Society for Industrial Archeology · New England Chapters

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SNEC President's Report

Since the last newsletter, the big news is the 18th Annual Symposium on Industrial Archeology in the New England Area held at Higgins Armory, Worcester, Massachusetts, on Saturday, February 19. In what may be a chapter record, the event attracted approximately 100 attendees to seven paper sessions, a free lunch, and a tour of the conservator's workshop.

On behalf of the chapter, I'd like to thank Martha Mayer for handling advance registrations and for helping Bill and Nancy Goodwin, to whom we are also greatly appreciative, for staffing the registration table at the event itself. After coordinating the national conference last June, Bob Stewart somehow had the energy and initiative to organize the symposium, too. Thank you, Bob!

While we didn't solicit formal feedback, the anecdotal evidence suggests that attendees were very pleased with the event; the one negative criticism was an expression of disappointment over not having enough time to tour the museum itself. The outstanding paper sessions included:

• Joyce Jones' historical overview of the ever-changing technologies and product mix at her Granville, MA company, Noble & Cooley Drum Shop

• Sara Wermiel's summary of the life and career of one America's first accomplished architects/ engineers, Alexander Parris

• Gilmore Cooke's insights into the history, and current status, of the Somerville Electric Light Company

• James Johnston's labor of love -- the fruit of his investigations into the New Palmer River Iron Works in Rehoboth, MA

• Max Miller's review of the extraordinary viaducts that were once part of the Air Line

Railroad between Boston and New York

• Suzanne Cherau's exploration of the hazards archeologists face in their own explorations, and what can be done to mitigate exposure to toxins

• Mark McGivern and Clark Griffith's white-knuckle account of the rescue of a historic Boston building whose foundation had been undermined by adjacent construction activity

We thank all the presenters for their contributions to an exceptionally successful conference!

For the record, I think we should note some of the contributory factors to the event's success as a guide for future efforts. These include:

Location: Higgins Armory is intrinsically interesting and as central a location (at least for SNEC members) as one could imagine.

Notification: After suffering a poor turnout two year's ago, we learned that members need sufficient advance notification of the event. We included a "save the date" notice in a mailing that went out to SNEC members in August 2004, then reminded members about the Symposium at every subsequent event before the Symposium itself.

Follow-up: Two weeks after the mail went out, we sent out an e-mail to remind members to register. This seemed to pick up a lot of additional registrations.

Free lunch: Current SNEC finances are very good, so the Chapter picked up the expense of the lunch at the event. Somehow, free food and IA seem to fit together like hand and glove...

Great content: Of course, the most important thing is the quality and variety of the presentations themselves, which were very good.

I ask all SNEC members to mark their calendars for two upcoming events: A Chelsea Tour, led by Sara Wermiel, on Friday, April 15 that will include Chelsea Clock, the Tobin Bridge and the Old Naval Hospital Grounds in Charlestown; and a Saturday, May 14 tour of the Noble & Cooley Drum Shop (plus other sites of interest). Please watch your mail for further announcements.

Jonathan Kranz

Rodney Swain

Rodney Swain, late of Darien, CT, and a former member of the national SIA and SNEC, died April 13 in Stamford, CT. In a lifetime of achievement in industry and manufacturing, one of the highlights was his work on Creslan, an acrylic fiber Rodney helped develop; it became the first synthetic fiber that could be mixed with wool and dyed to a uniform color. Contributions in his memory may be made to the Unitarian Universalist Society of Stamford, 20 Forest St., 06901, or to the Brookfield Craft Center, PO Box 122, Brookfield, CT 06804.

NNEC President's Report

Here is a summary of the state of the Northern New England Chapter and its activities during the past year. The chapter has 132 members, including 6 new members. The figure represents a net loss of 1 member for the year. The treasury is sound, and any member who desires to see the balance sheet may do so at the Annual Meeting or may contact the treaurer directly. The chapter conducted the following tours and events:

The 2004 activities of the Northern New England Chapter began on February 14, when the Chapter hosted the 17th Annual Conference on New England Industrial Archeology at Plymouth (NH) State University. Papers subjects included: (1) the archeology and recovery of part of the hull of the 19th century wooden schooner Lizzie Carr which was wrecked on the New Hampshire shore in 1905, presented by David Switzer; (2) a comparison of amphora cargoes from several different deep-water shipwrecks in the Black and Mediterranean Seas, presented by Brendan Foley; (3) early transportation canals on the Merrimack River, presented by William E. Gerber; (4) the propulsion of the Cross River (ME) ferries, presented by David Chaplin; and (5) the origins and developments of the Boston (MA) fire alarm telegraph system, 1845 to 1925, by Gilmore Cooke. About 60 people attended.

The Chapter did not hold a spring meeting and tour. Instead, we encouraged the Chapter membership to attend the 33rd Annual Society for Industrial Archeology Conference and Tour held in Providence, RI, June 10-14, hosted by the Southern New England Chapter. No count of NNEC attendees was taken.

The Chapter's Annual Meeting and Fall Tour were held on October 9, 2004, in Henniker, New Hampshire. David Coughlin organized the tour, which focused on the timber industry. The tour included the active Goss sawmill; the remains of a mid-nineteenth century paper mill that features an unusual 18th century power canal; two riveted-iron Pratt truss bridges designed by John Storrs, New Hampshire's first highway engineer; a company that constructs modern log homes; and the Hopkinton (NH) flood control dam and gate house. About 25 people attended.

NNEC members are reminded that the 34th Annual Conference of the Society for Industrial Archeology will be held in Milwaukee, WI, June 2-5. Information may be obtained at the web site events@siahq.org.

Dennis Howe

SNEC SIA Visits Hope Global and Grant's Mills

On October 8, 2004, fifteen members of SNEC SIA visited two sites in Cumberland, RI: Hope Global, a narrow-fabric textile company, and Grant's Mills, a privately owned 19th century saw and grist mill.

Hope Global

Founded in 1883 in Pawtucket, RI, the contemporary Hope Global is an international operation, with plants in Mexico, Brazil, and France, that thrives as a niche manufacturer of narrow fabrics, such as cargo nets, weather-stripping, and polyester straps, and braided products such as shoelaces and parachute cords. With the assistance of Kent Andrews, Charlie DaRosa, director of manufacturing, guided us through the facility's manufacturing processes.

Among the tour highlights were the looms used to created bands of wire braid that, in turn, form the "backbone" of rubber extruded automobile trunk weather strips. The looms shuttle the wire into a switchback pattern held in place with interwoven bands of polyester yarn. A surprising manufacturing twist: The wire is guided from its spools onto the loom with ordinary fishing rods -- their inherent flexibility makes them ideal for the rapid, intermittent switchback movements of the loom's wire shuttles.

Years ago, Hope Global bought the wire. But they found they could save money by extruding the wire themselves. Today, three parallel wire extruders, each with fourteen drawing stations, reduce .218" rod to .030" wire. The drawing process consumes as much as 50% of the facility's entire energy demands, yet the operation is phenomenally successful: By drawing the wire themselves, Hope Global reduces the cost of wire from $0.50/lb. to $0.30/lb., saving $60,000 every week.

The braiding operation gave us the opportunity to see old and new technology side-by-side. On one side of the center aisle we could see the older Wardwell braiders that are gradually being replaced by the new (and foreign) machines opposing them that are three-times faster. SNEC members struggled to follow the "Maypole dance" movements of the spindles that circled in a rapid blur. Much of the resulting braided product is transformed into shoelaces on special machines that seal the tips with plastic and cut the laces to the appropriate lengths.

In the weaving plant, Hope Global manufactures carpet strips, weather-stripping, cargo nets and an unusual "tunnel tie" product that incorporates a draw-string within the narrow fabric; when these strips are stitched onto automobile upholstery, the strings can be tugged tight to hold the seating in place.

Grant's Mills

Pat Blais, the current co-owner (with her husband) of Grant's Mills, gave us an informal tour of the old saw and grist mill on her property. Built in 1819 by Fenner Grant, the mill is fed by a man-made lake (still intact) that, in summer, would have been drained for use as a cow pasture. According to Blais, the best available evidence suggests there was an earlier, pre-revolutionary mill on her property, and that Grant recycled many of its beams in the mill extant today.

The current structure seems to be a hodge-podge of original elements and contemporary pieces: the roof and shingles are new, while the beams and most of the interior structural elements seem original. The saw is still in place, as is the "bed" that slid stock to it, but the power transmission pieces are broken and/or missing. There is an iron, flutter wheel in the water but it is dislocated from its axle. The stones from the grist works seem intact. The sluice works and races are in excellent shape, thanks in large part to the expert stonework by mason Moe Dubois and his sons.

As a result of previous work and advocacy by Pat Malone, the site has been surveyed by the Smithsonian, but as private property, grant money is hard to come by. With assistance, the Blais family hopes to conduct further research and restore the mill to its original design.

Jonathan Kranz

Somerville Electric Light Company: 1886 - 1903

The design and evolution of a successful enterprise

Introduction

This is the story of a medium size, investor-owned, electric light company, Somerville Electric Light Company or SELCO. SELCO had a brief but productive and successful life for 17 years from 1886 to 1903. The company was in fact what is now referred to as "a high technology startup". It was eager and willing to light up Somerville and to introduce electricity into people's home.

John Lienhard, professor of engineering history and author of the *Engines of Our Ingenuity*, defined good technology as "a complex fabric woven into people's hearts and imaginations." Electricity and electric lighting certainly qualify as good technology. Electric lighting was good technology because no one can imagine life without it today. The founders of SELCO brought electricity and lighting technology to the citizens of Somerville, Belmont and Arlington Massachusetts. Life for these folks would never be the same again.

The idea of providing electric arc lighting services to illuminate city streets in exchange for money precedes Thomas Edison. The idea of making and selling electricity belongs to earlier entrepreneurs, especially Charles Brush with his popular arc lighting system. He developed a very successful arc lighting system that was installed in cities nation wide. Brush is also credited with building the first central electric generating station. He was on the scene before Edison went to New York City to set up his incandescent lighting installation in lower Manhattan.

I will try to explain why SELCO implemented high engineering standards. From the beginning, the company took extraordinary steps designing and building reliable electrical lighting systems. These high standards were based on sound business principles:

Electric street lights had to be extremely reliable and available, except during periods of full moon. If not, company street lighting contracts could be revoked and future petitions for locating new poles could be delayed or denied.

Quality of illumination and reliability of service were basic principles for any company wishing to attract commercial and residential customers. Public acceptance of electricity by home owners and businessmen depended upon SELCO's performance in electric street lighting.

Therefore SELCO took special measures, which included the use of redundant or duplicate wires.

Founding the Somerville Electric Light Company

The first public account of the company's creation appeared in a newspaper article collected by the mother of Fred Pearson, one of the original incorporator of the company. The name and date of the newspaper that published the article are unknown:

The Somerville Electric Light Company was first incorporated under the laws of New Hampshire May 25, 1886. John A Cummings, Porter A Underwood, John E Burgess, Henry C Buck, Edwin F Mulliken, and LF Burbank were the incorporators. The first meeting of the company was held June 21, 1886, when Henry C Buck was elected president, John A Cummings, treasurer, and LF Burbank, clerk. The board of directors included all of the incorporators.

On February 9, 1887, the company voted to become a Massachusetts corporation and a charter was issued to it February 21, 1887. The charter members were Elmer H Capon, FS Pearson, AE Dolbear, James W Brine, Henry C Buck, and William H Brine. Officers were elected as follows: President, Elmer H Capon; treasurer, FS Pearson; clerk, Henry C Buck.

SELCO's mission statement was recorded in its corporate charter: "...... to manufacturer, buy, sell, to operate machinery for generating and transmission of electricity for light, heat, and power, and for any and all purposes for which electricity may be used. "

Electricity was high technology at that time. Arc lighting was a roaring business for electrical engineers to be engaged in and they were. Those best qualified to develop the technology were electrical engineers. It's not surprising to find that electrical engineers were the ones who founded SELCO.

The following individuals from Tufts College were major players in the founding of this company: ***Elmer H Capon***: educator, administrator; the first president of Tufts; ***Fred S Pearson***: company general manager and treasurer. He became chief engineer of Boston's West End Street Railway Company in1889. He accomplished great things before stepping aboard the Lusitania May 2, 1915; ***AE Dolbea***r: professor at Tufts College. Dolbear established the first electrical engineering courses at Tufts, which included field trips to electrical sites in Boston and Lynn. Dolbear encouraged young Fred Pearson to enroll in college; ***Henry C Buck***: Tufts graduate and assistant to Dolbear. Was elected president of the company while Pearson was general manager; ***Frank Ellwood Smith***: not a founder but a Tufts graduate. He came on board as bookkeeper in 1889. He was promoted to general manager and served as treasurer, replacing Fred Pearson upon his retirement in 1891; ***Elmer Capon***, company president, made the first sales call on February 23, 1887. He went to City Hall in Somerville to petition the Mayor and the Board of Aldermen to obtain rights to erect poles and wires along public streets. Many other petitions would be filed during the next 16 years. Petitions were initiated by Buck, Pearson and Smith. These are well documented in city records.

How business was developed

A temporary electric plant was built to give public demonstrations and get public support for electricity over oil and gas lamps. Space in an old gristmill at the corner of Webster Avenue and Prospect Street was rented and a fifty-light arc dynamo manufactured by American Electric Company was installed. Power for the dynamo was obtained from the engine that kept the millstones rolling.

SELCO's first electric contract in Somerville was authorized June1887. The contract was furnishing 50 arc lights for one year at 37 cents per night each night until 1 AM. The Committee for Fuel and Street Lights kept a close watch on installation of poles, and overhead wires. Each year the Committee prepared a detailed tabulation of arc and incandescent lamps supplied to the city:

- 1888: 54 arc lamps; added 16 more
- 1889: 70 arc; added 72 arc and 162 incandescent lamps
- 1890: 145 arc plus 162 incandescent; added 191 more
- 1891: 151 arc, 347 incandescent; added 5 arcs and 12 incandescent
- 1892: 158 arc and 356 incandescent lamps
- 1893: 276 arc and 222 incandescent lamps
- 1903: 594 arc lamps.

In addition to selling street lighting to Somerville, the company supplied electricity to Belmont and Arlington. The circuit to Arlington consisted of 30 miles of # 10 gauge copper wire. By 1889, SELCO began to develop the incandescent side of the lighting business. The first five incandescent lighting customers were: City Hall, Tufts College, a printing company, and two others. Each customer was given a large battery bank installed in their basement to supply incandescent lamps wired in the building. Each battery maintained a full charge by running a special charging generator back at the Willow Avenue plant.

In 1889, as poles were installed, 346 oil and gas lamps were discontinued and removed from city streets. The last oil lamp was removed in 1901.

Their central generating station on Willow Avenue

This section will describe the company's permanent central electric generating station at 110 Willow Avenue on the corner of Howard and Whipple Avenues. Construction began in 1887 and finished in 1889. Three sources of information are available for research from which to piece together the story of this facility: *Somerville Citizen's* feature article about the company; Smith's detailed Treasurer's Reports; Stone and Webster Engineering Company's 1903 inventory report.

The central station consisted of a brick boiler house, a square stack 120 feet high, a single story engine generator building, coal storage bin, offices, and shops. The original steam plant equipment consisted of boilers set with the Jarvis furnace, 80 pounds pressure steam regulated by an automatic damper, and three 90-horse power steam engines.

The steam engines were Armington & Sims machines rotating at 250 revolutions per minute, aligned and belted directly to electric dynamos. Line shafts were not used. The flywheels of individual steam engines were belted directly to dynamos by linked leather belts. Arc light generators consisted of four 50-light American machines, and one Thompson – Houston arc light dynamo. A special dynamo was used to charge batteries for incandescent lighting customers. One interesting design feature of SELCO's light plant allowed any lighting circuit to be supplied by any dynamo. In case of a breakdown or malfunction in a dynamo or its steam engine or driving belt, the lighting circuit could be manually transferred over to an operational unit.

Original plant equipment and systems were augmented or replaced over time by newer, larger and better equipment:

1889
- 3 steam boilers total rated 450 hp
- 3 steam engines 450 hp
- 7 dynamos

1891
- 3 steam boilers total rated 500 hp
- 4 steam engines 470 hp
- 10 dynamos

1892
- 4 steam boilers total rated 800 hp
- 4 steam engines 605 hp
- 11 dynamos

A modern Worthington condenser, cooling tower and auxiliary equipment were installed in 1900 to lower fuel costs. Other major changes made at that time included new large vertical steam engines and electrical conversion to 2300 volt three-phase alternating current generators.

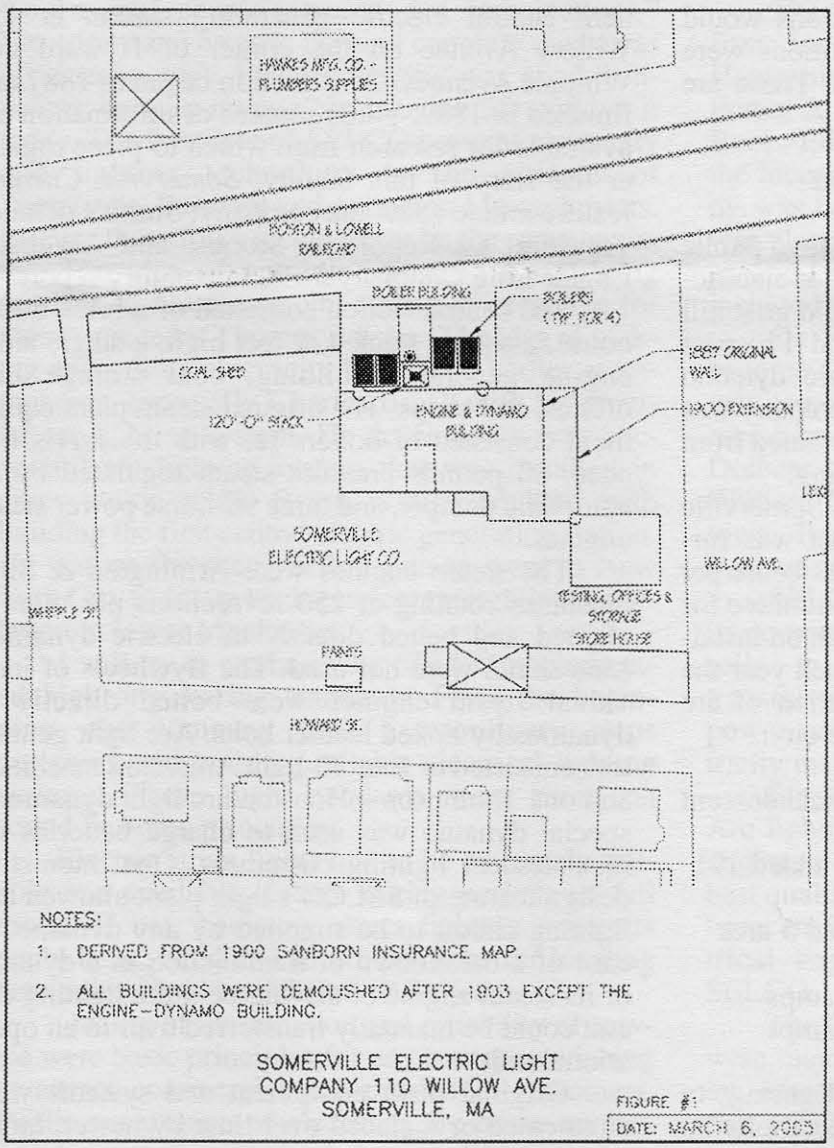


Figure 1

Old foundations were removed and the floor was raised to accommodate the condenser and vertical engines with their large flywheels. This work was phased in over a period of nearly a year. In 1901 the roof of the building was removed and raised 17 feet for a new traveling crane necessary to dismantle and maintain heavier steam engines and generators.

Another major change to the main building was extending the generator hall by 15 feet in the direction of Willow Avenue. This extension was necessary to house new switchboards as a result of converting to a 2300 volt three-phase distribution.

Stone & Webster Engineering Company Inventory of 1903

2- 250 hp Heine water tube boiler 1896
1-250 hp Babcock and Wilcox boiler 1890
1-250 hp Babcock and Wilcox boiler 1891
1 Worthington cooling tower
1 Worthington compound horizontal duplex condenser
2- no 6 Blake pumps
1 National heater
1 auxiliary heater
1 oil pump
1-12 ton traveling crane running the entire length of the engine room
6 ton traveling crane running through the extension of the building

Engines
1-15" x 30" x 30", 150 rpm, McIntosh-Seymour cross compound, vertical engine(435-600 hp);
1-20" x 40" x 20", 150 rpm, McIntosh-Seymour cross compound, vertical engine (755-1070 hp);
1-13" x 23" x 17", 210 rpm, McIntosh-Seymour cross compound, horizontal engine (225 hp);
1-15" x 23" x 17", 210 rpm, McIntosh-Seymour cross compound, horizontal engine (300 hp);
1-14-3/4" x 23" x 16", 230 rpm, Ames engine (260 hp);
1-8" x 6", 400 rpm, Sturtevant blower engine;
1 Rawson & Morrison hoisting engine (coal unloading).

Dynamos
1 General Electric ATB 48 –350 –150, 60 cycles, 3 phase generator coupled;
1 General Electric ATB 48 –500 –150, 60 cycles, 3 phase generator coupled;
1 General Electric AM8 00-900, 60 cycles, 3 phase generator belted machine;
1 General Electric A 120 – 125 cycles, 1 phase generator belted;
1 A 70 – 125 cycles, single phase generator, belted.

Exciters
1 General Electric MP4 – 13.5 – 850;
1 General Electric MP4 – 17 – 750;
3 General Electric D 7.5.

Switchboards
1 main switchboard containing 4 generator panels and 8 feeder panels, together with complete equipment of switches, phasing devices, ammeters, voltmeters and recording wattmeters for measuring the output of each circuit;
1 arc switchboard arranged for 20 circuits and 20 machines;
1 Auxiliary switchboard for operation of the A-70, A-120 and the AM8 - 100 –900 machines;;
1 switchboard for operation of 7 "tub" transformers and spare panel for an eight "tub."

Constant Current Transformers
7-100 light 6.6 amps General Electric "tub" transformers, oil insulated,

Street Lights
594 enclosed arc lamps, 6.6 amp by General Electric. Hung from mast arms provided with sleet-proof pulleys and Cutter insulating hangers.

Poles
3,534 poles situated in streets
128 set on private property
3,762 total
Pole Specification: squared poles made of hard pine were used in Somerville and round chestnut poles in Arlington. Poles were set in concrete.

Power Lines
888,941 feet - # 6 gauge wire for public service lines;
112,477 feet - #1 & 4 gauges for public service lines;
281,809 feet - # 1,6, & 4 gauges for public service lines;
448,206 feet - # 1, 2, 4 & 6 gauges for commercial alternating current lines;
152,701 feet - # 1 & 2 gauges for power lines.

Company performance and achievements

A measure of the company's growth is apparent from data and statistics given in previous sections. Other achievements will now be presented.

A comparison of SELCO's standing against the 56 utilities existing in Massachusetts in the 1890's is interesting. SELCO was ranked 10th out of 56 in payment of state taxes; 11th in assessed valuation.

Number of Metered Customers

Approximately 25% of total sales came from metered customers. The remaining 75% of sales came from street lighting contracts with Somerville, Belmont and Arlington. In 1896 there were 477 metered customers with sales amounting to $28,000. Sales for street lighting amounted to $ 88,000.

Gross Earnings and Operating Expenses

The company was doing well financially throughout its brief history. The following is from a statement of gross earnings and operating expenses from 1892 to 1902. Dollar amounts are rounded off in thousands of dollars.

Year Ending	Gross	Operating Expenses
1892	45.3	34,1
1893	69.7	46.2
1894	71.7	53.6
1895	76,1	50.1
1896	83.2	55,0
1897	88.9	56.8
1898	89.5	54.4
1899	92.8	57.1
1900	104.2	72.4
1901	108.1	75.2
1902	124.7	68.9

Contract with Lexington

SELCO in 1902 was on the verge of launching a major expansion to supply Lexington with electricity. A contract had been signed and a large 1000 kW General Electric generator had been purchased. The Edison Illuminating Company of Boston canceled the order in 1903 following the takeover.

Figure 2

Plant inspection

First refer to and study Figures 1 and 2. I became interested in the history of the building on Willow Ave in the fall of 2004. By studying the site, the building, studying the 1900 Sanborn map, and working with corporate records, I was able to understand the evolution of SELCO's central power station. The original 1887 engine generator building is still standing but abandoned, except for a portion of the building, which is rented to RCN for their cable network equipment.

Figure 2 shows the original engine generator building with its back to Willow Avenue. The old boiler building and stack would have been located on the left hand side of the main building.

Inside the vacant building, there are traces of a 1920 vintage indoor substation. I found a few slate switchboards, electrical building penetrations, vault for lightning arrestors, empty underground ducts, constant current transformers, a raised floor, empty cells for oil circuit breakers, empty compartments for buses without copper, and empty transformer vaults. But future investigations and research of the site may yet reveal hidden treasures.

Gil Cooke

Sources and References

"The Somerville Electric Light Company." Newspaper article in Mrs. Pearson's Scrapbook. Newspaper identification is unknown. Copy In the author's possession.

Annual Reports of The Board of Gas and Electric Commissioners of the Commonwealth of Massachusetts, Boston MA. 1887 to 1903.

City of Somerville Annual Reports, 1887 to 1903, Somerville MA.

Records of Mayor and Aldermen, City of Somerville. City Clerk's office, City Hall. Include petitions to locate poles and install wires, hearings, city orders, and contracts for streetlights.

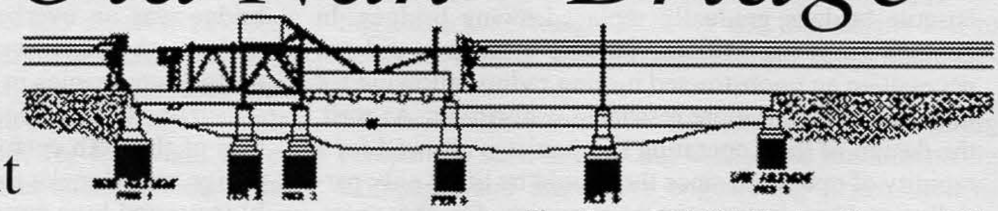
Stockholders Records and Corporate Records of the Somerville Electric Light Company, Boston Edison series; beginning Feb 10, 1887. Special Collection, Baker Library, Harvard Business School.

WH Blood, Stone & Webster memo, examination of the property for the Edison Electric Illuminating Company of Boston dated January 19, 1903. Part of the corporate records in the Special Collection, Baker Library, Harvard Business School.

"The Somerville Electric Light plant," *Somerville Citizen*, Jan 11, 1889.

The "Old Nan" Bridge

in Nantic, Connecticut



Elevation provided by Hardesty Hanover, LLP.

The "Old Nan Bridge" crosses the Niantic River in Connecticut, at the eastern boundary of the town of East Lyme, where the river channel meets with Long Island Sound. The bridge is one of a large number of historic resources along AMTRAK's Northeast Corridor that has been determined eligible for inclusion to the National Register of Historic Places. The bridge, erected in 1907, is scheduled to be replaced as part of the overall improvements planned within the Northeast Corridor Improvement Project funded both by the Federal Railroad Administration (FRA) and AMTRAK.

The bridge is of particular historical importance because it is part of the former New York, New Haven & Hartford Railroad Shore Line, which is presently part of AMTRAK's Northeast Corridor. The bridge is technologically unique since it presents a variation of the Scherzer rolling-lift design as it has a chain drive that allows the motor and the gears to be placed below the tracks, contrary to the typical design, where these components are located with the counterweight on the top of the structure itself.

The Railroad made its way to Niantic during the mid-19th century. The New Haven and New London Railroad had managed to complete a route between the cities of its name by 1852; the rails were interrupted only by a ferry crossing of the Connecticut River at Old Saybrook. The line was cheaply and poorly built, but its location was of strategic importance. In 1853, the New London and Stonington Railroad was chartered to fill the gap between these two towns but it was a financial failure and never went into full operation. In 1856, realizing that the link between the two towns was significant to the success of their rail line, the New Haven and New London Railroad acquired the bankrupt property and merged it with their own as the New Haven, New London and Stonington Railroad. Construction was completed, and rail service began between Groton and Stonington in 1858. However, success was short-lived for the line, which fell again into bankruptcy. The eastern end was sold to the New York, Providence and Boston in 1864, and the western section became the Shore Line Railway. The Shore Line route quickly turned out to be successful and attracted the more powerful New York and New Haven Railroad who leased the route in 1870.

In 1872, the New York, New Haven & Hartford Railroad Company was formed through the merging of the Hartford & New Haven Railroad with the New York & New Haven Railroad that controlled the Shore Line Railway from New Haven to New London (Stanford 1976). With this merger, the railroad operation between New York, New Haven, Hartford, Springfield and New London was combined into one system. In 1898, with its lease of the New England system extending from Boston to the Hudson River, the consolidation of the New York, New Haven & Hartford Railway service was completed, allowing for a network of railroads offering service to nearly every community in southern New England.

The King Bridge Company of Cleveland, Ohio obtained the contract to build a bridge over the Niantic River from the New York, New Haven & Hartford Railroad Company. Zenas King, born in Vermont, had moved to Cleveland, Ohio, and was employed, first as a carpenter-builder, and then as a salesman for an iron farm equipment company (Simmons 1989). In the 1850s, he turned his salesman skills towards the developing bridge industry, working for Thomas Moseley, a Cincinnati-based bridge maker (Darnell 1985). With the development of the industry, business entrepreneurs as well as design engineers created new bridge building techniques that could be offered to local and state officials. Zenas King saw the opportunities offered by this new industry, and in 1858 built his own factory in Cleveland, Ohio. Subsequently, in 1861 King obtained a patent for a bowstring arch truss apparently more efficient than the Moseley tubular arch design.

By the late 19th century, the King Bridge Company was one of the largest in the United States, having built more than 5,000 structures throughout the country (Simmons 1989). In particular, it had a large inventory of bridges built along the New England rivers with a sales office in Boston. Most of the bridges, particularly the ones built in Massachusetts, were movables structures with the use of various mechanisms. Swing bridges, most commonly built in the 19th century (Sloan 2004}, were large timber-truss bridges pivoting on a central pier. Larger and stronger bridges were built with advances in metal-truss technology and in the various mechanisms used in the bridge's movement.

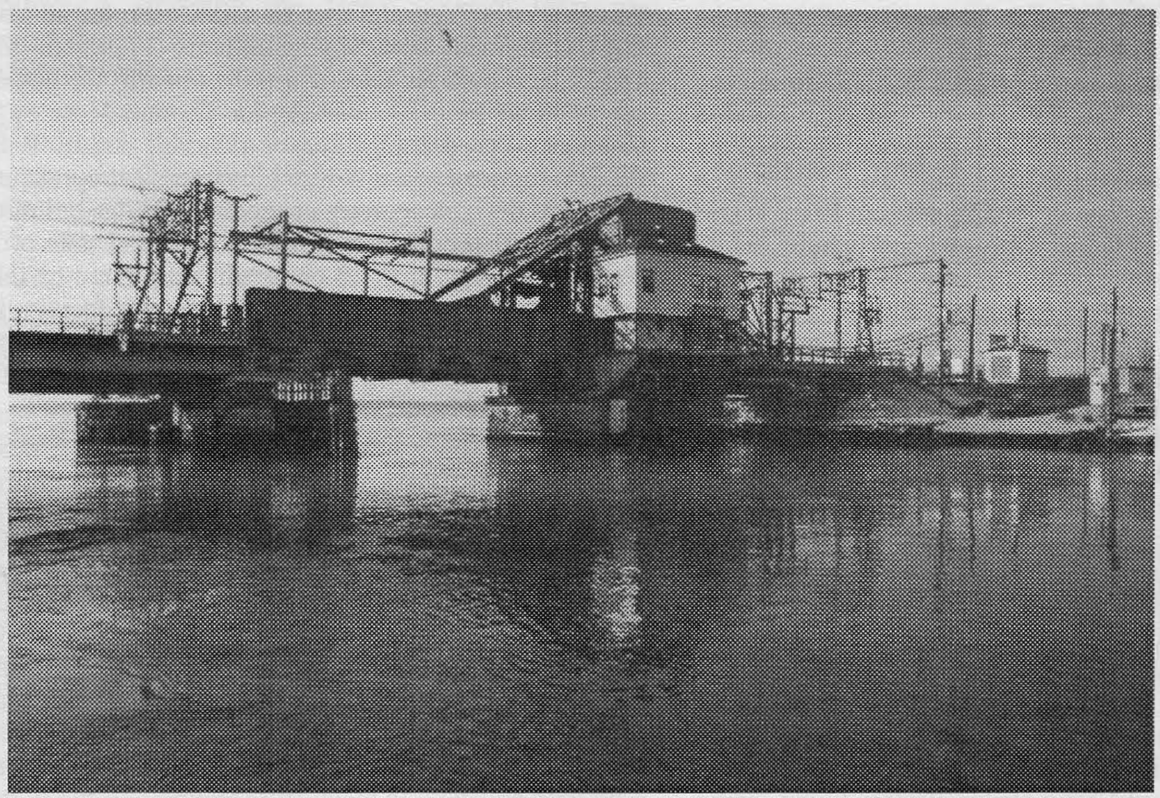
Electric driven motors replaced steam engines as bronze-bearing pivots replaced the iron rollers used in the construction of the earlier bridges. In the 1900s, bascule bridges gradually replaced swing bridges. In contrast to swing bridges, bascule structures did not necessitate an unobstructed turning radius, allowing for their placement in more restricted waterfronts. As well, the design of their operating mechanisms allowed for a rapidity of operation since they could be lifted only partially, making it less time-consuming for the users, either on the bridge or in the water.

There were three basic types of bascule structures: trunnion, roller bearing and roller lift. Published in 1916, Alexander Low Waddell's two-volume Bridge Engineering work provides a detailed explanation of these varieties of bascule design (Waddell 1916). In a trunnion design, the end of the leaf pivots around an axis with the trunnion essentially remaining in a fixed position. With roller bearing structures, the load moves on rollers along a curved track. Rolling lift structures were designed to have a moveable leaf that rolls back on segmental girders on the heel ends, with the girders assigned to tracks that are found on the top of the approach span.

The construction in Chicago of the Van Beuren Street bridge in 1893 marked the modern era for rolling lift bascule bridges. The bridge was the first movable structure that rotated rapidly a large-sized span up and out of the channel. William Scherzer, civil engineer, patented and designed the bridge and his company, the Scherzer Rolling Lift Bridge Company of Chicago, was to be known as one of the premiere engineering firms that designed more than 175 bridges nationwide before 1910. One of the most common designs of the Scherzer bridge was an overhead counterweight as well as an underneath counterweight particularly in demand with railroad companies in the first part of the 20th century.

The King Bridge Company realized that by the turn of the 20th century innovations in bascule bridge design would make these structures the most commonly requested by a number of public and private clients. The company's association with William Scherzer allowed the company to remain competitive and to offer the latest designs in bascule lift bridges. This partnership was particularly profitable when it came to the East Coast market. The fast-expanding urban development along the coast meant an increase in demand for navigable waterways as well as for roads and railroads. Structures serving to bridge the numerous navigable watercourses needed to allow for the efficient flow of road and railroad traffic.

The plan for the "Old Nan" Bridge was completed in January 1907, and construction of the masonry piers began in March. In the summer of the same year, the American Contracting Company would eventually erect the new structure. The "Old Nan" Bridge measures 294ft (89.6m) including the approach and comprises five spans resting on stone masonry piers and abutments. From west to east are noted a 48ft 3 inches [in] (14.7m) deck plate girder span, a 26ft (7.9m) deck plate girder span, a 68ft (20.7m) through girder movable span representing the bascule leaf, a 67ft 4in



View of Niantic Railroad Bridge towards Niantic Bay. Photograph taken by Luc Litwinionek (12/30/04)

(20.5m) deck plate girder span, and a 74ft 8in (22.8m) deck plate girder span. The movable span comprises a pair of riveted plate girders with a curved heel on the west end of the girders. An iron and concrete counterweight is placed above the girders. The fixed deck plate girder span, located immediately west of the heel, supports the lugged tread plates upon which the bascule rolls, as well as the framework for the chain drive. Fixed frames are located on either outboard side of the bascule leaf and run longitudinally. These fixed frames support the upper corners of the drive chains on idler sprockets.

The electric motor is located underneath track level, and delivers power to the drive chains through a series of reduction gears and associated shafting. The drive chains are arranged in an inverted triangle, the lowest vertex being the drive sprocket and the upper two vertices being the idler sprockets. The ends of each chain are anchored to a common pivot pin located at the center of the rolling segment girder of the bascule span. Rotation of the drive sprockets lets the chain pull the pivot pin horizontally to open or close the bascule. The segment girder rolls along a lugged tread plate located on the track girder of the fixed span when the bascule is in operation. As the lugs are engaged, slots found on the exterior curve of the segment girder allow for a proper alignment and prevent sliding of the bascule as it extends over its track. A capstan allows the leaf to be raised or lowered manually in case of mechanical malfunction.

The wooden operator's house, situated on the south side of the rolling lift span, is the center of operations of the movable span and the gates and signals found on the bridge. Many of the original architectural details of the 26ft x 12ft (7.9m x 3.7m) wood-frame operator's house have been removed or modified, though the house has kept intact its original massing and form. A platform with steel outriggers fastened to stone piers located on the northwest side of the bascule supports the building. A portion of the original layout remains unchanged inside the operator's house, including the presence of built-in storage cabinets, beadboard ceiling and walls, as well as various conduits, pipes and cables.

As part of the Northeast Corridor Electrification Project on the line between New Haven and Boston, an electric traction power-distribution system was installed in 1999 above the bridge. The catenary, which is the energized overhead contact-wire system, provides power to the train's pantograph. The main catenary on the bridge ends at a lattice steel portal, or "anchorage bridge," at the west abutment and the third masonry pier. A telescoping frame riding on the top of the rails that are set outside and parallel to the fixed span girders energizes the west approach span and the adjacent bascule span. The telescoping frame withdraws the conductor beam structure from the movable span as the bascule span is set into operation, permitting the counterweight to lower and the bascule leaf to be lifted without interference with the energized catenary.

The association between successful bridge building companies, such as the King Bridge and Manufacturing Company, and innovative engineering firms, such as the Scherzer Rolling Lift Company allowed for successful business partnerships during the period of industrialization occurring at the turn of the 19th century in this country and in particular in the Northeastern United States. These business partnerships allowed for technological advances in bridge design with the need for more efficient structures to accommodate the increase in railroad traffic along the Northeastern seaboard. The "Old Nan" Niantic Railroad Bridge stands today as a fine architectural example associated with this period and reflects the ingenuity brought forth with these business partnerships.

Luc Litwinionek and Cece Saunders,
Historical Perspectives, Inc

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Superheaters to Submarines...

Combustion Engineering, Inc.

Buildings 1 and 2

The documentation of Buildings No. 1 and 2 at Combustion Engineering in Windsor, Connecticut is unusual in terms of typical industrial archeology recordation projects. The buildings were mid-twentieth century functional industrial structures devoid of architectural ornamentation. Their historical and industrial significance lies in the research and development carried out at the site and the impact it had on nuclear power generation, primarily for submarines, during the cold war period.

Buildings number 1 and 2 were industrial structures located within a 580-acre site at 2000 Day Hill Road, Windsor, Hartford County, Connecticut. They were built in 1956 to support Combustion Engineering's development of nuclear power plants, particularly fuel elements. The buildings were demolished in 2004. Building #1 housed the Flexible Critical Experiment, a research nuclear reactor that operated at a nearly zero power level. During July 1956 this reactor achieved the first self-sustaining nuclear chain reaction that was accomplished in Connecticut. Building #2 was the site of the Advanced Critical Experiment, a research reactor for complex developmental work. This reactor achieved a self-sustaining nuclear chain reaction in November of 1956. Finalized specific engineering and physics design of individual reactors were carried out in these facilities. The recordation was focused on the path that Combustion Engineering followed to becoming a major contributor to nuclear power technology and on the effort completed by the engineers, scientists and technicians who worked on the site.

Combustion Engineering, Inc. and the path to Nuclear Power

The oldest component of the company that ultimately became Combustion Engineering, Inc. was the Heine Boiler Company, organized in 1882. However, while Heine's origin preceded that of other corporate components, it did not become a part of Combustion until the late 1920s, after it was organized as the Locomotive Superheater Company, incorporated on October 25, 1912.

Superheating was not utilized on early locomotives. Essentially, in a superheated steam engine the steam passed through a heat exchanger on its way to the cylinders. This raised the temperature of the steam, limited the amount of condensation on the cylinder walls and contributed to engine efficiency. A major factor in locomotive design was minimizing excess weight. However, if a lightweight superheater were available, railroads would be able to glean significantly more heat from fuel and produce more power at greater efficiency. The Locomotive Superheater Company designed a superheater for steam locomotives that soon became standard for the industry. By 1917 it began to build superheaters for stationary boilers.

Combustion Engineering Corporation organized in 1914 with the merger of two fabricators of fuel burning equipment - the American Stoker Company and the Grieve Grate Company. By the early 1920s Combustion Engineering absorbed several other companies involved with coal burning technology. In the late 1920s Combustion bought the manufacturing facilities of the Hedges-Walsh and Weidner Boiler Company in

Chattanooga, Tennessee. These acquisitions positioned the company to supply completely integrated solid fuel combustion systems.

While the technology of solid fuel combustion was advanced during the 1930s with development of regenerative air pre-heaters and high-efficiency coal pulverizers, Combustion Engineering's business during the Great Depression was stagnant. World War II pulled the company and the country out of the business doldrums. The company supplied about 5000 steam generator plants for the Liberty ships that formed a supply line to the various theaters of war. Combustion boiler systems powered about half of the boilers that were required during the war.

The company's activities during World War II focused on production rather than research and development. In 1946 research started on the feasibility of nuclear power generation. Because of its production technology in manufacturing large welded pressure vessels and the ongoing nuclear research, Combustion was positioned to become a major supplier of nuclear power plant components to the emerging nuclear energy industry. The company's first nuclear contract was for design and fabrication of oil-fired heaters for melting sodium to be used as the heat transfer agent in an experimental reactor.

The Work of Walter H. Zinn

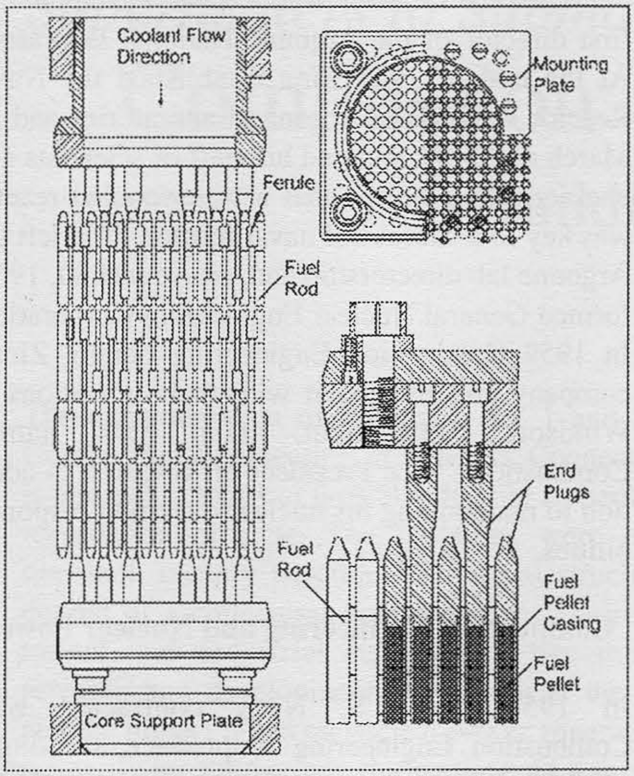
Much of Combustion Engineering's work in nuclear power development can be traced to the company's association with Walter H. Zinn. Zinn was a physicist who collaborated with Leo Szilard and Enrico Fermi while investigating nuclear chain reactions. He was a member of the team Enrico Fermi assembled to develop an atomic bomb under the Manhattan Project. As a team member, Zinn supervised all phases of construction of the first atomic pile at the University of Chicago and was the individual who started up the reactor by withdrawing the control rod that activated the world's first self-sustaining nuclear reaction. Zinn went on to design breeder reactors, and his boiling water reactor design served as a prototype for subsequent commercial reactors.

On July 1, 1946, Walter Zinn was appointed first director of the Argonne National laboratory. At the end of 1948 Zinn established the Naval Reactor Division at Argonne Laboratories and by March of 1949, Zinn and his staff of scientists and engineers determined that a water-cooled reactor was key to a successful naval reactor. Zinn left the Argonne lab directorship and, on August 30, 1956, formed General Nuclear Engineering Corporation. In 1959 Combustion Engineering bought Zinn's company and merged it with their operations in Windsor, Connecticut. Zinn was named Combustion's Vice President of Research in addition to maintaining his nuclear oversight responsibilities.

Combustion Engineering and Nuclear Power

In 1951 the U.S. Navy contracted with Combustion Engineering to produce a sodium-cooled reactor vessel and other components for the Seawolf, the world's second nuclear submarine. In 1953, Combustion's Nuclear Power Division was established. The company received the contract for the reactor vessel for the Shippingport Nuclear Power Plant, the world's first commercial-scale nuclear electric plant. They also contracted to design and build a reactor vessel for the first commercial sodium fast breeder reactor in 1955. This very complex unit was delivered to the Enrico Fermi nuclear power plant near Detroit in 1958.

The company had the ability to fabricate heavy pressure vessels, expertise in metallurgy and the capability for managing complex development projects. Combustion Engineering evolved into a major contractor for the U.S. Navy's nuclear reactor development program. In 1955 Combustion Engineering won a contract to build its first complete nuclear steam supply system to be installed in the submarine SSN Tullibee. That same year the company bought its Windsor, Connecticut site. By 1967 Combustion's shops were at capacity fabricating heavy nuclear reactor components and the company was noted as the foremost supplier of commercial reactor vessels. They were also one of five U.S. suppliers of nuclear fuel.



The uranium fuel is formed into small cylindrical ceramic pellets about one-half inch long by three-eighths inch in diameter. These pellets are loaded into Zircalloy or stainless steel tubing that is purged with helium and sealed. The rods are bundled together with spacers and retaining clips in a manner to allow free passage of cooling water.

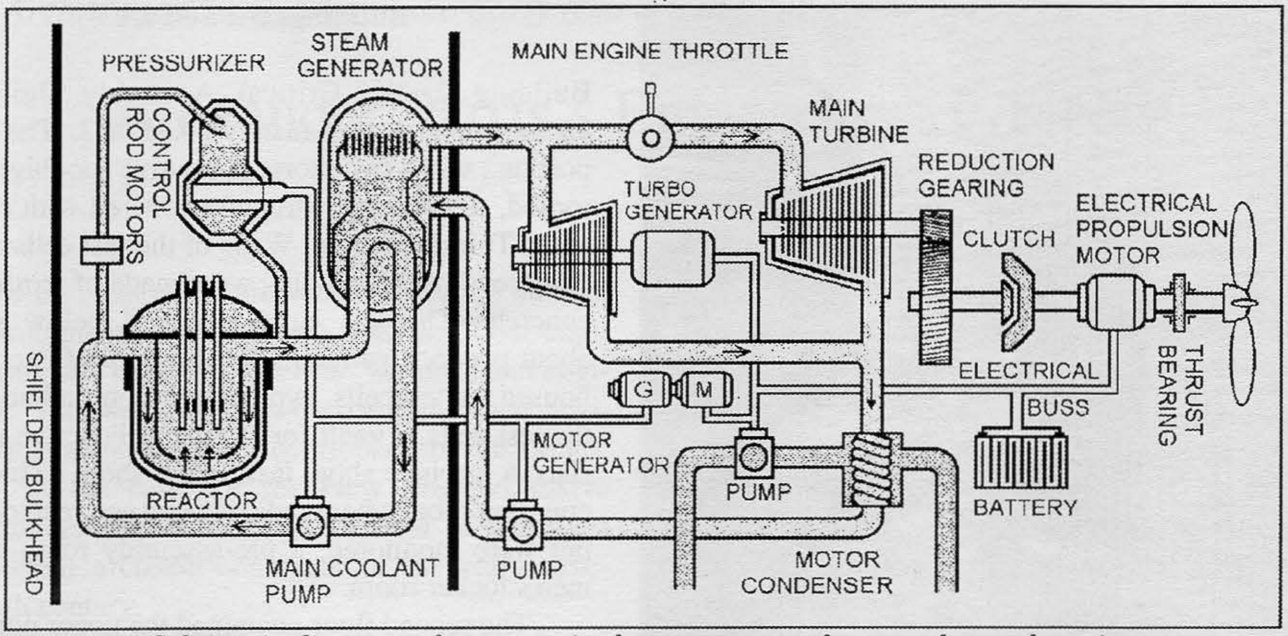
Combustion delayed entry into the market for nuclear steam supply systems (NSSS) until 1965, when the market had developed sufficiently to warrant additional suppliers. They received the first order for a nuclear steam supply system early in 1966.

Development of a Reactor for Submarines

In 1955 Combustion Engineering contracted with the U.S. Navy to build a prototype nuclear power system for an attack submarine. Completed in 1959, the S1C reactor system, with a rated power output of 33 megawatts, operated as a land-based U.S. naval training facility until finally shut down on March 25, 1993. A similar system was designed and built for installation in the U.S. Nuclear submarine Tullibee. (SSN 597). Tullibee was launched on April 27, 1960 and commissioned on November 9, 1960. She was designed as a nuclear-powered hunter-killer attack submarine. This was accentuated by her motto "Venator-Necator" (Hunter-Killer). The Tullibee was the first turbo-electric nuclear sub, a configuration that made her the quietest sub in the world when she was commissioned. However, the turbo-electric drive proved troublesome and the vessel had a reputation of being a "hangar queen." She was frequently designated as "Building 597" by the crew assigned to her. Tullibee was the first submarine to have a large 15-foot spherical sonar array, the complex "AN/BQQ" integrated sonar system. To free space for the array her torpedo tubes were placed amidships. The sonar design became the basis for all later U.S. SSN designs. The sub was highly automated to minimize crew size. The Tullibee was 272 feet, nine and one-half inches long, with a beam of 23 feet, four inches. She displaced 2,406 tons on the surface. Her small size and propulsion system made the Tullibee the world's stealthiest undersea vessel. The Tullibee was decommissioned on June 25, 1988 and scrapped at the Bremerton, Washington naval shipyard in 1996.

How a Submarine Reactor and Power System Operates

In a nuclear reactor, the heat is generated in the nuclear core, a thick walled pressure vessel containing the fuel rods. Pumps circulate coolant water through the core that is pressurized to prevent the water from boiling. This heated water flows through a heat exchanger, transferring its heat to water contained in a steam generator. The pressurized coolant water flows back into the core while the water on the secondary side of the steam generator boils. The steam formed flows to a turbine that drives the propeller shaft through a series of reduction gears. The rate at which the heat producing reaction occurs is controlled by inserting or withdrawing neutron absorbing rods into or out of the reactor.



Schematic diagram of a pressurized water reactor for a nuclear submarine.

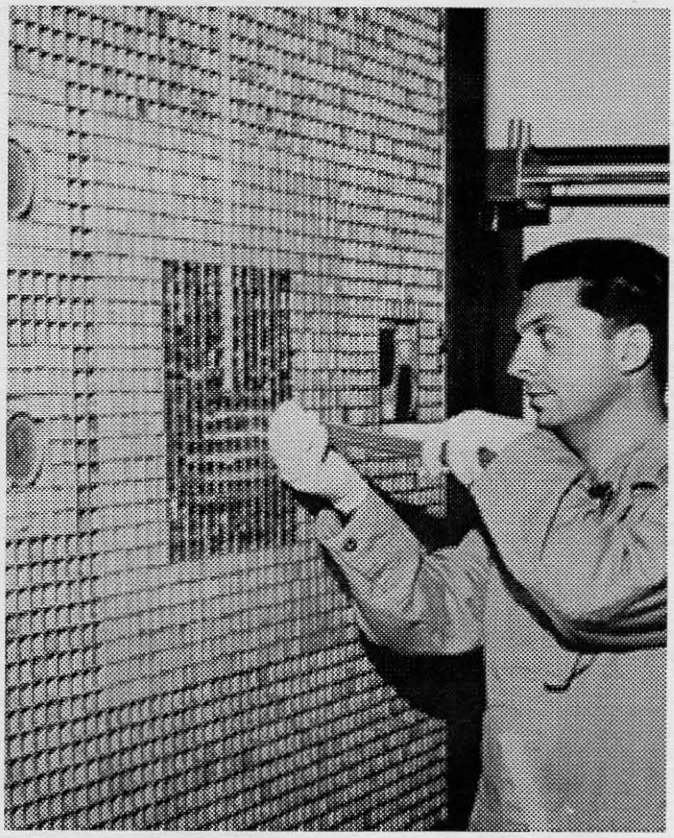
Building # 1

Combustion Engineering's work at the Windsor site began with the Atomic Energy Commission's (AEC) contracts directing research, development and manufacturing of nuclear fuel for the United States navy. These contracts also included construction, testing and operation of a naval test reactor, the S1C. Buildings 1, 2, 3, 5, 6 and 6A were built under these contracts for the development, design and fabrication of fuel elements subassemblies for U.S. Navy Submarines. Eventually this facility fabricated the nuclear fuel elements for all of CE's Nuclear Steam Supply System requirements. Building 1 was specifically built in 1956 to provide space for research and development of nuclear reactor experiments. The building served this purpose from 1956 to 1959. Contracts with the Atomic Energy Commission funded historic experiments including the Flexible Criticality Experiment (FCE) and the S1C. Building 1, known as the "Critical Facilities" Building, was the site of the first criticality experiment. The purpose of these experiments was to determine, in the laboratory, the properties of materials used in nuclear reactors, then to use that work as a basis to confirm analytical methodology. Once those properties were determined accurately the materials could be used in subsequent reactors without additional materials investigations.

Building 1 encompassed approximately 4,400 ft2. It was 100 feet long and 44 feet wide, a one story concrete structure covered with corrugated Transite siding. The building housed three reinforced concrete vaults, a reactor control room, a reactor component assembly area and rooms used to support research and development activities.

Building 1 housed the flexible critical experiment, which was a split-bed polyethylene moderated reactor. It was built in two horizontal beds with some heavy-duty springs, so that in the event of an emergency signal from the protective instrumentation, the two beds would spring apart to drop the reactor below criticality. In addition, there were control rods, located in the fixed bed. The flexible critical experiment had the two split-bed feature, but the core of the reactor was essentially a model of the final configuration. The core in this mock-up of a submarine reactor was formed of polyethylene moderators and strips of zirconium. When the beds were moved apart, technicians could access the two faces and load fuel strips into the reactor.

These Building # 1 experiments were necessary for development of the S1C reactor. The concept was to mock up the core of a submarine reactor then use it to develop experimental benchmarks for the various calculational methodologies for demarcating final reactor design. The experiments were conducted for about a year with the reactor first achieving criticality in July of 1956.



Technician charging experimental reactor mock-up in building No. 1. The year 1956 saw assembly of a model of a submarine reactor at the Windsor, Connecticut site. The model was used to develop experimental benchmarks for calculating and delineating the final reactor design.

After completing experiments for the S1C program, the building was used as a laboratory for the Nuclear Super Heater Program (NUSU). This design featured can-shaped fuel elements, about three inches in diameter. This was an innovative design with the fuel formed as an annulus between an inner and outer cladding, tubes carrying steam ran through the center of the annulus. The steam would be superheated as it passed through the tube. The design reflected some of the early design thinking of Combustion Engineering when it was developing and manufacturing superheaters. While a prototype nuclear reactor was never built using this design, the critical experiments necessary were completed. Another set of criticality experiments developed data for a boiling water nuclear super heat reactor. The design centered on a central core boiler with super-heating elements around it.

Buildings # 2 and 2A

Building 2, the Critical Assembly Building, encompassed approximately 24,352 ft2. The main portion., was a two-story, thirty-five foot high, flat roofed, steel-framed structure covered with corrugated Transite siding. Walls of the test cells at the North end of the building were made of reinforced concrete. The test cells extended below grade about twenty-five feet. The first floor of Section 2 housed the test cells, two control rooms adjacent to the test cells, a vault for storing radioactive materials, a machine shop, instrument shop, a shielded counting room where radioactivity and reactor output were monitored, a pre-assembly room and a men's locker room.

The second floor contained the upper portions of the test cells, air conditioning rooms, a storage room, men's and women's locker rooms, a lunch room, conference room, six offices and three undesignated areas. A section on the Northeast corner roof supported a tower that was not part of the original structure. It housed a crane for lifting components and rose 60 feet above the roofline over a portion of Test Cell #2.

Building 2A was a high bay area immediately North of Building 2, built in 1978 and connected to it by a fifteen-foot wide passageway. Building 2 was brought on stream for running experiments in 1957. The new facility was set up to conduct water-moderated experiments for the S1C program. Fuel bundles and operating conditions could be more accurately modeled in this facility.

The buildings were demolished in 2004 and the area will be developed as a brownfield site for light industrial uses. While the industrial activity at the site occurred in relatively recent times, the increasingly rapid advance of technology makes it necessary that sites exemplifying obsolescent mid-twentieth century industrial activities be recorded while records, personnel and artifacts are still available. While some of these activities did not last for very many years, they continue to have an impact on 21st century life.

Robert C. Stewart
Historical Technologies

An Architect and Engineer in the Early Nineteenth Century:

Alexander Parris's Engineering Projects

In the first half of the nineteenth century, a number of prominent architects also practiced civil engineering and called themselves "architect and engineer." Yet with one or two exceptions, their engineering work has been overlooked by historians. This is the case for the New England native Alexander Parris (1780-1852), one of the most important architect-engineers of the early nineteenth century.

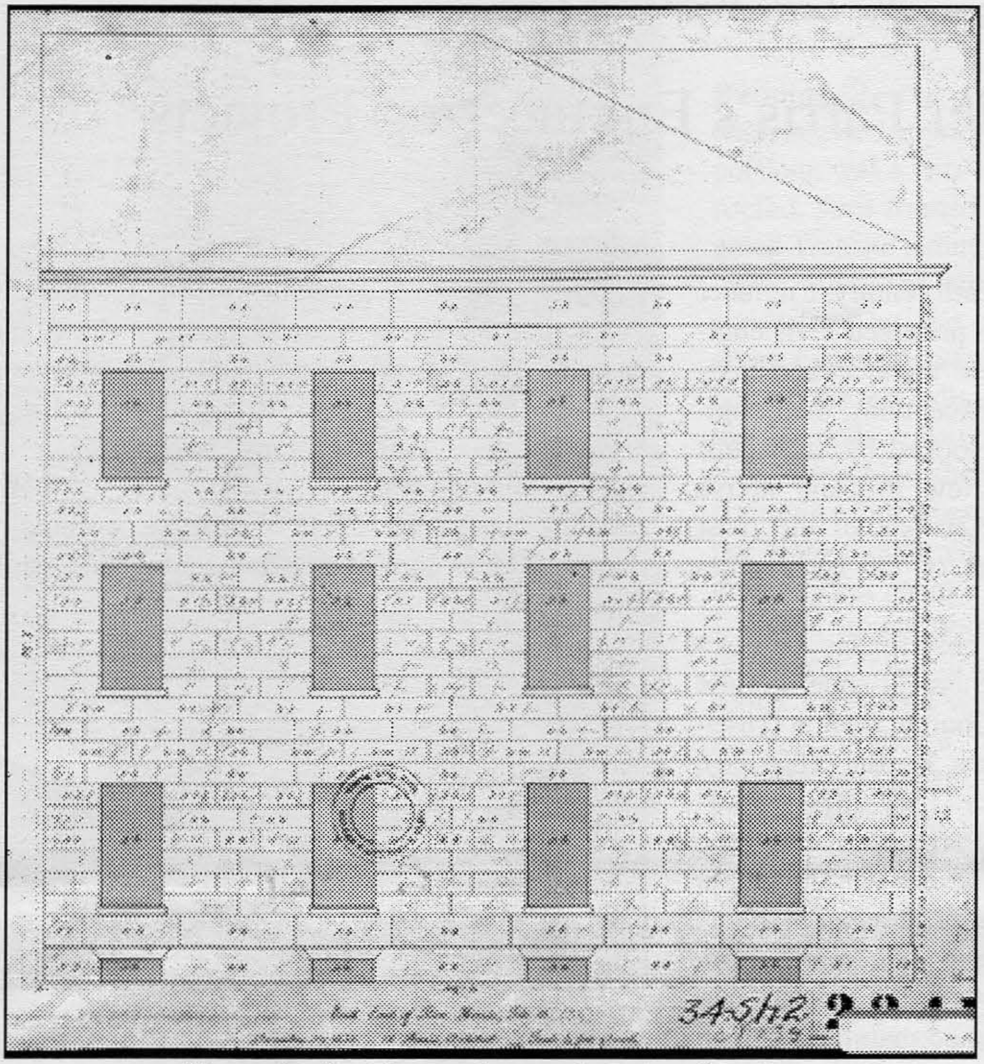
Today Parris is known only for his architecture – his monumental, classical-style granite buildings such as St. Paul's Church, Boston (1819-20); Quincy Market and stores, Boston (1824-26); and the Stone Temple, Quincy (1827-28). Yet during his professional career, Parris spent less time practicing architecture than he did working as an engineer. The period he practiced as an architect principally lasted only about ten years, from around 1818 to 1828. Then, from the late 1820s to the end of his life, Parris worked mainly (although not exclusively) on engineering projects, which included gunpowder magazines, a rope factory, lighthouses, beacons, seawalls, and dry docks. The client for most of these structures was the federal government. Importantly for enthusiasts of historic structures, many of his engineering projects are still standing.

Born in Halifax, Massachusetts, in 1780, Parris was apprenticed to a carpenter as a youth and later designed and built houses on his own account. He settled in Boston around 1808 and during the War of 1812, he served as a Superintendent in the Corps of Artificers, or builders. At the close of the war, he resumed working as a masterbuilder while trying to establish himself as a professional architect – meaning that he would offer design and construction supervision services, but not contracting. At this time, the profession of architect was hardly known in America. Moreover, given the dearth of architects, Parris had to teach himself how to draw and design. He got ideas for designs and structural systems from traveling – visiting important new buildings – and architectural books, including British building manuals such those by Batty Langley and Peter Nicholson. He eventually owned a large library of architectural and engineering books.

Structural engineering projects

Although he had an active architectural practice in the 1820s, at the end of the decade, architectural commissions apparently dried up, and Parris sought steady, if not particularly well-compensated, employment with the U.S. government. In 1827, he became a salaried assistant to Loammi Baldwin, Jr., who was the engineer for constructing the granite dry docks at the first two federal navy yards, in Boston and at Norfolk, Virginia. After these docks were largely completed, in 1833, Parris worked for the Board of Navy Commissioners on various projects at the Boston Navy Yard. Among the buildings he designed for the Navy were three structurally novel ones: a ropewalk, a sawmill, and a vaulted gunpowder magazine.

The ropewalk, a factory for spinning rope,



Alexander Parris storehouse elevation drawing, Charlestown Navy Yard, December 24, 1835.

was designed in 1834 and built 1835-37. It was an unusually large building, consisting of a three-story headhouse that contained the steam engine and boilers for driving the rope-making machinery, attached to a 1,265-foot long wing in which workers spun out rope. But the most novel feature of the building from a structural standpoint was the floor over the cellar rooms that housed the steam engine and its boilers: to prevent a fire in the engine room from spreading throughout the building, Parris made the floor over it out of cast iron beams filled with brick arches. This type of fireproof floor had been introduced in the late eighteenth century in Britain for constructing textile factories and warehouses, and Parris would have known of it from the English books he owned. This is the earliest known building in the United States to have iron beam and brick arch floors – a type of floor that became standard in iron-framed buildings from the 1850s until the 1890s.

At the same time he was working on the ropewalk, Parris built an unusual vaulted gunpowder magazine for the Navy at Chelsea, Massachusetts (1834-37). The ceiling of this one-story, rectangular structure was divided logitudinally and had seven shallow domes on each side; these were supported at the springing on ribs that spanned between pilasters at the outer walls, and granite posts in the center. Parris had already used this form of vaulting in three earlier projects, none of which are standing any longer. He wrote that he preferred what he called the "spheroidal form" to groin arching because it exerted less thrust. Although the Chelsea magazine still stands, it has been enlarged – surrounded by new walls on all sides and covered with a new roof. Parris's building survives, lacking its roof, inside these walls.

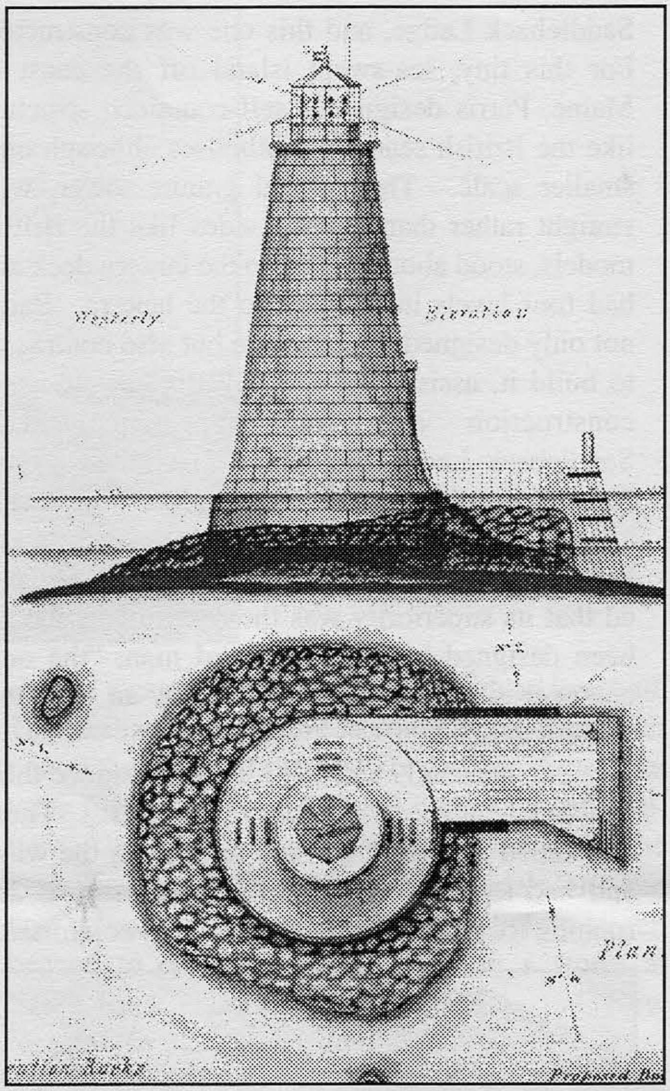
A final project at the Boston Navy Yard was a sawmill, built as an addition to the dry dock engine house (1837-40). In order to eliminate columns from the interior, Parris introduced unusual, iron and timber girders to span the 40-foot opening from wall to wall and support the second story. Each girder consisted of an iron frame roughly in the form of a queen-post truss, between timber beams. The top chord of the truss was made of cast iron bars, and the bottom chord consisted of two round, wrought tie rods; the ends of the chords were secured in iron boxes, built into the walls. Iron plates suspended from the top chord carried the timber beams and the iron tie rods, one under each beam. The timber beams then supported the joists for the floor above. While trussed girders consisting of a split beam with a frame between them were used in England in the eighteenth century, the English models were intended simply to keep the girder from sagging; the trussing was not even tied along the bottom. Parris, in contrast, built a complete iron truss for his girder; his adaptation seems to be original.

Lighthouses and beacons

In the late 1830s and 1840s, Parris became involved with the design and construction of lighthouses and beacons. He designed at least eight lighthouses, six of which were built, as well as three unmanned beacons. Three more lighthouses were patterned on his designs. In several cases, he also contracted to build them. Most of Parris's lighthouses were located at unusually remote and challenging sites. He collaborated with Gridley Bryant, the well-known master mason, engineer, and inventor, on several of the projects.

Up to this time, American lighthouses were structurally rudimentary. They came in two general forms: towers, not especially tall (60 feet was the about the tallest), or cottage-style lighthouses, consisting of a tower attached an end wall or poking through the roof of a dwelling. Most were built of wood or of stone. Even the stone lighthouses of this period, for the most, part had rubble walls, which were made of random-sized stones held together with mortar and finished with stucco. Parris's lighthouses were quite different, architecturally and technologically. His towers had walls of dressed granite, meaning that the stones had to be cut, fitted, marked, and assembled in courses in order, rather than piled and parged as in rubble walls. In addition, he designed an all-iron beacon, the first use of iron structurally (apart from the lantern) in lighthouse work.

Parris's first lighthouse project, in 1838,



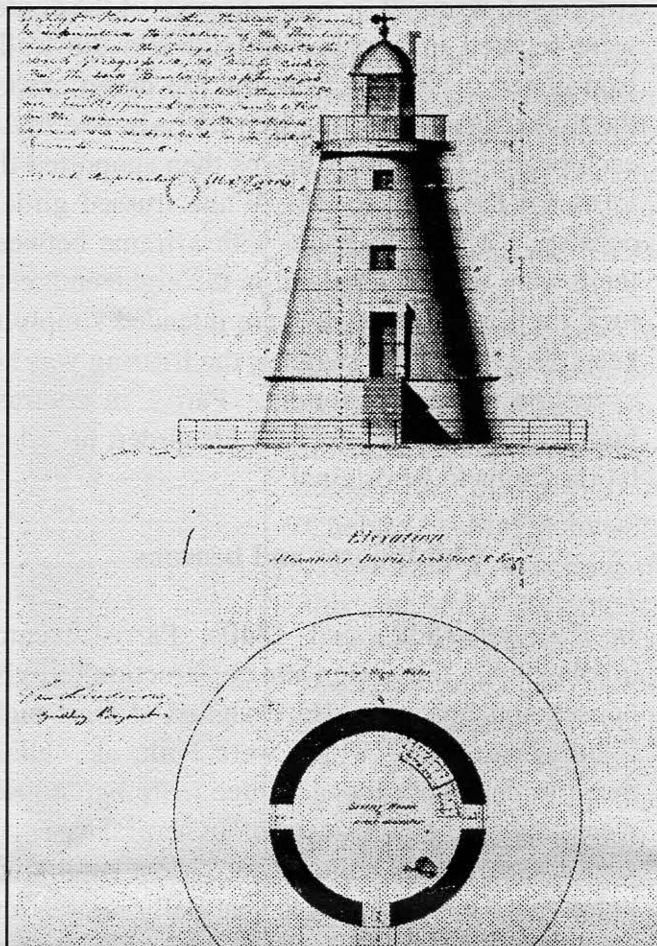
Alexander Parris drawing of the Execution Rocks Lighthouse.

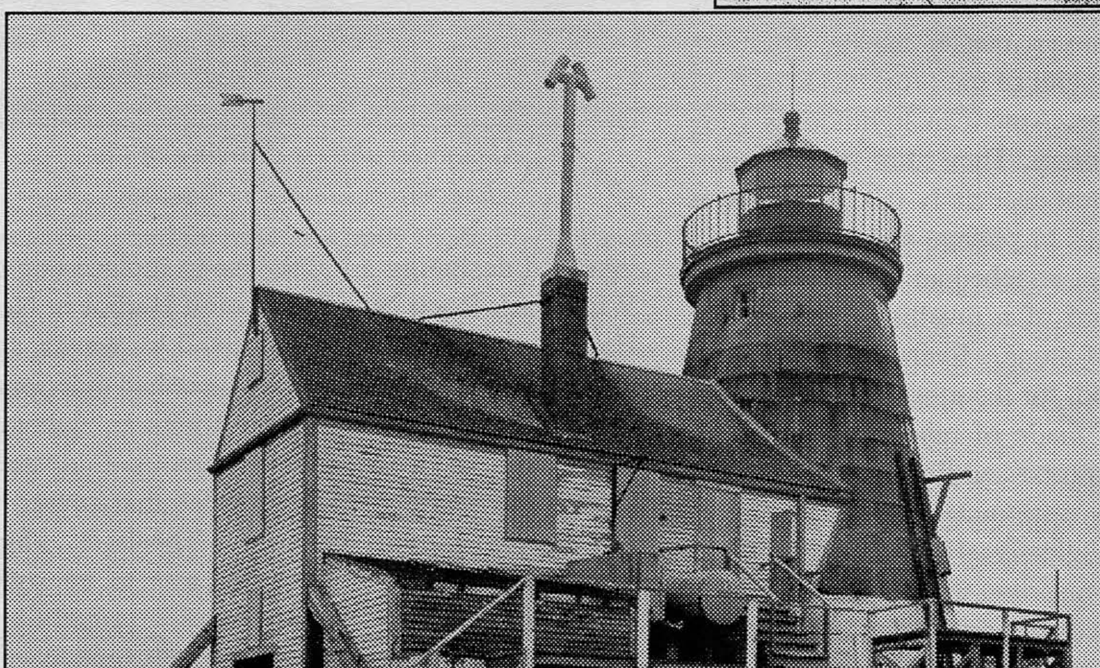
involved designing a lighthouse to replace one on Whaleback Rock near Portsmouth Harbor in New Hampshire. The site was buffeted by waves, and the walls of the existing tower there had deteriorated. Parris proposed replacing it with an elaborate tower, similar to Smeaton's famous Eddystone Lighthouse in England, with sides that curved in like the trunk of an oak tree. The base, which would be submerged at times, was to be solid, made of stones that interlocked horizontally and vertically. Probably because of the high cost – estimated at $75,000 – this project did not go forward.

The next year, 1839, Parris received his second lighthouse commission, for a tower on

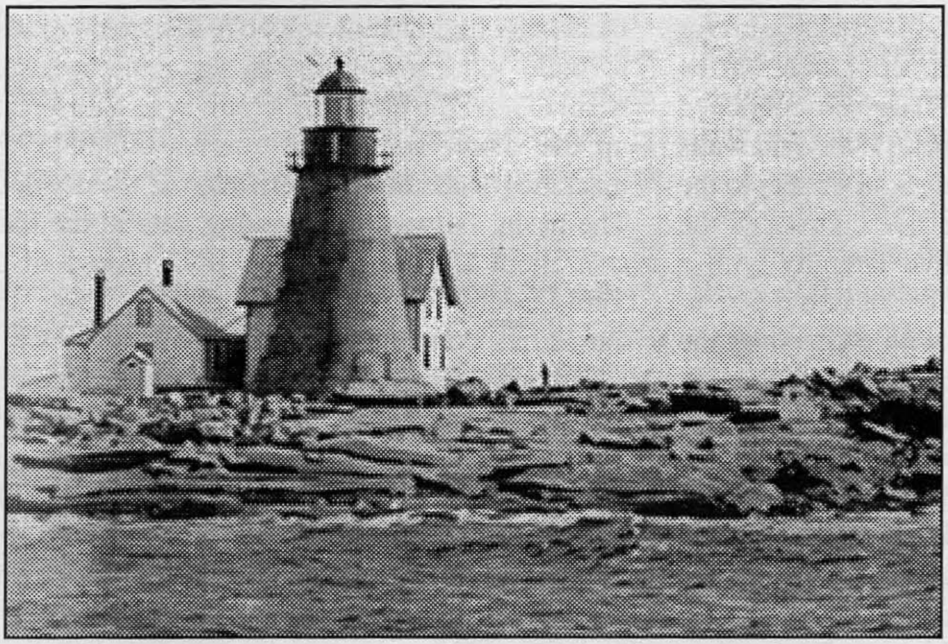
Saddleback Ledge, and this one was constructed. For this tiny, sea-swept island off the coast of Maine, Parris designed a self-contained structure like the British searock lighthouses although on a smaller scale. The conical granite tower, with straight rather than curving sides like the British models, stood about 31 feet to the lantern deck and had four levels in addition to the lantern. Parris not only designed the structure but also contracted to build it, assisted by Gridley Bryant. Its solid construction and fine appearance made Saddleback Ledge lighthouse a standout among New England lighthouses: a lighthouse inspector, after an 1842 tour, described it as the only really well-constructed lighthouse in Maine. He suggested that its superiority was the result of its having been designed by a professional man, "the only one ever erected in New England by an 'architect and engineer.'"

Between 1839 and 1843, Parris designed three beacons, two of which were built. These unmanned structures marked hazards in the water and had to withstand pummeling by storms and running ice in the spring. Parris's first commission





The c. 1839 Saddleback Ledge Lighthouse: above, the Alexander Parris drawing, and a photograph to the left.



The Mount Desert Rock Lighthouse.

was for a beacon on York Ledge, near the harbor at York, Maine. He used this opportunity to build what was for the United States a groundbreaking structure: an iron skeleton. For this partly submerged reef, Parris designed a prefabricated iron structure could be erected quickly once the foundations had been prepared. His model was a beacon on Carr Rock in Scotland, designed by Robert Stevenson and built in 1821. Manufactured in Portland, Maine, the superstructure stood about 34 feet high and consisted of six hollow, iron legs in a pyramid, which carried another hollow tube topped with a 3-foot diameter iron ball. To secure the structure to the ledge, the holes for the legs, and for the center plate that held the diagonal braces, were drilled directly into the rock, at the site. This was difficult and dangerous work, but the project was a success. Parris wrote that these methods could be used at other dangerous rocks. And indeed, iron skeleton lighthouses and beacons began to be erected on American shores with similar methods later in the 1840s, although not by Parris.

Parris's next two designs for beacons used traditional stone for the most part. His 1841 design for Round Shoal beacon, at the entrance to the Connecticut River, consisted of a cone with curving sides. The structure stood about 33 _ feet to the top, with a 19-foot tall masonry section that carried a cast iron column topped with an iron ball. To stabilize the structure laterally, Parris had holes cut on the edges of the first six courses stones that were filled with "joggles" – 8-inch cubes of granite. All the work was to be laid in hydraulic cement. Two years later, Parris made plans and cost estimates for a similar, though slightly larger, beacon to replace one destroyed in a storm at Black Rock Harbor in Long Island Sound, New York. This design was not implemented

In 1844, Parris was let go from the Boston Navy Yard. The next year, he designed a lighthouse for Minot's Ledge, near Cohasset, Massachusetts, but it was not constructed. By 1846 he must have wanted work badly, because he wrote to the federal official who oversaw the lighthouse service offering to superintend any planned lighthouses. He got the commission to build a lighthouse on Matinicus Rock, another remote outcropping on the Maine coast. The structure Parris designed – a dwelling with towers at each end – resembled the earlier lighthouse there, except the new one was made of hammered granite. From late fall to spring, 1846-47, Parris and Bryant built the dwelling and towers and they also improved the island's harbor so boats could land more easily.

In 1847, Congress passed a major lighthouse bill, and Parris was commissioned to design two of the lighthouses: for Execution Rocks and for Mount Desert Rock in Maine. Both were barren rocks surrounded by water. The self-contained lighthouse at Mount Desert Rock (1848) had walls of hammered granite and stood about 42 feet to the underside of the gallery. The five courses of the base (for 10 feet) were secured laterally with a band of stone that fit in a groove cut into the adjacent layer. It had four levels, with a cistern in the cellar for the keeper's water supply, and a staircase of cantilevered stone. Parris designed another conical granite tower for Execution Rocks in the approach to the East River, in Long Island Sound, New York. To build on this uneven collection of rocks, he used a cofferdam and, working inside, leveled the rocks to make a foundation. The base of the structure, which would be submerged in high water, was made solid and reinforced laterally with stone joggles. It was completed in 1849 (lighted in 1850).

Parris had a hand in building several other lighthouses in this period, but they were less complicated from an engineering standpoint.

Portsmouth Navy Yard and the floating dry dock

In April 1847, after finishing plans for Mount Desert and Execution Rocks lighthouses, Parris was offered a salaried position as engineer with the Portsmouth Navy Yard in Kittery, Maine, and there he superintended the construction of a stone wharf and other projects. Parris's first association with the Portsmouth Yard was in 1839, when he directed the reconstruction of a quay wall that had collapsed. The wall was in deep water and work was done from a cast iron diving bell. Parris went down in the bell to train the men in how to work from it.

Parris's arrival in 1847 was the start of an active period in development at the Portsmouth Navy Yard. His first projects included building a stone wharf, quay wall, and various buildings. The Yard needed a dry dock, and finally in 1848, Congress authorized funds to build one. The type selected was a patented Balance Floating Dry Dock, and its inventor and an associate contracted to build it. Parris designed and built a granite basin to hold the dock and a railway to haul vessels up the shore; and put in various buildings and machines needed for the operation of the dry dock. The basin, railway, and floating gate to the basin cost about $300,000. In his 1892 history of the Yard, George Henry Preble, U.S.N., wrote that Parris had complete control of this work, which took place during two building seasons, and noted that "during that time the engineer descended in the diving bell daily" to make inspections and direct the workmen. Parris worked on other buildings and improvements at the Yard during his time there, most notably another solid masonry powder magazine, known as Building 32 (1848-49).

Conclusion

One wonders how Parris felt about his two professions – whether he preferred architecture to engineering or vice versa. He had actively sought engineering positions. For example, in 1835, he went to Washington to seek work, carrying a letter of introduction from Loammi Baldwin. Baldwin rated Parris's abilities highly, stating, "Mr. Parris has acquired from reading and long experience much scientific knowledge important in various departments of construction, which is wholly unknown to common carpenters, and ordinary house builders. I have often witnessed the value of his acquaintance of this nature, which must necessarily add great confidence to the stability, and usefulness of constructions erected under his guidance." He suggested that Parris be appointed Superintendent of Public Buildings for the navy yards. But this did not come to pass; rather, Parris continued to work at the Boston Navy Yard on a project-by-project basis. But Parris also sought architectural commissions. He designed a few buildings between 1835 and 1837, and in this latter year, entered the design competition for a new customhouse in Boston, but lost out to Ammi Burnham Young. In 1844, having been let go from Boston Navy Yard, he applied for the superintendent position for the construction of a dry dock in

New York, but apparently did not get the job. Then, feeling "too much advanced in age to again enter the strife and competition for private employment," he moved to a farm he owned in Pembroke, Massachusetts. But his retirement did not last long.

While the civil engineer position in Portsmouth allowed Parris to continue his record of accomplishment to the last days of his life, one can imagine that he would have preferred architecture to engineering, simply because it was less physically demanding. After a life filled with the usual discomforts and hardships of the times, his lighthouse work sometimes required Parris to live on desolate islands in Maine while putting up the structures. At age sixty-six, he spent the fall and part of the winter on Matinicus Rock, rebuilding the lighthouse. At age seventy he apparently was descending "daily" in a diving bell. The possibility of working indoors must have had great appeal; nevertheless, he continued doing strenuous work. In his last years, his family stayed in Pembroke, and Parris traveled from there to Portsmouth as needed. In the federal census of 1850, Parris identified his occupation simply as civil engineer. He worked until illness brought him down two years later, and died at the age of seventy-one.

Parris contributed to the development of civil engineering in several ways. He successfully implemented novel structures, adapting ideas that he learned about in books or devised on his own solutions. Parris was one of the first Americans to use iron structurally in a large way. In addition, and very importantly, he trained many architects and engineers, including Gridley J. F. Bryant, son of Gridley Bryant, and Richard Upjohn, both of whom became prominent architects; and Calvin Brown, Benjamin Chandler, and Charles Hastings, who became civil engineers. Parris also passed on the architect-engineer tradition. Luther Briggs, Jr. (1822-1905) worked as a draftsman in Parris's office as a young man and then for Gridley J. F. Bryant. On the bookplate Briggs made to label his books, he identified himself as an "Architect and Engineer."

Sara E. Wermiel, PhD

[Ed. note: Sara E. Wermiel is writing a book about the work of architect-engineers in the nineteenth century. This article draws on her research, which was partly funded by the National Science Foundation. Her book on lighthouses, part of the Norton/Library of Congress Visual Sourcebooks series, will be available in 2006.

An archive of Parris documents is now available online through the Alexander Parris Digital Project: http://www.parrisproject.org/.]

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