11.1 Robbins and others at the blast furnace, February 21, 1951. (Photograph 296 by Richard Merrill, 1951.)

Conservation Methods

Brigid Sullivan

Before historical archeology was recognized as a distinct specialization governed by professional ethics and standards of practice within the formal field of archeology, excavation of historic sites was frequently driven by recovery of historic "relics." These material remains, including objects and structures, were used in the interpretation of daily life, becoming stage props for enriching the reconstructed historic scene. This was especially true in New England, where antiquarians like Wallace Nutting forged an indelible, if not always accurate, image of daily life in colonial America. Drawn from the archeological and archival record, these images became the visual foundation of the Colonial Revival movement in America.

In this spirit, in 1948, J. Sanger Atwill, president of the newly formed First Iron Works Association (FIWA), offered the local amateur historian/archeologist Roland Robbins the opportunity to excavate the remains of a seventeenth-century ironworks site in Saugus. Robbins would embark, as Mr. Atwill put it, "on an antique treasure hunt."[1]

On August 24, 1948, J. Sanger Atwill, President of the First Ironworks Association, wrote to me asking if I "would like to go on an antique treasure hunt." This treasure hunt, Mr. Atwill stated, was to locate and excavate, if possible, the foundations of "the Blast Furnace and Mill with undershot wheel.

Roland Robbins, Report of Archaeological Progress at the Old Iron Works Site, Saugus, Massachusetts, from September 10, 1948 to June 25, 1949.

Under the direction of Robbins, the focused effort to preserve materials recovered in the early 1950s excavation was extraordinary for historical archeology of this time. Robbins' interest in preservation of the excavated Saugus ironworks material went beyond the traditional lexicon of preservation techniques and formulas to embrace contemporary scientific methods and materials based on technical research in Europe and the United States.

Professional Conservation in the Early- to Mid-Twentieth Century

Interestingly, the time span of the FIWA excavations coincided with the growth of scientific conservation theory and practice, the center of which was arguably Harvard's Fogg Museum in nearby Cambridge, Massachusetts. Following the lead of the British Museum, which established a conservation research laboratory in 1920, Edward W. Forbes, director of the Fogg, set up the first technical department in an American museum in 1928. George L. Stout served as head conservator and Rutherford J. Gettens as the conservation scientist. Fine arts conservator Richard D. Buck joined the department in 1937, bringing a specialization of wood to the team. The Fogg Museum published the first technical journal focused on scientific conservation, ***Technical Studies in the Field of the Fine Arts***, from 1932 to 1942.

The Museum of Fine Arts in Boston and the Metropolitan Museum in New York established conservation laboratories in 1930 and 1931, respectively, and the influential Worcester Art Museum in Massachusetts developed a professional conservation lab in 1939. Harvard's Peabody Museum of Archaeology and Ethnology developed a conservation lab for their collections in the 1940s.

In the early days of professional conservation, the founding conservators of the new scientific movement and their museums were strongly interconnected. A 1949 *New York Times* article demonstrates this close collaboration, noting that

> Richard D. Buck, a member of the staff since 1937, today was appointed conservator of the Fogg Art Museum at Harvard University. A native of Middletown, N.Y., Mr. Buck was graduated from Harvard College in 1937, and received his Master of Arts degree from the university in 1938. He gained his conservation training with George L. Stout, director of the Worcester (Mass.) Art Museum, and former head of the conservation department of the Fogg.[2]

A few of these early conservationists, Rutherford Gettens, George L. Stout, and Richard Buck, would visit Saugus at the invitation of Roland Robbins.

Sanger came at noon . . . . I told him I was anxious to have the wooden relics treated for preservation. He didn't seem too concerned about their being treated. Said I would see Mr. Orchard, Curator of Peabody Museum about making arrangements for them to do the work. He made no comment.

Roland Robbins, "Saugus Ironworks Daily Log – 1949," May 23, 1949.

As a major museum entity in its own right, the National Park Service (NPS), along with other cultural and scientific organizations, benefited from the profusion of scientifically-based technical publications that rapidly became available during these years. These include ***The Preservation of Antiquities*** by Harold J. Plenderleith (London: The Museums Association, 1934) and Douglas Leechman's "Technical Methods in the Preservation of Anthropological Museum Specimens" (published in the ***National Museum of Canada Bulletin*** No. 67, 1931), which the NPS museum program recommended to its parks in all regions for guidance in preserving museum collections.

In 1936, J.C. (Pinky) Herrington took over management of historical archeology projects at Colonial National Historic Park in Jamestown, Virginia, and set up a conservation laboratory. The work of stabilizing and cleaning the material excavated at Jamestown was based largely on the published guidance of Plenderleith and Leechman.[3] ***A Field Manual for Museums,*** written by Chief NPS Exhibits Preparator Ned J. Burns in 1941, which included and expanded on Plenderleith's and Leechman's work was widely distributed to all NPS parks for decades. Not surprisingly, early professionally trained conservators hired by the newly formed NPS Branch of Museum Services were trained at the Fogg Museum, bringing with them a new sense of professionalism to what was previously a restoration craft.

11.2 Close-up view of the blast furnace tailrace with iron staples. (Photograph 411 by Richard Merrill, 1951.)

As the professional conservation community continued to grow in America and Europe, the first international Conference for the Study of Scientific Methods for the Examination and Preservation of Works of Art was held in Rome in 1930. The first International Institute for Conservation of Historic and Artistic Works (formerly known as The International Institute for the Conservation of Museum Objects) was incorporated in 1950. These international ventures created accessible forums in which to share research and discuss strategies for resolving complex preservation problems. For example, the 1939 discovery of the Sutton Hoo burial mounds in Suffolk, England, proved hugely important internationally. The decades-long conservation effort it entailed resulted in a major advancement in the knowledge of the conservation of waterlogged wood, corrosion chemistry, and the alteration of leather in wet archeological sites.

With an enduring period of preservation in mind, careful thought as to the proper method of preserving our artifacts must be taken.

Roland Robbins to Quincy Bent, March 16, 1950.

Preservation Activities at the Saugus Iron Works

It is clear from Robbins' meticulous field notes spanning the years 1948 to 1953 that he was aware of artifact preservation as a complex science rather than a recipe book. As a result, he sought a professionally acceptable program of treatments for the Saugus archeological finds. As early as May 1949, Robbins raised the issue of treating wooden artifacts with FIWA president J. Sanger Attwill, who reportedly "didn't seem too concerned" about preserving these objects.[4]

This exchange foreshadowed the frustration that Robbins would encounter in his dealings with the FIWA management team throughout the excavation, problems that eventually led to his resignation in 1953. Undeterred by Attwill's laissez faire attitude, he contacted his friend Frederick Johnson, curator of the Robert S. Peabody Museum of Archaeology at Phillips Academy in Andover, Massachusetts, who had experience in the recovery of waterlogged wood from his work on the Late Archaic-period Boylston Street Fish Weir site, located under the streets of the Back Bay area of Boston. This site, excavated in 1913 and then again in the 1940s by Johnson, "became a benchmark for the multidisciplinary application of scientific methods in archaeology."[5]

Robbins then contacted Frederick Orchard, Curator of archaeology and ethnology at Harvard's Peabody Museum, to discuss the possibility of the museum undertaking preservation of the excavated timbers of the tailrace and bellows base. Robbins reported that Orchard "told me that the museum is not set up to do the work I mentioned concerning dehydration of the tailrace beams and planking, bellows base, etc. He knew of no place where this work could be done (not only in the N.E. but no place in the country). He knew of no group or archeologist who could dismantle the number of tailrace remains for dehydration and preservation treatment and then reassemble same."[6]

11.3 Workmen applying preservative oil to timbers from the raceway. (Photograph 795a by Richard Merrill, 1953.)

The concern for the long-term preservation of the timbers continued, but in 1949–1950, the primary challenge shifted to preserving the enormous number of metal objects being excavated. During this period, metal preservation treatments were primarily those developed during the war to keep metal armaments stable and rust-free. They consisted of superficial rust reduction (mainly mechanical), possible surface passivation, and applying a protective coating to the core metal.[7] However, in terms of material characteristics, modern metal has little in common with archeological metal that has been buried in a damp site for three hundred years. The metal excavated by Robbins had only negligible core metal remaining and its shape definition existed primarily in the corrosion crust. On May 10, 1949, Robbins sent a collection of 19 metal specimens to Mr. C. H. Herty, Jr., of Bethlehem Steel, Bethlehem, Pennsylvania, for metallographic examination and on August 25, 1949, received the analytical report recommending future treatment.

In early 1950, Henry Hornblower, history buff and founder of the Plimoth Plantation Living History Museum, recommended to his friend and colleague Quincy Bent, chair of the FIWA Reconstruction Committee, that he contact James R. Bateman, an "iron restorative man" working with the archeological and museum laboratories at Williamsburg, Virginia.[8] Bent relayed this information to Robbins, who sent Bateman "a cross section of artifacts to be restored so as to determine whether it may be wise to consider his method when we are ready to prepare our museum exhibit."[9]

The archeological and museum laboratories at Colonial Williamsburg were well known and generally respected in the field of historic preservation. Supported by philanthropist John D. Rockefeller, the ambitious reconstruction had such a large endowment that few if any expenses were spared in the recovery, preservation, and interpretation of the various sites and their artifacts. In 1931, Rutherford Goodwin of the Colonial Williamsburg Foundation established a conservation laboratory to process and preserve of the huge amount of archeological material being excavated. In doing so, Goodwin relied heavily on the recently published ***Antiques, Their Restoration and Preservation*** by Alfred Lucas, a British Egyptologist and scientist who, along with Howard Carter, developed preservation treatments for the Tutankhamen tomb artifacts.[10]

As early as 1935, the Williamsburg conservation lab prepared a three-page document to serve as a protocol for treating excavated iron objects, ***Treatment for Cleaning and Preserving Excavated Iron Objects Found in the Course of Archaeological Excavation in Connection with The Williamsburg Restoration at Williamsburg, Virginia.*** Colonial Williamsburg made the document available to any interested museums or organizations between about 1935 and 1950; few changes were made to the original document during this time.[11] The standard treatments in the document included mechanical cleaning of corrosion crusts, electrochemical reduction using caustic soda (sodium hydroxide), zinc, and nitric acid, and applying a mixture of paraffin and microcrystalline wax as a protective coating. The document was slightly refined

We have here the problem of restoring and preserving hundreds of such items. Some of our artifacts exceed one hundred pounds in weight. I do not have time to attend to this work and I am attempting to have the Steel Institute to provide me with an assistant whose entire time would be given to the attention of our relics. If these plans materialize, I shall want to visit with you and get more detailed information.

Roland Robbins to Maurice Robbins, May 4, 1950.

11.4 Some of the iron artifacts before conservation. (Photograph 138 by Richard Merrill, 1950.)

in 1953 to include more specific information after conservators observed that the treatment effectiveness decreased when they reused an electrolyte solution to treat multiple batches of iron material.

Although Robbins sent the artifacts to Williamsburg in January 1950, he was not pleased with the prices Bateman quoted him. Moreover, Robbins felt uneasy about the long-term effect of a paraffin protective coating on the metal objects. The objects were returned in February and Robbins was disappointed in the results, noting that "possibly I had expected too much, especially after the good reports that Hornblower made, but the restored objects were not as good as I expected."[12]

Unwilling to use the Williamsburg lab, Robbins once again turned to Harvard. He contacted Dr. J. O. Brew, director of the Peabody Museum of Archaeology and Ethnology, for a referral to someone "who could go over our relics and properly treat and preserve them for museum purposes."[13] Brew recommended Karl Fernstrom, who held an A.B. in Anthropology and had a strong interest in colonial New England archeology, to examine and treat the collection on the premises, a huge plus over transporting it out of state. However, Brew stated that Fernstrom, although knowledgeable about ceramics, was not familiar with conservation treatment of wood and iron. Robbins felt an urgent need to get started on preserving the growing backlog of artifacts. Fernstrom could "apply himself to the method determined to be the most beneficial to our purposes," Robbins decided, and recommended that the Reconstruction Committee hire him.[14] Although Robbins corresponded with Fernstrom over a five-month period in 1950, it is unclear whether Fernstrom was actually hired as a salaried employee.[15]

Our museum is bulging with tons of various artifacts uncovered during past excavations. These visible legacies of the past are being classified and must be preserved for the future generations to revere and ponder.

Roland Robbins, "Report of 1949 Archaeological Progress at the Iron Works, June 1950."

In early April, Robbins attended the Massachusetts Archaeological Society Meeting in Attleboro. There he consulted with his friend Maurice Robbins, a founding member and first president of the Massachusetts Archeological Society, Massachusetts State Archeologist, and the author of ***The Amateur Archeology Handbook,*** which helped train several generations of archeologists across the country.[16] At the meeting, the men discussed the use of a paraffin coating on metal.[17] Maurice Robbins commented that he did not recommend the Bateman paraffin treatment, based on his experience and research. He also explained that he was now using a new lacquer marketed as a pressurized spray under the proprietary name of Krylon™. Robbins gave him an iron spike similar to the one restored by Bateman, planning to compare the results of both treatment techniques. The treated iron spike was returned on May 4 and Robbins was very pleased with the results. Later in May, Robbins wrote to Maurice Robbins that "I am getting ready to set up a system whereby we can prepare and preserve our metal artifacts . . . . I would like very much to visit with you and discuss several angles.[18]

By early June, Robbins began initial treatments trying to replicate the even black appearance of the spike treated by Maurice Robbins. Major elements of the first treatment protocol included testing for chlo-

11.5 Iron objects found at Saugus during excavations. (Photograph 1087b by Richard Merrill, 1953.)

rides with silver nitrate, electrochemical reduction by boiling in a caustic soda solution and zinc mossy for hours, mechanical cleaning, and final spraying with Krylon™.[19]

In 1951, Robbins invited Professor Herbert Uhlig, director of the MIT Corrosion Laboratory and author of the recently published and enormously influential ***Corrosion Handbook*** to visit the excavation site at Saugus.[20] Uhlig was surprised to see how much metal had survived centuries of burial and reviewed the 1949 metallographic analysis of twenty iron specimens selected by Robbins.[21] Uhlig also asked for a sample of the burial soil, as his current research centered on determining the scale or rate of growth of corrosion crusts. He approved of Robbins' use of caustic soda and zinc mossy for electrochemical reduction, but recommended electrolytic reduction instead. Although slower, this new method would be a more effective treatment. Uhlig offered to help set up the mechanical apparatus in Robbins' museum building. Always looking for a trained assistant to organize and preserve the huge amount of excavated material, Robbins asked Uhlig if Saugus could hire an MIT student over the summer to treat the artifacts with this new method. Uhlig thought it would be a great opportunity for a student.[22]

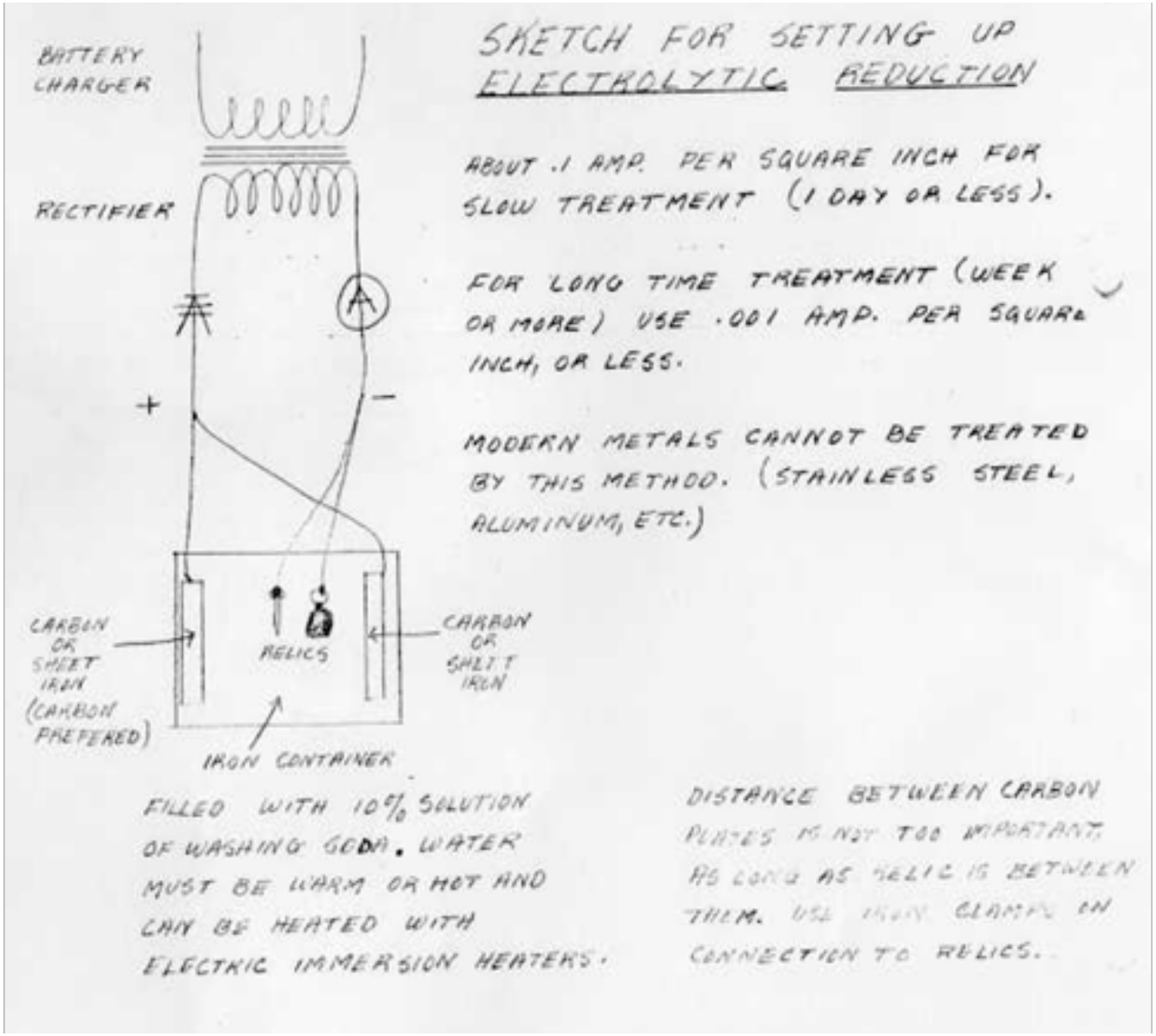
[Professor Uhlig] said that a more thorough treatment for our artifacts is by "Electrolytic Reduction" [and] said we could set up the mechanism necessary for this treatment here in my museum . . . . Below is a sketch of the device I could set up here to perform Electrolytic Reduction on my relics.

Roland Robbins, "Saugus Ironworks Daily Log – 1951," February 17, 1951.

Just a week after meeting with Uhlig, however, Robbins unexpectedly uncovered forty percent of the original Saugus waterwheel and three wheel spokes. Robbins wrote "Jackpot!" in his February 23, 1951, log.[23] With this dramatic discovery, the preservation focus shifted to the treatment of wet wooden objects. Robbins again asked the Peabody's Johnson for advice on immediate post-excavation preservation of wheel timbers. Johnson said that some of the wooden stakes from the Boylston Street Fish Weir site were preserved in an alcohol solution and essentially hermetically sealed. Johnson telephoned colleague Dr. Elso Barghoorn at Harvard's Biological Laboratories to discuss the problem. Barghoorn said that he would like some waterlogged wood samples for analysis and material testing, which Robbins later provided.

Johnson also recommended that Robbins consult with Professor F. O'Neill Hencken of the Peabody about preservation of the wheel. Hencken was a member of the Sutton Hoo recovery team in Suffolk, England, and was involved in experimental treatments of the Anglo-Saxon wood excavated in 1939. "This sounds very much like what we have at Saugus. It will be interesting to learn what Mr. Hencken has to say about the manner in which these relics were removed and preserved!" wrote Robbins in his daily log.[24]

Robbins met with Richard Buck, conservator at the Fogg Museum in April to discuss preservation of the waterwheel and associated timbers. Although Buck had experience in the analysis and treatment of very old wood, such as medieval and renaissance panel paintings and sculpture, and an interest in structural problems of wood excavated from wet sites, he had no practical experience. Robbins then visited Dr. F. O'Neill Hencken at the Peabody to discuss the method of treatment used for the waterlogged wood



11.6 Sketch of electrolytic reduction by Robbins in his daily log, February 17, 1951.

from the Sutton Hoo excavation. He discovered that the procedure involved gradual water displacement by soaking the wood in tanks of alcohol/hydrocarbon solvent, followed by immersion in a tank of melted wax. However, Hencken explained that the method was not entirely successful and that the National Museum of Norway in Oslo had improved upon it.[25]

Immediately after his visit with Hencken, Robbins telephoned Barghoorn to discuss the results of the water-content analysis of the wood fragments from Saugus and to explore the possibility of storing them at Harvard until they could be preserved. Barghoorn continued to experiment with a variety of known treatments and possible variations and also explored new directions in wet wood preservation. In early May, Robbins visited Barghoorn at his lab to view the progress of the treatment tests. Barghoorn demonstrated the basic treatment involving the immersion of the wet wood in hot paraffin wax until the water had been driven out of the wood.

I shall attempt to get Mr. Barghoorn down to Saugus so that he may receive a first hand account of our problem. Mr. Johnson also suggested that I contact Hugh Hencken about my problem. Hencken is at Peabody Museum, Cambridge. Said that Hencken had excavated several medieval boats in Ireland, they being buried in mud, or at the bottom of a pond or swamp. This sounds very much like the problem we have at Saugus. It will be interesting to learn what Mr. Hencken has to say about the manner in which these relics were removed and preserved!

Roland Robbins, "Saugus Ironworks Daily Log - 1951," March 14, 1951.

Later that month, Barghoorn recommended a treatment for the waterwheel in a formal letter to Robbins. Barghoorn explained that

> based on preliminary experiments with samples of wood taken from the old water wheel at Saugus, I am glad to say that a very satisfactory, feasible, and economical method to preserve them has been worked out in my laboratory. The wood specimens from the wheel are typical of anaerobically decayed timber, but fortunately these retain a sufficient amount of their original wood cellulose to make impregnation techniques applicable in preserving them in a relatively unmodified form. The method developed is one of hydrocarbon paraffin wax impregnation by immersion temperatures above the boiling point of water. Under suitably controlled conditions the moisture is replaced by liquid paraffin, which after penetration and cooling to room temperature, solidifies throughout to give support and body to the wood. In addition, a very satisfactory surface texture of the treated wood results.[26]

In June, Barghoorn and his assistant, Teresa J. La Croix, began treating the waterwheel components. Robbins reported to the FIWA Reconstruction Committee that

> The waterwheel has been carefully dismantled and its many pieces have been taken to Harvard College where Dr. Elso Barghoorn and Miss Teresa La Croix, his assistant, are treating and preserving this fabulous relic . . . . I also plan to carefully dismantle the pit in which the waterwheel operated and have it preserved. At a time when our new museum has been built, we shall assemble one side and both ends of the waterwheel pit and have the remains of the old wheel suspended in its original position. I believe

11.7 Robbins and Elso Barghoorn at blast furnace waterwheel, June 1, 1951. (Photograph 345 by Richard Merrill, 1951.)

> that this will prove to be one of America's outstanding Colonial relics . . . . I should point out that Dr. Barghoorn's method has provided the archaeological field with a new medium for preserving ancient wood. Such a process has long been sought by archaeologists and antiquarians. We are indeed fortunate in obtaining Dr. Barghoorn's scientific knowledge.[27]

With Barghoorn's blessing, Alvar™, a polyvinyl acetal resin used since the early 1950s to consolidate archeological woods, was applied to selected artifacts. This approach had been suggested by Fred Johnson, the Curator at the Peabody Museum in Andover, Massachusetts.[28] According to Robbins' daily logs, timbers were also treated with "floor oil" cut with thinner (presumably turpentine), which seems to be a generic term for a number of oils traditionally used to treat unfinished wood floors and other boards. The term "floor oil" could mean either linseed oil or boiled linseed oil, with the addition of other oils. Some of these, such as "range oil" (a petroleum based oil similar to kerosene), are quite flammable. Typically, more than four coats of floor oil were applied until the wood failed to absorb more.[29] Robbins and Barghoorn discussed the possibility of spontaneous combustion and carried out a controlled lit-match test to see at what distance from the flame the treated wood would combust. It proved to be less than one inch, which they thought safe, although Barghoorn recommended that a fan be used to keep air circulating within the museum.[30]

He [Barghoorn] took a small piece of wet wood (which I had given him) and placed it in quite hot paraffin . . . . Immediately the hot paraffin began simmering the water from the wood, actually the action was similar in appearance to the effervescence created when a glass of ginger ale is poured. When the wood had been dehydrated the effervescence ceased, completing the treatment of the wood now being impregnated with paraffin.

Roland Robbins, "Saugus Ironworks Daily Log – 1950," May 7, 1950.

Searching for a method to remove corrosion incrustations, Robbins gave an excavated nail and casting piece to William Porter of Enthone, Inc., who had visited the site on January 8, 1952, to discuss possible treatments for metal artifacts. Porter returned with the treated specimens several weeks later and Robbins thought "they turned out real well."[31] Porter used a method based on principles of electrolytic reduction; Robbins inquired about setting up the process on site.

The entry "Had men clean relics" occurs quite frequently in Robbins' daily logs, especially during periods of inclement weather. The men were employees of Bogart Co., a local construction contracting company hired by the FIWA to undertake work related to the excavation and construction of museum structures. The in-house preservation of organic and inorganic artifacts by Bogart's men continued throughout 1952. For example, they treated leather shoe soles with a ten percent solution of sulphate Neatsfoot oil, a procedure traditionally used for treating leather tack and utilitarian leather equipment.[32] They cleaned metal objects mechanically with wire brushes and picks; when the objects had dried thoroughly, they buffed them with Butcher's Paste Wax (carnauba and other waxes in turpentine and mineral spirits).[33]

Within about twenty years, most metal objects treated during and immediately after the excavation needed retreatment. These were conserved in 1973 by conservation contractor Dennis Piechota; por-

11.8 Harvard University paleobotanist, Professor Elso Barghoorn, consolidates an archeological timber using a water displacement/wax infusion technique, June 6, 1951. (Photograph 349 by Richard Merrill, 1951.)

tions of the collection were treated again in the 1980s by NPS conservator Ed McManus. Little happened to the collection until 2005, when the exhibits were dismantled and stored due to the structural rehabilitation of the museum and the artifacts were examined by NPS objects and wood conservators. The wheel fragments treated by immersion in melted paraffin by Elso Barghoorn were in good condition structurally, but the raceway timbers treated with "floor oil" were in poor condition, with friable surfaces and cross-grain checking indicative of fungal decay. Under the direction of NPS wooden objects conservator Al Levitan, the fragile oil-treated timbers were consolidated with polyvinyl butyral in alcohol (Butvar B98™), a treatment compatible with the earlier use of oil and of Alvar™. The waterwheel and raceway are now reinstalled in the museum with very little loss of historic material.

Every aspect of artifact preservation at Saugus was overseen by Robbins, who engaged the pioneer scientific conservation community in Cambridge, Boston, Andover, and elsewhere for guidance in treatment methodologies and materials. Robbins also oversaw the museum building and exhibition of the "relics." The work that Robbins did at Saugus was far from the "antique treasure hunt" proposed by J. Sanger Atwill in 1948.

Although no longer associated with the project after 1953, Robbins' interest in the site and engagement with the scientific community continued. In 1958, he recorded that "Professor Uhlig and I went to Saugus and dug up modern metals that we buried near the S.E. corner of the furnace on Wed. May 6, 1953."[34] The archeologist and the MIT scientist shared the intellectual excitement of evaluating the condition of these test artifacts. This same sense of inquiry and commitment drove Robbins to seek out the best artifact treatments available from the emerging field of scientific museum conservation and apply them to the emerging field of historical archeology in the early 1950s.