) paint layer. Andrea Guidi di Bagno, Chief Conservator, Paintings, at the Museum of Fine Arts, Houston, originally used Flashe colors in France in the 1970s as an underlayer for final inpainting, which would be completed in another medium. In this work, her palette was limited to Indian red, a black, and a white. She also has used them currently in the conservation of the work of Carlos Cruz-Diez. They are the preferred method of retouching on some of his work from the 1950s where he used Flashe himself (personal communication, Guidi di Bagno, 2010).

Flashe colors were used on a Rex Whistler mural in the mid-1980s in the collection of the Tate Gallery, Millbank site. Roy A. Perry, conservator at the Tate Gallery, recounts using the colors on the flood-damaged painting and states that using Flashe was “not the answer to our prayers (nothing was)” (Perry, personal communication, March 22, 2004). He states that although the color changing on drying is perhaps not as unpredictable with Flashe as with an acrylic medium, it can be counteracted by allowing the color to dry out and then redissolving it using an appropriate solvent, such as 1:1 mix of petroleum spirit and isopropanol or similar alcohol or a high aromatic content hydrocarbon. Additional medium can also be added simply by the addition of poly (vinyl acetate) (PVAc) resin, which can be acquired from most conservation material suppliers. He goes on to add that Flashe can crack over slick films as it shrinks on drying and, being brittle, is only suitable on fairly rigid, stable surfaces. He also notes that its solubility changes over time may require solvents that would affect many modern paints. These solvents include aromatics such as xylene and toluene.

(4) Source**(a) Physical**

Flashe vinyl colors are a poly (vinyl acetate) (PVAc) copolymer emulsion introduced in 1954 by Lefranc and Bourgeois (founded in Paris, France in 1720).

(b) Origins and manufacture

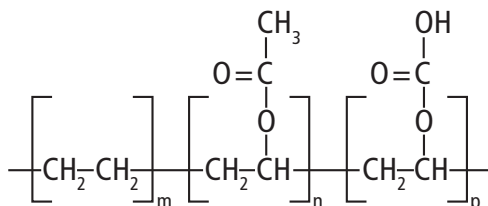
ColArt (Winsor and Newton) now works with Lefranc and Bourgeois, who created the colors. The chief paint formulator at Winsor and Newton offered this: “Flashe [paints are] based on a vinylacetate copolymer emulsion. They are formulated to give a flat matte finish” (via Mark Gottsegen, ASTM Scientist, February 3, 2004). They are currently manufactured by Winsor and Newton.

(c) Manufacturers and vendors

Flashe vinyl colors can be purchased directly through Winsor and Newton but are also available through a variety of online vendors.

(5) Chemical and Physical Properties**(a) Chemical classification**

Aqueous poly (vinyl acetate) (PVAc) copolymerized with ethylene and/or acrylic acid.

(b) Chemical formula/structure**(c) Solubility**

Dominique Rogers writes that Flashe paints were “easy to remove in acetone” (personal communication, March 3, 2004). In addition, Gerri Ann Strickler noted in 1983 that Flashe paints were “partially soluble in toluene and ethanol (separately) and soluble in xylenes as well as acetone” (Wolfe, personal communication, 2004).

Roy A. Perry also adds that its solubility changes over time may require solvents that would affect many modern paints (Perry, personal communication, March 22, 2004). The chief paint formulator at Winsor and Newton stated, “I would expect [Flashe colors] removability to be similar to acrylic emulsions, which also get used by restorers” (via Gottsegen, 2004).

(d) T_g

The glass transition temperature for PVAc will vary from 16–26°C.

(6) Preparation and Formulation

(a) Typical application methods

In conservation, Flashe is applied with a preferred inpainting brush, such as Winsor Newton Series 7. It is used like any other inpainting medium and is available in tubes (60ml); jars (125ml and 400ml); and pails (5kg custom order). The custom-ordered pails are used in artistic ventures, such as mural work, where the paints can be applied with a roller and the method of application is less critical. In conservation, jars are the most economical method of purchase. The paints are used straight from the jar and, ideally, a small amount can be placed on a palette with a small amount of poly (vinyl acetate) medium added if additional gloss is required. If additional gloss is required, the poly (vinyl acetate) medium type can be varied between AYAA, AYAC, and AYAF.

(b) Additives

Proprietary

(c) Storage/shelf life

In my experience, Flashe colors have a shelf life of no more than a year if not stored under ideal circumstances. These circumstances include dark storage at room temperature with the lids on. Once they are stored for a long period of time, opened and closed continually, or used in environments with varying climates, the components start to separate and it becomes more difficult to achieve the initial texture. Some colors are more likely to have separated than others depending on their initial formulation. In the author's experience, the reds and yellows are more likely to separate.

Dominique Rogers states (2004) that "mixtures can be kept in pots forever (I have some that are 15 years old) as long as you top them up with water from time to time or have very well-sealed pots."

(7) Handling Characteristics

(a) Appearance

Flashe vinyl colors are formulated to give a matte, opaque finish with high hiding power.

(b) Application

Flashe pigments are applied in the same manner as other retouching mediums and can be used with synthetic or natural hair brushes. They do, however, work best with a synthetic hair brush.

**(c) Modifications for special applications and effects
("Tricks of the Trade")**

Andrea Guidi di Bagno mentions that mixing the paints on a piece of rigid Mylar® is ideal: "As Flashe paints dry quickly in a film and are difficult to reconstitute, unlike a medium like Maimeri, it is best to use them sparingly. The residue can be released quickly from the Mylar with minimal waste" (Guidi di Bagno, 2010).

(8) Aging Characteristics

(a) Chemical process

Unknown; proprietary

(b) Resultant chemical and/or physical alterations

See directly below.

(c) Impact on appearance, solubility, and removability

Julie Wolfe states the following:

In April-July 2000 at the Guggenheim Museum, I purchased a light-fastness testing kit which tests to ASTM D 5398. I tested 18 colors and found that all but 4 colors appeared to be lightfast. The tyrian rose and brilliant orange permanently faded. In contrast, the red vermillion and orange actually darkened slightly. Colors tested were white, yellow ochre, gold yellow, brilliant orange permanent, orange, red vermillion, tyrian rose, carmine red, green oxide of chromium, chrome green, electric blue, sepia brown, black, raw umber, and ultramarine blue.

(d) Theoretical lifetime

Lefranc and Bourgeois makes no claim to the shelf life of Flashe vinyl colors. The colors should be well sealed and stored in dark storage to maximize shelf life.

(9) Health and Safety

(See Gianfranco Pocobene's article, "Poly (vinyl acetate)" in Volume 1 of the *Painting and Conservation Catalog: Varnishes and Surface Coatings*, p. 198.)

Poly (vinyl acetate) is a nontoxic material that is approved by the FDA for the packaging of food (Kirk-Othmer 1985, 1226). Many of the solvents that are used to dissolve PVAc are toxic. MSDS should be referred to when dissolving the resin.

(10) **Disposal**

(See Gianfranco Pocobene's article, "Poly (vinyl acetate)" in Volume 1 of the *Painting Conservation Catalog: Varnishes and Surface Coatings*, p. 198.)

PVAc resins are to be disposed of by incineration in a furnace or otherwise disposed of in accordance with the appropriate federal, state, and local regulations.

Erica James

Submitted June 2010

REFERENCES

Kirk-Othmer encyclopedia of chemical technology. 1985. New York: John Wiley & Sons.

b) Golden, Permanent Pigments (PVAc Emulsion)

(1) Principal Name

Golden Heavy Body Acrylics

(2) Other Names

Goldens: Golden's Acrylics

Under the heading of Golden Heavy Body Acrylics (GHBA), the company includes Historical Heavy Body Acrylic Hues, Iridescent/Interference colors, Neutral Greys, Acrylic Matte Colors, Fluorescent Acrylic Colors, and Phosphorescent Green. Compatible with the Golden Heavy Body Acrylics are Golden's line of Airbrush Colors available in opaque and transparent color sets. There is also a range of gels and mediums that alters the gloss and thickness of the acrylic paints.

(3) History of Use

(a) Industrial

Golden Artist Colors are produced primarily for artists. The Heavy Body Acrylics were introduced in 1980. Initially they were sold directly to artists in large containers in a limited geographic area. As they gained popularity with artists, they were offered in smaller jars (8 and 4 oz.). Tubes were introduced in 1990.

(b) Conservation

The conservation field has embraced Golden Heavy Body Acrylics (GHBA) for their quality, consistency, range of colors, versatility, and ease of use. Originally more commonly employed in objects conservation, they have increasingly been put to use in paintings conservation for inpainting, filling, and texturing.

The majority of use conforms to standard easel inpainting practices that rely on the employment of an isolating varnish layer prior to inpainting and final varnishes for even gloss and protection. In rare cases, GHBA are used without an isolating layer in instances where their reversibility in xylenes should effectively and safely separate them from the original, e.g., over water gilding or bole. Their opacity makes them useful when overpainting is necessary. The fluorescent and phosphorescent colors are not typically used in conservation.

(4) Source**(a) Physical**

GHBA are composed of pigments in an acrylic emulsion binder.

At the time of writing, 101 colors were available (73 colors, 7 neutral grays, 3 primaries, 7 historical colors, and 11 custom colors). The following information is from Golden's Product Information Sheet for Heavy Body Acrylics (see www.goldenpaints.com):

The majority of Golden's Heavy Body line is produced from single, unique pigments. About 30 of the colors are mixture colors. The mixture colors within the GOLDEN HB line of acrylics include Green Gold, Jenkins Green, Quinacridone Crimson, and Turquoise (Phthalo), as well as...Neutral Grays, Historical Colors, Blended Colors, and Primaries.

Inorganic Pigments...are produced either with naturally mined pigments (sienna, umber, ochre) or with synthetically manufactured pigments, (iron oxide, carbon black, etc.). Pigments that are both mined and manufactured include the Cadmiums, Cobalts, and Titaniums.

Organic Pigments...are synthetically produced through complex carbon-containing chemistry involving various materials including petroleum, coal tar, and natural gas. Many of these pigments have their roots in the chemistry of the 1800s, although widespread production didn't really begin until the 1930s. Even though they have only been available for several decades, organic pigments have demonstrated remarkable abilities to withstand the impact of light and weather.

(b) Origins and manufacture

The GHBA are produced by:

Golden Artist Colors, Inc.
188 Bell Road
New Berlin, NY 13411
Phone (607) 847-6767
www.goldenpaints.com

The binder is manufactured by Rohm and Haas.

(c) Manufacturers and vendors

The Golden Heavy Body Acrylics are widely available for purchase through art supply catalogs and stores.

(5) Chemical and Physical Properties

(a) Chemical classification

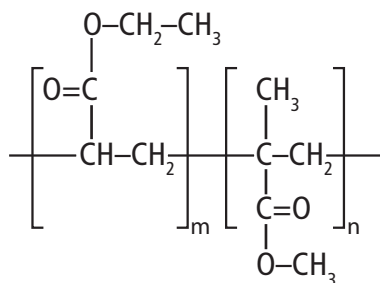
Acrylic Dispersion (Acrylic Emulsion)

Appearance is milky white or colored; there is a slight ammonia odor.

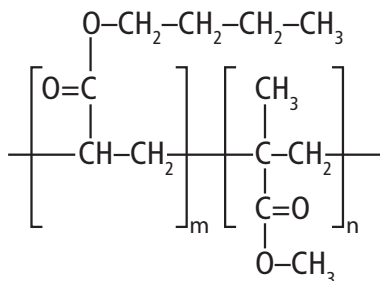
pH: 8.5–9.2.

(b) Chemical formula/structure

Poly (ethyl acrylate / methyl methacrylate) copolymer, $(C_5H_8O_2)_n \cdot (C_5H_8O_2)_m$.



Since the late 1980s, many resin formulations changed to poly (n-butyl acrylate/methyl methacrylate) copolymer, $(C_9H_{10}O_2)_n \cdot (C_7H_{12}O_2)_m$.



(c) Acrylic emulsion additives

Acrylic emulsion additives are described in the article “Conservation Concerns for Acrylic Emulsion Paints” (Jablonski et al., 2003). The list below is taken from the article:

Among additives to the acrylic emulsion:

- Initiators: most often persulfates, e.g., potassium persulfate.
- Chain transfer agents: e.g., dodecyl mercaptan.
- Buffers, to maintain a pH between 8 and 10, typically ammonia.

- Surfactants: typically added at 2–6% by weight. Some common surfactants are non-ionic (e.g., alkyl phenol ethoxylates) and anionics (e.g., sodium lauryl sulfate or dodecylbenzene sulfonate).
- Protective colloids: water soluble polymeric emulsifiers such as hydroxyethylcellulose and polyvinyl alcohol at 1 to 10% weight.
- Preservatives: to protect against the growth of microorganisms, generally at less than 1% weight. Commonly, methyl benzisothiazolinones, chloromethylisothiazolinones, barium metaborate, and formaldehyde donors, such as 1-(3-chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride.
- Residual acrylic monomers are also present at 50 to 1,000 parts per million or so, resulting from incomplete polymerization.

Among additives in paint formulation:

- Wetting agents: similar to surfactants used during polymerization. Typical wetting agents include alkyl phenol ethoxylates, acetylenic diols, alkylaryl sulfonates, and sulfosuccinates.
- Dispersion agents, typically polyphosphates or polycarboxylates.
- Coalescing solvents: typical coalescents are ester alcohols such as Texanol® (Eastman Chemical Co.), benzoate esters such as Velate® (Velsicol Chemical Co.), glycol ether esters, and n-methyl-2-pyrrolidone.
- Defoamers, typically mineral or silicone oils (e.g., polydimethylsiloxanes).
- Preservatives, as above.
- Thickeners and rheology modifiers: the most common group is that of cellulose derivatives, including hydroxyethylcellulose, methylcellulose, and carboxymethylcellulose. Also used, alkali-swelling polyacrylate emulsions and Polysaccharides, e.g., xanthan and guar gums. A newer group of rheology modifiers is that of hydrophobically modified ethoxylate urethanes (HEUR).
- Freeze/thaw stabilizers, 2–10% ethylene or propylene glycol.

According to product literature, the HB line of acrylics contains no additional flattening agents, opacifiers, or other solids that might interfere with the clarity of their pigments. This decision was made to allow their colors to retain their clearest and cleanest quality, especially when used in washes or glazes.

Product literature specifies formaldehyde as a preservative in the raw acrylic emulsion. The MSDS lists the presence of both ammonia and propylene gly-

col in all the acrylic formulations. Aluminum oxide and crystalline silica are listed in matte acrylics, gels, and mediums; semi-gloss lists only aluminum oxide.

(d) Solubility

GHBA are ready to use from the jar. Water may be used to wet or thin them slightly without consequences; however, the color appears lighter after its addition and dries significantly darker, making color matching more difficult. Golden's product literature cautions: the more water added to the acrylics, the greater the subsequent shrinking of the paint layer. Too much water will reduce the binding capability of acrylic paints and tends to flatten out their sheen.

The acrylics are not considered solvent miscible. Solvents will disrupt an acrylic film, especially a fresh one. Golden literature specifies that the acrylics are sensitive to the addition of solvents but suggests that if the addition of solvent is desired, the solvent should be first diluted with water to reduce the shock.

(e) Tg

The glass transition temperature is near or below room temperature. The paint film softens at around 60°C.

(6) Preparation and Formulation

(a) Typical application methods

Application methods for conservation purposes differ substantially from the methods described by Golden for general use by fine artists. Paint can be used directly from jars, but more commonly a palette is set up with the paints (and additional medium if desired). The palette will dry out at different rates depending on the climate and the amounts of paint. A water mister can be used to extend the working time of the paints or anything that slows water evaporation, such as a cover, a piece of Mylar®, or proximity with a damp sponge. Dried paint cannot be brought back into use and must be discarded. Paints are generally discarded at the end of a session. If a larger quantity has been mixed, it must be stored in an airtight jar, or the palette must be covered or sealed.

If acrylic inpainting is done as an underlayer that will have glazing layers or varnish applied over it, care must be taken not to pick up the acrylic film with solvents. When the acrylic inpainting has dried, a spray application of a resin in xylenes will not disturb it; the acrylic layer can be sealed in between layers of resin. Cautious brush applications of resins in mineral spirits are

also possible but only to an extent; it will eventually swell or pick up the acrylic underlayer.

Application is typically by brush, but the acrylic paints and gels lend themselves well to other applications, such as palette knife or modeling tool when necessary to duplicate not just color but texture. Acrylic colors and gels can be applied as a fill material for lacunae.

(b) Additives

The paints' thickness and gloss can be altered with the addition of different media allowing for the duplication or approximation of a full range of oil paint techniques, including very heavy impasto, heavily ridged brushstrokes, palette knife marks, and other textures.

i. Gels and Mediums

The fluid media are thinner than the gels, are pourable, and can be used to thin the paints and alter gloss. The gels and mediums, without the paint, can be used to add texture to a flat fill before or after the color has been matched.

The gels are more viscous and do not pour. Gels are divided into different consistencies and sheens. The heaviest gels hold stiffer peaks but dry to a satin semi-transparent finish (waxy looking). In general, the mediums dry water-clear and glossy, as do the gels except for the heaviest and where specified in their description.

Extra Heavy Gel/molding paste has the heaviest body and holds the highest peaks; it exhibits less shrinkage than the other heavy gels and retains some transparency. Self-Leveling Gel is glossy and clear; it will do what its title suggests. It is useful for dot infilling and leveling out uneven fills and transitions; it can also increase the gloss of acrylic inpainting applied locally like a varnish.

Acrylic Flow Release is a concentrated surfactant; it contains no drier. It holds onto water and pulls moisture from the atmosphere. The addition of the flow release makes the paint sticky. It must be diluted according to instructions (10:1); it is of limited use for conservation purposes.

Retarder is described in product literature as "an additive used to increase the open (drying) time of acrylic paints. Useful for 'wet in wet' techniques and reducing skinning on the palette." It is of limited use for conservation purposes.

ii. Airbrush Colors

Golden produces sets of opaque and transparent airbrush colors that are fully compatible with the other Golden acrylics. The airbrush acrylics are water thin and finely ground; they deliver an amazing amount of color in a very thin layer and are very useful in recreating missing glazes, for glazing broad areas of color, and in any application requiring a great deal of color and no bulk. Naturally, they work very well when airbrushed as well.

In addition, the Airbrush Medium can be used to thin the heavier acrylics without loss of color or film strength. An Airbrush Transparent Extender increases transparency and film hardness in the airbrush colors and is the recommended diluent for the airbrush colors.

(c) Storage/shelf life

Store at room temperature. Avoid higher than normal temperatures. Do not allow paints to freeze. Once frozen, they cannot be reconstituted, which is a concern for delivery to colder climates. Replace caps tightly. Once dried out, they cannot be returned to use with either water or solvent.

GHBA have a reasonably long shelf life. Shelf life varies with individual pigments. Six to ten years is not an unreasonable expectation. Even with diligent storage, jars of acrylic will eventually get chunky or tough. A 4-oz jar of Golden Acrylic at Williamstown Conservation Center that is between 13 and 20 years old is still wet to the touch but exhibits undesirable texture and clumping; Mark Golden recalls a large container of cadmium red at use in an artist's studio that was close to 25 years old.

(7) Handling Characteristics

(a) Appearance

GHBA are available in a full range of colors, both in jar and tube. The paint has a creamy texture similar to mayonnaise in weight and consistency. The heavy body of the paint allows for a fairly convincing recreation of missing impasto and heavier brushstrokes on damaged oil paintings, in some cases allowing “one step” fill and inpainting where smaller lacunae can be compensated with color and texture simultaneously.

They are described as thixotropic in the literature—vigorous stirring will return a slightly settled or seemingly thickened jar to its original creamy texture. The acrylic film remains flexible and feels slightly soft to the touch. Vigorous rubbing of the film will cause it to pill or crumble, especially when not completely dried. Because of its flexibility, it is difficult to scrape into the acrylic with a scalpel without rolling up or deforming the acrylic. The flexibility does allow for some manipulation of the surface before it dries com-

pletely, including burnishing prominent edges with a fingernail or similar device.

(b) Application

Paint is ready to apply direct from the jar. A full range of media and gels are available to modify the texture, gloss, and thickness. Application is typically by brush but also using a palette knife, fingers, airbrush, etc.

(c) Modifications for special applications and effects (“Tricks of the Trade”)

An especially dry atmosphere might require extra measures (like a spray mister) to keep paints from drying out too quickly. Many conservators have recommended the use of a wet palette with a lid to keep paints “open” long enough to finish larger inpainting projects. (Several conservators mentioned this tip.)

Use water to thin the paint, but adding too much makes correct color matching difficult, as the color lightens a great deal on the palette. Also, too much water makes a weaker film and slows drying time. The weaker film wrinkles easily and does not lend itself to further working in that area. A general recommendation is not to add water to the gels, as it increases shrinkage.

Gels are used for increasing the thickness and for manipulation of texture without affecting color. A caution: there will always be some shrinkage in the gels as they all contain water. There is less shrinkage in matte and high solid gels. Thicker gels have longer drying times. The shrinkage is documented by the manufacturer but is not a problem that conservators have found noticeable in use.

To achieve matte colors for inpainting—and especially effective on murals—mix Golden Acrylic titanium white with gouache. The acrylic is used as a medium and stabilizes the drastic color shift that gouache can display as it dries. The modified gouache colors have a matte surface reflectance (not the slightly plastic look one can get with acrylics) (Nina Roth Wells, personal communication, 2008).

A tip gleaned from the Golden website and tested by the author is to mix Quinacridone Crimson and Phthalo Green (blue shade) to make a deep black.

A few of the Golden acrylic colors are especially useful for modifying other colors by way of their high intensity and translucency. Among these, Green Gold and Quinacridone/Nickel Azo Gold are invaluable. No sane individual would reach for Green Gold off the shelf thinking it would be great for in-

painting old paintings—it is a virulent pistachio color—but oddly enough, it is often just the right translucent undertone for many an aged oil color.

(8) Aging Characteristics

(a) Chemical process

- Acrylics are polymerized before the paint is manufactured, and no further chemical reactions are needed to form a film. The film is formed with the evaporation of water.
- Acrylic films can undergo chemical changes as they age that might cause chain breakage or additional cross-linking that would result in hardening, but these changes are very slow.
- Acrylic films become brittle at low temperatures, experiencing a drop in flexibility in a temperature range just above freezing (between 0 and 15° C). A brittle acrylic film would be susceptible to mechanical damage—cracking, breaking. (Jones, 2004)

(b) Resultant chemical and/or physical alterations

Yellowing is a negligible concern with acrylics; they essentially remain clear. Surfactant emulsifiers are exuded after film formation and remain after aging. Even after aging, acrylic films remain flexible. Aged acrylic films remain removable in xylenes (Smith, 2007).

From GOLDEN Acrylics product literature (see www.goldenpaints.com):

Pigment Selection and ASTM Standards

Every color within the HB Line is approved for professional artist use according to ASTM Standards for Artist Materials. These standards regulate paint consistency and demand fineness and lightfastness of chosen pigments, use of 100% acrylic binder, freeze-thaw stability, and accuracy of labeling for pigments used. Evaluation by an approved toxicologist is required. Of the 101 HB colors, 94 within the line are considered excellent in lightfastness (the ability to withstand color change due to exposure to light). The remaining 7 are rated very good for lightfastness. GOLDEN does not use any colors within the HB line rated less than very good. Those colors rated as very good include the two Naphthols, Hansa Yellow Light, Permanent Green Light, Dioxazine Purple, Green Gold, and Primary Yellow. It should be noted that of the colors rated as excellent in lightfastness, the Cadmium colors are especially sensitive to the combination of light and moisture, so outdoor use of these colors should be avoided.

(c) Impact on appearance, solubility, and removability

GHBA exhibit good lightfastness and present no noticeable shift in color over time. There is no evidence to suggest that an aged acrylic film would present any increasing difficulty in removal over time. GHBP remain removable in xylenes. Freshly applied acrylics have a window of reversibility in water as well as mineral spirits. Reversibility in conservation practice depends as well upon the use of an isolating layer.

At the easel, recent extensive retouching has been removed from the surface of an isolating varnish with applications of a slow evaporating mineral spirits or by swelling with water followed by mineral spirits.

(d) Attraction and retention of dirt and grime

The attraction and retention of dirt and grime is a concern with acrylics used as an artist's material. The Smithsonian *Museum Conservation Institute* notes in the Care of Acrylic Paintings section:

The surfaces of the soft acrylic films hold onto dust and dirt. The paint may even flow around the particles over time, so that they are incorporated into the film...Acrylic paintings attract and gather dirt easily. Acrylic emulsion paints used in the fine arts have glass-transition temperatures (T_g) near or below room temperature. This means that acrylic emulsion films will always be soft at room temperature...acrylic resins are nonconductors and tend to have electrostatic charges on their surface which attracts dirt.

While there is reason for concern about the “cleanability” of fine art acrylic paintings, it is less of a concern with acrylics as they are used in conservation inpainting. The quantity tends to be smaller, thinner, and protected by a varnish—and its function, as a non-original addition, demands that it be distinct and removable and ultimately replaceable.

There has been no anecdotal information to suggest that the attraction of dirt or grime is a problem associated with GHBA in their use as an inpainting medium. However, the possibility for attraction and retention of dirt is at its peak while the film is still wet or soft and before the film dries completely. With that in mind, additives of products such as Acrylic Flow Release (a concentrated surfactant) and Retarder should be used very cautiously or not at all to minimize the potential for trapping dust and particulates in the inpainting layer.

(e) Theoretical lifetime

Frank N. Jones suggests that “While it is not known how long acrylic films will retain their physical qualities, evidence...suggests they will last hundreds if not thousands of years (2004). Individual pigments are rated for lightfast-

ness according to ASTM standards; Golden doesn't use pigments with lower than "lightfastness II."

(9) Health and Safety

Since the GHBA use water as a diluent, they have a very low impact on one's health. Used sensibly, they are among the safest choices available for inpainting. Health and safety concerns are primarily focused on the individual pigments. The release of small amounts of formaldehyde and ammonia during drying is worth noting. Individual jars are labeled in accordance with ASTM standards and carry warnings where needed. Hazardous component information for individual pigments can be found in the MSDS.

The same pigment is safer in its acrylic dispersion than as a loose particulate.

(10) Disposal

Best practice focuses on allowing unused pigment to dry and disposing of it as a solid. Wipe excess paint from the brush prior to rinsing with water to minimize the amount of pigment released into the water system.

Montserrat LeMense

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IV.

Pigments

A. PIGMENTS OVERVIEW

1. Characteristics to Match

a) **Hue**

Hue refers to what is most often thought of as color, i.e., the apple is reddish-orange. It must be remembered that the same pigment may have a different hue when applied transparently versus opaquely. Hue is affected by the choice of binder. The same pigment may appear to be a slightly different hue in different binders. In addition, the hue of a pigment may change subtly depending on how fully it is coated and bound by a binder.

b) **Intensity, Saturation, Chroma**

These terms describe how pure or intense a color is, unrelated to hue or how light or dark the color is. Generally, a pigment appears more saturated when applied transparently than when applied opaquely. The intensity of a pigment's color is affected by the choice of binder and how fully the pigment is bound. Leanly bound pigments tend to appear less intense than those that are more fully bound. Lean paint films generally will become more saturated if varnished or coated with additional medium. Burnishing a paint film, especially a leanly bound one, may permanently increase its color saturation.

c) **Value**

Value refers to how light or dark a color is irrespective of its hue and saturation. The value of a pigment is affected by the choice of binder and how well it is bound. A pigment is more transparent, and therefore, darker when there is minimal difference between the refractive index of the pigment compared to that of the binder. Leanly bound pigments tend to be lighter in value than those that are fully bound because light is scattered by the textured paint surface. Leanly bound paint films will generally become darker if "varnished" with additional medium. Burnishing a paint film, especially a leanly bound one, will often permanently darken it.

d) Particle Size

The particle size of a pigment may affect the appearance of the resulting paint film. Sometimes the optical quality provided by coarse natural pigments cannot be matched by finely ground modern replacements (Ruhemann 1968, 247). In addition, a paint containing exceedingly fine modern pigments may not match well if used to inpaint a loss in a film containing very coarse pigments such as azurite. This optical disparity may be diminished if the painting is given a substantial coat of varnish but would be heightened if left uncoated.

2. Pigment Qualities

a) Refractive Index

The refractive index (RI) describes the relative amount that light is refracted or bent when moving from a vacuum into a given material (Taft 2000, 70–72). When light moves between materials possessing the same RI, it is not slowed and its direction remains constant. The two materials would be virtually transparent in each other. The closer the RI of a pigment is to its binding media, the more transparent the pigment will appear (Taft, 70–71). The refractive indices of the various binders used in inpainting are covered in other chapters in this volume and volumes in the catalog. Comprehensive lists of pigments and their refractive indices can be found in Gettens and Stout (1966), Eastaugh (2004a, 2004b), and the Artists' Pigments handbooks issued by the National Gallery of Art, Washington, D.C. (Berrie 2007, Feller 1986, Fitzhugh 1997, Roy 1993). Individuals interested in specific RI numbers should consult those volumes.

To reduce variables when describing and comparing pigments in the sections below, the author utilized a single binder—a 50/50 v/v mixture of PVAc AYAA and PVAc AYAC in a 80/20 v/v mixture of ethanol and diacetone alcohol. The resin mixture was diluted with the solvents as required. The exact percentage of resin in solution was not standardized. The RI of the PVAc mixture is 1.4665 at 20°C (Gettens and Stout, 75). This should be kept in mind when the author's observations differ from your own.

b) Compatibility

It is important that the conservator choose pigments that are compatible with each other and with the binders and varnishes used for the inpainting and restoration of a painting. There are historical pigments that cannot be safely mixed together, especially when an aqueous medium is used (Thompson 1956, 94). In historical practice, painters were warned, among other restrictions, not to mix pigments that contained lead with those that contained sulfur (Thompson, 94). Modern pigments do not suffer these limitations. The conservator may need to resort to archaic pigments to avoid metamerism (e.g., azurite) or for specific optical qualities (e.g., lead white). The conservator using archaic pigments should consult Gettens and Stout (1966), Harley (2001), Wehlte (1967),

and the aforementioned Pigment Handbooks issued by the National Gallery of Art for compatibility issues.

Some pigments are unstable in alkaline and/or acidic environments. The pigments discussed in this chapter are stable in the common inpainting mediums with the exception of Prussian blue, which may be too sensitive to high pH to be used in an acrylic dispersion binder (Berrie 1997, 200). Conservators using media with a pH outside of the norm should consult the appropriate literature (see Church 1901, Doerner 1934, Gettens and Stout 1966, and the Pigment Handbooks issued by the National Gallery).

c) **Undertone and Mass Tone**

Many pigments exhibit two different colors depending on whether they are applied as a transparent or an opaque film. The hue perceived when the color is applied transparently is known as the undertone (Gottsegen 2006, 137–138). The top tone or mass tone is the color of the pigment when viewed opaquely (Gottsegen, 137–138). The undertone is generally warmer and more saturated than the mass or top tone.

d) **Lightfastness**

Lightfastness describes the relative ability of the pigment to withstand ultraviolet and visible light without changing color or fading. Pigments that are quickly affected by light are called fugitive. Almost all of the pigments discussed below are sufficiently lightfast to be used for inpainting. The few remaining pigments have been retained because they are either very commonly used despite their deficiencies or have unique qualities that make them valuable, such as alizarin crimson. (For an in-depth discussion of lightfastness, see Church 1901, Doerner 1934, Gettens and Stout 1966, Harley 2001, Wehlte 1967, and the Pigment Handbooks published by the National Gallery.)

e) **Specific Gravity**

It is sometimes important to think about the relative density of a given quantity of pigment compared to those with which it is mixed. Conservators could encounter problems if they were to mix very dense pigments with less dense ones, especially if the paint is highly dilute. The less dense pigments may float to the surface of the paint before the medium has set. This could greatly distort the final appearance of the color mixture.

f) **Size, Shape, and Uniformity**

Size, shape, and uniformity/heterogeneity of pigment particles can greatly affect the optical and physical properties of the resulting paint. It is often advantageous for conservators to emulate the textural/tactile quality of the paint they are attempting to match, especially when the painting is leanly bound or unvarnished or when trying to match a historic coarsely ground mineral color.

Splintery pigments, those that lack uniformity of particle size and shape, and natural earths that contain colorless components tend to open up a paint film. This allows light

to pass through the film and bounce back at the viewer, creating a more vibrant color effect (Bernstein 2005). Mixtures of pigments that possess these qualities are often brighter and cleaner than those created using homogeneous, finely divided pigments. The author first heard of this phenomenon from the paintings conservator Jim Bernstein.¹

g) **Tinting Strength**

Tinting strength refers to the power of a given pigment to impart its color to a mixture (Gottsegen, 138). This is usually measured by mixing a given percentage of the pigment with white and comparing the strength of the tint to that of other pigments mixed with the same white. Pigments with a high tinting strength impart more color than those of lower tinting strength.

h) **Covering Power**

Covering power refers to the relative degree of opacity a pigment confers to a paint layer of a given thickness and bound in a given medium compared to other pigments.

i) **Toxicity**

Many pigments are composed of heavy metal salts that can be toxic when inhaled or absorbed through the skin. Nontoxic pigments should be substituted for toxic ones when the circumstances allow. Gottsegen has included the hazards associated with each pigment in his pigment table (Gottsegen, 154–198). When it is deemed necessary to use more dangerous pigments, conservators should limit their exposure by always wearing gloves and a mask. (See also Church 1901, Doerner 1934, Gettens and Stout 1966, and Wehlte 1967.)

3. Pigments Arranged by Color

The author made paintouts of most of the pigments described below (see accompanying illustrations on page 287–289). Kremer Pigments produced almost all of the pigments tested, although some of them had been repackaged by Sinopia. The mid-value azurite and vivianite were procured from Natural Pigments. The remaining pigments were obtained from the collections of the author and that of the Winterthur/University of Delaware Program in Art Conservation. The author used x-ray fluorescence (XRF) to confirm the authenticity of a few samples that were not definitively labeled.

a) **Whites**

Titanium white (titanium dioxide, rutile) PW 6. Titanium white is very opaque and has the most covering power of any of the white pigments. It is a very cold white and can quickly gray out color mixtures and tints. Titanium white and tints made from it are quite cool and bluish when applied in a translucent manner over a darker color. All colors mixed with titanium white gray quickly. Grays mixed from it are noticeably cold.

Zinc white (zinc oxide) PW 4. Zinc white is a semi-opaque white with average tinting strength. It is thought to whiten in resin colors (Feller 1966). Stephen Pichetto used zinc white for retouching, and his inpainting significantly whitened (Hoenigswald et al., 2001, 125). Some conservators suggest that zinc white should not be used for inpainting (Bernstein 2005).

Lead white (basic lead carbonate; flake white, cremnitz white, ceruse) PW 1. Lead white is a semi-opaque pigment with moderate tinting strength. Its hue is a warm white. Colors tinted with lead white retain far more of their innate hue than those tinted with titanium white. Colors mixed with lead white are generally warmer than those of the same value mixed with titanium white. Scumbles tinted with lead white are less blue than those containing titanium white. Lead white is a very toxic pigment that should only be used if it is considered absolutely necessary and with appropriate safety gear, including gloves and dust mask. The author suggests that if conservators must use lead white, they should pre-disperse a substantial amount of the pigment into the appropriate medium following proper safety practices. This would eliminate the need to handle the dry pigment on a routine basis.

Titanium buff (natural titanium dioxide) PW 6:3. Titanium buff is opaque and possesses a creamy yellowish hue. The warmth of titanium buff can be used to create very warm grays and tints.

Lithopone (zinc sulfide-barium sulfate mixture) PW 5. Lithopone is semi-opaque, more than zinc white but less than lead white (Gettens, 125). The author did not test this pigment.

Other whites and inert pigments:

Barium sulfate (natural mineral and synthetic: barium sulfate; permanent white, blanc fixe; base for lakes) PW 21. The pigment is relatively transparent but much less so than the calcium pigments. It could be used to contribute some turbidity to a color mixture while only slightly raising its value (Bernstein 2005).

Calcium carbonate (natural calcium carbonate: whiting, lime white; synthetic calcium carbonate: precipitated chalk, oyster shell white, Gofun shirayuki, Japanese pearl white) PW 18. Calcium carbonate is a very transparent pigment with very little covering power or tinting strength in resin-bound colors. It is much more transparent than titanium, lead, and barium white. It is slightly more transparent than kaolin. Calcium carbonate is less transparent than the silicate fillers mentioned in the appropriate section below. The pigment can be used to adjust the transparency of any of the pigments mentioned or as a matting agent without greatly altering hue or saturation.

Calcium sulfate (natural gypsum, precipitated calcium sulfate) PW 25. Transparent. The pigment has little covering power or tinting strength and resembles calcium carbonate in its chromatic qualities.

Kaolin (china clay, hydrous aluminum silicate) PW 19. Kaolin is transparent but more opaque than the calcium whites and possesses a low tinting strength. The pigment tested was warmer in hue when bound in PVAc than the other pigments in this section. Kaolin could be used in a similar manner as calcium carbonate but the resulting mixture would be lighter and warmer.

Glass platelets, 15 microns. Glass platelets are a very transparent white/filler. They, along with glass beads, are probably the best choice for matting a color without changing its value or hue. By adding the platelets along with additional binder, the conservator can make a color more transparent and cut its tinting strength without changing its hue or saturation. In this manner, titanium white can be made more transparent and modern organic colors can be tamed to more closely resemble the traditional lakes. Jim Bernstein (2005) has performed extensive experiments with the addition of colorless inert materials to inpainting media.

Glass beads 0–50 microns. These are another matting agent that has little effect on hue or value. They can be used in a manner similar to glass platelets.

Fumed silica works well as a matting agent. Extremely fine varieties less than 1 micron may impart a grayish cast to the paint to which it has been added (Bernstein 2005).

b) Blacks

Bone black (“ivory” black from burnt bones) PBk 9. Bone black is a semi-transparent black with good tinting strength. It will gray and muddy all mixtures containing any white. It can be added to pure colors to darken them or to those containing white to gray and cut saturation when this effect is required. Bone black makes a cold gray with titanium white and a warmer gray with lead white.

Mars black (manufactured iron oxide black) PBk 11. Mars black comes in a few variations. All are opaque, have very high covering power, and most are warm blacks. They are less saturated and lighter in color than bone black especially when leanly bound. The exact hue of grays made of it depends upon the variety used. Mars black quickly dirties paint mixtures.

Lamp black, PBk 10. Lamp black is a very fine, dense, greasy pigment. It is a quite saturated bluish-black when fully bound. Grays made with it and titanium white are very blue, while those made with it and lead white are much less so.

Vine black (ground charcoal) PBk 8. Vine black is composed of splinters and chunky particles. It is a less saturated and colder black than bone especially when leanly bound. The pigment exhibits a pronounced granularity especially when diluted or mixed with another finer pigment. Vine black does not impart a lot of color. It is useful for darkening a color without making it muddy.

Spinel black, PBk 26. Opaque. The pigment is very dense and possesses high tinting strength and covering power. Spinel black was created to be the blackest black and is

evenly nonreflective across the visible spectrum (Kremer 2005, 25). It could be useful for creating deep, rich blacks and is the deepest of the black pigments even when leanly bound.

Manganese black (manganese dioxide) Pbk 14. Opaque. The pigment is very heavy, with high covering power and tinting strength. Manganese black is quite gray especially when leanly bound.

Black dyes. The use of dyes for inpainting is discussed in section V of this volume.

c) Blues

Ultramarine blue light (complex silicate of sodium and aluminum with sulfur) PB 29. The pigment is very transparent, a lighter and less violet version of ultramarine. It is probably a better choice when attempting to match true lapis ultramarine. Tints with titanium white appeared far grayer than those tested with lead white.

Ultramarine blue deep, reddish (complex silicate of sodium and aluminum with sulfur) PB 29. The pigment is a very transparent, clean, and reddish-blue of moderate to good tinting strength. Its hue cannot be mixed from other pigments.

Cobalt blue, standard (oxides of cobalt and aluminum) PB 28. Cobalt blue is a moderately transparent blue of low to moderate tinting strength. Its hue is a mid-tone blue that is difficult to mix from other pigments. The pigment is much lighter in hue when leanly bound. The hue does not gray as much in tints with white as do similar mixtures with most other blues.

Cerulean blue (oxides of cobalt and tin) PB 35. Cerulean blue is a semi-transparent pigment with low tinting strength, and its hue is a slightly greenish blue. The color of leanly bound cerulean is much lighter than when it is fully bound. The pigment grays in mixtures with white. Cerulean blue is valuable for its unique color despite its low tinting strength. Cerulean may be useful for matching the finer, greener varieties of azurite.

Prussian blue (ferric ammonium ferrocyanide) PB 27. The pigment is extremely transparent and possesses a very high tinting strength. Prussian is a very saturated greenish-blue that appears almost black in mass tone. Leanly bound, the pigment can exhibit some bronzing. It is greener than phthalocyanine blue, green shade. Prussian blue is cooler and grayer when mixed with titanium white than when mixed with lead. Mixtures in either titanium or lead white produce a color that is grayer than the same mixtures made with phthalocyanine blue. Prussian blue is indispensable for 18th-century paintings and can usually be substituted for phthalocyanine blue when working on traditional paintings. The pigment can be added to bone black to produce deep, inky, and cold blacks.

Phthalocyanine blue, green shade (copper phthalocyanine) PB 15. The pigment is extremely transparent, high in tinting strength, and saturated. Its tinting strength can make it hard to control. The pigment exhibits bronzing when leanly bound. It is much

lighter in mass tone when leanly bound than is Prussian blue. Very clean greens can be mixed from the pigment and saturated yellows. Tints with white are cleaner than those with Prussian.

Phthalocyanine blue, red shade (copper phthalocyanine) PB 15.6. This pigment is very similar to PB 15 except that its hue is less green. It exhibits the same bronzing when full strength and leanly bound.

Cobalt turquoise (cobalt, chromium, aluminum, oxide spinel) PB 36. The pigment is made in a range of shades from bright blue-turquoise, often called cobalt blue greenish, to deep blue green turquoise (Seymore 2003, 135). The author only tested the latter variety. Cobalt turquoise, dark is semi-transparent with a very low tinting strength. Its hue is a clean but substantially greener version of cerulean blue. It is grayed when mixed with both lead and titanium white.

Indathrene blue, indigo shade (organic) PB 60. The pigment is very transparent and possesses a good tinting strength. The hue is a deep but unsaturated blue. Tints with white are substantially grayed but appear more reddish than when unmixed. While the pigment purports to resemble natural indigo, one would need to add some black to the paint to approximate the historic color.

Manganese blue (barium sulfate permanganate) PB 33. The pigment is an extremely transparent, saturated greenish blue with a very low tinting strength. It is a very useful color but is no longer being manufactured. Its hue is quite difficult to mix from other pigments but can be approximated using phthalocyanine blue green shade, phthalocyanine green or viridian, and a transparent extender. It can cause metamerism when used to inpaint sky and therefore is generally not a good choice for skies containing ultramarine or azurite

Historic blues:

Azurite deep, coarse grind (natural copper carbonate) PB 30. Coarsely ground azurite is a translucent pigment of weak tinting strength that possesses a deep mid-blue hue. It is very difficult to manage and so granular as to make it almost impossible to create a workable paint without the addition of another fine textured pigment. It is impossible to make a coherent, evenly covering paintout of this pigment alone in a resin binder. The result resembles a wash of blue sand. The gross particle size of coarsely ground azurite is so alien to modern pigments that the azurite will often sink in mixtures, especially when well diluted in a solvent. This pigment may be useful when inpainting losses in an area of azurite of a similar color to avoid metamerism or when the coarse texture of the original pigment plays an important role in the final appearance of the painting.

Azurite fine, PB 30. The pigment is semi-transparent, less so than the coarse grind above and more so than the extra fine grind below. It possesses a weak tinting strength and a relatively clean hue between that of cerulean and Prussian blue. Azurite fine made a granular but satisfactory paint when ground into PVAc. The granularity became more pronounced as the paint was diluted.

Azurite, extra fine grind, PB 30. The pigment is semi-transparent with less than average tinting strength. The hue of finely ground azurite shifts drastically towards a dull green-blue as compared to the varieties described above. The pigment can be made into a satisfactory paint. The color and other optical properties of the pigment can be well utilized when inpainting the distant vistas seen in Flemish and Renaissance backgrounds.

d) Browns and Neutrals

Burnt umber (iron oxide with some manganese dioxide) PBr 7. The pigment is a deep, rich, relatively transparent brown with average tinting strength. The hue becomes very dull in mixtures containing white.

Raw umber, Cyprus (iron oxide with some manganese dioxide) PBr 7. The color is semi-transparent with a moderate bias towards green. The pigment is easily diluted to transparency. Raw umber appears much lighter in value when leanly bound. The pigment is useful and necessary for inpainting many pre-modernist paintings. Raw umber can be added to color mixtures and glaze layers to dirty them. One conservator uses raw umber to shade mixtures rather than black to avoid the desaturation associated with adding black to color mixtures (Roth-Wells, personal communication, 2008). Grays are often best mixed from raw umber and white rather than black and white unless a very cold gray is required.

Raw umber greenish, dark (iron oxide with some manganese dioxide) PBr 7. The pigment available from Kremer Pigments is semi-transparent, slightly gritty, and exhibits a very greenish-brown hue. The color could be very useful for inpainting losses to the background on 19th-century American portraits.

Mars Browns (synthesized iron oxide) PBr 6. Mars browns are made in a few colors. All are very opaque and dense. They make a good covering paint but may be quite dull compared to the natural earths.

Davy's gray (gray green slate) PBk 19. The pigment is a warm, slightly greenish gray with very low tinting strength. It can be used to shade a color mixture without overly cutting chroma or appearing too heavy (Ruhemann 1968, 249). It is probably best used to dirty a color or as a superimposed layer to emulate patina.

Rottenstone. Rottenstone may be used in a manner similar to Davy's gray as a transparent greenish-gray "dirt" color. The pigment can be used to dirty up other colors or, even better, as a surface effect to emulate an incompletely cleaned surface.

e) Greens

Chromium oxide green, PG 17. The pigment is completely opaque, even over black, and exhibits a very high tinting strength. The color of chromium oxide is a dull, warm green. The hue, saturation, and value remain constant no matter how leanly it is bound. The color shifts slightly towards a cooler green with great dilution.

Phthalocyanine green, blue shade (chlorinated copper phthalocyanine) PG 7. The pigment is an extremely high tinting strength, clean, and transparent bluish-green. Its color can be far too intense and garish for traditional paintings; however, almost any green can be mixed from it. Its color cannot be mixed from other pigments. Use phthalocyanine blue, phthalocyanine green, yellow shade, or the transparent yellows to adjust its temperature while retaining the saturation of the mixture. Less saturated pigments or complementary colors can be used to adjust the intensity of mixtures made with phthalocyanine green, blue shade. Very transparent browns can be mixed from the pigment when added to mixtures of transparent saturated reds and yellows. The tinting strength is so powerful that it quickly overpowers mixtures containing it.

Phthalocyanine green, yellow shade (chlorinated copper phthalocyanine) PG 36. The pigment is very transparent with an extreme tinting strength. Its hue is a middle-green, which is retained with dilution. The pigment is very dark when full strength and leanly bound. Tints with white are cooler. The pigment would be helpful for mixing very strong warm greens. It would probably be a good starting point when attempting to match true emerald green (copper aceto-arsenite).

Viridian (hydrated chromium oxide) PG 18. The pigment is transparent with average tinting strength. Its color is cold, minty green, which shifts slightly bluer with dilution and even more so with white. Mixtures with viridian become muddy much more quickly than those with phthalocyanine green. The pigment is useful to inpaint cracks within skies when mixed with white, often with additions of burnt sienna. The light passing through a turbid medium effect makes the color appear blue.

Cobalt green light (Rinmann's green, complex of cobalt and zinc) PG 19. The pigment is semi-opaque with a low tinting strength. Its hue is a subtle blue-green. The pigment can be granular (Seymore 2003, 158).

Cobalt green (cobalt green-blue oxide, oxides of chromium, cobalt, and aluminum) PG 26. The pigment is semi-opaque with low to medium tinting strength. Two shades of the pigment are produced: a blue green and a grass green (Seymore, 157).

Cobalt bottle green (oxides of titanium and cobalt) PG 50. The pigment is relatively transparent, with low to medium tinting strength. Its hue is a grayish cold green that does not brighten up on dilution. Mixtures with white are even more gray and cold. The sample tested was slightly gritty.

Green earth or terre verte PG 23. Green earth is found in a number of hues ranging from a warm green-gray to a moderately clean, subtle green. All are rather dull, transparent, and earthy greens with minimal tinting strength in resin colors. Green earth is probably more useful in water media than resin colors. The pigment is often quite gritty.

Bohemian green earth, extra fine. PG 23. This grade of green earth is an especially clean green variety. It may be useful despite its low tinting strength in resin bound colors.

f) Oranges

Cadmium orange (cadmium sulfoselenide; some variants are co-precipitated with barium sulfate or as a filler) PO 20. The pigment is relatively opaque with good tinting strength. Cadmium orange is made in hues ranging from a warm scarlet to a deep yellow. They are bright as single pigments but dull somewhat in mixtures and with white. The color and qualities of cadmium orange can make it useful for scumbling over dark spots or fly specks where the orange hue can offset the turbid medium effect (Bernstein 2005).

Titanium orange (mixed phase system of titanium, chrome, and tin) PBr 24. The pigment is an opaque dull orange with low to medium tinting strength. Titanium orange can be used in a manner similar to cadmium orange to cover dark spots (Bernstein 2005).

Irgazine orange (DPP: diketo-pyrrolo-pyrrole) PO 73. DPP colors are relatively opaque organic colors that resemble the qualities of the cadmium colors of the same hue. DPP pigments lack the toxicity of the cadmiums, which they have replaced in the coating industry (Kremer 2005, 20).

Irgazine orange, transparent PO 73. The pigment is extremely transparent with good tinting strength. The mass tone is warm-red, but the pigment becomes more orange with dilution.

Isoindolor orange, PO 61. The pigment is a very transparent, relatively pure orange pigment. The hue shifts towards warm yellow with dilution. It can be used as a replacement for the fugitive and unavailable alizarin orange, although it may require a touch of a transparent red to achieve the exact hue.

Orange earth (natural iron oxide) PR 102. Orange earth is a relatively opaque pigment with strong tinting strength. The hue is a very warm orange-red-brown. The color becomes surprisingly saturated with dilution. The hue is grayed somewhat when mixed with white but the mixture is very like pink flesh.

g) Reds

Cadmium red light (cadmium sulfoselenide; some variants are co-precipitated with barium sulfate or as a filler) PR 108. The pigment is a warm, scarlet, and opaque red, which is a good substitute for genuine vermilion (mercury sulfide). Cadmium red light is useful for making and modifying opaque oranges. It exhibits good tinting strength and coverage but dulls in mixtures and with white.

Cadmium red medium (cadmium sulfoselenide; some variants are co-precipitated with barium sulfate or as a filler) PR 108. The pigment is an opaque, cherry-red body color with good tinting strength and coverage. Cadmium red medium dulls in mixtures and with white. The pigment can be used to make dull opaque purples.

Cadmium red deep, extra deep (cadmium sulfoselenide; some variants are co-precipitated with barium sulfate or as a filler) PR 108. The pigment is a cold, dull, opaque, and deep red color with good tinting strength and covering power. Cadmium red deep is dull in mixtures and with white. It can be used to make dull, opaque purples.

Irgazine reds (DPP: diketo-pyrrolo-pyrrole) PR 254, PR 255, PR 264. DPP colors are relatively opaque organic colors, which resemble the qualities of the cadmium colors of the same hue. DPP pigments lack the toxicity of the cadmiums, which they have replaced in the coating industry (Kremer 2005, 20).

Alizarin crimson (synthesized organic lake) PR 83. Alizarin crimson is very transparent, darker, warmer, and slightly browner in hue than quinacridone red. The pigment's mass tone is much darker when leanly bound. Alizarin retains its warmth with dilution. The pigment is a lake of synthesized alizarin, the primary coloring component of rose madder, which it replaced. The conservator could add an extender such as glass platelets to more closely emulate the earlier pigment. Alizarin exhibits less than satisfactory lightfastness and should probably be replaced with quinacridone red or another lightfast transparent cool red whenever possible.

Irgazine transparent scarlet. The pigment is a very transparent color of good tinting strength that approximates the hue of cadmium red light. It remains brighter and more saturated in mixtures and with white than does the cadmium pigment.

Quinacridone red (organic, linear quinacridone) PR 192. The pigment has high tinting strength, moderate transparency, and is a very intense, transparent, and clean cold red. Quinacridone red appears quite rose when diluted. The sample tested was granular and difficult to disperse into PVAc. The pigment makes clean violets with dioxazine purple, ultramarine blue, or quinacridone violet and surprisingly clean oranges with the transparent yellows despite its cool hue. Its hue is similar in both titanium and lead whites. Quinacridone red may be a good place to start when attempting to emulate alizarin crimson, rose madder, and the cochineal lakes. The conservator would probably need to add substantial amounts of extender and an additional neutral color such as burnt umber to help offset quinacridone's intense chroma and to provide the warmer hue associated with the historic colors.

Other modern organic red pigments:

There are a vast number of organic red pigments available. Almost all are bright, transparent pigments but they do vary greatly in lightfastness. The author has listed only those used or tested by him or suggested by other conservators.

Iron oxide reds:

Iron oxide pigments come in a wide variety of hues and color purity. Natural earths will vary in hue and opacity from batch to batch. Conservators should experiment with a number of iron oxide pigments to determine their favorites. The author has only listed the pigments he has experience with.

Venetian red (natural iron oxide) PR 101. Venetian red is an opaque pigment with strong tinting strength. Manufacturers often substitute the mars colors for the natural earths in their products. The hue is a mid-reddish-brown. The color becomes much more saturated with dilution. Tints with white are a warm pink.

Burnt sienna (natural iron oxide) PB r7. Burnt sienna is a transparent, rich, reddish-orange-brown with moderate tinting strength. It is darker in mass tone than most iron oxides. The hue is quite rich when used alone as a glaze but dulls quickly with white.

Transparent red oxide (iron oxide) PR 101. The pigment is a more transparent, cleaner, deeper, and colder version of burnt sienna. It is great for natural looking but intense glazing colors. The sample tested was quite gritty.

Mars red (synthesized iron oxide) PR 101, 102. Mars reds are produced in a number of shades from orange-red to violet-red. All are very opaque and dense. The color of the mars reds tends to be cleaner than their natural counterparts at least in mass tone. Natural earths can sometimes make a brighter paint as they are more transparent and are a mix of particle sizes.

Indian red (synthetic iron oxide) PR 101. Indian red is an extremely opaque pigment with strong tinting strength. The hue is a cold red-brown, which warms slightly with dilution. The hue is grayed when mixed with white.

h) Violets

Cobalt violet light (cobalt(II)-phosphate) PV 49. The pigment is semi-transparent and possesses an extremely weak tinting strength. The color of cobalt violet light is a pale subtle pinkish violet. The pigment is of minimal use in resin-bound colors except as a glaze.

Cobalt violet dark (cobalt(II)-phosphate) PV 14. The pigment is more transparent and possesses a better tinting strength than the light variety. The hue of cobalt violet dark is a deep reddish violet.

Manganese violet (manganese ammonium pyrophosphate) PV 16. The pigment is transparent, with a relatively weak tinting strength, and is not an especially pure violet. The mass tone is much cooler and lighter when leanly bound. Manganese violet is quickly muddied when mixed with titanium white but substantially less so when mixed with lead white.

Dioxazine purple, red shade (organic, carbazol dioxazine) PV 23 RS. The red shade, discussed here, is much more lightfast than the blue shade. The pigment is an extremely intense, powerful, and transparent violet with a high tinting strength. It appears almost black in mass tone. The hue becomes warmer as the paint is diluted. Dioxazine purple can be useful for making transparent blacks. The pigment may have a bronze sheen if it is leanly bound and not intermixed with other pigments. Mixtures with titanium white appear quite gray-purple but are more saturated in lead white.

Mars violet (iron oxide) PR 101. Mars violet is manufactured in a few variations, from cold red-brown to dark brown-purple. The pigments exhibit extreme opacity and tinting strength. The paint is far lighter in mass tone when leanly bound. All of the mars violets have a hue in the brownish range and gray to a great extent when mixed with titanium white. This is less pronounced when mixed with lead white.

Quinacridone violet (organic, linear quinacridone) PV 19. The pigment is extremely transparent, possesses a pronounced tinting strength, and is a very saturated red-violet. Quinacridone violet becomes bluer as it is diluted. Its color temperature can be further adjusted with quinacridone red to warm or with dioxazine purple or ultramarine blue to cool. The addition of an extender and a brown pigment would be required when attempting to emulate the less saturated red and violet lakes used in the past.

i) **Yellows**

Cadmium yellow medium and deep (cadmium sulfide; some variants are co-precipitated with barium sulfate or as a filler) PY 37. The pigments come in a number of hues, but all are opaque, warm yellows. The pigments exhibit good tinting strength and coverage but are less opaque than cadmium orange and red. The color of the pigment is somewhat dulled in mixtures and with white. Cadmium yellow medium and deep are useful for making and modifying opaque oranges.

Cadmium yellow light or cadmium lemon (cadmium zinc sulfide; some variants are co-precipitated with barium sulfate or as a filler) PY 35. The pigments are opaque cold yellows with good color saturation. Tints with white retain the color's brightness and saturation. The pigment is useful for making and modifying opaque greens with blues and greens. Some believe that the lighter cadmium yellows, those containing zinc, may be prone to lightening or the chalking seen with zinc white (Ruhemann 1989, 251).

Irgazine yellow, PY 110. The pigment is relatively opaque, possesses high tinting strength, and resembles cadmium yellow medium. The hue is quite orange in mass tone but shifts towards yellow with dilution.

Nickel titanium yellow (nickel titanate, titanium yellow, oxides of nickel, antimony, and titanium) PY 53. The pigment is a moderately opaque, pale, greenish yellow. The color is only slightly dulled when mixed with white but greens made from it are not especially bright. The pigment is probably a good starting point to emulate lead-tin yellow and Naples yellow light. Nickel titanium yellow closely resembles the obsolete barium yellow. It could also be used to modify other yellows or greens, like brightening up an ochre.

Cobalt yellow (cobalt potassium nitrate) PY 40. The pigment is a transparent middle yellow that maintains its saturation in mixtures with white. The color of the mass tone is less intense than when diluted.

Iron oxide yellows:

Iron oxide pigments are available in different hues and color purity. Natural earths will vary in hue and opacity from batch to batch. The conservator should experiment with a number of iron oxide pigments to determine which are suited for the task at hand. The descriptions below only include those pigments that the author painted out.

Yellow ochre (natural iron oxide) PY 42. The pigment exhibits moderate opacity and tinting strength. Its hue is a slightly dull yellow. It becomes more intense the more thinly it is applied.

Raw sienna (natural iron oxide) PBr 7. The pigment is a darker, cleaner, and more transparent version of yellow ochre. Raw sienna mixed with bone black can make a good transparent “dirt” color. Raw sienna mixed with white has been used to inpaint the cracks in skies to create a greenish blue, exploiting the effect of light traveling through a turbid medium.

Mars yellow (synthesized iron oxide) PY 42. The pigment is moderately opaque. Mars yellow can be made in a few different shades. These are all purer and are cleaner in hue than the natural products. Despite this, the color effect using the mars colors is sometimes duller than that made from natural earths that have a mixture of particle sizes and include colorless components (Bernstein 2005).

Transparent yellow oxide (iron oxide) PY 42. The pigment is a more transparent, cleaner version of raw sienna. It is great for natural looking but intense glazing colors. The sample tested was quite gritty.

Quinacridone gold (organic; linear quinacridone) PO 48. The pigment is extremely transparent, more so than nickel azo yellow. Its mass tone is dull orange-brown-yellow but becomes a strong yellow-gold with dilution. Its color is substantially dulled in mixtures containing white. This pigment is very useful for warming up paint mixtures and providing the yellow associated with degraded natural resin varnish.

Quinacridone brown-gold (organic; linear quinacridone) PO 49. The pigment is very transparent. Its mass tone is brownish-yellow, and it becomes more yellow when diluted. Mixtures with white resemble full strength raw sienna.

Nickel azo yellow, artificial Indian yellow (nickel complex azo) PY 150. The pigment is quite transparent. Its color is a dull greenish yellow in mass tone but exhibits a moderately saturated and slightly acidic yellow when diluted. The color dulls slightly when mixed with white. This is more pronounced with titanium white than with lead white. The sample tested was quite gritty and difficult to make into a paint. This quality diminished when other pigments were added to the mixture. Nickel azo yellow is a very useful color when a transparent warm yellow is required.

Quindo (Azo) green-gold (nickel azo) PG 10. The pigment is quite transparent. It exhibits a dull sap green hue in mass tone but brightens up to a saturated, acidic, and green-

ish yellow when diluted. The pigment's saturation is greatly diminished when mixed with white. The sample tested was slightly gritty.

Other modern organic yellows:

A wide variety of organic yellow pigments is available. Like the organic reds, these tend to be bright transparent pigments with varying lightfastness.

4. Special Effect Pigments

Bronze powders quickly oxidize and change color even when well bound. Therefore, there is little to recommend their use. Mica iridescent colors are a superior substitute when one needs to emulate a metallic finish with pigments.

Mica iridescent pigments are created by coating mica flakes with titanium dioxide and/or iron oxides which create a realistic metallic effect but do not oxidize (Kremer 2005, 31; Seymour 2003, 37–38). Iridescent pigments are available in a variety of metallic and pearlescent shades. They can be useful for inpainting losses to metallic finishes in place of bronze powders.

Fluorescent pigments are inherently fugitive to light (Gottsegen 2006, 152). Their only use to the conservator is for inpainting losses in areas of fluorescent paint.

There are a number of specialty pigments such as duotone, iridescent, and interference pigments created for the coating industry. Conservators would have little use for these unless they are called to inpaint losses in a contemporary work that utilized such a pigment.

5. Useful Pigment Mixtures

a) Historic Strategies and Mixtures

The following are strategies and mixtures used by notable conservators.

(1) Helmut Ruhemann

In his book, *The Cleaning of Paintings*, Helmut Ruhemann (1968) provided a list of the pigments he used for inpainting. Within this chapter he included a discussion of modern pigments and pigment mixtures that he suggested for emulating archaic, unstable colors (Ruhemann, 247–251). This information is summarized in the following table:

Modern Pigment	Can Substitute For
Titanium white	lead white
Prussian blue	Prussian blue and to a lesser extent, azurite and blue verditer
Opaque oxide of chromium	less stable mixtures of verdigris with lead white or yellow lead oxide
Zinc white	lead white when titanium white would be too opaque
Cadmium yellows & oranges	Yellow lead oxide, Lead tin oxide, red lead, orpiment, realgar, chrome yellows and oranges, Naples yellow, and other obsolete and impermanent colors in this hue range
Cadmium red	vermilion
Mars colors	natural earths
Ultramarine artificial	Natural lapis lazuli ultramarine
Cerulean blue	azurite
Davy's grey	inpainting where the use of black and white would be too heavy
Indian yellow (coal tar) & Hansa yellow	vegetable dye lakes, gamboges, saffron, and the unavailable genuine Indian yellow
Viridian	verdigris, malachite, green copper resinate, and emerald (Paris) green
Cobalt blue	azurite and smalt
Cobalt green	malachite and other copper greens
Alizarin crimson	natural madder lake
Nickel titanium yellow	pale cadmium yellows
Quinacridone red	red lake, despite the fact that it is not as deep

Ruhemann includes the following pigment mixture:

Alizarin orange mixed with black makes a useful transparent brown for the emulation of bituminous brown glazes and brown that have become more transparent with time.

(2) Bettina Jessell

Bettina Jessell (1977) recorded the inpainting strategies and pigment mixtures that she learned and adapted from the conservator Helmut Ruhemann. Those that relate to pigment choices are summarized below:

- Conservators should choose their pigment palette in an attempt to follow that of the original painter.
- Pigments chosen to inpaint a ground layer should probably be more opaque than those for retouching the paint layer proper.
- Jessell points out that the oil binder in aged paintings has darkened and become brown. This has an effect on the color of the paint film. She therefore based "...all colors (even black and white) on a mixture of red and green, covering or transparent according to the layer being inpainted."

She then added whichever pigments seem to match those of the painter's, again transparent or covering as required.

- The heightened transparency and saturation of aged paint films can be replicated by the addition of very small amounts of highly transparent lake colors and bone black.

Color mixtures:

- Deep blacks: ivory black with a little Prussian blue.
- Caucasian skin tones.
- Medium skin tones: light red (or cadmium red or burnt sienna), viridian, Naples yellow, and titanium white.
- Shadows: add ultramarine blue to medium tone.
- Skies: viridian (not blue), burnt sienna, and titanium white. This mixture takes the turbid medium effect and the darkening of the oil into effect.
- White garments (shirts, ruffs, etc.): titanium white, viridian, burnt sienna, and often some ivory black.
- Very dark hot glaze: bone black and alizarin orange.
- Fiery red glazes on early Italian and Northern painting: alizarin crimson, alizarin orange, and bone black.
- Hot glazes: Indian yellow and burnt sienna.
- Brilliant, light colors: First underpaint in pure white, then glaze with transparent color.
- Semi-transparent monochromatic brown underpainting: burnt sienna, raw sienna with a little black.
- Fly-specks, or small stains, should be given a covering coat of underpaint and then glazed with the design layer color in a transparent medium.

(3) Joyce Plesters

Joyce Plesters used the following recipe and mixture of pigments to imitate copper resinate greens (Court, personal communication, 2008):

- Transparent green:

7 parts by wt.	Indian yellow (Winsor and Newton, synthetic)
2.5 parts by wt.	Monastral (phthalocyanine) green (I. C. I. grade GS)

- Opaque green:

10.5 parts by wt.	Yellow ochre (Ralph, Nye, & Biddle)
1.5 parts by wt.	Cadmium yellow pale (Winsor and Newton)
1 part by wt.	Monastral (phthalocyanine) green I. C. I. grade GS)

Mix the dry pigments together on a ground glass sheet with a palette knife. Then add a few ml. of ethanol to give a fairly wet paste. Grind very well with a muller. Allow to dry out thoroughly in a warm place, preferably overnight, then scrape from the glass plate and muller. Wet and rub out again a small sample and if it is not completely homogeneous and streaks of any one pigment are visible, repeat the wet grinding. Pass the thoroughly dried pigment through a fine sieve and pack into dry jars (Court 2008).

(4) Tom Carter

In 1980, Tom Carter at the National Portrait Gallery, Washington, D.C. mixed varying proportions of bone black, alizarin crimson, and Indian yellow on the palette to create an incredible range of saturated transparent browns such as are commonly encountered in old oil paintings (Court 2008).

(5) John Brealey

John Brealey suggested the following pigment mixtures (Stoner, personal communication, 2008):

Transparent discolored oil medium color: mixtures of burnt sienna and viridian.

Transparent dirt color: raw sienna and bone black.

Opaque dirt color: red earth and chromium oxide.

Brealey used a translucent mixture of raw sienna and white to inpaint dark cracks in a sky. The turbid medium effect would make the inpainting appear greenish blue.

b) Turbid Medium Effect

When a lighter color is applied translucently over a darker color, the resulting hue appears far more “blue” because of the “effect of light passing through a turbid medium.” The conservator can compensate for this bluing by adding more of the complementary color, orange, to the mixture, thereby neutralizing the blue. As mentioned earlier, cadmium orange and titanium orange have been suggested for this purpose (Bernstein 2005).

Another strategy is to take the shift toward blue into account when mixing a color. This is the principle behind Ruhemann’s and Brealey’s use of yellow tints to imitate blue-green.

One conservator mentioned the use of genuine Naples yellow (lead antimonate) for tints rather than white to diminish the bluing effect associated with applying a lighter color over a darker one (Roth-Wells, personal communication, 2008).

c) Matching Aged Surfaces and Patination

(1) Increased Transparency

The refractive index of oil paint increases over time, coming closer to the refractive indices of most pigments. This results in the oil paint appearing to become more transparent over time. This can create a paint layer that is deeper and more intense than when it was originally painted depending on the ground color below (Ruhemann, 357). A newly applied paint containing the same pigments would appear less saturated than the original. Conservators often need to use more intense, saturated pigments to inpaint losses in old paintings. Using very transparent pigments and applying them in a manner more transparent than the original paint usually achieves this effect. The problem has diminished in recent years with the ready availability of stable, very saturated, and transparent pigments in almost any hue required. Very transparent, inert fillers such as glass platelets, glass beads, and fumed silica can be added to a paint to make it more transparent without altering its hue. The following are a few suggestions for specific issues:

- To get darker and richer blacks, highly saturated and deep colors like Prussian blue, phthalocyanine green, or dioxazine purple can be added to bone black (Bernstein 2005). Other conservators substitute non-historic blacks such as spinel black to achieve the necessary depth and richness. Some even add alcohol-soluble black dye to their PVAc medium to solve the problem.
- The conservator may require rich browns not possible by mixing standard earth colors. A range of very intense dark browns can be mixed from a few deep, very transparent, and saturated colors. Some use a mixture of ivory black or Prussian blue, alizarin crimson, and synthetic Indian yel-

low (nickel azo yellow) (Court 2008). The author has experimented with mixtures of quinacridone red, Prussian blue or phthalocyanine green, and nickel azo yellow to create glowing browns. Dioxazine purple, phthalocyanine green, and nickel azo yellow can also be mixed to create very useful intense browns. One variant resembled a bituminous glaze.

(2) Darkened Media

The darkening of the oil binder over time can change the color of a paint layer. To replicate this effect in their inpainting, Ruhemann, Jessell, and Brealey added brownish pigment mixtures to all of their colors to impart the necessary color shift.

(3) Patination

Often a paint layer acquires a yellowish patina from remnants of degraded varnish and grime that it was considered prudent to leave on the surface. Some address this by adding brownish-yellow pigments to paint mixtures. Raw sienna is a common ingredient in such mixtures. Additions of quinacridone gold and quinacridone brown-gold are useful for creating a paint that approximates the color of very yellowed natural resin varnish.

It is often necessary to approach this problem in stages. A common method is to inpaint the loss the way the conservator believed that it originally looked. This is generally slightly lighter and slightly colder or grayer. The patination layer can then be applied on top of this layer. The conservator can tailor the patina, adding raw sienna, nickel azo yellow, or quinacridone gold to suggest remaining varnish or add a layer that resembles dirt, using such recipes as listed above from Ruhemann, Jessell, and Brealey. Davy's grey or rottenstone may be well-suited for emulating accumulated grime.

Pigment Timeline and Primary Elements for Characterization Using X-Ray Fluorescence (XRF)		
Pigment	Primary Element(s)	Introduction
White		
Chalk	(Ca, S)	Ancient
Gypsum	(Ca, S)	Ancient
White lead	(Pb)	Ancient
Barium sulfate, artificial	(Ba, S)	1782
Zinc white	(Zn)	1780s
Lithopone	(Zn, Ba, S)	1850
Titanium white	(Ti)	1916
Black		
Bone black	(Ca, P)	Ancient
Ivory black	(Ca, P)	Ancient

Pigment Timeline and Primary Elements for Characterization Using X-Ray Fluorescence (XRF)		
Pigment	Primary Element(s)	Introduction
Mars black	(Fe)	Mid-1800s
Brown		
Brown ochre	(Fe & pos. Al, Si, Ca)	Ancient
Umber	(Fe& pos. Al, Si, Ca)	Ancient
Sienna	(Fe& pos. Al, Si, Ca)	Ancient
Van Dyke brown	(Organic, Fe, Al, etc. pos.)	1500s
Mars colors	(Fe)	Mid-1800s
Blue		
Lapis lazuli ultramarine	(Al, S, Si, Na, & pos. Ca)	Ancient
Egyptian blue	(Cu, Si)	Ancient
Azurite	(Cu)	Ancient
Vivianite	(Fe, P)	Medieval
Synthetic copper blues	(Cu)	Medieval
Smalt	(Co, Si, & K)	1400–1500s
Blue verditer	(Cu)	1500s
Indigo	(Organic)	1600s in the West
Prussian blue	(Fe)	1704
Cobalt blue	(Co, Al)	1802
Synthetic ultramarine	(Na, S, Si, Al)	1827–1830
Cerulean blue	(Co, Sn)	1860
Manganese blue	(Mn, Ba)	1935
Phthalocyanine blue	(Cu, Cl)	1935
Cobalt turquoise light and dark	(Co, pos. Li, Ti, Zn, Cr)	1973
Green		
Green earth	(Fe, Si, Al, K & Mg)	Ancient
Malachite	(Cu)	Ancient
Verdigris	(Cu)	Ancient
Synthetic copper greens	(Cu)	Medieval
Scheele's green	(Cu, As)	1775
Emerald green	(Cu, As)	1814–1822
Cobalt green, Rinman's green PG 19	(Co, Zn)	1780 (introduced in 1830s)
Ultramarine green	(Na, S, Si, Al)	after 1827
Chromium oxide green	(Cr)	1840s
Viridian or hydrated chromium Oxide	(Cr)	1840s
Cobalt Green-Blue oxide PG 26	(Co, Cr, Al)	Late 1800s
Phthalocyanine green	(Cu, Cl)	1938
Cobalt green PG 50	(Co, Ni, Ti)	1960

Pigment Timeline and Primary Elements for Characterization Using X-Ray Fluorescence (XRF)		
Pigment	Primary Element(s)	Introduction
Yellow		
Yellow ochre	(Fe & pos. Al)	Ancient
Raw sienna	(Fe & pos. Al)	Ancient
Orpiment	(As, S)	Ancient
Yellow lead	(Pb)	Ancient
Naples yellow	(Pb, Sb, & pos. Zn in 19th c.)	Ancient, 1600s-still avail.
Lead tin yellow	(Pb, Sn)	1300–1750
Patent yellow, Turner's yellow	(Pb, Cl)	1781
Strontium chromate yellow	(Sr, Cr)	1807
Barium chromate yellow	(Ba, Cr)	1807
Indian yellow	(Mg)	1800s-1908
Chrome yellow	(Pb, Cr)	1809
Cadmium yellow	(Cd, S, & possible Zn & Ba)	1846
Zinc yellow	(Zn, Cr)	1847–1850
Mars yellow	(Fe)	Mid-1800s
Cobalt yellow or aureolin	(Co)	1861
Nickel titanium yellow	(Ni, Ti, Sb)	1960s
Red		
Red ocher	(Fe & pos. Al, Si)	Ancient
Burnt sienna	(Fe & pos. Al, Si)	Ancient
Burnt umber	(Fe & pos. Al, Si)	Ancient
Realgar	(As, S)	Ancient
Cinnabar	(Hg, S)	Ancient
Red lead	(Pb)	Ancient
Vermilion	(Hg, S)	Medieval
Red lakes based on plants and bugs	(possible Al and/or Ca)	Medieval
Cochineal lakes	(possible Al and/or Ca)	1500s
Chrome red	(Pb, Cr)	1809
Pure scarlet, iodine scarlet	(Hg, I)	1814
Mars red	(Fe)	Mid-1800s
Ultramarine red	(Na, S, Si, Al)	after 1827
Alizarin crimson, synthesized madder	(Al)	1868
Cadmium red	(Cd, Se, S, & possible Ba)	1910
Violet		
Murex or imperial purple	(organic)	Ancient
Red lakes based on plants and bugs	(possible Al and/or Ca)	Medieval
Cochineal lakes	(possible Al and/or Ca)	1500s
Ultramarine violet	(Na, S, Si, Al)	after 1827

Pigment Timeline and Primary Elements for Characterization Using X-Ray Fluorescence (XRF)		
Pigment	Primary Element(s)	Introduction
Mars violet	(Fe)	Mid-1800s
Cobalt violet	(Co, early versions had As)	1859
Manganese violet	(Mn)	1868
Alizarin violet	(Al)	1868
Dioxazine violet	(organic)	1929

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ENDNOTE

¹ Conservators who are interested in learning more about this are encouraged to attend the Mastering Inpainting Workshop that Bernstein teaches or to contact Jim directly.

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VENDORS OF MATERIALS USED FOR PAINTOUTS

Pigments:

Kremer Pigments

247 West 29th Street
New York, NY 10001
Phone: (212) 219-2394 or (800) 995-5501
Fax: (212) 219-2395
<http://kremerpigments.com>

Sinopia

321 Seventh street
San Francisco, CA 94103
Phone: (415) 824-3180
Fax: (415) 824-3280
www.sinopia.com/
sinopiasf@sinopia.com

Natural Pigments

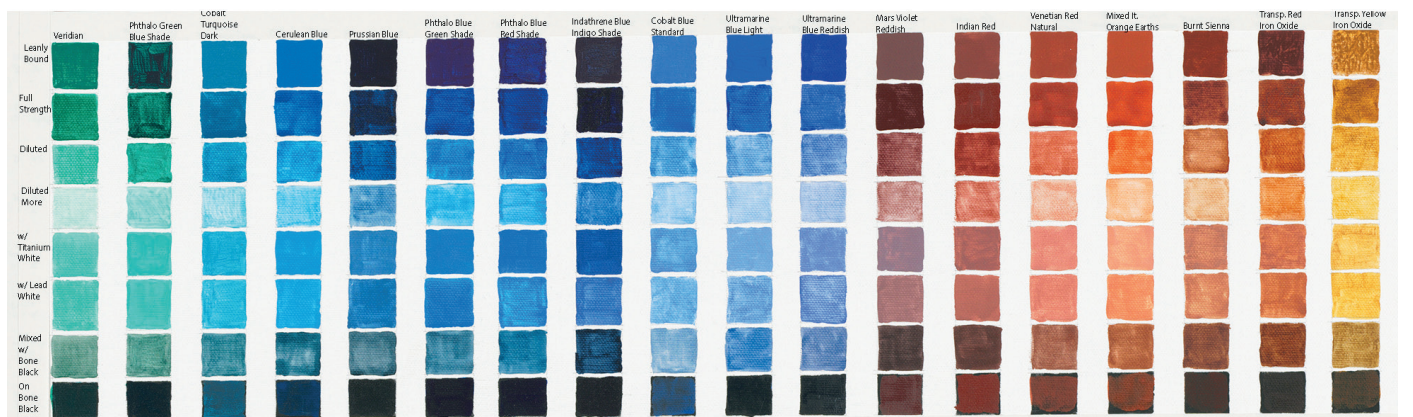
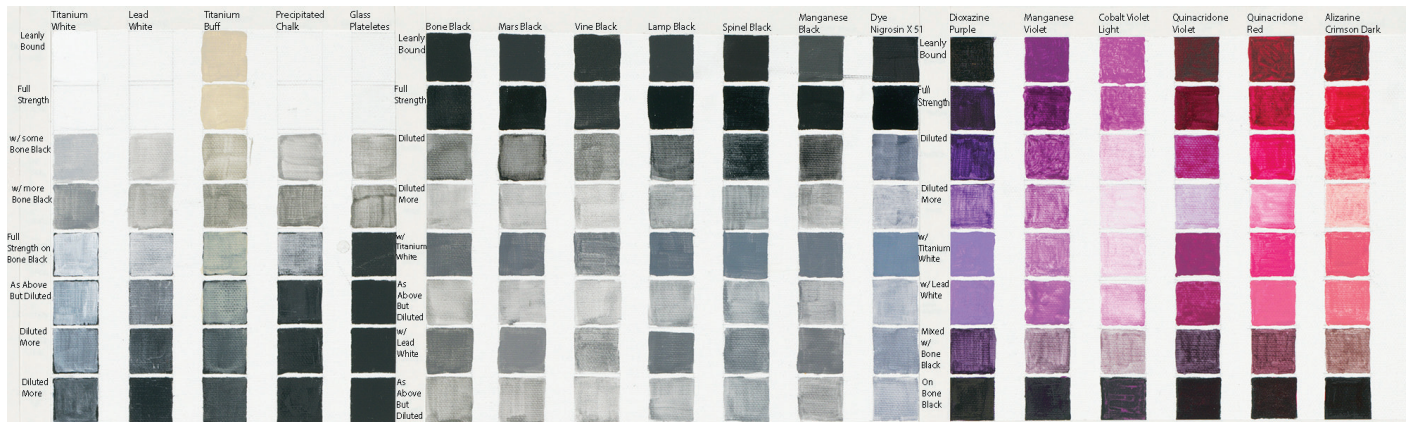
Phone: (888) 361-5900
<http://naturalpigments.com>

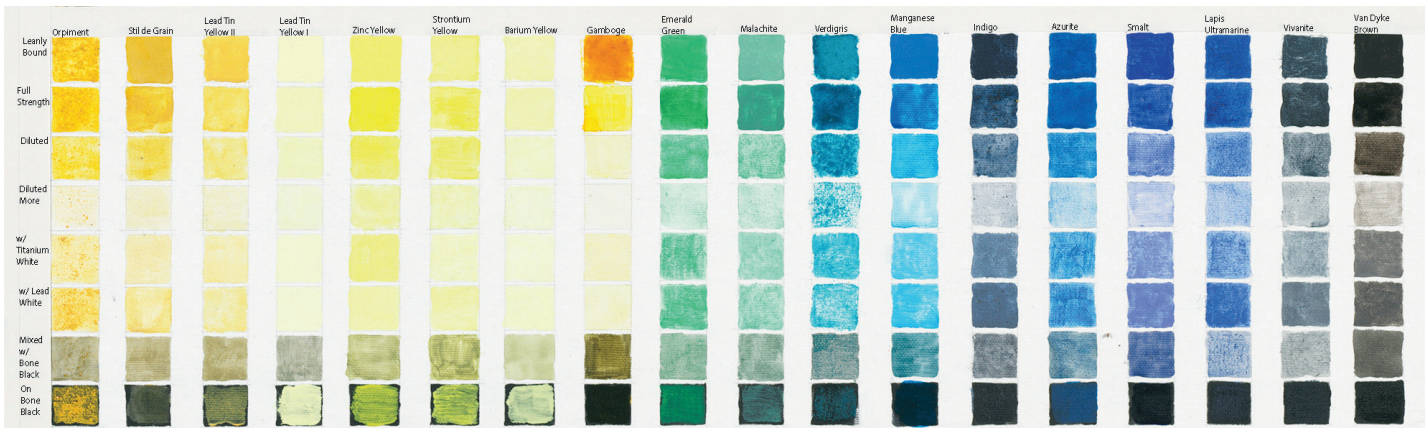
PVAc, AYAA, and AYAB resins:

Conservation Materials Limited

1395 Greg Street, Suite 110
Sparks, NV 89431
Phone: (800) 733-5283

A SELECTION OF HISTORIC AND MODERN PIGMENTS BOUND IN PVAc





Author's paint-outs are included at full size elsewhere on this disc.

Pigments Overview | Useful Pigment Mixtures | Matching Aged Surfaces and Patination

	Titanium White	Lead White	Titanium Buff	Precipitated Chalk	Glass Platelets	Bone Black	Mars Black	Vine Black	Lamp Black	Sprink Black	Manganese Black	Dye Nigrosin X 51	Dioxazine Purple	Manganese Violet	Cobalt Violet	Quinacridone Violet	Quinacridone Red	Alizarin Crimson Dark
Leahly Bound																		
Full Strength																		
Diluted																		
Diluted More																		
w/ Titanium White																		
w/ Lead White																		
Mixed w/ Bone Black																		
On Bone Black																		

	Cadmium Red Extra Deep	Cadmium Red Medium	Transp. Vinyzine Scarlet	Cadmium Red Light	Transp. Vinyzine Orange	Cadmium Orange Light	Hyazine Yellow Deep	Cadmium Yellow Extra Deep	Cadmium Yellow Medium	Cobalt Yellow	Quinacridone Brown-Gold	Nickel Azo Yellow	Cadmium Lemon	Nickel Titanium Yellow	Azo Green-Gold	Chromium Oxide	Phthalic Green Yellow-Gold	Cobalt Berlin Green
Leahly Bound																		
Full Strength																		
Diluted																		
Diluted More																		
w/ Titanium White																		
w/ Lead White																		
Mixed w/ Bone Black																		
On Bone Black																		

	Veridian	Phthalic Green Blue-Blue	Turquoise Dark	Cerulean Blue	Prussian Blue	Phthalic Blue Green-Blue	Phthalic Blue Red-Blue	Indanthrene Blue Indigo-Blue	Cobalt Blue Standard	Ultramarine Blue Light	Ultramarine Blue Dark	Mars Violet Paste	Indian Red	Heckler Red Natural	Terra Occidentalis Orange Earths	Burnt Sienna	Transp. Red Iron Oxide	Transp. Yellow Iron Oxide
Leahly Bound																		
Full Strength																		
Diluted																		
Diluted More																		
w/ Titanium White																		
w/ Lead White																		
Mixed w/ Bone Black																		
On Bone Black																		

	Raw Sienna	Yellow Ochre	Burnt Umber	Raw Umber	Raw Umber Greenish	Green Earth	Bohemian Green Earth	Dry's Grey Grey-Green Slate	Robertson's	Carmine Nacazar	Dragon's Blood	Brazil Lake	Rose Madder	Vermilion	Red Lead	Realgar	Naples Yellow	Chrome Yellow Medium
Leahly Bound																		
Full Strength																		
Diluted																		
Diluted More																		
w/ Titanium White																		
w/ Lead White																		
Mixed w/ Bone Black																		
On Bone Black																		

	Orpiment	Shi de Gran	Lead Tin Yellow II	Lead Tin Yellow I	Zinc Yellow	Strontium Yellow	Barium Yellow	Gamboge	Emerald Green	Malachite	Verdigris	Manganese Blue	Indigo	Azurite	Smalt	Lapis Ultramarine	Wronite	Van Dyke Brown
Leahly Bound																		
Full Strength																		
Diluted																		
Diluted More																		
w/ Titanium White																		
w/ Lead White																		
Mixed w/ Bone Black																		
On Bone Black																		

B. OPAQUE AND TRANSPARENT PIGMENTS

1. Introduction

A working knowledge of the relative transparency or opacity of various pigments will allow a conservator to exploit this property when inpainting. *Opacity* has been defined as “the degree of obstruction to the transmission of visible light” (ASTM 1987). Opacity is thus a relative term, and few paint films are either absolutely opaque or absolutely transparent. *Hiding power*, a term often used synonymously with opacity, is actually a *measure* of opacity (Brill 1980, 85) that can be expressed numerically (ASTM 1987). *Hiding thickness* is the thickness of a specific paint formulation required to achieve opacity (Eastaugh, personal communication, 2005).

The opacity of a paint film is determined to a large extent by the relationship of the refractive indices of the pigment(s) and the binder (or whatever surrounds the pigment, including air pockets). In general, the closer the refractive indices are, the more transparent the paint. Exact refractive indices (η) of many pigments are listed elsewhere (see Eastaugh et al. 2004, Gettens and Stout 1966). The refractive index of polymerized linseed oil is 1.48 (fresh) – 1.57 (aged) (Horie 1995, 185). Walnut oil and poppy oil are listed as $\eta = 1.480$ and $\eta = 1.477$ respectively (Gettens and Stout, 39). The refractive indices of many natural and synthetic resins used as binders in inpainting can be found in Volume 1 of the *Painting Conservation Catalog*. Most of these refractive indices fall within the range given above for linseed oil. Microcrystalline wax with a molecular weight of 600 has $\eta = 1.45$ (Horie, 86). It is difficult to find refractive indices for water-soluble media. Casein has $\eta = 1.53$ (Horie, 184) and dried egg yolk $\eta = 1.525$ (Phenix 1997).

The other factors affecting paint opacity are complex, but include pigment particle size, shape and regularity, dispersion and flocculation, pigment-volume concentration, smoothness of the surface, and thickness of the paint layer. Both adulterants and natural impurities can affect opacity. Thomas Brill has written an excellent and in-depth explanation of how refractive indices and other factors affect paint opacity (Brill 1980). Because of these factors, even the same type of pigment from different sources can vary in opacity. The properties of a pigment from a natural source will vary from the properties of the synthetic analogue. In addition, some relatively opaque pigments can be used in glazes due to their high tinting strength, since only a small concentration of pigment is necessary.

In general, historic pigments except lead pigments are more or less transparent, modern organic pigments are transparent, and most modern inorganic (metal-based) pigments are opaque (see Kremer 2004 and www.specialchem.com). However, there also seem to be exceptions to these rules.

Needless to say, any chart of pigment opacity can only give an indication of the opacity of an inpainting mixture, which will be affected by all the factors described above. In addition, it happens occasionally that sources disagree on a certain pigment's opacity. In the list that

follows, opacity is generally understood to be that in oil or resin-type media. Pigments with “shifting” characteristics, i.e., those that are more opaque when used in some water-based media, are marked. Finally, specialist pigments suppliers offer such a wide variety of pigments that it is impossible to include them all on the list.

Conservators are encouraged to consult these companies and their catalogs when seeking solutions to specific problems or to find the characteristics of modern pigments. Please note that pigment *permanence* is only summarily indicated and needs to be checked separately, as does *toxicity*.

2. Chart of Pigment Opacity

Paint Opacity	
Whites ⁺	
Barium white (Natural barium sulfate. Barites, permanent white)	transparent*
Blanc fixe (Synthetic barium sulfate)	transparent* but less than natural barium sulfate
Chalk (Natural calcium carbonate. Whiting, lime white. Synthetic calcium carbonate: precipitated chalk)	transparent*
Calcite (Natural calcium carbonate. Oyster shell white, Gofun shirayuki, Japanese pearl white)	transparent*
Lead white (Basic lead carbonate. Flake white, Cremnitz white, ceruse)	opaque
Lithopone (Zinc sulfide-barium sulfate mixture)	opaque
Titanium white (Titanium dioxide. Rutile)	very opaque
Zinc white (Zinc oxide. Chinese white, permanent white)	opaque, but less so than titanium or lead whites
Yellows	
Barium yellow (Barium chromate. Lemon yellow, permanent yellow)	semi-opaque
Bismuth yellow (Bismuth-vanadium-molybdate)	opaque
Cadmium yellows and oranges (Cadmium zinc sulfide. Adjectives: lemon, opaque, pale, middle, deep, orange)	opaque, slightly less than chrome yellow. Paler shades slightly more opaque due to smaller particle size
Cadmium yellow (or orange) lithopone (Cadmium zinc sulfide-barium sulfate mixture)	fairly opaque
Chrome yellows and orange (Pure lead chromate. Adjectives: lemon, middle, deep, orange)	opaque
Chrome yellow (Lead chromate and lead sulfate)	opaque, but less than pure lead chromate
Cobalt yellow (Potassium cobaltnitrite. Aureolin)	transparent
Diarylide yellow (Diazo)	transparent
Gamboge (A tree gum resin)	transparent
Hansa yellow and orange (Product of aniline derivatives + acetoacetanilide.)	transparent, decreases with increasing proportions of extenders
Indian yellow, true (Magnesium salt of euxanthic acid)	translucent

⁺ Format: pigment name (approximate composition; alternative names)

* shifts towards opaque in some water-based media

• questionable permanence

Opacity: opaque, semi-opaque, translucent, or transparent

Paint Opacity	
Indian yellow, synthetic (Nickel azo)	transparent
Intense yellow (Zirconium-praseodymium-silicate)	transparent
Lead-tin yellow (Lead-tin oxide, types I and II)	opaque
Mars yellow (Hydrated iron oxide)	semi-opaque, but the most translucent of the yellow iron oxides
Massicot (Yellow monoxide of lead. Litharge differs slightly; see Gettens and Stout 1966)	opaque
Naples yellow (Lead antimoniate. Antimony yellow)	opaque
Nickel-titanium yellow (Nickel titanate. Sun yellow)	translucent
Orpiment (Yellow sulfide of arsenic. Arsenic yellow. Synthetic: King's yellow)	opaque
Quinacridone gold (Quinacridone)	transparent
Realgar (Orange-red sulfide of arsenic. Arsenic orange)	opaque*
Sienna, raw (Iron and aluminum oxides plus hydrous silicates)	transparent, especially Italian sources
Strontium yellow (Strontium chromate. Strontian yellow, lemon yellow)	semi-opaque
Yellow ocher (Hydrated iron oxide with silica and clay.)	opaque*, clay-rich types most opaque; calcium carbonate-rich types less opaque
Zinc yellow (Zinc chromate. Zinc chrome, citron yellow, primrose yellow)	semi-opaque
Reds	
Alizarin crimson (Synthetic organic lake. Alizarin madder, rose madder)	transparent
Cadmium red (Cadmium sulfo-selenide. Selenium red. Adjectives: scarlet, light, medium, deep)	opaque
Cadmium red lithopone (Cadmium sulfo-selenide and barium sulphate)	opaque
Carmine lake• (Natural organic lake. Crimson lake, Florentine lake)	transparent*
Chrome red (Basic lead chromate. Chrome orange, American vermilion)	opaque

+ Format: pigment name (approximate composition; alternative names)

• questionable permanence

* shifts towards opaque in some water-based media

Opacity: opaque, semi-opaque, translucent, or transparent

Paint Opacity	
Irgazine red (Synthetic organic)	opaque
Iron oxide reds, natural earths (Iron oxide 10–95% + silica and clay. Red ochre, caput mortuum, sinopia, Spanish red, Pozzuoli red)	opaque, but high tinting strength
Iron oxide reds, synthetic (Mostly pure iron oxide: Red oxide, Indian red, English red, Turkey red, iron oxide + extenders: Mars red, Venetian red, Pompeian red.)	opaque, but high tinting strength. Mars red makes satisfactory glazes.
Madder lake• (Natural organic lake. Rose madder, crimson madder)	transparent
Naphthol red• (some) (Monoazo)	translucent
Ocher, burnt (Yellow ocher heated to remove the water of crystallization. Light red)	semi-opaque
Permanent red (Precipitated organic pigment. Helio fast red, scarlet lake)	semi-opaque
Quinacridone reds and magenta (Quinacridone.)	transparent
Red lead• (Lead tetroxide. Minium, Saturn red, orange lead)	opaque
Vermilion (Mercuric sulfide. Natural European mercuric sulfide: cinnabar.)	opaque
Browns	
Bitumen• (Natural hydrocarbon mixture. Asphaltum)	transparent
Brown ochers (Natural admixture of ocher and manganese oxide)	opaque
Green earth, burnt (Iron-III- silicate and alumina. Burnt terre verte, Veronese brown)	translucent
Quinacridone burnt orange (Quinacridone quinone)	transparent
Sienna, burnt (Calcined iron oxide. Pompeii red, Italian earth)	transparent
Umber, raw (Hydrous iron oxide and manganese dioxide with aluminum silicate Cyprus umber)	translucent
Umber, burnt (Calcined iron oxide and manganese dioxide with aluminum silicate)	translucent, but a few dark varieties are fairly transparent
Van Dyke brown• (Bituminous lignite or brown coal. Cassel earth, Cologne earth, Rubens' brown)	transparent

† Format: pigment name (approximate composition; alternative names)

• questionable permanence

* shifts towards opaque in some water-based media

Opacity: opaque, semi-opaque, translucent, or transparent

Paint Opacity	
Greens	
Blue-green oxide (Cobalt chromium compound)	translucent
Chrome green (Lead chromate + ferric ferrocyanide. Cinnabar green, Brunswick green)	opaque
Chromium oxide green (Chromic oxide. Reading green)	opaque
Cobalt green (Cobalt zincate. Zinc green, Rinmann's green, Saxony green)	opaque
Emerald green (Copper aceto-arsenite. English green, Paris green, Schweinfurt green, Veronese green)	translucent
Green earth (Ferrous silicates + aluminum and magnesium. Terre verde, Bohemian earth, Verona green)	translucent
Malachite (Basic copper carbonate. Mineral green, mountain green Synthetic: green verditer, green bice)	transparent
Permanent green deep (Hydrated chromium oxide + barium sulfate)	transparent*
Phthalocyanine green (Phthalocyanine. Monastral green, thalo green, heliogen green)	transparent
Verdigris (Basic copper acetate)	transparent
Viridian (Hydrated chromium oxide. Guignet's green, emerald oxide of chromium)	transparent, but thick layers can be opaque
Zinc chrome green (Zinc chromate + ferric ferrocyanide)	opaque
Blues	
Azurite (Basic copper carbonate. Mountain blue, copper blue. Synthetic•: blue verditer, blue bice)	translucent
Cerulean blue (Cobaltous stannate)	semi-opaque*
Cobalt blue (Cobalt aluminate. Thénard's blue, azure cobalt. Adjectives: light, dark.)	semi-opaque*
Egyptian blue (Calcium-copper silicate. Blue frit, Pompeian blue)	transparent
Indigo• (Plant extract indigotin; also exists as the synthetic thioindigo)	translucent
Indanthrone blue (Anthraquinone)	transparent

+ Format: pigment name (approximate composition; alternative names)

* shifts towards opaque in some water-based media

• questionable permanence

Opacity: opaque, semi-opaque, translucent, or transparent

Paint Opacity	
Lapis lazuli (A complex sulfur-containing sodium aluminum silicate. Natural ultramarine, azure)	transparent*
Manganese blue (Mixed crystal barium sulfate-permanganate)	translucent
Phthalocyanine blue (Copper phthalocyanine. Monastral blue, heliogen blue, thalo blue, fast blue)	transparent
Prussian blue (Ferric ferrocyanide. Berlin blue, Chinese blue, Milori blue, Paris blue)	transparent
Smalt (Cobalt silicate in the form of glass frit. Saxon blue)	transparent
Ultramarine blue, artificial (Sodium aluminum silicate-polysulfide. French ultramarine, French blue)	transparent*
Violets	
Cobalt violet (Cobalt arsenate [paler], cobalt phosphate [deeper], or a mix of the two)	translucent
Dioxazine violet (Oxazine. Dioxazine purple, carbazole violet)	transparent
Manganese violet (Thought to be manganese ammonium phosphate. Permanent violet)	translucent*
Mars violet (Synthetic iron oxide)	opaque
Quinacridone violet (Quinacridone)	transparent
Ultramarine violet (Sodium sulfosilicate. Ultramarine red)	translucent
Blacks	
Bone black (Carbon + calcium phosphate, calcium sulfate and salts)	semi-opaque, but used to glaze metal leaf
Ivory black: today virtually synonymous with bone black.	
Lamp black (Pure carbon, with possible oily components. Carbon black)	opaque
Manganese black and manganese gray (Manganese dioxide)	opaque
Mars black (Ferroso-ferric oxide. Iron oxide black, iron black, mineral black)	opaque, but high tinting strength; used to glaze metal leaf
Slate gray	transparent*
Spinel black (Contains copper and manganese)	opaque
Vine black (Mostly pure carbon. Spanish black, blue black, cork black)	semi-opaque

+ Format: pigment name (approximate composition; alternative names)

• questionable permanence

* shifts towards opaque in some water-based media

Opacity: opaque, semi-opaque, translucent, or transparent

3. Exploiting Opaque and Transparent Pigments When Inpainting

a) Introduction

Since the colors of many historic paintings are built up through the use of numerous relatively transparent paint layers, some conservators try to imitate the layered technique of each painting as closely as possible, feeling that it results in the best inpainting match. Others may fear that glazes will not have acceptable color permanence for inpainting.

Determining whether the original passage was painted with opaque or transparent pigments gives the conservator the possibility of achieving an inpainting that matches not only the color but also the depth and luminosity of the surrounding original paint. Observation of Van Heemskerck's flesh tones suggested that his mixture of azurite, yellow ochre, vermilion or iron oxide red, and lead white pigments could be useful in inpainting renaissance flesh colors. In various proportions, you get all shades of pink, grey, purple, light brown, etc. This mixture is luminous, as opposed to a mixture of white and black or white and umber (Woudhuysen-Keller, personal communication, 2005).

Glazing with transparent pigments can be used as an alternative to mixing pigments together. For example, Titian's technique of creating a very dark green by applying a green glaze over a dark red layer could be useful in inpainting (Woudhuysen-Keller 2005).

Applying a transparent or translucent final glaze over a slightly pale area of inpainting is a method used by many conservators to achieve an exact match to the original. For example, John Brealey recommended underpainting a large loss in a translucent oil painting with the *pure* color in tempera and then glazing in varnish medium with raw sienna and ivory black as a transparent "discolored linseed oil" color (Stoner, personal communication, 2005).

A scumble of opaque pigments, applied thinly enough to be semi-transparent, can create a dull, bluish, or hazy effect. For example, in an adjustment of another John Brealey technique, mixing raw sienna with white makes a good starting translucent color to inpaint black cracks in blue skies. Due to Rayleigh's law, the milky "scumble" of those colors turns bluish and often matches the surrounding sky. The color can, of course, be adjusted with ultramarine or viridian, etc., according to the sky (Stoner 2005). Naples yellow can be used to scumble over darker paint and create this bluish effect, also known as the turbid medium effect. Wehlte commented that Prud'hon used Naples yellow scumbled over brown underpainting for shadows of flesh tones (Feller 1986).

Titanium white has such high opacity that scumbles are easily made by combining it with translucent or even transparent pigments.

b) Mixtures Exploiting Opaque Pigments

Naples yellow is an opaque pigment that can be substituted for whites in mixing. A mixture of yellow ochre and cerulean blue can be useful for aged, warm sky colors (O'Malley 1994).

Mixtures of titanium white, vine black, and yellow ochre can be useful to inpaint pale sky blues, possibly with less risk of metamerism problems than when blue pigments are used.

Chromium oxide green and Venetian red make a good opaque "dirt" color (Stoner 2005, attributed to J. M. Brealey).

c) Mixtures Exploiting Transparent Pigments

A glaze of Indian yellow plus vine black can imitate a yellowed varnish.

A general glazing mixture consisting of ivory black, burnt sienna, and Indian yellow is helpful to imitate discoloured varnish or for the final glaze on top of tempera, as well as having many other uses. With more burnt sienna, the tone is warm; with more Indian yellow and black, it is cooler and more greenish. It is a very versatile mixture (Massing, personal communication, 2005, attributed to J. M. Brealey).

Mixtures of Indian yellow, alizarin crimson, and ivory black can be used to create deep, transparent browns. Mixtures of black, Indian yellow, and earths are useful for glazing (O'Malley 1994).

A range of transparent darks that can mimic dirt, discolored varnish residues, etc., can be mixed with alizarin, Indian yellow, and phthalo green. By varying the proportions very slightly, you can make a warmer or cooler and more or less golden brown (Gifford, personal communication, 2005).

Dark glazes can also be mixed using alizarin, Indian yellow, and Prussian blue. Vary the proportions to create all shades of transparent brown, gold, purple, or black (Woudhuysen-Keller 2005).

Phthalo blue or viridian can be added to deepen blacks (O'Malley 1994). A transparent black can be mixed from dioxazine violet and viridian.

Quinacrinone Gold (Golden PVA) is totally transparent with great tinting strength. It can warm up a black dye color (for example, Nigrosin from Kremer pigments is a cold black that can be warmed up by the gold), or it can add that "discolored linseed oil" look to your mix. For 17th-century paintings, burnt sienna and viridian together are another great starter for aged linseed oil matches (Stoner 2005).

Raw Sienna and Ivory Black make a good transparent "dirt" color (Stoner 2005, attributed to J. M. Brealey).

Hooker's green in Charbonnel and Bruno di Garanza from Maimeri will make any shade of degraded/not-so-degraded copper resinate green (Metzger, personal communication, 2004). (Maimeri lists the components of Bruno di Garanza as viridian, diarilide yellow, and anthraquinone. Hooker's green is generally a mix of Prussian blue and, traditionally, gamboge or, more likely today, synthetic yellow pigment.)

Plesters' greens are replacements for copper resinate greens designed to have good permanency by Joyce Plesters, formerly of the Scientific Department, National Gallery, London. Plesters transparent green consists of 7 parts by weight Indian Yellow (Winsor and Newton synthetic) plus 2.5 parts by weight Monastral Green (I.C.I. grade CS). (Plesters Opaque Green: see in the section below.) Mix the dry pigments well together on a ground glass sheet (as large as possible) with a palette knife. Then add a few milliliters of methylated alcohol to give a fairly wet paste. Grind very well with a muller. Allow to dry out thoroughly in a warm place, preferably overnight, then scrape from the glass plate and muller. Wet and rub out again a small sample and if it is not completely homogeneous and streaks of any one pigment are visible, repeat the wet grinding. Pass the thoroughly dried pigments through a fine sieve and pack into dry warm jars.

d) **Mixtures of Opaque Plus Transparent Pigments**

Adding 1– 2% Titanium white to a transparent pigment can make the paint more opaque when this is desired (Kremer 2004).

Plesters opaque green (see above): 10.5 parts by weight yellow ochre (Ralph Nye and Biddle), 1.5 parts by weight cadmium yellow pale (Winsor & Newton), and 1 part by weight Monastral green (I.C.I. grade GS). Mix following the instructions above.

Finally, when it is necessary to match a brilliant color, an observation by Ralph Mayer may be useful. He pointed out that mixing white with a transparent pigment results in the best clarity of tone. Using alizarin as an example, he describes the effect "as if each particle of white were surrounded by an envelope of the transparent red...Tints or mixtures of opaque colors are usually duller" (Mayer 1991, 163).

Janine Wardius

Submitted September 2007

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C. METAMERISM

We tend to think of color as an inherent physical characteristic of a substance, and to an extent that is true. However, external changes can dramatically affect the hue that a substance appears to have. The appearance of a color is not independent of the conditions in which it is viewed. When a conservator is trying to mask damage with invisible inpainting, this may create difficulties. A loss hidden to perfection in one set of viewing conditions may stand out in stark contrast to the surrounding paint in others. This phenomenon is called metamerism.

1. Viewing Conditions

a) **Illumination**

Different types of changes in the viewing conditions can have an effect. The most common, perhaps, is a change in the source of illumination under which the painting is viewed. This is because the spectral power distribution, or the relative amounts of different wavelengths of light that each light source contains, varies considerably. For example, daylight has a fairly even distribution of the different wavelengths of visible light. Tungsten, on the other hand, has a relatively small amount of short wavelength or blue light, and a very large amount of longer wavelength or red light. If you matched a color in the natural light of the restorer's studio and then put it back on the wall in a museum gallery with light provided by a tungsten bulb, much more red light would be shining on it. A retouching that had a little more red in it than the original paint might have matched perfectly well in the even light of daylight. However, with the extra red light provided by the tungsten bulb, it will reflect more red and will no longer match.

b) **Viewer**

Another factor is the viewer. Different people can have biological variations in their color vision. In addition, the lens of the eye becomes progressively yellow with age. A retouching made by an older conservator may prove visible to a much younger viewer (Staniforth 1985, 102).

c) **When Photographed**

Metamerism can also be a problem when a work of art is photographed. A freshly restored painting, photographed for the exhibition catalog, suddenly displays every damage with its metameric retouching. The relative sensitivity to color of color film is different from that of the human eye. Therefore, colors that match to the eye may not match in a photograph. Digital photography may offer a means to correct these problems by adjusting the hue on the computer after the image has been captured.

2. Preventing Metamerism

Because you cannot know under what varying conditions a painting will be viewed in the future, the only way to prevent metamerism from occurring is to match as closely as possible the reflectance curve of the original with the reflectance curve of your retouching. Where you know which pigment or combination of pigments the artist used, and can obtain the same ones, this is not a problem.

However, that is rarely the case. In addition to the problem that some pigments are no longer available or have been found to be unstable, the explosion of available modern pigments and their proprietary formulations have made this process extremely difficult. In addition to the increase in the number of possible pigments used, many applications of paint are complex mixtures of pigments. Michael Swicklik et al. have devised a method, in a relatively simplified way, of analyzing the reflectance of the original and determining a retouching color or color combination that would have a similar reflectance curve. Practically speaking, this is not always possible, as not every conservator has access to a spectrophotometer.

Alternatively, if you know or can make an educated guess as to the original pigment(s), if this pigment is no longer available you can use published reflectance curves of the original and of modern pigments to choose a pigment with a similar reflectance curve. If you know the painting will be viewed under different sources of illumination, check your retouching under all those different light sources. The medium does not significantly affect the shape of a paint's reflectance curve. Adding white to a pigment increases the overall level of reflectance but does not change the shape of the curve and therefore does not have an effect on metamerism.

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Submitted May 2009

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V.

Dyes

A. KREMER ZAPON STAINS/DYES

The Kremer Zapon stains have been used by some conservators as a way to intensify colors on an existing inpainting palette or as a glaze on top of areas if inpainting to adjust the color (see “Inpainting Application Techniques,” below).

1. Format/Preparation for Use

The Zapon stains/dyes are metal-complex dyes manufactured in powder form and available through Kremer Pigments. The dry powder stains/dyes are available in the following colors:

94000 Nigrosin black x 51

94010 Yellow 157

94020 Red 471

94030 Blue 807

a) Preparation for Use

The dyes are soluble in various organic solvents including ethanol, isopropanol, 1-methoxy-2-propanol (commercially available as Arcosolv® PM or Solvenon® PM), and ethyl acetate. The yellow dye is also soluble in acetone. They are only partially soluble in hydrocarbon or aromatic solvents. The blue dye is soluble in toluene.

Typical preparation for use involves first making a solution of the dye in solvent, then adding that solution to an inpainting medium. Dispersion of the dye works best if the inpainting medium is already dissolved in its respective solvent. Some common examples include dry pigments mixed with MS2A or MS2B in Stoddard solvent or commercially available colors like Golden MSA paints mixed with xylenes. The Zapon dyes can be dissolved in a very small amount of alcohol, sometimes as little as a few drops, and then mixed into the medium by dispersing the dye with a brush. Using only a small amount of alcohol allows it to evaporate from the medium so that it won't affect the working properties if hydrocarbon or aromatic solvents are being used. For inpainting

palettes where the diluent has completely evaporated, it is possible to re-dissolve the colors with hydrocarbon or aromatic solvents even if they contain the Zapon dyes. After the initial mixing, the dye stays dispersed in the medium.

If the diluent for the inpainting medium has the same solubility range as the stains, then the stains can be added to the dissolved medium directly in powder form and then dispersed by brush. It is highly recommended that only a small amount of the powdered stain be added at a time due to its high tinting strength. The preferred way to control the intensity of the color is to follow the procedure described above and make a solution of the dye first, and then add it to the medium.

For ease of use, some conservators keep a small glass vial of each dye dissolved in ethanol and then add the dye solution to their palette as needed. An alternate method of preparation involves creating a separate palette with the dyes dispersed in an inpainting medium.¹ This makes it possible to have a clean dye palette that is available to be re-dissolved as needed to adjust the colors on a regular palette. The preparation of this palette is similar to the methods described above; the powdered dye is dissolved or wet up in a small amount of alcohol (typically ethanol), then the medium of choice is added on top of the dye solution. The dye should be completely mixed with or covered by the medium so that it does not powder and contaminate the other colors or increase the potential of inhalation or for getting the powder on clothes or skin.

The dyes can be re-dissolved in the same diluent used for the particular medium as long as the dyes are well dispersed when the palette is made. A separate dye palette makes the colors available to add as a glaze layer or to mix with other colors on a regular inpainting palette (see “Inpainting Application Techniques” below). Once the colors have hardened, the palette can be easily stored or transported.

b) Inpainting Application Techniques

Three inpainting approaches have been described for the Zapon dyes. The majority of conservators who have used the dyes mix them with dry pigments bound in PVAc. The most common solvent used for inpainting with the dyes is ethanol. In all descriptions, the dyes were added on top of one or more layers of isolating varnish, typically PVAc.

(1) Intensifying Colors for an Existing Inpainting Palette

The dyes can be added to an inpainting palette to adjust colors made up of dry pigments bound in a medium or a commercially available paint (such as Golden PVA or Golden MSA). The method of adding the dye to colors already on a palette is dependent on the type of medium used (see preparation for use above). Adding the dye to a pre-mixed color makes it possible to shift the hue or temperature of that color or increase its transparency without losing a certain level of intensity. This approach has often been used for intensifying blacks, particularly in Northern European paintings. One benefit of using the dye to adjust a pre-existing color is that the color can be adjusted without building up thick layers

with inpainting. In addition, some pigments can be coarse or relatively large in particle size, which can affect the texture of inpainting. Inpainting with the dyes does not alter the surface texture substantially, making the dyes a frequent choice for inpainting on smooth panel paintings or paintings on copper.

(2) **Applying an Intense Base Color**

A relatively intense glaze of dye can be laid down on a fill as a base color, and then subsequent layers of inpainting can be applied on top to further adjust the color or texture.

Laurent Sozzani described his method for recreating certain glazing techniques as follows: “When I have a really hot glazed area, I have found that I have better luck doing the opposite of what the artist did...first I lay in the glaze, which is invariably too intense and too hot...over a base color, and then I scumble back over the glaze layer...and bring it to the correct tone” (personal communication, July 31, 2008).

(3) **Applying a Top Glazing Layer**

The dyes have also been applied as thin, transparent glazes on top of a base color to adjust the tone or value of that underlying color. This glazing technique has also been used to simulate a “dirty varnish” appearance. The glaze can adjust old, discolored areas of inpainting or be applied to localized damages on a painting with a yellowed varnish if full treatment is not carried out. For this technique, conservators have often used a combination of the dyes, with the main portion of that mixture being the yellow dye. Combinations of black, red, and yellow have also been used to create a brown-colored glaze.

2. Color Characteristics²

The Kremer Zapon dyes have a high tinting strength and vary in intensity and coloring strength depending on the concentration of the dye in the medium and the thickness of the application. The value or lightness of the colors is also dependent on the concentration of the dye. The colors are very clean and provide relatively pure color.

The colors have been classified by a color index number, a standard classification system that is prefixed with the initials C.I. and followed by a number that identifies the color. The color index numbers are grouped in ranges according to chemical structure (Wikipedia.org) (See Table 1: Chemical Characterization on page 306).

Qualitatively, the yellow dye is relatively warm in tone, which does not appear to change with varying concentration of the color. The red has been qualified as magenta in hue and is slightly cool in tone. Thinner glazes or washes of the red appear to be less cool than a more concentrated layer when observed on top of a white layer or ground. The blue has a slight greenish hue, similar to cerulean pigments. The blue has been combined with the

yellow to achieve certain transparent shades of green. Some conservators prefer not to use the blue when trying to match colors such as azurite, smalt, ultramarine, or indigo in Old Master paintings.³ The black is relatively cool in tone; adding a small amount of yellow to the black produces a warmer hue.

3. Opacity/Transparency

The opacity/transparency of the dyes is dependent on the medium being used, the thickness of application, and the concentration of the dye in the medium. In higher concentrations, the dyes can provide a very intense color and appear almost opaque when applied over a fill. Lower concentrations of the Zapon dyes provide intense, transparent color. The transparent quality of the colors and the potential to achieve intense color in a thin layer have been the main reasons that conservators choose the Zapon dyes for inpainting.

4. Chemical Composition

Product literature from Kremer indicates that the stains/dyes are pure complex-metal dyes.⁴

Table 1: Chemical Characterization

Zapon Stain/Dye	Chemical Characterization
94000 Nigrosin black x 51	C.I. Solvent Black 27
94010 Yellow 157	C.I. Solvent Yellow 82
94020 Red 471	C.I. Solvent Red 118
94030 Blue 807	C.I. Solvent Blue 70, phthalocyanine metal complex

Chemical characterization provided on Kremer MSDS sheets. Last updated February 16, 2009.

5. Chemical Reactivity/Stability

Table 2: Chemical Reactivity/Stability

Zapon Stain/Dye	Chemical Reactivity/Stability	Hazardous Reactions
94000 Nigrosin black x 51	Negligible	Risk of dust explosion
94010 Yellow 157	Negligible	Risk of dust explosion
94020 Red 471	Negligible	Risk of dust explosion
94030 Blue 807	Humidity should be avoided Thermal instability >220°C	Risk of dust explosion

Details regarding chemical reactivity provided on Kremer MSDS sheets. Last updated February 16, 2009.

6. Lightfastness⁵

The lightfastness of the dyes can differ depending on the binding medium, the concentration of the colorant, and the thickness of the layer (personal communication, Eva Eis, Kremer Pigmente, 2008).

Table 3: Lightfastness Ratings	
Zapon Stain/Dye	Lightfastness Rating
94000 Nigrosin black x 51	7–8
94010 Yellow 157	7–8
94020 Red 471	7–8
94030 Blue 807	7

The lightfastness ratings as provided by Kremer representatives are in accordance with ISO 105-A02 (assessment of change in shade) and ISO 105-A03 (assessment of bleeding) (personal communication, Birgit Schiemann, Kremer Pigmente, 2008).

7. Toxicity

Table 4: Health Hazards	
Zapon Stain/Dye	Health Hazards
94000 Nigrosin black x 51	Hazard designation unknown Contact with skin/eyes/clothing, inhalation, and ingestion should be avoided.
94010 Yellow 157	Environmentally hazardous: very toxic to aquatic organisms Contains 6% complex-bound chrome. Contact with skin/eyes/clothing, inhalation, and ingestion should be avoided.
94020 Red 471	Contains cobalt. Contact with skin/eyes/clothing, inhalation, and ingestion should be avoided.
94030 Blue 807	Not considered hazardous according to EEC Directives 67/548/EEC and 88/379/EEC Contact with skin/eyes/clothing, inhalation, and ingestion should be avoided.

Toxicity information provided on Kremer MSDS sheets. Last updated February 16, 2009.

Table 5: Recommended Safety Protection

Recommended Personal Protection	
Protective gloves	EN 374 Nitrile rubber (0.4mm) Chloroprene rubber (0.5mm) Polyvinyl chloride (0.7mm)
Respiratory protection	Particle filter EN 143 or 149, type P2 or FFP2
Eye protection	Safety glasses with protective shields (EN 166)

*Personal protection information provided on Kremer MSDS sheets
Last updated February 16, 2009.*

Important note to reader: There have been recent concerns and discussion regarding the use of the Kremer Zapon stains. The concern relates to the potential of the dye to move through a medium, or migrate, while the solvent remains in that medium. Once the solvent has evaporated, it is unlikely that the dye will then move through the medium. There is also a potential to move the dye through the medium if the solvent has not fully evaporated before layering on top or from later applications of varnish or inpainting that might re-dissolve the dyes. Conservators have typically used the dyes with relatively fast evaporating solvents, such as ethanol. There is also a concern with later removal of inpainting or varnish where the stain would be re-dissolved and potentially discolor porous or imperceptibly porous paint films, both original and recent. Currently, there has been no scientific study directly related to these concerns.

Acknowledgments: I would like to thank Laurent Sozzani for his detailed descriptions of inpainting with the dyes and Carolyn Tomkiewicz for sharing her past experiences with using the dyes as well as her inquiries with Kremer Pigmente regarding the manufacture and use of the dyes.

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ENDNOTES

- ¹ This method of creating a dye palette was described by Laurent Sozzani, Painting Conservator at the Rijksmuseum, Amsterdam. A petri dish can be used for the dye palette because not a lot of color is necessary due to the intensity of the dyes. A ceramic dish with wells can also be used.
- ² According to product literature, the Zapon dyes have not been rated in the CIE or RGB color spaces.
- ³ Petria Noble, Head of Paintings Conservation at the Mauritshuis, indicates that her department commonly uses Prussian blue as a substitute for the blue Zapon dye since Prussian blue is a transparent color that more closely matches the blues encountered in 17th-century Northern European paintings.
- ⁴ In e-mail correspondence from 26 August 2008, Eva Eis of Kremer Pigmente described the dyes as 1:2 metal complexes composed of a central atom and two azo molecules.
- ⁵ Lightfastness rating number available in Kremer product literature and online. See www.kremer-pigmente.com.

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VI.

Compensation for Gilded Surfaces

A. METHODS OF LOSS COMPENSATION FOR GILDED SURFACES

1. Introduction

Gilded surfaces, in which a thin layer of gold is attached to a support, can become worn through cleaning, handling, or general age and therefore sometimes may need to be repaired. While it may seem an obvious choice simply to replace an area of gilded loss using the same method by which it was first applied, this is not always possible or necessary. Methods of compensation vary widely. These include regilding by traditional or nontraditional means; application of powdered gold; and non-gold techniques in which paint, sometimes composed of powdered metal, is used to imitate the gilded surface. To fully reintegrate an area of gilded loss, it is often necessary to distress or tone a newly gilded area as described below. It is important to apply any compensation on top of an isolating layer. Thornton suggests Soluvar® or Acryloid® B-72 for isolating water gilding, while only Soluvar®, with its less polar solubility, is appropriate for isolating oil gilding (1991b, 218).

The information below summarizes the most commonly used techniques for gilded loss compensation, including those used by past restorers and present-day conservators.

2. Gilding Compensation: Superficial vs. Larger Loss

To determine the best method for gilding compensation, it is first necessary to assess the extent of the damage, which generally falls into one of two categories. Superficial compensation is adequate for an area that has been scratched or mildly abraded so that the gilded surface alone is disturbed. More complicated compensation may be required when the extent of the loss is such that both the gilding and underlying surface are damaged or when the damaged surface includes raised gilding or ornamentation, such as punchwork or sgraffito.

a) Superficial Compensation

(1) Non-Gold Techniques

Many of the non-gold compensation techniques now in use were first employed by Italian restorers who followed the lead of the early 20th-century Italian art historian Cesare Brandi, an advocate of reintegration that did not seek to conceal the damage completely. Brandi described this approach as the “second principle” in his book on art restoration theory: “Restoration must aim to reestablish the potential unity of the work of art, as long as this is possible without producing an artistic or historical forgery...” (Bonsanti 2003, 86). Even earlier, this approach had been suggested by other Italian art historians, such as Giovan Battista Cavalcaselle who wrote in 1877, “Wherever the colors are missing just lay a neutral tone nearing the original colors, but keeping it somehow below the vivacity of local zones” (Bonsanti, 83). A benefit of this methodology is that the conservator does not interfere with the original balance of the painting as a work of art or an historic document.

However, among the disadvantages is that non-gold techniques can never recreate the reflective surface of the original, resulting instead in a matte surface.

- (a) **Areas of lost gilding may be inpainted in a flat monochromatic color with yellow ochre or another neutral tone.** The goal is for the eye to pass more easily over the area of loss without disturbing the balance of the original painting. The level of gloss can be adjusted by applying a surface coating or by the choice of paint medium. For example, Liquitex Matte Medium can be mixed with ochre watercolor paint to compensate for matte areas of water gilding, whereas Liquitex Gloss Medium can be tinted reddish brown with watercolors to restore burnished areas of loss (Moyer and Hanlon 1996, 186).
- (b) **A variety of Italian techniques discussed in greater detail elsewhere in the Inpainting volume also may be used for gilded loss,** either using paint alone or by adding metal powder or mica pigment in a “shell gold” technique (see below) to better replicate the light refraction of the original surface (Ciatti 2003, 198).
- (c) **Proprietary acrylic iridescent paints are best used in situations where the gilding is abraded rather than completely lost,** since these paints are fairly translucent and generally have low hiding power. They are made by Golden, Liquitex, and Hyplar, among others. Powdered iridescent pigments also are made to mix with a conservator’s choice of binding medium, but Thornton feels that the commercially prepared paints are more convenient and work as well (Thornton 1991b, 226–7).

- (d) **Metal powders traditionally have been used, but they should be avoided**, since they tarnish over time. However, the tarnish process can be slowed by coating the metal powder with varnish (Thornton 1991b, 226).

(2) Gold Powder Techniques

- (a) **“Shell” or powder gold may be mixed with weak gum arabic**, weak size, or egg white and inpainted in an area of gilded loss. This often is more successful in a loss that was originally oil rather than water gilded (Green 1979, 39–42). To keep the resulting surface from becoming too glittery, the powder should be as finely ground as possible.
- (b) **For a similar effect, finely ground mica powder may be mixed with various media**. It is also possible to apply the binder first to the area of loss and then stipple the powder into the binder with a stiff brush before the medium dries (Moyer and Hanlon, 189).

(3) Mordant Gilding

Mordant gilding using either traditional or nontraditional materials is an excellent means of reintegrating loss in areas that were originally mordant gilded, since it can provide an appropriate level of sheen and covering power for the affected area. Its uses are not limited to replacing mordant gilt areas, but it is not the best choice for gilding where punchwork or incised lines are present, since the mordant would fill the tooled areas during application, preventing a crisp impression.

(a) Oil

Cennino Cennini describes the preparation of linseed oil, the traditional oil used for gilding, in his book sections on oil painting and mordant gilding (1960, 58, 96–8). When oil is used as the mordant, the oil or oil-resin mixture should be painted with a small brush in the desired design area and allowed to partially dry to a flexible, tacky surface. If gold is laid onto the oil mordant too soon, it will wrinkle and deform (Thornton 1991b, 221).

(b) Wax

When the gilding is lost, but the original bole is present, a technique using a wax mordant may be used to recreate an area of loss. The wax used may be in the form of a neutral colored commercially prepared shoe polish, which contains wax and rosin. It is thinly applied to the area of loss, allowed to dry, and then polished with a soft cloth. The mordant can be activated by the warmth and moisture of a breath, after which the gold leaf is immediately laid down and tamped with dry cotton. After a few minutes the gold will have set, and the surface may be polished with dry cotton, resulting in

a lightly burnished appearance similar to that of burnished antique gold (Dwyer Modestini 2003, 222).

(c) Acryloid® B-72

Similar in application to the oil gilding, Acryloid® B-72 may be brushed onto a surface to act as a mordant for gold leaf. The B-72 should be allowed to dry completely and harden. Hardening time depends on the solvents used. Volatile solvents such as acetone will result in a fast drying time, while a slower evaporating solvent has the benefit of allowing the mordant brushstrokes to even out. Once sufficiently dried, the film may be reactivated with a solvent, such as petroleum benzine (alone if the film retains some solvent) or a mixture of 3:1 petroleum benzine:ethanol. The leaf may be applied immediately and tamped with dry cotton. Thornton suggests that this method works best on flat or slightly curved surfaces, since the solvent-activated surface does not stay tacky for long. The surface may be burnished with an agate or polished with dry cotton wool to the desired finish (Thornton 1991b, 222).

(d) Acrylic emulsions

Acrylic emulsions are “surfactant-stabilized suspensions of high-molecular-weight acrylic resin beads in aqueous medium” (Thornton 1991b, 222). Among this group of stable acrylic media are Hyplar, Liquitex, and the Rhoplexes. These media may be tinted with dry pigments or applied in their clear form.

i. Hyplar, Liquitex, and Rhoplex® B-60-A

A thick layer of either Hyplar or Liquitex medium or a thin layer of Rhoplex B-60-A may be applied to an area of loss with a brush, taking care to avoid air bubbles in the film. Rhoplex B-60-A dries quickly, so care should be taken to apply the film evenly. The layer should be left to dry completely, at which point the gilder may activate it by rewetting it with water or by breathing onto the surface to fog the film (Thornton 1991b, 224). Once the fog clears, gold leaf should be laid onto the surface and tamped with dry cotton wool. This surface then may be gently polished with dry cotton wool. These acrylic emulsions are best used as mordants on flat surfaces, large areas of relief, and highlights, since the medium does not maintain its tack for long, limiting the amount of working time (Thornton 1991b, 224).

ii. Rhoplex® N-580 mixed with Rhoplex® B-60-A

Rhoplex N-580 mixed with Rhoplex B-60-A increases the working time, since the N-580 maintains a tacky surface forever. Thornton suggests mixing them in equal parts to increase the hardness of the N-580, resulting in a mordant with a tack similar to traditional oil gilding. He

also advises that the addition of “less than 1% of a synthetic surfactant such as Aerosol OT will keep the Rhoplex from beading up on a shiny surface” (Thornton 1991b, 224). The extra working time gained allows this technique to be used in more intricate areas of design.

b) Larger Loss Compensation

(1) Gesso, Bole, and Gold

The traditional choice for deep losses in gilded areas is to compensate by applying layers of gesso, bole, and gold as described by Cennini (1960, 70–74, 79–82). The gesso should be built up to just below level with the surrounding surface to leave room for the bole. The bole should be made of a clay that best matches the original bole in color, applied thinly to the gesso in a series of layers, and allowed to dry completely. In preparation for gilding, the bole should be wetted with water by brush to reactivate it. The gold leaf may be laid down, covering an area larger than the loss so that the edges may be feathered to better blend with the original (Green 1979, 40). Gold manufactured today is beaten by machine, creating a much thinner layer than that made in the early Renaissance. Modern gold leaf is typically 1/25,000-inch thick (Green, 40), and it is often advisable either to apply a double layer of gilding or to ensure that the gold used is thicker, as is Manetti Deep Double (Leonard 2003, 225–232). With this method of gilding, it is possible to recreate the punchwork or incisions in the area of loss, with the proper tools. Unfortunately, if the loss is too shallow, the fill may be brittle and a crisp punch may not be possible (Fly and Klaar 2004, 6). Conversely, if the gesso fill is too deep, a crack pattern different than that of the original surface may occur in the fill area on drying.

(2) Polyvinyl Alcohol

In Thornton’s chapter in *Gilded Wood: Conservation and History*, he mentions a number of alternatives to the water gilding methods described above using modern materials in place of the traditional ones (1991b, 224–6). Among these variations is the use of clay bound with polyvinyl alcohol instead of gelatin or glue. The polyvinyl alcohol can be activated with water on a brush and then gilded. One may also take a more commercial approach and use Kolner Burnishing Clay, a proprietary bole bound in polyvinyl alcohol that is sold in a wide variety of colors.

(3) Compo

Composition or compo, as it is more commonly known, is a material often used to recreate ornament in gilded objects. It may not be useful for losses on flat gold ground paintings, but it could be used on raised areas of decoration and frames. Most recipes for compo consist of various proportions of rabbit skin glue,

ground pearl hide glue, boiled linseed oil, powdered or crushed rosin, water, and gilder's whiting (Thornton 1985, 113–26). Compo is flexible and can be molded into any shape. It is also pliable enough to take impressions from silicone rubber dental impression compounds to recreate the texture of a surface. An ornament replaced by compo is generally first created in a mold, allowed to set, and then attached to the object, often with epoxy (Thornton 1991a, 12). It is possible to gild directly onto compo after it has hardened by “water polishing the surface with a wet finger or cloth and pressing gold leaf or imitation gold leaf onto the tacky surface” (Thornton 1991b, 222).

(4) **Wax-Resin**

Wax-resin fills are another option for deep losses in gilding. This method gives the appearance of a bole underlayer but allows for more flexibility to create a textured, gilded fill of sufficient detail to match original punchwork or surface texture. One recipe with which the author has found success is a mixture of equal parts yellow beeswax and ketone resin (Fly and Klaar, 7). Pigment may be added to tint the wax-resin to match the color of the bole (Thornton 1991b, 224). The wax is poured into the area of loss and allowed to set. The fill may be flattened and smoothed using a tacking iron and metal plates. A silicone mold may be used to take an impression of any texture or punchwork the conservator wishes to recreate. Wacker Elastosil M4600A/B is a good choice of mold-making material, since it retains a transparency on curing, making it more useful for accurate placement. The wax-resin fill may be gilded by the same process as the wax mordant above by breathing on the surface to activate the wax and laying the gold down.

3. Reintegrating New Gilding

In addition to the burnishing and polishing techniques described above, it is often necessary to alter the new gilding to better blend with its surroundings.

a) **Distressing the Gilding**

Newly gilded surfaces may be distressed either mechanically or with a solvent. Mechanical means include using fine steel wool, a fiberglass eraser, or a scalpel (Green, 40). These can be scratched gently into the new gilding to create the effect of older gold, better blending with the original. Applying mineral spirits with a small brush to new gilding will also partially remove the gold, achieving a distressed surface (Dwyer Modestini, 222).

b) **Toning the Gilding**

Matte varnish may be used to dull down bright new gilding. When toning newly gilded areas with paint, thin, translucent glazes should be applied to avoid a thick, flat, painted

look (Green, 40). Many types of paint can be used to tone gilding, including watercolor (Dwyer Modestini, 222) and dry pigments in Acryloid® B-72 (Dunkerton 2003, 242). Other alternatives include Gamblin Colors or dry pigments in Mowilith® 20 or MS2A, provided it is kept translucent and the solvent used is compatible with the method used for regilding. Proprietary paints like Maimeri or LeFranc and Bourgeois dispersed in varnish may also be used for toning, since they uniformly disperse into the varnish due to their finely ground and already wetted particles (Thornton 1991b, 227).

Joanne Klaar Walker

Submitted February 2010

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VII.

Tips

A. EGG-TEMPERA FOR RETOUCHING CRACKS IN OLD MASTER PAINTINGS

As Chief Restorer at the Metropolitan Museum of Art in New York, John Brealey introduced to his many interns and fellows the following formulation of dammar/egg tempera. It was used primarily in the retouching of cracks, not to inpaint the crack away but only to reduce the visual distraction of dark cracks on lighter areas, mainly in skies or flesh tones. A principle advantage is that the cracks can be covered quickly. The thin paint is pulled into the crack by capillary action and any “overpaint” can be buffed off and away from a varnished surface with cotton after it is dry.

Recipe:

Cleared egg yolk:	1 part
Thick dammar:	1 part
Water:	1 part

Put the egg yolk into a small-necked jar. Slowly add dammar in small amounts, shaking vigorously. After dammar, slowly add water in small amounts, again shaking vigorously to create an emulsion-like solution.

This medium is then mixed on the palette with pigments previously ground in water. In skies, raw sienna and titanium white mixtures were most commonly used.

On a painting with a sufficiently dry varnish, cracks can be painted over quickly. The paint will be drawn into the cracks, and any excess can be buffed off the surface on drying.

Laurent Sozzani

Submitted June 2004

B. PASTEL USED TO MATCH OIL/WAX EMULSION

A system was developed by trial and error to successfully retouch a badly scratched and scuffed painting by Arthur Dove. The medium was one of his oil and wax emulsions on a painting dating from 1937. The surface had a velvety, soft surface quality to it. Pastel was mixed on a piece of mat board to match the desired color, in the process creating a small mound of medium to use as the dry pigments for retouching. The pastel mixture was then applied to the affected areas with a brush using Jim Bernstein's "dry water" (1/2 water:1/2 acetone). The combination of a fast-drying diluent with a chalk/pigment medium provided a near perfect match for Dove's uniquely matte paint film.

Lilli Steele

Submitted June 2004

C. PASTEL USED TO HIDE STAINS IN UNPAINTED CANVAS

It isn't always possible or advisable to remove discreet marks and stains from unpainted canvas, especially when dealing with color field paintings on cotton canvas from the 1950s and 60s. Disrupting the delicate surface structure of the fabric through the application of local treatments, both wet and dry, can quickly lead to unintended problems that may be difficult or impossible to correct.

In some instances, when treating these paintings the author has resorted to toning marks, stains, and abrasions using pastels with good results. The pastels can be applied using a paper stump and adjusted using a sable brush.

Like the canvas, pastels have a nonreflective, matte appearance and are easily reversed with a soft brush and/or vacuum suction should the need arise. The primary downside is that you are applying a material on top of the canvas to simulate a color that comes from within the canvas, and the inpainting will always be evident when the painting is viewed from an extreme angle.

The soft pastels that the author uses are manufactured by Rembrandt and Sennelier. As a class of materials, pastels can be less than lightfast when compared with other artists' materials, but he has used five colors that presumably contain very little if any fugitive colorants (raw sienna 234.10, yellow ochre 227.9, and yellow ochre 227.10 from Rembrandt, and yellow ochre 116 and brown ochre 126 from Sennelier).

Jay Krueger

Submitted April 2010

D. SYNOPSIS OF ARTICLE ON SELECTING PIGMENTS FOR INPAINTING

Article title: “Multiple Pigment Selections for Inpainting Using Visible Reflectance Spectrophotometry.” In *Studies in Conservation* 47(2002): 46–61. By Roy S. Berns, Jay Krueger, and Michael Swicklik

When inpainting a painting, it is very difficult to attain a color match that does not change with the viewing conditions. Ambient lighting conditions with color temperature shifts in addition to changes in the viewing angle of the observer often cause the inpainted areas to shift in color, a phenomenon known as metamerism. This article shows how to utilize a small aperture spectrophotometer and spreadsheet software to select pigments that will minimize color shifts.

The method relies on a single constant simplification of the Kubelka-Munk turbid media theory and on restricting spectral analysis to 420nm and above in order to develop an easily usable database of pigments. By taking a spectral measurement of an area adjacent to the paint loss to be inpainted and subjecting the result to a multiple linear regression, the chosen spreadsheet software selects a set of pigments that potentially shows the least metamerism. The article outlines the theory of this methodology in depth and also provides a step-by-step description of how it should be employed for inpainting applications. The authors cite examples of two successful conservation treatments—for Barnett Newman’s *Dionysius* and Sanford Robinson Gifford’s *The Desert at Siout Egypt*—to illustrate the method.

Michael Swicklik

Submitted November 2008

E. IMAGE PROJECTION AS AN AID TO RECONSTRUCTIVE RESTORATION

A photographic or other reproduction that documents a former, better preserved state of a painting can be used to support reconstructive retouching of altered or lost features. The two techniques described below will maximize the accuracy of placement, proportions, and contours of reconstructed elements through the use of the reference image projected onto the work of art. These comments will not address philosophical or ethical issues surrounding degrees or styles of visual compensation, but will be restricted to basic practical matters.

Projection of the reference image allows the fullest application of the information it contains to the task of reconstruction, as well as the best possible reintegration of what might otherwise be completely decontextualized fragments of surviving original paint. Two points should be observed if the reconstruction is to take best advantage of the reference documentation:

The reliability of the reference image must be investigated as thoroughly as possible. Special care should be taken to consider the accuracy of the image's tonal and/or chromatic rendering of the painting; specific distortions or deficiencies may require attention in interpreting the image.

The success of all projection-guided reconstruction depends on accurate registration between the reference image and the surface of the work of art. Reliable registration can be achieved by aligning at least three widely separated features. This usually entails considerable trial and error due to various possible sources of geometric distortion in the original photography and in the alignment of the projection device relative to the work of art. Perfect registration can be elusive, but the effort to achieve it pays off in superior results.

1. Technique One: Direct Projection

a) **Equipment and Setup**

For direct projection of the image onto the work of art using a slide-, overhead-, or digital projector, the projector should have the capacity to adjust image size as well as focus. An easel with smoothly operating mechanisms and lockable casters is important. The projector is set up at a suitable distance to produce an actual-size image of the painting or a part of the painting. The best possible registration may involve adjustments to the position of the projector, the painting on the easel, or the easel itself. It has proven helpful to start by having the surface of the painting plumb and perpendicular to the beam of the projector. The projector should be level, and the center of the projected image should correspond to the midpoint of the corresponding portion of the painting. It may be helpful to have shims or shallow wedges on hand. The registration and focus

of the projected image are best checked with a piece of white paper held to the surface of the painting. Once the projected image is congruent with the painting, it is a good idea to unplug the projector rather than turn it off with the switch to avoid shifting it out of alignment. The light level in the workspace should be adjusted for an optimum balance between the visibility of the projected image and the painting itself. Because this method requires working with reduced visibility, it is primarily useful for ensuring accuracy of drawing, specifically the placement of contours and reference marks to be followed while retouching afterward under standard lighting conditions for retouching. It is preferable to apply any such guide drawing in a medium that can be removed later in the reconstruction process without disrupting the retouching or varnish surface.

2. Technique Two: Stereomicroscope Projection

a) Equipment and Setup

This technique was developed for reconstruction of fine details. It superimposes a photographic image onto the painting surface using a stereomicroscope. The microscope must have a continuously variable zoom and individually focusable eyepieces. Although it is possible that a number of models and makes of microscope could be used or adapted for the technique, it was developed using a Wild-Heerbrugg M8 with 10X oculars. The particular configuration of the M8 allows a disc of film cut from a detail slide of the source photograph to be placed, as described below, at a location in one ocular tube such that the photographic image and the surface of the painting can be viewed simultaneously in perfect focus. To compensate for the generally lower level of light reaching the eye through the photographic image, it is necessary to place a neutral density filter in the other ocular tube to obtain a convincingly merged stereo image. The best density for this filter can be chosen from a selection made from bracketed, out-of-focus transparencies of a neutral gray subject.

b) Scale and Preparation of the Photographic Image

It is desirable to make reference to and work on as large an area as possible, which means working in the range just above the microscope's lowest magnification. The lowest magnification on the M8 stereomicroscope used, 6X, gives a field of view of about 1-5/8" diameter and at 9X, a field of view of about 7/8" diameter. At any given microscope magnification, the actual image size on the slides made from the source photograph must fall within a specific range. In our experience, the most useful ratio of the slide image has been 1/2 to 3/4 life size.

Any general reference on photography can provide guides for figuring magnification ratios, but here is a practical tip for achieving ratios in this range: the 35mm format seen in a camera viewfinder represents an area 25mm x 35mm (or roughly 1" x 1-1/2"). A 50mm (about 2")-long feature on the *painting* that fills the short (25mm/about 1") dimension of the format will appear at 1/2 life size on the film; if that same 50mm-long feature is made to fill the long (35mm/about 2") dimension of the format, it will be 3/4

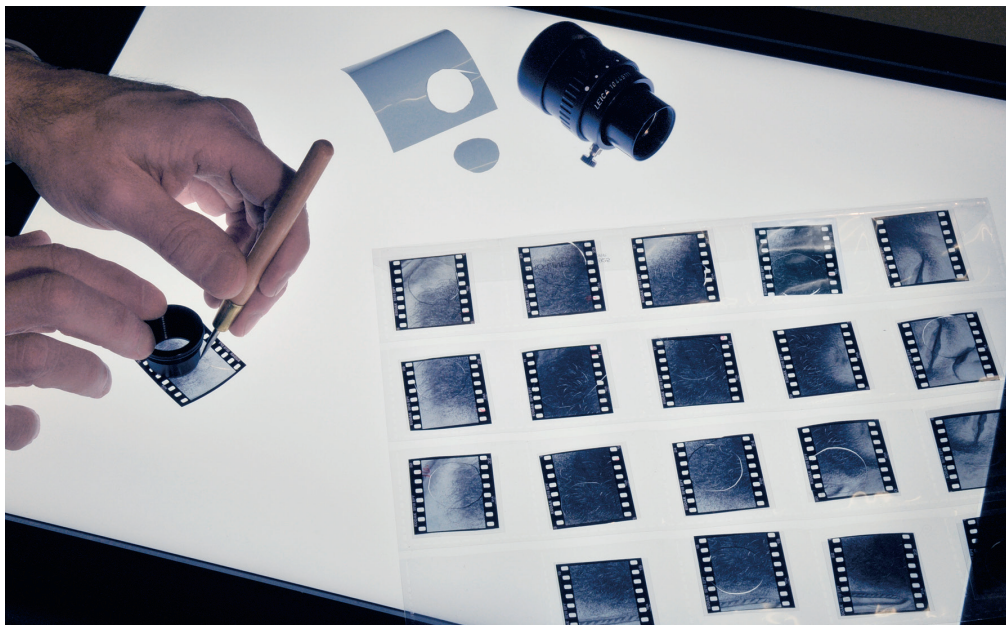


Fig. 1: Page of Overlapping Slide Views



Figs. 2 & 3: Cutting of Film Discs and Their Attachment to Microscope Eyepiece

life size on the film. Note that the size of a feature on the source photo itself does not matter, just the relationship between the size of the feature on the slide image made from it and the actual size of the feature as measured on the surface of the painting.

Obviously, the reconstruction of an area bigger than the field of view of the microscope requires making a number of overlapping slide views (see fig.1). It is also useful to bracket exposures and select what provides the most information in any particular area.

To make the photographic film disc that goes in the microscope, the slide film is removed from its mount and placed on a light box. An eyepiece is removed from the microscope ocular tube and the short section of knurled, threaded tube at the end opposite the lens is unscrewed and removed. This piece is placed with its narrow end down on the slide film to select the area of interest. The circular shape of the tube's exterior is scored on the film with a sharp needle and scissors are used to cut out the disc, which

is then affixed to the narrow end of the tube with small tabs of clear adhesive tape (see fig. 2). The short threaded tube, with film disc attached, is then screwed back into the eyepiece, which is then inserted back into the microscope ocular tube (see fig. 3). A disc cut from the neutral density filter slide can be affixed to the other eyepiece in the same way. Either eyepiece can be used for the reference image, although a survey of a few colleagues has suggested there may be an advantage to pairing the photographic image with one's dominant eye.

c) Focus and Registration

The painting is positioned under the microscope in the most convenient orientation for working; the image-containing eyepiece can be rotated within the ocular tube to match this orientation. To begin, the photographic image is focused using just the eyepiece diopter focus for that eyepiece; it helps to have an illuminated sheet of white paper under the microscope. The white paper is removed and the painting surface is brought into focus. If the painting surface does not have distinct enough features to allow focus to be judged clearly through the photographic image, a piece of white paper with some dark lines drawn on it can be placed on the paint surface as a focusing aid. Once the photographic image and the painting surface are in focus in one ocular, the other ocular can be focused. Next, the photographic image and the paint surface are brought into registration by using the microscope zoom to increase or decrease the magnification of the painting to match the scale of the photograph. Registration is confirmed by matching up at least three widely separated features visible in both the photographic image and on the painting (brushstrokes, cracks, losses, or the like.)

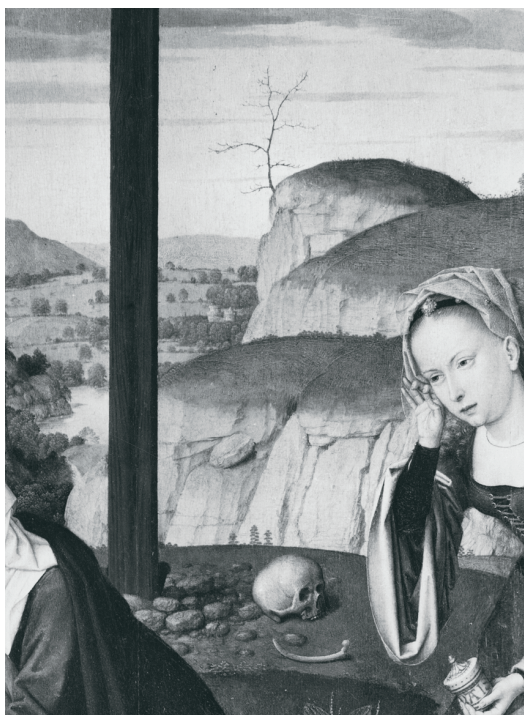
With everything in place, the image and paint surface in the closest possible registration, and with a little practice, it becomes possible to visualize the photographic features as resting on the paint surface, at which point they can be followed to reconstruct what is missing. Checking the progress and quality of the retouching while working is a simple matter of looking through the neutral density filter eyepiece only. Checking something on the photographic image only is easily done by slipping a piece of white paper under the microscope. In practice, the work may involve much looking through the "photograph" eyepiece only, in which case an eye patch can be worn on the other eye to eliminate the discomfort of keeping it closed for prolonged periods. The color and overall appearance of the reconstruction can be checked and adjusted under normal viewing circumstances, away from the microscope, as frequently as necessary.

When reconstructing a larger form that also contains fine detail, it is best to alternate between the direct and microscope projection methods, combining the particular advantages of each. Also, it is worth noting that the projection techniques described here could be equally useful for some types of objects other than paintings.

Mark Tucker

Submitted May 2004

Gerard David, *Lamentation*, John G. Johnson Collection, Philadelphia Museum of Art, Cat. 328



1. Detail from c. 1900–10 photograph: rocks at base of Cross and middleground tree



2. After 1930s treatment. Same view with rocks and tree removed in 1930s cleaning



3. Before inpainting, recent conservation treatment.



4. Same view of painting with rocks and tree restored using directly projected photographic image

**Stereomicroscope projection
for reconstruction of fine
details:**

Jacometto Veneziano, *Portrait of a Lady*,
John G. Johnson Collection, Philadelphia
Museum of Art, Cat. 243



1. Detail from c.1900–10 photo



2. Same view of painting showing loss of painted
details (strands of hair, eyebrows) in 1930s cleaning



3. Same view of lost details restored using stereo-
microscope projection



1. Detail of archival photo: St. Jerome's beard

Simon Marmion, *St. Jerome and a Cardinal Praying*,
John G. Johnson Collection, Philadelphia Museum of
Art, Inv.1329



2. Same view with large portion of beard
removed in 1930s cleaning



3. Same view of beard reconstructed using a
combination of stereomicroscope and direct
projection

F. SIMULATING CRACKS IN OLD MASTER PAINTINGS

In *The Cleaning of Paintings*, Helmut Ruhemann named three methods to simulate paint cracks in Old Master paintings: drawn, painted, or scratched (p. 184). The following tips, gathered as part of a limited and informal survey, suggest that conservators rely on these same techniques today.

Drawn cracks are made with a sharp pencil on top of the retouching.

Preference is divided between hard and soft pencils.

Painted cracks are made using a finely pointed brush and black paint.

The use of watercolor allows working back in with resin-based paints or varnishes without blurring the crack (Frank Zuccari, personal communication, 2010). Ox gall may be added to the watercolor to reduce surface tension.

When using watercolor, the cracks can be narrowed and sharpened further by brushing the edge with a clean, moist watercolor brush (Charlotte Hale, personal communication, 2010) or a microspatula (Dianne Modestini, personal communication, 2010).

Scratched cracks are made using a needle or needle-tool to incise lines into the fill or retouching.

Cracks may be scratched into a layer of Plaka. Used as a fill material, Plaka is easily carved and the colors are opaque. But, since Plaka must be removed mechanically, it should be applied only as a thin layer on top of a gesso fill that itself covers areas of complete loss in the painting.

When a dark-colored fill is used beneath the retouching, the scratched cracks will be dark (Knut Nicolaus, *The Restoration of Paintings*, 1999, page 299; as noted by Joyce Hill Stoner in her book review that appeared in the January 2000 issue of the *WAAC Newsletter*).

Scratching may be useful if the cracks are wide (David Bull, personal communication, 2010).

Cracks are more often brownish, rather than black. Care should be taken to simulate fewer cracks than one might think necessary, to avoid the area taking on a life of its own. The underlying retouching should be kept slightly lighter, cooler, and brighter since the addition of cracks will make it darker, warmer, and dirtier (Dianne Modestini, personal communication, 2010).

Elizabeth Walmsley

Submitted December 2010

VIII.

Instruments and Equipment

A. TYPES OF LIGHTING

1. Lighting

a) **Artificial Light**

There are three basic types of artificial light-producing lamps in common use in conservation labs today.

(1) **Tungsten (Incandescent Lamp)**

Tungsten lamps give off light by sending electric current through the enclosed coiled tungsten filament, thus heating it. They come in a large variety of forms and voltages for household and commercial uses. This type of lamp is generally not energy efficient, however, and gives off a lot of heat for the amount of light produced. Tungsten bulbs cover the whole spectrum but tend to emit more in the red region.

(2) **Fluorescent**

Fluorescent lamps are typically tubular-shaped glass and contain mercury vapor. The inside of the glass is coated with a powder, which phosphors or fluoresces in the wavelength emitted by the mercury vapor when excited by electric current. There are many phosphors with varying spectral characteristics. The standard office bulb, cool white, emits little to no light in the red region while the majority of the light is emitted in the green spectrum. Manufacturers can pick phosphors to create different color ratings. For full spectrum bulbs, they add red-emitting phosphors to the mix, but the bulbs still lack some wavelengths, and they have spikes in other areas (red, green, and blue). Fluorescent lamps are more energy efficient than tungsten lamps.

(3) **Metal Halide (Halogen Lamp)**

Metal halide lamps are a type of gas discharge lamp. The addition of small amounts of metal halide to a mercury vapor mixture within the lamp improves/modifies the color of the light. This type of lamp emits much less heat than an equivalent tungsten lamp and is typically more energy efficient than fluorescent lamps. Wide ranges of full spectrum bulbs with varying color output are manufactured.

b) **Natural/Window Light**

Natural light from the sun, particularly the more even and less directional light from north-facing windows, is often the best source of light for most inpainting purposes. Some conservators prefer this in the form of diffuse natural light as experienced during cloudy but bright and/or foggy days. Many conservators choose to set up so that the daylight is at a raking angle to the surface being inpainted, to highlight details of the surface. Two downfalls of relying solely on natural light for inpainting include uncontrollable changes in the amount of light due to the time of year, weather, or geographical location; and the potential for inpainting to exhibit metamerism in some gallery lighting. Checking the painting in the lighting conditions in which it will be displayed or using lights similar to the display condition to supplement natural light while inpainting can help mitigate the latter.

c) **Color Temperature**

In lighting, the term *color temperature*, which is measured by the unit Kelvin, is used to describe the appearance of a light source. In general, lighting above 4000K is considered cool and is often bluer in appearance, while lighting below 3200K is warm and appears more yellow. Choosing a light source with an appropriate range or color temperature can be important to help avoid metameric failure when inpainting is viewed under a different light source. Many conservators choose to work at or around a color temperature range of 5000–6000K, a range that is often similar to natural light. It is important to note that the Color Rendering Index (CRI) and color temperature of a lighting source are closely related. For example, a bulb with a color temperature ranging between 5000–6000K cannot be compared to natural light unless the CRI of the lighting source is above 90.

d) **Color Rendering Index**

The Color Rendering Index (CRI) is a method for describing the effect of a light on the color of an object. Knowing the CRI of lamps and other light sources can be useful when comparing different light sources for inpainting. The CRI can distinguish between light sources that emit the same “color” of light. The higher the CRI of lamps with color temperatures of 5000–6000K, the better objects appear compared to natural/window light and the outdoors.

2. Characteristics of Individual Lamps Currently in Use by Conservators

a) **Burton CoolSpot® Lamp**

Typically used in the medical field, Burton CoolSpot® lamps are available in varying models, including a freestanding floor stand model. This halogen lamp produces a strong beam of light (with 4 separate intensity settings for spot size) with mid-range color temperature, averaging 3500K. This color temperature is ideal for inpainting when the ambient lighting consists of mixed warm and cool overhead fluorescent lights and natural/window light.

b) **Fotolite Stand Light Paired with Compact Fluorescent Bulbs**

The Fotolite stand light is a much more economical alternative to many of the high-priced photography and gallery lights available. Designed as a light source for painting portraiture and still life subjects, this artist lamp stands 7 feet high with an aluminum cone intensifier and wooden handle for adjustments. The lamp can be paired with various “daylight” compact fluorescent bulbs (up to 75W). Unfortunately, for inpainting purposes, just one light is typically not enough, so multiple are needed. In addition, some conservators find that many of the daylight rated compact fluorescent bulbs are too cool in appearance when used in this setup, making it difficult to inpaint blues and greens.

c) **Lowel Scandels Light and Cone**

Lowel Scandels light and cone setup is typically referred to in the conservation field as “Scandels.” The lamp fixture is fitted with eight small fluorescent lamps within a Polycarbonate Lamp Shield set inside a cone intensifier. The lamp is available as either “daylight,” at a color temperature of 5300K, or in the “tungsten corrected” variety at 3000K. While the “daylight” variety efficiently mimics natural/window light, interchanging a few bulbs can allow the conservator to carefully control color temperature and intensity, catering to specific lighting or inpainting needs. Many conservators use these lamps to boost existing daylight in their studio while inpainting. Unfortunately, these lights can be quite expensive.

d) **SoLux Track Lights/SoLux Bulbs**

SoLux Premium Low Voltage Track Lighting is currently available in a variety of different styles with bulbs available in four different color temperatures—3500K, 4100K, 4700K, and 5000K—and a variety of beam spreads, including narrow-spot, spot, narrow-flood, and flood. These incandescent bulbs differ from other incandescent sources as they are designed to emulate daylight by reducing portions of the visible spectrum (particularly in the red region). Combination of these light sources can create acceptable lighting conditions for color mixing and inpainting (i.e., two 3500K narrow-flood lights

and two 4700k spotlights). While the heat created by these lamps is dissipated through the back of the lamp, this can be hot to the touch if the lamps need to be repositioned during the inpainting process. SoLux lighting is currently used by a number of museum galleries around the world.

e) **Fluorescent Tubes for Overhead Lighting**

When faced with selecting overhead lights, many conservators turn to fluorescent lighting sources. There are a variety of color-corrected and “superior color rendering” varieties of fluorescent tube lights manufactured for household and commercial use. Alternatively, some conservators choose a mix of warm- and cool-toned fluorescent lights to achieve a desired range of light. Below is a selection of fluorescent bulbs currently in use by conservators with their associated parameters.

(1) **Philips TI950 Full Spectrum Fluorescent Bulbs**

These fluorescent bulbs are available in various lengths and have a color temperature of 5000K at a CRI of 98.

(2) **GE Chroma 75 Fluorescent Light Bulbs**

Although a lighting industry standard for color matching, the GE Chroma 75 is distinctly blue in appearance with a color temperature of 7500K and a CRI of 92.

(3) **Osram-Sylvania Fluorescent Tube Light Bulbs**

Very slightly warmer in tone, the Osram-Sylvania Fluorescent Tube Light has a color temperature of 4100K and a CRI of 75.

(4) **Sylvania Daylight F20t12/D Fluorescent Bulbs**

These bulbs have a color temperature of 6500K and a CRI of 76.

f) **Smith-Victor 600 Watt Halogen Softlight**

This halogen light provides a soft, non-glaring, even, and diffused light that can be good for inpainting. Designed as a photography light, it is available in a kit of three lights (amounting to a total of 1800W), which includes aluminum light stands and a cart with wheels.

B. PALETTES AND MIXING TOOLS

1. Palettes

a) **Ground Glass**

With a nonporous hard surface, ground glass palettes are perfectly suitable for mixing or dispersing colors while allowing for fairly easy cleanup of inpainting materials. The slight “tooth” of the glass can vary depending on what size grit was used to rough up the surface, giving it a matte appearance. The color of the palette can be changed slightly by placing colored paper beneath the ground glass. If a neutral palette is desired, one could put the appropriate hue of colored grey paper beneath the glass plate. In addition, commonly used color names can be taped on the underside of the glass around the perimeter of the palette, indicating their locations.

b) **Tempered Glass Palettes**

Commercially available in various sizes, tempered glass is glass that has been processed to increase its strength and durability as compared with normal glass. Tempered artist’s palettes have a smooth, nonporous surface ideal for mixing colors while inpainting. Wiping with a solvent or scraping with a razor scraper easily cleans the smooth surface after use. These types of palettes are available as clear glass or sometimes with a white, grey, or black vinyl or acrylic lacquer coating on the back. Some come with optional nonslip feet that can be placed on the backside of the palette to keep it from sliding.

c) **Mylar[®]-Covered Fome-Cor[®]**

As an economical alternative to commercial palettes, some conservators cover a piece of black or white Fome-Cor board with Mylar (adhered with tape). The smooth surface of Mylar can be used for mixing colors or medium and pigment by brush. When finished, the Mylar can be disposed of and the Fome-Cor reused. The Mylar can also be saved to document the colors/media used for a particular inpainting project. In addition, by creating a small Fome-Cor step with round cavities cut into it, certain types of diluent containing vials can be held securely with the palette.

d) **Empty Plastic Pans or Watercolor Paint Tins**

Available in various sizes and shapes, plastic pans and watercolor paint tins are typically used for watercolors but can be used to contain and mix pre-made conservation paints. This type of palette is small in size, lightweight, easy to transport, and generally fairly inexpensive. One minor drawback to using the plastic is that over time, it can become scratched and stained.

e) Ceramic Tile

Available in various sizes, shapes, and colors from most home improvement stores, palettes made from fine-grade glazed porcelain tiles are a favorite among many conservators. Ceramic tiles are easy to clean and scrape since they do not have a lip around the edge and are very sturdy. These palettes also slide around much less than lightweight plastic or Fome-Cor palettes.

f) Nesting Porcelain Bowls

Nesting porcelain bowls are made of similar materials to the ceramic tile palette described above. These small round white palettes are typically three or four inches in diameter with a shallow bowl-shaped mixing surface. They are designed to stack within one another while keeping the mixing surface clear of the bottom of the next bowl. Sets typically come with a porcelain cover.

g) Plexiglas[®], Acrylic Glass, or Plastic

Poly Methyl Methacrylate (PMMA), commonly known as Plexiglas, can be a suitable palette material. Plexiglas is softer and more easily scratched than glass, but does not break as easily and generally costs less. It can also have a poor resistance to certain solvents, such as aromatics and chlorinated hydrocarbons, which may cause swelling or dissolving of the surface. Use of solvents with a Plexiglas palette should be tested prior to use. Neutral palettes can be achieved if an appropriate hue of colored grey paper is placed beneath the transparent piece of Plexiglas.

h) Watercolor Palette (Paper Pads)

For certain types of media including watercolor, gouache, and PVAc, some conservators use paper watercolor palettes for color mixing and inpainting. This type of palette typically comes in books of forty to fifty sheets of coated or smooth white paper. The greatest advantage to using this type of palette is the ease of clean up; once a single sheet has been used, it can simply be torn off and disposed of. However, if the paper comes in contact with a substantial amount of moisture, the palette paper can become buckled and more difficult to work with.

i) G-10

An inexpensive, somewhat green alternative to commercial palettes is to recycle scraps of G-10 board (epoxy-coated fiberglass fabric) for use as an inpainting palette. G-10 can be cut into custom sizes, is stackable, and is already used by many conservation studios. Use of solvents with a G-10 palette should be tested prior to use.

2. Mixing Tools

a) Glass Pigment Mullers

Mullers are used to disperse pigments into the intended medium for inpainting. Commercial mullers can be granite, marble, or glass. The grinding surface is often frosted or slightly granular to facilitate the mixing process. Some conservators recommend making small mullers by cutting down glass stirrers used in chemistry labs to make a miniature glass muller for use on an inpainting palette.

b) Brushes

Brushes used for inpainting often double as a mixing tool. They can be used to mix prepared colors of inpainting paint or dispersed pigment with an inpainting medium. Further information on brushes is detailed in “Characteristics of Individual Inpainting Brushes,” below.

c) Metal Spatulas and Palette Knives

Available in various shapes and sizes, metal spatulas and palette knives are usually made from flexible steel blades that do not possess sharp cutting edges. In the absence of a glass muller, this type of tool can be used particularly well on a ground glass palette for relatively smooth dispersion of pigment and mixing of pigments and media. Although not as convenient, they can also be used on Mylar, palette paper, and Fome-Cor type palettes.

d) Mortar and Pestle

The pestle is a blunt, heavy stick-shaped tool used for crushing, grinding, pounding, or mixing of materials; the mortar is the corresponding bowl. Conservators can mix or disperse pigments and/or medium using these tools. When used with inpainting materials, mortars and pestles should be made of a smooth, nonporous material to avoid staining or absorption of the material being mixed. Compared with ceramic mortars, glass mortars and pestles tend to be more fragile but will not reduce the particle size of the pigments as much as a ceramic set. Glass is also stain-resistant and can be used with liquids/mediums. Other suitable materials include various types of stone and porcelain.

3. Handling and Care/Maintenance

a) Palettes

While glass and ceramic palettes are heavier and sturdier for the dispersion of pigments and the mixing of paints, they can also be easily broken if dropped or subjected to a hard impact. Palettes with a smooth, nonporous surface like glass or glazed ceramics can sometimes be scraped clean or cleaned with a solvent that will dissolve the inpaint-

ing medium in use. An additional advantage to the disposable palette is less exposure to solvents during cleanup.

b) **Mixing Tools**

With the exception of brushes, the mixing tools described above can all be cleaned in a general method using a solvent that will dissolve the materials being mixed, followed with soap and water. Brushes should be gently rinsed immediately after inpainting using a solvent that dissolves the inpainting medium in use. Periodically they should also be washed with soap and water (or paint brush cleaner) then allowed to dry vertically in a brush holder after reorienting the brush hairs.

C. INPAINTING BRUSHES

1. Overview

An inpainting brush is usually characterized by its small size and fine needle-like point. Brush fibers can be natural or synthetic, although most conservators prefer natural varieties. Round watercolor brushes between sizes 000 and 2 are most commonly used as inpainting brushes. Since small brushes are more difficult to manufacture, they typically cost more than their larger counterparts, making good inpainting brushes fairly expensive. Proper cleaning, care, and use of an inpainting brush are essential to prolonging its useful life. Further information on brush fibers, handle types, and brush handling and care are described in detail by Monica Jaworski in the Equipment section of volume 1 of the PSG Painting Conservation Catalog, *Varnishes and Surface Coatings*, pages 225–236.

2. Characteristics of Individual Inpainting Brushes

a) **Winsor and Newton Series 7**

The Winsor and Newton Series 7 Kolinsky round brushes are made in England of pure Kolinsky sable. The black painted handles are less than eight inches long, with a center point of balance. They have seamless nickel-plated brass ferrules, and the hair forms a sharp point with good spring. If properly cared for, these brushes will have a long life. Although the Series 7 is commonly used as an inpainting brush among conservators, it is also one of the more expensive brushes available.

b) **Winsor and Newton Series 707**

The lesser-known Winsor and Newton Series 707 round brushes are the same as the series 7, but are of a slightly lesser quality. These less expensive brushes have been discontinued by the company but are still available from many retailers. These brushes make for a good student-grade brush.

c) Winsor and Newton Series 7 Miniature Brushes

The Winsor and Newton Series 7 Kolinsky Sable Miniature brushes (formerly series 12) are crafted the same as the Series 7, but they have shorter, pure red sable bristles. These brushes are described as being excellent for small detailed work. The black polished handle is also shorter than the standard series 7, at approximately five inches. Some conservators feel this brush holds a point longer than the regular Winsor and Newton Series 7 brushes.

d) Da Vinci Restauro

The Da Vinci Restauro Kolinsky round brushes are made in Germany of pure Kolinsky sable. The handles are approximately eight inches long and have triangular-shaped heads, which is very useful in keeping the brush from rolling away when laid flat on a palette or table. The brush has nickel-plated brass ferrules and hair that forms a sharp point. These brushes were specifically designed and manufactured for art restoration and generally carry a mid-range price tag. It is recommended that you order the brush one size larger to equal the Standard English size since these brushes are sized using the European sizing system.

e) Da Vinci Cosmotop Spin Series 5580

The Da Vinci Cosmotop Spin round brushes are hand-made in Germany with high-quality synthetic fibers. The tuft of the brush is developed to act like natural hair by using a variation of synthetic filaments that differ in diameter. This brush has a large belly and a fine point.

f) Dragon's Tongue

The Dragon's Tongue round brushes are made from Tajmir Kolinsky Sable and are manufactured for Cheap Joe's Art Stuff. They sell for almost half the price of many inpainting brushes. The blue lacquered handles are approximately eight inches long and have nickel ferrules. The Kolinsky tuft on this brush is slightly longer than other round brushes but still has decent spring.

g) Daler-Rowney Diana Series

Daler-Rowney Diana Series Kolinsky round watercolor brushes are hand-made in England with pure Kolinsky sable. They have black handles that are approximately eight inches long with nickel-plated brass ferrules. According to the manufacturer, these brushes are considered to be among the finest produced and are available in sizes 000 to 8.

h) Kalish Series 1

Kalish Series 1 Kolinsky round brushes are hand-made in Ireland from pure Kolinsky sable. The black handles are approximately eight inches long and have nickel-plated

brass ferrules. The hair forms a sharp point and has good spring and a long life if properly cared for. This brush also has a mid-range price.

i) Isabey Series 6227Z

Isabey Series 6227Z Kolinsky round brushes are made in France with pure Kolinsky red sable. They are fabricated with smooth black handles and seamless nickel-plated ferrules. The tufts on these brushes have pronounced bellies, which are supposed to make them react better. With this model, the brush hairs come to a sharp point and come in sizes 00 to 14.

j) Isabey Series 6201

The Isabey Series 6201 Kolinsky Travel Brushes are hand made in France from pure Kolinsky sable hair. These brushes are similar to the series 6227Z described above, but the benefit of this brush is that it disassembles for travel. When assembled, the brush is standard length.

k) Raphael Series 8404

The Raphael Series 8404 is a Kolinsky round watercolor brush made in France with Kolinsky sable. These brushes are described as having a full body and a sharp point and are available in size 0 to 12.

l) Raphael Series 8408

The Raphael Series 8408 is similar to the 8404 described above but has a much more finely tapered tip. This short-handled brush is polished black with a cream-colored end. The brushes are available in a smaller size than the series 8404.

m) Stencil Brushes

Stiff-bristle stencil brushes sold in artists' supply stores can be used to "splatter" inpainting materials to mimic an aged coating or to emulate a layer of patina. Sometimes it is helpful to cut the brushes to create a stiffer head.

n) Toothbrush

Similar to the stencil brushes described above, some conservators will opt to use a toothbrush to get a fine splatter effect rather than cutting down the hairs on a stencil brush.

D. EQUIPMENT AND MATERIALS TO ADJUST INPAINTING

1. Overview

While mixing a desired color is extremely important during the inpainting process, acquiring the desired gloss, sheen, and/or texture from an inpainting medium can be equally important. Most conservators prefer to achieve an appropriate texture during the filling process prior to inpainting. However, even after carefully selecting a particular type of inpainting material, adjustments are occasionally necessary both during and after the inpainting stage. Adjustments to inpainting can sometimes be accomplished by the use of tools such as burnishers, dental tools, and scalpels, and at other times through the direct use of additives to the inpainting medium. In addition, it is inevitable that a conservator will at times need to remove recently applied inpainting from an area. Various cloths, sponges, and pickup materials can be used for this purpose, depending on what is needed. In addition, such transfer/pickup materials and abrasives can be used to adjust inpainting in different ways than equipment and additives.

2. Adjustment Equipment

a) Burnishers

Burnishers are typically used in conjunction with water-gilding to give the gilded surface a higher level of gloss and sheen. Today they are fabricated from highly polished agate stones that come in a variety of shapes and sizes. For inpainting purposes, burnishers can be used to achieve a smooth or glossy finish when rubbed across an inpainted surface. Some conservators recommend placing either silicone release Mylar® or Japanese tissue paper between the burnisher and the area of inpainting. Burnishers should be stored in cloths to keep the agate surface clean and free of scratches.

b) Silicone Molds (Surface Molds)

Several flexible materials have been used for rubber-like molds and casts of painted surfaces to recreate texture in areas of large loss. Silicone molds are now widely used in painting conservation and primarily consist of silicone polymers and fillers. A popular commercial manufacturer is Elastosil® (distributed by Wacker), which produces silicone polymers in a variety of different grades: Elastosil® M 4541 is best for transferring texture using only weight; M 4600 A/B remains transparent once cured (but can become somewhat rubbery); and M 1470 is useful for casting surfaces that exhibit high relief. When applying the silicone directly to the surface of the painting, it is important to test and isolate the area that is to be cast by applying a thin coat of varnish. (*Note:* Be sure to omit Tinuvin from the varnish as it will interfere with the curing process.) While these

molds are often used to texture a variety of fills (i.e., wax/resin, gesso/resin, etc.), they have also been used to texture the surface of freshly applied inpainting.

c) **Dental Tools (Carvers and Probes)/Spatulas**

Dental tools have proven useful in emulating surface patterns (i.e., craquelure) on existing fills, but can also be used on recently inpainted surfaces. Most dental tools are made of stainless steel and are approximately 6-1/2" in length. Spatulas come in a variety of shapes and sizes (small spatulas are referred to as minarettes) and can be useful when manipulating heavy-bodied inpainting mediums. Carvers can be used to scratch away the uppermost layer of inpainting to reveal lower layers to achieve a desired pattern or texture.

d) **Scalpels, Exactos[®], and Other Small Knives or Blades**

Sharp-edged tools such as small, tipped surgical scalpels or Exacto knives can assist with texturing inpainting but also in reducing unwanted buildup of a fill/inpainting material. In addition, they can be used to adjust the gloss and look of inpainting by gently scraping the sharp side of the blade against the inpainted surface.

e) **Clay Modeling Tools**

More commonly used in conservation for localized consolidation and flattening of paint, clay-modeling tools can also be used to adjust inpainting. Available with rubber, silicon, or Teflon[®] tips, the soft flexible tips on these tools can be used to gently burnish or compress areas of inpainting.

f) **Engraver's Pen**

Engraver's pens have vice holders that can be used with various ball-shaped micro engravers and pointed tips. The tip can be used to scratch and matte inpainting as well as adding fine cracks.

3. Inpainting Additives

a) **Ox gall**

This natural product, taken from the gall bladder of a cow, is traditionally used by artists as a wetting or leveling agent in pigment dispersion or for water-based paints. Many conservators also use this as an additive to their inpainting medium to adjust sheen and/or to improve the handling and flow of the medium. Ox gall is often used as a wetting agent when inpainting with watercolors.

b) **Bulking Agents**

Kaolin is a type of clay composed of fine, absorbent particulates that are formed by the weathering of aluminum silicates. As a filler/bulking agent, it is generally used in its

white powder form. Gypsum (calcium sulphate) and chalk (calcium carbonate) are also used as bulking agents as they both have relatively low tinting strength and are somewhat absorbent. Kaolin particles tend to be finer than gypsum and chalk and could be used when emulating a smoother, even film and can be more receptive to burnishing.

c) **Glass Microballoons, Glass Beads/Platelets**

Glass beads/platelets are a soft, white, powder-like substance that can be used as a low-density extender for inpainting media and as a thickener for fill materials. Glass beads/platelets can also be used to decrease the level of gloss in a paint film and can help avoid “ghosting,” a phenomenon occasionally encountered with other fill/bulking materials. Beads are generally 0–50 microns while platelets are > 15 microns.

d) **Fumed Silica**

Fumed silica is very fine amorphous silica made by the combustion of silicon tetrachloride vapor with oxygen and hydrogen. Similar to glass microballoons, fumed silica can be used as an extender and a thickener in addition to cutting unwanted gloss created by overbound paint films. Two commonly used grades are CAB-O-SIL® M-5 and Gasil 23. CAB-O-SIL has an extremely small particle size of 0.2 to 0.3 microns while Gasil 23 has an average particle size of less than 3 microns. It should be noted that adding too much silica could cause muddiness or introduce grayness to the overall color.

e) **Gum Arabic**

Adding a bit of gum arabic to watercolor or gouache media increases glossiness and transparency.

f) **Varnish/Resin**

Many conservators use small amounts of varnish or resin as an additive to their inpainting medium to improve the gloss or give more body to the medium.

g) **Wax**

Small amounts of wax can be added to inpainting media to matte down or adjust the sheen of inpainting. This is often done by dissolving the wax into the solvent used for inpainting and then directly mixing this with the inpainting medium. Microcrystalline waxes are often chosen for their stable properties.

4. Cloths and Abrasives

a) **Silk**

Natural fiber silk has a smooth surface that can be ideal for the removal of small amounts of inpainting without disturbing most of the inpainting around it. By dampen-

ing a small area of the silk with a tiny amount of the inpainting resin or diluent in use, it can be used to carefully pick up unwanted inpainting.

b) Polyester

A synthetic and economical alternative to silk, polyester cloths can be used in a similar manner as described above or as an abrasive to remove unwanted inpainting.

c) Emery Boards/Sandpaper

Emery boards or sandpaper, available in various grits, are great for reducing gloss and adjusting the texture of or reducing inpainting. Acrylic nail emery boards (available at cosmetic retailers) are thin and somewhat flexible, allowing for greater control than with normal sandpaper.

d) Steel Wool

Steel wool is another abrasive material that is readily available in various grades and can be used to reduce the gloss/sheen of inpainting. It can be used as is, or, for better control, a small piece of steel wool can be twisted onto the top of a bamboo skewer, like a Q-Tip®.

E. MISCELLANEOUS AIDS

1. Overview

As our profession has grown, so has the number of instruments, tools, and innovations used to make the conservator's job a little easier. This section is devoted to the description of those devices that help us inpaint, but that did not fit elsewhere in the chapter.

2. Visual Aids

a) Matte Black Gloves/Clothing

As a type of visual aid, some conservators wear matte black gloves or black clothing while inpainting. This allows the conservator to inpaint without the reflection of their hand/skin or clothing color obscuring or interfering with the tone or color of the inpainting paint being applied. This is especially useful when inpainting a dark or glossy color.

b) Magnifying Loupe

The term magnifying loupe can refer to various types of magnification eyewear and accessories that attach to regular glasses or to standalone magnification eyewear such as an Optivisor®, Mageye®, Magna Vision®, or Eschenbach®, among others. Some conservators find magnifying Loupes to be extremely helpful for inpainting purposes.

c) Mock-Ups

Mock-ups allow a conservator to test the effects of inpainting materials before beginning the inpainting process on an actual artwork. Painting out samples can oftentimes answer questions related to layering, the use of particular pigment, and the overall choice of medium/media for inpainting.

d) Archival Photography

Although not used extensively in painting conservation, archival photographic processes can be used to tackle challenging inpainting issues. By taking an archival print of an artwork (taken before damage, previous restoration campaigns, etc., occurred), a transparency can be made to reproduce an image of the painting that is one-to-one in scale. This transparency can then be used for comparative purposes or to reregister damaged areas of the painting. Some conservators have used projectors in conjunction with transparencies, projecting the image directly onto the artwork or area of damage. For more information on such techniques, see “Image Projection as an Aid to Reconstructive Restoration” in this volume.

e) Gray Studio Walls

Some conservators find it easier to work in a studio with a neutral grey paint on the wall behind the work of art that they are inpainting.

3. Other

a) Mahlstick

Mahlstick is a vertical stick that is often made with a soft leather end (or fabric filled with cotton or stuffing material) that is used by painters to support their brush-holding hand. Some conservators use this instrument, or a variation on it, to support their hand while inpainting. This allows for very precise and careful inpainting while keeping the conservator’s hand away from the painting surface. Vertical mahlsticks do not have a cushioned tip but instead attach to the top of the easel, sliding left and right so that no part of the instrument comes in contact with the painting.

b) Modified Gloves

Many conservators use the technique of modifying cotton or nitrile gloves to keep their hands clear of the painting, while still allowing for good handling of their inpainting brush. Often conservators will cut the tips from the fingers of the glove, leaving only the pinky finger intact.

Katrina Bartlett and Kristin deGhetaldi

Submitted March 2009

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RESOURCES CONSULTED

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Blick Art Materials. www.dickblick.com

Conservation Support Systems. Conservation Restoration and Archival Products: Brushes. www.silcom.com/~css/

Delasco. Lighting/CoolSpot. www.delasco.com/pcat/1/Lighting/CoolSpot/dlmibo27

GE Lighting. www.gelighting.com/na

Gettens, R. J., and G. L. Stout. 1966. *Painting materials: A short encyclopedia*. New York: Dover Publications.

Lowel. The world leader in lighting. www.lowel.com

Nasco. Arts & Crafts. Fotolite Stand Light. www.enasco.com/product/8100257?ref=recent#details

Smith-Victor Corporation. www.smithvictor.com/index2.asp

SoLux. Brilliance of Daylight 24/7. www.solux.net

Sylvania. Osram-Sylvania. www.sylvania.com

True Sun. Philips TL950. www.truesun.com/philips_TL950.php

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IX.

Vendors of Inpainting Materials

Conservator's Emporium

18124 Wedge Parkway, Suite 458

Reno, NV 89511

Phone: (775) 852-0404

Fax: (775) 852-3737

www.consemp.com

Pigments, conservation colors, resins, inerts/fillers, tools

Art Preservation Services

315 East 89th St.

New York, NY 10028

Phone: (212) 722-6300

Fax: (212) 427-6726

www.apsnyc.com

Visible light meters, UV light meters, inpainting light banks

Ciba Specialty Chemicals

Ciba Colors Division

P.O. Box 2678

High Point, NC 27261

Phone: (800) 474-4731

www.cibasc.com

DPP (Irgazine) and Quinacridone pigments; Orasol dyes

Conservation Resources International

5532 Port Royal Rd.

Springfield, VA 22151

Phone: (800) 634-6932

Fax: (703) 321-7730

www.conservationresources.com

Flügger® Acrylspactel, resins (Laropal A-81), conservation instruments and equipment, fillers [Gasil 23 matting agent (fumed silica), glass microballoons, Kaolin (BP grade), Cabosil M-5), gilding materials

Conservation Support Systems

P.O. Box 91746

Santa Barbara, CA 93190

Phone: (800) 482-6299

Fax: (805) 682-2064

www.silcom.com/~css

Pigments (dry and mica), conservation paints [Maimeri, Golden paints (PVA, MSA)], Charbonnel (formerly known as LeFranc and Bourgeois), Orasol Dyes, Schminke, and Gamblin, B-72 color chips, CSS Restoration Colors (B-72), Aquazol, B-72, resins (Laropol A-81), inpainting brushes, painting knives, gilding materials, lighting instruments, magnifiers, solvent/dust masks, conservation instruments and equipment (i.e., minarette spatulas)

Conservator's Emporium

18124 Wedge Parkway, Suite 458

Reno, NV 89511

Phone: (775) 852-0404

Fax: (775) 852-3737

www.consemp.com

Pigments, conservation colors, resins, inerts/fillers, tools

L. Cornelissen & Sons

105 Great Russell Street

WC1B 3RY

London, England

Phone: +44 (0) 20 7636 1045

www.cornelissen.com

Excellent English colorman that opened in 1855. Cornelissen has a great variety of rare and contemporary (mica as well) pigments and other supporting materials (mixing slabs, Mullers, mortars and pestels, glass jars, etc.). They have a physical store and a catalog that allows for phone orders. Their catalog can be viewed online.

Dakota Art Pastels

P.O. Box 2258

Mount Vernon, WA 98273

Phone: (888) 345-0067

Fax: (888) 345-0063

www.dakotapastels.com/

Pastel pencils (Carbothello), pastel sets, chamois, Sofft Art sponges, Dahle pencil sharpener, dust masks

Daniel Smith

4150 First Avenue South
P.O. Box 84268
Seattle, WA 98124-5568
Phone: (800) 426-6740
Fax: (800) 238-4065
www.danielsmith.com

Dry pigments, gold and other leafs, gilding tools and supplies, brushes, dust masks. They are one of the few sources for Gen. Lapis and Malachite oil paint as well as the only supplier of obscure oil colors like Gen Turquoise and Purpurite. Painting knives. Palettes, mortar and pestles. Makes their own watercolors (even an entire line using historic mineral pigments).

Day-Glow Color Corporation

4515 St. Clair Avenue
Cleveland, OH 44103
Phone: (800) 4-DayGlo
www.dayglo.com
Day-Glo Pigments

Dermatologic Lab & Supply, Inc.

608 13th Ave.
Council Bluffs, IA 51501-6401
Phone: (800) 831-6273; (712) 323-3269
Fax: (800) 320-9612; (712) 323-1156
questions@delasco.com
Burton Halogen CoolSpot Lamps, various medical grade lamps and spotlights

Dick Blick Art Marterials

P.O. Box 1267
Galesburg, IL 61402
Phone: (800) 828-4548
Fax: (800) 343-5785
www.dickblick.com

Wide range of artist materials including paints, brushes, nesting porcelain bowls, tempered glass palettes, clay modeling tools, and Ox gall

Dow Chemical Co.

2030 Willard
Midland, MI 48674
Phone: (800) 447-4369
www.dow.com
Methocel® cellulose ethers

Eschenbach Optik

904 Ethan Allen Highway
Ridgefield, CT 06877
Phone: (203) 438-7471
Fax: (203) 438-1670
www.eschenbach.com

Frame mounted magnifier (visors) or “clip-on” magnifier (for glasses). Lenses: 2.0, 2.5, 3.0x.

Fisher Scientific

(listings across the United States)

Phone: (800) 766-7000
www.fisherscientific.com

Inerts, reagents, solvents, micro swabs, glass vials with lids

Gamblin Artist Colors

P.O. Box 625
Portland, OR 97207
Phone: (503) 235-1945
Fax: (503) 235-1946
www.gamblincolors.com

Gamblin® Conservation Colors (Laropal A-81 Resin), information relating to arrangements of different palettes

Gilded Planet

(Distributor for Sepp Leaf Products)

Phone: (415) 407-5097
www.gildedplanet.com

Gold Leaf, mica powders, gilding and decorative finish supplies and tutorials. Internet-direct one-stop shopping.

Golden Artist Colors

188 Bell Road
New Berlin, NY 13411
Phone: (800) 959-6543
Fax: (607) 847-6767
www.goldenartistcolors.com

Conservation Colors: MSA, B-72, and PVAc, fluid matte acrylics, dispersions, mediums

Hercules Chemical Inc.

Aqualon Division
Hercules Plaza
Wilmington, DE 19894
Phone: (800) 345-0447
www.aqualon.com

Aqualon®, Culminal®, methylcellulose, sodium carboxymethylcellulose ether gums

Iconofile

(Subdivision of Natural Pigments; refer to Natural Pigments for contact information)

Phone: (707) 539-8215

Fax: (408) 516-9442

www.iconofile.com

Historical pigments, gilding supplies, icon painting supplies

Italian Art Store

84 Maple Avenue

Morristown, NJ 07960

Phone: (800) 643-6440

Fax: (973) 644-5074

www.italianartstore.com

Watercolors, paints, brushes, Schmincke Horadam 48 half-pan paint box sets

Jerry's Artarama

Order Dept.

P.O. Box 58638J

Raleigh, NC 27658

Phone: (800) 827-8478 (24-hour phone ordering)

Fax: (919) 873-9565

www.jerrysartarama.com

Huge online and catalog source for low- and high-quality art supplies (watercolor tins) of all kinds.

They also have some physical storefronts, check the website for locations. Jerry's carries most larger national and international manufacturers of pigments, watercolors (Schminke Horadam), brushes. No conservation colors. Empty watercolor tins and palettes.

Kama Pigments

85 Jean Talon Ouest #4,

Montréal, Québec

Canada, H2R 2W8

Phone: (514) 272-2173

www.kamapigment.com/index_en.html

Good Canadian resource. Dry pigments (historic and contemporary), mica powders, brushes, mullers, dust and solvent masks, fumed silica. Painting spatulas. Individual circular, small plastic containers with lids. They have an online store.

Kremer Pigments

247 W. 29th St.

New York, NY 10001

Phone: (212-219-2394

Fax: (212) 219-2395

www.kremer-pigmente.de

www.kremerpigments.com

Historic and contemporary dry pigments (incredible range), as well as traditional materials not available anywhere else like jars and bottles, brushes, dust masks, etc. They are helpful and willing to answer questions. The storefront is tiny, but well stocked, if you have the chance to visit. Makes their own line of watercolors and retouching B-72 conservation colors. Offers Mica pigments, specialty pigments (Duo-tone), and Day-Glo pigments. Empty watercolor tins and palettes. 14 full pans of watercolors for retouching gilded surfaces. DPP (Irgazine Pigments) and Quinacridone Pigments; Orasol (Alcohol Soluble Dyes). Their catalog contains a lot of information and is very extensive.

Cannot order directly from Germany website (if you can, they might charge more). Order from U.S. website.

Lowel

90 Oser Avenue

Hauppauge, NY 11788

Phone: (800) 645-2522; (631)273 2500

www.lowel.com

Lowel Scandels lights and accessories

(Manufacturer only; links to local dealers on website)

Micromark

340 Snyder Ave.

Berkeley Heights, NJ 07922-1595

Phone: (800) 225-1066

Fax: (908) 665-9393

Micro tools, sanding wands

MisterArt.com

913 Willard St.

Houston, TX 77006

Phone: (866) 672-7811

Fax: (866) 672-3754

www.misterart.com

Artist materials, Winsor Newton series 7 and series 7 miniature sable watercolor brushes

Museum Services Corp.

385 Bridgepoint Dr.

South St. Paul, MN 55075

Phone: (651) 450-8954

www.museumservicescorporation.com

Lascaux products, gilding supplies, Orasol (Alcohol Soluble Dyes), Maimeri, dry pigments, waxes, syringes, tweezers, silicone rubber mold making

Nasco-Fort Atkinson

901 Janesville Avenue
P.O. Box 901
Fort Atkinson, WI 53538-0901
Fax: (920) 563-8296
www.enasco.com/artsandcrafts
Fotolite Stand Light

Natural Pigments

Natural Pigments LLC
P.O. Box 112
Willits, CA 95490
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www.naturalpigments.com/

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