PRESERVING AND RESTORING FURNITURE COATINGS

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Introduction

Coatings accomplish several functions when used in conjunction with wooden objects. First, and probably foremost in terms of the fabricator's intent, is that coatings alter the appearance of the surface. That is, coatings serve some aesthetic purpose. Second, coatings offer protection to the object's surface (spills, abrasion, etc.) and structure (RH shifts and ensuing dimensional-change-caused deterioration). Finally coatings provide scholars, including conservators and historians, information regarding the practices and technologies of the past.

As with other considerations when evaluating historic artifacts of all kinds, these factors must be integrated with the precept that all materials which exist as part of an object contribute to the integrity and uniqueness of that object. Both historic and contemporary fabricators of wooden objects generally consider(ed) coatings, particularly "non-decorative," to be a potentially sacrificial element of the whole. However, for the reasons enumerated above, conservators do not consider any portion of an object to be routinely expendable, including finishes and coatings.

Contrary to the "strip and dip" approach to dealing with coatings so prevalent in many commercial refinishing and restoration shops, conservators and sensible restorers attempt to preserve the coating on the object whenever possible. This is not to suggest that coatings are never altered or replaced in the course of conducting a conservation treatment on an object. In many cases this intrusion must take place, but the ideal is to intercede minimally and to leave the surface as undisturbed as possible while assuring stability for, and preservation of the artifact. Preserving finishes and treating degraded coatings requires a broad base of knowledge and diverse skills, including the knowledge of coating materials and their deterioration, as well as craft skills necessary to manipulate the films, whether in preserving existing films or applying new coatings.

The manifestation of coating deterioration depends *en toto* on the kind of film-forming materials used, additives used to modify that material, and the various environment conditions to which the coating has been subjected. A beginning point in the treating and preserving of coatings is the most specific description of the coating system possible. Coating systems can range from simple single component applications to sophisticated preparations applied in an exacting and complex procedure.

As with the approach in other portions of this monograph, this section will be an overview of the field of coatings as a whole. Any of the areas of discussion here, coating materials and techniques, coating deterioration, and treatment of degraded coatings, could and have filled volumes. In addition to existing literature, dozens of conservators and other scholars are continuing to prepare articles, monographs and books on the subject of furniture coatings. With that in mind the reader is reminded of the superficial nature of the information presented here (in general), with particular emphasis on the temporal pertinence of the treatment section. The conservation treatment of damaged furniture finishes is a relatively new discipline, and it is likely that much of the framework discussed for such treatments will be superceded by new techniques and approaches in relatively short order.

Coating Materials

The scope of materials used to form finishes on furniture and wooden objects is a broad one encompassing ingredients from several categories. The most general distinction delineating coatings is whether they are transparent (varnishes), opaque (paint or polychromy) or metallic (leaf). Among these are waxes, gums, and oils, plus natural and synthetic resins, all of which can be used as transparent coatings. By the addition of dyes or pigments to transparent materials, paints are formulated. Paints are also formed by the addition of colorants to liquids which are not usually employed as transparent coatings, such as casein or "milk paint." There are also coatings of applied metal sheet, such as gold and silver leaf, which are adhered to a wood or mineral substrate with protein or resinous binders. Finally, there are film-formers which do not fit neatly into any of the aforementioned categories, such as *urushiol*, or Oriental lacquer, which is a reactive latex with vague similarities to both oils and resins, and which can be used as a transparent or opaque coating. Within the organization of this document *urushiol* is included with natural resins.

A second broad category of definition for coating materials involves the drying mechanism of the film, which in turn may reveal chemical and physical properties such as solubility, thermoplasticity, rheology, and others. Drying mechanisms are separated into two broad categories; solvent release and polymerization. In solvent release or "spirit varnish" systems the coating film is a residue remaining after the evaporation of the volatile solvent from a solution containing the solvent and the involatile film-former. Polymerizing or "reactive varnish" systems harden rather than dry. This is accomplished by the polymerization of the mono- or oligomeric constituents of the formulation. In most cases the exact chemical reaction process of the polymerization is relatively unimportant for either the creating craftsman or the conservator/restorer.

In addition to film-forming materials, coating formulations frequently contain additional materials to enhance certain properties of the coating. These additives can alter working

characteristics of a liquid coating during application, or visual or physical properties of the dried films. Common additives to coating systems are solvents, plasticizers, gloss suppressants, retarders, colorants, and chemical degradation inhibitors.

There are several ways of organizing reviews of materials. Here, the information about the coatings is loosely grouped according to the respective material's functionality as a coating on wood. It must also be noted that many, if not most formulations of coatings for wooden objects contain components from several of the groupings. Reviews of coating materials by chemical constituency can be found in several of the references listed at the conclusion of this chapter.

Waxes

Waxes are among the most ancient of coating materials, predating written history. Traditionally, waxes came from either animal or vegetable sources, but in recent generations the development of wax-like materials has emerged from the synthetic chemistry fields, particularly petrochemicals. Regardless of chemical composition, all waxes and wax-like materials are used in a similar manner as coatings, and the many varied formulations of wax mixtures created and used through the ages, exhibit a surprising similarity in their working properties. As a group, waxes and wax-like materials tend to be extremely stable and form excellent vapor barriers when an uninterrupted layering is achieved.

There are several sources for animal waxes including sperm whales (spermaceti), fleece (lanolin), and oriental insects (Chinese wax and Lac wax), but in general the only animal wax of importance for coating furniture and other wooden objects is beeswax. Lac wax, a by-product of processing seedlac into shellac (see below), is much harder than beeswax and is used in formulations of polishing and coating waxes but remains a wax of relatively minor importance.

Beeswax is secreted by bees for use in construction of the honeycomb, and is removed from the comb by melting it with heat. The exact properties of the wax in use (color, hardness, melting point, etc.) Are determined by the processing of the raw wax once extracted from the honeycomb. Beeswax can be purified via filtering a molten or dissolved liquid solution to tailor the exact physical properties within the limits of the original raw material, and frequently the visual properties of the wax are altered by bleaching with light or chemicals. Beeswax tends to be soft with a low melting point of 60-65°C.

Important vegetable waxes are carnauba and candelilla, with esparto, ouricuri (or ouricury), and berry wax as minor components in some coatings. Carnauba is a palm wax, present as a film on the leaves of some South American palm trees. The wax is

extracted by cutting off the leaves and drying them, followed by mechanical removal of the powdery wax by grinding and beating the dried leaves. Carnauba is purified in much the same manner as beeswax, and is the hardest of all naturally occurring waxes. Because of this hardness it is very durable as a protective coating, but it is too hard to be used without modifiers to make it more workable and pliable. Carnauba's melting point is nearly 20°C higher than that of beeswax and the two are frequently used in combination, with the beeswax acting as the modifying (softening) adulterant.

Candelilla is also a leaf wax, being derived from a shrub indigenous the U.S. southwest and northern Mexico. Candelilla is extracted by cutting and drying leaves followed by shredding the plant material and soaking it in tanks for solvent extraction. Candelilla is not as hard as carnauba and has a lower melting temperature around 70°C. It is most commonly used as a less expensive substitute for carnauba.

Mineral or synthetic waxes include materials obtained from processing petrochemicals, either by petroleum distillation or extraction from coal and coal related geologic deposits. As a group mineral waxes are among the most stable organic coating materials, and tend to be considered as reactively inert. These waxes include paraffin and microcrystalline waxes, ozokerite and ceresine, and montan.

Paraffin wax, as might be ascertained by the name, is a saturated hydrocarbon derived from petroleum with chain lengths of 25-30 carbons. The physical properties of specific paraffins are entirely dependant on the processing of the petroleum and the chain length of the molecule. Microcrystalline waxes are also long chain hydrocarbons but contain cyclic and branched structures, modifying their physical properties. Microcrystalline waxes have slightly higher molecular weights than paraffins, and thus are harder and have higher melting points.

Ozokerite is a derivative of bitumen and is a relatively crude raw material. Usually ozokerite is processed to become ceresine wax by heat and the addition of sufuric acid, with the resultant ceresine being the supernatant of the reacted crude wax. After the impurities of the heated solution have settled, the liquid ceresine is decanted.

Montan wax is extracted from decayed organic matter wich is not completely mineralized. It is obtained through either solvent extraction followed by steam or acidic distillation. Montan is nearly opaque and very hard, with a melting point of around 75°C.

Waxes can be applied as clear coatings on objects, or as opaque paints. For either application the wax must be made into a liquid mixture which allows the appropriate manipulation of the material for application onto the surface of the substrate. Liquifying the waxes can be accomplished by heat and solvents, and to some extent by emulsifying.

Historically, the most straightforward method of wax finishing was to simply prepare the surface as usual, then deposit solid wax directly onto the surface of the wood. This would be accomplished by rubbing solid block wax onto the surface, then burnishing with a bundle of dried grasses, whether horsetail reeds, straw, or other grain stalks. Through the vigorous scouring of the surface, the wax is partially liquified and pressed into the surface both physically and thermally, and built up to a thickness adequate to accomplish the desired surface character. The final step, as with most wax finishing, would be to buff with coarse linen followed by soft flannel or the like.

In heated application of wax coatings, the wax mixture is cut into small shavings and gently heated in a double boiler or other device. Depending on the process of the application, the surface to which the wax is applied is also heated. By such a technique the early "French polishes" were accomplished. The surface to be coated was placed near the fire or stove and the molten wax was worked into the surface of the wood. This could have been repeated as often as needed to build up the layers of wax to the desired thickness. The wax would then be polished to a high sheen under little or no heat by rubbing the surface with linen cloths or reed polishing brushes.

The use of wax liquified by solvents involves introducing the wax shavings into a container holding petroleum spirits or turpentine. This wax varnish could then be applied to the surface without the addition of heat, and harden by solvent evaporation. This too could be polished to a relatively high sheen. Clear wax coating of all types was a common practice in the fabrication of pre-industrial furniture.

Using hot wax as a paint layer is called "encaustic" and is one of the oldest forms of applied painted decoration. Encaustic paint is prepared by mixing molten wax and pigments on a heated palette, and then applied to the surface of the object using spatulas or stiff brushes. Wax was also present in other oil/resin type paints, both in solution and as emulsions.

Oils

Oils, or more properly drying oils, are also coating materials with foundations that predate recorded history. Drying oils used in finishing wooden objects are all of vegetable origin, mostly squeezed from nuts and seeds. Among oils used as wood coatings are linseed oil, walnut oil, poppy seed oil, tung oil, oiticicia oil, soybean oil, and a number of others.

Drying oils harden by a chemical reaction between oxygen and the fatty acids which compose the oil, a process which may be modified by the specific preparation schedule and process. Polymerization may be initiated and accelerated by heating the oil, saturating it with oxygen, or by adding metal salts to act as catalysts called "driers" to the formulation during refining. Frequently all three modifications are employed in concert

during refining. Oil films take considerable time to harden and are usually flexible, vapor permeable membranes which become increasingly intractable with age.

By far the most predominant oil for use as a coating for wooden objects is linseed oil, whose prominent position among oils dwarfs all the others. Linseed oil is a product of flax seed and is obtained by crushing and pressing the seed, resulting in raw oil. The oil may be used in this form but is frequently processed and purified using a large number of procedures to achieve specific properties. As mentioned above linseed and other oils may be modified to enhance the drying qualities of an oil film. Linseed oil may be used alone as a transparent film, or as a binder for opaque coatings (oil paints).

Linseed oil may be used alone as a transparent coating simply by applying it to the surface of the object to be coated and allowing the film to harden in a matter of hours or days, depending on the extent of the modifications implemented during the refining process. In most cases the excess oil is wiped off the diminish the film thickness and speed up drying by allowing greater oxygen interaction with the oil. This technique is frequently enhanced by burnishing the freshly oiled surface with heated pads, which serve to simultaneously accelerate the polymerization and to polish the surface yielding a relatively durable finish of high gloss.

Linseed oil may also be used in conjunction with other ingredients (mostly resins) to form transparent varnishes (see below). These varnishes may be combined in turn with pigments to form oil paints. Both varnishes and paints may be further modified with silicates or stearates which control the gloss of the dried film.

Natural Resins and Gums

Resins and gums are film-forming materials which are themselves naturally solid and must be induced into a liquid state, unlike oils which begin as liquid but become solid through chemical reaction. In that fact lies the essential difference between oils and resins (and gums). For resins and gums the drying process is exactly the opposite of the liquifying process. If solvents are the liquifying agent for resins, then the loss of solvent to evaporation is the mechanism for drying. In many cases the resins are combined with drying oils to form oil/resin varnishes which have a two-step drying process. First, the solvent which is used to liquify the resin evaporates, followed by the polymerizing of the oil component.

The difference between natural resins and gums can be difficult to define, and are thus they are presented together in this section. In addition, the terminology is often imprecise, particularly in historical recipes. In general, much of the distinction revolves around the hardness of the natural materials and their solubility. Harder materials are referred to as resins and softer materials are gums. A further distinction is made in

common usage, wherein gums are those materials defined as being soluble in cold water, and resins are not. However, this distinction become increasingly murky when consulting historical texts and recipe books which refer to ingredients as gums or resins while contemporary usage invokes the opposite definition. Further confusion is brought by the delineation of these soft film-formers as either balsams, which are not water soluble, and gums which are water soluble. Additionally, contemporary usage defines natural resins in two ways. If extracted from a living plant they are balsams, and if not from living plants, they are mineralized or fossil resins.

Vegetable resins

Most naturally occurring resins are of vegetable origin, even if one of the most important resins for furniture coatings is shellac, an insect exudate. Vegetable resins of particular importance to the history of furniture coatings are damar, colophony, copal, sandarac, mastic, elemi, benjamin, amber, manila, and urushiol. Gums include turpentine of various origins (common turpentine "thinner"is more properly called spirits of turpentine), gum arabic, and gum tragacanth. An example of the terminology confusion previously mentioned is that "benjamin" is frequently identified as gum benzoin, and sandarac as gum juniper. The following list of natural resins and gums is hardly a complete one, but merely represents a brief survey of those historically employed. A short description of these is as follows.

Damar (or more properly damars), results from the harvesting of exudates from trees in Malaysia. It is frequently difficult to specifically ascertain the source tree of the resin, because the word "damar" simply means "resin" in the native language. Damars are harvested by slashing or wounding trees and collecting the raw exudate which may be solid or liquid, akin to the tapping of maple trees for the sap to be processed into maple syrup. Damar is easily dissolved in a variety of organic solvents allowing a relatively simple filtering and purification procedure. Damar, like many natural resins, is a pale yellow material once processed. Due to its broad solubility and its compatibility with many other resins, particularly at slightly elevated temperatures, damar is often used in the formulation of varnishes. If the varnish formulation is a solvent release system (the varnish is dissolved in solvent only) a rapidly drying, relatively hard and brittle film can be obtained. Combining damar with a drying oil yields a varnish with higher gloss due to longer hardening time, and greater film flexibility because oils do not achieve the same degree of solidification as resins. Either formulation can be altered with gloss modifiers, and both can be applied by brush or spray.

Colophony, or rosin, is the resin from coniferous trees. Rosin is obtained either by extracting the sap from living trees, or by steaming it out of cut coniferous wood. Rosin is usually very brittle in film form, darkens quickly once dry, and is not considered too desirable as a coating. Because of these characteristics, colophony was a cheap substitute

for other resins in spirit and oil varnishes.

Copal is one of the more important natural resins, and was historically a main ingredient in the formulation of varnishes. Like damar, the term copal actually refers to an imprecisely defined group of natural resins. While all copals are of vegetable origin, some have been fossilized and some are balsams, or exudates from living trees. Copal is not easily dissolved however, and usually needs to be in hot oil to fully liquify. For that reason it was mostly used in oil/resin varnishes. Widely used copal resins were kauri, congo, and pontianak.

Sandarac is a relatively soft resin which is obtained as a balsam from North African conifers. Sandarac, like rosin, was used in spirit varnishes as an inferior substitute for more expensive resins.

Mastic is another relatively soft resin, and originates as an exudate from the pistachio trees of the Mediterranean. Mastic is soluble in both spirits and oils, and remains soluble for extremely long periods of time. Its pale color makes it very useful where a transparent varnish in desired.

Elemi is a very soft resin, probably the softest of all natural resins. Elemi is soluble in both alcohol and turpentine spirits, but is too soft to be used as a primary varnish resin. It is frequently used as a plasticizer for harder varnish resins.

Benjamin, or benzoin, is a resin obtained as a balsam from Indonesia. Benzoin is not particularly useful as a film-forming material, and was instead important as a perfume in the varnish.

Amber, a fully fossilized vegetable resin, is among the most prized and durable natural resins. Amber is mined from the ground primarily in Europe, and has historically been used as a gemstone. Amber is very difficult to dissolve, requiring considerable time in a vat of boiling oil before becoming completely liquid. However, the varnish obtained from this use of amber is considered to be among the very finest natural resin varnishes.

Urushiol, or Oriental lacquer, is derived from the sap of the rhus tree, an eastern relative of poison sumac. Urushi is employed as a purified liquid from the exudate, and has varying transparence depending on the age of the tree, climate, and other environmental factors. Urushi dries by a enzymatic hydrolytic polymerization, becoming virtually inert upon drying.

Turpentine and other coniferous soft resins were obtained from processing sap from coniferous trees, which was in fact part of the same process for obtaining colophony. Whether either turpentine or colophony was to be the product or the by-product depended

on the perspective of the enterprise.   Turpentine resins were historically called turpentine gums because of their softness. Special formulations of gum terps include Venice turpentine and Strasbourg turpentine.

Water soluble gums, used primarily as media for decoration rather than protective coatings, include gum arabic and gum tragacanth. Arabic has always been the preferred material, providing a transparent and glossy film. Arabic is obtained from the African acacia tree.

Animal resin

The only animal resin of importance in furniture coatings is shellac, or gum lac. Shellac is an exudate from the insect Laccifer lacca, which is indigenous to India and Indochina. The female lac bug exudes a protective coating around herself and thus around the tree branches on which she is living, in order that her offspring are protected until they have developed fully. This exudate contains resin, wax channels (through which the maturing offspring must tunnel and escape), and laccaic acid, or lac dye.

Deposits of the exudate are removed with the branches as they are cut off the host tree, and are called "stick-lac" in this raw state. Stick-lac is crushed, winnowed, and washed to remove dirt and lac dye, which is water soluble. At this point the material is called "seedlac", which may be used in spirit varnishes or may be processed for further purification. Additional processing includes filtration by heating and squeezing molten lac through linen filter cloths, or by heating and dissolving the lac and filtering with finer filtering methods. In addition, the naturally present wax may be removed from the lac in a solvent extraction process, and resulting shellac resin may be bleached in aqueous, alkali solutions. Shellac of widely varying quality, composition, and properties can be obtained depending on the harvest, climate and species of host tree, and the extent to which the raw material is processed.

Shellac varnish was one of the most widely used furniture finishes in our recent past (c. 1725-1925), and remains popular among many craftsmen and furniture conservators. One particular application of shellac which is widely admired is a technique called "French polishing," popular from about 1825 on, whereby the a dilute mixture of shellac in alcohol is applied on a tightly wrapped cloth pad known as a "rubber." French polishing yields a finish of remarkable sheen and clarity, which is frequently imitated by other finishing methods and materials. As a thermoplastic material, shellac is somewhat susceptible to chemical and thermal attack, but in general, shellac films remain stable for very long periods of time.

Synthetic resins

The first, and still most important, synthetic resin widely used as a coating is cellulose nitrate, which was first widely available at the end of the 19th century. Nitrocellulose "lacquers" were formulated by nitrating cellulose in an acid solution, forming cellulose esters. Due to the synthesis process, these original films were extremely unstable and degraded quickly, although recent developments in the manufacture of nitrocellulose lacquers has yielded a material of much greater stability. Following World War I cellulose acetate was developed as a non-explosive substitute for cellulose nitrate, and is considerably more stable as a coating.

Another important resin family, particularly as used in conservation, are the acrylics. Originally formulated late in the 19th century, acrylics are the product of esterifying acrylic acids. Acrylic resins tend to be more stable than nitrocellulose, and in some cases are extremely stable. Acrylics are widely used in virtually every phase of the modern coatings industry, including furniture. Their stability, along with thermoplasticity, durability and specific solubilities, make acrylics, particularly methacrylates, the resin of choice for a wide range of restoration treatments.

Synthetic resins which are thermosetting include urethanes, phenolics, amides, polyesters, epoxies, and amino resins. These resins have achieved wide popularity in industry because of their extreme durability over relatively short periods of time, and their ability to be adapted to industrial coating practices. Their intractable nature and questionable stability usually remove them from consideration for use as coatings in the treatment of historic wooden artifacts.

Proteins

There are two principle protein coating for wooden objects; casein and tempera. Casein is processed from the curd of soured milk, hence its common name "milk paint." Tempera is a medium of egg yolk and water. Both tempera and casein are initially water soluble materials which become less soluble once dry; in the case of milk paint, the coating becomes virtually intractable when dry. Protein media are never used as transparent coatings, although they may have such a low pigment content as to be translucent.

Additives

Additives for coatings include solvents which allow the film-forming material to become liquid, and other materials such as plasticizers and flatting agents. Sanding lubricants modify the properties of the dried coating, and driers catalyze and accelerate the hardening process for oil based coatings.

Solvents, as the name implies, are used to dissolve the resin (the "solute") into an

appropriate liquid (the "solvent") which can be applied to the surface of the object. Solvent/resin solutions may be designed and formulated to fit specific characteristics required for the coating, either while liquid or once dry.

> Note: The study of solvent relationships to coating is a huge one far beyond what is possible in this document. For information on this subject, the readers are directed toward sources listed in the bibliography.

Driers are added to oil varnishes to facilitate the drying polymerization of the film, and the most commonly employed driers are metal salts. Plasticizers, flatting agents, and sanding lubricants are added to alter the properties of the dried film. Plasticizers include oils, rubbers, and resins softer than the primary film-forming resin in a coating, and act to keep the hardened film flexible and prevent fracturing or shattering of the film. Flatting agents, which disperse incidental light on the coating film thus reducing specular reflection, include metal stearates and silicates. Sanding additives, which act as dry lubricants, also include metal stearates, primarily of zinc. Additional modifiers for coatings are ingredients which aid flow during application, producing a smoother more continuous fil, and suspending agents which are necessary for emulsifying and suspending pigments in paint.

Polychromy

Materials used in polychrome finishes, or decorated painted surfaces, are little different than those used in transparent finishing. The primary difference is the presence of a colorant in the varnish solution which imparts to the finisher the ability to form painted patterns on the surface of the object. Artistic technique for the application of these paints is as disparate as the practitioners, ranging from itinerant folk artists to trained painters working in large ateliers. Design sources for these decorations are also varied, and include a continuum from completely fantastic abstract designs with origins in folklore, to published pattern books with the most sophisticated images art and artists have to offer.

Colorants for polychrome are derived from a number of sources, and they fall into one of two categories; pigments or dyes. By definition, pigments are opaque, being particulate suspensions in the medium employed. Dyes, on the other hand, must be soluble in the medium in which they are used, and are therefore transparent. As with all other material in this treatise, the following is a superficial survey of those colorants most commonly used for furniture coatings.

The first and probably the most ancient of the opaque colorants are the earth colors, which are basically naturally occurring mineral (mostly clay) pigments. They are, in other words, designer dirt. Earth pigments include umbers, ochres, siennas, chalk, Indian red and terra verde. Pigments were also made from naturally occurring mineral gemstones

such as azurite, ultramarine, and malachite. Due to the rarity and cost of these pigments, many were replicated by using ground colored glass.

Black pigments, which are not readily present in natural clays, were (and still are) fabricated by charring organic matter, producing ash black. The characteristics of these "carbon blacks" depends on what was being burned as well as the fuel and temperature of the fire. Another source of black colorant was asphaltum, a natural tar.

Metal complex pigments were synthesized by a wide variety of procedures and include: lead, zinc, titanium and other whites, cobalt, copper, and prussian blues, copper and arsenic greens, iron, sulfur, lead and chrome reds, chrome, sulfur, lead and arsenic yellows, and a host of others. Some metallic pigments were used to imitate or accentuate metal flake, and include powdered materials of an immense range of metallic alloys. These are often referred to under the generic identifier "bronze powders." More contemporary metal-flake pigments are in reality mica flakes of very precise structure and manufacturing specifications.

The final category of colorants are dyes and the pigments made from dyes, which are called lakes. Traditionally dyes came from vegetable and animal sources, but these have been supplanted by synthetic organo-metallic and azo dyes. Vegetable dyes included any coloring material which could be removed from any plant. Commonly used vegetable dyes included madder root, berry dyes, saffron, alkanet root, indigo, and annatto. Vegetable dyes also included dyes extracted from wood, such as logwood and fustic. Animal dyes were cochineal, lac, and kermes, all from insects, and tyrian, a brilliant purple dye from shellfish.

Lake pigments were formulated by using the dyestuff to color an inert mineral powder, usually calcium carbonate or alumina. By combining the dye with a mineral base to form a pigment, transparent colorants could be made opaque, increasing their coloring power and stability. However, lakes are generally not as opaque nor are they lightfast as true pigments.

Metal leaf

The technique of applying metal leaf, frequently called "gilding" regardless of the metal in question, involves the gluing of thin metal foil to the surface of an object. Metals employed in this manner include gold leaf, which ranges from pure 24 karat to an alloy of about 16 karat. The most commonly used gold leafs are the alloys around 22 karat, which may be obtained in a variety of shades, depending on the alloy composition. Silver is also widely used, both pure and in alloy, and a number of copper and aluminum alloys have been developed.

Gilding may be adhered directly to a wood substrate, but it is much more common for leaf to be placed on a mineral ground. The ground is called gesso, and is a mixture of calcium carbonate, calcium sulfate, or koalin and protein glue. Layers of the gesso are built up on the wood substrate until the appropriate surface is achieved through texturing, smoothing, and carving. If the desired visual effect is one of moderate sheen, the leaf may be applied onto the gesso, using the glue in the gesso as the binder, a technique known as "water gilding." Another option is "oil gilding," which uses an oil/resin varnish as the size and results in a matte surface. For the most brilliant gilded surface, the gesso must be smoothed and additional layers of ground must be added. These final layers of ground are called bole, which is comprised of a clay/glue mixture. Bole enables mechanical burnishing of the substrate with a cloth, usually linen, which in turn provides a nearly flawless substrate to which the leaf is applied in the water gilding manner. Once applied, the gold leaf itself can then be burnished to a mirror surface with a polished stone.

Following the application of the leaf, the surface can be toned and glazed to achieve a wide array of desired visual effects. Non-gold leaf is frequently coated as a protection from oxidation and tarnishing.

COATINGS DETERIORATION

Deterioration of coatings encompasses several different processes: reactions which change the chemical constituency of the film materials, mechanical failure which may or may not be relative to the chemical changes but are definitely related to environmental fluctuation/rheological relationships, and induced damage through use and inappropriate treatment and maintenance. The simplest manifestation of this last occurrence is the removal and damage of surface coatings via abrasion as witnessed in coatings being simply scratched or rubbed away completely.

Specific coatings degrade in specific manners, but the problems of all coatings can be covered in a broad, general discussion with reference to individual problems as needed.

Chemical degradation of coatings depends on the chemical stability of the coating materials themselves, and environmental factors which may assist any degenerative reactive process. The most frequently encountered chemical degradation involves changes in the polymeric condition of the coating; it either becomes more polymerized and crosslinked, or breaks down and depolymerizes.

> Note: It must be emphasized at this point that crosslinking, which is so desirable in the formulation of contemporary coatings, is considered to be a negative characteristic by conservators.

Deterioration processes can be inherent in the material and occur because of the presence

of oxygen. Reactions can also be induced or accelerated by electromagnetic radiation. Finally, the presence of chemicals which are added to the surface once the coating has been completed can induce degradation (see below). Detailed technical descriptions of the chemical decomposition of coating materials are available in several texts listed in the bibliography at the conclusion of this monograph, and the reader is directed toward them for further information.

Two clear examples of continued polymerization of coatings are drying-oil-containing films which become increasingly non-thermoplastic with age, and the continued oxidative hardening of the surface coating. The intractability of these films would not be a problem were it not for the increasingly chromaphoric character of these films which may become yellowed and less transparent with age. At its most severe the problem is severe the coating which is supposed to enhance the substrate, will instead eventually obscure it. In that circumstance the observer is faced with a coating, that is both detrimental to the proper interpretation of the surface that is also inexorably integrated with that surface through penetration and crosslinking.

In the past this particular problem has been exacerbated by maintenance of wooden objects with various oil polishes applied to the surfaces of those objects. Egregious examples of this are objects who have been "cleaned" with a (traditional) mixture of linseed oil, spirits of turpentine, beeswax, and vinegar. Unfortunately for the objects in question, linseed oil becomes extremely chromagenic in the presence of acids, and in fact turns black over a relatively short period of time. Evidence of this method of "preserving" furniture and wooden objects is readily apparent in most museum collections.

Other forms of chemical degradation of coatings include the application of liquid chemicals which attack the surface coating itself and may destroy the coating film. This would include the introduction of organic solvents (e.g. alcohol on shellac, etc.), acids, or alkali solutions. These liquids may degrade the film to the point where it is no longer a viable whole, or may simply remove all or part of the coating by dissolving it. Also, some pigments and colorants can be altered by the encroachment of chemical pollutants through exposure to acidic or caustic environments which change the chemical structure of the colorant molecules, thus changing the colors of the film through which object is seen.

Electromagnetic radiation contributes to the deterioration of coatings in two primary ways. The first is the basic thermodynamic factor of reaction rates increasing with the input of energy. Thus, for example, if a surface is being heated by light or infrared, the degradation reactions will accelerate. A second manner in which radiation affects the surface coating is the effect of ultraviolet radiation, which breaks down resins and bleaches coatings, colorants and surfaces.

On its own, electromagnetic radiation, of which visible light is a small part, causes degradation resulting in fading or color change to most components of furniture coatings. While these changes can be compensated for (as detailed below), they are generally permanent, non-reversible phenomena and the underlying damage itself cannot be undone.

The mechanism and manifestation of deterioration of metal leaf on furniture occurs both at the microscopic metal layer at the surface and in the underlying ground or size layers. In the first instance the damage can be caused by surface contamination, as in instances where non-gold portions of the leaf oxidize or tarnish, thus changing color from that intended by the makers.

> Note: Pure gold is "24 carat." Anything less than pure gold is an alloy comprised of a portion of gold along with other metals. For example, "23 carat gold is 23 parts pure gold and one part other metals, usually copper or silver.

Most common damage to metal-leafed surfaces is in the form of abrasion, as the soft metal foil is literally rubbed off by use or housekeeping.

Equally probable is damage to leafed surfaces through the deterioration not of the metal leaf, but rather of the underlying ground that is the foundation of the entire system of applying the material. In the case of oil gilding, the oil/resin solution used to glue the leaf down to the surface degrades, and the gold telegraphs exactly that underlying deterioration, be it fracture, delamination, or other flaw. If the deterioration also involves he mechanical failure of a supporting gesso layer or bole layer (which are particularly susceptible to repeated humidity cycles), this can in turn cause fracture and delamination to the laminar system.

RESTORING COATINGS

Treating damaged or degraded coatings, like any aspect of thoughtful furniture care, begins with an examination and evaluation of the affected area. This examination has three main components. The first of these is to visually ascertain the damage and, if possible, create a thesis as to the cause of the deterioration. Visual examination includes the use of UV, IR, and microscopy to further develop the characterization of the surface. The second method usually employed to evaluate the coating condition is to test the surface with solvents, to see if and how the coating reacts to individual solvents or combinations of solvents. Finally, the examination involves analytical methods, including instrumental determination of the coating constituency. Further explanation of the role that each of these components takes in the formulation of the treatment strategy will be included as this discussion progresses.

Following the examination, the practitioner should have a good idea of the coating composition, or at least its primary characteristics. An accurate determination of the stability and the cause of deterioration place them one step further to the successful design of the treatment procedure. It is in this step that experience with and knowledge of historic coating materials and techniques is invaluable. The three broad classes of coatings, transparent films, polychrome, and metal leaf, each have problems and solutions specific to them. While each individual material has unique characteristics, the framework for approaching the solution to problems can be dealt with in a relatively similar fashion. Finally, the treatment must take into consideration the expectations and requirements to be placed on the object once the treatment is complete.

What do we need to know?

Furniture caretakers must possess a wide range of craft skills and knowledge; joinery, marquetry, veneering, carving, turning, and of course finishing. However, craft skills alone are not enough, skilled practitioners must have scientific and historic knowledge as well. When faced with the task of dealing with finishes on furniture, we must approach each problem and address four broad areas of concern. These are: preserving historic artifacts; paint and varnish chemistry; furniture history and construction; and the craft of furniture finishing. While these four areas might seem to be unrelated, they must be integrated into all treatment procedures to insure successful finish care and preservation.

Most furniture finishers develop an intuitive understanding of the materials they use. The knowledge of what works and what doesn't is compiled during years of experience and practice, success and failure. This anecdotal information is usually quite accurate, but it is also very limited. In order for this core knowledge to fit into a rational context, and ultimately expand, the finisher must begin to study materials science in general, and specifically paint and varnish chemistry.

The finisher who does not pursue this endeavor can progress no further than his own limited experience. This experience generally does not include a study of the fundamental nature of finishes, much less the areas of optics, color theory or analytical methodology. By understanding the nature of finishes as chemicals on the surface of the wood, the finisher can greatly expand his abilities to use different finish materials.

Without the knowledge of chemistry a finisher can observe, but may not fully understand processes and reactions. For the caretaker of historic furniture this understanding is critical as there may not be a second chance when working on a historic finish. For example, if the wrong solvent or procedure is used to clean a surface, the existing finish may be destroyed. A new one may be applied, but the old finish is lost forever. So, a good knowledge of the chemical nature and properties of the solid finish film, its solvents, and its behavior at each step of existence, is essential. This framework provides

for an understanding of the compatibility of different materials, the condition of a finish film, and the behavior and deterioration not only of historic materials but also of contemporary finishes.

The third area of concern is the history of furniture, including design styles, structure, and finishing processes. It is very important to know what is an appropriate finish for the piece in question, so that any actions undertaken will be sympathetic to it. Scientific analysis of finish samples can provide some clues, however, most practitioners do not have access to instrumental chemical analysis and must base their conclusions on knowledge of historic finish processes. These decisions can be more easily reached if we are familiar with historic materials, their use, and their appearance. The list of historic finish materials is a long one encompassing hundreds of different items. To these one must add all of the new materials which have been developed in recent times. We deal with furniture not only of the ancient past but also of the recent past. In addition to "antiques", museums and collectors are acquiring furniture whose makers are still living, so the our historical knowledge must cover all periods.

As the final step in furniture making, finishing has a long tradition, and the more we know of it's history, the better we can deal with finish problems. All of this contributes to determining whether a finish is potentially original and should be retained or whether the existing finish is incorrect and of little historic significance (such as polyurethane on a Philadelphia Rococo piece). In situations where the finish has been completely destroyed, history can provide essential clues as to finish materials and even original appearance.

Finally, we must be well-versed in the craft of wood finishing. Even if we were to have a full understanding of the chemical and historical aspects of finishes, that knowledge is of little value without the craft skills needed to solve the problem. We must be <u>able to do</u> what is necessary, <u>not just decide</u> what is necessary. The craft skills employed in finish conservation are virtually identical to those used other finishing procedures, although the application of those skills may be highly specialized.

Deciding What to Do

The goal is to stabilize and preserve artifacts. Since each artifact is different in terms of materials, construction, history, condition, and end use, each treatment situation is unique. This is true for all artifacts, whether they are paintings, sculpture, furniture, or any other object of historic or artistic importance. Because of these individual differences there are no rote methods, no "how-to" recipe book treatments that will work in all cases. In fact, in the articles which discuss treatments, the information presented is intended to be appropriate only for the specific application cited by the author.

Rather than having strict DO and DON'T rules, we rely instead on the abilities and

experience of the practitioner to make correct judgements within broad guidelines. These general guidelines revolve about respecting the historic, physical and aesthetic integrity of the object. Every effort should be made to preserve that integrity. This means that trying to leave the object as undisturbed as possible and yet insure the long term stability, function and preservation of that object. A balance is always sought between stabilization and restoration, which may require alteration of the piece as it currently exists, while preserving the historic information contained or discovered in the piece being treated. For example, how was the piece originally fabricated, and what has been its history since?

It follows that some general conclusions can be reached for furniture preservation which direct all treatment procedures, including finishes. First and foremost, existing finishes should be left in place unless they are clearly inappropriate to the object or so badly degraded that they do not serve any of the three functions outlined earlier: aesthetic "enhancement, " surface protection, and providing a historical record..

On the whole, we must be concerned with implementing a multi-faceted approach for stabilizing and preserving furniture, that is much broader than restoration, or the physical repair of existing damage. While restoration or refinishing certainly may be part of the process, in many instances it is not as important as an understanding of the nature of the materials, the treatment of their deterioration and ultimately their preservation. Interpreting, preserving, protecting and restoring finishes on historic furniture combine to form one goal within the larger framework of furniture care.

Fortunately there is, in principle at least, a common objective on the part of furniture caretakers across a broad spectrum of experience based on honest good will. The interested and engaged aficionado who doesn't care about the implications of preserving personal, family, and social history is, in my experience, a rare bird. They may not be well-skilled, well-trained, or well-informed, but in my observation they are well-intentioned and willing to "do the right thing" when guided toward informed choices.

Common sense dictates the fundamental truth that each object has a purpose and was intended to serve a function. However, the purposes and functions may change depending on the specific circumstances. Inside the museum, the object's function and purpose is often to just stand there and look a certain way, and bear the evidence of history. Outside the museum, the functions can be and often are utilitarian; the chair actually has to hold a large adult safely, and the dining table has to actually resist the attacks of food, alcohol, pets, and kids. These are very real limits and expectations. And while neither set of functions is right or wrong, each has its proper role. The problem in decision making and furniture care occurs when we apply the wrong expectations and limitations to the wrong circumstance.

The task is to find a process that works for making decisions in the broadest possible set

of circumstances. I have succeeded, in my own mind at least, in devising a framework for doing exactly that, in the guise of a series of questions whose honest answers provide insightful guidance for responding to the deterioration of nearly every object in every circumstance.

1. *How is the object? What is its nature? What is its problem?*
2. *What was/is/will be the environment of the object? What is the end use?*
3. *What are the ethical constraints?*
4. *What can be done?*
5. *What do you want to accomplish?*
6. *Finally, what resources do you have and how will you consume them?*

For convenience, I have coupled these questions into pairs of competing concepts.

I.   The needs of the object vs. The needs of the user
II.   What would we like to accomplish vs. What are we able or unable to accomplish?
III. How can we ethically preserve historic integrity vs. How much time and money have you got?

Once these notions are addressed, and questions answered, we are well on the way to designing a thoughtful, reasonable, and ethical path to future actions (or inactions)

Deciding What Materials to Use in Restoration

One relatively straightforward method is selecting the "best" available materials to achieve the results. Material quality is certainly a fundamental factor in furniture preservation and restoration as we try to engage in treatments that will remain "healthy" for centuries.

There are many considerations about the use of materials used in finishing, refinishing, and caring for finishes on historic furniture. First and foremost, the functions outlined earlier, providing protection and modifying appearance, form the cornerstones, but others are equally important. Second is the choice of materials which, if necessary, can be removed without further damage to the object. This might become necessary when the materials used deteriorate (remember, everything deteriorates), the object suffers further abuse, or a better treatment method is found in the future. Third, and related to the second point, is the use of materials known to be stable over long periods of time. Fourth, restoration should be detectable under close scrutiny, to insure that future caretakers and scholars are not confused or misled by what may appear unaltered to casual or uninformed viewers. Finally is the practitioners obligation to keep accurate and detailed records for future reference.

The combination of craft skills with materials science in choosing stable finishes eliminates some historic materials from consideration while adding other modern ones to replace them. An example of this would be using specially formulated acrylic copolymer resins rather than commercial acrylic lacquers or modified nitrocellulose lacquers. Although nitrocellulose is considerably more stable now than in the past, it still degrades much more quickly than acrylic coatings and is therefore not the first option in most cases. Acrylic copolymers are applied in the same manner as nitrocellulose lacquers and could be formulated for commercial finishing. It should be noted, however, that these copolymers are designed with very specific performance characteristics which may not be identical to those required of commercial finishing lacquers.

Another instance of a traditional material being inappropriate for finish care is linseed oil or other drying oils. Oils crosslink with age, which means that they are not easily removed, and under some circumstances may darken considerably. A finish undergoing a chemical reaction which turns it very dark and makes it difficult to remove, is a problem indeed. However, not all finish materials used in furniture care are expensive or exotic, and not all traditional materials should be avoided. The perfect example of this is shellac, which is widely used in furniture conservation because it is very stable and remains reversible for long periods of time.

Finally, there is the vast wonderland of finishing materials and processes waiting to be discovered. Recently my fellow Senior Furniture Conservator at SCMRE received two patents for furniture polishes developed here, combining to provide the most stable and highest performing furniture polishes thus far. I have at least four items in my notebook that may be accorded such in the future, and other colleagues have been turning their attention to coating formulations for several years. Only time will tell where our paths lead.

Transparent Coatings

Options for treating transparent coatings depend on the type and extent of damage, the coating material in question, and the desired outcome at the conclusion of the treatment. Certainly, no attempt is made here to describe every possible type of damage and deterioration manifest in coatings. Instead, the guidelines presented are an attempt to provide some direction within that broad framework to help focus our consideration of the damage and also the appropriate treatment options available to compensate for it.

As we review options for the treatments of coatings, it is important to remember that not all treatments deal exclusively with degraded coating films. Often the treatment concerns only portions of the coating strata, which reinforces the need to fully characterize the nature of the existing coating system(s). This documentation combined with a clear idea of what the treatment should accomplish, enables the caretaker to design the appropriate

treatment procedure.

The following treatment options and procedures are presented in that light. As has been discussed elsewhere in this piece, the ideal is to intervene the minimal extent necessary to stabilize the object and accomplish the treatment goals. Determining the proper treatment of transparent coatings is fundamental for treating coatings of any kind, and is usually the foundation on which all further action is based. The conceptual basis for the following list of options is based on the assumption that it is preferable to begin with a conservative approach, and if that is not successful progressing through a series of slightly more intrusive options, until a treatment is completed. For several of the broad option categories, several additional considerations are explored, each of which must be evaluated and considered. The options below are roughly listed from least intrusive to most, but this listing is by no means the final word on the subject.

A non-exclusive hierarchy of treatment options begins, as always, with:

1. Doing nothing except stabilizing the environmental conditions. As described earlier, a great number of the problems associated with coatings deterioration are mechanical. Diminishing mechanical stresses through mitigation of environmental fluctuations (relative humidity especially) should always be part of the best possible scenario for preserving coatings.

2. Cleaning the surface is the least intrusive action to be taken by which an alteration to the object is attempted. Cleaning surfaces can be straightforward, as in the removal of light dust and dirt, or complex, as in the removal of overvarnishes or other accretions such as polishes. The first step in this procedure is to precisely determine what is supposed to be on the surface of the object and what is not appropriate.

Methods for removing unbound dirt and grime from the surface of a coating are similar to cleaning procedures for wood surfaces with the additional consideration that coatings can be physically or chemically more fragile than wood. Careful mechanical removal of grime from the surface can be useful for the object. However, fractured films are susceptible to further damage if an attempt to brush or rub off dirt is carelessly done. When this type of cleaning is used on coating films with extensive fracturing, characterized by a network of fissures in the surface, the result can be to simply push dirt into those fissures, leaving the surface no cleaner than before the attempt. If the fracturing is more severe, and the coating is lifting or cleaving, the mechanical action of dusting can literally knock coating off the surface. In this instance the coating would be more damaged by the cleaning than by the continued presence of dirt on the surface.

In many circumstances the grime on the surface is more strongly adhered than can be simply "dusted off" and a liquid cleaning solution must be employed. Solutions under

consideration should be tested in small, discreet locations to determine efficacy of the techniques and the cleaners' effect on the coating materials which are to be saved. Simple aqueous detergent systems are among the first to be considered, providing the coating is unaltered by the water in the cleaner. Due to the fact that degraded organic materials are sensitive to extreme pH conditions, non-ionic detergents are preferred, even though as cleaners they are not as effective as strongly alkali solutions. Because all cleaning procedures are potentially damaging to the object, it is often preferable to employ two weakly effective cleaners than a single more powerful solution which may cause damage. Common aqueous cleaners, like Orvus, are 5% solutions of detergents applied with cotton swabs or pads. It is important to keep from saturating the surface of the object with the cleaner, to avoid abrading the surface with the cleaning swab or pads, and to immediately rinse and dry the area after cleaning is complete.

If the surface coating being cleaned is sensitive to the presence of water in the cleaning solution, non-aqueous detergent mixtures can be used. A number of alternative detergents are available which are soluble in petroleum thinners or other mild organic solvents. These cleaners should be employed in a similar manner as aqueous solutions.

One final method of removing surface dirt from the coating is the use of poultices, which can be extremely effective in cases where wetting of the surface is not desirable or the mechanical removal of the contaminant is not feasible. A useful example of this application would be to address an alternative solution for the problem described at the beginning of this section, where a fractured surface was "cleaned" and the dirt simply forced into the fissures. In this instance a poulticing mixture could be applied to the surface, flowing into the crevices yet not saturating the surface with solvent. As the gelled cleaner contacts the adulterant, it adsorbs or absorbs the material, removes it from the surface and leaves a clean, undisturbed coating. Ideally the poultice will have some physical integrity in order to facilitate its removal by enabling the poultice to be peeled from the surface once the cleaning is complete. For that reason, poultices should contain a soft, film-forming ingredient such as methyl cellulose or low weight (poly)vinyl acetate (PVA) or (poly)vinyl alcohol (PVOH) resin along with the cleaning agent itself. Several detailed descriptions of these procedures and poultice formulations are present in the literature, and the reader is advised to consult them for further technical information.

In many instances the goal of the cleaning procedure is much more than simply removing dirt; it may involve removing contaminants integrated with or attached to the coating. In other words, partially removing a portion of the coating itself. The materials selected for removal may be accumulations of polishes and waxes, varnish overcoats, or defacement. To repeat an earlier caveat which cannot be overemphasized, it is imperative in such treatments to fully characterize the strata of coating materials and decide which layers will be removed. Selective removal of coating material from the coating falls into two categories, one which will be discussed here and the other later on. This brief description

will deal with removing adulterants on top of the coating strata critical to the interpretation of the object, while a later discussion will center on the removal of degraded material within the strata of importance. The distinction is truly more art than science, and the assignation of layers as adulterants vs. important varnishes can be well reasoned or completely arbitrary and capricious.

Cleaning strategies for adulterants depend on the results of the initial examination, particularly the results of the solubility spot tests. Thermoplastic materials, such as waxes and some resins, can be removed easily with relatively mild solvents. Oil polishes and oil/resin varnishes are less thermoplastic, and depending on the formulation of the coating can also be removed with solvent solutions, although stronger solvents are required. Other procedures available include using solvent gels to control manipulation of the solvent(s), making soaps from oils and resins which can effectively remove some overcoatings selectively, and using enzymes such as lipase to digest and break down oil containing layers.

Mechanical cleaning is an entirely different conceptual approach to the selective removal of either solidified adulterants or degraded coatings. By this technique, if the underlying materials are stable enough, selective portions or areas are literally ground away with very mild abrasives to reach a layer of desired materials, or mechanically scraped away with tools to accomplish the same ends. Whether or not this approach is considered "low impact" is a matter of much debate, and both "pro" and"con" arguments can be articulated persuasively.

3. Another relatively minor intrusion on the coating is the visual compensation for damage in localized areas. Applying varnish and colorants to scratches and nicks involves little other than the introduction of a small amount of material to the surface in order to provide some measure of visual uniformity. All compensation for damage regardless of extent, should be done with stable, thermoplastic coatings and permanent colorants. Most furniture conservators feel comfortable with shellac combined with pigments or dyes for this purpose, but any coating material which fulfills the specific requirements of the treatment is acceptable. In addition to dyed shellac, common approaches to inpainting transparent coatings include dyes in other resin solutions, pigments in solution, and watercolor washes and gouache. It is prudent to mention at this time that inpainting should not done directly on bare wood, but should instead be executed as a laminate with resin coats above and below, which serve to isolate the coloring layer in between. It should also be mentioned that visual compensation can be conducted at the conclusion of any of the treatment options, and can be applied by brush, spray or pad.

4. If the surface coating is clean and physically sound yet needs additional optical saturation and enhancement, a wax coat may be applied. This may be defined as a

maintenance procedure, but in the holistic approach to preservation of artifacts, the line between the different activities can be blurred.

5. If the coating is clean but not physically sound, i.e. too fragile to survive the rigors of applying and buffing a coat of wax, the surface can be saturated with an easily removable resinous coating. This accomplishes not only physical consolidation of the fractured or flaking film, it also provides optical saturation and enhancement. This procedure also lays a stable foundation for additional compensation, such as inpainting.

6. Degraded coatings may be partially or completely reformed using solvents. The success of this approach depends entirely on the thermoplasticity of the existing film material. Solvent release coatings are good candidates for this procedure, even if degraded and partially polymerized. Conversely, reactive coatings like oil/resin varnishes are not as likely to be improved by such an approach.

The basic procedure for reforming is to first determine which, if any, solvents modify and reliquify the existing coating. If the intent is to only partially reform the coating, such as when re-adhering a delaminated coating to the substrate, the solvent may be introduced in a vapor chamber with good success. If the intent is to more thoroughly reform the film, to actually reliquify it and allow it to flow out, then the solvent may be used in liquid form.

One factor which must be overcome is that many coating films, while remaining soluble, require a longer exposure to solvents in order to complete the dissolution. As a consequence, the solvent exposure to the coating must be lengthened. In partial, vapor-based reformation, the solution is to simply leave the vapor chamber supplied with solvent for as long as it takes for the treatment to be complete. For complete reformation, solvent mixtures with low volatility must often be used. Mixtures are formulated depending on the specific problems encountered. Common "retarding" solvents such as glycol ethers, are used since they are both excellent solvents, and can remain active on a treated surface for days. Coatings which are being altered can be allowed to reform unassisted, but further manipulation of the softened film with a polishing rubber is common.

7. The next option would be to conduct the reformation process with the addition of a compatible resinous component to the reforming solution. This allows simultaneous reformation and augmentation of the film.

8. Partially removing the degraded coating has already been mentioned (Option 2, above). The rationale behind this technique is that the presence of too much degraded material unduly complicates the treatment procedure. Removal of coating material can be accomplished mechanically by abrasion, or chemically by solvent or soap solutions. Following removal of the material, the remaining coating can be manipulated by the

means already discussed: it can be waxed, consolidated, recoated, or reformed.

9. The final option for treating degraded coatings is to remove and replace the damaged film. Removal can be mechanical (abraded, scraped or chipped) chemical (solvent removal) or biochemical (using enzymes to render the film non-viable). The replacement base varnish should be a solvent release (thermoplastic) formulation, chosen with careful regard to the characteristics desired of the final finish.

Polychrome

Polychromed surfaces present all the problems associated with transparent finishes with the additional dilemma of a completely inflexible component within the coating surface. Transparent varnishes are important to the interpretation of an object and as such should be retained whenever possible. However, if a strong enough rationale can be presented, part or all of the coating material can be manipulated or even removed and replaced. In contrast, polychrome surfaces not only aid in the interpretation of an object, they are frequently the entire basis for that interpretation. For that reason polychrome surfaces are virtually sacrosanct, and any manipulation which could destroy the visual character of the decoration is not an option.

In general, as with transparent finishes, the goals of any treatment involving a decorative painted surface determine the treatment options. The framework presented for treating transparent coatings pertains also to polychrome surfaces, although obviously not all the specifics are applicable.

1. Cleaning the accretions and adulterants which obscure the polychrome is the least intrusive treatment, although it can be very important. Cleaning procedures outlined in the preceding section apply to the treatment technique here as well.

2. As with transparent coatings, stable polychrome surfaces can be visually enhanced by the application of wax or resin coatings.

3. Solving the problem of polychrome being susceptible to fracturing and cleaving as outlined in the Deterioration Section requires that in many treatments, the decorative surface must be stabilized and adhered to the substrate. Since cleavage and chalkiness, and their associated loss, are the most prevalent problems faced by polychrome objects, consolidation of the paint layer is a common portion of treatments. This can be accomplished by impregnating the surface with resins or waxes.

4. A special technique that has been developed in response to the problem of cupping and tenting, where delaminated and distorted polychrome no longer conforms to the substrate. To resolve the problem, an adhesive must be introduced into the void between the

substrate and the coating and the lifted material "massaged" into contact and conformity with the substrate. If the cleaved coating is too brittle to be manipulated without further damage, it can be plasticized by moisture or heat, or both. In circumstances where the substrate has shrunk, it may be necessary to trim some of the tented coating in order to allow the set-down paint to fit into the space remaining. Setting down lifted polychrome flakes is usually done through a transparent membrane (e.g. Mylar) with weights, clamps, or heated spatulas used to iron the flakes down into place.

5. Inpainting, or visual compensation for missing polychrome, is usually the final step in treating damaged paint surfaces. Inpainting can be conducted at any time in the treatment, and can be used in conjunction with any of the options already listed. Inpainting is executed in a laminated manner, with an isolating layer below and above the added paint layer. As with all treatments, stable and reversible coatings and colorants are preferred. Techniques for inpainting vary as widely as the restorer's talents and philosophical approach to the treatment. Materials used for inpainting include acrylic resin and emulsion paints, synthetic dyes in natural or synthetic resin solutions, as well as watercolor wash and gauche. Painting techniques vary from verisimilitude to neutral value crosshatching which merely acts to diminish the distraction caused by the damaged area.

Metal Leaf

In the Deterioration Section it was pointed out that most deterioration of leafed surfaces is not with the leaf itself but with the substrate. Exceptions would be abrasion loss of leaf and oxidized non-gold leaf. The former is easily rectified by eliminating all unnecessary contact with the surface, and the author knows of no reasonable approach yet devised to solve the second problem. In general, treatment options for leafed surfaces revolve around the repair of the ground, as already implied.

1. The first option for damaged leaf-work, regardless of manifestation, is to remove and eliminate the cause of damage.

2. In instances where the mineral ground (gesso or bole) is weak and no longer integral, it must be consolidated. Depending on the extent of damage and the style of gilding or leafing, the consolidants of choice would be gelatin or synthetic resins, notably acrylics in solution or emulsion.

3. Once the ground has been stabilized, or if it is stable to begin with, the surface can be cleaned. Extreme care must be employed because of the inherent fragility of the microscopically thin metal leaf, and the likelihood that the binder holding the leaf to the surface could be damaged by vigorous cleaning.

4. Losses, whether of the substrate or of the ground can then be replaced. Traditional techniques of workmanship are most often used.

5. Ground which is unstable and cannot be satisfactorily re-united to the substrate may be removed and replaced.

6. Once the ground has been stabilized and cleaning is complete, areas of loss to the metal leaf may be re-leafed. Pigment or dye toning is frequently employed following the application of new leaf to diminish the visual disparity between old and new leaf.

7. In extreme cases, the entire object may be re-leafed, and the new leaf visually modified to fulfill the aesthetic requirements of the treatment.

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