"AURORA BLUE": PAINT RESEARCH IN AN OREGON UTOPIAN SOCIETY, CA. 1870

by

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A THESIS

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A blue paint color, known as "Aurora Blue," was used in the Aurora Colony (1856-1883) at Aurora, Oregon. The color now used is a light blue which does not correspond to historical samples. The nature and use of this paint was investigated using primary source documentation, field and laboratory analysis, and a personal computer data base as an interpretive tool. A thorough overview of the field of paint research has been presented and issues examined.

The pigment was found to be Prussian blue. The hues spanned a range between light blue and deep purple blue. It was used on chair rails, baseboards, and other interior wood architectural elements and furniture pieces. Examination of account books indicated the possibility of home manufacture and mixing of the pigment until the mid 1870s when commercial paint appeared in the records.

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CHAPTER I

INTRODUCTION

In the winter and spring terms of 1984, I conducted a partial inventory of Oregon furniture in the collection of Mrs. Ruth Powers, of Oregon City. The collection featured numerous pieces made at the Aurora Colony (1856-1883) at Aurora Mills, Oregon. Several painted items, including a dough box and a flute case, still exhibited an original blue paint which Mrs. Powers called "Aurora Blue." I learned that the use of this blue color (hue, value and chroma), also known as "Colony Blue," on certain architectural features of building interiors and on furniture pieces, was a distinguishing feature of the Aurora Colony. While this was not the only color used, it was considered to have been the most common and to have been used widely on a variety of elements. It is the only color specifically associated with the Colony.

In subsequent visits to Aurora, however, I noticed that, while the museum has a few pieces displaying original paint of a similar hue to that on the pieces in Mrs. Powers' collection, the color used on the repainted architectural elements throughout the museum buildings and on many repainted furniture pieces, is a much lighter, noticeably different blue. In apparent deference to this discrepancy, the museum displays a variety of blue hues on wooden cut-outs of musicians in their exhibit of Aurora band instruments.

What this color had been originally--in terms of hue, value, and chroma--had, over time, become unclear and what it was chemically was not known. The question, What is "Aurora Blue"? clearly needed to be investigated. A developing interest in paint research and analysis, therefore, led me to choose "Aurora Blue" as a case study in which to apply paint research methodology.

Because this project investigated the nature and use of one paint color in an entire community, over a period of time, rather than attempting to distinguish a color that had been used on a single structure, at a given point in time, certain procedures typical to paint analysis, such as establishing a chromochronology, were not useful, while some atypical ones, such as using a data base, were (see Chapter V). However, the full range of paint methodology was examined. What is presented is not only what was done, but also, alternatives and options that were not available or were not appropriate to this study.

The Aurora Colony

Established by charismatic leader Dr. William Keil as a utopian community, Aurora, Oregon is located in Marion County approximately thirty miles due south of Portland (see figure 1). Keil, who took the designation Doctor in spite of having no medical or formal theological training, came to Oregon with part of his following in 1856. Several other groups came in later migrations. They had previously lived as a communal group in Bethel, Missouri where they had settled in 1844, and where some remained. Many of Keil's followers had split from the Rappite sect in Economy, Pennsylvania. The Aurora settlers were primarily of German descent, including very recent immigrants. They did not consider themselves a religious sect, but rather practised a version of Lutheranism.

Their social organization followed that of many similar utopian settlements established in the nineteenth century. Goods were owned communally and work done for the common good. Celibacy, however, was not required nor marriage prohibited. Families were allowed to build and live in their own homes on outlying farms and in the village (see figures 2 and 3).

Industrious, hospitable and musical, the Colonists' relations with "outsiders" were unusually good. The distribution and exchange of goods within the community took place in the Colony stores. The one still standing was also patronized by non-members. Across the street stood the one for the Colony members.[1] The Colony Hotel was widely

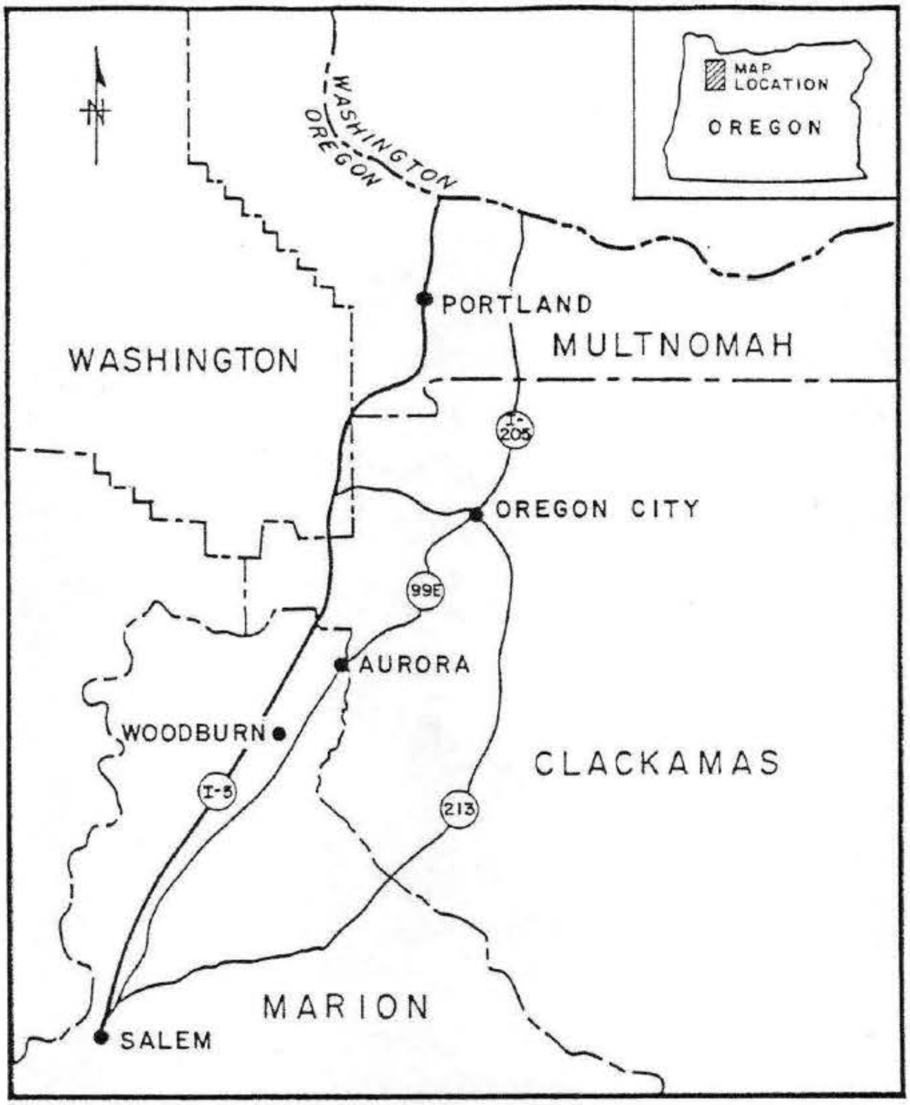


Figure 1. Aurora, Oregon is located in Marion County approximately thirty miles due south of Portland.

Figure 2. View of Aurora, Oregon, 1877-1890. (Used by permission of Aurora Historical Society.

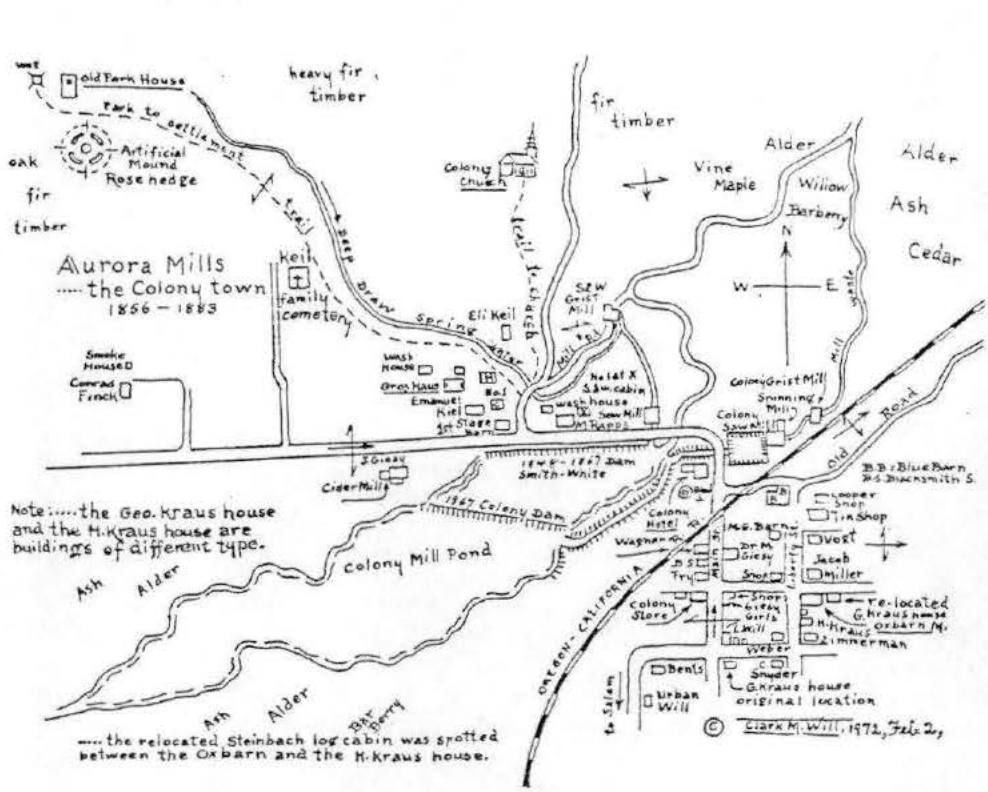


Figure 3. Aurora, Oregon 1856-1883 as drawn by Clark Moore Will in 1972, including recent re-location of Giesy-Kraus house. (Used by permission of Aurora Historical Society)

known for its excellent food, and the Colony band was well-regarded for the quality of its musicianship. Agriculture and weaving were other major Colony endeavors, and like the Shakers, the Aurora Colonists made distinctive, high-quality furniture. While simple in form, with many pieces similar to that made by the Shakers, Aurora furniture was characterized by skilled turnings. The group ceased to exist as a communal organization shortly after Dr. Keil's death in 1877. While many Colony families continued to live in Aurora, it no longer operated as a "Colony" and in 1883, the property, which had been held in common, reverted to private ownership.

In 1974, Aurora was designated an Historic District by the National Register of Historic Places. While a highway cutting through it has modified the configuration, the town retains a large number of buildings original to the Colony. The oldest surviving residential structure is the Giesy house of 1865. Several other dwellings from the 1870s also survive including the large two story residence of Dr. Keil's son Frederick Keil. The more modest home of Emma Giesy, and later George Kraus--now called the Giesy-Kraus house--has been moved and restored, and is now owned by the Aurora Historical Society which operates it as a Museum in conjunction with the Ox Barn and the Steinbach log cabin (see figure 4). The homes of William Fry, Charles Snyder, Solomon Miller and Michael Rapp also remain from this period, as does the Colony store. Many buildings, however, are no longer extant including the hotel (destroyed in 1934) and the workshop building, also known as the Giesy girls' house. William Keil's house, known as "Das Grosse Haus," burned down in 1906 and the church which sat on a hill above the town was demolished in 1911-12.

The buildings of the Aurora Colony used in this study are typical for the community. Simple rectangular, two story, gabled structures with end chimneys, they are eighteenth century in essential characteristics and in most exterior and interior detail. The houses are usually two rooms in width with a staircase, either enclosed or open, within a central hall. One room is the kitchen; the other, the parlor; the former furnished with a wood stove, the latter with a large brick fireplace. The simplicity and vigor of the colors found seem in character with the vernacular, unsophisticated quality of these interiors. Examples elsewhere in the country combine to suggest the survival of eighteenth century color (and other) traditions well into the nineteenth century in vernacular circumstances. Except that the gable end is its front, the plan of the store is similar in many interior respects to the descriptions given here of the houses.

Detail within and without is made up of assemblies of flat boards; curvilinear profiles are virtually absent. The interior trim boards--baseboards, wainscot rails, chair rails and peg board rails--have been planed with quirk and bead edges. That detail seems to constitute the only ornamental element. The two story porches on the store and on the Keil house are exceptional for having turned work. Planing mills and sash, door and blind factories had arrived in most Oregon cities by the late sixties or early seventies but Aurora seems to have made no use of machine made building materials during that period. The Colony had its wood-working shops, though the equipment may have been primarily for the production of furniture. The finish

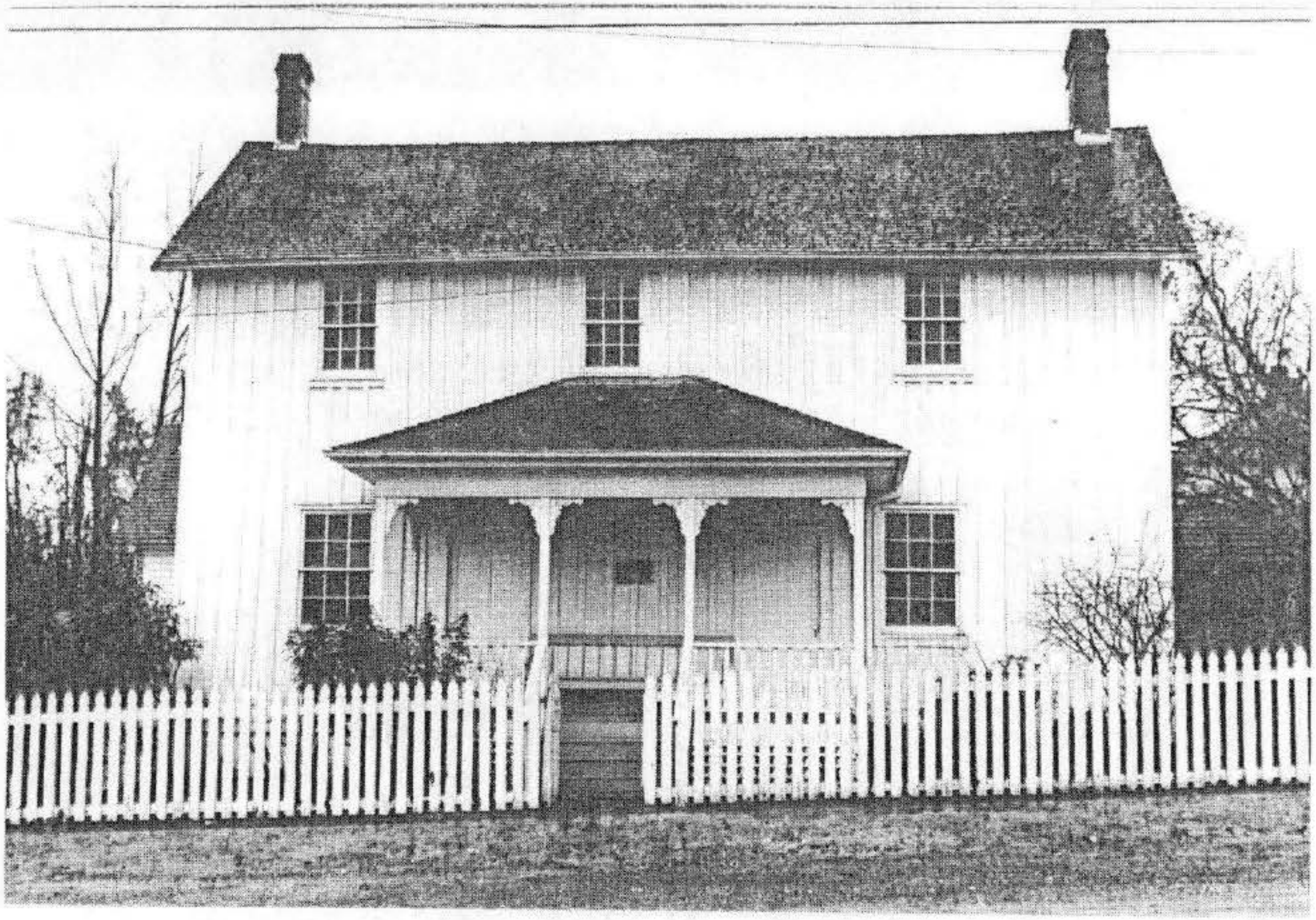


Figure 4. Giesy-Kraus house, Aurora, Oregon, now owned by the Aurora Historical Society and re-located on the grounds of the Ox Barn Museum.

elements found on the Colony buildings of this time appear to be hand-made. For example, interior doors usually are of vertical boards with quirk bead edges and two horizontal batts behind. In these boards hand planing is evident.

The interiors in most buildings were plastered. In the bedrooms there was usually a chair rail and at six feet around the room a strip with pegs for hanging clothes (peg board) like that found in Shaker dwellings. A baseboard might serve as the lower rail of a wainscot which went to window sill height with an upper rail below a small cap with a bullnose face. A single, horizontal board about two feet in width usually filled the wainscot panel. In other cases, and always in second floor rooms, a board acted as a chair rail, the panel below being of plaster (see figures 5, 6, and 7).

The Project

The purpose of this study was to ascertain the original blue color (or colors) used by the Aurora Colonists, visually and chemically; to discover where and how it was used; to learn its source; and to attempt to duplicate it. The hypotheses investigated were:

1. That "Aurora Blue" is an identifiable pigment
2. That "Aurora Blue" was regularly used by the Aurora Colonists on certain lements of building interiors
3. That the pigment was consistent even though the

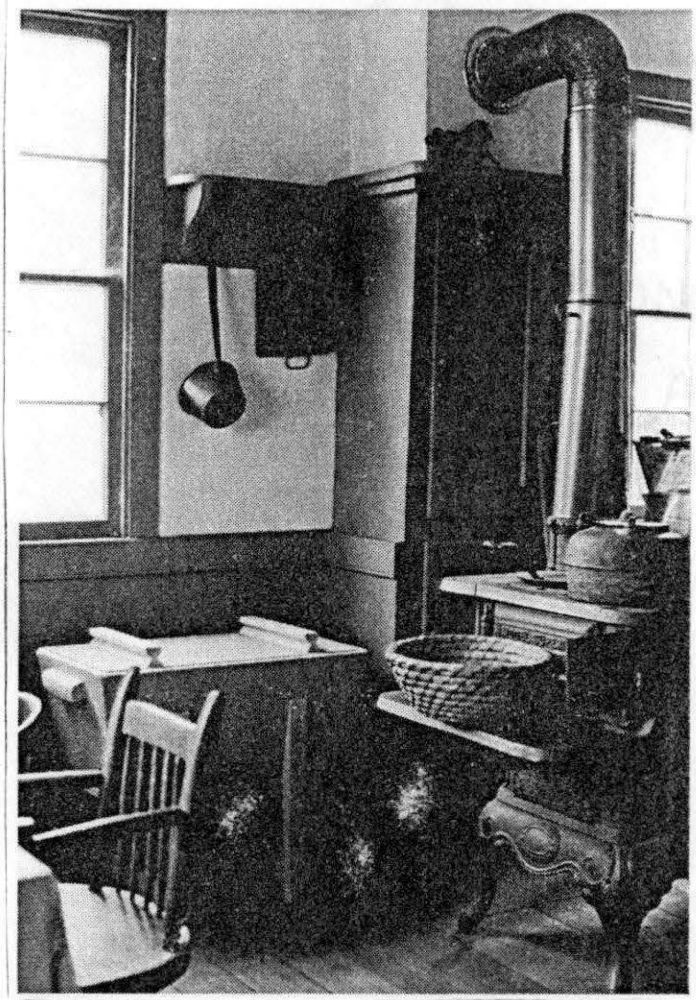


Figure 5. Kitchen of Giesy-Kraus house.

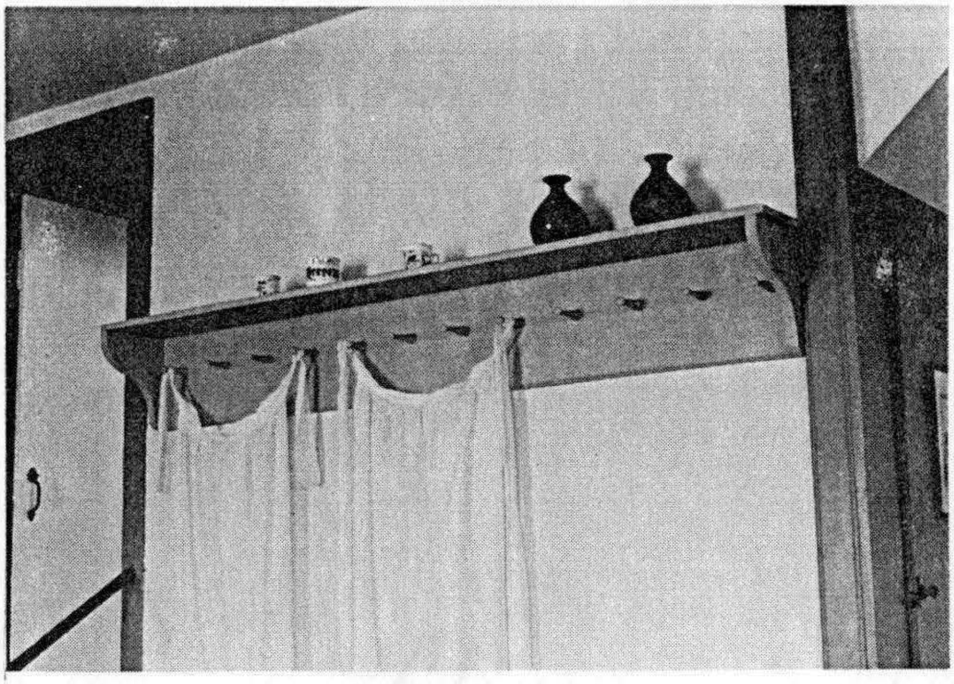


Figure 6. Peg board in kitchen of Giesy-Kraus house.

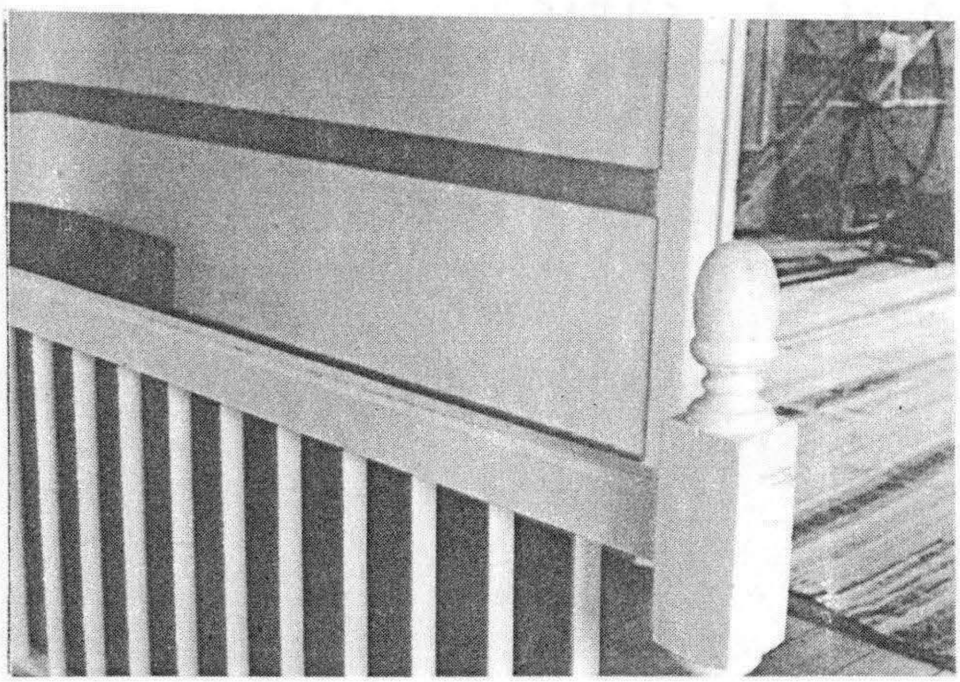


Figure 7. Upstairs hall of Giesy-Kraus house.

difference in mixing created visual variation within a small spectral range in hue, value and chroma

4. That glazes and undercoats may have been used
5. That the Colonists may have manufactured their own pigment and mixed their own paint

The study did not attempt to determine how the color presently being used evolved from the original hue, or to determine whether or not the blue used was exclusive, within any geographical boundaries, to the Aurora Colony. It was assumed that there was enough of the original color left on the architectural features in the structures to make a determination of where and how the color was commonly or typically used.

Five structures were investigated: the Giesy-Kraus house (ca. 1875), the Keil house (1870), the Giesy house (1865), the Fry house (1874) and the Colony store (Pioneer Hall) building (1871). Of these, the most thoroughly examined was the Giesy-Kraus house. As a house museum, it was more accessible and the opportunities for sample taking were greater than in the occupied dwellings. In addition to the structures, several pieces of furniture (four trunks, a dough box and a cupboard) all in the possession of the Ox Barn Museum, were sampled, as well as a piece of baseboard which had been removed and discarded from the Becke house (ca. 1872). Eighty-seven samples were taken in all, of which forty-eight were from the Giesy-Kraus house. Paint analysis and examination of documentary evidence was used to determine the original pigments, and a color notation system was employed to optically establish and record the range of blue hues. Architectural elements on which the color was found were noted. Appropriate information was entered into a home computer data base and manipulated for interpretation. Pigments were mixed to duplicate some of the original colors, and the results were matched to the samples visually and spectrophotometrically.

This study, thus, proposed to bring the present knowledge of "Aurora Blue" into consonance with the historical record. (The present, erroneous color is illustrated in plate 1.) In so doing, it should underscore the importance of both paint analysis and documentary evidence as tools to be employed, from the outset, in establishing original paint color. It should also highlight the issues, problems, and importance of accurate color matching.

Plate 1. Fireplace of Giesy-Kraus house as painted at time of study.

Notes

[1]Though the business set-ups within the Colony are not clear, there was definitely more than one company which handled retailing and goods exchange. There were also at least two structures which housed the exchange of retial goods, the one now known as the Colony Store was probably the Giesy Co. William Keil also operated a goods exchange business. He apparently dealt exclusively with Colony members and also ran the communal eggs and butter distribution. Frederick Keil was also involved in retailing within the Colony. Also see note 2, Chapter IV.

CHAPTER II

HISTORY OF PAINT RESEARCH

It is well-known that the unearthing of Pompeii in the early nineteenth century led to a renewed and academic interest in Classical architecture which changed the appearance of cities throughout Europe and the United States. The wall paintings found in Pompeii were extremely influential in understanding the Classical use of polychromy and painted decoration as well as interior design. What is less well-known is that these paintings also led to the earliest (known) interest in the analysis and identification of painting materials. This took the form of two short publications dealing with the pigments and mediums of the wall paintings--a paper by M. Chaptal of France,[1] and one by the English scientist, Sir Humphrey Davy.[2] While this field began with a study of architectural painting, it developed into the highly technical state in which we find it today primarily through work in the area of fine arts research and conservation.

> Really serious study of the materials of early painting had to wait nearly another hundred years, when they were again taken up about the turn of this century by the late Arthur Pillans Laurie of England; Dr. Laurie's chemical and microscopic studies on materials of art covered half a century during which he issued a long series of papers and books of artists' paints and painting.[3]

"The 1930s seem to have been the golden decade in the analysis of painting materials."[4] Dr. A. Martin de Wild, of Holland, published a book, long the standard in the field, entitled The Scientific Examination of Paintings, based on his technical studies of the Dutch Masters.[5] A. Eibner, of Munich, researching in paint chemistry, applied his methods to ancient paintings, especially wall paintings and published papers on the application of microchemistry to the examination of paintings.[6] Two other researchers who also produced papers at this time were Dr. Scheffer, professor at the Technical High School in Delft and de Wild's teacher; a pupil of Eibner's, H. Hetterich.[7] A series of papers on pigment identification through microchemistry was published in various journals and languages by Dr. Selim Augusti of Naples, an expert on Pompeian paintings,[8] bringing the subject full circle in its first fifty years. It was also in the 1930s that Rutherford Gettens first began publishing on painting materials.[9] His book, Painting Materials: A Short Encyclopedia, written with George Stout and published in 1942 (reprinted by Dover in 1966) is still considered the standard in the field.

A hiatus created by World War II ended in the 1950s when Dr. Paul Coremans and his colleagues at the Institute Royal du Patrimoine Artistique de Belgique published the results of their studies on the materials in Flemish Primitive paintings.[10] In 1956 Joyce Plesters, of the

National Gallery in London, published her much cited paper "Cross-sections and Chemical Analysis of Paint Samples" in Studies in Conservation,[11] also still a standard reference.

The area of architectural analysis and conservation has lagged behind its fine arts counterpart. "The first basic research into American paint colors was carried on at Colonial Williamsburg. This led to the formulation c. 1940 of a palette of colors which were accepted for decades as objectively valid for eighteenth-century architecture."[12] It also appears to have short circuited further research and the improvement of research methods in this field for about twenty years. In 1966 two research projects were carried out which examined paint materials and the housepainter's craft.[13] Then in 1968 Penelope Hartshorne Batcheler, an architect with the National Park Service's Office of Archaeology and Historic Preservation, published her paper "Paint Color Research and Restoration".[14] She credits Anne F. Clapp, reservation specialist (a conservator) of the museum (fine arts and artifacts) branch of the National Park Service, with introducing her to the analytical methods of cross-sectioning and pigment testing. This was apparently the first instance of information sharing between fine arts conservation and historic preservation on the subject of paint analysis. Ms. Batcheler's succinct article is still probably the most frequently cited work in this field.

In the early 1970s the work being carried out in the field of fine arts conservation began to be recognized by other preservationists as applicable to historic paints. Morgan W. Phillips, of the Society for the Preservation of New England Antiquities (SPNEA), was a leader in this endeavor.[15] The North American International Regional Conference held in Williamsburg, Virginia, in 1972 gave notice and voice to this subject in papers presented by Mr. Phillips and Robert L. Feller.[16]

Conservators of the fine arts have continued, however, to be the leaders in the development of new technology for paint analysis. This may be due to the fact that their work is carried out in galleries and museums where they have access to equipment not commonly available to preservationists. It may also be due to that field's longer history as a scientific discipline--a position only now being attained by historic architectural paint analysis.

The publication Recent Advances in Conservation, contributions to the IIC (International Institute for Conservation of Historic and Artistic Works) Rome Conference, in 1961, geared to the work of fine arts museums, is reflective of the continued progress in this area.[17] The contributions of Augusti, Gettens, E. T. Hall and W. J. Young are specifically directed to paint analysis. Augusti's article, published in French, discusses several methods, grouping them into two categories--destructive and non-destructive--some of which are also discussed by Hall and Young. Destructive techniques--those which involve extracting a sample from the work of art--include: microscopic examination, chemical tests, spectrographic analysis, and x-ray diffraction. Non-destructive analysis is carried out by visual examination using magnifying devices, and by infrared photography, emissions radiography, x-ray fluorescence, and gamma ray spectrometry.[18] E. T. Hall and W. J. Young discuss the non-destructive techniques of x-ray (gamma ray) spectrometry and electron-probe microanalysis.[19]

By the 1970s these techniques still constituted the state of the art. Studies in Conservation, the periodical publication of the International Institute for Conservation (IIC), carried several articles discussing studies in which these techniques were used.[20] The National Gallery in London began publishing Technical Bulletins in 1977 which featured articles about their uses of technology in painting analysis. They used gas chromotography for analysing mediums; spectrophotometry to identify certain pigments and measure color change; polarizing light microscopy for pigment identification; as well as optical microscopy of paint cross-sections.[21] Ashok Ray described the limitations of some of these methods in his article on the use of laser microspectral analysis in 1979. This method, invented in the early 1960s was "well-suited to qualitative analysis of multi-layered paint fragments where compositional information about one or more layers is required individually."[22] It "provides a valuable adjunct to the examination of the layer structure of minute paint flakes by optical microscopy, and when information gathered from these two techniques is combined with x-ray diffusion studies using the powder camera method, the majority of the inorganic materials found in paintings can be identified with certainty.[23] In January 1985, the author visited the National Gallery and was shown around by Ms. Plesters. She indicated that the combination of procedures outlined above still constitutes their methodology.

The field of historic preservation has not been able to utililze the full range of this technology and has tended to focus on the less technical procedures. The expense of the equipment and the lack of personnel trained in its use are probably the main reasons for this. The National Park Service's North Atlantic Historic Preservation Center in Boston represents the most current technology in historic architectural paint analysis in the United States. Writing for the <u>Bulletin</u> of the Association for Preservation Technology in 1978, Carole L. Perrault described the procedures in detail. The researchers rely on <u>in situ</u> optical examination and laboratory microscopy (primarily to establish a chromochronology, rather than for pigment identification), chemical testing and polarizing light microscopy. The latter is used primarily where definitive answers are not provided by the first two methods. A spectrophotometer is employed for color matching. The procedures used at the Center result from the goals of their analysis and their policy that all procedures and tests should be "uncomplicated enough that most professional preservationists can conduct the analysis with some confidence in the results."[24] Ms. Perrault states:

> The NAHPC's approach to paint research is governed by several factors. Foremost is the National Park Service's policy regarding historic structures. NPS projects taken on by the Preservation Center are primarily restoration and preservation-oriented. Therefore, they are approached with the intent of restoring the structure(s) to some point in time or preserving them as they are. This philosophy dictates the type of information sought from the paint samples. Generally, the objective of the paint analysis is to derive architectural data that eventually may assist in an 'accurate' restoration--whether this involves recording alterations to the structure or determining the visual appearance of the structure at the target restoration date.[25]

Notes

[1]Rutherford J Gettens, "Proposal for a Handbook on Analysis of Materials of Paintings," in Recent Advances in Conservation (London: Butterworth's, 1963), p. 26. Paper titled "Sur Quelques Colours Trouvee a Pompeia," Annales de Chimie (Paris) 10 (1809): 21-31.

[2]Gettens, "Proposal for Handbook," p. 26. Paper titled "Some Experiments on the Colours Used in Painting by the Ancients," Philosophical Transactions of the Royal Society of London 105 (1815): 97-124.

[3]Ibid., p. 26.

[4]Ibid.

[5]Ibid.

[6]Gettens, "Proposal for Handbook," p. 26. Paper titled "L'Examen Microchimique des Decoration Murales" Mouseion 13-14 (1931): 70-92.

[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]Ibid.

[11]Joyce Plesters, "Cross-sections and Chemical Analysis of Paint Samples," Studies in Conservation 2 (1956): 110-157.

[12]James Marston Fitch, Historic Preservation: Curatorial Management of the Built World (New York: McGraw-Hill Book Company, 1982), p. 247.

[13]Richard Candee, "Housepaints in Colonial America, Their Materials, Manufacture and Application," Color Engineering 4 (no. 5 and 6, 1966) 5 (no. 1 1967) and Theodore Zuk Penn, "Decorative and Protective Finishes, 1750-1850, Materials, Process and Craft," Bulletin of the Association for Preservation Technology 16 (no. 1 1984): 3-45.

[14]Penelope Hartshorne Batcheler, "Paint Color Research and Restoration," Technical Leaflet #15, History News 23 (October 1968).

[15]His first publication on the subject was "Discoloration of Old House Paints: Restoration of Paint Colors at the Harrison Gray Otis House, Boston," Bulletin of the Association for Preservation Technology 3 (no. 4 1971): 40-47.

[16]Published as Preservation and Conservation: Principles and Practices (Washington, D. C.: The Preservation Press, 1976).

[17]Recent Advances, pp.19-38 passim.

[18]Selim Augusti, "Les Methodes d'Analysis Appliquees aux Oeuvres d'Art et aux Antiquites," in Recent Advances, pp.19-25.

[19]E. T. Hall, "Methods of Analysis (Physical and Microchemical) Applied to Paintings and Antiquities," in Recent Advances, pp. 29-32. W. J. Young, " Application of the Electron Microbeam Probe and Micro X-rays in Non-destructive Analysis," in Recent Advances, pp. 33-38.

[20]Studies in Conservation 14 (1969), 19 (1974), 21 (1976), passim.

[21]National Gallery Technical Bulletin 3-8 (1979-1984), passim.

[22]Ashok Ray, "The Laser Microspectral Analysis of Paint," National Gallery Technical Bulletin 3 (1979): 43.

[23]Ibid., p. 48.

[24]Carole L. Perrault, "Techniques Employed at the North Atlantic Historic Preservation Center for the Sampling and Analysis of Historic Architectural Paints and Finishes," Bulletin of the Association for Preservation Technology 10 (no. 2, 1978): 11.

[25]Ibid., p. 8.

CHAPTER III

BACKGROUND RESEARCH

Before attempting paint analysis, it is necessary to have an understanding of those pigments which might be found. This includes knowing what pigments were available and/or commonly used, as well as their historical chemical and physical make-up.

Research on blue pigments reveals three types in common use in the mid-nineteenth century. Ultramarine, one of the oldest blue pigments, had been made of ground lapis lazuli until 1828 when a means of manufacturing it artificially was discovered.[1] It was not actually manufactured commercially, however, until 1854-1856.[2] Cobalt blue, a synthetic pigment, was discovered in 1802 by Thenard. Both of these pigments were expensive and neither were color fast in white lead, which was the common lightener until zinc white was commercially available in the mid-nineteenth century.[3] The third common blue pigment was Prussian blue. It was "probably used the most of all the blues by painters and decorators...."[4] It is easy to speculate, then, that Prussian blue was the pigment used in Aurora.

Chemical and Physical Make-up of Prussian Blue

> Its history now dates back nearly two centuries, and its discovery was accidental. One Diesbach, [of Berlin] in [1704], while he was precipitating a solution of alum to obtain a white base for the manufacture of lakes, used some potash that had been rectified with animal oil, and instead of precipitating a white substance, it precipitated a blue one. He had purchased the potash from a man named Dippel, who, having been informed of the occurance, traced it to the proper cause and was able to produce Prussian blue. The process was kept a secret as long as possible, but in 1724 it was discovered by Woodward, [of England] and by him made public.[5]

Chemically, Prussian blue is ferric ferrocyanide, a complex compound of iron and cyanogen. Different processes produce variations in the product. The methods for making it are described in more or less technical terms in various sources. Maire says:

> Its manufacture is as simple as can be, and is done by various processes, the necessary agent being prussiate of potash. This is obtained by fusing the potash of commerce with blood or other animal refuse. After careful preparation, it is of a yellow color. It is added to another solution made from two parts of alum and one part of sulphate of iron, the mixture filtered and allowed to settle. A double decomposition ensues, in which the iron combines with the potash of the prussiate, forming a sulphate of potash, while the prussiate of iron is thrown down, the sulphate of potash being held in solution.
>
> On the other hand, a similar decomposition takes place with the alum, and the superabundant carbonate of potash is mixed with the solution of prussiate of potash. By this means a sulphate of potash is formed, and the alumina or base of the alum is precipitated. These two precipitates, prussiate of iron and alumina, are produced at the same instant of time and are intimately mixed, producing a substance of a brilliant and intense blue, the Prussian blue of commerce; this, of course, after it has been well washed and dried.
>
> Whatever may be the system and methods of manipulation, - and these may differ greatly, - the

equivalents of the above must be present to produce Prussian blue.[6]

Paul Hasluck, writing in 1907, describes the process thus:

> There are several methods of manufacturing Prussian blue, the following being a common one: - A solution of copperas (ferrous sulphate...) is made with cold water in a tub; in another tub is prepared a solution of yellow prussiate (potassium ferrocyanide...), the two solutions are then run into the precipitating tub, when "white paste," a bluish-white precipitate of potassium ferrous ferrocyanide...immediately separates. The clear liquid is drained off, and the precipitate washed as rapidly as possible with several changes of water. The precipitate is afterwards treated with a solution of bleaching powder (calcium hypochlorite...) and hydrochloric acid..., whereby it is oxidised to ferric ferrocyanide, or Prussian blue.... After again washing the precipitate with several changes of water, it is filter pressed, and dried in the dark at a temperature of about 130° F.[7]

A much earlier source, more appropriate to the date of the work in Aurora, is the <u>The Arcana of Arts and Sciences</u> by Dr. M. Parker published in Washington, Pennsylvania, in 1824. His description reads more like a home recipe.

> Take, of blood, any quantity and evaporate it to dryness; of this dry blood, powdered, take six pounds, and of the best pearl ash two pounds; mix them well together in a glass or stone mortar; then put the mixed matter into crucibles or earthen pots, filled about two thirds; the crocks or crucibles being covered with a tile, but not luted. The calcination should be continued as long as any flame arises from the matter or rather till the flame becomes slender and blue, for if the fire be very strong a small flame would arise for a very long time and great part of the tinging matter would be dissapated and lost. When the matter has been sufficiently calcined take the vessels which contain it out of the fire and as quickly as possible throw it into 2 or 3 gallons of water, and as it soaks break it with a wooden spatula that no lumps may

> remain. Put it then into a proper tin vessel, and boil it for the space of 3 quarters of an hour or more; filter it while hot through paper in tin cullinders, and pass some water through the filter when it is run dry to wash out the remainder of the lixivium of blood and pearl ashes--the earth remaining in the filter may be then thrown away. In the mean time dissolve of clean alum four pounds, and of green vitriole or copperas two pounds, in three gallons of water; add this solution gradually to the filtered lixivium so long as any effervescence appears to arise on the mixture; but when no ebullition or ferment follows the admixture, cease to put in more. Let the mixture then stand at rest, and a green powder will be precipitated; from which when it has thoroughly subsided, the clear part of the fluid must be poured off and fresh water put in its place, and stirred well about with the green powder, and after a proper time of settling this water must be poured off like the first. Take then of spirit of salt double the weight of the green vitriole and alum added to the lixivium, which will soon turn the green matter to a blue colour; and after some time add a proper quantity of water and wash the colour in the same manner as has been directed for lake, etc. and when properly washed proceed in the same manner to dry it in convenient lumps. The brightness, deepness and coolness of Prussian blue, are proof of its goodness; for, with these qualities, it may be depended on for standing well. Sophistication, or anything amiss, may be seen by its being more foul and purple.[8]

F. W. Weber puts it very succinctly: "When solutions of yellow prussiate of potash...and iron (ferric salts) are brought together (keeping the iron salts in excess) Prussian Blue (ferric ferrocyanide) is formed as a deep blue insoluble precipitate."[9] He says that because of its cheapness, iron vitriol (copperas) is the ferrous salt usually employed. When mixed with yellow prussiate of potash it forms "a white precipitate, which when exposed to air, or if treated with Nitric Acid, is oxidized, thereby developing Prussian Blue."[10] The blue hue produced by these methods "may have a purple, bronze or green cast to it or it may be quite a pure blue, depending upon the manipulation during the process of formation."[11]

The variety of hues is echoed in the variety of names by which the color was known and marketed. The 1956 edition of Color Index, in which Prussian blue is listed as C. I. Pigment Blue 27, gives the most complete list of names.[12] Those most frequently listed by other authors as well are Milori Blue and Chinese Blue, which is a soluble pigment also called Soluble Prussian Blue (though the literature is contradictory on this point). Other names include: Berlin Blue, Paris Blue, Steel Blue, and Bronze Blue also mentioned by others, as well as Gas Blue, Iron Blue, Ammonia Blue, and Potash Blue listed by Color Index alone. Mineral Blue and American Blue are names cited by Weber.[13] Hasluck (1906) explains that three distinct products are grouped under the name Prussian blue: Soluble Prussian blue, insoluble Prussian blue or Williamson's blue, and Turnbull's blue, all with different chemical formulas.[14] Antwerp Blue was a pale (high value) blue of the same hue which has been replaced by Brunswick Blue.[15]

In addition to the hues mentioned in the quotation above, both Hurst and Mayer describe the color as "deep greenish-blue". They also say that in its pure or concentrated form it has a bronze sheen.[16] These are, seemingly, characteristics of the soluble Prussian blue, however, not the insoluble one. The insoluble form is mixed with water but has a tendency to fade and is not used as an architectural paint.

> There are two qualities of Prussian blue, which may be thus described: Quality No. 1 is very good; quality No. 2 is good for nothing. The good should have a decided blue tone of great clearness; that is the only tone of it worth having. The other has a purplish or dirty blue-black tone, and no amount of trying to doctor it up will help any. The tints made from it are invariably sickly, miserably muddy-looking, and never give satisfaction. Any tint made from Prussian blue of good quality and a suitable white base is very clear, clean-toned, and fairly permanent under proper conditions.[17]

The use of the term "fairly" with regard to its permanence seems appropriate because the literature, again, is inconsistent on this point. Mayer calls it "the most disputed member of the blue group as regards permanence" and concludes it is borderline.[18] The quality of the Prussian blue pigment used (which, as mentioned, varies greatly) is a consideration in discussing permanence, as are some of its other characteristics.

Functionally, Prussian blue is a transparent pigment of great tinctorial strength (tinting ability) "capable of absorbing enormous quantities of linseed oil....One may well wonder at the strength and power of [its] coloring matter. A pound of it will tint a ton (2000 pounds) of white lead to a decided sky blue."[19] It consists of very fine particles and is, therefore, easily held in suspension in the linseed oil. This transparent quality is another factor in its apparent impermanence since it renders it less able to mask the yellowing of a linseed oil medium. Used as a watercolor, Prussian blue fades somewhat when exposed to light but will recover when put in darkness. In oil, however, it "resists exposure to air, light, and most of the other atmospheric influences which act on pigments...."[20] A characteristic that distinguishes it from other blues is that it disappears when used with any alkali, such as soda, potash, ammonia, or lime, in favor of a brownish color (iron oxide).[21]

Several things can be learned from this review. First, Prussian blue could be produced in a variety of ways. Its manufacture could be carried out by resourceful individuals without a scientific background, using readily available materials. Its ease of manufacture and ability to be mixed with white lead made it a universally common choice when blue color was desired. The various processes yielded variety in color and quality of product. And while relatively stable, it was subject to aging problems. These facts support the probability that Prussian blue was the pigment selected in Aurora and further suggest that it was possible for the Colonists to manufacture it themselves. They also indicate qualities of the pigment which need to be considered when trying to understand and reproduce the color.

Notes

[1]The discoverer of this is listed variously as Guinet by Joyce Plesters, "Cross-sections and Chemical Analysis of Paint Samples," Studies in Conservation 2 (1956): 136, and as Kottig by Rutherford J. Gettens and George L Stout, Painting Materials: A Short Encyclopedia (New York: Dover Publications, 1966), p. 167.

[2]Gettens and Stout, p. 167.

[3]Ibid. and Frederick Maire, Modern Pigments and their Vehicles (New York: John Wiley and Sons, 1908), p. 32.

[4]Ibid. p. 148.

[5]Ibid. 1714 is the year stated by Maire. 1704 is given as the year of the discovery of the pigment by George H. Hurst, A Manual of Painters' Colours, Oils, and Varnishes, 5th ed., revised by Noel Heaton (London: Charles Griffin and Company, Limited, 1913), p. 204.; Ralph Mayer, The Artist's Handbook of Materials and Techniques (New York: The Viking Press, 1957), p. 66.; and F. W. Weber, Artist's Pigments: Their Chemical and Physical Properties (New York: D. Van Nostrand Company, 1923), p. 101.; whereas F. N. Vandewalker cites 1700, The Mixing of Colors and Paints (Wilmette, Illinois: Frederick J. Drake and Co., 1950), p. 21.

[6]Maire, pp. 148-149.

[7]Paul N. Hasluck, Painters' Oils, Colours, and Varnishes (Philadelphia: David McKay, 1907), p. 60.

[8]Dr. M. Parker, The Arcana of Arts and Sciences (Washington, Pennsylvania: J. Grayson, 1824), pp. 137-138. Wording and spelling are exactly as written.

[9]Weber, pp. 101-102.

[10]Ibid.

[11]Vanderwalker, pp. 21-22.

[12]Color Index, 2 vols., 2nd ed. (London: Society of Dyers and Colourists, 1956), 2:2777.

[13]Weber, p. 101.

[14]Hurst, p. 243.

[15]Hasluck, p. 59.

[16]Hurst, p. 245.; Mayer, p. 66.

[17]Maire, pp. 149-150.

[18]Mayer, p. 88.

[19]Maire, pp. 149-150.

[20]Hurst, p. 246.

[21]Hasluck, p. 62; Hurst, p. 246; Maire, p. 150; Mayer, p. 89.

CHAPTER IV

DOCUMENTARY RESEARCH

In 1874, Dr. Keil reported to Charles Nordoff that goods produced within the community were freely given to Colony members and no accounts were kept except of those items which were imported from or sold abroad.[1] However, detailed accounts were kept of such things as wool production and butter and egg distribution within the Colony, as well as of transactions involving goods and cash in exchange for items from the several merchandisers.[2] From these account books, one can get a fair idea of the kinds of goods available to and used by the Colony members. To satisfy the hypothesis that the Colonists may have manufactured their own pigment and mixed their own paint, the books were thoroughly examined for transactions involving blue pigments or their ingredients. This information also served to supplement and corroborate evidence from the field and laboratory research.

The singular mention of Prussian blue in any of the books examined was contained in an entry of August 1, 1857 in which Jane Bonney purchased two dollars worth of the pigment from "Truman." Censuses and other information indicate that these were not Colony people, but the entry reveals that the pigment could be purchased in Aurora.[3] The first mention of paint was on July 8, 1876, when G. Zigler bought one gallon of Averill Paint. Table 1 shows subsequent purchases of paint by other customers within the next several days and over the next several months.[4] It is clear from these entries that, at least from this point on, commercial paint was available to the Aurora Colonists. Entries for "pks" of paint, boxes of paints, and boxes of colors could refer to pigments to color paint bases. However, an advertisement or label, found in one of the books, for The Averill Chemical Paint Company reads,

> The pioneer in mixed paints, is composed of the best materials known to the trade: Pure Linseed Oil, Strictly Pure White Lead, Pure French Zinc, and the Purest Colors procurable for tinting, which, by our process of manufacture, are so united as to produce a paint which is at once more durable and more beautiful than can be produced by any other process of manufacture....

Patents were granted for this paint, or manufacturing process, March 25, 1858, and July 16, 1867. The use of commercially manufactured paint in the Colony in the late 1870s corresponds to its acceptance nationwide at that time.[5]

All the structures in this study, however, were built prior to this earliest, 1876, paint entry. What were the Colonists doing for paint at the time these buildings were constructed? The account books show numerous entries for ingredients which could have been used to manufacture

TABLE 1. Print-out of account book paint entries (See Appendix B for complete information.)

bk	date	item	customer
A	Aug 1 57	prussian blue	Jane Bonney
A	Sep 26 57	paint brush	Wm. Haris
-	Apr 2 64	wallpaper	T. J. Gregory
F	Apr 23 74	1 white wash brush	Wolff, Keil & Co.
G	Jun 13 74	10 rolls wallpaper	Dan Snyder
G	Jun 9 76	16 rolls wallpaper	Rudolf Giesy
F	Jul 8 76	1 gal. Averill Paint	G. Zigler
F	Jul 10 76	2 cans paint	M. Bachert
F	Jul 12 76	5 cans paint	Bach
G	Aug 26 76	1 box colors	Ulbrand
F	Sep 4 76	2 gal. O W O Paint	-
F	Sep 27 76	1 can paint	Wm. Mill
F	Oct 24 76	4 pks. paint	H. Kraus to/of Sachs
F	Nov 15 76	2 cases	-
F	Nov 16 76	1 case paint	S. Seiz
F	Jan 15 77	1 case paint, busted	-
K	Jun 28 77	1 can paint	Kocher Family
F	Jul 5 77	3 boxes paint	S. Smith
J	Sep 6 77	50# white lead	-
J	Sep 6 77	1 paint brush	-
J	Jun 27 78	25# white lead	Hildlson (cr.)
K	Oct 16 78	3 rolls wallpaper	Samuel Miller
I	Oct 30 79	colors #14	-

TABLE 1. Continued

bk	date	item	customer
L	Feb 26 81	5 rolls wallpaper	John Wolfer
L	Mar 21 81	5 gal. paint	Lawrence Ehlen
I	Apr 1 81	1 white wash brush	-
L	May 21 81	5 gal. "Rub" paint	Lawrence Ehlen
L	Jun 7 81	1 white wash brush	Thomas Brady
L	Jun 30 81	1 tin white lead	Lawrence Ehlen
L	Jul 10 81	100# white lead	Link Family
L	Jul 10 81	10 gal. oil	Link Family
L	Jul 10 81	1 paint brush	Link Family
I	Aug 1 81	100# white lead	Burkholder
I	Aug 1 81	5 gal. raw oil	Burkholder
I	Aug 1 81	3 in. paint brush	Burkholder
I	Aug 1 81	5 gal. D. F. oil	W. Ehlen
L	Sep 2 81	100# white lead	Burkholder Family
L	Sep 2 81	4 gal. raw oil	Burkholder Family
L	Oct 14 81	1 can oil	George Kraus
L	Oct 14 81	3 rolls wallpaper	George Kraus
L	Oct 18 81	1 white wash brush	George Will
L	Oct 18 81	bbl. lime	George Will
L	Oct 24 81	1 can boiled oil	George Smith
L	Oct 24 81	5 gal. boiled oil	Burkholder Family
I	Dec 81	1 can raw linseed oil	-
I	Dec 81	1 bkt Pioneer Wh Lead	-

Prussian blue pigment according to contemporary recipes. References to blue vitriol, vitriol (which can be blue, green, white, or red), and copperas (which is sulfate of iron or green vitriol but, as a term, was synonomous with vitriol of all shades) were extremely common. Numerous entries were also found for potash, sulphur, and alum, all of which could be used in the manufacture of the pigment. It would be easy to conclude from this that, in these early years, the Colonists were indeed making their own pigment.

Several considerations have to be taken into account, however. First of all, these ingredients each have a large number of other uses. Blue vitriol (cupric sulfate) can also be used as an agricultural fungicide, algicide, bactericide and herbicide; a food or fertilizer additive; a mordant in textile dyeing; a leather preservative; a wood preservative; and a topical antifungal agent. In fact, a frequent purchaser in Aurora was David Wagner, a saddler. Copperas (ferrous sulfate) has many of the same uses including that of a leather dye. Alum, in addition to its use in the manufacture of Prussian blue, can also be used for tanning leather, as a mordant in dyeing, for hardening gelatin, for baking, and for purifying water.[6] Furthermore, even if the Colonists manufactured the pigment, they would have needed linseed oil and white lead to make it into paint. These items were not being sold, nor were brushes to apply it.

Before 1872, all the structures were owned by the Colony, not by individuals. The Colony may, therefore, have painted the houses with paint not recorded in the accounts. It is also possible, even if the houses were not painted until they passed to the individual owners, that these items were being supplied free of charge to the Colony members and were not, therefore, passing through the account books. Likewise, these supplies may have been purchased out of the area or at stores for which the accounts are not available. A fourth consideration is that the houses in Aurora were not painted at all in these years. Nordoff, in 1874, states that the people dressed in a drab way and that the Colony had a shabby appearance.[7] He specifically mentions the lack of curbing and loose animals as contributing to this and says nothing of color. But, it could be that the exterior of the houses were not painted at this time, and if they were not, the interiors may not have been painted either. While it does not seem like a likely explanation, and there are other indications to the contrary, it cannot be discarded as a possibility.

We can, therefore, speculate that if blue color was applied to the structures prior to 1876, the pigment was very likely manufactured in the Colony and mixed with paint materials supplied by the Colony or purchased elsewhere. It can be said with some certainty, however, that after 1876, commercially produced paint was used in Aurora, though this may have been mixed with the colorant by hand.

Notes

[1]Charles Nordoff, Communistic Societies in the United States (New York: Dover Publications, 1955 reprint ed., Harper and Brothers, 1875), p. 220.

[2]According to the titles and contents of the account books in the possession of the Aurora Historical Society, it appears that William Keil and Co. operated a store which catered exclusively to Colony members. The accounts for this store were kept by William's son, Frederick Keil, who apparently operated the store on his own after his father's death in Dec. 1877. A book, commencing in 1872, was kept for Wolf(f), Keil and Co., but on October 29, 1875 the company name suddenly changes to Wm. Keil and Co. Several books indicate Frederick Keil also ran a store, at least at one point, in conjunction with Frederick Giesy. One title page reads "F. Keil's Co....F. Giesy in [sic.] Co. with the same firm." The book records transactions beginning in 1863. At the dissolution (beginning Aug. 1, 1881) the book being kept was turned over to "F. Giesy". The accounts in the books of these companies (above mentioned) were kept for individuals, families or businesses--such as the Hotel and the restaurant--with each account on a separate page. Frederick Giesy may also have been the owner of the store for which records were kept exclusively by date and served non-members of the Colony as well as Colony members.

[3]The entry was in one of the, apparently, Giesy Store account books which served outsiders as well as Colony members.

[4]In account book for Wolf(f), Keil and Co./Wm. Keil and Co. See data base print out.

[5]William Seale, Recreating the Historic House Interior (Nashville: American Association for State and Local History, 1979), p. 35.

[6]The Merck Index, 10th ed. Marthat Windhoz, et. al, ed., (Rahway, N. J.: Merck and Co., Inc., 1983).

[7]Nordoff, p. 222.

CHAPTER V

PAINT ANALYSIS

Accurate paint restoration consists of three phases:

1. The original paint layer, or that to which the restoration will return, must be established
2. The layer must be tested and interpreted to ascertain its actual original color
3. The color, having been determined and corrected, must be matched

Each of these phases may consist of several steps.

The goals of this project were to identify a pigment, establish the elements on which it was used, notate its color range, and match some of the hues. The data collected within the various phases is of three kinds: documentary research, field and laboratory observation, and laboratory testing.

Generally, to determine the first or desired layer, cratering and/or scraping may be carried out. Cratering consists of using a surgical scalpel[1] to scoop out a shallow, dish-shaped "crater" through the paint layers and into the substrate. The crater is sanded using successively finer grit paper and mineral oil to expose and widen the layers, which can then be examined with a hand lens to establish the number and colors of the layers of paint. This was done on the baseboard from the Becke house. Scraping is used to expose greater areas of color and has the advantage of showing the surface character of the paint. It helps in identifying graining and marblizing and is recommended by ICCROM (International Center for Conservation, Rome). However, to determine the color of the first or second layer only, the removal of a small chip of paint may be all that is needed, and such proved to be the case in this project. This method was chosen as appropriate to the nature of the structures studied since they had already been restored or renovated and the defacing which would result from cratering or scraping would have been unacceptable.

Based on the background research, it was hypothesized that the pigment used was Prussian blue. Since this pigment fades when mixed with water and loses its color--turns brown--when applied to plaster, the examination was restricted to wooden architectural elements including door and window trim, mantlepieces, wainscoting, chairs rails, and baseboards, built-in cupboards, shelves, peg boards, and some free-standing pieces of furniture.

Field and Laboratory Methodology

Field observation served to locate the blue color and identify objects to sample. Microscopic examination in the laboratory then established with certainty the presence or absence of blue pigment.

After a visual examination of the architectural elements, samples were taken from those on which a blue color was found, suspected, or thought to have been present at some time. Areas where the paint had already been chipped, as a result of use, often clearly revealed the presence or absence of blue paint in early layers. Eighty-seven samples in all were extracted with a scalpel from inconspicuous areas that would yield maximum information. Corners and the junctures of molding and wall are places where the best samples are often found because paint accumulates in these areas, and they may harbor remnants if paint removal has been undertaken in the past. The samples were collected in coin envelopes which were marked with the house, the room, the element and the location on the element from which the sample was taken. Equipment used for extracting samples is shown in figure 8.

Charts were prepared indicating the architectural elements sampled; whether blue was found; if not, what color was found; and whether the element appeared to have been stripped and refinished (see Appendix C). The purpose of the charting was to assure that all the elements on which blue might be found were examined in every room and to establish which elements were commonly, or ever, painted blue. This was done in response to the hypothesis that "Aurora Blue" was regularly used on certain elements of building interiors. The major limitation to determining this was, again, the fact that the buildings had been restored or renovated and some of the elements had been stripped or replaced with new pieces.

The information from the charts and the results of the laboratory examination were transferred to a computer data base to aid in their interpretation. Twenty-eight of the eighty-seven samples revealed blue color. With the exception of baseboards, the architectural elements

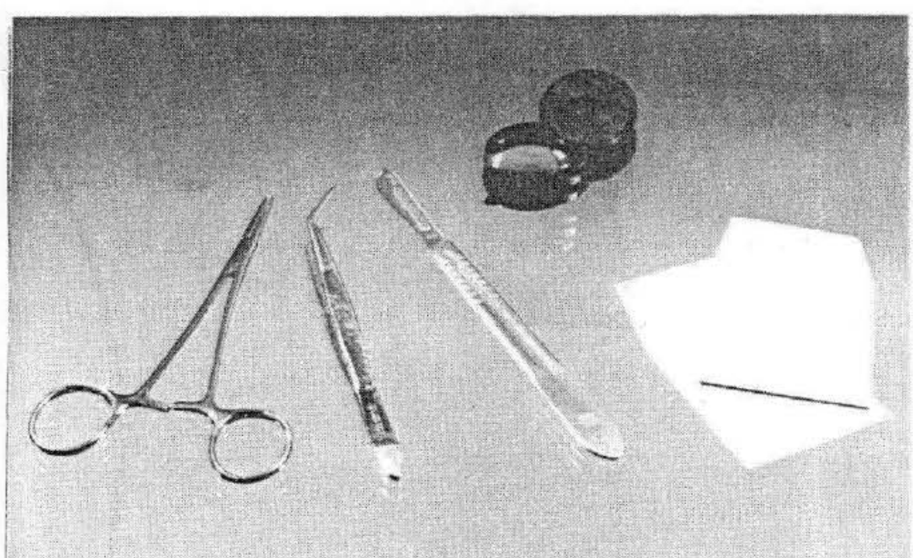


Figure 8. Equipment used for sample extraction.

originally selected for painting blue were unique to each house sampled. Blue paint was found on the baseboards of the Giesy-Kraus, Giesy, Keil, and Becke houses. The Giesy-Kraus house had blue paint on the chair rails in the kitchen, parlor, upstairs hall, and north bedroom; the peg board in the kitchen; the fireplace surround and mantlepiece; and the stair and stair railing. Other locations where the color was found include a post on the second floor of the Colony Store, the wainscot in the south bedroom of the Keil house and a parlor wall in the Giesy house. All other examples were found on furniture pieces.[2] While doors and door and window trims appear to have always been painted in these houses, no blue paint was found on any of these elements. Likewise, the floors, which were also often painted, revealed no blue color (see Appendix D).

When collecting samples for dating purposes--establishing a chromochronology--it is necessary to extract some of the substrate to assure that the very earliest layer is included. While dating was not a goal of this project, it was, nonetheless, important to include the wood substrate in the samples to determine whether or not a primer was used. Also, because the first coat of paint penetrates the surface of the wood, the substrate might reveal remnants of pigment embedded in the wood even if the original paint had been stripped or scraped off. This proved to be the case.

The North Atlantic Historic Preservation Center researchers mount their paint chips in microcrystalline wax in petri dishes to do the preliminary examination and for permanent storage. They consider quantity important because only by examining many samples can aberrations in the painting processes and/or specialized painting procedures, such as graining, be accounted for through a microscope.[3] The samples most complete in revealing the chromochronology are then, sometimes, made into cross-section slides. Since, chromochronology was not a major consideration, the NAHPC procedure was not explicitly followed. In the interest of avoiding defacement, very small chips were extracted which made them difficult to mount. It was found that by emptying the envelopes onto the microscope platform and manipulating the bits with a craft knife and tweezers the early layers could be observed, undercoats and glaze coats determined, and the blue layers isolated and matched. Often the matching was performed on a small clump of pigment which was barely visible to the naked eye.

Polyester resin cross-section slides were made of a few samples in which the layering was either unclear or exemplary. The former were then re-examined; the latter used for photographing and as permanent records. There are a number of variations on this process, but the basic procedure is essentially the same wherever it is used.[4] In this study, a layer of the resin (mixed with hardener) was poured into each compartment of an ice cube tray. After it dried, the paint chips were set into the compartments. The location of each chip in the tray was noted, by number, on a chart. A second layer of resin was then poured over the top.[5] An easier variation of this (learned after the fact) is to simply write the sample number on the dried resin with a waterproof marking pen before pouring on the second layer, producing a permanent, integrated identification.[6] The dried "cubes" were then removed from the tray and cut in a small mitre box at an angle that revealed and widened the layers. 220 grit open coat and 600 grit sandpaper were used in succession to smooth and level the surface. The slides were then polished to clarity by rubbing them on a thick leather pad covered with an auto polishing compound.[7] (This equipment is shown in figure 9.) These slides succeeded in revealing information--such as the presence of a glaze layer--which was not apparent using the other procedures (see plate 2).

Cratering and scraping done on the baseboard from the Becke house had revealed a dark layer that appeared to be glaze. Preliminary microscopy of the paint chips taken from the board had failed to conclusively confirm this. The cross-section slide made the layer show up much more clearly. The darkness of the layer, however, left some doubt as to its nature. Additional microscopy of slides of

Figure 9. Equipment used for making cross-section slides.

Plate 2. Cross-section of paint chip from fireplace of Giesy-Kraus house.

samples from the board made at the paint analysis laboratory at Columbia University subsequently confirmed that this layer was indeed glaze which had severely darkened as a result of overpainting.[8] The original cross-section slide of this sample also confirmed the presence of a white undercoat below the blue layer as can be seen in plate 3.

Plate 3. Cross-section of paint chip from baseboard of Becke house.

Glazes and/or undercoats were found in additional samples as well. Samples number 4, 11, 12, 40, and 41 from the Giesy-Kraus house and sample number 66 from the Giesy house were covered with clear glazes which had yellowed to varying extents. In numbers 12, 41, and 66 the layering was somewhat indistinct. This could indicate that the layer was not actually a glaze but the result of migration of the oil in the finish coat to the paint surface. (For a further discussion of this, see Chapter VI.) Undercoats were primarily of three colors: white, gray and brown. In addition to that on the Becke house baseboard, mentioned above, white was found in samples from the Giesy-Kraus house and the Giesy house. Brown and gray were found only in the Giesy-Kraus house.[9] Thus, the hypothesis that glazes and undercoats may have been used was proven to be true. (A discussion of the effects of glazes on paint color and a data base print-out of the findings can be found in Chapter VI.)

Chemical Tests

Chemical tests were carried out at the chemistry department of Oregon State University with the help of graduate student Leonard Schussel. The purpose of chemical testing is to use chemical reactions to produce color typical of certain compounds. The limitation is that it will verify the presence only of that pigment or substance which has been tested for and cannot indicate whether, or what, other substances might also be present. The procedures followed were basically those described by Joyce Plesters.[10] Suspecting Prussian blue, which is ferric ferrocyanide ($Fe_4[Fe(CN)_6]_3$), selected samples were tested for iron. Samples tested were numbers 3, 9, 11, 22, from the Kraus house; 67, from the Giesy house; and 83, from a trunk in the Steinbach Log Cabin. The first step is to get the pigment compound to go into solution. Plesters uses 4N NaOH and dissolves the precipitate of ferric hydroxide in HCl. These tests used .5 milliliters of .2 molar HNO_3 (nitric acid) which produced a yellow precipitate. Two to three drops of Br_2 aqueous (bromine and water) were then added to change Fe^{++} to Fe^{+++} and to hold the yellow color of the precipitate produced by the nitric acid. (It was found that the samples had to be mashed up in the nitric acid and stirred into the bromine to get enough in solution for the tests to work.) KSCN (potassium thiocyanate) was then added (2 ml. of .6 molar solution) to produce the characteristic red (or pink) color of the iron complex $Fe(SCN)_3$. This confirms the presence of Fe^{+++} which proves the pigment to be Prussian blue.

Sample number 3 was tested in the first lab session, then re-tested in the second to confirm the iron found the first time. Having proved the test, the remaining samples were tested, as was a blank test tube for a control. Samples 11, 67, and 83 gave the darkest red color. Sample 22 was darker than either 3 or 9 which were both light pink. Numbers 11, 22, 67, and 83 all had a value of "6" in the Munsell Color Notation System while 3 and 9 had a value of "4". (A thorough explanation of the Munsell Color Notation System is given in Chapter VI.) Thus, the darker color could result from the higher concentration of blue pigment in the paint color. It could also result, however, from some chips providing larger sample of paint irrespective of the concentration.

Subsequent tests were done on samples number 76, from the Keil house; 41, from the Giesy-Kraus house; and 66 and 67, from the Giesy house using a test which capitalizes on a quality of the pigment itself. As stated in the historical literature, Prussian blue loses its color and turns brownish when used with an alkali (base). It can, therefore, also be tested for by applying a base to the sample which turns it brown, then applying an acid which restores the blue color. This test was performed on the samples using .1 molar NaOH (sodium hydroxide) as the base and .6 molar HCl (hydrochloric acid) as the acid. Samples 66 and 67 consisted of very small particles which necessitated putting them into the solution. The change to brownish was discernable but the restoration of the blue was not. The other samples (76 and 41) were larger pieces and both parts of the test were clearly evident and positive.

Additional grains of the same samples originally tested were also tested for the presence of lead in order to determine if white lead was used as the vehicle for lightening the Prussian blue pigment. Again, Plesters was the source for the test. The first attempt proved inconclusive so a second series using larger samples was run. This series included a known lead sample and a blank test tube. The samples were first dissolved in nitric acid.

HCl and KI (potassium iodide) were then added to produce a yellow precipitate which became apparent only after the samples were left to sit for several minutes. Plesters' test calls for one drop of dilute HCl and one drop of KI, but it was found that the proportions depended upon the dilution of the HCl since considerably more KI is needed than HCl to produce the yellow preciptate indicator. Following Plesters, after the formation of the precipitate, the samples are heated to recrystallize it into golden "spangles". These tests required super-cooling after the heating to produce a clearly discernable yellow color with "spangles." Only samples 3 and 22 clearly indicated the presence of lead, 22 producing a very strong yellow.

Also carried out at the Oregon State University laboratory was a test to determine the medium. Dimethylformanide (DMF) was applied to the paint on a board from the Becke house. The soft texture produced confirmed that oil had been used as the vehicle. This test was also attempted on a small sample under the microscope but it was not possible, in this circumstance, to discern a texture change.

These tests, then, confirmed the hypothesis that "Aurora Blue" is an identifiable pigment, and further, that the blue produced in Aurora was Prussian blue pigment mixed with white lead in an oil base. No other pigments particles were observed during the microscopic examination of the samples so none others were tested for. If any other pigments or substances were used in the paint, chemical testing for individual elements could not determine it unless tests for the particular, suspected elements were also conducted. This limitation of chemical testing can be overcome by resorting to more sophisticated methods such as x-ray techniques or laser microspectral analysis. Polarized light microscopy, which is based upon the color of the crystals when a polarizing filter is placed above the microscope objective, is a somewhat more available technique and is the one used by the researchers at the North Atlantic Historic Preservation Center. The absence of other observable pigments, however, make their presence unlikely.

Notes

[1]This scalpel may be purchased from a surgical supply outlet. A number of differently shaped blades are available. #20 makes a good choice. Forceps should be used to insert and remove the blades as they are extremely sharp. A craft knife is sometimes used instead but the researcher found that it was not sharp enough for sample extraction procedures and tended to break up the layers.

[2]The furniture was not systematically sampled. Rather, samples were taken only from pieces on which blue paint could be seen. The purpose, in this case, was to determine if the same pigment was used and to note color. Defacement is an even greater issue in dealing with furniture than with architectural elements.

[3]Carole L. Perrault, "Techniques employed at the North Atlantic Historic Preservation Center for the sampling and analysis of historic architectural paints and finishes," Bulletin of the Association for Preservation Technology, vol. X, no. 2 (1978). p. 15.

[4]A variation discussed by Nicholas Petraco and Frances Gale, "A Rapid Method for Cross-sectioning of Multilayered Paint Chips," reprint from Journal of Forensic Science (April 1984): 597-600. Josephine Darrah, conservator, Victoria and Albert Museum, London, discussed another variation in an interview January 11, 1985.

[5]It does not work to drop the chips onto the wet resin of the first layer as they sink to the center bottom and, later, cannot be accessed easily by sanding. Waiting until the resin sets slightly, and dropping the chips onto it does not work either because the chip does not adhere well enough and will come off.

[6]Devised by Morgan Phillips August 14, 1985.

[7]These can be glued to glass or plastic slides or slide covers, if desired, to facilitate labeling.

[8]Slides were made and analyzed by Frances Gale of Columbia University. Frank Matero, also of Columbia University confirmed the analysis.

[9] Three of the gray examples were on the fireplace surround and mantlepiece and could be a carbon deposit rather than an undercoat. However, a gray undercoat was also located by the stair in the kitchen.

[10] Joyce Plesters, "Cross-sections and Chemical Analysis of Paint Samples," Studies in Conservation 2 (1956): 137, 143, 152.

CHAPTER VI

COLOR ANALYSIS

Color Matching

Three methods of color matching were attempted in this study:

1. Visual matching of samples to Munsell Color Notation System chips
2. Spectrophotometric matching
3. Mixing of pigment to reproduce visual and spectrophotometric matches

A phenomenon which has been observed by this investigator, as well as several others,[1] should be noted at this point. It appears (in a number of samples) that, as the coats of paint dried, some of the linseed oil migrated to the surface. Since linseed oil yellows or darkens when placed in darkness, this migration of oil to the surface can seriously distort the color of the top portion of paint coats which have been glazed or overpainted (and thus, placed in the dark). It creates a gradation of color, with the greatest concentration of pigment near the bottom of the layer and the intensity lessening at the top (see figure 10). The amount (or degree) of yellowing or darkening depends upon the length of time the paint layer is exposed to light before being overpainted. The longer it is exposed, the less it seems to darken.[2] This problem is exacerbated by contemporary painting theory which held that successive coats of paint should increase in elasticity, which is accomplished by the addition of oil.[3] The linseed oil in the new coat may penetrate the previous layer and cause further darkening in the top part of that layer. Thin layers may be penetrated to a large percentage of their depth.[4] It is, therefore, important to match color to that portion of the layer nearest the bottom. Phillips suggests that paint samples be taken at thick lumps caused by drips and junctures with woodwork. In these areas a larger quantity of pigment can be found which contains a minimum of oil while having been protected from fading.[5] Before matching, the sample is exposed to ultraviolet light

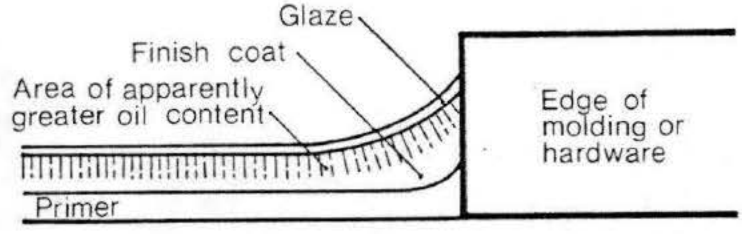


Figure 10. Cross-section of paint layers near juncture of molding or hardware showing thickening which can occur in these areas. (After Morgan Phillips)

(or, in the case of Prussian blue, visible blue or violet light) to bleach the darkened oil back to its original transparency.

The first matching to be done was visual. The Munsell Color Notation System was used for this purpose. It should be noted here, that the vocabulary used to describe color characteristics in this study is that used by A. H. Munsell. It has been chosen for this purpose because it is clear, definitive and generally accepted; and because the Munsell Color Notation System is based upon it. The terms used by Munsell to designate the three qualities of color are <u>hue</u>, <u>value</u> and <u>chroma</u>.

> HUE is the name of a color. [It] is the quality by which we distinguish one color from another, as a red from a yellow, a green, a blue, or a purple. (This names the hue, but does not tell whether it is light or dark, weak or strong,...)
> VALUE is the light of a color. [It] is the quality by which we distinguish a light color from a dark one. (Color values are loosely called tints and shades, but the terms are frequently misapplied.)
> CHROMA is the strength of a color. [It] is the quality by which we distinguish a strong color from a weak one.[6]

In the Color Notation System, these three qualities are utilized for notation. Each hue is divided into four numerical categories as it moves from the preceeding hue to the succeeding one. The categories are: 2.5, 5, 7.5, 10. There are ten hues, red, yellow, green, blue, purple and the combinations yellow-red, green-yellow, blue-green, purple-blue, and red-purple. In notating a color, the hue is expressed with the number followed by the initial(s) of the hue. Thus, 2.5 B denotes a blue hue which is close to blue-green, 10 BG. Value and chroma are expressed as numbers in the form of a fraction (value/chroma). Value is represented in both odd and even numbers with 2 indicating the darkest value (that closest to black) and 9 the lightest (that closest to white). In the Munsell Book of Color which provides this standard for color notation, chroma samples are provided only for even numbers with 2 indicating the weakest chroma (that farthest from pure hue). By way of example, the strongest 2.5 blue sample in the book is expressed 2.5 B 5/10.

The (unbleached) paint samples containing blue hues were matched to Munsell chips and the colors notated. As far as possible, matches were made to pigment near the bottom of the layer of paint where the color was least altered by time.

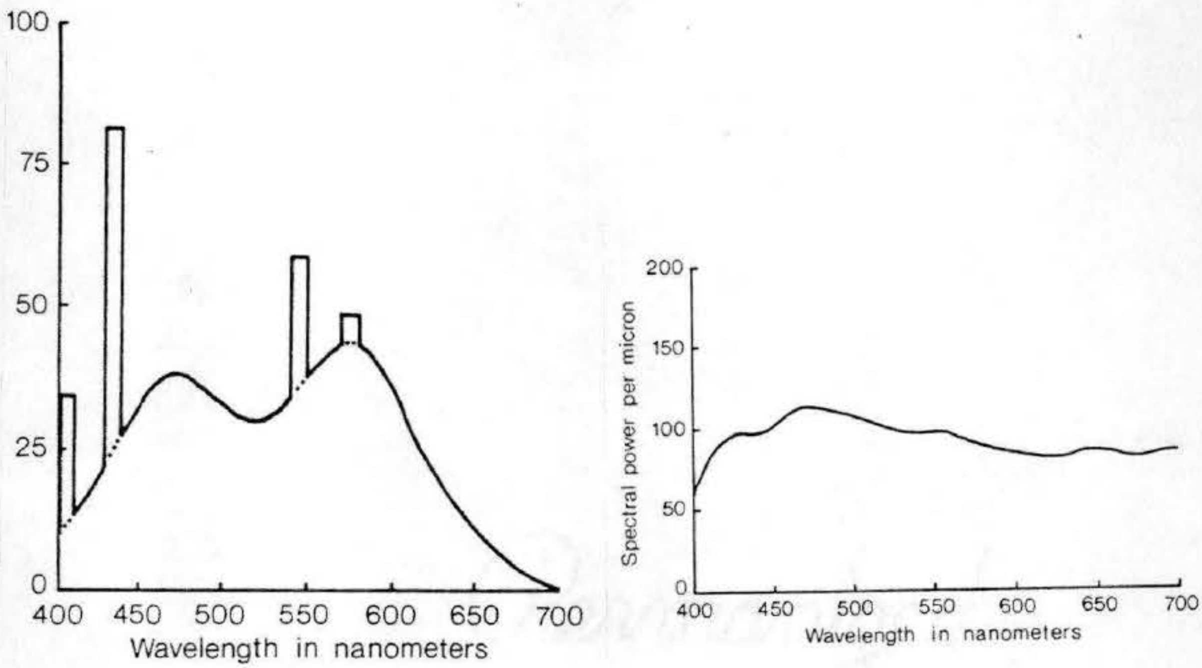
Probably the greatest difficulty in matching the samples to the color chips resulted from the fact that the pigment in the samples was varied and lively, even within a microscopic piece (as can be seen in plate 4), while the color in the Munsell chips was very even and flat. This problem extends to the reproduction of paint colors using modern products to substitute for historic paints. The liveliness in old paint results from hand grinding and mixing of pigments and from historic application techniques.

Modern, commercial paints, carefully formulated and machine mixed to assure even color and application, cannot possibly simulate this quality. Reproduction colors, manufactured in this way, may actually appear quite different, and the overall effect in a room most surely will.

Plate 4. Photomicroscopy of paint chip from mantle of Giesy-Kraus house showing liveliness of paint.

The light source under which a color is viewed influences its appearance. A phenomenon in which this is exemplified is metamerism. The colors in metameric pairs match under one type of light (such as incandescent, fluorescent, or daylight), but, because they actually have a different spectral reflectance curve, do not match under another lighting condition.[7] Non-metameric matches have the same spectral curve and, consequently, change equally under different light sources. It is therefore important to consider the appropriate light source to be used for color matching and to note the light chosen.

Many investigators use a double-armed, fiber optic lamp for their microscope work, including color matching, because of its ability to focus reflected light directly on the subject. This lamp uses a quartz iodide source which has a good tungsten balance and produces a very white light. Its limitation is that as a tungsten light, it is on the red end of the spectrum. A blue filter is, therefore, introduced somewhere between the light source and the object, which effectively corrects the color of the light by flattening out the spectral curve towards the red end of the spectrum and creating a curve that more closely approximates daylight. Full spectrum fluorescent lamps are now available that render extremely true color, but since even daylight is not really full spectrum, the color is not as the human eye would actually percieve it under any usual circumstances. The National Gallery in London uses a small, daylight fluorescent-tube microscope lamp for color matching under low magnification.[8] Since artificial illumination in historic rooms would have been candles, kerosene or gas lighting, which cannot be reproduced electrically, it was decided, at least in the initial matching, to use a daylight fluorescent-tube to try to simulate the natural quality of the daylight conditions under which the color would have been seen on an overcast (western Oregon) day (see figure 11).



Daylight Fluorescent

Overcast Day

Figure 11. Comparative spectral distribution of fluorescent light source and overcast day.

A second round of color matching was then carried out using a fiber optic lamp with a blue filter. This was done to test the metamerism of the matched pairs. In seventeen of the twenty-seven cases, exactly the same matches were produced indicating the paint samples and the Munsell chips were non-metameric pairs.[9] The cases in which a difference was observed under this light source varied by only one step of either hue, value or chroma. It is possible, at least in some cases, that the difference could have resulted from matching to a portion of the pigment which contained a greater or smaller amount of oil than in the previous round. An example of a metameric pair is shown in plate 5.

The value of discovering whether or not the matches are metameric lies in understanding how to reproduce the color on the walls of a room. To ascertain the accuracy of the color of a batch of mixed paint in a metameric pair, the matching must be done under exactly the same lighting conditions as those under which it was originally matched. With a non-metameric pair, any lighting conditions will produce accurate results.

A. 10 B 4/6 B. 2.5 PB 4/6

Plate 5. Munsell Color chips of metameric matches to paint sample from fireplace of Giesy-Kraus house. A. Fluorescent light. B. Tungsten (fiber optic) light.

A further caveat on this subject involves the related phenomenon of observer metamerism, in which different individuals have differing color perception even with the same illumination. This makes it important that the same observer be involved in all the matching decisions.

Visual Characteristics of Prussian Blue in Aurora

Twenty-one different blue hues were identified in twenty-eight paint samples ranging from 10 BG to 2.5 PB. (10 BG, 2.5 B, 5 B, 7.5 B, 10 B, 2.5 PB) Values ranged from 7 to 3 and chromas ran a range from 10 to 2 (see Table 2).

The most frequently identified hue was 2.5 PB which was found in three different locations: the Giesy-Kraus house (1870), the Colony store (1870), and on trunks from the Fry estate, but in differing values and chromas. 2.5 PB 4/6 and 2.5 PB 3/6 (adjacencies in the Color Notation System) were found in both the Giesy-Kraus house and on the Fry trunks. Only two other colors were found in more than one house. 7.5 B 6/6 was found on the baseboards of both the Giesy and Keil houses, and 2.5 B 5/4 was found on a cupboard in the Ox Barn as well as on the baseboard from the Becke house. While this would seem to indicate that the color variation was due to differences in the mixing of new batches, it was greater than that which could be accounted for in this way.

The difference between the blues in one house and those in another is readily perceivable to the naked eye; the

TABLE 2. Data base print-out showing location and color notation of samples containing blue under two different light sources.

#	house	room	element	fluorescent	fiber optic
87	Becke		baseboard	2.5B 5/4-5B 5/4	2.5B 5/4-5B 5/4
51	Colony St.	back rm.	fireplace surr.	10BG 5/2	
50	Colony St.	back rm.	fireplace surr.	10BG 5/2	
56	Colony St.	upstairs	outside window	2.5PB 5/10	2.5PB 5/10
66	Giesy	upst. hall	baseboard	2.5B 6/4	2.5B 6/4
67	Giesy	upst. hall	baseboard	7.5B 6/6	
69	Giesy	family rm.	wall	10BG 7/4	10BG 6/2-6/4
75	Keil	n. bed.	baseboard	7.5B 6/6-7.5B 6/4	5B 6/4
76	Keil	s. bed.	wainscot	10B 6/6	10B 6/6
77	Keil	s. bed.	wainscot	10B 6/6	10B 6/6
34	G-Kraus	upst. hall	baseboard	5B 4/8-5B 3/8	
40	G-Kraus	upst. hall	chair rail	2.5PB 3/6	2.5PB 3/6
4	G-Kraus	kitchen	chair rail	2.5PB 4/6	10B 4/6
12	G-Kraus	parlor	chair rail	2.5PB 4/6	10B 4/6-2.5P4/6

TABLE 2. continued

#	house	room	element	fluorescent	fiber optic
41	G-Kraus	n. bed.	chair rail	2.5PB 4/6	2.5PB 4/6
25	G-Kraus	kitchen	chair rail	2.5PB 4/8	10B 4/6-2.5P4/8
9	G-Kraus	kitchen	chair rail	5B 3/4	5B 3/4
18	G-Kraus	parlor	fireplace surr.	2.5PB 4/6	2.5PB 4/6
14	G-Kraus	parlor	fireplace surr.	7.5B 4/6	7.5B 4/6
11	G-Kraus	parlor	mantlepiece	2.5PB 4/6	10B 4/6
22	G-Kraus	parlor	mantlepiece	2.5PB 4/6	10B 4/6
3	G-Kraus	kitchen	peg board	5PB 3/4	2.5PB 3/4
2	G-Kraus	kitchen	stair	2.5PB 4/8	2.5PB 4/8
33	G-Kraus	upst. hall	stair rail	7.5 B 4/6	5B 4/6
81	Ox Barn	main	cupboard	2.5B 5/4	2.5B 4/4
84	Steinbach		Fry trunk	5PB 3/6	2.5PB 3/6
85	Steinbach		Fry trunk	2.5PB 3/6	5PB 3/6
83	Steinbach	bedroom	trunk	2.5PB 4/6	10B 4/6

variation of the blues within any single structure is not so perceivable. This can be seen in plate 6. Differences in manufacture probably account for some variation in the hues, but the value and chroma differences would have been a function of the amount of pigment mixed with the white lead filler--the degree to which the pigment was diluted with white. The slight deviations within each structure were probably the result of hand mixing the pigment into a commercially produced white base. Pre-mixed paint would have been more consistent in color. From structure to structure, however, these differences were far greater than the normal variations which hand mixing could be expected to produce. It can be surmised, therefore, that personal taste was a major factor in creating this wide range of blues.

The third hypothesis states that the pigment was consistent even though the difference in mixing created visual variation within a small spectral range in hue, value and chroma. While the pigment was found to be consistent, the color varied within a much greater range than expected.

The visual appearance of the paint was also influenced by the use, or lack of use, of undercoats and glazes. As has been mentioned, undercoats were used in several examples, especially in the Giesy-Kraus house. It is difficult to assess the difference in visual impact since the paint has been overpainted in most instances.

A. 2.5 PB 3/4 B. 2.5 PB 5/10 C. 7.5 B 6/6

Plate 6. A. and B. Munsell Color chips of blue found in kitchen of Giesy-Kraus house. A. Chair rail. B. Peg board. C. Blue of baseboard of Giesy house.

However, comparing the Giesy baseboard, which is undercoated and has not been overpainted, with furniture pieces still exhibiting only the original layer(s), without undercoats, the undercoated paint is less transparent in quality, whereas the transparency on some of the trunks, for instance, actually allows the grain of the wood to show through. Glazes which, in Aurora, contained no pigment, added to the glossiness of the surface and served to protect it. Table 3 lists the glazes and undercoats found.

Bleaching of Paint Chips

The purpose of bleaching paint samples is to reverse the yellowing of the linseed oil caused, over time, by the paint layer having been overpainted and, thereby, placed in darkness. The procedure is usually done using a near-ultraviolet light source. There is, however, the

TABLE 3. Data base print-out of glazed and undercoated elements.

#	house	element	fluor.	glazed	undercoat
87	Becke	baseboard	2.5B 5/4-5B	very darkened with time	white
66	Giesy	baseboard	2.5 B 6/4	greener than 10 BG 5/2	white
67	Giesy	baseboard	7.5 B 6/6	undetermined	white
2	G-Kraus	stair	2.5 PB 4/8		gray
4	G-Kraus	chair rail	2.5 PB 4/6	10 BG 3/6	salmon
11	G-Kraus	mantlepiece	2.5 PB 4/6	10 BG 3/4	gray
12	G-Kraus	chair rail	2.5 PB 4/6	2.5 B 4/2	brownish
14	G-Kraus	fireplace	7.5 B 4/6		gray
18	G-Kraus	fireplace	2.5 PB 4/6		gray
22	G-Kraus	mantlepiece	2.5 PB 4/6		gray
33	G-Kraus	stair railing	7.5 B 4/6		white
40	G-Kraus	chair rail	2.5 PB 3/6	10 BG 3/4	brownish
41	G-Kraus	chair rail	2.5 PB 4/6	could be oil migration	brownish

problem of damage being caused to fugitive pigments in this process; so the length of time the sample can be exposed to the light is a matter requiring careful judgement which must be gained through experience. In the case of Prussian blue pigment, Phillips speculates that "visible blue or violet light might be better for bleaching than ultraviolet light. Visible light might affect the pigment less, since Prussian blue particles would probably reflect much of the visible blue light, whereas they would absorb much of the ultraviolet light."[10]

A cross-section slide of a chip from the Becke house baseboard revealed the presence of a layer of glaze. This, when painted over, had darkened. Early in the project, an area of the board had been scraped to this layer, exposing the glaze to daylight. After several months, adjacent portions were scraped. A difference in color between the two areas was immediately apparent; the daylight had bleached the linseed oil in the glaze (see plate 7). Both scraped areas of the board were then exposed to fluorescent (visible blue) light for thirty-six hours. After this time the color difference was barely perceptible--illustrating the effectiveness of the accelerated, visible blue light bleaching process. An extracted sliver of the board exposing an interior portion of the paint layer was also bleached with the fluorescent light. The Munsell notation before bleaching was 5 B 5/4 to 2.5 B 5/4. After exposure this changed to 7.5 B 5/4, a hue closer to purple than to green, indicating the reduction of yellow (see plate 8).

Bleaching, with fluorescent light, was carried out on ten additional samples representing each of the remaining structures or objects in the study. Numbers 18, from the fireplace surround in the parlor of the Giesy-Kraus house and 83, from a trunk in the Steinbach Log Cabin were exposed to the light for thirty-six hours. These samples showed no change in color. They were both 2.5 PB 4/6, which is a middle-value and a middle-chroma. The remaining eight samples (numbers 3, 12, and 40, Giesy-Kraus house; 50, Colony store; 69, Giesy house; 76, Keil house; 81 and 84, furniture pieces) were bleached for approximately seventy-two hours. Three of these (3, 12, 84), likewise, showed no change in color. In numbers 40, 69, and 76 a change was perceptible, but was so slight that it really did not constitute a full step in the Munsell Color Notation System. Samples number 50 and 81, however, exhibited a clear shift to the adjacent, more purple hue (see Table 4). In all five instances where some change was percieved, the shift was in hue but not in value or chroma. Where no hue shift took place, a low oil content in the paint or in the matched portion of the chip, would help explain the lack of change. If this is true, it testifies to the efficacy of matching to the lower portion of the paint layer.

Plate 7. Baseboard from Becke house before bleaching with visible blue (fluorescent) light.

A. 5 B 5/4 B. 7.5 B 5/4

Plate 8. Munsell Color chip matches to blue on baseboard from Becke house. A. Before bleaching. B. After bleaching.

TABLE 4. Data base print-out of bleached notations compared to unbleached notations under fluorescent light.

#	house	element	fluorescent	bleached
87	Becke	baseboard	2.5B 5/4-5B 5/4	7.5B 5/4
50	Colony St.	fireplace surr.	10BG 5/2	2.5B 5/2
69	Giesy	wall	10BG 7/4	2.5B 7/4
76	Keil	wainscot	10B 6/6	2.5PB 6/6
40	G-Kraus	chair rail	2.5PB 3/6	5PB 3/6
12	G-Kraus	chair rail	2.5PB 4/6	2.5PB 4/6
18	G-Kraus	fireplace surr.	2.5PB 4/6	2.5PB 4/6
3	G-Kraus	peg board	5PB 3/4	5PB 3/4
81	Ox Barn	cupboard	2.5B 5/4	5B 5/4
84	Steinbach	Fry trunk	5PB 3/6	5PB 3/6
83	Steinbach	trunk	2.5PB 4/6	2.5B 4/6

Color Mixing

Paint mixing was approached in two ways: using commercial artists' oil colors (Grumbacher and Windsor-Newton), and manufacturing dry Prussian blue pigment in the laboratory then mixing it with commercial artists' oil colors.

The baseboard of the Becke house provided the only sample large enough on which to run comparative spectral curves with a spectrophotometer. That blue (7.5 B 5/4) was, therefore, one of those selected for color duplication. The 7.5 B 5/4 Munsell color chip was used for matching during the mixing process rather than the paint on the board because the paint on the Munsell chip was more dense and even, and it was easier to hold it adjacent to the mixed paint. While an exact match was not obtained, a color which was extremely close was achieved by mixing Prussian Blue, Flake White (the only white pigment available which contained lead), Lamp Black and Yellow Ochre with purified artist's linseed oil.

Paint was also mixed in an attempt to duplicate 2.5 PB 4/6, a color found on several samples from the Giesy-Kraus house as well as on the trunk mentioned above. For this, Prussian Blue was again mixed with Flake White and Lamp Black but Alizarin Crimson was substituted for the Yellow

Ochre. Plate 9 shows the materials and pigments used to mix the duplications.

Plate 9. Mixing duplications of Aurora blues.

It is doubtful that the original painters added other pigments when mixing their colors in Aurora, and no others were observed through the microscope. The need to do so in these duplication attempts most likely results from the great variation in color that the manufacture of Prussian blue can produce, as attested to by the descriptions quoted in Chapter III. Since the surest way to get a non-metameric match is to use the original pigments, this characteristic of Prussian blue makes its reproduction for restoration work particularly difficult.

Using Gettens and Stout as a guide,[11] Prussian blue pigment was manufactured in the Oregon State University chemistry lab in which the chemical tests had been carried out. The process is described in the reference, but no amounts or proportions are given. It was, therefore, necessary to make educated guesses regarding how much of each reagent to use. Ferrous ammonium sulfate (copperas is ferrous sulphate) was mixed with potassium ferrocyanide and dissolved in water. This produced a light blue color. Potassium dichromate was then mixed with sulfuric acid, and that mixture was added to the first solution. The solution instantly turned a dark blue which matched the color spot on the tube of Grumbacher Prussian Blue. At this point, (just for "good measure") a bit more potassium dichromate was poured into the beaker and the color immediately became more purple. It was interesting to note the degree of change in the color when the additional potassium dichromate was poured in as this testifies to the ease with which the color of the pigment can be made to vary, corroborating the historical literature.

The solution was filtered (using a regular coffee filter) yielding a blue precipitate of a very fine grain (small particle size) as illustrated in plate 10. When this was dried and mixed with linseed oil and Grumbacher Flake White it, fortuitously, produced values of 2.5 PB--2.5 PB 3/4 and 2.5 PB 4/6 (see plate 11). However, this would probably be characterized by Maire as "quality No. 2...good

Plate 10. Prussian blue pigment
mixed in lab at Oregon State University.

Plate 11. Mixed duplications of Aurora blues; some using artists' oils; some using dry pigment mixed in lab.

for nothing...[having] a purplish or dirty blue-black tone" which no amount of doctoring up will help.[12]

Reflectance Spectrophotometry

A reflectance spectrophotometer is a device which plots the spectral curve of a colored sample by bouncing beams of monochromatic light of continuously variable wavelength off of a solid (white) standard (usually magnesium oxide, MgO) and a solid colored sample. While spectrophotometry can be used to actually identify pigments, it is most often used in architectural paint analysis to create a permanent record of the color.[13] The color cannot, however, be understood or duplicated using the curve. Rather, a color which has been mixed to match visually can be tested for accuracy and metamerism by comparing its spectral curve to that of the original sample. Metamerism is indicated each time the lines of the curves cross each other.

The opportunity to use spectrophotometry in this study was limited by the need for a sample large enough to use in the machine (the minimum size being about 1/4" x 1/8"). This could only be provided by the Becke house baseboard. Hence, it is the only example of an "Aurora Blue" for which this type of permanent record has been made.

The spectrophotometry was carried out at Oregon State University[14] on the sample, on the corresponding Munsell chip (7.5B 5/4), and on the mixed duplication. As can be seen on the chart in figure 12, the curve of the mixed duplication joins the curve of the sample and crosses the curve of the Munsell chip in two places, indicating metameric matches. However, as noted, these were not exact matches. The curves of the sample and the Munsell chip, on the other hand, are reasonably parallel and do not cross. These sympathetic curves indicate very similar colors, and the absence of crossings prove the non-metameric quality of the pair.

To carry out ideal paint restoration, a paint color should be mixed using original pigments to produce a spectrophotometric curve which indicates a good, non-metameric match. The original pigments, and hand mixing will, in addition, give the color the liveliness and vibrancy of the original. If the color must be reproduced using modern pigments, sophisticated, newly-developed equipment should be used which plots the spectrophotometric curve and calculates the formula needed to produce a non-metameric match.[15] In either case, the spectrophotometric curve serves not only to assure the match, but also provides a permanent record of the color which time cannot alter.

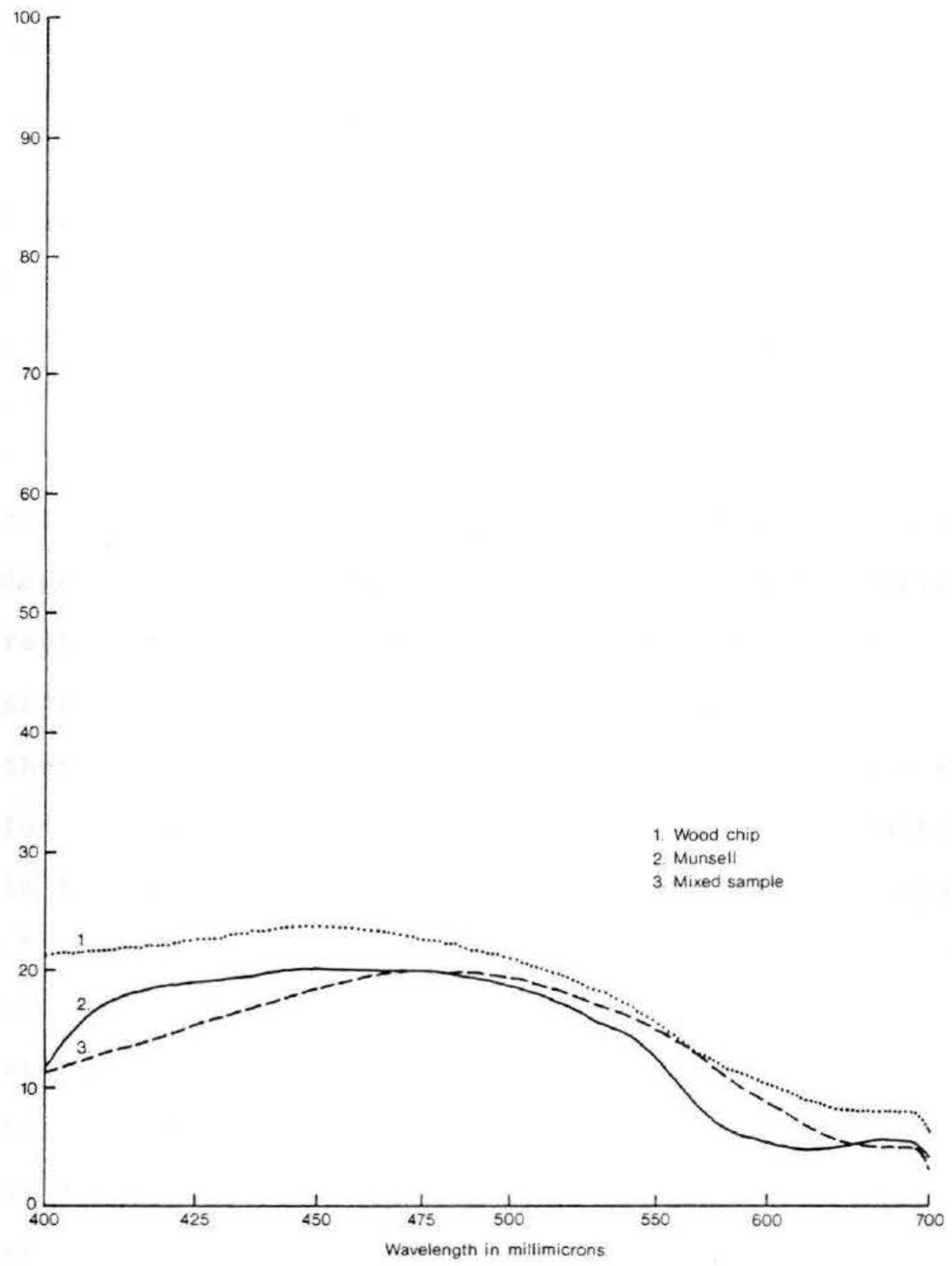


Figure 12. Spectrophotometric curves of blue paint from Becke house, corresponding Munsell color chip and mixed duplication of color.

Lighting in Historic Rooms

The foregoing discussions raise the problem of lighting in historic rooms in which paint colors have been carefully restored. Historic lighting was most likely candlelight, lamp oil, or gas. These fuels create an ambience significantly different from electricity. The result is that the carefully restored color actually looks considerably brighter than it did originally. What should be done to counteract this? Obviously, the ideal would be to restore the original lighting as well, but safety considerations disallow this solution in most cases. Furthermore, candlelight and oil lamps produced smoke which soiled and darkened historic paint colors. Light bulbs could be used which would simulate the historic ambience of the low level lighting, but generally they produce a light which is too even. Paint colors could be altered to counteract the bright and/or even quality of modern electric light, but this would necessitate historically inaccurate color and is therefore unacceptable. This is a subject, however, which needs to be considered when restoring an historic room as well as in analysis.

Notes

[1]Morgan W. Phillips, "Problems in the Restoration and Preservation of Old House Paints," in Preservation and Conservation: Principles and Practices (Washington, D. C.: The Preservation Press, 1976), p. 275.

[2]Morgan W. Phillips, "Discoloration of Old House Paints: Restoration of Paint Colors at the Harrison Gray Otis House, Boston," Bulletin of the Association for Preservation Technology 3 (no. 4, 1971): 40-47.

[3]Alvah Horton Sabin, House Painting (New York: John Wiley and Sons, Inc., 1929), pp. 25, 28.

[4]Phillips, "Discoloration of Old House Paints...," pp. 40-41.

[5]Phillips, "Problems in the Restoration and Preservation of Old House Paints...," p. 275.

[6]A. H. Munsell, A Color Notation (Baltimore: Munsell Color Company, 1926), pp. 18-19.

[7]Light and Color (Cleveland, Ohio: General Electric Company, Lighting Business Group, 1978), p. 18.

[8]Joyce Plesters, "Cross-sections and Chemical Analysis of Paint Samples," Studies in Conservation 2 (1956): 113.

[9]As a check, a Glenn Colorule, manufactured by Sidney Blumenthal and Co., Shelton, Connecticut, was placed under the two different light sources and matches were found which were different for each source. This showed the light sources to be different enough for matamerism to be apparent if the pairs were metameric.

[10]Phillips, "Problems in the Restoration and Preservation of Old House Paints...," p. 275.

[11]Rutherford J. Gettens and George L. Stout. Painting Materials: A Short Encyclopedia (New York: Dover Publications, 1956), p. 149.

[12]Frederick Maire, Modern Pigments and their Vehicles (New York: John Wiley and Sons, 1908), p. 149-150.

[13] Ruth M. Johnston, "Spectrophotometry for the Analysis and Description of Color," Journal of Paint Technology 39 (June 1967): 348.

[14] Operation carried out by Professor John Yoke.

[15] Fuller O'Brien Paint Company's San Francisco Plant utilizes this equipment and makes it available to its clients.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

This paper has attempted to delineate and discuss paint analysis, and its attendant problems, at various levels of technology and to illustrate its usefulness and importance in architectural paint preservation and restoration. The blue paint of the Aurora Colony was used as a case study in an effort to determine the pigment used, the colors produced, where it was applied, and its source. While techniques chosen were specific to the goals of the project, other options were also put forth to expose the range of possible methodologies.

Five hypotheses were examined using five historic structures in Aurora. Microscopy and chemical testing were employed to determine the pigment and the colors. This investigation was supplemented by literary and documentary research. The colors were matched to the Munsell Color Notation System to record the range of blue hues. Commercial and laboratory manufactured pigments were mixed to duplicate original hues, and spectrophotometry was employed to check and record one such match.

The point should be made that to do a thorough job of paint analysis several methods of investigation must be combined; as each reveals slightly different information, and they build on each other. For instance, while examining the chips under the microscope gives a sense of the paint layers, the colors, and the quality of the grinding and mixing of the pigment, the cross-section slides are invaluable for distinquishing finish coats from undercoats and establishing a chromochronology. Chemical analysis will identify the pigments and mediums but can tell nothing of the value and chroma of the hues since it cannot indicate proportions of pigments to fillers or medium. Mechanical analysis can delineate proportions and/or formulae but mixing and application techniques remain to field and laboratory observation, as does color matching. Furthermore, it is not enough to just identify the pigment and the color; the effects of aging need to be understood. Finally, in reproducing the color for restoration, metamerism must be taken into consideration to allow greater accuracy in color matching and as a factor in the selection of room lighting.

Conclusions

What, then, is "Aurora Blue"? Chemically, it is Prussian blue pigment mixed with white lead in an oil medium. It may have been manufactured in the Colony in its early years, but was probably purchased from a commercial supplier during and after the 1870s. Visually, however, there is no one color which can be termed "Aurora Blue." The blues identified span a wide range of hues, values and chromas, from a rather light blue on the green side to a rich purple blue. In terms of a definition, "Aurora Blue" should probably only be used to refer to the fact that some variant of Prussian blue was used in Aurora more frequently than any other single color.

In general, the visual differences between the blues from house to house were very apparent and much greater than that within any one house, which suggests that the changes from house to house were deliberate and according to preference. The subtler variation of shades within each house was probably the result of hand mixing and suggests the Colonists mixed pigments into a commercially produced white base.

It is, likewise, difficult to say with certainty which architectural elements were painted blue. This, like the color, may have been a question of individual preference, though blue baseboards seem to have been quite common. Furniture pieces also seem to have been rather frequently painted blue, though not enough furniture was sampled to supply any real conclusions, and much has been stripped and refinished.

The Giesy-Kraus house, having been the most thoroughly studied, provides the main source from which conclusions regarding the use of blue paint can be drawn. The hues were 5B, 7.5B and 2.5PB with chromas and values in the middle range giving them a deep richness. Blue was found in every room in the house except the south bedroom. Most commonly painted blue were the chair rails. Blue chair rails were found in the kitchen, the parlor, the upstairs hall and the north bedroom. The kitchen also contained a blue peg board, and in the parlor the fireplace surround and mantlepiece were blue. Additionally, blue was found on the stair leading from the kitchen and on the stair railing.

The use of undercoats and glazes was established, but, in both cases, the practice was inconsistent. Undercoat colors varied from white to reddish brown. Where glazes were used, they appeared to have been clear (with no pigment added) but to have yellowed or darkened with time and as a result of overpainting.

If a structure in Aurora were to be restored today and the owner wished to use "Aurora Blue" appropriately, the following guidelines could be provided.

1. Use Prussian blue pigment in a lead white base to arrive at the color
2. Hand mix the color using a linseed oil medium
3. Select a color (hue, value and chroma) from the Munsell Color Notations listed herein, or a very

similar color within the same range

4. Restrict the use of blue to chair rails, baseboards, peg boards, fireplace surrounds and stair rails
5. Vary the value and chroma slightly from room to room as would be affected by hand mixing

Speculative Conclusions

Based on samples taken in which colors other than blue were found, some speculation can be made regarding the palette used in the kitchen of the Giesy-Kraus house. Against the background of the white plaster walls and ceiling, the chair rail which ran around the entire perimeter of the room was painted a rich blue. The wainscot below it appears to have been coral or salmon colored, bordered by a light green baseboard. The floor was a very dark color, possibly black. Above the chair rail, samples from the window trim indicate it was cream or white. Hanging on the plaster wall was a pegboard of blue and a spice shelf of coral.

Elsewhere, rich green, olive, light brown, cream, and gray have been identified. The Fry house yielded evidence of bright yellow paint on the upstairs window trim and the closet beneath the stair still harbors a section of a dark red, wood-grained (dark glaze over salmon) wainscot and chair rail. In the back room of the Colony store the marblized fireplace is still intact. Thorough analysis has not been done on any samples other than the blue ones. This is an area where further research is needed--more samples need to be taken from these structures, chemical and mechanical analyses performed, and color matching carried out. But, the palette indicated by this study suggests that the Aurora Colonists enjoyed a colorful environment.

At this point, it therefore seems appropriate to add a sixth guideline to those enumerated above.

6. Use other colors (in addition to the blue) with the same vernacular feeling, or forthright quality, in the kitchen and, perhaps, some of the other rooms. These might include salmon, mustard yellow, olive green, turkey red, as well as neutrals such as gray, cream, and biege. Graining may be used on doors or wainscoting.

There is no indication that the Colonists had a special verbal, written or symbolic association with any one color--more than any other--for interior uses. However, it may be pertinent to mention, one exterior treatment. With perhaps only one exception, the painted exteriors of residential, commercial, and civic buildings in the Colony period are shown as white. A few of these "white" exteriors may also have had trim accented in deeper colors. "Blue" was given civic emphasis in Aurora in reference to the community horse barn--a stage barn--which was demolished after the turn of the century. It was called (or described as) the "Blue Barn", though whether or not it was actually painted blue is not known. Several black and white panoramic views of ca. 1875 show this building as one with white trim and sash and a dark body color. Should that color have, in fact, been blue, the building's name would be explained, and the importance of the color blue to the community would be more firmly established.

The earliest paint layers on the several buildings studied at Aurora must date from the last years of the third quarter of the nineteenth century. How common these colors were in Oregon (or elsewhere), however, cannot be surmised from this evidence. The uses of color schemes must be considered in terms of their context, including the type of building and the architectural characteristics of the building. To what extent, in historic preservation, the scheme of one building might be considered as applicable to others built at the same time, in the same territory, poses some difficult questions. These structures were hardly representative of rural building in Oregon at the time, and their interior detailing and color schemes may be unrepresentative of Oregon as well.

APPENDIX A

OUTLINE OF STEPS AND PROCEDURES FOR PAINT RESEARCH

I. Establish the goals of the project--why the research is being carried out. All other procedures are chosen with reference to these goals. Some will not be applicable to certain purposes.

II. Carry out background research on:

- paint colors and chemistry
- the community
- the building
- the building owners or users
- documents specifically pertinent to project

III. Carry out field work

- cratering
- scraping
- examination with hand lens or field microscope
- sample extraction
- devising and filling out forms or charts

IV. Prepare samples for laboratory analysis after initial examination

- mount in wax
- make cross-section slides

V. Carry out laboratory analysis

- microscopy
- chemical testing
- "high tech" procedures

polarizing light microscopy

x-ray diffusion or x-ray fluorescence

laser microspectral analysis

VI. Carry out color matching

This can be done at time of initial microscopy

match to Munsell Color Notation System and

determine metamerism by

using daylight fluorescent source

using fiber optic source with blue filter

bleach linseed oil with ultraviolet or fluorescent light

re-match to Munsell Color Notation System

mix color to match

VII. Carry out spectrophotometry

to check metamerism

to establish record of color

APPENDIX B

COMPLETE PRINT-OUT OF ACCOUNT BOOK PAINT ENTRIES

TABLE 5. Account book entries showing transactions involving paint and related materials from 1857 to 1881 when the Colony was officially dissolved.*

bk	page	date	item	price	customer
A	43	Aug 1 57	prussian blue	2.00	Jane Bonney
A	29	Sep 26 57	paint brush	.50	Wm. Haris
-	-	Apr 2 64	wallpaper	.62	T. J. Gregory
F	108	Apr 23 74	1 white wash brush	-	Wolff, Keil & Co.
G	38	Jun 13 74	10 rolls wallpaper	-	Dan Snyder
G	45	Jun 9 76	16 rolls wallpaper	-	Rudolf Giesy
F	147	Jul 8 76	1 gal. Averill Paint	2.40	G. Zigler
F	147	Jul 10 76	2 cans paint	2.00	M. Bachert
F	147	Jul 12 76	5 cans paint	4.50	Bach
G	69	Aug 26 76	1 box colors	-	Ulbrand
F	152	Sep 4 76	2 gal. O W O Paint	5.00	-
F	153	Sep 27 76	1 can paint	1.00	Wm. Mill
F	154	Oct 24 76	4 pks. paint	3.20	H. Kraus to/of Sachs
F	156	Nov 15 76	2 cases	3.80	-
F	156	Nov 16 76	1 case paint	2.20	S. Seiz
F	160	Jan 15 77	1 case paint, busted	.75	-
K	20	Jun 28 77	1 can paint		Kocher Family
F	172	Jul 5 77	3 boxes paint	2.75	S. Smith
J	4	Sep 6 77	50# white lead	-	-
J	4	Sep 6 77	1 paint brush	-	-
J	-	Jun 27 78	25# white lead	-	Hildlson (cr.)
K	97	Oct 16 78	3 rolls wallpaper		Samuel Miller
I	-	Oct 30 79	colors #14	-	-
L	65	Feb 26 81	5 rolls wallpaper	-	John Wolfer
L	8	Mar 21 81	5 gal. paint	-	Lawrence Ehlen
I	-	Apr 1 81	1 white wash brush	-	-
L	8	May 21 81	5 gal. "Rub" (?) paint	-	Lawrence Ehlen
L	1	Jun 7 81	1 white wash brush	-	Thomas Brady
L	8	Jun 30 81	1 tin white lead	-	Lawrence Ehlen
L	78	Jul 10 81	100# white lead	-	Link Family
L	78	Jul 10 81	10 gal. oil	-	Link Family
L	78	Jul 10 81	1 paint brush	-	Link Family
I	-	Aug 1 81	100# white lead	-	Burkholder
I	-	Aug 1 81	5 gal. raw oil	-	Burkholder
I	-	Aug 1 81	3 in. paint brush	-	Burkholder
I	-	Aug 1 81	5 gal. D. F. oil	-	W. Ehlen
L	4	Sep 2 81	100# white lead	-	Burkholder Family
L	4	Sep 2 81	4 gal. raw oil	-	Burkholder Family
L	97	Oct 14 81	1 can oil	-	George Kraus
L	97	Oct 14 81	3 rolls wallpaper & 4' boarder	-	George Kraus
L	80	Oct 18 81	1 white wash brush	-	George Will
L	80	Oct 18 81	bbl. lime	-	George Will
L	47	Oct 24 81	1 can boiled oil	-	George Smith
L	95	Oct 24 81	5 gal. boiled oil	-	Burkholder Family
I	-	Dec 81	1 can raw linseed oil	-	-
I	-	Dec 81	1 bucket Pioneer White Lead	-	-

*NOTE: To the extent possible, all entries are recorded exactly as they appeared. Entries for wallpaper are also included both as a matter of interest and because they are indicative of the availability of non-essential goods of this nature and of the consumers' interest in decorating their homes.

Account books are lettered arbitrarily by this researcher as follows: A. no title, entries date from 1856 to 1870; B. no title, entries date from 1864 to 1868; C. Wm. Keil & Co. Account Book 1861-1917; D. F. Keil's Co. - "F. Giesy in Co. with the same firm; E. no title, entries date from 1870 to 1875; F. Wolff-Keil & Co. Ofc. Book then on October 29, 1875 it becomes "Wm. Keil & Co."; G. F. Keil & Co.; H. no title, wool carding entries date from 1867 to 1874, account entries from 1882 to 1885, "Bought and Sold in 1899" accounts at end; I. F. Keil and Co. - Goods Wanted and Ordered; J. Aurora Co. Wm. Keil & Co. from 1887; K. Aurora Town and Colony Book, F. Keil & Co. Day Book No. 1 July 1, 1877; L. F. Keil & Co. January 1, 1881 to July 31, 1881, F. Giesy August 1, 1881; M. F. Giesy & Blotter August 1, 1881 to March 31, 1884.

APPENDIX C

CHART USED IN FIELD WORK

Name of house: ______________________________

Address: ______________________________

Owner: ______________________________

Rooms and elements investigated:

	blue found prelim.obs.	other color	stripped/ refin.	sampled	results
living room					
door					
door frame					
baseboard					
wainscot					
chair rail					
mantlepiece					
surround					
molding					
floor					
parlor					
door					
door frame					
baseboard					
wainscot					
chair rail					
mantlepiece					
surround					
molding					
floor					
kitchen					
doors					
door frames					
baseboard					
wainscot					
chair rail					
peg board					
cupboards					
floor					

Figure 13. Chart used in field work.

	blue found prelim.obs.	other color	stripped/ refin.	sampled	results
Bedrooms doors					
door frames					
baseboard					
wainscot					
chair rail					
molding					
floor					
Hall doors					
door frames					
baseboard					
wainscot					
chair rail					
molding					
floor					
Stairs					
Closets					

Figure 13. Continued

APPENDIX D

COMPLETE PRINT OUT OF LABORATORY RECORDS

#	house	room	element	location	color(s)	fluor. notation	fiber optic	glazed	undercoat	bleached	notes
87	Becke		baseboard		white, blue, brown, blue, blue	2.5B 5/4-5B 5/4	2.5B 5/4-5B 5/4	very darkened with time	white	7.5B 5/4	microscopy at Columbia
50	Colony St.	back room	fireplace	marblizing	blue, ...	10 BG 5/2 (approx.)				2.5B 5/2	blue has translucent quality, layers mixed
51	Colony St.	back room	fireplace	marblizing	blue, white, salmon,red-brown, bits of metal or mica	10 BG 5/2					blue has translucent quality
49	Colony St.	main	post	under fixture	cream						
55	Colony St.	upstairs	doorway to back room		cream, white, salmon, grainy grayish, white						
52	Colony St.	upstairs	partition above stairs		dark gray, white						
53	Colony St.	upstairs	second post on s. side		white, lt. beige, salmon, white						
54	Colony St.	upstairs	second post on s. side		very light blue-green over white	greener than 10 BG					
62	Fry	n. bedroom	closet	handle	whitish						
61	Fry	n. bedroom	closet door	inside	very light green						
64	Fry	n. bedroom	window, s. wall	sill	bright yellow, green, pink, rose beige						
63	Fry	n. bedroom	window, w. wall		bright yellow, green, pink, rose beige						
58	Fry	parlor	chair rail	in closet	light salmon, indian red glaze, dark glaze						red grained
59	Fry	parlor	closet dr. under stairs		pink, peach, pale blue						colors not listed in order, layers confusing, marblized (?)
60	Fry	parlor	door to bedroom	frame	brownish red-violet, ochre, transluscent lt.green, reddish brown, tan						final layers, cream, greenish dark cream. marblizing (?)
57	Fry	parlor	wainscot	in closet	light salmon, dark brown glaze						red grained
28	G-kraus	kitchen			dark (?), cream, salmon,						first layer uncertain
5	G-kraus	kitchen	baseboard		light green						green may be oxidation of some sort
6	G-kraus	kitchen	baseboard								
4	G-kraus	kitchen	chair rail		blue with glaze	2.5 PB 4/6	10 B 4/6	10 BG 3/6	salmon		color embedded in wood fibers
9	G-kraus	kitchen	chair rail		blue	5 B 3/4	5 B 3/4				color embedded in wood, difficult to match accurately
25	G-kraus	kitchen	chair rail		blue	2.5 PB 4/8	10 B 4/6-2.5 PB 4/8				
7	G-kraus	kitchen	cupboard		gray						
8	G-kraus	kitchen	door to parlor		brown						
29	G-kraus	kitchen	door to parlor		cream, white, dark brown, ...						
27	G-kraus	kitchen	free-standing cupboard		cream, white						
26	G-kraus	kitchen	nw. window trim		cream, white						
3	G-kraus	kitchen	peg board		blue	5 PB 3/4	2.5 PB 3/4			5 PB 3/4	
30	G-kraus	kitchen	spice shelf		cream, salmon,...						
2	G-kraus	kitchen	stair	base	blue	2.5 PB 4/8	2.5 PB 4/8		gray		traces of red
31	G-kraus	kitchen	wainscot	by stairs	cream, salmon,...						
32	G-kraus	kitchen	wainscot	nw. corner	cream to beige, salmony						colors darker, duller than 31
43	G-kraus	n. bedroom	baseboard		taupe, poss. with olive glaze						
41	G-kraus	n. bedroom	chair rail		blue with glaze	2.5 PB 4/6	2.5 PB 4/6	could be oil migration	brownish		
44	G-kraus	n. bedroom	door from hall		brownish						
45	G-kraus	n. bedroom	e. door trim		brownish						
42	G-kraus	n. bedroom	w. door trim		white						appears new
15	G-kraus	parlor	baseboard	top, right of firepl.	brown						
16	G-kraus	parlor	baseboard	bottom, right of firepl	brown to brownish red						
12	G-kraus	parlor	chair rail	left of firepl.	blue with glaze	2.5 PB 4/6	10 B 4/6-2.5 PB 4/6	2.5 B 4/2	brownish	2.5 PB 4/6	glazed could be oil migration, no distinct layering
23	G-kraus	parlor	cupboard by chimney		gray, white						
18	G-kraus	parlor	fireplace		blue	2.5 PB 4/6	2.5 PB 4/6		gray	2.5 PB 4/6	
14	G-kraus	parlor	fireplace trim		blue,red, gray, white, light blue	7.5 B 4/6	7.5 B 4/6		gray		
13	G-kraus	parlor	floor	between boards	none						dirt, varnish
24	G-kraus	parlor	floor	near hearth	blackish, red						
20	G-kraus	parlor	front door		white						
19	G-kraus	parlor	front door trim		brown				cream		
11	G-kraus	parlor	mantlepiece	back	blue with glaze	2.5 PB 4/6	10 B 4/6	10 BG 3/4	gray, could be carbon		some glazed areas greener
22	G-kraus	parlor	mantlepiece		blue	2.5 PB 4/6	10 B 4/6		gray		
10	G-kraus	parlor	peg board		white, gray						
21	G-kraus	parlor	se. window trim		bluish gray, white				white		
17	G-kraus	parlor	wainscot	near fireplace	white						
1	G-kraus	porch	cupboard		green						
46	G-kraus	s. bedroom	baseboard		taupe, olive glaze						glaze layer quite distinct
47	G-kraus	s. bedroom	chair rail		brown, dark blue, light blue				brown (?)		blue bits present wh. may be from below brown layer
48	G-kraus	s. bedroom	door		beige to gray						
34	G-kraus	upstairs hall	baseboard		lt. gray to beige, dk. brown, olive glaze	5 B 4/8-5 B 3/8					blue is isolated chunk from first or second layer
40	G-kraus	upstairs hall	chair rail		blue with glaze	2.5 PB 3/6	2.5 PB 3/6	10 BG 3/4	brownish	5 PB 3/6	greenish glaze very distinguishable
36	G-kraus	upstairs hall	door to s. bedroom, trim		white with flecks of blue						very small amt. of blue pigment in white paint
39	G-kraus	upstairs hall	newell post	base	dark green (emerald or forest)						
35	G-kraus	upstairs hall	stair box		white, olivish glaze (?)						
38	G-kraus	upstairs hall	stair rail		salmon, olive glaze (?)						flecks of undeterminable dark pigment visible in glaze layer
33	G-kraus	upstairs hall	stair rail	base	salmon, blue	7.5 B 4/6	5 B 4/6		white		
37	G-kraus	upstairs hall	stair rail	baluster	cream						
69	Giesy	family room	wall	by fireplace	pale blue, light green, gray	10 BG 7/4	10 BG 6/2-6/4			2.5 B 7/4	blue and green layers indistinct boundary, could be linseed oil leaching
70	Giesy	family room	wall	by fireplace	pale blue, light green, gray						same as 69, hard to find spot to match to
65	Giesy	upstairs hall	baseboard	loose board	pale blue-green with glaze			greener than 10 BG	gray		
66	Giesy	upstairs hall	baseboard	loose board	blue with glaze	2.5 B 6/4 scrape	2.5 B 6/4	greener than 10 BG 5/2	white		
67	Giesy	upstairs hall	baseboard	loose board	blue with glaze	7.5 B 6/6		undetermined	white		what appears to be glaze could be linseed oil leached to surface?
68	Giesy	upstairs hall	door to bath		brownish-grayish light green						looks like lots of linseed oil in paint, turned brown
78	Keil	basement	door to outside	outside	blue-green	greener than 10 BG					
71	Keil	entry hall	baseboard		gray						only 1 layer, looks original
75	Keil	n. bedroom	baseboard		blue with glaze, beige, white, greenish white	7.5 B 6/6-7.5 B 6/4	5 B 6/4	undeterminable			does not appear to be mixed with oil, reddish veining in cracks of blue
73	Keil	n. parlor	baseboard		white						
76	Keil	s. bedroom	wainscot		blue, white, light green, gray green	10 B 6/6	10 B 6/6			2.5 PB 6/6	
77	Keil	s. bedroom	wainscot		blue, white, light green, gray green	10 B 6/6	10 B 6/6				
72	Keil	s. parlor	baseboard		dark transparent, grayish, lt. olive, green, white						
74	Keil	upstairs hall	baseboard		white, gray, white, greenish white						
81	Ox Barn	main	cupboard by door	base near back	blue, brown	2.5 B 5/4	2.5 B 4/4			5 B 5/4	difficult to match, pigment mixed with wood fibers, var. w/in particles
84	Steinbach		trunk, (A70-731)		blue	5 PB 3/6	2.5 PB 3/6			5 PB 3/6	surface = dirt (?), glaze (?)
85	Steinbach		trunk, (A70-731)		blue with light creamish glaze	2.5 PB 3/6	5 PB 3/6				
82	Steinbach	bedroom	trunk (A70-1185)	inside edge	yellow-green						
83	Steinbach	bedroom	trunk (A70-675)	inside edge	blue with reddish brown varnish	2.5 PB 4/6-2.5 PB 3/6	10 B 4/6			2.5 B 4/6	
86	Steinbach	shed addition	dough box		indian red						

GLOSSARY

Definitions given are not necessarily complete, but refer specifically to the use of the term in this paper.

CHAIR RAIL: a board, about three inches wide, running around the perimeter of a room approximately three feet above the floor, often capping a wainscot.

CHROMOCHRONOLOGY: a recording of the colors of the paint layers in an extracted sample in the order in which they appear.

CROSS-SECTION SLIDE: a paint chip embedded in a "cube" of polyester resin which has been cut, ground and polished into a thin, transparent section across the paint layers.

DATING: using paint layers, together with other evidence, to establish the date of a structure or of alterations to a structure.

FIBER OPTIC LAMP: a lamp which employs flexible, glass rods to carry the light from the source to the desired location by internal reflection.

FUGITIVE PIGMENTS: pigments which lack permanence usually due to fading.

GLAZE COAT: a thin, somewhat transparent coat of film-forming material, sometimes containing pigment, used to slightly alter the color of and/or give a shiny appearance to the color coat.

GRAINING: painting a surface in imitation of wood grain. Paint layers are manipulated with tools in such a way as to interrupt their continuity.

HUE: acccording to Munsell, the name of a color or the quality by which we distinguish it from other colors.

MARBLIZING: painting a surface in imitation of marble. Paint layers consist of colors laid on individually, not forming a continuous film.

MICROSCOPY: examination or investigation using a microscope.

MUNSELL COLOR NOTATION SYSTEM: a system for notating color devised by A. H. Munsell based on the three qualities of color: hue, value and chroma. This is thoroughly explained in the section of this paper on color matching.

PEG BOARD: a flat board, sometimes attached to a wall, which has dowels extending out providing pegs on which clothes or chairs may be hung.

SPECTRAL REFLECTANCE CURVE: a line on a chart which records the reflection of various wavelengths of monochromatic light off of a colored sample measured against a white standard.

SPECTROPHOTOMETRY: in this case, reflectance spectrophotometry. The use of a spectrophotometer to measure and record color by plotting a curve of the spectral distribution of reflected light at various wavelengths.

SUBSTRATE: the base material to which paint is applied, such as wood or metal.

UNDERCOAT: a layer of paint used to prepare the surface to receive the color coats.

WAINSCOT: the lower portion of an interior wall surface which has been covered with a lining material, usually wood.

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