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The Common Wood Floor: Interpretation and Treatment of Wood Plank Flooring in Historic Buildings

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THE COMMON WOOD FLOOR

INTERPRETATION AND TREATMENT OF WOOD PLANK FLOORING
IN HISTORIC BUILDINGS

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Contents

Introduction

Wooden flooring is ubiquitous in historic American architecture; high-style or low-style, residential or commercial, east-coast or west-coast, eighteenth century or nineteenth century. Within a room, the floor typically accounts for 25 percent of the interior surface and it is often the only surface that one actually touches. It bears the weight of the room; persons, furniture and all the sundry articles of decoration and daily use. Carpeted, painted, varnished or bare, the finish or covering of a wooden floor is the foundation of visual interpretation in an historic interior.

The utilitarian nature of floors and floor coverings makes preservation and interpretation extremely difficult. There are few eighteenth or nineteenth century floor finishes or coverings surviving in situ, and it is only in the last three decades that historians have pieced together the fragmentary evidence in an effort to understand just what early American floors looked like; how they were covered or finished and how they were cleaned and maintained.

Carpeted or painted floors were typical of high style urban interiors by the onset of the American Revolution, but it is now generally accepted that, until the nineteenth century, the vast majority of wooden floors were maintained without the benefit of any finish or covering whatsoever. Paints and varnishes, and certainly textiles, were so costly as to be used only sparingly in all but the finest and most public spaces. Floors were typically left bare and swept, scrubbed and sanded clean. By the turn of the nineteenth century prominent rooms of prosperous middle class homes were brightened with a linseed oil or beeswax floor polish, and toward mid-century the mechanization of the

textile industry made floor coverings like venetian or ingrained carpets affordable and fashionable. Floor painting and painted floorcloths became popular as well, continuing the trend of covering or disguising the structural wooden floor. Not until the end of the nineteenth century did wood reemerge as a fashionable finish flooring material.

Ironically, at the turn of the twenty-first century, wide plank floors of woods like pine or yellow poplar are flaunted, and with very few exceptions, the floors of historic buildings are coated with one or another of linseed oil, wax, resin-varnish, polyurethane, or some other protective finish. Certainly, there are valid, practical reasons for a protective finish on a surface that sees such heavy use. Water, salts and abrasion from shoes and soils, can be both destructive and difficult to clean. Transparent coatings can provide a barrier to moisture, water borne salts and ultra-violet radiation, and resist the effects of abrasion and discoloration. Often, however, in preparation for the protective coating, floors are stripped of previous finishes by machine sanding operations that remove some of the wood surface as well.

It is a recurring theme in the ever-expanding field of Historic Preservation that current, conventional methods and materials must be critically evaluated; both for their compatibility with preservation standards, and for their efficacy when applied to historic work. In the case of wooden flooring, the contemporary industry has standardized the finishing process around the requirements of a single group of similar, synthetic coatings and as a result, the practice of wholesale floor sanding for surface preparation has developed into a regular part of the cyclical maintenance of wooden floors. But this practice is inherently destructive. It obliterates patination and finish history, and violates a fundamental goal of historic preservation - the conservation of historic fabric.

Preservation professionals cannot continue to rely on the methodology of the floor finishing industry. Current methods, which have developed around the requirements of urethane resin coatings, are destructive to both the surface and the structural integrity of historic flooring. Furthermore, modern coatings, or modern applications of traditional coatings, are often inconsistent with the visual requirements of an historic interior.

The field of Preservation must adapt established technical and ethical methodologies to the care of wood floors. This thesis will demonstrate the necessity for such an adaptation, and present the framework for a new, preservation-oriented methodology that specifically addresses the selection of a durable, yet visually authentic floor treatment. A methodology that must take into account the results of previous treatments in similar situations and determine under what conditions the chosen finish must be effective. A methodology that guides informed and considered choices. These choices must balance both the historical aesthetic and the long-term protection of historic material, since an inappropriate finish material or application method can lead to a loss of historic fabric due to maintenance problems, premature finish failure or repetitive refinishing procedures.

Such a methodology would have at least three requirements; an historical understanding of floor treatments, a technical understanding of available coatings and their characteristics, and a framework for interpretative philosophy. Beginning with a review of primary and secondary historical sources chapter 1 will outline the evolution of transparent coatings technology and applications specific to domestic architectural treatments for unpainted interior woodwork, in eighteenth and nineteenth century America. This progression of material technology and evolving use will then be followed

into the twentieth century to explain the discrepancy between modern and historical approaches to floor finishing and maintenance.

Chapter 2 will discuss the divergence of industrial coating development from the aesthetic concerns of historic preservation and related fields. Modern floor coatings have been exclusively developed for properties of strength, adhesion and durability, by way of industrial applications and large scale production. While such properties are also key aspects of wood floor finishes, performance must be balanced with preservation requirements including both authenticity of materials and visual characteristics, and reversibility or maintainability of finishes which are critical to the protection of the underlying historic material. Comparisons of industry standards and guidelines with those of the preservation field highlight the incompatibility of these two approaches to floor protection and maintenance. Too often the response of the historic preservation field has been either defeatist, accepting modern coatings as an unpleasant compromise, or reactionary, deferring to traditional, natural finishes.

Modern coatings technology has been adapted to isolated aspects of historic finishes conservation, through the application of research methods and analytical techniques, and in the use of synthetic polymer coatings as isolation layers, consolidation treatments and substitute coatings. During the last two decades, advances in coatings research and the development of coatings and systems specifically for visual qualities have offered new materials and formulations geared toward traditional optical characteristics. Research thus far specific to fine arts conservation has advanced new chemical data which make quantifiable, standardized comparisons possible between and among traditional and modern finishes. Such an approach could also be useful if applied

to architectural finishes analysis and some of these developments have already resulted in finish systems applied to both historic floors, and to new plank floors in historic buildings and period rooms.

Chapter 3 builds on this background to present a methodology for the interpretation, treatment and practical maintenance of historic wooden floors. Each step in such a process is informed by those preceding it; condition assessment helps to prioritize the requirements of protection, which determine treatment parameters. Ethical dilemmas of authenticity, substitution and functional compromise can only be confronted with a clear understanding of the condition and historicity of the fabric.

Every historic wooden floor exists in its own unique circumstances that must be considered individually and in combination to determine the most effective and appropriate treatment. Similarly, each one of many possible treatments has a unique combination of maintenance requirements, performance characteristics and visual qualities. By comparison of these circumstances with treatment options, one or more solutions can be identified. Standardized methods and materials are rarely applicable to historic work, a fact that necessitates continual reassessment of accepted practice. The following chapters will provide another node along that continuum, respectfully building upon the work of many others cited throughout, and hopefully contributing to the appreciation and preservation of wooden floors.

Chapter One: Historical Use and Treatment of Wood Flooring

Wood is an extremely versatile construction material. In all cultures where suitable timber exists in sufficient quantity to be used for building, it has been continually used in a multitude of structural and decorative applications. A balance of compressive and tensile strength unique among unprocessed natural building materials make wood ideal for horizontal clear spans required by flooring systems. Furthermore, wood species well suited for floor surfaces possess insulating and shock-absorbing qualities by virtue of low thermal conductivity, low density and flexibility.[1] Even among the infinite array of synthetic materials available today, wood and wood products are still the most pervasive flooring materials in American residential architecture.

Of course, the types of wood products and the way that they are used as flooring has changed. The distinction between the structural floor or subfloor, and the finish floor, must be acknowledged straightaway for it is of critical importance in understanding both the changes in the use of wood as a flooring material over time, and also the evolution of the aesthetic treatment of domestic flooring in general. Subfloor and finish floor are modern terms, applied generically in architecture and construction today to describe all kinds of flooring materials. Although other authors have employed historical nomenclature to describe multiple layers of flooring materials,[2] here the focus is contemporary treatment of a specific historic material. Extensive use of comparisons across a wide time frame necessitates a clear, direct terminology, familiar to the contemporary reader.

A floor treatment is here defined as a distinct non-wood layer on top of the finish floor. A floor treatment is what makes up the surface of the finish floor, which is the ultimate focus of this thesis. Floor treatments include the absence of applied finish as well as the entire range of stains, sealers and coatings, since the visual effect of a wood finish floor is the combination of both the physical microstructure of the wood surface, and any other substances on the surface that alter its visual characteristics. Dirt and other residues become part of the surface appearance of an unfinished wood floor, bonding with the wood in much the same way as an applied coating. Discussion of floor finishes will also rely on modern convention to differentiate between the many materials and formulations both traditional and modern. A glossary is included in the appendix for additional clarification.

It is important to briefly outline the historical use and treatment of wood floors in this country as a preface to the discussion of approaches to preservation. This outline will not attempt much beyond broad generalization, identifying trends and technical advances which grossly affected flooring use and treatment over time. At any one moment in history there are also great variations across cultural, economic and geographic lines. The scope of research and the expertise of the author are primarily concentrated in southeastern Pennsylvania, and much in the way of specific historical information is drawn from the Philadelphia area. The intention of the analysis is more general however, and Philadelphia being the largest colonial city, the first national capital and a center of commerce and culture throughout the nineteenth century, justifies extrapolation.

The general attitude toward floor treatment and the range of typical treatments can be distinguished by three broad eras in American history, each roughly corresponding to a century: the eighteenth century, during which wooden floors were generally unfinished and uncovered; the nineteenth century, during which the same structural wooden floors were increasingly covered by carpet, floorcloth, linoleum, paint and wooden finish floors; and the twentieth century, during which plain wood planks become desirable as a finish floor in their own right, often being applied over subfloors of solid wood or plywood. Of course, these eras are not precise and the transformation of one into the next was gradual. More precise information about the range of possible treatments for any particular building can only be determined by considering the specifics of its location and the economic status of its inhabitants.

For the purposes of this thesis there are two elements to consider: the use of wood both as a subfloor, and a finish floor; and the use of transparent coatings as finishes for wooden floors. A chronology of floor coverings will be presented first, followed by a discussion of the availability of transparent wood finishes in America, and their use as floor finishes.

Eighteenth Century

The treatment of floors in colonial America is a reflection of the daily life of its people. Outside of the major cities life was principally a family-centered struggle for subsistence. Food, clothing, household utensils and farm implements were all grown or wrought at home, or swapped among neighbors.[3] Skilled labor was traded as well, symbolized most dramatically by accounts of mass cooperation like barn raising.

Gradually, as villages formed at intervals in the countryside, skilled craftsmen were able to live more by their craft and less by their land. Still, at the close of the Revolutionary War the new nation was composed mostly of sparsely settled wilderness. More than half the state of Pennsylvania was not settled until after 1792.[4] So it is not surprising that there was little concern in most households for the decorative appeal of the floor.

In *Floor Coverings in New England Before 1850*, Nina Fletcher Little states that "some of the urban and most of the rural population continued to live with bare or sanded floors (until well into the nineteenth century) or depended upon a few home-made rugs to provide warmth and a modicum of luxury in the best rooms."[5] Sand served a dual purpose as both a cleaning material to aid in the regular scrubbing of the floor surface, and when dry it was left on the floor and brushed into freehand patterns, as a kind of floor covering. Sand decorated floors are described by contemporary sources in both the eighteenth and nineteenth centuries and such treatment was likely widespread before other floor coverings became affordable.[6]

During the second half of the century, the wealthier urban dwellers were beginning to acquire imported floor coverings including grass matting and floorcloths. Still, before the nineteenth century, any floor covering was a luxury. Von Rosenstiel and Winkler report in Floor Coverings for Historic Buildings, that "In 1775, for example, when Philadelphia was the largest city in America – and one of the largest in the English-speaking world - floor coverings of any type appeared in less than three percent of the [probate] inventories."[7] After the Revolutionary War, domestic production began to offer less expensive - though often lower quality - goods, which expanded the market and set the stage for the industrial revolution.

Nineteenth Century

During the first half of the nineteenth century, the combined effects of national expansion through both the development of reliable routes of inland transportation, and the beginning of the industrial revolution, made a wide variety of floor coverings available and affordable. Water-powered woolen mills at the turn of the century were patterned after the established British textile factories and by 1830 there were several dozen factories in America producing woolen cloth.[8] In the 1820's, new tariff laws imposing taxes on imported carpets, encouraged domestic textile manufacturers to branch out into carpet production, and by 1832 the Lowell Manufacturing Company in Lowell, Massachusetts produced over 100,000 yards of hand-woven, ingrain and Brussels carpet[9].

With the factory system in place an era of invention and expansion began. By the 1850's the first steam-powered Brussels carpet looms were producing eight times the daily yardage of hand-operated looms.[10] In 1867 the endless-chain mechanized Axminster loom was perfected and put into operation, dramatically improving the production of American ingrain carpet.[11] Carpeting became an essential element of fashionable, upper-middle- and upper-class parlors and dining rooms, especially in the northern states, and especially during the fall, winter and early spring. In summer, straw or grass matting, which was cooler and less susceptible to insect damage, would stand-in for wool carpets.[12]

Throughout most of the century carpets remained an expensive floor covering, and most American homes continued to rely on the more common coverings like floorcloths, home-made rugs and matting.[13] Floorcloths increased in popularity until the

advent of linoleum, invented in 1863, and were still commercially available in the early 1900's. Linoleum was more durable and longer wearing because the color and pattern went through to the backing. After the turn of the century, printing and inlay processes were developed to create a wide variety of original and imitative patterns including wood parquet and the decorative motifs of carpets.[14]

Under all these coverings, wooden floors remained unfinished. In the best rooms of the house wood flooring was invisible beneath matting, carpeting, floorcloths, or linoleum, while the floors of other rooms were coated with paint or left bare. This invisibility often led to lower quality installations since builders knew that the work would be completely covered.[15] Depletion of mid-Atlantic forests and improvements in transportation brought more southern yellow pine flooring to northern states. The wood products industry, like many others, was changing from local and regional trade to national and international trade. This period is defined by the development of the American industrial economy. A continual progression of new industrial machinery and processes provided the swelling middle class with an unprecedented variety of decorative floor coverings that they could afford, and which continued to cover the common wood floor.

Twentieth Century

At the close of the nineteenth century, domestic architecture settled into this modern notion of decorative variety, and the distinction between subfloor and finish floor. The decorative frenzy of the Victorian age was displaced in the late 1800's by the new philosophies of modern taste. William Morris, Charles Eastlake and American

critics like Clarence Cook emerged as spokesmen for reform in household decoration, and their motto was simplicity. In 1881, Cook touched on the contemporary issues of domestic economy and hygiene in *The House Beautiful*. He argued that "the advantage of a hardwood floor....is so great on the score of health and labor-saving, that it would seem as if only the prejudice that comes from old associations could long keep up the fashion of carpets."[16] Of course, carpets did not go away, but the status of wood as a finish flooring was established, and along with it the practice of applying a transparent finish.

It is interesting to observe the relationship between the relative cost of wood and its use as finish floor. During the eighteenth and much of the nineteenth century wood was plentiful and inexpensive; so common a building material as to be undesirable as an interior finish. Conversely, during the last century the increasing scarcity of timber has increased its cost relative to other modern finish materials. This may have been the most direct influence on the decorative status of wood flooring.

It is particularly revealing that wood plank floors were viewed almost exclusively as subfloor during much of the nineteenth century. Then, as now, even in modest homes structural flooring was covered or obscured wherever possible, and otherwise left bare. Any transparent coatings applied to wooden floors prior to the Civil War were in an effort to render the surface easier to clean, not to draw attention to the floor surface or enhance the visual characteristics of the wood itself.[17] But from the 1880's to the 1960's, wood flooring steadily grew to become one of the most desirable of finish flooring materials.

The National Oak Flooring Manufacturers Association (NOFMA) was established in 1909 in an effort to standardize products and facilitate expansion of the national market for wood flooring. Grading rules for manufactured flooring were established informally in 1904 and NOFMA published and began administering similar rules in 1909. Soon after its inception NOFMA began to include manufacturers of all hardwood species of flooring and in the 1930's the U.S. Department of Commerce adopted NOFMA grading and milling standards for the Federal Commercial Standards.[18]

NOFMA's softwood counterpart, the Southern Pine Association (now the Southern Forest Products Association) was founded in 1915 with many of the same objectives. SPA established grading rules and instituted grade marking in 1924.[19] These associations and others like them consolidated the industry and completed the transition from local mills to national production and distribution. Throughout the first half of the twentieth century wood finish flooring increased in popularity and uniformity. Standard widths and species were installed in houses all over the U.S. For fifty years wood was the standard finish floor, reaching a peak in terms of industry output in 1949, before the influx of plywood, synthetic fiber carpeting and vinyl sheet flooring.[20]

Transparent Finishes in America

The use of transparent finishes, variously called varnishes, liquid varnishes, spirit varnishes, lacquers, shellacs, waxes and polishes, has its beginnings at least as far back as Egyptian civilizations, as is revealed by surviving furniture and mummy cases. Written references to liquid varnishes appear with increasing frequency and variation, but with little change in methods or materials, from the tenth century manuscripts of Theophilus to

the nineteenth century trade manuals of Pierre Tingry.[21] Although many formulations were published, the recipes of individual varnish makers were often shrouded in secrecy. Variations in the usage and meaning of terminology over time, between the arts, trades and industry, and from one geographic region to another add to the confusion. Even at the present time chemical classifications differ from industry classifications, which differ from common trade classifications. Although terminology is defined in the appendices, several historical references in the following chapters will highlight the difficulty of understanding historical patterns of use for specific coating materials and finish systems.

By the nineteenth century, large-scale production was mechanized, and the mystery of formulations was embraced by a commercial emphasis on quality. Throughout this era of traditional, natural finishes, new materials were occasionally incorporated, but few had critical significance. The search for the perfect resin or varnish formulation continues even at the present. Advances in the technology of extracting and refining raw materials, especially after 1800, had the greatest impact on the tradition of transparent finishes until the advent of synthetic resins in the twentieth century.

Arguably, any transparent wood finish prescribed for furniture or woodwork could have been used as a floor finish. In general though, what little is known about nineteenth century floor finishes suggests that only a handful of finishes were used. Drying oils and waxes, especially linseed (flaxseed) oil and beeswax, were locally produced, relatively inexpensive and widely available by the end of the eighteenth century. By 1810 there were 171 mills in Pennsylvania alone, producing two-thirds of the flaxseed oil in the U.S.[22] Shellac and other imported resins were also used for floor finishes although availability is the key to their use in America. Principle sources of the

better quality resins were and still are in Africa, Australia and southeast Asia, and although these resins were used in colonial America, they were relatively rare and costly.

A growing inventory of analyzed and documented finishes surviving in nineteenth century buildings does suggest that spirit varnishes, including shellac and rosin varnish, were used more extensively than oil varnishes for architectural finishes during the nineteenth century.[23] The colored shellac resin was imported into Europe by the end of the seventeenth century, but it was not until the 1790's that the development of chemical bleaches rendered it suitable for transparent finishes.[24] There are still very few examples of shellac varnished floors before the Civil War, but towards the turn of the century shellac joined drying oils and waxes as the standard coatings for wood finish floors. By 1938, the U.S.D.A reported that "70 percent of the floors in large cities in the East are being finished with shellac, 20 percent with floor seals, and 10 percent with varnish, in spite of the fact that nearly all who give technical advice about floor finishing rate shellac as the least desirable of the three."[25]

The transition from bare to finished floors took place gradually, first using oils to improve stain resistance and reduce maintenance. By 1870 the Manufacturer and Builder recommended oiling a floor because "grease spots, of course, will not affect the wood thus treated; and much less scrubbing than is necessary for a plain floor will suffice to keep it clean. Moreover, the appearance is improved with oil. Many of our native woods, prepared in this manner, become positively handsome. Finally, it gives the surface a harder texture, which makes it wear longer and more uniformly."[26] Recommendations for floor stains, varnishes and wax polishes appear in decorating books and architects and builders journals with increasing frequency during the 1880's.

In 1877 Rhoda and Agnes Garrett recommended that bedroom floors "be stained and varnished and kept frequently rubbed with that wholesome compound, bees'-wax and turpentine."[27] The S.C. Johnson Company, initially a parquet flooring manufacturer, began producing a paste wax finish in the early 1890's which was specially formulated for wood flooring. The principle ingredient was carnauba wax, a vegetable wax that was first exported from Brazil to Europe in 1845.[28] Carnauba's luster, hardness and high melting point make it a beautiful and durable floor finish and the success of Johnson's first paste wax led to many other wax finish formulations that became a staple of wood floor finishing during the twentieth century.

A passage from a 1935 U.S.D.A circular provides a summary of floor finishing practice in the early 1900's:

> Years ago floors were commonly finished with repeated applications of hot linseed oil, each application buffed by hand; and when the surface was saturated with oil, it was waxed and maintained by waxing at suitable intervals. Because unbodied drying oils such as linseed penetrate into wood relatively deep, a good many applications were necessary, making the process rather laborious; but the finish was correspondingly durable, did not show scratches, and was readily patched at places of maximum wear without refinishing the entire floor. The pure linseed oil finish dried hard enough to be free from any tackiness and made a floor that was very easily kept clean by dry mopping. In time the finish darkened, partly because of the change in color of the wood itself and partly because drying oils and varnishes become discolored with decomposition products as they age. Since the finish saturated a substantial layer of the wood, this darkening effect was more serious than it is with a superficial coating of varnish.

> As time passed, the drying oil finish was increasingly adulterated with nondrying mineral oils until at the present time floor oils have become cheap products often containing no drying oil at all. The mineral oils prevent proper hardening of linseed oil, thereby keeping the finish tacky, so that it clings to dirt and the finish ultimately becomes very dark in color or even black. Largely because of the adulteration of floor oils the old oil finish fell into disrepute and for a long time has been replaced by varnish, shellac, shellac and varnish, or shellac and wax finish.[29]

Initially developed for industrial applications, synthetic resin coatings were first introduced at the turn of the twentieth century. Cellulose nitrate in 1900, cellulose acetate in 1910, and phenol formaldehyde in 1909 drew initial attention as clear coatings, but these early synthetics were in many cases less stable than the natural resins already in use. The introduction of vinyl acetate in 1928, and acrylic in 1931, provided the first important new resins for transparent finishes, but were initially impractical for large-scale production.[30] Nitrocellulose lacquer and urea resin alkyd coatings were marketed commercially after World War II with moderate success, although they were difficult to work with and offered little improvement over traditional materials.[31]

It was not until the 1950's, with the formulation of oil modified urethane finishes, that synthetic coatings came into common use as floor finishes. Polyurethane coatings were initially troublesome for several reasons: they were slow in drying, especially when applied too thickly; they darkened light toned woods and yellowed with age; they were sensitive to repeated or continual wetting, often turning black beneath sinks or at entranceways; the cured films were not repairable when localized wear or staining

marked an otherwise sound finish; since the highly polymerized resins adhere poorly to previously finished surfaces, thorough sanding was required for refinishing.[32]

Epoxies and other synthetic resins have become established as floor finishes for industrial conditions, but their cost and difficulty of application have limited their use as residential floor finishes. Polyurethane coatings however, have been consistently refined over the last four decades to overcome their initial shortcomings. Recent developments in waterborne polyurethane coatings have completed the urethane monopoly of the floor finishing industry at the turn of the twenty-first century.

[1] Walter L. Salter, *Floors and Floor Maintenance* (New York: John Wiley and Sons, 1974), 83.
[2] Helene Von Rosenstiel and Gail Caskey Winkler, *Floor Coverings for Historic Building* (Washington, D.C.: Preservation Press, 1988), 11.
[3] Sylvester K. Stevens, *Pennsylvania; Titan of Industry, Volume 1*, (New York: Lewis Historical Publishing Company, Inc., 1948), 22.
[4] Philip S. Klein and Ari Hoogenboom, *A History of Pennsylvania* (University Park, PA: The Pennsylvania State University Press, 1980), 186.
[5] Nina Fletcher Little, *Floor Coverings in New England Before 1850* (Sturbridge, MA: Old Sturbridge Village, Inc., 1967), 4.
[66] Little, *Floor Coverings*, 4-5; Helene Von Rosenstiel, *American Rugs and Carpets From the Seventeenth Century to Modern Times* (New York: William Morrow and Co., Inc., 1978), 9-10; Rodris Roth, *Floor Coverings in 18th Century America* (Washington D.C.: Smithsonian Institution Press, 1967), 48; Elizabeth Garret, *At Home* (New York: Harry Abrams, Inc., 1990), 75.
[7] Von Rosenstiel, *Floor Coverings*, 41.
[8] Peter M. Molloy, *Homespun to Factory Made: Woolen Textiles In America, 1776-1876* (North Andover, MA: Merrimack Valley Textile Museum, 1977), 54.
[9] Von Rosenstiel, *American Rugs and Carpets*, 94.
[10] Ibid., 119.
[11] Ibid., 96.
[12] Garret, *At Home*, 193-194.
[13] Garret, *At Home*, 53.
[14] Ibid, 68-71.
[15] Von Rosenstiel, *Floor Coverings*, 117.
[16] Clarence Cook, *The House Beautiful* (New York: Scribner, Armstronf and Co., 1878), 128.
[17] Von Rosenstiel, *Floor Coverings*, 164.
[18] National Oak Flooring Manufacturers Association, "NOFMA; Protecting, Informing and Educating Consumers for 90 Years" from the *Oak Flooring Advocate*, association newsletter (NOFMA, fall, 1999).
[19] Southern Forest Products Association, webpage, *SFPA History* (www.sfpa.org/About_SFPA/sfpa_history.htm)
[20] NOFMA, "NOFMA."
[21] Alvah Horton Sabin, *The Technology of Pain and Varnish* (New York: J. Wiley and Sons, 1927), 6-23.
[22] Stevens, *Pennsylvania*, 250.
[23] This comment is based on personal communication with several conservators and preservationists including David DeMuzio, Senior Conservator of Furniture and Woodwork at the Philadelphia Museum of Art, and Donald C. Williams, Senior Furniture Conservator at the Smithsonian Institution.
[24] Robert D. Mussey. "Early Varnishes; the Eighteenth Century's Search for the Perfect Film Finish," Fine Woodworking, 35(1982): 55-56.
[25] R.K. Helphenstine, Jr. and Frederick L. Browne, *Selection, Installation, Finish, and Maintenance of Wood Floors for Dwellings*, circular no. 489, (Washington DC: U.S. Dept. of Agriculture, 1938), 19.
[26] "Oiled Floors." The Manufacturer and Builder 2, May (1870): 203; reprinted in the APT Bulletin 3, no. 4 (1971): 9-10.
[27] Rhoda Garrett and Agnes Garrett, *Suggestions for House Decoration in Painting, Woodwork and Furniture* (Philadelphia: Porter and Coates, 1877), 69.
[28] Frank S.Welsh, "Frank Lloyd Wright's Use of Wax at Wingspread for Clear Finishes and Paints," Microscope 47, no. 1 (1999): 34.
[29] Helphenstine and Browne, *Wood Floors for Dwellings*, 19.
[30] Deiter Stoye and Werner Freitag, editors, *Resins for Coatings.* (New York: Hanser Publications, 1996), 123; Robert L. Feller, Nathan Stolow and Elizabeth H. Jones. *On Picture Varnishes and Their Solvents.* (Washington: National Gallery of Art, 1985), 130.
[31] Charles A. Graham, "The Treatment and Maintenance of Timber Floors"; quoted in Salter, *Floors and Floor Maintenance*, 207-208.
[32] Salter, *Floors*, 210-212.

Chapter Two: Contemporary Approaches to Interpretation and Treatment

Wood Flooring Industry

Throughout the twentieth century, the wood flooring industry has continually refined a system of manufacture, installation and finishing which was initially mechanized and developed at the end of the nineteenth century.[1] The use of oils, waxes and varnishes on wood floors during this period is concerned with enhancing the visibility of the wood surface as well as protecting it, a marked change from disinterested treatment of wood floors prior to the 1870's. Interest in accentuating the natural surface characteristics of wood flooring has led to the selective development of wood finishes which form relatively thick films; both visually and physically isolating the wood from its environment. Wear and patination of the finish or of the underlying wood surface is generally perceived as undesirable.[2]

Modern finishing materials and procedures are specifically developed for the conditions found in new installations; their use for refinishing existing floors is predicated on the assumption that surface preparation includes wholesale sanding to expose clean, sound, bare wood. In the last fifty years, the wood flooring industry has refined a finishing system that, when applied to the floors of an historic building, is incompatible with the fundamental principles of historic preservation. In essence, the industry dismisses the concept of treating an existing, worn or damaged finish in any way other than to remove it and the underlying wood surface by sanding.[3]

Since the popular acceptance of varnished wood floors in the late nineteenth century, advocates of wood flooring have stressed its natural beauty and easy care. The

declarations of Clarence Cook in the 1870's are still echoed in NOFMA product literature today describing "the soft sheen of beautiful wood floors [which,] properly finished, are the easiest of all floor surfaces to keep clean and new looking; unlike carpeted or resilient floors that show wear regardless of care."[4]

General classes of floor finishes that are recommended by the National Oak Flooring Manufacturer's Association (NOFMA) and the National Wood Flooring Association (NWFA), include the following: penetrating sealers, typically a drying oil or proprietary formulation consisting primarily of a drying oil; waxes, recommended only as topcoats over penetrating sealers; and urethane surface finishes, of which four types are identified for use. Shellac and nitro-cellulose lacquer are specifically mentioned as problematic finishes that were superceded by modern urethane coatings. No other natural or synthetic resin coatings are identified, except by the blanket statement that "these products [other coatings] were commonly used as floor finishes before today's modern formulations were introduced. However, they are rarely used today, and generally are not considered as durable as the modern finishes."[5] The modern finishes referred to are all urethane resin coatings. Specifically they include oil-modified polyurethane, water-borne urethane or urethane/acrylic combinations, moisture-curing urethane, and acid-curing urethane.

Other sources published during the last thirty years describe a broader range of recommended finishes including natural resin varnishes, drying oils and waxes. Several authors discuss the selection of finish materials as a question of durability versus renewability or maintainability.[6] On the one hand, synthetic resin coatings, specifically urethane coatings, are extremely durable and resistant to staining, however they are not

easily repairable or renewable when the finish does eventually become worn or damaged, and generally require regular sanding at ten or twenty year intervals. Other, more traditional finish systems like penetrating oils, waxes and natural resin varnishes, are less durable and more susceptible to staining, however they can often be repaired easily and the finish can be maintained indefinitely without repeated sanding. As early as the 1970's, even as urethane coatings were beginning to catch on with owners of historic buildings, concern was mounting within the new flooring industry that repeated sanding was dramatically shortening the life of new wood flooring installations.[7]

The exclusive development of urethane resin coatings in residential floor finishing - and by default, refinishing - is indicative of the assumption that flooring will be prepared by sanding, since the main disadvantage of all classes of urethane coatings is poor adhesion to previous finishes; including other urethane finishes.[8] In fact, the industry's reliance on urethane coatings for new floors has resulted in its supplanting all other finish systems used for refinishing as well. Here it is critical to understand that this crossover is largely the result of a lack of differentiation between finishing and refinishing trades; rarely do floor finishing contractors specialize in refinishing methods or materials that differ from new finishing. More typically, finishing and refinishing services are rendered by the same firm and by the same mechanics. While it may be acceptable to regularly sand and refinish non-structural, contemporary finish floors, preservation of an historic floor, especially when it is a single-layer structural floor, requires a more conservative approach.

Technical manuals of both NOFMA and NWFA require sanding the entire surface of a previously finished floor prior to refinishing, although neither manual specifically

addresses the rationale for doing so. Clearly, the rationale is simple and correct; the best adhesion of most finish systems, but particularly urethane resin coatings, is achieved by providing a clean, dry, smooth and porous substrate whereby both chemical and mechanical attachment will be maximized.[9] Although the NOFMA manual recommends that the sanding operation remove less than 1/32 inch, this can only refer to the ideal conditions of a new installation; the manual also recommends repeated sanding with coarse grits for rough or uneven floors.[10] It is not uncommon for the sanding process to remove 1/8 inch or more from historic wooden floor, especially when the sander is removing paint, or where the floors are even slightly cupped or worn.[11]

Again, the underlying assumption of these guidelines is that the end product should be as uniformly flat, smooth, and blemish free as possible. In the case of historic floors, however, not only are these imperfections of wear, age, and use often desirable visual characteristics from an interpretive standpoint, but also the wood surface and the accumulated layers of finish and patina constitute historic fabric. Furthermore, although the original thickness of the floor boards may be over one inch, tongue-and-groove edge jointing can limit the maximum depth of sanding and wear to 1/4 inch or less before it breaches the groove. It becomes clear that an historic floor may only survive one sanding and refinishing process before there are structural repercussions.

Historic Preservation Standards and Guidelines

> "Identifying, retaining and preserving interior features and finishes that are important in defining the overall historic character of the building, including columns, cornices, baseboards, fireplaces and mantles, paneling, light fixtures, hardware, and flooring...."[12]

The Secretary of the Interior's Standards and Guidelines address in general terms both retaining and preserving historic finishes, as well as providing for the protection of the underlying historic substrate. In the case of wooden floors there can be, in many instances, a conflict between the aesthetic priority of authenticity, and the historical priority of protection. On the one hand it is critical to replicate the visual qualities (e.g., color, gloss and depth) of an existing or documented historic treatment, in order to achieve the necessary integration of the floor as part of an architectural space. The color and gloss of a floor surface affect the perception of light, scale and color in the room or space as a whole. On the other hand, the treatment of a wooden floor will have a direct affect on rates of deterioration and decay caused by water, soil and abrasion. Some finishes provide a sacrificial barrier to damage and wear, others allow the floor surface to degrade along with the finish.

Reversibility and renewability, or maintainability, are also important aspects to consider regarding preservation of fabric. In the case of floor finishes, reversibility is limited by both the solubility of the fully cured finish, and also the depth which the finish penetrates the wood during application. In truth, no floor treatment is completely reversible, but the relative degree to which the historic fabric is damaged by removal operations can be quantified and compared. For instance, a shellac varnish remains easily soluble in alcohol after it is fully cured and aged, so that it can be removed completely with very little affect on the underlying wood surface. An oil modified polyurethane varnish, however, is highly insoluble after cure, requiring mechanical sanding for removal which also removes the underlying wood surface.

While a treatment may not be reversible, maintainability can reduce the frequency of, or eliminate the need for, removal operations. Since penetrating sealers are absorbed into the porous wood surface they are difficult to remove without damage. Sealers that are also topcoated with paste wax, however, can be maintained indefinitely with regular cleaning and occasional renewal by applications of additional wax.[13]

The focus on urethane systems by the new flooring industry has in many ways created a barrier between historic preservation and the refinishing trades. Increasingly, professionals in the field of historic preservation are recognizing that wholesale sanding and refinishing of historic floors is not only visually inaccurate, but also physically destructive. Although the Secretary's Standards are not specifically prescriptive, the common theme of all recommendations is to avoid destructive methods and means when making treatment decisions.[14] It is important to recognize that standards and guidelines do apply to common wood flooring, just as they do to all other architectural finishes. Similarly, the same technologies that are applied to the preservation and conservation of other historic materials and finishes can and should be applied to historic wooden flooring, in order to identify authentic treatments that will conserve the fabric.

Analytical Techniques

The history of housepainting in America has been the subject of intense research during the last fifty years. The application of analytical chemistry and microscopy to historical coatings research has provided new insight into the materials and techniques of the past, but the focus of this new research as typically been on paint colors and decorative techniques. Organic binding media have proven more difficult to identify and

characterize than inorganic paint pigments, and although the general classification of media (e.g. oil, casein, collagen glues) has typically been sufficient to enable accurate replication of paints, precise characterization of media is much more critical to the identification and replication of transparent coatings. Natural resin varnishes, for instance, are dependent entirely upon combinations of resins, oils and waxes for specific film properties.

Identifying the finish history of interior architectural surfaces is fundamental to the preservation or conservation agenda for any historic building. The scope of analysis is dependent on the specific requirements and expectations of each individual site, but ideally includes microchemical analysis for media identification. Finish histories that include transparent coatings present special problems, both because they are more difficult to identify than pigmented coatings and because they are often composed of several binding media. Documentation of floor finishes is further complicated by their context, since these surfaces were subject to the daily effects of foot traffic.

Oil, wax, and varnish films are very thin in comparison to paint films and they were typically renewed with regular, successive topcoats. Often these topcoats varied in composition from those applied before them and the solvents in the topcoat might partially dissolve and combine with the older finish. Distinguishing between such thin, colorless, and often indistinct layers, can be impossible even in cross section with a microscope.[15] Furthermore, clear finishes may be similar or identical to underlying or overlying paint media, disguising their existence. Often a key factor in the discovery of a surviving clear finish layer is the expectation of finding one. Knowing where to expect to find oils, waxes or varnishes, based on photographic and written documentation of the

building compared with historical, geographic and economic patterns of use, may be the most effective way of finding them.

If identifying finish stratigraphy is the first step, then the second step is characterizing the binding media. Several analytical techniques, ranging from on-site investigation to laboratory analysis can be applied to transparent finishes, in order to broadly or precisely characterize the chemical constituents. Two methods commonly used for in-situ analysis are solvent testing and long-wave, ultra-violet light fluorescence. Since many coating films can be dissolved or softened by specific solvents, methodical spot testing with a variety of solvents can lead to preliminary conclusions. For instance, even an aged shellac film remains highly soluble in alcohol, while a copal resin oil varnish might only soften in a less polar solvent like toluene. The presence of plant or shellac resins can be further identified by the use of a hand-held ultra-violet light. Shellac resins fluoresce orange or yellow while plant resins like copal or mastic fluoresce bright white.[16] The fact that it is used by decorative arts conservators to identify repairs, restorations and alterations to finishes, is a testament to the sensitivity of this technique.

These general characterizations can be used to guide sampling and further analysis with more sophisticated laboratory instruments, which can provide highly specific media identification. Fluorescent staining microscopy can be used to identify lipids, like linseed or walnut oil, and certain resins.[17] Thin-layer chromatography offers the most precise media analysis, which can be further characterized by mass spectrometry. Of course, these are expensive and exclusive analytical techniques that require skilled interpretation; they are rarely employed for architectural finishes

identification, but where they are available and justifiable, media characterization can be very precise

Media analysis should be approached as a progression from simple, inexpensive tests to the more sophisticated, and should emphasize the need for multiple, corroborative analyses. Testing schemes should acknowledge the requirements of site and budget and must be guided by an informed expectation of finish history.

Development of Floor Finishes For Historic Preservation

The body of research employed in the realm of architectural finishes is largely the product of fine arts scholars and art historians. This is especially true for transparent finishes because, while picture varnishes were almost universally applied to paintings of several media during the eighteenth and nineteenth centuries, clear coatings saw very limited use in house painting. Still, the similarity of purpose and effect between picture varnishes and transparent architectural coatings justifies the convenience of interpreting this substantial body of work in the service of architectural finishes research.

It is not a great leap to make the connection between easel painting and housepainting. The landscapes and still-lifes found on walls, over mantels, and on door surrounds and fire boards were painted by artisans with one foot in art painting and one foot in housepainting. This common marriage of art and craft is one bridge by which materials and techniques of painting were shared. A common source of supply, the colourman of the last three centuries, provided the raw materials to artists and tradesmen in appropriate quantities, and suggests a forum for the communication of method and formulation.

Discussion of floor finishes is supplemented with a compendium of significant materials, contained in the appendix, to clarify the terminology of choice. Various solvents, waxes, oils and resinous materials are the primary constituents of traditional varnishes. These materials are commonly classified in the twentieth century literature by type and by botanical or animal source. The relatively recent determination of the chemical composition of natural resinous materials has made possible a detailed chemical classification of binding media like that of Masschelein-Kleiner.[18] Since this thesis is principally involved with finish systems which are a product of material combinations, descriptions are simply categorized by type of constituent; for example, resin, wax, solvent or oil.

Picture Varnishes and Optical Properties

Each varnish formulation whether natural or synthetic produces a more or less perceptible, unique visual appearance, but general differences between the two classes are recognized as a critical deficiency of synthetic coatings. Despite the similar chemical composition of natural and synthetic resins, it is clear that synthetic coatings differ greatly from the natural varnishes precisely because they were developed for their physical and mechanical properties, and not for their optical qualities. So it would be pure coincidence if they were to produce the same optical effects as natural materials that were empirically developed over several centuries for a principally esthetic application. On the other hand, it stands to reason that the technology has promise, and that it could be directed towards development of a more visually compatible product.

Recently, investigation into this issue of optical quality has provided insight into the various chemical characteristics responsible for the visual effects of clear films. Initial research in the 1950's identified differences in refractive index and viscosity as potential explanation for variations in gloss.[19] These preliminary findings have been consistently corroborated by empirical selection of restorers and conservators. Viscosity of solutions is largely a function of the molecular weight of the resin, and synthetic resins typically have molecular weights on the order of 50 – 100 times those of natural resins.[20]

Certainly, viscosity has an established effect on the surface characteristics of a film. High viscosity coatings reproduce the surface texture of the substrate. A low viscosity coating will produce a more uniform, smooth surface with greater reflective qualities and higher gloss. The characteristic fluidity of natural resin solutions, even at high solids content, allows them to settle into the irregularities of a paint film to create a smooth surface. Conversely, most synthetic resin solutions increase in viscosity rapidly as they dry and do not self-level.

The refractive index of a coating layer is also important relative to the substrate or the underlying paint system. As a topcoat over a painted surface, a varnish with a refractive index nearly equal to the paint binder will provide an indistinguishable interface. Synthetic resins, as a rule have significantly lower refractive indices than natural resins. Certain resins, most notably ketones, have a refractive index more comparable to natural resins, and have been used as picture varnishes by paintings conservators.[21] Ketones have not proven stable enough for use as architectural finishes, however, and the cost of ketone resin coatings is prohibitive as well.[22]

The optical effects of coating layers are also directly affected by the physical degradation of the film, and this has been the chief motivation for interest in synthetic resins for picture varnishes. All clear coatings degrade at different rates and with various qualities, and this ephemeral nature necessitates a cycle of maintenance and refinishing that includes regular removal and re-application of the finish. Of course, this type of maintenance is often avoided or forgotten, especially in the case of architectural finishes. More commonly, in an attempt to rejuvenate the gloss of a darkened, degraded film additional coats of wax or varnish were applied without bothering to remove those previous. Initial excitement about synthetic coatings centered on the hope for a more permanent solution, which would reduce the frequency of maintenance and reapplication. The zeal with which various synthetic formulations were put to use in the 1950's, 60's and 70's, has since been tempered by the empirical realization that they too degrade; and although regular maintenance is often reduced, it can come at the expense of more frequent re-finishing.

Continued attempts at refining synthetic resins for use in conservation and for use as coatings to replicate historic finishes have made gradual progress. Similarly, synthetic additives have been used to modify synthetic and natural resin coatings.[23] At present there has been only limited success, and architectural conservators generally restrict the use of synthetic coatings to isolation layers, consolidation treatments and specific durability compromises. Often, however, wood floors fall under the category of durability compromises.

Floors and floor finishes should be approached by the conservator with the same general guidelines as other building materials. The ideals of minimal intervention and respect for historical substance motivate the use of similar or identical traditional materials. In short, whenever possible or practical, traditional natural materials should be employed to the same affect as the original or historic finish. A key element of this argument is the fact that the effectiveness of a finish material is dependent upon its compatibility with the substrate. Natural finishes were developed for use with, and have a chemical and generative link with the natural materials on which they were originally applied. This physical and chemical compatibility often translates into high performance of the substrate/coating system that exceeds the durability expectations of the coating materials.

The esthetic distinctions of natural finishes also provide rationale for replication with similar, natural materials. Replication of natural finishes can sometimes be achieved with synthetic materials, but often the esthetic value of the aging process on the optical qualities of the film is critical to historical interpretation. The original visual intent of a surface finish may be reproduced by synthetic replication, but the subtleties of patination are unique to the specific original materials. To address this issue, traditional waxes or varnishes are sometimes applied as topcoats over a synthetic coating.

Since the primary requirements of any conservation treatment are to protect existing fabric and to provide some identification of intervention, transparent isolation layers are also commonly used to distinguish treatments from historic films or substrates. The requirements of reversibility often dictate the use of a simple, stable synthetic

formulation as an isolation barrier over which a finish or top coat can be applied to achieve the desired visual effect. Isolation layers also serve as buffers or barriers against future cleaning and enable the removal and reapplication of topcoats without damage or loss to the underlying wood surface. Isolation treatments are generally chosen for their chemical stability and clarity, as well as for their specific solubility characteristics, which should differ from both the overlying finish and the underlying historic fabric. As an example of such a system applied to floors, conservators at the Philadelphia Museum of Art have used acrylic resin coatings with paste wax finishes on the floors of period rooms.[24]

Fortunately and unfortunately, the coatings industry is extremely dynamic: new materials are developed and introduced; formulations are modified and improved; manufacturers and suppliers continually re-market products under new names. It is important for the field of historic preservation to monitor the development of this and similar industries, and to advocate for the development of materials suitable for preservation and conservation.

[1] Salter, *Floors,* 184; John H. Englund, "An Outline of the Development of Wood Moulding Machinery," APT Bulletin 10, no.4 (1978), 21-27; J.Richards, *A Treatise on the Construction and Operation of Wood-working Machines*. New York: E. and F.N. Spon, 1872.
[2] Salter, *Floors*, 206.
[3] This statement is based on the published guidelines of the following wood flooring industry associations representing both manufacturers and trades: National Oak Flooring Manufacturer's Association. "Finishing Hardwood Flooring." *NOFMA Technical Service Manual Publication no. 9* (1997); National Wood Flooring Association. *Technical Reference Manual, Section 4.* Ellisville, MO: NWFA, revised 1999.
[4] Oak Flooring Institute, *Wood Floor Care Guide* (Memphis, TN: NOFMA, 1997), 1.
[5] NOFMA, "Finishing Hardwood Flooring," 9.
[6] Daniel L Cassens and William C. Feist, "Finishing and Maintaining Wood Floors" (North Central Regional Extension Publication no. 36, 1980); Bill O'Donnell, "Reconditioning Floors," Old House Journal 8, no. 10 (1985): 201, 218-219; Patricia Poore, "Picking a Floor Finish," Old House Journal 9, no. 5 (1981): 107-113.
[7] Salter, *Floors*, 210, 211.
[8] Guy Weismantel, *Paint Handbook* (New York: McGraw-Hill, 1981), 10-21.
[9] Weismantel, *Paint Handbook*, 1-4.
[10] NOFMA, "Finishing Hardwood Flooring," 11.
[11] This statement is based on my own experience with several dozen flooring projects where floor sanding was employed in the refinishing process. Additionally, conversations with other preservation professionals confirm the fact that 1/32 of an inch is an extremely optimistic figure.
[12] *The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings*, Revised edition (Washington, D.C.: Government Printing Office, 1990), 38.
[13], Cassens and Feist, "Finishing and Maintaining Wood Floors," 6; Salter, *Floors*, 217-218.
[14] *Standards and Guidelines*, 38-39; Kay D.Weeks and H. Ward Jandl, "The Secretary of the Interior's Standards for the Treatment of Historic Properties: A Philosophical and Ethical Framework for Making Treatment Decisions," in *Standards for Preservation and Rehabilitation, ASTM STP 1298,* ed. S.J. Kelley, (American Society for Testing and Materials, 1996), 8.
[15] Andrea Gilmore. "Analyzing Paint Samples," in Paint in America; the Colors of Historic Buildings, ed. Roger Moss. (Washington D.C.: Preservation Press, 1994) 176.
[16] Ibid, 181.
[17] Farrell, "Pigments and Media," in Paint in America; the Colors of Historic Buildings, ed. Roger Moss. (Washington D.C.: Preservation Press, 1994), 202.
[18] Liliane Masschelein-Kleiner. *Ancient Binding Media, Varnishes and Adhesives.* (Rome: ICCROM, 1985.)
[19] Robert L. Feller. "Factors Affecting the Appearance of Picture Varnish," Science, 125(1143-1144): 1957; Garry Thompson. "Some Picture Varnishes," Studies in Conservation, 3(64-78): 1957.
[20] E. Rene de la Rie, "The Influence of Varnishes on the Appearance of Paintings," Studies in Conservation 32 (1987), 5.
[21] Ibid, 3.
[22] Conversation with Casandra Meyers, principal, Meyers Conservation, Washington D.C..
[23] E. Rene de la Rie. "Polymer Stabilizers. A Survey with Reference to Possible Applications in the Conservation Field," Studies in conservation, 33 (1988): 9.; Christopher W. McGlinchey. "An Examination of New Products of Interest to the Conservation Field," from the proceedings of the Ninth Triennial Meeting of ICOM Committee for Conservation. (Dresden, Germany: ICOM, 1990) 563-567.
[24] Conversation with David DeMuzio, Senior Conservator, Furniture and Woodwork, Philadelphia Museum of Art.

Chapter Three: Methodology

Every historic wooden floor exists in its own unique circumstances that must be considered individually and in combination to determine the most effective and appropriate treatment. Similarly, each one of many possible treatments has a unique combination of maintenance requirements, performance characteristics and visual qualities. By comparison of these circumstances with treatment options, one or more solutions can be identified.

The specifics of the preservation program, as restrained by budgetary limitations, must strike a balance between interpretation and protection of the historic fabric. Ideally, the historicity of the wood flooring, and more specifically, of previous and existing surface finishes, should be determined by the existence of primary or secondary documentation of original or prevalent early finishes. In the absence of clear documentation, a review of the historical eras during which the floor was in service, the specifics of the building's geographic location, and the economic status of its owners, may also suggest a variety of contemporary finishes. Analysis of the existing surface and any vestiges of pre-existing finishes should be undertaken to whatever degree budgets allow, in order to corroborate documentary findings regarding finish chronology, identify specific material constituents, and determine the condition of the existing surface finish.

The condition of the wood flooring must also be determined, board-by-board, both structural integrity and surface integrity: smooth and sound, versus rough and splintery. Such an assessment may be limited to a summary identification of repairs to be made, but should include determination of species, grade, thickness, type of joinery,

moisture content, and if possible, range of moisture content over the course of a year. This information will guide treatment decisions regarding surface preparation and finish selection as well as identifying structural problems or deficiencies.

To apply this data to treatment selection, the requirements of future service must be understood, including an estimation of the type and amount of traffic, the type and degree of degradation mechanisms (e.g., abrasion by soils, patterns of temperature and humidity fluctuation), and the scope and regularity of maintenance activity. Finally, the treatment should meet the visual and functional requirements of the finished floor within the context of the individual and collective interior spaces.

Although the sequence described is idealized, it is important that, whatever the order and degree, each aspect of the methodology be addressed.

Documentation

Documentation of both archival information and physical evidence is a fundamental procedure of historic preservation. This process of establishing and documenting the history of a building, and its representative elements of structure and ornament, can and should be applied to the floor as a prerequisite to treatment. The following excerpt from the National Park Service's Preservation Brief number 35 provides a summary:

> Primary historical research of an old building generally encompasses written, visual and oral resources that can provide valuable site-specific information. Written resources usually include letters, legal transactions, account books, insurance policies, institutional papers, and diaries. Visual resources consist of drawings, maps, plates, paintings and

photographs. Oral resources are people's remembrances of the past. Secondary resources, comprised of research or history already compiled and written about a subject, are also important for providing a broad contextual setting for a project.

Historical research should be conducted well in advance of physical investigation. This allows time for important written, visual, and oral information to be located, transcribed, organized, studied and used for planning the actual work. A thorough scholarly study of a building's history provides a responsible framework for the physical investigation; in fact, the importance of the link between written historical research and structural investigation cannot be overestimated.[1]

It is unnecessary to elaborate here since detailed recommendations and procedures can be accessed through the National Park Service or other historic preservation organizations like the National Trust for Historic Preservation. The key is to employ the same process of documentation to common floors, as to any other surface or element.

Surface Finish Analysis

The scope of analysis is dependent upon the specific requirements and expectations of each individual site. Guided by an informed expectation of finish history provided by preceding documentation, investigation should unfold as a progression from simple, inexpensive tests to more sophisticated analyses, and should emphasize the need for multiple, corroborative results.

The primary goal of any investigation prior to treatment will be to determine the nature and condition of the existing surface. In most cases, spot testing with specific

solvents and cleaning materials can determine the type of finish and the best method of cleaning it, often providing enough information to rule in or out the possibility of retaining and renewing the exiting finish. In a case where the floor is unfinished, several cleaning operations may be required to remove different types of stains before further treatment.

In some cases investigation will extend to microscopic analysis, to establish a chronology of previous finishes. Additional chemical testing and microchemical analysis can also be utilized to determine specific constituents of existing finishes. All these activities are ultimately intended to inform the selection of appropriate treatment, which should employ the least destructive and most reversible means to render the best protection from the most visually accurate finish. It is also important to stress that surface finish analysis should not be perceived as an expensive luxury of big-budget restorations. As described in the previous chapter, limited investigation of existing finishes can reveal a great deal of information, often increasing the cost-effectiveness of treatments.

Condition Assessment

Condition assessment of historic flooring in this context focuses specifically on the wood, as separate from a surface finish. It is critical to determine the physical integrity of wood floors in historic buildings as a prelude to treatment, because of both the symbiotic relationship of substrate and finish, and the structural relationships of individual boards within a floor.

Condition assessment will lead to determination of grade and species by recording normal characteristics as well as defects. Assessment should quantify defects such as knot-holes and nail-holes, cracks and checks, and areas of wear, damage and decay. It should also qualify grain orientation and physical characteristics like color, hardness and texture. Thickness of the boards and the span between joists should be determined to verify structural capacity. Two sources that define terminology and describe grading assessment, in more and less detail respectively, are Panshin and de Zeeuw, and NOFMA.[2]

If there are two layers of flooring, both layers should be assessed to whatever degree possible. This may be partly accomplished where the underside of the subfloor is visible in a basement or crawlspace. When a two-layer floor is inspected, it is important to determine whether or not the two layers were installed simultaneously. Although it became more and more common throughout the twentieth century to install two-layer wood floors in new buildings, finish floors were also installed over earlier single-layer floors in existing buildings.[3]

For buildings of the nineteenth or twentieth centuries, grade and species determination can provide indirect evidence of historical floor treatments, as well as informing expectations for the efficacy of subsequent treatment. In general, better grades of hardwood flooring were likely intended for exposure as a finish floor, while poorer grades and softwoods were likely concealed beneath floor coverings. In this respect the quality of the installation may also reflect the original intent.[4]

Determination of species rarely needs to be highly specific, but is more a question of relative density and grain characteristics. Differentiation between hardwood species is

less critical than between softwoods, especially with twentieth century floors, since, in general, hardwoods possess characteristics more suitable for wear resistance and finish adhesion than softwoods.[5] Although there is more localized variation in eighteenth century floors, between 1800 and 1900 wood flooring in the U.S. became a more unified commercial product, primarily consisting of a relatively few species, varying from region to region. After 1900, species variety again increased, but as a result of the use of a wider variety of imported and domestic hardwoods, and still the majority of wood flooring was confined to a few North American species, namely, oak, maple, fir and yellow pine.[6] Species identification can be made on site or a sample can be sent to a laboratory for identification. The U.S. Forest Products Laboratory in Madison, Wisconsin is an invaluable resource for technical information regarding wood and wood products, and will identify wood samples for a small fee.[7].

Wood moisture content can be checked with a hand-held, resistance moisture meter. Multiple readings should be taken in random locations and at both the top and bottom of floorboards wherever possible. Basements and crawlspaces often provide access to the underside of floorboards and these areas are also prone to moisture problems. Since most building interiors experience seasonal variations in relative humidity levels, it is useful to take moisture content readings at monthly or quarterly intervals to determine annual highs and lows. This regular fluctuation in wood moisture content can have significant effects on wood behavior and finish compatibility. At a minimum, a baseline moisture content reading should be documented prior to treatment, both to screen for incipient problems, and to provide a comparative reading to aid in the assessment of future problems.

Service Requirements

> Wood floors can be maintained in good condition by any one of various types of finishing methods, if good materials are properly applied and if maintenance methods appropriate for each type of finish and for the degree of wear to which the floor is subjected are employed. No one type of finish can be said to be superior in all respects and none will long continue to give good service unless it is suitably maintained. The secret of a good floor lies in thorough understanding of the nature and limitations of the particular kind of finish chosen and in careful following of the appropriate maintenance program.[8]

With an understanding of historic context, contemporary context can be addressed and the process of designing a treatment begins. Given the existing conditions of the flooring and surface finishes, and the historical and aesthetic expectations of interpretation, service requirements must be defined in order to refine a list of potential treatments. Service requirements typically include expectations of the type and amount of foot traffic, ambient temperature and humidity levels, and performance expectations (resistance to staining or scratching, frequency of maintenance, frequency of renewing or refinishing). Treatment design will likely be a dynamic process of defining the expectations of the program and identifying treatment characteristics, comparing scenarios and considering variables. Potential mechanisms of damage and decay also must be defined and considered. In general, all floors are exposed to the same mechanisms of damage and decay – moisture, abrasion, salts and UV degradation - but the degree and intensity can vary widely.

Abrasion from foot traffic is often the most important element to be considered. The number of inhabitants and visitors and the types of shoes they may be wearing will largely determine the frequency of required maintenance for any given treatment. In addition to abrasion from shoe soles, foot traffic can also transport abrasive grit and moisture from soils, and salts, oils and weak acids from roads, parking lots and sidewalks. The distribution of traffic within a building, and patterns or traffic lanes within and between rooms should also be factored into treatment design, as should any other unique conditions of the site or program that might affect treatment performance. Protection of high traffic floor surfaces with small period floor coverings like carpet runners or floorcloths can reduce cleaning and maintenance frequency.

The resources available for regular maintenance will also be a key factor in the selection of a treatment. The amount of time allotted for maintenance tasks on a daily, weekly, monthly or annual basis should be conservatively matched with the requirements of any proposed treatment. It is important to differentiate between maintenance that can be performed by a resident, owner or permanent staff and that which must be contracted to skilled mechanics. In-house resources involve more complex long-range planning to assure that the skills, equipment and materials that are necessary for the care and maintenance of the floor are continually available and dispatched with the appropriate frequency. Contracted resources will require both budgetary planning and the resourcefulness and diligence to find and supervise a competent contractor.

Treatment strategies and materials must be evaluated for effectiveness and compatibility with the historic context. At this point the list of potential treatments will likely be rather short since aesthetic requirements and performance criteria eliminate many possibilities. Here it is important to determine the track record of specific treatments in comparable circumstances. Furthermore, the future maintenance requirements of these short-list treatments should be compared to determine advantages of one treatment over another. Maintenance materials and procedures should also be checked to verify that there are no potential hazards to surrounding materials or to personnel.

The process of evaluating treatments should involve communication with finish suppliers and manufacturers, local craftsmen and conservators, and local or regional historic preservation organizations. Often the best place to start is with a local preservation organization like the Fairmount Park Historic Preservation Trust in Philadelphia, a regional organization like SPNEA (the Society for the Preservation of New England Antiquities) or even a national organization like AIC (American Institute for Conservation of Historic and Artistic Works) or the National Park Service. Local museums, especially historic house museums or art museums with period rooms or interior settings, often have experience with treatment selection and are willing to exchange information on materials, contractors and suppliers. A State Historic Preservation Office, city Historical Commission or local Historical Society often can provide contact information for house museums, conservators or craftsmen, as well as other resources.

Almost invariably, treatment evaluation will include questions of authenticity and substitution. While it is impossible to prescribe universal laws that apply to all cases, the National Park Service offers guidelines that are helpful.[9] Clearly, there is a need for ongoing discussion, both generally and specifically, of these recurring dilemmas, though the scope of this paper does not permit deeper analysis. In the end, what is critical is that careful consideration is given to the unique problem that each wood floor presents. The best solution for each set of circumstances is reached through a thoughtful and methodical process.

[1] Travis C. McDonald, *Understanding Old Buildings; the Process of Architectural Investigation*, Preservation Brief no. 35 (Washington DC: Preservation Assistance Division, National Park Service, U.S. Department of the Interior, 1994), 3.
[2] A.J. Panshin and Carl de Zeeuw, *Textbook of Wood Technology, Vol. 1* (New York: McGraw-Hill, 1970), 276-337; National Oak Flooring Manufacturer's Association. *Official Flooring Grading Rules* (Memphis, TN: NOFMA, 1999).
[3] Helphenstine and Browne, *Wood Floors for Dwellings*, 6.
[4] Von Rosenstiel and Winkler, *Floor Coverings*, 117.
[5] R. Bruce Hoadley, *Understanding Wood; a Craftsman's Guide to Wood Technology*, (Newtown, CT: Taunton Press, Inc., 1980), 12.
[6]Helphenstine and Browne, *Wood Floors for Dwellings*, 4-5; Salter, *Floors*, 86-91.
[7] Information about wood identification and services can be found at http://www2.fpl.fs.fed.us.
[8] Helphenstine and Browne, *Wood Floors for Dwellings*, 20.
[9] *Standards and Guidelines*, 8.

Conclusion

The interpretation and treatment of wood floors is a quintessential preservation problem, complete with all the technical and philosophical quandaries so common to the care of historic buildings. Wood flooring is a structural element, supporting furniture, furnishings and occupants, and it is also often a decorative surface, requiring regular care and protection. The treatment of floors in historic buildings is critical to the interpretation interior space since floor surfaces provide a physical, structural foundation for architectural space, while they also impart an aesthetic and sensory presence.

Currently, the professional standards of the wood flooring industry do not meet the guidelines of recognized historic preservation standards for the treatment of historic fabric. The methods and materials offered by conventional flooring contractors are not compatible with the requirements of good preservation practice. Why then, do preservation professionals continue to rely on these modern methods and materials by default, often disregarding the golden rule of protection, dismissing floors as functional surfaces, and traditional finishes and maintenance as archaic? Without a clearly defined process of interpretation and treatment selection, it is difficult to resist the inertial effect of a conventional, standardized and universally recognized treatment system.

At least as early as the 1970's the use of synthetic resin coatings like polyurethane was being questioned by professional flooring installers and consultants, specifically because of the effect of regular sanding on the life of a tongue-and-groove joined floor. The Old House Journal published several articles in the 1970's and 1980's relating the opinions of several flooring experts regarding the compatibility of polyurethane with old

floors. One article from the May 1981 issue included a statement that still applies twenty years later, "go to just about any hardware store and ask what you should put on your sanded floor – they'll recommend polyurethane varnish. The whole country stoutly believes in new 'no maintenance' products."[i]

Compounding these concerns is the modern propensity for finishing wood floors in the decorative manner of twenty-first century style. Although it is often difficult to resist the urge to expose and glorify the natural materials and craftsmanship in historic buildings that are so rarely seen in contemporary architecture, to do so would often clash with historical practice.

The discrepancy between historical fact and contemporary interpretation must be acknowledged and addressed. This is not to say that all eighteenth century floors should go unfinished, or that visual authenticity should take precedence over either the protection of historic fabric or over the practicality of maintenance requirements. Instead I contend that all three can be served by choosing the appropriate treatment from an ever-widening array of choices: regular maintenance treatments for bare floors; traditional, natural stains, sealers and coatings; and modern synthetic or hybrid sealers or coatings.

What is critical is to establish a more methodical approach to historic wooden floors that is consistent with recognized historic preservation standards and ethics: first and foremost, do no harm. As preservation professionals, we must once again reassess the status quo while continually reexamining alternatives, both traditional and modern, which better protect historic fabric.

The objectives of this thesis have been threefold: to establish the range of historical treatments and finishes for wood flooring in America; to identify and clarify the

shortcomings of conventional wood finish systems used in historic buildings; and to establish that existing interpretive philosophy is applicable to historic wooden flooring, as are the range of investigative and analytical technologies currently applied to other architectural finishes. The creation of a guiding methodology, specific to the nature and context of wood flooring, but derived from established procedures applied to other historic materials and systems.

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[1] Poore,. "Picking a Floor Finish," 108.

Appendix A: Glossary of Historical Terms

Axminster

Originally a hand-knotted carpet imitating Turkish carpets. Machine-woven Axminsters were perfected in America in the 1870's (Von Rosenstiel, *American Rugs and Carpets*, 178.)

Balsam

The raw, unprocessed resin, specifically from pine trees. Processing by heating yields the commercial resin called **rosin**. Distillation of the gasses produced by heating balsam yields **turpentine**, (traditionally referred to as spirit(s), oil, or essential oil of turpentine.)

Boiled Oil

Historically, boiled oils were truly boiled in order to facilitate the dissolving of metallic oxides (typically lead) which accelerate the drying process. The modern, commercial product is prepared at lower temperatures with more easily soluble metallic driers.

Brussels Carpet

"A looped-pile carpet with a linen warp and weft and worsted pile. The pile formed over a wire was invented in Brussels about 1710." These carpets first became popular in England and were one of the first loom-woven carpets to be widely used in England and America (Von Rosenstiel, *American Rugs and Carpets*, 112.) See **Wilton Carpet**.

Clear Coating

This is a modern blanket classification for all transparent coatings, including all traditional varnishes, and all modern resin coatings. See **varnish**.

Drying Oil

These oils form solid films by chemical reaction with oxygen. (Linseed, Tung, Walnut)

Floorcloth

A generic term for a woven floor covering of wool or linen, sometimes painted to be water resistant. Used as a carpet and also on top of a carpet to protect it (Von Rosenstiel, *American Rugs and Carpets*, 180.)

Glaze

Glazes are transparent topcoats, generally pigmented, which contribute qualities of depth, gloss and smoothness to a multiple-layer wallpaint.

Gum

Gums are exudations from various plants that are used as binders in water soluble paints. While similar in nature to **resins**, gums are physically distinct in that they are soluble in water but not in alcohol. Gums are not used in architectural coatings.

Ingrain

An American term for a flat-woven, all-wool, reversible carpet in which the design on the face is reproduced in reverse colors on the back (Von Rosenstiel, *American Rugs and Carpets*, 181.)

Lacquer

In the strictest sense, lacquer refers to a high quality resin derived from a tree (Rhus verniciflua) native to China and cultivated in other Asian countries, most notably Japan, and to the varnish prepared with it. Historically, the term has been used generally to describe all coatings that dry to a high gloss, or to varnishes made with **shellac.** It is also a modern, commercial term for any coating that dries by evaporation of solvent.

Linoleum

A plain colored, durable floor covering made from linseed oil, invented in England in 1864 and then manufactured and widely used in the U.S. until the 1970's (Von Rosenstiel, *American Rugs and Carpets*, 181.) Now used as a generic term for similar sheet flooring

Natural Resins

Various copals, dammar, mastic, sandarac, **rosin**, elemi, amber, **shellac** and **turpentines.**

Oilcloth

A painted **floorcloth.** They were extremely popular floor coverings during the nineteenth century when production became highly developed.

Picture Varnish

Varnish used as a topcoat for easel paintings.

Resin

"A solid, semisolid or liquid substance (organic and noncrystalline), of nonuniform and often high molecular weight, which in the solid state usually possesses a softening or melting range and exhibits conchoidal fracture." (Stoye, *Resins for Coatings*, 1.) Resin can refer to both a raw, unprocessed substance (see **balsam**), and a refined coating ingredient. Traditionally, **natural resins** used in **clear coatings** are secretions or exudations from certain species of trees, and are differentiated from gums by the fact that they are insoluble in water. **Synthetic resins** can be both purely synthetic and modified **natural resins.**

Rosin

Rosin is often understandably confused with the more general term, **resin**. Rosin is a resin, produced by heating **balsam**.

Shellac

Lac is the raw resin produced by the lac insect (Laccifer lacca). Shellac refers to the purified resin, in a commercial flake, or leaf form, and to the **spirit varnish** made by dissolving the resin, typically in alcohol. **Stick lac** refers, literally to the the twigs and branches which are encased in the raw lac when it is harvested. After the stick lac is initially processed to separate the resin from the wood and to remove other impurities it takes the form of small maroon beads, called **seed lac.** The commercial, purified **resin** is sold in three forms resembling their names; button lac, flake shellac and crushed shellac.

Synthetic Resins

There are far too many to list, but several main classes used in architectural coatings are urethanes, alkyds, acrylics, vinyls, ketones, epoxies and silicones.

Turpentine

Historically, turpentine referred to the raw resinous material of various conifers, and the distillate of these materials was typically referred to as spirits or essential oil. The modern usage of turpentine is specific to the distillate of **balsam**.

Varnish

Any clear or pigmented transparent coating, being generally composed of a **resin** dissolved in a liquid vehicle, and specifically used as a protective and/or beautifying topcoat. In its broadest sense, varnishes could include all **clear coatings**; **lacquer** is a varnish, **shellac** is a varnish, commercial polyurethane coatings are used as varnishes. There are two classes of traditional varnishes: **spirit varnishes**, in which a resin is delivered in a volatile solvent, and which dry by evaporation of that solvent, and cure by coalescence of the resin; and **oil varnishes**, in which a resin is dissolved in a **drying oil** and may be thinned with a volatile solvent. Oil varnishes dry first by evaporation of any volatile component, then by oxidation of the oil, and cure by further oxidation of the oil and by cross-linking between oil and resin polymers. There are two other modern resin coating types, one which cures by reaction with water vapor (moisture-cured urethane coatings), and one which cures by chemical reaction of one component with another (two-part epoxy coatings).

Wilton Carpet

A **Brussels** variation with a cut pile which was manufactured in Wilton, England. Both **Brussels** and **Wilton carpets** were woven on hand-operated draw looms, and were traditionally woven 27 inches wide (Von Rosenstiel, *American Rugs and Carpets*, 112.)

Appendix B: Compendium of Floor Finish Materials

NATURAL MATERIALS

Oils

Within the class of vegetable oils, the drying oils have been a staple binder, vehicle and solvent throughout the history of the varnishing trades. Drying oils form continuous films by chemical reaction when exposed to air. The principle reactions of oxidation, polymerization and cross-linking of polymers, are catalyzed by oxygen and light, and can be aided by the addition of metallic salts. Historically, the addition of lead oxides like litharge, massicot, or minium was understood to dramatically decrease drying times of oil binder paints, and litharge was also commonly added to fixed oil varnishes.[1]

Drying oils like linseed or tung are commonly used alone as penetrating sealers for wood flooring, or as a preliminary sealer in concert with topcoats of wax. Oils are also used as solvents and vehicles for several varnish resins, and are the primary constituent in many proprietary oil-based finishes. Among the drying oils, linseed oil has been and continues to be the most commonly used for architectural finishes. Extracted from flax seed (*Linum usitatissimum*), its chemical composition is variable depending on seed quality and processing methods, but generally consists of concentrations of linolenic, linoleic, oleic, and stearic acids.[2] Linseed oil was cheap and readily available in America very early, factors that assured its prevalence in architectural finishes. It is also the modifying oil of choice in synthetic alkyd resin coatings. The combination of a

cross-linking oil with a hard, film-forming resin, can result in a very flexible, durable and tough finish.[3]

Waxes

Waxes are substances that are generally solid at room temperature but have low melting points (less than 100° C). Natural waxes are derived from mineral, vegetable and animal sources and are essentially composed of esters of long chain acids and alcohols.[4] Beeswax was inexpensive and readily available in America very early, and is an ancient, established wood finish. Of the many natural waxes only beeswax and carnauba wax saw significant use historically as architectural finishes. Fortunately, both are still readily available and are still principle ingredients in high quality paste waxes recommended for floors. Waxes can be used as a maintainable, protective topcoat for almost any type of floor finish, but are most commonly used with penetrating sealers.

Natural Resins

Resins are widely used film forming materials for all types of transparent finishes. The variety of resinous materials put to use in paints and coatings has steadily increased throughout history, and continues presently into the realm of synthesized resins. The combination of two or more different polymers in a coating can result in working properties that are distinct from those of any individual resin.[5] Combining different resins within a coating has been practiced by tradesmen for centuries, searching for the

ideal combination of disparate characteristics. Development of this technology continues to drive the introduction of new synthetic resin materials.

Resins are amorphous polymers built up from single, organic, isoprene units. The chemical class of terpenes, which includes most resinous materials, is sub-divided into monoterpenes, sesquiterpenes, diterpenes, triterpenes and rubbers. The mono- and sesquiterpenes, like turpentine, are liquids and are generally good solvents for the di- and triterpene resins used in varnishes. Terpene resins include Venice and Strasburgh turpentines, rosin (colophony), sandarac (gum Juniper), copals, dammar, mastic and elemi.[6] Important non-terpene resins include amber and shellac. Amber is a hard fossil resin which is difficult to solubilize. Confusion between amber and copal resins is common in early textural sources and there is some question as to the extent of its use as a varnish resin. These and other resinous materials were used in a multitude of varnish recipes published throughout the last four centuries, however, with the exception of shellac, few were ever used in floor finishes.

Much is already written about the various resin sources and their associated characteristics and properties, but for the purposes of this paper it is important to give shellac special mention. A growing inventory of analyzed and documented finishes surviving in nineteenth century buildings suggests that shellac varnishes were used more extensively than other clear finishes after 1800.[7] Although the colored resin was imported into Europe by the end of the seventeenth century, it was not until the 1790's that the development of chemical bleaches rendered it suitable for clear coatings.[8] On floors, shellac was common by the end of the nineteenth century, and throughout the first

half of the twentieth. It is readily soluble in alcohol and forms a hard and durable finish, but it is not moisture resistant, so it was typically topcoated with wax or another varnish when used on floors..[9]

Shellac is the purified resinous secretion of the lac insect and is the only significant animal-source resin. In various forms the lac resin is referred to as stick lac, seed lac, button lac or gum lac.[10] The composition of the shellac resin is a complex mixture of fatty acids and sesquiterpenes on a cedrene skeleton, and a small percentage of wax.[11] The lac resin is still commercially available in button or flake form, in many grades and colors. Shellac is currently used extensively as a clear finish by furniture and architectural conservators, both because of its esthetic and functional characteristics, and because it is often a part of the intact finish history of the furniture or building.

Balsam

Balsam is a general term describing the natural exudates of coniferous trees. Balsams are also referred to in historical literature as gem rosin and as various types of turpentine (common, Cyprus, Strasburgh or German, and Venice). Only the finest varieties of Strasburgh (*Abies excelsa* or *Abies pectinata*) and Venice (*Larix decidua*) turpentine were used historically in clear or pigmented coatings.[12] Venice turpentine was used most extensively as a softener in early varnish recipes. Typically, balsams were processed by heating, into rosin, a soft resin, and during the eighteenth century, the collection of the liquid by-product by distillation, became more common. This liquid was commonly called spirit of turpentine, essence of turpentine, or oil of turpentine and is

referred to today simply as turpentine.[13] Although balsams may have been included in floor varnish formulations historically, their use was specifically as an additive to counteract a tendency of many resin films toward brittleness.[14]

Gums

Gums are vegetable mucilages produced by certain plants, which are generally soluble in water, and have been used as binders for water colors. They are mentioned here chiefly to differentiate them from resins, with which they are often confused. The historical use of gums as architectural clear coatings is unlikely due to their hygroscopic nature, and no evidence of such use was found in the literature.

Solvents

Until the nineteenth century in America, only turpentine and ethyl alcohol were commonly used in housepainting. The introduction of distillates of coal tar and petroleum, during the second half of the century, widely increased the variety of available solvents. Industrial development of other synthesized solvents like esters and ketones, has continued the trend throughout the present century, but turpentine, alcohols and mineral spirits remain the most common in architectural coating formulations.[15] As mentioned above, linseed oil was also used as a solvent for several resins.

Solvents also served a second purpose, that of thinning oil varnish formulations to achieve brushable viscosity. The viscosity requirement of a coating is determined by the method of its application, the range of acceptable working and setting times, and the desired properties of flow and film gloss. High ratios of solvent to oil also reduces the

gloss of paint or varnish films, and flat finishes, popular in the early nineteenth century took advantage of this effect.[16]

Turpentine

Turpentine has become the common name for the distillate of pine balsam historically referred to as spirits-, oil-, or essence-of-turpentine. Its use as a solvent and thinner increased dramatically during the eighteenth century in step with its increasing production and export as a commercial product.[17]

The composition of turpentine is a complex chemical mixture of aromatic hydrocarbons, varying in proportion according to the species of pine tree that provides the raw balsam.[18] Good quality turpentine is a mild solvent for fats, soft resins and oils and it was widely used for spirit and oil varnishes that included such resins as copal, dammar, mastic, and the turpentine balsams.

Alcohol

Ethyl alcohol is the solvent of many spirit varnishes. Traditionally referred to as spirit of wine, it was used as a solvent for sandarac, mastic, dammar, copal and shellac. The process of distillation of alcohol developed over several centuries but was quite sophisticated by the seventeenth century, and spirit varnishes were used extensively in colonial America. Purity of the solvent is critical to its performance, the inclusion of small amounts of water being the chief adulterant, and empirical tests for water content are suggested in many contemporary trade publications.[19]

Petroleum Distillates

Petroleum distillates were first introduced in the late nineteenth century as an inexpensive substitute for turpentine. Initial problems with the unpleasant odors of drying films were eventually overcome by removing sulphur and olefin hydrocarbons.[20] These odorless distillates are typically called mineral spirits or white spirits, and because they are dramatically less expensive than turpentine, they have taken over the lion's share of the commercial solvent market during this century. Toluene and benzene have also been used as solvents for varnishes.

SYNTHETIC MATERIALS

Resins

Gettens and Stout define synthetic resins as "complex, amorphous, semi-solids or solids that are made by chemical reaction from a variety of raw materials."[21] A more precise definition is provided by Dieter Stoye in the introduction to *Resins for Coatings*:

> Synthetic resins are resins obtained by addition polymerization, polyaddition or polycondensation which may or may not be modified by natural substances (fatty oils, natural resins and the like). The term synthetic resins is also understood to mean natural resins modified by chemical reaction (esterification, hydrolysis, and the like). In contrast to the natural resins, a large proportion of synthetic resins can be converted by crosslinking into thermosets.[22]

Alkyds

Alkyds are esters of polyalcohols and polycarboxyl acids which are typically modified with vegetable oils for use as paints and coatings. After 1930, oil modified alkyd binders rapidly replaced natural drying oils, although those same oils were and are used as the modifiers. Alkyd oils have superior film hardness and weatherability and dry much more rapidly than the traditional linseed drying oils. Alkyds are easily and widely modified by varying the type and content of oil in the resin, as well as by a host of synthetic fatty acids and other additives.[23]

Urethanes

Urethane coatings have been embraced by wood finishing trades and widely used as clear varnishes for furniture, floors, paneling and wood trim. Of the five general types of urethane coatings, classified by film formation, two are typically used as architectural finishes.

Oil modified urethanes cure by oxidation. The modification of urethane by alkyd oils produces working properties very similar to traditional varnish formulations. The resulting polyurethane films have superior hardness and resistance to abrasion, common solvents and household chemicals. Oil modified urethanes also dry rapidly and have a nearly unlimited pot life.[24] Like most synthetic coatings, a key detriment is their plastic looking finish. There is also a tendency of polyurethane to blacken and fail rapidly once the film has been breached. This rapid failure may be explained by the fact that the film is so impervious to moisture. Like a wax film, once water gets underneath the surface it becomes trapped and affects adhesion.

Aqueous polyurethane dispersions have seen increasing use as furniture and architectural coatings as Volatile Organic Compounds restrictions have tightened. They dry by evaporation of the water and coalescencence of the polymer particles. Melamine formaldehyde resins or polyisocyanates are also added to some formulations to produce chemical crosslinking reactions that increase film strength.[25]

Acrylics

As a class of synthetic resin coatings, acrylics have been widely used in architectural conservation. Their popularity is the result of colorless, stable, and water resistant films.[26] Acrylics can be copolymerized to produce different characteristics of hardness, solubility, adhesion and elasticity, and can be prepared as aqueous dispersions.[27] Several acrylic varnishes have seen extensive use as conservation finishes. Although their optical properties are not ideal for all applications, the stability and long term solubility of acrylic coatings like Paraloid B72 are established and predictable. Acrylic coatings can be used as top coats, consolidation coatings or isolation layers.

Ketones

Ketone resins are formed by condensation with various formaldehydes, vinyls and other monomers.[28] Cyclohexanone resins have been selected out as useful picture varnish binders because of the similarity of their optical properties to those of traditional natural varnishes. The similarity has been partially explained as a function of molecular weight and refractive index.[29] Unfortunately, the cyclohexanones autoxidize rapidly, which results in a decrease in solubility and an increase in brittleness. Although the aged films are not as prone to yellowing as natural finishes, their longevity is only a marginal

improvement. Efforts to improve upon the basic compatibility of ketones include testing of polymer stabilizers and an attempt to synthesize a more stable derivative.[30] The use of a two-layer system, whereby the ketone varnish is protected by an acrylic topcoat, has also proven effective as a picture varnish. [31] Still, ketones are more promising than they are useful as floor finishing materials.

Solvents

The solvents employed in synthetic resin coatings are the same as those used in natural resin formulations; primarily petroleum distillates like mineral spirits. Stronger solvents like benzene and toluene are employed by conservators in special applications and in the removal of cured films.

Additives

A wide variety of natural additives have been used traditionally to manipulate the working and setting properties of liquid coatings and to improve the characteristics of the cured film. In addition to metallic driers, various natural substances are suggested by trade literature to remedy coating deficiencies, but their beneficial effects are often described in a superstitious tone. Much of the initial development of synthetic resin formulations was an effort to alter and adapt natural materials by esterification.[32] Similar adjustments and fine-tuning of formulations has been accomplished with natural and synthesized additives. Presently, the variety of compounds available, and the complexity of their interactions within a coating formulation, vastly exceed the traditional roles of

natural modifiers. Additives are now critical components of most synthetic coatings and are deserving of some mention, although it is beyond the scope of this paper to describe them in detail.

Metallic driers like salts of lead, cobalt and manganese and are still the most extensively used coating additives. The trend toward low toxicity in paints and coatings has increased attention to non-metallic driers like orthophenathroline.[33]

Polymer stabilizers are particularly useful additives for clear coatings. Anti-oxidants and ultra-violet light stabilizers mitigate the degradation of films, an issue that is key to conservation applications. Current research has attempted to identify the most effective stabilizers for use in conservation coatings like picture varnishes.[34]

Other additives used in clear coatings include glossing agents and flatting agents, and various modifiers of water borne coatings, like wetting agents, coalescing agents and preservatives.

[1] Theodore Zuk Penn.,"Decorative and Protective Finishes, 1750-1850," Bulletin of the Association for Preservation Technology, 16(1, 1984): 22,34; 19,20.
[2] Rutherford J. Gettens and George L. Stout, *Painting Materials, A Short Encyclopedia.* Second ed. (New York: Dover Publications, 1966) 33.
[3] Weismantel, *Paint Handbook*, 78.
[4] Masschelein-Kleiner, *Ancient Binding Media*, 48.
[5] E. De Witte, "Resins in Conservation: Introduction to Their Properties and Applications," in the Proceedings from the Symposium, *Resins in Conservation*, ed. J.O. Tate, N.H. Tennent, J.H. Townsend. (Edinburgh: Research Centre for Social Sciences, 1983) 1-1.
[6] Masschelein-Kleiner, *Ancient Binding Media,* 75.
[7] This comment is based on personal communication with several conservators and preservationists including: Frank S. Welsh, Principle, Welsh Color and Conservation; David DeMuzio, Philadelphia Museum of Art; and Catherine Meyers, Principle, Meyers Conservation.
[8] Mussey, "Early Varnishes," 55-56.
[9] T. Hedley Barry, *Natural Varnish Resins* (London: Ernest Benn Ltd., 1935), 272.
[10] Penn, "Decorative Finishes," 24.
[11] Masschelein-Kleiner, *Ancient Binding Media,* 90.
[12] Ibid., 78.
[13] Penn, "Decorative Finishes," 23.
[14] Ibid, 17.
[15] Gettens and Stout, *Painting Materials,* 201.
[16] Richard Newman, "Historic and Modern Oil Paints: Composition and Conservation," in *Paint in America,* ed. Roger Moss (Washington D.C.: Preservation Press, 1994), 264.
[17] Penn, "Decorative Finishes," 23.
[18] Gettens and Stout, *Painting Materials,* 201.
[19] William T. Brannt. *The Painter, Gilder and Varnisher's Companion.* (Philadelphia: H.C. Baird and Co., 1902) 52.
[20] Gettens and Stout, *Painting Materials,* 196.
[21] Ibid, 66.
[22] Deiter Stoye and Werner Freitag, *Resins for Coatings* (New York: Hanser Publications, 1996), 1.
[23] Stoye, *Resins,* 60.
[24] Weismantel, *Paint Handbook*, 16.6-16.9.
[25] Stoye, *Resins,* 194.
[26] Weismantel, *Paint Handbook*, 16.10.
[27] Stoye, *Resins,* 307.
[28] Ibid, 159.
[29] de la Rie, "The Influence of Varnishes," 10.
[30] E. Rene de la Rie. "The Chemistry of Ketone Resins and the Synthesis of a Derivative with Increased Stability and Flexibility," Studies in Conservation, 34(9-19): 1989, 9; de la Rie, "Polymer Stabilizers," 9.
[31] De Witte, "Resins in Conservation," 1-4.
[32] Robert Selby Morrell and Barry T. Hedley. *Synthetic Resins.* (London: Ernest Benn. Ltd., 1937) 78.
[33] Weismantel, *Paint Handbook*, 3-13.
[34] de la Rie. "Polymer Stabilizers," 9.

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