Society for Industrial Archeology · New England Chapters

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CONTRIBUTORS

Dennis Howe, James L. Garvin, Bill Gerber, James H. Johnston, Jonathan Kranz, Martha Mayer, Ellen Remlinger, Sara Wermiel

NORTHERN CHAPTER OFFICERS

Dennis Howe, President
David Coughlin, 1st Vice President
Victor Rolando, 2nd Vice President
David Starbuck, Secretary
Carolyn Weatherwax, Treasurer

SOUTHERN CHAPTER OFFICERS

Jonathan Kranz, President
Martha Mayer, Secretary
Bob Goodwin, Treasurer

EDITOR

David Starbuck
PO Box 492
Chestertown, NY 12817-0492
starbuck@netheaven.com

Call for Papers
the Eighteenth Annual Conference on
New England Industrial Archeology
to be held on Saturday, February 18, 2006
at Plymouth State University,
Plymouth, New Hampshire

Papers are invited for presentation to the 18th Annual Conference on New England Industrial Archeology to be held on February 18, 2006 at Plymouth State University.

The conference is an annual project of the Southern and Northern New England Chapters of the Society for Industrial Archeology, which alternately sponsor and co-host the meeting with the host institution. The purpose of the conference is to encourage the study of the material culture of our industrial past, and exchange information on all aspects of our industrial heritage.

Papers with a strict thirty-minute time limit may describe field investigations and other research and findings concerning such topics as structures, machinery, industrial sites, manufacturing processes, technology, labor, etc. Also, reports on efforts at conservation, restoration, rehabilitation, public education or advocacy programs are welcome. Topics relating to typical New England industries are encouraged but not absolutely necessary to be included in the program.

Persons who wish to present a paper are asked to send by either USPS or E-mail an abstract and title, along with a short biographical note about the author by January 10, 2006 to:

Dennis Howe, Paper Chair
22 Union Street
Concord, New Hampshire 03301-4250
(603) 224-7563
E-mail: earlyhow@verizon.net

SNEC President's Report

On Saturday, September 24, SNEC members gathered in New London, CT for a combined event and business meeting. The tour, organized by SNEC secretary Martha Mayer, was an insightful and thoroughly enjoyable visit to a number of New London landmarks including the Hopsin-Chapin building, the Northeast Corridor RR swing bridge, the Custom House, additional highlights on Bank Street, Union Station and the jewel in New London's crown, Fort Trumbull. At Fort Trumbull, we were treated to an illuminating presentation by Paul McGinley whose firm, McGinley Kalsow and Assoc., had directed the fort's restoration. The chapter is deeply grateful to Martha, Paul and all the hosts who contributed to a terrific event.

At the business meeting, the following slate of officers were re-elected to another one-year term: Jonathan Kranz as president, Martha Mayer as secretary, and Bill Goodwin as Treasurer. According to Bill's comprehensive and exceptionally well-organized report, SNEC year-to-date expenses were $5,873.68. Our income, primarily for dues, came to $5,190.46. We have a Fidelity Cash Reserve balance of $5,484.18 and a checking account balance of $4,795.62.

Members agreed, by voice vote, to a membership dues amount of $18, reduced to $15 for those who respond to the membership renewal mailing by January 31. We also agreed to a special new member's introductory discount of $10.

We reviewed the year's activities, which included:
• The 18th Annual Symposium on Industrial Archeology in the New England Area, organized by Bob Stewart and held at the Higgins Armory on February 19;
• The April 15 Chelsea Tour of Chelsea Clock, the Tobin Bridge, and the old Naval Hospital grounds, organized and conducted by Sara Wermiel;
• The May 14 visit to Old New-Gate Prison and Noble & Cooley Drum Company, hosted by the Jones family;
• And the September 24 New London tour organized by Martha Mayer.

On behalf of all chapter members, I want to thank all the hosts and volunteers who made these events so successful.

At the meeting, I also announced a new upcoming event, a tour of the historic aircraft and automobiles at the Collings Foundation in Stow, MA on Saturday, October 22.

Members were (and are) encouraged to invite friends and colleagues to become members of SNEC. I also announced that I would put together a chapter website this year.

Jonathan Kranz

NNEC President's Report

The Northern New England Chapter held its Annual Meeting on October 15, 2005, at the American Precision Museum in Windsor, Vermont, where the members voted on a change in chapter officers. Betty Hall will not continue as first vice president due to her pressing responsibilities as the President of the New Hampshire Archeological Society. David Coughlin will move from second V.P. to fill Betty's position. Victor Rolando was elected to the second vice president position. The other officers will continue to serve the chapter in the same rolls as before: Dennis Howe, President; Carolyn Weatherwax , Treasurer; and David Starbuck, Secretary. Prior to the meeting, members toured the renovated museum and witnessed demonstrations of many of the early machines in the museum's large collection. Sue Richardson (NNEC-SIA), who serves on the museum's board, presented a slide program featuring archeological excavations of the remains of an early grist mill that once operated near the museum. The meeting was followed by lunch at the Harpoon Brewery and a visit to the glass-blowing works of Simon Pierce.

The chapter will host with Plymouth State University the 18th Conference on New England Industrial Archeology on February 18, 2006. A call for papers is contained in this newsletter. I volunteered to be the paper chair and David Starbuck is coordinating at the University. Please feel free to submit a proposal for a paper. The conference always features non-professionals and professionals in the program. It is the opportunity to share research that is considered important.

The spring tour of the NNEC will be held in the Burlington, Vermont, area, organized and planned by Victor Rolando. The program and date is to be announced.

Dennis Howe

The American Precision Museum, Windsor, Vermont

PIN-CONNECTED BRIDGE OF 1897 RECEIVES GRANT

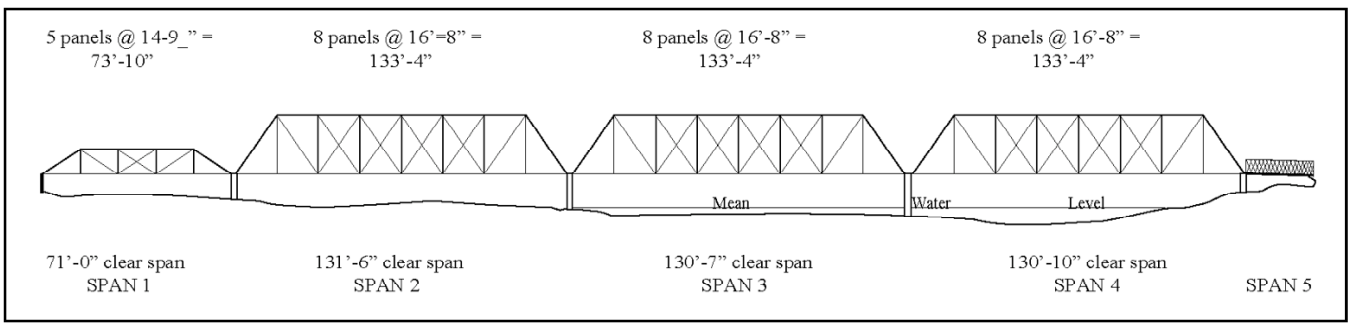
The Town of Shelburne, New Hampshire, has been awarded a $220,000 "Save America's Treasures" grant for rehabilitation of Meadow Bridge, which spans the Androscoggin River. Built in 1897 by the Groton Bridge and Manufacturing Company of New York, the steel Pratt truss bridge is pin-connected, utilizing massive bolts or "pins" instead of rivets to connect its structural members.

With a total length of 504 feet, the four-span Meadow Bridge is one of the longest pin-connected bridges ever built in New Hampshire, and is one of only a few dozen multi-span pin-connected bridges to survive nationwide. The bridge is supported by now-rare cylindrical steel piers rather than by a stone substructure.

Meadow Bridge was bypassed in 1984. By 2000, one of its four piers was being undermined by riverbed scour, causing two of the trusses to lean and twist. In 2003, recognizing the engineering significance of the bridge, the New Hampshire Department of Transportation offered to pay 80% of the estimated $1.4 million cost of rehabilitation if the town would raise 20% of project costs ($280,000) and assume ownership of the bridge after restoration.

This was a daunting challenge for a town of some 380 people, but the community partnered with the New Hampshire Division of Historical Resources (the SHPO) to nominate the bridge to the National Register of Historic Places and to apply for the "Save America's Treasures" grant. Meanwhile, NHDOT contracted with Chesterfield Associates of New York to move the two endangered trusses to temporary storage on the banks of the river.

In February, 2004, a single huge Manitowoc



Model 999 crane with a 160-foot boom picked up the two spans, each estimated to weigh 72,000 pounds before the removal of its wood plank floor, and placed the trusses gently on temporary steel trestles on each side of the river. The undermined river pier was later lifted from the bed of the stream.

One of only two “Save America’s Treasures” grants ever made for preservation of a bridge, the award will greatly enhance the ability of the little town and its allies to raise the remainder of the needed match. If fundraising and project mobilization follow the expected timetable, the bridge will be rehabilitated between the summer of 2006 and the autumn of 2007. With a grant from the New Hampshire Charitable Foundation, the Town of Shelburne and the staff of the North Country Council have also planned a recreational and interpretive park at one end of the restored crossing.

James L. Garvin

Middlesex Canal Musem

The several histories of the Middlesex Canal leave one with the impression that steam-engine powered towboats that were tried on the canal, were not successful, and the idea was abandoned. This is generally true for the canal itself but ignores the fact that, by 1815, the M'sex was part of a complex that totalled over 100 miles of canals and navigable waterways, most notably the Merrimack River.

My research about John Langdon Sullivan's steam tow boats presented at the fall meeting of the Middlesex Canal Association on November 13 suggests the development and use of these boats may have been much more extensive, and may have continued considerably longer, than earlier historians understood. The several "generations" of hull and engine combinations that were tried, their configurations, how they were used, and the extent of success (or lack thereof) achieved involved collaboration with engine makers Oliver Evans (of Philadelphia. PA) and Samuel Morey (of Orford, NH), and others. Many patents were issued as a result of development. Efforts were made to employ towboats on other rivers (e.g., the Connecticut and some southern rivers).

The Middlesex Canal Museum is located in N. Billerica, MA.

Directions to the museum: From Route 3, take exit 28, Treble Cove Rd. Turn towards North Billerica and follow the brown signs. And/or at about 3/4 mile bear left at a fork. After about another 3/4 mile cross Route 3A at a traffic light. Go about 1/2 mile; bear right, then turn right onto Old Elm St. (becomes Faulkner St.) Go about 1/4 mile to where the road crosses the Concord River, by the Mill Dam. The Museum & Visitor Center is in the Faulkner Mill on your left. You can park across the street on your right, just beyond the falls.

Bill Gerber

Editor’s note: This article was modified to the past tense from Mr. Gerber’s original submission because his presentation occurred before the publication of this newsletter.

SNEC Tours New London, CT

Prior to its annual meeting, The SNEC conducted a walking tour in New London, CT, on September 24. This account provides a summary of the day and brief descriptions of the architectural highlights.

The tour included stops at four historic structures located along the historic harbor area from Shaw Cove to the middle of downtown: the Hopsin-Chapin Factory Building (1885) at 69 Hamilton Street; the US Custom House (1833) at 150 Bank Street; a former warehouse at 84 Bank Street (predates the Custom House) and Union Station (1888). The annual SNEC meeting was held in former barracks at Fort Trumbull (1850), now a modern conference center. The variety of design and construction among these buildings provides a good sense of the rich architectural heritage that New London possesses.

New London historian, Sally Ryan, accompanied SNEC members during the morning; she provided background on the history of the city and on Bank Street architecture as the tour proceeded. Private owners who graciously permitted access to their property were the following people:
Robert Wildes for the Hopsin-Chapin Building;
Charlotte Hennigan for 84 Bank Street; and
Todd O'Donnell and Barbara Temkin for Union Station.

The New London Maritime Society provided a tour of the Custom House. Arrangements with the Connecticut Department of Environmental Protection, which manages the Fort Trumbull State Park, included use of the conference center for a pot- luck lunch and access to the restored Fort and Visitor Center.

Hopsin-Chapin Building. Richard Gipstein, an architect (AIA) who previously studied the structure, provided an account of the structural system for the remaining building at the Hamilton Street site. He worked with New London Landmarks, Inc., a conservation, preservation and revitalization organization (newlondonlandmarks@hotmail.com), in completing the Historic Resources Inventory that listed the building with the Connecticut Historical Commission.

Hopsin-Chapin Manufacturing Company .
Photo by Sara Wermiel.

The Hopsin-Chapin Manufacturing Company made hot water radiators and boilers at a block long foundry and machine shop erected in 1885 across the street from Shaw Cove. The facility is depicted on a 1911 Aero View of New London (Library of Congress, American Memory, http://memory.loc.gov/ammem). What remains now is less than one half the length of the original structure. A conventional post and beam floor

Arch formed with 15 nailed laminations of one-inch thick (nominal) lumber.
Photo by Sara Wermiel.

structure has been inserted under the original laminated wooden arch construction. Otherwise, little has been altered.

A large open factory space (approximately 70 ft. wide) with a vaulted roof and clerestory was created by fabrication on-site of wooden arches.

These were formed with 15 nailed laminations of one-inch thick (nominal) lumber. The arches are spaced at approximately eight-foot intervals and positioned on large concrete bases at each end; they are 6.5 ft wide by 13.5 ft. deep. The roof deck is supported by 2x8 purlins spaced at 24 in. on center, perpendicular to the arches. A monitor roof runs the entire length of the vault to provide light and ventilation; it is conventionally framed with wood studs, rafters and diagonal bracing. (The weight of the roof monitor has caused deflection at the top of the arches, where flattening of the curve is noticeable.) The roof profile is completed on both sides of the arches by small shed roofs Twelve inch thick brick walls enclose the building.

The post and beam structure under the arches creates a second floor level supported by 2x10 floor joists spaced 16 in. on center. The joists are supported by paired 3x8 carrying beams at each arch bay that are in turn supported by a series of 8x8 wood posts with flared wood capitals. The carrying beams are the main support for the second floor and also act as tension members to counteract the horizontal thrust of the arches. For this function, the butt joints where the beam sections meet are connected with thru-bolted metal tie plates. The beams are also thru-bolted there they cross the arches to withstand the tensile forces. The first floor is a concrete slab-on-grade of unknown thickness.

The resulting framing system is a stable, self-supporting structure with a long span upper level, capable of supporting heavy floor loading. The current use of the building is for storage of lumber and other construction supplies in support of a yard in business across the street where water once flowed. Shaw Cove has been reconfigured/filled significantly since the construction of the Hopsin-Chapin building, as has New London harbor in general.

US CUSTOM HOUSE. The building has been in use by customs officials since 1659 and serves today as the oldest operating customhouse in the country. Roberts Mills, the first federal architect, designed this classic Greek Revival granite building. Among his other works are the Washington Monument and the US Treasury Building, both in Washington, D.C., and other New England customhouses (Newburyport and New Bedford).

Originally adjacent to the Thames River, the

Vaulted ceiling in basment of US Custom House. Photo by Sara Wermiel.

cruciform design in the basement and sub-basement produced four sizeable storerooms on each level. This allowed storage of incoming goods and contraband. Mills included vaulted ceilings throughout the building, including the basements. The comers in each stone storeroom are not square, but present a diagonal face. One rationale for these features is strength, due to the vulnerability of the structure to flooding.

Exterior doorways on the eastern and southern sides would have allowed access to vessels tied up adjacent to the building. Currently, due to fill and reconfiguration of the harbor, the Thames is a block from the Custom House. A new exhibit at the Custom House includes design drawings for the building and 19th century photographs that allow comparison with the current harbor configuration and appreciation of the changes that have occurred since the time when New London was the second largest whaling harbor in the country.

Among the design highlights at the Custom House are the substantial front doors made with live oak from the USS Constitution. In addition, the flying staircase between the first and second

Cantelever stairs. Photo by Sara Wermiel.

floors appears to project from the wall with no other support. However, each step is notched into the one below it. This distributes load appropriately and the entire SNEC group made the ascent and came back down, no problem.

The Custom House is open Wed-Sun, 1-5 pm and by appointment (860-447-2501)

84 BANK STREET. This early 1800 stone structure has seen many renovations since its original use as a harbor warehouse. The brief stop during the walking tour was to show the latest successful iteration and allow comparison with the Custom House basements. Occupied by a wine and spirits shop now, the walls of the single cavernous stone basement room are exposed and show evidence of a stone extension to the riverside of the original building. The openings in the original riverside wall add to the sense of strength conveyed by the general design. The current combination of simple, but dramatic design and the utilitarian use of space to store and display stock appear to contribute to the success of a young business that is known in the New London area.

UNION STATION. This was H. H. Richardson's last station he died two years before its completion in 1888. The massive brick structure with hip roof and Romanesque details dominates the view for those approaching by land, water or rail. Through

New London Union Station. Photo by Sara Wermiel.

the leadership of New London Landmarks, in 1975 the station was saved from demolition and underwent extensive restoration. Currently involved in a land-use dispute, the building anchors a transportation center that links trains (Amtrak) and buses (Greyhound) adjacent to ferry boat connections to New York, Rhode Island and Massachusetts. Todd O'Donnell conveyed some 20th century history about use of the building by Cold War defense contractors and described the continuing challenges to maintaining the structure as changes occur on neighboring property. He provided a tour of the station interior, including modern offices sandwiched between the original upper floors.

FORT TRUMBULL. This third level defense project was constructed from 1839 to 1850 as part of a national coastal defense system under George Cullum of the US Army Corps of Engineers. Granite obtained from nearby Millstone Point quarries was used to build the Egyptian Revival fortress; an irregular pentagon with projecting ramparts.

The existing fort stands at the end of 230 years of military history. After continuing harbor defense and the start of the US Coast Guard Academy, work concerning anti-submarine research and technology was undertaken at Fort Trumbull during the Cold War. In the mid 1990's the Underwater Sound Laboratory was closed as the Navy focused its efforts in Rhode Island. The State of Connecticut restored the Fort and the asso-

ciated waterfront to create a State Park.

SNEC life member Paul McGinley was involved with the Fort restoration project. During the September 24 meeting, he provided an illustrated presentation on the work with photos of conditions before, during and after the project. He described the delicacy in removing 20th century trappings from a 19th century setting. In the end, however, the tight, secure status of the Underwater Sound Laboratory during the second half of the 20th century preserved Fort Trumbull. As a result, the now restored Fort is in excellent condition. Displays on 19th century artillery and living quarters and Cold War R&D convey the history of the Fort in situ. The adjacent Visitors Center provides multi-media interpretations and presentations on the full story of the Fort.

The Fort and Visitor Center are open Wednesday through Sunday from 9am to 4pm from Memorial Day through Columbus Day. The Park grounds are open from 8 am to sunset. The fishing pier is accessible 24-hours a day. (http://dep.state.ct.us/stateparks/parks/fort_trumbull.htm)

Martha Mayer

SNEC Visits Old New-Gate Prison and Noble & Cooley Drum Company

On May 14, approximately fifteen members of SNEC SIA visited two sites near the "tooth" that bites down from the Bay State's border into northern Connecticut: Old New-Gate Prison and Copper Mine in East Granby, Connecticut and Noble & Cooley Drum Company just up the road in Granville, Massachusetts.

Site supervisor and museum assistant Lance Kozikowski served as our guide through the copper mine and prison, located on a beautiful bluff overlooking 475 acres of wildlife refuge. First developed as a mine in 1705, the site proved economically unsuccessful; the obligation to ship the excavated ore to England for further processing undermined the commercial viability of the operation. After the Revolution, the lack of a water source for power made large scale smelting operations impossible.

In 1773, the warren of underground tunnels was selected as an "enlightened" punishment alternative (to severed hands and such) for convicted criminals. The original intent was for the prisoners to earn their keep through mining -- in fact, their sentences were often extended so that they could earn enough to cover keep plus court costs. But the mining tools at their disposal also proved to be handy instruments for escape; in later years, prisoners made nails instead.

Today, the sandstone mine walls are streaked with tell-tale signs of copper. Navigation is tricky, requiring sure feet on wet ground that slopes at steep angles to follow the copper veins. Despite slick floors, narrow passages and continued reminders of the risks of radon poisoning, we pressed forward. Lance noted that the constant 52˚ F temperature discouraged the growth of viruses and bacteria, so we, like the prisoners who proceeded us, were exposed to little risk of contracting TB.

Noble & Cooley Drum Company was born in 1854; the current location has been in operation since 1889. Jay Jones, who owns Noble & Cooley with his mother, Joyce, walked us through different yet complementary processes: the construction of world-class professional-quality snare drums and the creation of toy drums for the retail market.

The snares begin life as hard sugar-maple logs that are cut into planks which are scarfed (tapered) at each end then steamed overnight in what looks like an oversized autoclave. (Jay had to stomp on the door wheel with both feet to open it!) The steamed planks are put on a bending machine; the resulting circular drum bodies dry for 3 - 4 days within appropriately sized forms before completing their drying within wax-lined sections of Sonotube for 8 - 12 weeks. In all, a Noble & Cooley snare drum requires 37 distinct operations before completion.

Jay demonstrated a number of unusual and

interesting tools, including an 1890 rotary veneer cutter -- belt driven -- that can handle a log as long as 42" and us much as 36" in diameter, and a E.W. Bliss guillotine cutter. But the star of the show was the 1926 8-color litho press with automatic inking used to print patterns on the tin bodies of toy drums. A unique and advanced tool in its day, the press uses pattern rolls that date back to 1914.

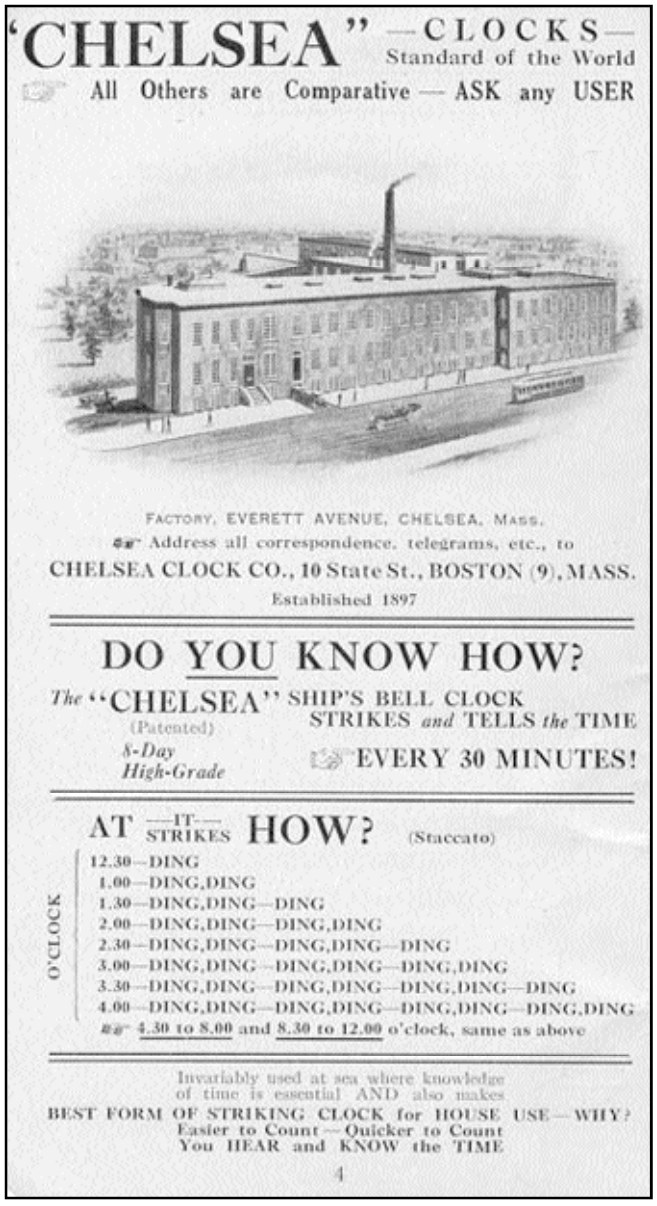
Once printed, the metal sections are embossed, curled, locked into a circle then placed in a vertical roll former to roll back the sharp edges before receiving their Mylar drum heads. While the company maintains an inventory of toy drums, competition from China, combined with price pressures from large retailers like Wal-Mart and Toys-R-Us, makes future toy drum manufacturing uncertain.

Jonathan Kranz

Report on SNEC-SIA Tour of Sites in Chelsea, MA, April 15, 2005

The tour included the factory of Chelsea Clock Company; offices and maintenance garage of Massport's Tobin Bridge; and several buildings on the old U.S. Naval Hospital grounds in Chelsea, Massachusetts. From research I've done on architect-engineer Alexander Parris and a survey of industrial sites in Chelsea I completed some years ago for the Massachusetts Historical Commission, I found some neat places in Chelsea and have wanted to show people a few highlights ever since. Since my survey, one site – Strahan wallpaper company – has folded and several other buildings have been demolished. It seemed that this tour had to happen now or never, so I organized it.

First stop, Chelsea Clock Co., which manufactures a variety of styles of clocks and barometers today, but its most famous product is and has been the analog, manual ship's bell striking clock. The company still occupies a factory at 284 Everett Ave. in Chelsea, which Joseph Eastman built in 1896 after Chelsea businessmen persuaded him to move his clock-making from Roxbury (original building still standing, plus a 1942 extension and smaller additions). Eastman quickly failed, and the following year, under Charles Pearson, Chelsea Clock Company was organized. There was a market at the time for novel sorts of clocks, and Chelsea Clock Co. was the first to introduce one that struck ship's bells. This happened after Eastman lost the company; nevertheless, one chronicler of the firm suggests that his clock designs, along the with factory, "marked the



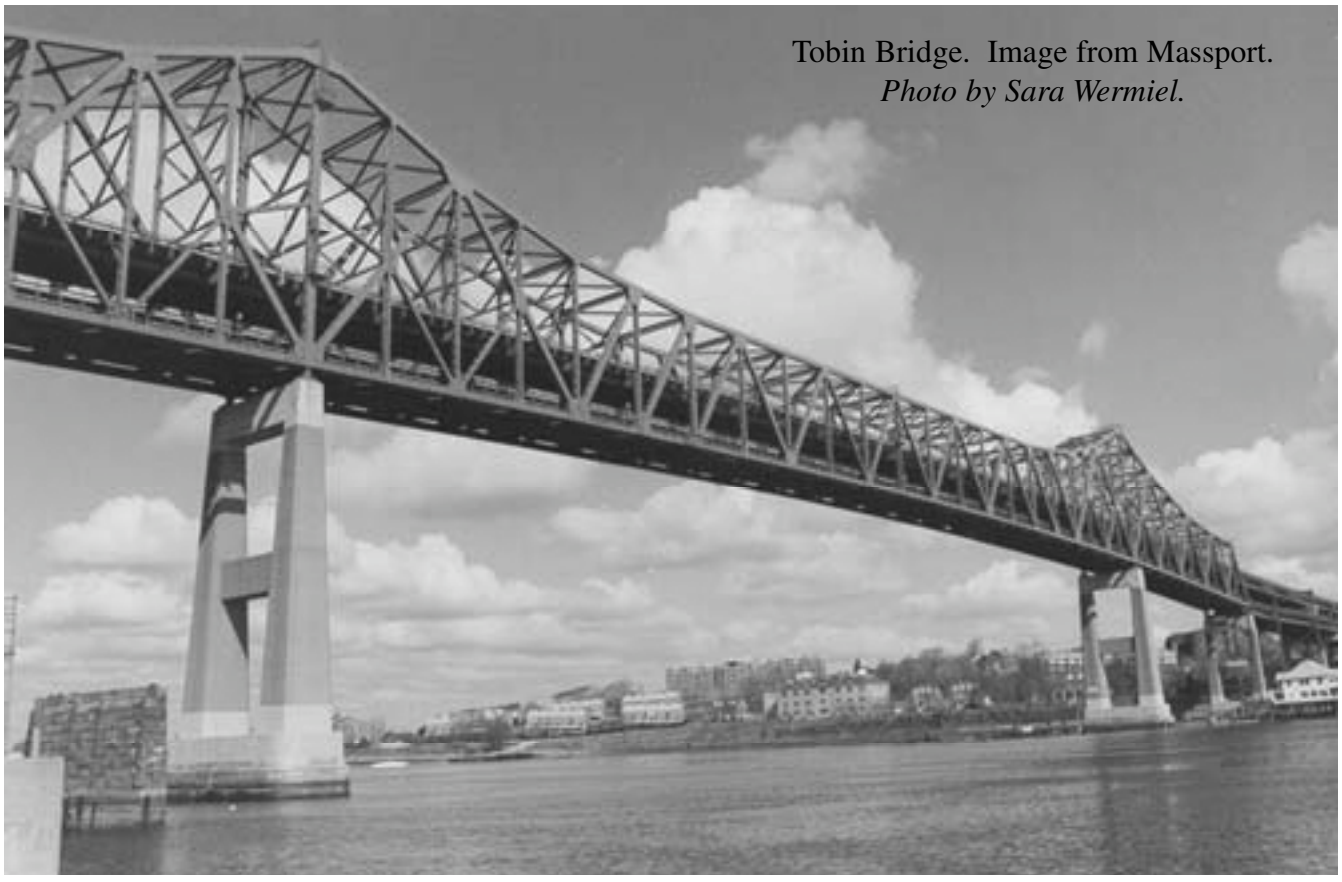
From a 1920s Chelsea Clock Co. catalogue.

physical and technical beginnings of the Chelsea Clock Company." But it "was the business talent of Charles H. Pearson" that sustained the new company. Over the years, the company made a great variety of clocks, and timing and measuring devices. Its manual time-only clocks were widely used on ships and by the federal government. The company has only a small staff today compared to past times and repairs as well as manufactures clocks. A website with information about the company's history (and source of the quote above) is http://www.chelseaclockmuseum.com/index.html

On our tour, we first saw how brass cases of the clocks were made. A worker fed rough-form clock cases into an automatic milling machine, which ground the brass to the size required. Next we saw a room filled with ancient-looking machines that made tiny clock parts. In the face-making department, the faces for the high-end ship's bell clocks were made to exacting standards. A worker demonstrated how a face was silvered and showed us what was considered a defect, which was practically invisible to a layperson. All these operations took place on the ground floor; parts were transported by a dumbwaiter to the assembly rooms on an upper floor. There we saw workers assembling new clocks and repairing old ones. We met a woman who specializes in putting together ship's bell clock movements who has been working for the company for over 50 years.

The next stop on our tour was the Tobin Memorial Bridge. Spanning between Boston (Charlestown) and Chelsea and carrying Route 1, the bridge opened in 1950. The main structure is a cantilevered truss, 1,525 feet long. The part crossing the Mystic River includes an 800' uninterrupted center span. Its two decks, each with three travel lanes, are stacked one above the other, the northbound deck on the bottom and southbound on the top.

First we visited the bridge's maintenance facility, which is located near the Chelsea end of the bridge. It is here that the trucks and equipment workers use to inspect and maintain are stored.



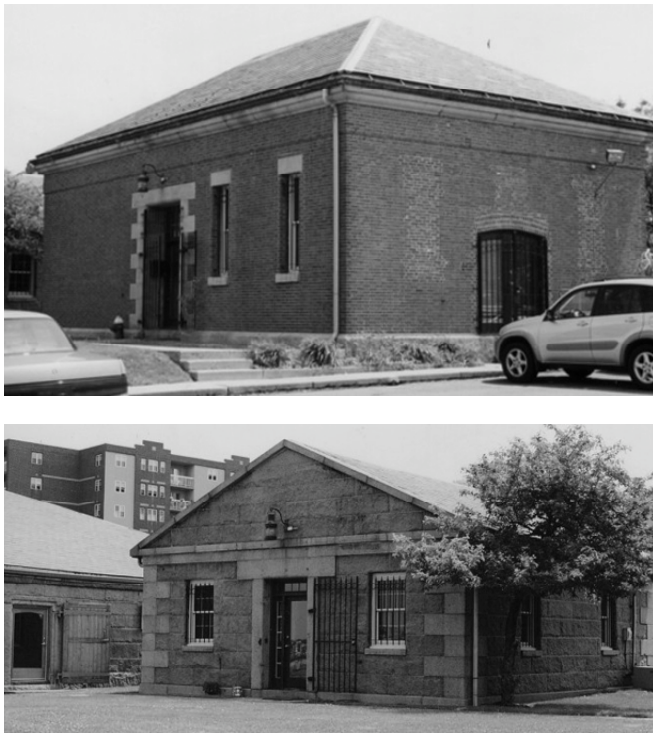
Tobin Bridge. Image from Massport.
Photo by Sara Wermiel.

The most notable thing about these trucks is their enormous size. One truck had a bucket on an articulated arm that could maneuver inspectors so they could see under the bridge deck.

Next we crossed the bridge to the Boston side and snaked our way to a parking lot under an approach to the bridge. Here we took the elevator to the bridge offices. Yes, the administrative offices are in the air, hanging from the upper deck, underneath the toll plazas. The bridge manager presented a slide show about the bridge and its history. Originally called the Mystic River Bridge, it was built by an independent authority and financed by revenue bonds, which are paid off with tolls. Charles A. Maguire & Assoc. of Boston and J. E. Grenier Co. of Baltimore designed the bridge. The slim (36' wide road width), double-decker design was chosen to reduce the amount of land that had to be acquired and the number of people displaced. As it was, many homes were taken; many of these were actually moved to other lots in the city. After the slide show, we went to the upper deck to see the toll plaza and a counting room, where the income from this veritable cash machine is briefly stored.

One memorable story we heard was about a meeting some of the Tobin Bridge staff had with colleagues in San Francisco. During the meeting, the San Francisco people became alarmed; "did you feel that?" they demanded to know. The Tobin people, so accustomed to vibration in the offices on the bridge, hadn't noticed an earthquake.

The last stop on our tour was the old Naval Hospital grounds in Chelsea. Between 1832 and 1836, the U.S. Navy built a hospital for enlisted personnel on a hill surrounded by the Mystic River and Island End River. Alexander Parris was the architect of the hospital (it is the large building in the center of the picture of the Tobin Bridge). Later, a marine hospital (for civilian seamen) was built further up the hill; over the years, a large hospital complex developed. In 1940, the marine hospital moved to a new location, and finally, in 1974, Chelsea Naval Hospital closed. The site, now called Admiral's Hill, has been extensively redeveloped for residential use



Ordnance buildings, Chelsea.
Photo by Sara Wermiel.

Fortunately, several significant buildings survive, and we visited these. Part of the hospital grounds, along Island End River, had been used by the Navy to store ordnance, and three historic ordnance buildings are still standing there. One is Alexander Parris's 1834-37 magazine (see my article on Parris in the last SIA NEC Newsletter, vol. 26 no. 1, 2005). The owner would not allow us inside to view the vaulted ceiling. But the friendly owner to two adjacent, roughly contemporaneous buildings did let us in; one of these has a groin vaulted ceiling.

Our group continued the tour on foot, passing Parris's Naval Hospital, which has been converted to residential condos, and then bushwhacked our way up a hill to the 1855-57 marine hospital. Designed by Ammi Young, then Supervising Architect of the Treasury Department, this building is fireproof, and the floors throughout the building are made of iron beams and shallow brick arches. We were able to see the arches in a condo,

which a friendly resident let us in. The building has a fine cast iron arcade on its south side, and an ugly Mansard roof that was added in the 1860s.

The buildings at the old Naval Hospital grounds can be seen from the outside and are worth a stop when you are next in Chelsea.

Sara Wermiel

Interior of Alexander Parris's powder magazine: granite post supporting ribs and shallow domed vaults. Photo by S. Wermiel

Plymouth Cordage Museum

PLYMOUTH, MA - THE MUSEUM IS OPEN. Beginning this October the Plymouth Cordage Museum opened to the public every Saturday and Sunday throughout the year from noon. to 4 p.m.

The museum brings to life a time when Plymouth was the major player in the rope industry. Ships off-loaded huge bales of hemp and sisal from Mexico, Haiti and Cuba at the Cordage dock and human 'spiders' spun the raw material into rope.

The majority of employees, known as operatives came from Germany, Portugal and Italy. Because of mix of languages and the din of the machinery that surrounded them, they developed a unique sign language. The museum is trying to locate former employees, or their families, who may be able to share that sign language so that piece of history can be preserved along with the large collection of memorabilia at the Plymouth Cordage Museum.

Don't know what a human 'spider' is? Drop by the Museum and find out.

The Plymouth Cordage Museum is located in the Tower Building, 10 Cordage Park, Plymouth, off Route 3A. Open Saturdays and Sundays from noon to 4 p.m. handicapped accessible. Donations accepted but admission is free. For information and to pre-schedule a tour during the week contact Ellen at 508-746-7707 or visit www.plymouthcordagemuseum.org.

Ellen Remlinger

MARK YOUR CALANDER

Eighteenth Annual Conference on New England Industrial Archeology

Saturday, February 18, 2006 at Plymouth State University, Plymouth, New Hampshire

Franconia Blast Furnace Retrospective

Franconia, NH, blast furnace. Photo by Emil Koller.

On July 16, 2005, the Northern New England Chapter celebrated the 200th anniversary of the Franconia, New Hampshire, iron industry. The celebration included a program of speakers who presented a retrospective of the research of the surviving blast furnace that was led by Victor Rolando in 1994-1996, a history of early iron making in America, a tour of the furnace site and demonstrations of iron working by skilled blacksmiths.

Sponsors of the event and participants involved in the planning and implementation included the Franconia Area Heritage Council; Jewell Friedman, Curator at the Iron Furnace Interpretive Center; Roger Aldrich; Don Eastman; Bob Hall; the New England Blacksmiths Association and the Northern New England Chapter.

About fifty people attended the event. James Johnston (SNEC-SIA) described for them his research in 17th century iron making and the distinctions between bloomery forges and blast furnaces. Dennis Howe (NNEC-SIA) related his experiences with the 1994-1996 recording project at the blast furnace and the importance of IA. Blacksmiths David Court, Courtney Mead and Jennifer Stackpole demonstrated how iron was formed into tools, hardware and other useful forms with heat, hammer and anvil.

The blast furnace represented by the remains seen today on the west bank of the Gale River was constructed in 1859 with split granite, lined with refractory brick and bound together with horizontal iron bars. The furnace was one surrounded by wooden buildings where the molten iron was formed into pigs. The wooden structures burned in 1884 and the works were abandoned. The first iron making began in Franconia c. 1805 and the first blast furnace was erected about 1811. At succession of stacks were constructed and/or rebuilt by the iron company prior to the extant 1859 furnace.

A copy of Rolandos research report is on file at the New Hampshire Division of Historic Resources or the New Hampshire Historical Society Library. Both are located in Concord, NH.

Dennis Howe

James Johnston, metallurgist, and David Court, Blacksmith. Photo by Emil Koller.

The New Palmer River Iron Works

Summary
Blast furnaces, bloomeries and forges were not encouraged by the British in the late 17th and early 18th centuries. The New Palmer River Iron Works, not counted in the official tallies, began making wrought iron from bog ore in 1721 This bloomery apparently used up much of its bog ore around 1735, experimented with mountain ores from nearby Cumberland, and ceased operations as a bloomery in 1757. It was located in Rehoboth, a Town within Old Rehoboth, lying in the Southeastern part of the Massachusetts Bay Colony, between the bog ore swamps, the lake-bed ore sites, and the mountain ore sites of Cumberland, (then part of Old Rehoboth and now part of Rhode island). Land Deeds, citing shareholders, included lists of the buildings and equipment, from which capitalization costs have been estimated. Although the site has been disturbed by State road construction, evidence for the Cumberland connection exists today at the site and is supported by deeds defining shareholder changes, with a change in ownership at the time of Cumberlandite tests. Part of the site has been preserved by the present day Town of Rehoboth.

Blast furnaces and Bloomeries
The early 1700's were marked by substantial growth in the number of blast furnaces making cast iron in the Southeastern Massachusetts Bay Colony. There were 10 blast furnaces during the 1700 to 1730 period, all in the Southeastern Massachusetts Bay Colony. During that same period, the number of officially counted bloomeries in the same area numbered 19 (Ref 1). Initially, both the blast furnaces and bloomeries were using iron bog ore gathered from the swamps of southeastern Massachusetts. Local people knew that cranberries grew in the iron bogs, and thus after the blast furnaces died out, and there was a market for cranberries, the iron bogs became the preferred sites for the first of our modern cranberry bogs (Ref 2). For example, Pope's Point furnace in Carver, Mass. is located in the middle of major commercial cranberry fields stretching for miles in all directions. Its 20 foot x 20 foot furnace foundation stones can still be seen, and there are still several large piles of slag nearby. It produced cast iron hollowware such as kettles and other kitchenware and survived until almost 1800.

Most early blast furnaces, i.e. those before 1750, that survived, as well as those that were newly built, changed to lake-bed ores. The swamp bog ore sources were being used up and it is possible that the iron quality was not the best, due to impurities. The numerous ponds in the area yielded thousands of tons dredged from the bottom with rakes. A few Southeastern Bay Colony blast furnaces such as Carolina and Lower Furnace in Cumberland[1] were using "mountain ores" such as magnetite (Ref1).

As far as is known, all of these early blast furnaces were physically large, typically 20 feet tall, and all involved major capitalization as well as prodigious operating labor to make charcoal and mine ores. A blast furnace takes 1-2 weeks to heat up and must then run 24 hours a day.

Cast Iron from a blast furnace cannot be hammered into bar or plate. It contains 4% to 5 % carbon and is brittle. Even so called "malleable" cast iron only survives hammer indentations and modest bending, not size reduction. Cast iron can be refined by burning out the carbon. The resultant wrought iron of this indirect process is generally ductile.

Bloomeries produce wrought iron by a direct process directly from ore. it contains up to 5% slag, which may be crystalline or glass, but is ductile. When stretched out into bar or plate, it is essentially low-carbon steel with stretched-out slag or "fiberglass" in it: bend it to breaking and the fibrous structure can be seen. Iron or steel, made by fire refining to remove carbon from cast iron, also substantially eliminates most of the fibrous slag. There really isn't much difference between iron without slag-glass, and low carbon steel, but iron masters of that era thought of steel as something stronger and sometimes heat treatable due to higher carbon content and less slag.

Bloomeries in southeastern Massachusetts made wrought iron in a small furnace or hearth directly from swamp bog ore, and later from lakebed ore. Swamp bog ore typically contains under 18% iron, so there was a lot of residue. Lakebed ore generally contains around 40%. Mountain ores and lakebed ores may contain as much as 66% iron, but the bloomery process needs slag to help protect the iron from the air blast and to soak up impurities. So, some slag components were sometimes added to mountain ores, and then the product was similar to iron made with lower iron content.. The early hearth for refining from cast iron, was also small but necessarily different in design, involved little or no slag, and was conducted by means of an air blast near the surface where an operator could watch the refining process. Typically a wrought iron furnace or hearth for the direct process is 1/10th the size of a blast furnace, say 2 feet high, uses 1/10 the air blast, and can be shut down at night, requiring only 2-3 hours to heat up in the morning instead of a week or two The essential physi-

cal difference between blast furnaces and bloomeries, besides size, is that reduction to iron occurs above the air blast in the blast furnace but below the air blast in bloomeries. These differences drastically affect carbon content, which is very high in cast iron and low in wrought iron.

Whereas there were only three blast furnaces in the Massachusetts Bay Colonies prior to 1700, there were six documented bloomeries (ref. 1), including two by Joseph Jencks Jr. (ref. 3). As noted above, there were 10 blast furnaces in the Bay Colonies during the 1700 to 1730 period. During that same period, the number of bloomeries, on the list submitted by the Governor to the British Board of Trade, in the Massachusetts Bay Colonies numbered 20, including that of Joseph Jenck's son, Nathaniel, in what is modern day Pawtucket. The Board of Trade count in 1758 was 12 blast furnaces and 23 bloomeries, but that was the official report for British consumption. However, the ratio of two bloomeries to one blast furnace held for all 3 reports. In fact there were many more bloomeries not counted. This is a fact that is not surprising, considering the 1719 British uneasiness and attempts to deny colonists from making shaped castings, and finished wrought iron such as nails and hinges (Ref. 3, p. 481 and Ref. 17). This British attitude was well known throughout the iron making community.

Deed and Probate records

The New Palmer River iron Works was one of these uncounted bloomeries. It shows up in registered deeds and probate records of early 1721, and was located in a remote area of Town, but it is not in Town Meeting records, in early historian's writings, nor in Bay Colony Board of Trade lists.

In a Probate Will record in 1721, Samuel Bliss left 29 acres to Nathaniel Bliss' fourth son, adjoining the "New Iron Works" lying on Palmer's River (ref. 4). A Proprietor's deed and later a Registry deed (ref. 5 and ref. 6)) conveyed 1/2 acre and then 1/4 acre of Solomon Horton's land, lying by the Palmer River Iron Works, to a partnership comprised of Jonathan Kingsley, blacksmith, Robert Carr, shipwright, Edmund lnguls[2], and Ebenezer Garnsey*, housewright. Hannah Carr, Wife of Robert Carr and later his executrix, inherited a 1/4 share/part of the Iron Works valued at £100 in 1721 (ref. 7). As executrix, she also purchased a 1/8th share of the iron works and its 2 1/4 acres of land from Edmund Inguls for £50, and cited riparian rights for 40 years commencing March 17, 1721 by lease from Bliss heirs (ref. 8). This 1/8th share remains unaccounted in later sales, and Aaron Kingsley, son of Jonathan and also a blacksmith, evidently acquired a 1/4 share/part from either Hannah Carr or Ebenezar Garnsey, as noted in a subsequent sale of their shares to a noted group of Boston investors.

In April of 1735, the two Kingsleys each sold their 1/4 part of the iron works and its land of 2 1/4 acres to a group from Boston comprised of Win. Bollan, gentleman, Henry Laughton, shopkeeper and Amos Wood, merchant (Ref. 9, Ref. 10). Jonathan, now 65 years old, sold for £8O and Aaron for £125. Richard Harding of Swansea also sold both his 2 1/4 acre interest, and the adjoining 22 acre piece with the iron works pond known as the "Beaver Pond" to them for £62, but no mention of any share in the iron works. Richard Harding states that he obtained title to the 22 acre piece from John Reed of Abbington, Mass (ref 11). The remaining 1/2 share of the iron works remains unaccounted for, as does the 1/8th share from Inguls to Hannah Carr.

Three months later, Bollan, Laughton and Wood sold all the land and all shares to William Jones of Rehoboth and Boston for £50 (ref 12). He died, leaving everything to his son ,John Jones (ref. 13), who was involved with a bloomery in Attleboro with the Sweet family. Under John Jones ownership, the Palmer River Iron Works evidently continued with limited operations until 1757. At that time, land, "Beaver pond, dams and canals, the old iron forge, house standing, hammer, anvil and tongs", were sold for £30 to Nathaniel Bliss, including "iron hoops over ye wagon wheels" (14). There was no mention of waterwheels or bellows. There is no further deed record of the iron works, except in 1853 when the then-current owner, Cyrus Wheaton, noted "the structure still standing" (15). An upstream dam failure, soon thereafter, probably swept the structure away, as it did other buildings downstream.

Investors Bollan, Laughton and Wood paid well in 1735 and then almost immediately sold at a substantial loss. After discussing buildings, equipment. costs, and archeological findings, this paper will then address the probable reasons for this apparent inconsistency, i.e. the loss, by knowledgeable iron merchant investors.

Buildings and Equipment

The Inguls to Carr deed is perhaps the most useful for determining the equipment on hand at the time of the riparian rights declaration. At that time, the New Palmer River Iron Works consisted of "anvil, hammer, bellows, bellows wheel, water wheel, iron barrs and tongues(tongs)"---, "house over the iron works, coal house[3], and dam with all stones and underwood"(ref 8). Later, in 1735, Jonathan cites "colehouses and colebarns (plural)" together with "dam and the pond" (ref 9), and Aaron makes it "dams" and adds a "dwelling house" (ref. 10). Merchants Bollan, Laughton, and Wood confirm the dwelling house in the sale to Jones. Then in 1757, when Jones sold to Bliss, there appears

the citation of "all edifices" including the "dwelling house now standing on the land!, as well as the "old iron works, forge, hammer, anvil, toiigs, stones, and all dams, canals and flumes, all appurtenances, and hoops on ye wagon wheels"(ref 14). However, there was no mention of either bellows nor waterwheels in this last sale.

Various technical factors attest to the design of the furnace or hearth, waterwheels, bellows and hammer, and also to the quality of the buildings. From personal experience, the author can state that a) it is not possible to make wrought iron with a continuous feed of wet charcoal in a short stack furnace or hearth, b) most people would not care to live with the amount of charcoal dust produced in a single smelt, much less on a daily basis, c) during startup, a charcoal furnace produces enormous quantities of carbon monoxide,enough to kill unless well ventilated, and d) the exhaust gas stack emits glowing charcoal particles with fire potential. As soon as the system is hot, in roughly 10 minutes, the exhaust or stack gas can be burned, but even then, the carbon monoxide level is significant. Wood roofing adequately resists the charcoal embers, but canvas, thatching, or wood with cracks between boards are vulnerable. Sturdy, well ventilated, cleanly roofed forge structures, and water-proof charcoal house structures were therefore a necessity very early, and indeed, as noted in the Cyrus Wheaton deed, a "structure" presumed to be the iron works building, survived into the mid 19th century. The "house over the Iron Works" also probably gave way to a separate dwelling very early, as Jonathan was married to Mary Cole and Aaron to Patience Cole, both from nearby Swansea (ref. 16) and both were daughters of another wealthy shipwright. Both families apparently lived at the site during the iron making season, or else the extra house was intended for hired help. These are significant factors in any cost study of iron works buildings.

Costs and Value

The author, with the help of colleagues, has roughly estimated the cost of the New Palmer River Iron Works as of 1720, as shown in table 1. The size of the ironworks was selected based upon an existing stone structure at the site. The "iron works with dwelling over it", and the cole house were then cost estimated based upon a modern day "barn raising" of a barn with post-and-beam construction. The water wheel and forge furnace estimates are based on actual experience in modern times making similar units. The bellows and hammer frame have been estimated by imagining their construction based upon typical drawings, piece by piece. Hammer and anvil are priced at going rates of cast iron of 40 shillings per 100 pounds of weight (Ref. 23). Evidently, the iron works had been running before and certainly would need a months worth of charcoal and ore by March 1721, so cost estimates include 5 tons of bog ore and 5 tons, or about 500 bushels, of charcoal required to smelt it. "Minor" details like nails, wood, leather, ore cart wheels etc. were probably not minor then, because they required hard cash. One of the bigger "minor" items was the expendable iron "nose" (tuyere or blast nozzle) for the bellows.

Actual costs are confused by the fact that housewrights Inguls and carpenter Garnsey became share holders. Edmund Inguls appears to have settled with Hannah Carr for £50 for an additional 1/8th share. They probably built the buildings and may have built the hammer frame, waterwheels, ore carts and other items but not the bellows nor the furnace/hearth: the latter were probably built by Jonathan Kingsley. This intrinsic cost reduction due to their participation, as craftsmen and carpenters, is ignored: instead, they are considered as being paid an average wage. The new house identified by Aaron Kingsley in his 1735 sale is not included. Incidentally, the iron works building was not quite finished by opening day, and Hannah Carr paid a carpenter £7.l6sh to complete it (ref. 7). This is included in the cost estimate, as it also happened with the modern barn, used as the cost model, too. Neither the land nor the water rights lease is included.

Conversion of labor costs to pounds sterling requires a judgment of typical wages. The following

	Labor, Man Months	Cash, British pounds, £
Anvil & Hammer @ 400 Lbs.	----------	£ 15
Iron Wrks w/ house over	16	£ 8
Hammer Waterwheel, 12 Ft.	12	£ 1
Hammer cam & lever	9	£ 5
Hammer Foundation	1	£ 1
Furnace/hearth	2	-----
Crib dam	10	-----
Mining tools & wagons	----------	£12
Tongs & tuyrers	----------	£ 3
Charcoal barn	5	-----
Bellows waterwheel, 4 Ft.	9	-----
Bellows(3) w/ crossover valve	12	£ 1
Dressed bellows leather	----------	£ 2
Reheat & forge hearth	2	-----
Canals & flumes	10	-----
Deadhead w/ pulley	1	-----
Misc. Materials (delivered)		
Timber	----------	£10
Rock	----------	£ 2
Iron Hardware	----------	£ 8
Rope	----------	£13
Prepare 1 month operation		
Charcoal, 500 Lbs.	----------	£8
Iron Ore, 5 tons	2	
	91	£91

TABLE 1
PALMER RIVER IRON WORKS COST RESULTS
Basis: 1720 deed descriptions. Not including land

wage data were found; reported or changed to shillings per month (sh/mnth) as follows. A family's son, loaned out, received 7 sli/mnth. Repair work by a craftsman ran 101 sh/mnth. One laborer received 25 sh/mnth for a short term 13 day job, and a collier making charcoal, got 60 sh/mnth (Ref 23). The author assumes that the Kingsleys and the two housewrights, Ingalls and Garnsey, each hired an assistant at 25 sh/mnth, and the author places the partners "wages" at 100 sh/mnth. Then the labor cost conversion figure between 25 shlmnth and 100 sh!mnth would average out to around 65 sh/mnth. The total is £296 for labor plus £89 cash or £384. This compares well with the total capitalization value of the four iron works partners at [400. So, even though there is confusion in the Carr will and probate about parts vs. shares, the figure of £400 is valid.

For orientation purposes, bar iron typically cost slightly over £2 per 100 pounds of weight, and cast pig iron about [2 per 100 weight. Forged items, such as forging tongs, typically cost 6 shillings per pound of weight, or a 3 times markup. Charcoal ran about 6 shillings per bushel (18 lb. per bushel, but 20 lb. per bushel in wet weather) in small quantities. Corn cost 3 shillings per bushel, and an entire farm, complete with house, barn and many acres could be bought for £30 (Ref. 23).

Operations at the Iron Works apparently focused on finished goods, particularly ship fittings and tools, wagon parts, and agricultural implements. They probably did not sell raw bar iron because swamp bog ore has a very low iron yield. The author has concluded that they would be doing very well to make a ton of bar iron per year, which would have sold for only about £45. It is very likely that they sold ship fittings and tools to Carr's shipyard. E. Nichols states that his grandmother, a Kinsley descendant, told him "don't lose the shovel, it was made here", and there were the "hoops on ye wagon wheels" in the last deed of sale. Most items were complex, as noted from Aaron's will evaluations, and may have been priced personally by Aaron before his death. After browsing through Aaron Kingsley's will and looking at the item values, the author guesses that the iron works income averaged £35 per month.

Twenty years of operations between 1735 and 1757, under John Jones, apparently reduced operations to the making of wagon wheels, a highly specialized craft but not a normal bloomery function, probably with decay of the water wheels, wearing out of the hammer, particularly the cam and hammerhead strap, and the end of the swamp bog ore at the site. The iron works apparently closed in 1757. There are no family history, deeds, nor written materials known to suggest otherwise.

Physical Evidence and Artifacts

Figure 1, a 1952 aerial photo which has been modified by the author, shows the approximate layout of the area in 1721. The white rectangle on the left is intended to represent the location of the iron works building. There is a low stone wall surrounding it, and it is owned today by the Town of Rehoboth, Massachusetts. In 1757, a town pound was declared at or near this building location, and its ownership has been confirmed with a right-of-way easement in modern times by new deeds (Ref. 24). Both past and present owners of the rest of the site are supportive of it. Although the stone enclosure around it may have been the iron works building foundation, it was rebuilt by the Boy Scouts in 1965. In fact, the foundation contains a modern iron staybolt for anchoring telephone poles inside one of the stone walls, so it is clearly not the original foundation, although it is probably the original stones and approximate placement.

There is a large, flat stone, about 2 feet by 4 feet, in the middle of the enclosed area. It has grooves about ? inch deep cut into it around its periphery. The intended use of the stone is unknown and the purpose of the grooves is not clear, but perhaps to help anchor timbers supporting the anvil.

There is a channel depression adjoining the south side of the enclosure, possibly for waterwheels, which

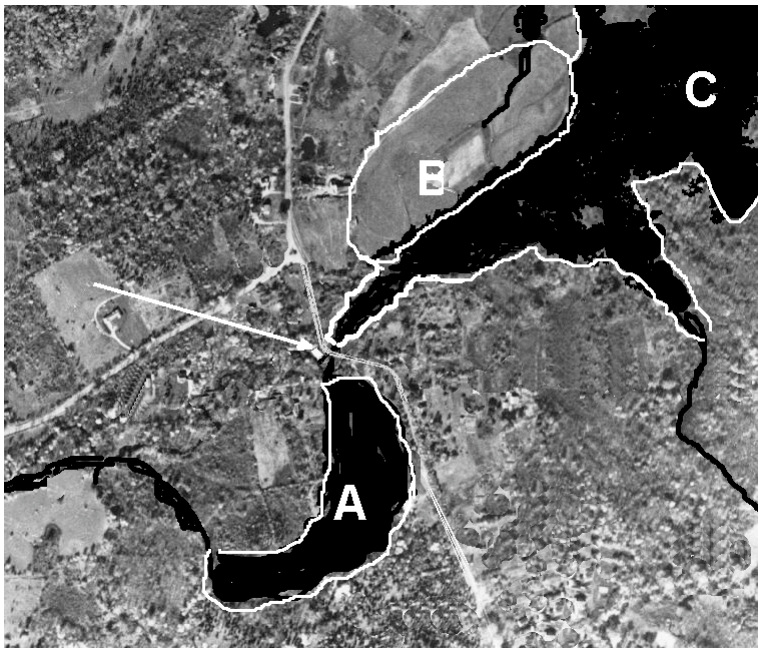


FIGURE 1. 1952 Aerial modified to 1721.
New Palmer River Iron Works Building at arrow.
Areas outlined in white identified as follow:
Early Iron bog mine---------"A"
Later Iron bog and pond ---"B"
Early pond area----------"C"

has not been explored.

An alternate location, upstream about 200 feet, is very unlikely as the iron works building. Deed descriptions, anchored by a large rock along the river, do not support it. It is a likely appearing site, but hydraulic head for waterwheels is lacking. Most stone work found in it today was placed there by a prior property owner in 1998. Large amounts of charcoal in the soil next to it are attributed to a former modern farmer[4]. However this particular site for the iron works building cannot be ruled out entirely, pending further archeological findings.

The large oval near the top of the photo of both Figure 1 and 2 was a bog ore area and a pond, as was the gray area south of the Iron Works. The "beaver pond" of deed reference was the blackish mess in the middle right. Either it or the oval served as a "fresh meadow" for hay when not ponded. Figure 2 shows the same aerial view from a satellite in 1995. The only alteration of this photograph is the white rectangle to provide orientation of the iron works location. The oval is about 1 1/2 mile around. This area was originally noted in the iron works deeds as an iron works pond on lease from Nathaniel Bliss, and then partially owned by one of the participants, Richard Harding. There are two hillocks in the middle of the oval, roughly at the centroids of each end. The author's father-in-law once described such features as evidence of a deadhead for clearing swamps or shore line; he having done so as a youth. A deadhead is a post with a pulley, around which horses could move outwards radially to scoop earth up into a circular berm, and return the scoop by means of the pulley. There are two kinds of bog iron ore in it even today, one with a chocolate brown lumpy appearance and another with a yellow-brown spongy feathery substance and much vegetable matter. There are also various patches of blue-black sand streaked with yellow in the clay along the banks of the river behind the oval. These have not yet been analyzed. In the 19th century, the oval was used as a horse trotting track, but it is not known which owner smoothed out the berm from mining into use for horses.

The West-East street, County St. today, in this second photo of Figure 2 did not exist in 1721, and was created sometime in mid 1700. Note the change in the river course This was probably done at the time of building the West-East street, and involved a significant reduction of hydraulic head available for waterwheels. An early Coast & Geodetic survey (1952) map shows a dug canal leading into the oval from a dam in the river upstream. Vestiges of the canal remain, but the dam was removed in about 1998. Inspection of the land today, indicates that there were at least 2 dams, possibly 3, one at or near the iron works building and one upstream to feed another pond. The 3rd possible dam is suggested due to a straight line of boulders just east of the trash pile. Of course, the additional pond outlet that fed yet another downstream canal, lying parallel to the south berm of the oval, must also have been regulated with yet another dam, boards or something of that nature, draining into the canal as it does today. Canals and dams in the area are further confused by flowage work conducted in the middle of the 1800's for downstream cotton mills. Work is continuing, to try to pin down dates and dam locations.

In 1952 the Commonwealth of Massachusetts re-routed Rte 118, the North-South Highway, through the middle of the iron works site. They replaced an old bridge, known as the Iron Works Bridge,

FIGURE 2. 1995 Satellite Photo

Modified only to show building as white rectangle.
The oval near the top became a harness exercise track in the 19th century.

moving it in the process[5]. Local residents, W. Francis and E. Nichols hovered over the new bridge work and individually reported that workman found nothing except square hewn logs, some of which they retrieved, but which have since crumbled to dust. The Commonwealth found wood in test borings. E. Otis Dyer, who has built a wood and stone dam suitable for a water wheel, identified these logs as probablyfor a stone-filled crib dam. Mr. Nichols took a photograph, figure 3, showing a ripple in the river at the place where the timbers were found, and at the location of the new bridge.This ripple was believed by his grandmother to have been vestiges of a dam close to the iron works building. Upstream canal modification made by the State is duly identified on the State's site plan and was minor. The State has been contacted. They reviewed their files (Bridge project # R-4-8) and found no evidence of anything else.Local residents have been finding lumps of bloomery scoria at this site for years, but did not fully recognize them as such. When the Nichols family once owned the site,which they used as a potato field, they turned up dozens of scoria lumps. The author found 3 lumps buried in stone walls here, and Mr. Win. Francis, a local historian, found the scoria lump shown in figure 4. He donated it to the Rehoboth Antiquarian Societymuseum where it is today. It weighs 60 pounds and is 14 inches in diameter x 10 inches deep. The author concludes from the measurements of its size that the furnace or hearth in which it was made, was about 15 inches in diameter, not square, and extended about 15 inches deep below the air tuyere. If it was a furnace it was probably 30 inches overall height. If it was a hearth, then it was 20 inches high. Either type could yield up to 50 pound blooms, but not with swamp bog ore. Assuming the low percentage of iron in swamp bog ore, they probably only recovered 10 to 20 lb. weight of iron from the smelt that once produced this particular piece of scoria. They would have used between 90 and 130 pounds weight of swamp bog ore.

Nathaniel Bliss II bought the entire site in 1757, which sale included "Tongs". In 1999, the owner of the oval-pond area site removed a section of the barn on the site that had decayed, and found several tongs in the rubble. One of the crudely made tongs weighs 22 pounds with 3 foot handles and is capable of gripping 4 inch stock. It is too big for general use around a farm forge. This pair of tongs is shown in Figure 5 and is probably from the iron works.

Casual inspection of the site revealed several extremely heavy, very large stones[6], black with a sparkly-like appearance (something called Widmenstatten pattern). These proved to be Cumberlandite, Rhode Islands State Rock, a magnetic mineral found only at Iron Mine Hill in Cumberland (Ref. 25). Identity was confirmed by Rhode Island geologist, Michael Kieron.

The Cumbertand Connection

When the Europeans arrived in America, Iron Mine Hill was roughly 1200 feet x 500 ft and 150 feet high. However, the author visited Iron Mine Hill recently to collect samples and learned that practically all of the hill is now gone. Geologist Shaler claimed that it was strewn eastward all the way to the Cape by glaciers (Ref. 25). The author surveyed over a mile of stone wall on his property, which is in line with iron Mine Hill and Cape Cod, with a commercial metal detector and a magnet and found no Cumberlandite whatever. The odds are too great for the multiple pieces at the iron Works site to have been deposited at the site by glacier action.

Cumberlandite created a rash of iron-making activity in the 1730-50 era, with at least one blast furnace, Unity Furnace, was built to exploit it. David

FIGURE 3

1939 photograph of dam site from old bridge. Arrow points to ripple caused by remains

FIGURE 4
Scoria found on site of New Palmer River Iron Works by Wm. Francis. Dimensions and weight: 14 inch Dia. x 10 inches high. 60 pounds.

Ingram has studied ownership of Iron Mine hill, the Joseph Staples mine, other nearby "mountain ore" sites and 3 other blast furnaces in Cumberland (Ref. 20). It appears that numerous Boston merchants, including Bollan, Laughton and Wood, rotated ownership of ore rights and land rights in most of these mines in the time frame of 1734 to 1737. This ownership history is too convoluted to present here, but the bottom line is that Bollan, Laughton and Wood most likely sent samples to the New Palmer River Iron Works in order to retain their position. The principle owner of Iron Mine Hill, Obadiah Ballou, would certainly have allowed it, because a bloomery is not a significant competitor to blast furnaces for iron ore, and he was selling to blast furnaces. In 1736 he sold the land to Bollan and Sanderson: i.e. the Bollan of the Bollan, Laughton & Wood group.

Cumberlandite contains substantial amounts of titanium, between 10 and 15%, as well as iron and silica. The titania-iron oxide-silica combination causes a very viscous slag which is quite different than normal in either blast furnace or bloomery smelting. It was notorious as a difficult ore due to the titania. However, in small added quantities, it apparently produced high quality cast metal and was used later at Hope blast furnace by adding it to hematite from Cranston. RI. Bloomery operations involve formation of a liquid slag at the blast nozzle, out of which iron is formed below the tuyere. During melting of the ore, the molten ore cannot adhere to the blast nozzle or it may choke off the air. The molten ore slag drips down, leaving behind a residual mass or scoria/cinder/skull. The slag must be non-viscous, liquid, and in the case of swamp bog ore being used, the scoria left behind has to remain tightly bound as a lump. The separation of slag from scoria may be thought of as somewhat analogous to the inverse of freezing of ice in salt water: the water becomes saltier, the ice purer. In this case, the slag becomes higher iron and the scoria tends towards a tightly bound silica compound. Both bloomeries and blast furnaces rely on slag compositions to reduce/eliminate phosphorous and to change other things as well. If the slag will not run well as a liquid, then this leads to trouble and no iron. These are the technical factors encountered by the New Palmer River Iron Works people, working with the Cumberlandite samples furnished by Bollan, Laughton and Wood. The Kingsley's very likely produced iron by mixing it with large quantities of their own swamp bog ore. It was probably forgeable, although just barely. This result is likely because they sold the company and received their money However, the Cumbelandite is still there, so neither they nor subsequent owners fully solved the problem.

Clues to Other Bloomeries in the Immediate Area

In 1680, Jonathan Kingsley (1671 to 1750) and his older brother, John, were declared orphans (Ref. 22)) by the Town. Their guardian has never been identified, but may have been Robert and Hannah Can. Whoever it was, was very conscientious and caring, for Jonathan's older brother, John, moved to Windham, Connecticut, and received his land inheritance (ref 27). Jonathan's son, Aaron, ended up living in the original homestead and died a wealthy man. This is significant to our study because someone must have taught Jonathan the bloomery business. By the time the iron works started, Jonathan was 50 years old. Who was his teacher? Was it the same as the guardian or did Jonathan go to work elsewhere? Recognizing that the iron-making teacher and mentor was probably not Robert Carr, but including him as a candidate, then the candidates are: Jathniel Peck, Robert Carr, Joseph, Nathaniel, or Daniel Jencks, lchabod Bosworth, William Jones, a Benjamin Tower descendant, Jonathan's uncle Steven Kinsley, or possibly George Leonard. Finally, although definitely not iron masters, it is necessary to include Bollans, Laughton and Woods because of the Cumberland connection. The author has done only such research to be certain that most of these candidates did operate or own bloomeries in the immediate area of the Kingsleys, or had other relevant connections but details and relationships remain to be established. They are as follow:

Jathniel Peck started a forge in early 1700 in the Town of Rehoboth (Ref. 23) about 3 miles upstream from the Palmer River Iron Works. It is a fact that there are numerous large scoria pieces at the suspect site, so

it was a bloomery.

In 1703, Ichabod Bosworth applied to the Town of Old Rehoboth for permission to "run a hammer that goeth by water dam allowed on ox pasture run"(Ref. 26). It was most likely a bloomery because of the large powered hammer and so early in the century. The property description places it in the south part of East Providence, so it was within walking distance to commute.

The Jencks forge of Pawtucket, was within a horse trip and there was a bridge over the Blackstone river near the Jencks forge. Joseph Jencks II is noted in Old Rehoboth records as receiving the right to dig ore in the Rehoboth Commons (Ref. 22), so Jencks or his sons also made some iron from bog ore.

George Leonard bought an iron bog ore property in 1706 in the Town of Rehoboth (Ref. 28) and requested permission in 1726 (Ref. 29) to extend his mining operation to remove the iron ore from under Taunton Street, a modern day street in today's Rehoboth. Mining debris is still visible at the site. While Leonard's Chartley forge was beyond commuting distance, Jonathan may have met him and moved there for a while.

There was a third bloomery and forge started in mid 1700 by Ebenezar, Jathniel Jr. and Shubael Peck, which survived up into the 19th century (Ref. 26 and Ref. 23). It was located about 500 yards downstream from the original Jathniel Peck operation, and many pieces of scoria have been found there too. Iron ore was purportedly brought from Bristol (Ref. 26).

Robert Carr and Richard Harding were from Swansea and very wealthy, as is clear from Can's will inventory and Harding's investments. At some point in time, Aaron and his wife Patience moved into the Kingsley family homestead[7] near Swansea, about 3 miles from the Iron Works, where Aaron died in 1780 (ref. 16).

Aaron died a wealthy man, and identified numerous complex iron forgings for distribution in his will. Although tightly connected to Swansea, both Jonathan and Aaron were very active in Rehoboth Town politics as evidenced by their frequent presence in Town meeting records. The 3 shipyards, Carr's, Cole's and Lee's, along the south of Swansea and Somerset, required considerable ship fittings and tools. Harmony Foundry on Cole's River in Swansea is at or near a site thought to have once been a forge/bloomery for Cole shipyard and maybe Carr's. Maybe Jonathan worked there.

William Jones son, John Jones, was later associated with the Sweets at a forge in Attleboro, and William had iron investment experience, as he invested heavily in iron mines as well as producers too, but he was not an iron master. John Jones also shows in deeds as an investor, not an iron master, but he had many connections.

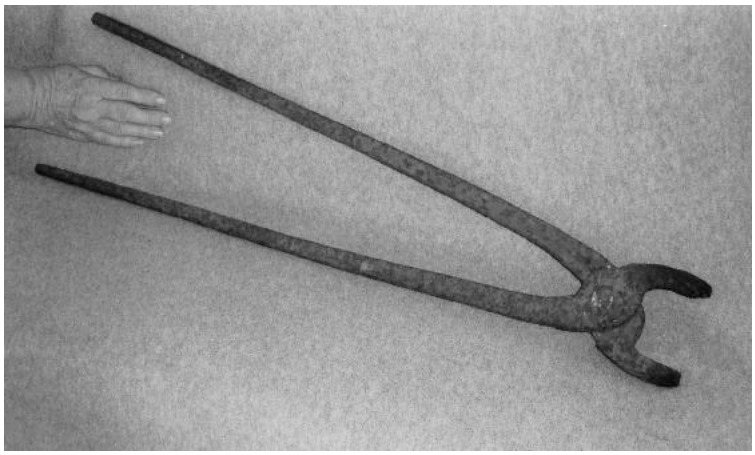


FIGURE 5
Tongs found on site of New Palmer River Iron Works.

A descendant of Benjamin Tower of Rehoboth may have been involved with the Kingsleys. The descendant mined iron ore in Cumberland (ref. 21). Jonatha's uncle, Steven Kinsley, dropped the g from his family name, to distance himself from Tories, and moved to Braintree in the late l600's. Did he Work for the Leonards?

Bollan, Laughton, and Wood bought or invested in an impressive number of iron mines, bloomeries, forges and blast furnaces in the Bay Colony around 1735. They were loyalist Tories who lost their investments in 1776. They clearly knew many or most of the furnace and forge operators, and were certainly well informed on all the rumors and facts of the iron community. They may have been instrumental in squiring Jonathan Kingsley around to various bloomeries. Study of these names, Bollan, Laughton and Wood, leads to further bloomery operations throughout the Bay Colony, some of which are generally known, some not. It might be most useful to track down their purchases and losses, and certainly whenever any researchist, historian or reader sees their names, individually or as a group, he/she should expect iron activity.

Population and Population Density

At the end of the 17th century, the population of the Southeastern part of the Massachusetts Bay Colony was on the order of 11,000 people or about 1800 homesteads, when based on 6 people per family (Bowen, Ref. 19, p.14). The land, stretching from Cape Cod through Cumberland RI, measured about 1,000 Sq. miles for an average of 350 acres per homestead, or 58 acres per person.In 1720, there were about 2400 people in 400 homesteads in Old Rehoboth, an estimated population based upon straight-line interpolation between Bowen's count for 1689 and the census of 1763/5 (ref.

19, p.9-i 1). Old Rehoboth then amounted to 169 square miles for an average of 45 acres per person or 270 acres per household. However many of these families were concentrated around the Old Rehoboth "Ring of the Green" or Commons, around which the original proprietors lived and worked.

The Town of Rehoboth as it is known today, was remote from the "Ring of the Green", covers 47.2 Sq. miles, and had about 110 households and 770 people in 1720, This is based on Snape's number of 235 homesteads in 1771 (Ref. 23). It assumes the same growth rate as Old Rehoboth, and uses her average number of 7 persons per household. Families were spread out, without a large village center, so the average density is more meaningful. This average was 232 acres per homestead or 39 acres per person.

Discussion and Conclusions

Jonathan and Aaron Kingsley got £80 and £125 respectively, for their two 1/4 shares in the sale to the Boston merchants, a modest return on their initial capitalization value of £100 each. It is postulated that the Boston merchants thought Cumberlandite could or would be workable and took the risk. However, the fact that the lumps are still there is convincing evidence that little or no further iron was made from Cumberlandite after that. It is further speculated that bog ore was substantially used up in the pond area, or that the iron quality was too poor to continue. Richard Harding, an iron works investor, owned the property, including the pond, and sold to the Boston merchants for £62, bringing their investment to a subtotal of £267. The other half ownership is not explained. A few months later, Bollan, Laughton and Wood sold everything, iron works, land, pond and all, to Win. Jones for £50, so either they owed Jones some kind of debt or they cut their losses. Apparently the waterwheels and bellows completely wore out between 1735 and 1757, but the business survived as a forge making wagon parts. The final sale to Nathanial Bliss for £30 in 1757, probably spelled the end of the New Palmer River Iron Works as a going business. There is no further documentation to suggest its further operation.

Bloomeries were an attractive investment in the late 1600's and early 1700's. It was possible for a small local group of people to handle it by raising around £400 plus land, and to operate with a couple of people. This is as opposed to the major investment of 2 or 3 times that for a blast furnace, and the requirement for 24 hour operation. Bloomeries could be a "do it yourself' project. Blast furnaces could not. The bloomery was a small unit, generally at some remote swamp site where there was some form of iron bog ore, operational on a daytime or even occasional basis, and thus did not attract much attention. The blast furnace were so big that ships at sea reported their flares.

The New Palmer River Iron Works was a microcosm example of an uncounted bloomery. It affected about 10% of the town population during construction and a significant number of families during it's operational lifespan.

There were numerous bloomeries in the Southeastern part ov Massachusetts Bay Colony that were not included in official tallies in the early part of 1700. With uncounted bloomeries in the Town of Rehoboth numbering 3, although probably not at the same time, it is certain that there were many more in Old Rehoboth and many, many more in the Southeastern portion of the Massachusetts Bay Colony. However there were so many blast furnaces in Middlboro and Carver, there may not have been enough manpower to also sustain a large number of bloomeries in those towns. Many or most bloomeries probably reverted to local forges or refineries after 1750, and gradually diminished in number.

Before 1750, it appears that bloomeries were a major Massachusetts Bay Colony Industry with major impact on the areas economics, hidden from view, and overshadowed only by their cousins, the blast furnaces of Southeastern Massachusetts.

Acknowledgments:

E Otis Dyer Sr., Surveyor and Engineer, located the New Palmer River Iron Works site from deeds, interviewed descendants, and contributed much to understanding the site historically. Otis Dyer Jr., Engineer and Surveyor, made it possible for the author to read and understand deeds, found further information in Proprietors' records and deeds pertaining to the ownership structure, conducted substantial research, and served well as a "devil's advocate". David Ingram, historian specializing in blast furnaces and especially the casting of cannon, also helped with cost evaluations and the Cumberland connection, a prodigious search in its own right This iron works has emerged as a significant early Massachusetts Bay Colonial site because of their support.

Notes

1. Curnberland, Woonsocket, East Providence, Pawtucket, Attleborough, North Attleborough. Seekonk, and Rehoboth were part of Old Rehoboth. Old Rehoboth, later known as Rehoboth Province, was part of Plymouth Colony. Swansea and Barrington were also part of Old Rehoboth, but separated from it in 1670. Plymouth Colony was divided down and absorbed by Massachusetts Bay Colony in 1691. Bounds were established separating Attleborough from the Town of Rehoboth in 1694. For more details of this most complex history, see Bowen of Ref 19, Vol. I, Chap. I.
2. The spelling of Edmund Jnguls varies, a practice common

in early deeds. He was also spelled Edmond and sometimes lngalls. Garnsey was also spelled Garnsy.
3.Charcoal was customarily spelled "cole" and "coal", a problem when dealing with 19th century ironworks, when use of real coal was being developed.
4. Chester Munroe Jr. advised that his father used the area near the big rock for a dump and for brush burning.
5. A photograph of the old bridge remains on file with the State.
6. The drill holes are there because recent property owner. Roger Durand, drilled these rocks in order to break and move them.
7. The Kingsley house has survived to the present day and is undergoing restoration.

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Key to abbriviations
BCP means Bristol County Probate Record
Rprop means Rehoboth Proprietor Records
BCRD-LD means Bristol County Registry of Deeds, Land Deeds Records

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