VERMONT DIVISION FOR HISTORIC PRESERVATION: THE STATE PLAN

CONTEXT: VERMONT'S IRON-MAKING INDUSTRY AND MANUFACTURING (1790-1900)

**1) How it developed (geographic; cultural; social; other influences):** Vermont's iron-making industry developed in association with other pioneer works (grist and saw mills, blacksmith shops, etc), which reflected the needs of early settlers in the state. Ironworks were built near water power, ore beds, and sources of fuel (charcoal); blast furnaces along lower elevation sites near good roads to transport heavy ingots; bloomeries sometimes at higher elevations (i.e. Bristol, Cady's Falls, Lincoln, etc). The works were also influences by Lake Champlain and the ironworks that developed in New York. The Lake and later the Champlain Canal changed the character of Vermont ironworks from a larger number of small speculative operations in pre-canal days to costly, high production works after the canal. The railroad eventually brought in better iron made cheaper than local works could produce and ended iron-making in Vermont. Iron-working, in the form of machine shops (mill gearing, machinery, tools, scales) and foundries (agricultural implements, castings, stoves, railroad iron), expanded to reach peak production about 1880-1890, dwindling in numbers and production thereafter.

**2) Limitations of development:** Vermont ironworks were limited by the quantity and quality of its ore (earlier ironworks worked bog ore; later works imported ore from NY to mix with and improve the quality of locally-made iron); the length of the winters, which froze streams that powered the works; the works' remoteness from major industrial centers and seaports nearer to the ocean.

**3) Known geographic distributions and patterns:** Pre-1800 ironworks were distributed near developing population areas that created the demand for raw iron product. With better transportation (road, railroad, and lake barges) industrial demand commenced (1800 -1850) and ironworks located closer to fuel, ore, and more reliable water power. Better than 90% of the ironworks operated to the west of the Green Mountain range, concentrated in Addison and Rutland Counties.

**4) Historic highlights (i.e., significant events [natural and social], people, technical advances, social trends, etc.):** Earliest ironworks in Vermont were developed by major political figures: Nathaniel Chipman, Ira Allen, Matthew Lyon, etc. The first ironworks in the NY Adirondacks imported ore from the Basin Harbor area. Major NY ironworks, the Crown Point Iron Co was founded by Vermonters: Penfields and Hammonds of Pittsford. Blast furnace at East Bennington used preheated blast (hot blast) year before generally accepted date (1834) for first use at a furnace in New Jersey. In 1809, Monkton Iron Co at Vergennes attempted use of piston driven blast machinery, 26 years before accepted date of use in Northeast; first documented successful use was 1839 by Conant at Brandon. Last significant bloomery forges in New England operated in Vermont (1850-1880's): Salisbury, Vergennes, Fair Haven, Lincoln, East Middlebury; then known throughout US industry for high quality wrought iron. Most all major 1790-1830 Vermont ironworks families interrelated: Austin, Harwood, Lothrop, Page, Dike, Sax, Bogue, Keith, Drury, Cooley, Conant, Broughton, Penfield, and Sutherland; also Colburn and Davey.

**5) Time frame:** 1785 to 1890. **(justification:** archival research [see (10) below, selected bibliography].

**6) Property types known and/or expected:** Stone-built blast furnace structures; workers housing; village support (blacksmiths, carpenter shops, schools and churches, company stores and offices, ironmaster's house, etc); industrial support (ore crushers, washers, and roasters; dams and flumes; iron mines; charcoal kilns, and coal and ore storage sheds; forge hearths; triphammers and anvils; waterwheel and turbine pits); slag heaps; puddling furnaces; foundry cupola furnace and pattern (mold) shops.

**7) Information gaps/research questions:** Specific uses and applications (local or exported) of raw iron (cast and wrought) before ca. 1850; published references to ironworks at places otherwise not supported by local histories or field inspections (C.R. Harte's research notes unlocated); pre-1850 ore processing data (washing, roasting, etc); definition of 'pocket furnace' in local histories undetermined through archival research or field inspection.

**8) Biases:** Disproportionate physical sizes of blast furnaces and forges and extent of remains result in misleading economic conclusions based on numbers of field remains as compared to documented operations.

**9) Relevant constituencies:** Vermont State Parks; private property owners; U.S. Forest Service; local (town, county, and state) archeological and historical societies; Society for Industrial Archeology (SIA); industrial labor history societies; hiking and camping associations; public educational television.

**10) Selected bibliography:** See V.R. Rolando manuscript <u>200 Years of Soot and Sweat</u> 1985 (copy at DHP).

**Prepared by:** Vic Rolando **Date:** August 9, 1985

SUGGESTED READING LIST - 19th CENTURY IRON AND CHARCOAL MAKING
Updated to May 1, 1985

Ironworks - General:

W. David Lewis Iron and Steel in America Greenville, Del: The Hagley Museum, 1976, 64pp, illus, biblio, index ($3.50). - Excellant.

David Weitzman Traces of The Past: A Field Guide to Industrial Archeology New York: Charles Scribner's Sons, 1980, 227pp, illus, biblio, index ($17.95). - Good for both young people and 'the experts'.

Kenneth Hudson The Archeology of Industry New York: Charles Scribner's Sons, 1976, 128pp. illus, biblio, index ($10.00). - North America and Europe.

William F. Robinson Abandoned New England New York: Little, Brown and Co, for the N.Y. Graphic Society, 1976, 211pp, illus, biblio, index ($19.95)> - Poorly written but interesting.

Joseph E. Walker Hopewell Village: The Dynamics of a Nineteenth Century Iron-Making Community Philadelphia: University of Pennsylvania Press, 1966, 526pp, illus, biblio, index ($5.95). - Excellant.

Mary Stetson Clarke Pioneer Iron Works Philadelphia: Chilton Book Co, 1968, 80pp, illus, biblio, ($3.97). - Good for young people.

Victor R. Rolando A Survey of Stone Blast Furnaces of New England and Eastern New York State Unpublished Ms, 1977, 141pp, illus, biblio, index. - Somewhat outdated by current research. Copies at UVM Library, Burlington and VHS Library, Montpelier.

Ironworks - Vermont:

Richard S. Allen "Furnaces, Forges and Foundries" Vermont Life Winter 1956-57, pp. 2-9, illus. - Somewhat outdated by current research but good reading.

Gina Campoli "Current Research in New England: Vermont - The Troy Furnace Site" Society for Industrial Archeology - New England Chapters Vol 1, No 2, October 1980, pp. 11-13. - Field work at the Troy Furnace Site, Vt.

Brandon, Vermont: A History of the Town The Town of Brandon, 1961, biblio, index, ($5.95) pp. 11-13. - Brandon and Forestdale ironworks.

Carl Seaburg and Stanley Paterson Merchant Prince of Boston: Colonel T.H. Perkins, 1764-1854 Cambridge, Mass: Harvard University Press, 1971, Chapter 18 "Short Blast on the Otter" pp. 199-210, biblio, index ($22.50). - Monkton Iron Co, Vergennes, ca 1808-09.

Ironworks - Vermont (cont):

Victor R. Rolando Ironmaking in Vermont: 1775-1890 MA Thesis, The College of Saint Rose, Albany, NY, 1980, 132pp, illus, biblio. - Somewhat outdated by current research. Copies at UVM, Burlington; VHS Library, Montpelier; The Rutland Historical Society, Rutland; and Sheldon Museum Library, Middlebury.

___________ "Eighteenth Century Forges" VAS Newsletter Burlington: The Vermont Archeological Society, Inc, No 27, April 1979, pp. 5-6, illus, biblio. - Overview of 18th-century forge sites in Vt.

___________ "Search for Vermont Furnaces Yields Dramatic Discoveries" VAS Newsletter No 32, August 1980, pp. 1-4, biblio. - Description of blast furnace; sites at Bennington, Dorset, Forestdale, and Troy, Vt.

___________ "Stone Blast Furnaces in Vermont" VAS Newsletter No 33, October 1980, p. 6. - List of blast furnace sites located as of 1980.

___________ "Searches Find More Vermont Furnace Sites and a Standing Ruin in 1981" VAS Newsletter No 38, January 1982, pp. 4-5, biblio. - Sites located at Bennington, Orwell, and North Dorset.

___________ "Current Research in New England: Vermont - Iron and Charcoal Sites" Society for Industrial Archeology - New England Chapters Vol 5, No 1, 1985, pp. 13-14. - Background leading to location of ca. 1825 Colburn blast furnace at West Haven, Vt.

Hon. Harvey Munsill, Esq The Early History of Bristol, Vermont The Book Committee of the Bristol Historical Society, (1979?) ($11.75). - "Forges": pp. 107-112. - Forges along the New Haven River and Baldwin Creek in Bristol.

Aleine Austin Matthew Lyon: "New Man" of the Democratic Revolution, 1749-1822 University Park, Penn: The Pennsylvania State University Press, 1981, 192pp, biblio, index ($19.50). - Lyons Works at Fair Haven.

Charcoal Making - General:

Jackson Kemper III American Charcoal Making Eastern National Park & Monument Assn, US Dept of Interior, (1960's?) 25pp, illus. - Good little Park Service booklet on making charcoal in mounds.

Rob Woolmington "Coking Charcoal Down in Rattlesnake Gutter" Yankee Magazine December 1979, pp. 80-85, 132-134. - Charcoal kilns in Massachusetts and southern Vermont.

Suggested Reading List - 19th Century Iron and Charcoal Making (cont)

Charcoal Making - Vermont:

Rob Woolmington "The Charcoal Era" Vermont Summer Magazine Bennington: The Bennington Banner, July 7, 1977, pp. 17-20. - Charcoal making areas in southern Vermont.

____________ "Ghost Towns in New England" New England Boston: The Boston Globe, October 23, 1977, pp. 38-40, 42, 44-45. - Abandoned charcoal making towns in southern Vermont.

J.R. Chapin "The Charcoal Burners of The Green Mountains" Outing Magazine April 1885, pp. 4-18, illus. - Charcoal making at Mt Tabor in the 1880's; copy at VHS Library, Montpelier.

Victor R. Rolando "Current Research in New England: Vermont - Charcoal Kilns" Society for Industrial Archeology - New England Chapters Vol 3, Nos 1/2, 1982, pp. 12-14. - Field work in southern Vermont in 1982; copy at VHS Library, Montpelier.

____________ "Current Research in New England: Vermont - Charcoal Kilns" Society for Industrial Archeology - New England Chapters Vol 4, No 1, 1984, pp. 3-4. - Field work in southern Vermont in 1983; copy at VHS Library, Montpelier.

____________"Current Research in New England: Connecticut - The Connecticut Charcoal Company" Society for Industrial Archeology - New England Chapters Vol 5, No 1, 1985, pp/ 5-6. - Present-day charcoal making 'the old way', with modern twists; comparative to Vermont work. Copy at VHS Library, Montpelier.

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(File B:SRL.585)

IRON INDUSTRY

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Lyman Batcheller's forge, ca. 1840.

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IRON INDUSTRY - BUILDING TYPES

Bellows
Blacksmith shop
Bloomery
Dam
Flume
Forge
Foundry
Furnace: Pudding, Air, Reverberatory
    Anthracite
    Blast
    Charcoal
Hammer, tilt
Kiln
Mill, slitting
Mine - open pit
Offices
Race
Smelter
Turbine
Water wheel
Wheel pit
Worker housing

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## Ironworks - General:

W. David Lewis Iron and Steel in America Greenville, Del: The Hagley Museum, 1976, 64pp, illus, biblio, index ($3.50). - Excellant.

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Brandon, Vermont: A History of the Town The Town of Brandon, 1961, biblio, index, ($5.95) pp. 11-13. - Brandon and Forestdale ironworks.

Carl Seaburg and Stanley Paterson Merchant Prince of Boston: Colonel T.H. Perkins, 1764-1854 Cambridge, Mass: Harvard University Press, 1971, Chapter 18 "Short Blast on the Otter" pp. 199-210, biblio, index ($22.50). - Monkton Iron Co., Vergennes, ca. 1808-09.

Christine M. Peleszak The Abandonment of Leicester Hollow BS Thesis, UVM, Burlington, 1984, 111pp, illus, biblio. - Awarded Honors by UVM Dept of Agriculture.

Ironworks - Vermont (cont):

Victor R. Rolando Ironmaking in Vermont: 1775-1890 MA Thesis, The College of Saint Rose, Albany, N.Y., 1980, 132pp, illus, biblio. - Somewhat outdated by current research. Copies at UVM, Burlington; VHS Library, Montpelier; The Rutland Historical Society, Rutland; and Sheldon Museum Library, Middlebury.

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____________ "Search for Vermont Furnaces Yields Dramatic Discoveries" VAS Newsletter No. 32, August 1980, pp. 1-4, biblio. - Description of blast furnace; sites at Bennington, Dorset, Forestdale, and Troy, Vt.

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____________ "Current Research in New England: Vermont - Iron and Charcoal Sites" Society for Industrial Archeology - New England Chapters Vol. 5, No. 1, 1985, pp. 13-14. - Background leading to location of ca. 1825 Colburn blast furnace at West Haven, Vt.

Hon. Harvey Munsill, Esq The Early History of Bristol, Vermont The Book Committee of the Bristol Historical Society, (1979?) ($11.75). - "Forges": pp. 107-112. - Forges along the New Haven River and Baldwin Creek in Bristol.

Aleine Austin Matthew Lyon: "New Man" of the Democratic Revolution, 1749-1822 University Park, Penn: The Pennsylvania State University Press, 1981, 192pp, biblio, index ($19.50). - Lyons Works at Fair Haven.

Charcoal Making - General:

Thomas Egleston "The Manufacture of Charcoal in Kilns" Transactions of the American Institute of Mining Engineers Vol. 6, May 1879-Feb. 1880, pp. 373-397. - Copy at UVM Library; includes some Vermont data. An excellant research tool.

Jackson Kemper III American Charcoal Making Eastern National Park & Monument Assn., U.S. Dept. of Interior (1960's?) 25pp, illus. - A good little Park Service booklet on making charcoal in mounds.

Rob Woolmington "Coking Charcoal Down in Rattlesnake Gutter" Yankee Magazine December 1979, pp. 80-85, 132-134. - Charcoal kilns in Massachusetts and southern Vermont.

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____________ "Ghost Towns in New England" New England Boston: The Boston Globe, October 23, 1977, pp. 38-40, 42, 44-45. - Abandoned charcoal making towns in southern Vermont.

J.R. Chapin "The Charcoal Burners of The Green Mountains" Outing Magazine April 1885, pp. 4-18, illus. - Charcoal making at Mt Tabor in the 1880's; copy at VHS Library, Montpelier.

Victor R. Rolando "Current Research in New England: Vermont - Charcoal Kilns" Society for Industrial Archeology - New England Chapters Vol. 3, No. 1/2, 1982, pp. 12-14. - Field work in southern Vermont in 1982; copy at VHS Library, Montpelier.

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____________"Current Research in New England: Connecticut - The Connecticut Charcoal Company" Society for Industrial Archeology - New England Chapters Vol. 5, No. 1, 1985, pp. 5-6. - Present day charcoal making 'the old way', with modern twists; comparative to Vermont work. Copy at VHS Library, Montpelier.

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The Green Mountain Iron Company: 1823-1865

The blast furnace stack that stands today at Forestdale, Vermont is the remains of that built about 1823 and modified in 1854. People associated with the works' operations included Stephen Smith of Leicester and Samuel Buell of Brandon in 1824, Royal Blake and Barzillai Davenport in 1824, and Blake and (Charles?) Hammond in 1836. The works at this time were known as the 'upper works' to distinguish it from the works at Brandon village. In 1845, the furnace produced 1200+ tons of pig iron and stove castings. The works was organized into the Green Mountain Iron Company in 1854 and the casting of parlor stoves was the mainstay of production. But that same year an unsuccessful attempt was made to convert the stack to burn anthracite instead of charcoal for fuel. It shut down soon after. In 1864, the works was owned by the Brandon Iron Company and included three newly-built bloomery forges. The furnace was fired in early 1865, the first time since 1854, and it along with the forges operated for about two months, only to shut down again, this time for good.

In 1974, a few years after being donated to the Vermont Division for Historic Preservation, the furnace and a few surrounding acres were placed on the National Register of Historic Places. Under Division ownership and care today, lack of public funds prevents needed stabilization/repair of the stack and maintenance and interpretive restoration of the grounds.

Further reading:


Brandon, Vermont Brandon, The Town of Brandon, 1961.

Peleszak, Christine M The Abandonment of Leicester Hollow (undergraduate thesis: BS in Environment Program - UVM Burlington, 1984) pp. 11-17.



Vic Rolando
Exploring Local Industry: Middlebury 1800-1900
November 8-10, 1985

They left Bennington in the fall of 1798, came north, and first made an effort to purchase the water-power in Highgate now known as Keyes' Falls, then owned by a man by the name of Potter, and then called Potter's Falls; but he refused to sell, and they then concluded to purchase from Silas Hathaway the undivided half of 200 acres (Simeon Hathaway, Jr., owning the other half of the 200 acres), on the westerly side of the river at Swanton Falls, which took in all the water-power below the dam on the west side of the river. After closing their trade, Feb. 23, 1799, they returned to Bennington, and my father from thence to Taunton, Mass. In the spring, Elisha Barney employed a man by name of Ricord to come to Swanton and build a small house, and assist in preparing for the erection of a forge. He also furnished a span of horses, and hired Mr. John Dunbar to go to Swanton with them and take his family with him. As Dunbar was a bloomer by trade, it was designed he should work at making iron as soon as the forge was completed. Capt. Rufus came from Bennington with Dunbar to Swanton, and remained during the season, boarding at the widow Holgate's, the only tavern then in the place. He superintended building the forge, forge-dam and long flume from the main dam to the forge-pond. They had to dig a channel where the forge-pond now is, then covered with a heavy growth of pine. This was in 1799, and they built a small frame-house, at that time connected with the forge privilege, on "the Island"—the first frame-house on the west side of the river, about 6 rods to the west of the house now owned by Geo. Bullard, 2d. This house was demolished years ago. Having given a careful oversight to these operations during the season, Capt. Rufus returned to Bennington, Elisha having remained in Taunton during the year. At length, Feb. 20, 1800, he, with wife and two children, Rufus and Evaline, left Taunton with horses and sleigh for Swanton, by way of Bennington, arriving there in 5 days. Leaving there the next Wednesday morning, they proceeded on their way toward Swanton. There came on a severe storm, and snow fell very deep and hindered them much. On the third day, near night, the sleigh turned over, and all were buried in snow. It being near night, and no tavern near, they sought lodging at a private dwelling near. The people received them kindly, but could not lodge them, so they took their own bed from the sleigh, and made it on the floor, and passed the night very comfortably. They arrived in Swanton on the Tuesday night after leaving Bennington, and lodged at the house of Levi Hathaway, a log-house which stood on or near the place where C. H. Bullard carried on the manufacture of wagons and sleighs many years. There is now no building on the spot. The next morning they took breakfast at Holgate's. There were then large stumps on the green, and they nearly covered with snow. They crossed the river on the ice, and took up their residence in the small frame-house built the season previous. It was, however, already occupied by two families, James Hoard and wife and Asa Witherell and wife and some 4 children. Their domicile was not very airy, but they were young and could endure privations, looking forward for better days. At that time the west side of the river was covered with the forest nearly to the river. A spot had been cleared on what is known as Willow Point, near the mouth of the Forge brook. On this spot there was a little grass, but in no other place nearer than about a mile below the Falls, on a plat now covered by a beautiful grove of pine trees, which have come up and grown since that time. There were a few farms cleared by the Indians, two or three miles below the Falls, one in particular where the Indian village formerly stood, now the farm owned by Asa Brooks. There was also the Wagoner farm, with Rood's and Hilliker's, already mentioned. There was one saw-mill only on the west side of the river, that was at the west end of the dam owned by Hathaway. This saw-mill, with the house they moved into, and a log-house on the site of the one now owned by the Scott family, and occupied at the time by John Dunbar and family,

FORGE BLDG

CHARCOAL

BOG IRON FORGE

were all the buildings on the west side of the river at the time of their arrival about two months after, the beginning of the present century.

On the east side of the river there were 9 families: Joseph Robinson, living in a house near where Nelson Bullard now resides; Levi Hungerford and Dr. Smith, both families in one house, on the flat ground near the old tannery below the hill, in rear of the old stone house; Thos. Butterfield, on summit of hill near where the old stone house now stands; Orange Smith, house near where the Ferris house now stands; Widow Holgate, whose husband, Asa Holgate, died about one year previous, house near where Lorenzo Lasell's now stands; Joseph Clark, house below the hill near the residence of A. Forbes; Old Spoor, as he was called, house on hill-side near the present site of bank; Jonathan Butterfield, house near the old ferry.

There were no goods kept in the place for sale, nor were any to be had nearer than St. Albans Bay. There was also a house standing on land now owned by Geo. M. Kidder, near the hollow east of the village, in which Alex. Ferguson soon after kept a small assortment of goods for sale.

John B. Joyal, who lived to a great age, as will be noticed in another place, then lived at, and kept a ferry about one mile south of the village, and some time after assisted in building and kept a toll-bridge near where the ferry was kept, which ever after went by the name of Old John's bridge. Levi Scott, who married Silence, the daughter of Capt. Rufus Barney, at Bennington, made his arrangements to leave Bennington with Elisha Barney, but did not in consequence of the severe storm, but waited a few days, and arrived in Swanton about one week after. He moved into one part of the log house occupied by John Dunbar. The Scott family have ever since retained the land on which this first house on the west side of the river was built. Scott took a part of Capt. Rufus Barney's interest in the forge. He, Rufus, came on about the month of May, bringing with him his Uncle Jonathan and his two sons, who all labored during the season on the forge and improvements connected therewith. In the meantime, wood was prepared and set together in large heaps, and a covering of straw and earth placed over them. These heaps were called coal pits, a name not very appropriate, as a pit denotes a hollow or depression, while these were exactly the reverse. These pits were set on fire at the top, and the fire regulated by vents made through the earth covering, and thus slowly burned to charcoal. A number of these were burned during this season, Asa Witherell, an old man, being the collier. Bog ore was dug from the wet land about a half mile east of the village, and was then known as the ore swamp. This kind of ore was formed by being deposited from water, highly impregnated with iron, which stood on the surface of the swamp nearly or quite the year around. It was shoveled from the surface of the ground, the water generally covering it, the workmen standing in the water. After much of labor and delays, they got the forge completed, and commenced making iron in Nov. 1800, this being the first wrought iron made in this section of country. The business was discontinued during the winter, and resumed in the spring of 1801. To Seth Pollard belongs the distinction of making the first iron in Swanton. According to the recollection of my mother, he waited here a long time for the completion of the forge, before leaving for Bennington, which he did soon after making the first iron. John Dunbar also worked at the business, from the start, or nearly so, he probably being what was known as the "hammersman," or the man that forged the iron under the hammer.

There were a number of iron workers, or bloomers, ready for work on the completion of the forge, among the names remembered by my mother are Major Keep, Isaac Williams, Job Spinks, and a collier by the name of Heddell.

About the time of the completion of the forge, perhaps a little before, Lemuel Barney, son of Capt. Rufus, arrived and stayed some two months, when he left for

Canaan, Conn., where he had previously married Anna Hinman. He returned to Swanton the winter following, but did not bring his wife. She, however, came in the spring of 1801, and they began keeping house on the east side of the river, remaining there about four months, when they moved into the house occupied by Elisha Barney, taking the part which Witherell had previously vacated. After Lemuel arrived with his wife, his father, Capt. Rufus Barney, in 1803, gave up his interest in the iron business to him, and Levi Scott, his son-in-law; they then (1803) owning one-half, and Elisha Barney owning the part if not all of the other half.

After this Capt. Rufus took no direct interest in the business, but came up from Bennington every year for many years after, to see how his brother and children were doing.

This first forge was erected on what is known as the forge privilege, at the easterly end of the forge dam.

Iron was made in considerable quantities from year to year, and was sold principally to blacksmiths from the neighboring towns, much of it was made into tire-iron, sleigh-shoes, mill-irons, plow-shares, etc. The price of common bar-iron was $7 per 100 lbs., (gross,) and remained so more than 20 years.

About 1816, this forge was burnt in the night. When on fire, a timber burnt off and fell on the gate-lever, raised the gate and set the large hammer in motion, which striking the solid anvil very fast, made a loud noise, and roused many from their slumbers. It was rebuilt and carried on mostly by Lemuel Barney, until about 1821, when the old building having become dilapidated, its use was discontinued and a new forge built on the westerly side of it, by Elisha Barney and Robert Foster, his son-in-law, in 1821; carried on by them until 1824, when it was purchased by R. L. & H. W. Barney, who carried on the business for many years.

This building becoming old, was removed and a new one erected in its place, in the summer of 1849, by Friend H. Barney, son of Lemuel, H. W. Barney, son of Elisha, W. S. Thayer, son of Amherst, and E. S. Meigs, son of Benjamin. This forge for making iron was a great improvement on the old one. This company operated the forge only a few years. After this, Mr. F. H. Barney continued the business, manufacturing mostly "blooms," for the southern market, until about 1868. Since which, there has been no iron manufactured in the place, and the forge suffered to go to decay, when in 1872, it was entirely removed and a fine lumber circular saw-mill erected in its place, owned [1882] and carried on by A. J. Barney, son of H. W., built about 1875.

Thus after 68 years from its commencement the business has gone down; the causes are not a mystery; bog ore that was abundant, and could be had for the shoveling from the surface of the ground, since about 1835 became scarce by the lands that produced it being drained; coal which for many years was cheap, after wood had been cut off and become valuable, became dear, and it became impossible to compete with works in more favored regions.

IRON

demise of iron industry as coal, wood and ore dwindle

Mr. C. H. Mead tells me he has heard his father, Caleb Mead, say that about 1810, he dug bog ore from land directly in front of where the present residence of Deacon Harvey Stone now stands, and drew what he could with a horse-team to Sheldon furnace all of one winter.

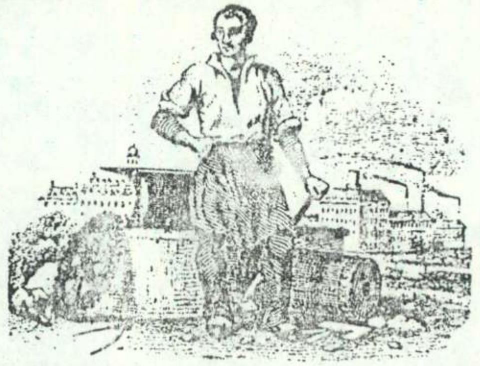
### POTASH.

The first settlers in clearing their lands, made large quantities of ashes, and many of them procured potash kettles, and commenced manufacturing potash, which was sold to merchants, or sent direct to the Montreal market. It was about the only article they could then produce and turn to cash. I remember once hearing a manufacturer say about 1826, the most of the farmers relied on their ashes to get money to pay their taxes.

POTASH

Aside from the farmers who made potash on a small scale, were the merchants also that produced it in larger quantities. There was an establishment for making it on the easterly bank of the river, about 50 rods below Barney's marble mill, a little above the present "brick yard." This

IRON INDUSTRY



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# Society for Industrial Archeology · New England Chapters

VOLUME 8 NUMBER 2 1988


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The Newsletter is jointly sponsored by the Southern and Northern New England Chapters of the Society for Industrial Archeology. This issue was typeset and printed by the Printed Word, Inc. of Concord, New Hampshire.


## IA CONFERENCE

The second annual Conference on New England Industrial Archeology will be held on February 4, 1989, at Old Sturbridge Village, Massachusetts. The conference is jointly sponsored by the Northern and Southern New England Chapters of the Society for Industrial Archeology, and will feature an address by, and discussions with, national SIA President, Emory Kemp.

In the paper sessions, one focus will be the developments in the emerging Blackstone Valley Heritage Corridor, an amalgam of state parks in Massachusetts and Rhode Island with a National Park Service component. Patrick Malone, with Gregory Galer, Beth Parkhurst and others, will describe the inventory of the corridor. Larry Gross will offer the results of a team investigation of the Dudley Shuttle Company of Wilkinsonville, a site included in the area, along with Carolyn Cooper, who will describe her work on the machinery inventory, and Paul Hudon, who will present material on the history of the company. Michael Roberts will discuss efforts to create an interpretive plan for the corridor.

A second focus will be on a parallel region with overlapping themes, when a group from Old Sturbridge Village will describe their current research. Proto-industrial development in the Quinebaug Valley will be presented by David Simmons (blacksmithing), John Worrell (pottery), Martha Lance (mills) and Myron Stachiw (neighborhood economy).

The conference is scheduled to begin with registration at 9:00 AM and will continue until 4:00 PM, with appropriate breaks for lunch and conversation.

## Editorial

All of our members are encouraged to attend the upcoming Second Annual Conference on New England Industrial Archeology, to be held at Old Sturbridge Village on February 4.

Also, the Northern New England Chapter is preparing for a recording project to be held at an ironworks site in Vermont next May or June. This is the site of the Forestdale iron furnace, located just east of Brandon (and south of Middlebury). Vic Rolando, who has spent many years researching iron and charcoal sites in Vermont, has prepared a special article on Forestdale for this issue of the Newsletter. The Forestdale site is on property administered by the Vermont Division for Historic Preservation, and they are especially excited at the prospect of our members coming to help clear, record, and interpret the site. All interested NNEC and SNEC members who would like to participate are urged to stay in touch with either me or Vic Rolando for additional details. Further information will appear in the spring issue of this Newsletter.

David Starbuck
Rensselaer Polytechnic Institute

Sunday, 10 am to 5 pm.

The museum is on the north bank of the Charles River one block from Central Square in Waltham. A foot bridge connects the museum with the municipal parking lot off Pine Street.

For further information on group rates or special school programs, call (617) 893-5410.

## Article

### The Green Mountain Iron Company

[Editor's Note: The Northern New England Chapter will be holding a week-long recording project at this site next May or June.]

At a town meeting in 1778 at Brandon, Vermont, it was voted that should sufficient iron ore be discovered in the town, an ironworks would be built. The next year, there was a request by the town to lease an ironworks site and its water power. It is unknown exactly where in the town the ironworks activity was planned since the next few years saw works operating in the village and also two miles to the east, at what today is called "Forestdale."

By 1790, a forge built in Brandon village by Blake had been bought by Avery, Curtis, and Sawyer (Curtis was associated with a furnace in Dorset; Sawyer with a forge in Salisbury). A few years later it was reported that Brandon had iron foundries and forges where good bar iron was being made. The forge changed hands a number of times; at one time it manufactured shovels from ore mined at Forestdale. From the Forge at Brandon village, the shovels found markets as far away as Boston, MA.

In 1796, soon after arriving from Auburnham, MA, John Conant purchased half of the mills and water power in Brandon. He and his father-in-law, Wait Broughton, worked together for a number of years building mills along the Neshobe River in the village. At the same time, John Smith was making bar iron at his forge at Forestdale. But in 1810, a major iron discovery occurred at Forestdale that started a series of industrial events in the town, including the construction of blast furnaces at Brandon village and at Forestdale.

These furnaces were but two of nearly three dozen blast furnaces that are known to have operated in Vermont. As part of a state-wide IA survey of Vermont by the author (now in its tenth year), the sites or ruins of 15 blast furnaces have been located. The sites of another 18 blast furnaces known to exist through archival research or inconclusive field evidence have yet to be precisely located, although locations of most have slowly been narrowed to relatively small geographic areas of probability. There are additional vague archival hints of a few more blast furnaces in Vermont, but it will take more archival and field work to decide where to look.

The known blast furnace sites are generally in the valleys east of the Green Mountain range. Dates of operation of these blast furnaces range from 1788 (Orwell) to about 1883 (Pittsford), and locations are as shown in Table 1.

John Smith's forge made iron at Forestdale in 1810 with ore that came from beds dug locally at Leicester Hollow. Around 1823 a blast furnace went into operation at Forestdale, smelting ore from beds a half mile away. The major output of the furnace was pig iron, but a variety of ornamental iron such a vases, statues, and chairs were also cast. In 1845 the output of the furnace reached 1200 tons, not including 800 stove castings.

Some names connected with the Forestdale furnace operations during this time were Stephen Smith of Leicester and Samuel Buell of Brandon in 1824; Royale Blake and Brazillai Davenport in 1827; and Royal Blake and (__?__) Hammond in 1836. Hammond might have been Charles Hammond, who a few years earlier was part owner of the Bennington Iron Company; or possibly Charles F. Ham-

*Table 1. Locations of Blast Furnaces in Vermont.*

| | | | |
|---|---|---|---|
| *Bennington* | 4 + *1** | *Wallingford* | *1** |
| *Bristol* | *1** | *Woodford* | *1** |
| *Pittsford* | *1* | *Weybridge* | *1** |
| *Shaftsbury* | *1** | *Brandon* | *1** |
| *Vergennes* | 2* | *Manchester* | *1** |
| *Forestdale* | *1* | *Waitsfield* | *1** |
| *East Dorset* | *1* | *West Haven* | *1* |
| *St. Johnsbury* | *1** | *North Dorset* | *1* |
| *Orwell* | *1* | *Highgate* | *1* |
| *Tinmouth* | 2 + 2* | *Plymouth* | *1** |
| *Sheldon* | 2* | *Clarendon* | *1* |
| *New Haven* | *1** | *Troy* | *1* |

* *Not precisely located.*

mond who operated ironworks at Crown Point, N.Y., in the 1840 period (or both?). An 1827 record mentioned the ore bed, furnace, and a coal house with 5000 bushels of charcoal. A diary of DeWitt Clinton Clarke (a relative of J.A. Conant and a partner in the Brandon village works) mentioned an "Upper Furnace," called the "Hammond and Blake Furnace," which was most likely the furnace at Forestdale.

Brown hematite ore was mined at the foot of a sandy hill to the east of the furnace, near the base of higher mountains. Some 1849 costs were:

Iron ore...$1.75 per ton, at the mine
Iron ore...$2.50 per ton, after washing
Charcoal...$5.00 per 100 bushels.

Before charging it into the furnace, the ore was washed to remove clay, stones, and dirt, allowing for a more efficient smelting process. The yield of the furnace was 5½ to 6 tons of iron a day; the annual capacity was about 1200 tons.

From papers at the Vermont Historical Society Library, Alvin B. Jones was found to have hauled the tonnage shown in Table 2 "to the lake" (Lake Champlain) for Royal Blake. The record also showed that Jones hauled 201 loads of flux for the furnace from April 1844 through January 1845.

Kettles, tools, wagon equipment, fireplace furnishings, stoves, and even small cannon were cast and sold throughout the Northeast and as far away as Ohio. One shipment to Chipman Point Landing on Lake Champlain included a number of stoves, 59 axes, 12 draft chains weighing 2400 pounds, and 5 two-horse wagons, plus an

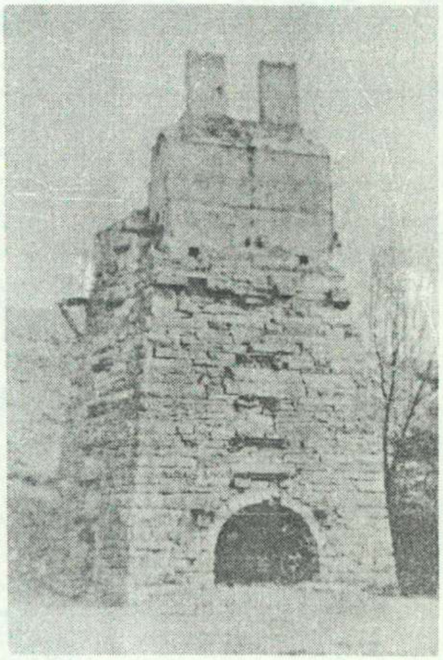
*Table 2. Tonnage hauled by Alvin B. Jones.*

| DATE | LONG TONS SHIPPED |
|---|---|
| Sept. 1844 to Jan. 1845 | 9.93 |
| May 1845 to June 1845 | 6.99 |
| Oct. 1845 | 2.31 |
| Oct. 1846 to Nov. 1846 | 2.43 |
| Sept. 1847 | 0.98 |

assortment of kettles, skillets, five dogs (heavy iron rods), spiders (cast iron frying pans with legs), and flat irons, for a total value of over $1000. This was at a time when beef cost five cents a pound and butter about 15 cents a pound!

By 1854 the Green Mountain Iron Company had been organized, and the Forestdale furnace works had been acquired. Parlor stoves were the mainstay of production, and many such stoves with their raised "G.M. Iron Co" lettering still grace homes in Vermont (including one that is part of the author's collection of cast iron Vermont stoves). The Company enlarged the stack's inside to fuel it with anthracite coal instead of charcoal, but the experiment was apparently unsuccessful because the furnace shut down the same year. Anthracite gave the iron different characteristics than charcoal; for example, a higher sulfur iron. Ironworks throughout the country were attempting to convert to coal at this time and finding it difficult. More successful were those who razed and completely rebuilt their stack, redesigning it specifically to burn coal. The Company's failure, however, could have been for economic as well as technical reasons. The 1850s were difficult economic times, and many ironworks throughout the country were being abandoned.

Insofar as known archival material indicates, dimensions and operating characteristics of the original blast furnace are unknown. When enlarged in 1854 by the Green Mountain Iron Company, the stack stood 42 feet high with bosh walls 9 feet in diameter. Blast was preheated to 600 degrees F by means of heating ovens and conveyed into the hearth by three 4-inch diameter tuyeres. A pair of blowing cylinders measured 30 inches in



*Circa 1900 view of the stack's north wall before it collapsed. Note the blast heating oven at the top.*

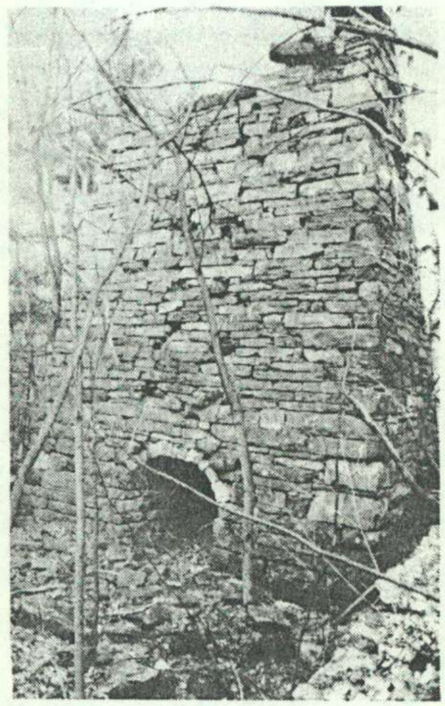
diameter with a five-foot stroke. They were waterwheel driven. Ambient air from the cylinders was pumped into a damping sylinder connected atop the blowing cylinders to reduce pulsations in the blast, and through a pipe to the top of the stack to the heating ovens (which drew hot exhaust gases to heat the incoming cold air). The heated air was conveyed down to the tuyeres through pipes that were run between the walls of the stack for insulation.

When the Brandon Iron Works took over operation about 1864, the bosh was widened to ten feet and the tuyeres to 4 inches in diameter. The waterwheel, which was probably overshot, measured 12 feet wide by 36 feet in diameter at this time.

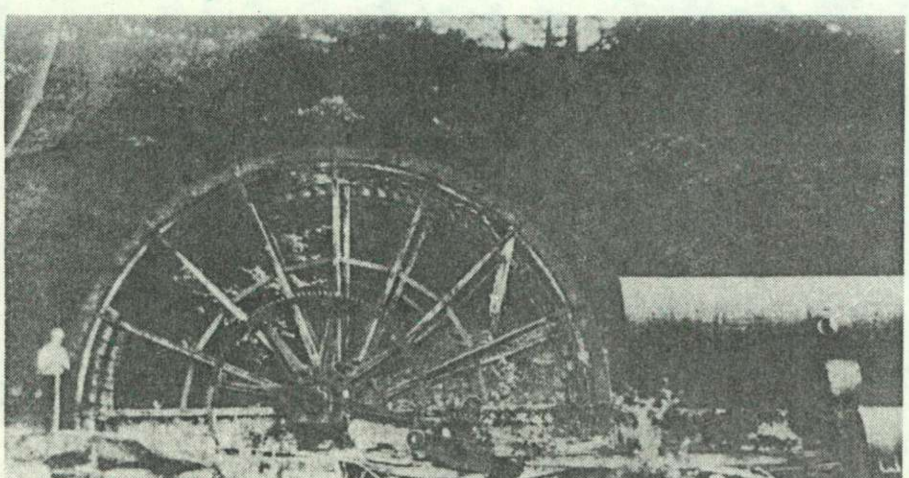
Three bloomery forges and a 1500-pound trip hammer were also built at Forestdale in 1864 by the Brandon Iron company. They were located about 400 feet east of the furnace. The forges, working ore beds that were located a half mile away, produced 85 tons of bar iron during their brief two months of life in the spring of 1865. The blast furnace, also fired up for the first time since 1854, made 784 tons of cast iron. By year's end, however, the forges and furnace were quiet, never again to operate. These, as well as other buildings of the Brandon Iron Company (not to be confused with the Brandon Iron & Car Wheel Co. of Brandon village) are shown on the Beer's 1869 map. The map also shows the shafts of the iron mines a half mile south, where ore was at that time being processed into paint pigment.

The blast furnace today stands at Forestdale, however precariously, in the midst of growing underbrush. From dimensions taken in December of 1983, the stack measures very close to 31-1/2 feet square. The north wall, which contained the casting arch, is collapsed, revealing the in-wall and bosh wall. Arches in the west, south, and east wall measure 7'8'', 7'11'', and 7'11'', respectively, at ground level. The narrower west arch is probably the result of shifting and settling of the walls, which are laid-up rough stonework. This west archway extends 10 feet into the base of the furnace to an iron ring in the ceiling. Open stonework at the interior end of the archway allows partial visibility diagonally to the right, across the inside corner into the end of the south archway. It is unknown if this was an original design feature. In 1983 the tuyere holes were visible inside the three archways, and by means of a hand-held mirror, the interior bosh and hearth linings could be inspected. Collapse of some brickwork since then hides the tuyere holes, although a new opening inside the east archway allows the unsqueemish to crawl into and stand up inside the stack.

Except for the in-wall, bosh, hearth walls, and possibly the top ovens, no



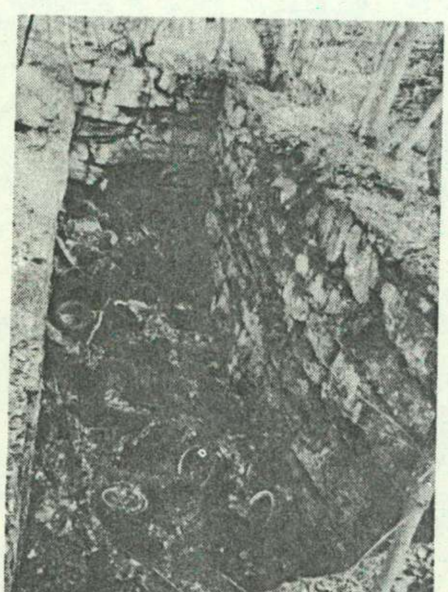
*West wall of the furnace stack in the fall of 1983.*



*Circa 1900 view of the waterwheel and blast machinery (furnace is off photo to right. For idea of scale, note man standing at left of wheel.*

brick was used in stack construction. Various makes of firebrick are found about the base of the stack, including one made in Troy, N.Y.

Immediately east of the stack are the large stone mounts of the blowing tubs, and beyond is the deep, stone-lined waterwheel pit. The dozens of old auto and truck tires that lie discarded at the bottom give "wheel pit" a new meaning! (A state highway shed stands just uphill from the stack and the wheel pit.) The head race can be followed east to the dam site by means of iron hoops that probably held an approximately 18-inch diameter wood pipe. And all around the area and across Route 73 are the remains of cellarholes, vestiges of the community that once thrived about the works. South across Route 73 from the works stands the stone block house built by Royale Blake, where hinges in the rear, wooden part of the house, were made at the ironworks. On the north side of Route 73, just uphill from the state highway shed, remains of what local residents claim to have been a "cup" or a casting furnace lie under roadside fill. It has also been described as once having a stone tower similar to that of the blast furnace, but much shorter. Could have been part of the stonework associated with the charging bridge? Whatever it was, it hopefully remains protectively buried for future study. John Smith's circa 1800 forge was probably located about 100 yards northwest of the furnace stack, near where the present-day dirt road leads into the furnace property from the village.



*Waterwheel pit at Forestdale; the state highway department shed is directly uphill (right).*

The furnace and approximately 10 acres of furnace grounds were donated to the Vermont Division for Historic Preservation (DHP) by Mr. and Mrs. Welland Horn; and in 1974 the blast furnace property was placed on the National Register of Historic Places through the efforts of Chester Liebs (with some assistance by the author). The stack was fenced off following continued deterioration of its north wall. Since then, DHP has been unable to do much toward stabilizing the ruin due to budget constraints. Trash along the stream reflects the numbers of campers who annually use the grounds at will; in the cellarhole of one of the works' tenements is a plastic sheet "tent." But renewed interest in the furnace and property by DHP could lead to significant activity there in 1989.

Under the direction of Audrey Porsche, recently assigned by DHP to administrate the Forestdale furnace site, and the leadership of our own David Starbuck, a major volunteer effort by NNEC/SNEC-SIA membership is being looked for early next spring by the DHP in the form of a thorough week or weekend recording session. On October 29 of this year, an inspection party consisting of Audrey, Dave, Dennis Howe (NNEC President), Bill Murphy (VAS President), Bob West, and the author spent some chilly hours in drizzle and flurries hiking over the entire furnace area. The current plan is to cut back the foliage in advance, followed closely by the recording week/weekend. Results of the session should go a long way toward providing DHP with what it needs to interpret the site, and hopefully they will soon be able to stabilize the furnace stack.

*Ornate parlor stove cast at the Green Mountain Iron co. furnace at Forestdale (c. 1850); part of the author's collection of cast iron Vermont stoves.*

Vic Rolando
Pittsfield, MA

Please return
to Giovanna

FORGES, FURNACES, AND FOUNDRIES

A brief description of the various furnace names, dimensions, and applications to the iron industry.

for

<u>Exploring Local Industry, Middlebury 1800-1900</u>
The Sheldon Museum, Middlebury, Vermont

November 8-10, 1985

by

Victor R. Rolando
Researcher of Vermont Industry

## Forges, Furnaces, and Foundries

The iron industry was, and still is, fraught with technical terms and expressions that appear to sound alike, but each describe a specific industry process. Such things as a blast furnace, air furnace, cupola furnace, heating furnace, etc., all tend to confuse. Historians genarally lumped all these expressions under the all-inclusive category of the forge, leaving it to later generations of historians to sift through the words and try to figure out exactly what was going on at the forge.

The word 'forge' can be a noun or a verb; it can be a place where iron was worked or it can be the working of iron. Working iron usually meant heating, melting, hammering (manually or by machine), molding, rolling, drawing, and shearing. The latter three were normally associated with foundry operations. Historians also called a place where iron was made a forge, which additionally included such operations as smelting, casting, puddling, reducing, etc. A forge, therefore, can be interpreted to mean almost anything connected with the iron industry, depending on the time period of the published material and the technical background of the historian. The forge could have been a full-scale blast furnace operation; it could have been a blacksmith's shop. The word 'forge' should be approached carefully and skeptically.

Early histories abound with statements that "At an early time a furnace operated in the town..." with no further information. Depending on such other factors as proximity to water power, iron ore, fuel, and market, the 'furnace' could have been a blast furnace; it could have been a small farrier's shop. Follow-up field work usually uncovers the secret, although a knowledge of the furnace structure and dimensions is important for interpreting the remains in addition to being able to recognize the site when it is seen.

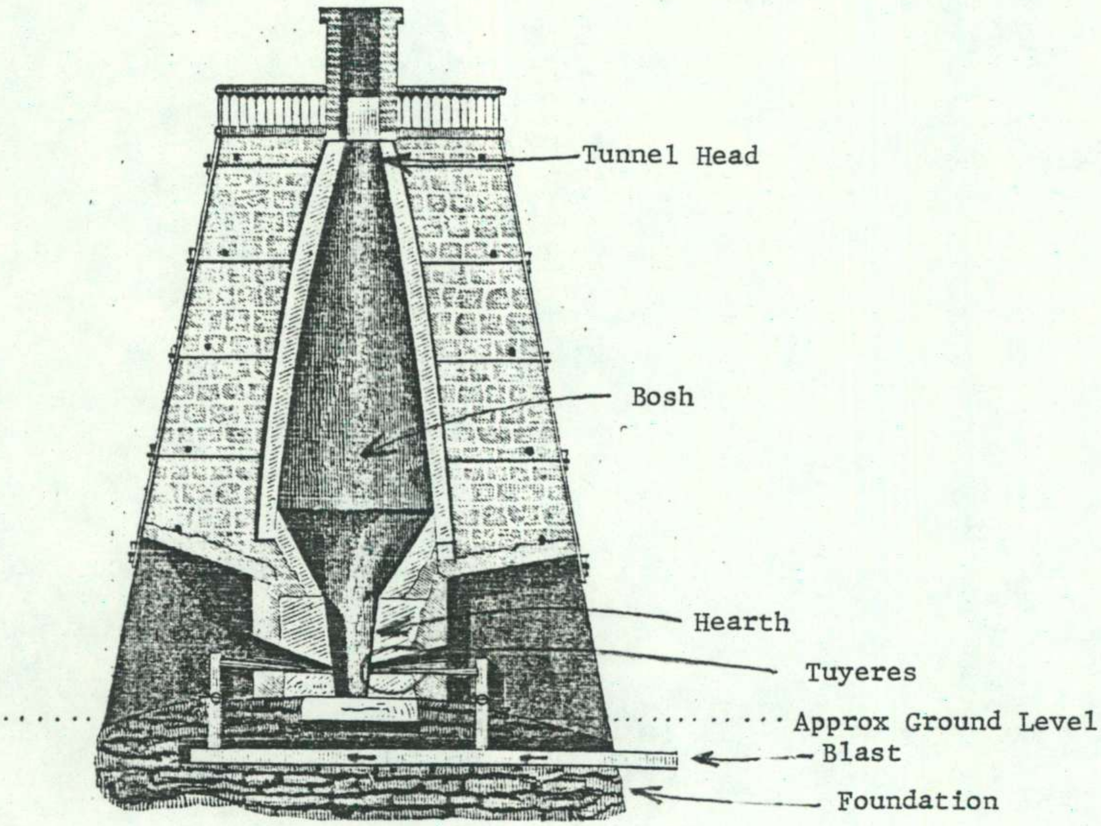
The 19th century witnessed the final transition of the iron industry from the technically stagnant Middle Ages through the frenzied Industrial Revolution and into the 'modern' 20th century. During that 100-year period, the industry experienced so many technical improvements that many blast furnaces were obsolete a dozen years after they were built. A correct description of the industry and its furnace artifact for the 19th century is therefore impossible since no period is typical of the entire century.

The 1840's has been chosen for the period of description for a few reasons. For one, the 1840's was a period when works' owners were comparing notes, sharing technical knowledge, and learning that 'secret processes' were hindering not only the general growth of the industry but also their individual growth. Owners were starting to recognize that iron making was a chemical process and that almost insignificant variances in furnace design and materials made significant changes to the quality of the final iron product. By the 1840's, iron associations started forming and books on the art of making iron started appearing, giving us a good documented point to analyze the state of the industry. And, by the 1840's, the iron industry in Vermont was in transition; numbers of iron-making blast furnaces and bloomeries were decreasing but the manufacture of agricultural implements was increasing.

A few blast furnaces continued to operate in Vermont after the 1840's; the Green Mountain Iron Company stack at Forestdale to 1865 and the Vermont Iron Co stack at Pittsford to the 1870's. But the 1840's generally mark the high-water mark of blast furnace activity in Vermont. It is a good sample period.

## The Charcoal Blast Furnace

By the mid-1800's, blast furnaces fueled by anthracite were appearing in the Northeast. Anthracite was tried unsuccessfully at two places in Vermont. The abundant local forests, however, provided sufficient fuel for Vermont's blast furnaces.




Section of a charcoal furnace through the tuyere arches.

The charcoal blast furnace was generally 35 feet high and set 30 feet square at the base on a foundation 32 feet square and extended some 6 to 10 feet below ground. The walls of the stack sloped inward so that this 35-foot high stack was 15 feet square at the top, approximately a quarter the area of the base. The outside walls were made of hard, dense stone, capable of withstanding the weight of everything above without cracking. This outside wall was unmortared. The inside walls, where the heat of the furnace reduced the ore, were made of a refractory quality stone, usually sandstone, although by the 1840's some types of refractory bricks (fire brick) were starting to be used.

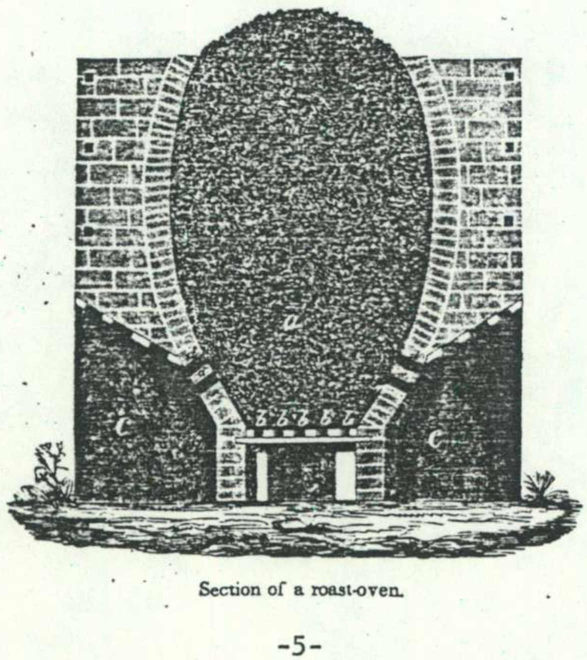
As the name implies, the charcoal blast furnace was fueled by charcoal and its high temperatures created by the forced blast of air. The blast was continuous, although only 1/4 to 1/2 pound per square inch, it was none-the-less of high volume, pumped by large bellows or air cylinders run by waterwheel. The blast was introduced into the furnace interior through cast iron nozzles called tuyeres (pronounced too-wee'- r's), located inside the three tuyere arches (see above figure).

The fourth archway, the largest of the four, was the work arch, where ironworkers maintained the hearth and periodically tapped slag and molten iron from the furnace interior.

The blast furnace had one sole purpose, which was to reduce iron ore to molten iron that when cooled, became a relatively hard, high-carbon cast iron. The blast furnace ran night and day without stop, except for malfunctions. Continuous blasts lasted several months, sometimes 15 to 18 months. In Vermont, however, frozen winter streams limited the blasts from spring to fall. The life of the fire brick usually defined the length of the blast. During the blast, all fuel, flux, and ore had to keep coming to the top of the furnace stack while molten slag and iron was drawn from the bottom. Nothing was allowed to interrupt the rhythm of wagons arriving and leaving, roads had to be kept clear, no holidays or weekends stopped the process.

## Ore Roasting Ovens

After the iron ore was crushed, separated, and washed, but before it was prepared for charging the blast furnace, it was sometimes roasted. The process of roasting the ore removed such imputities as sulfur, hydrogen, chloride, arsenic, and phosphurous. These were drawn off as gas, and in the case of sulfur, also reduced the chance of explosion in the blast furnace. Although called roasting ovens, they had all the external appearance of a short (12 to 18 feet high) blast furnace.

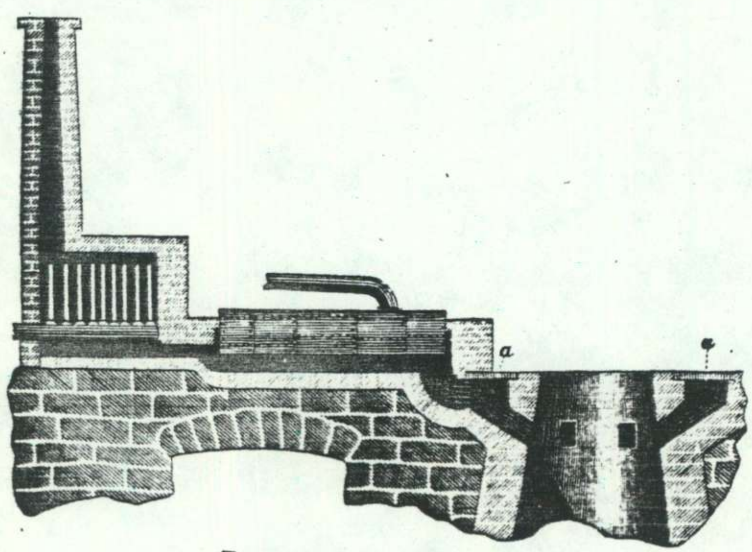



Section of a roast-oven.

Raw ore mixed with charcoal was loaded into the oven through the large hole at the top, a fire of wood or charcoal started at the bottom, and the whole mass smoldered, roasting away water and gas. When complete, the bottom grates were pulled out and the treated ore shoveled into waiting wagons. An oven of 50 tons initial capacity yielded 30 tons of roasted ore every 24 hours. (The process is very similar to that employed at lime kilns.)

Hot Blast Ovens

A significant technical improvement to the blast furnace made in the early 19th century was that of preheating the blast. This was found to significantly increase the smelting temperature and reduce the charcoal to iron ratio. Initial heating ovens were small stoves standing next to the base of the blast furnace through which passed thin-walled pipes carrying cold air from the bellows to the tuyeres. The pipes were heated by fire in the stove fueled by charcoal or wood. In time, the stove was replaced in favor of utilizing the heat of the waste gases exiting the top of the blast furnace.

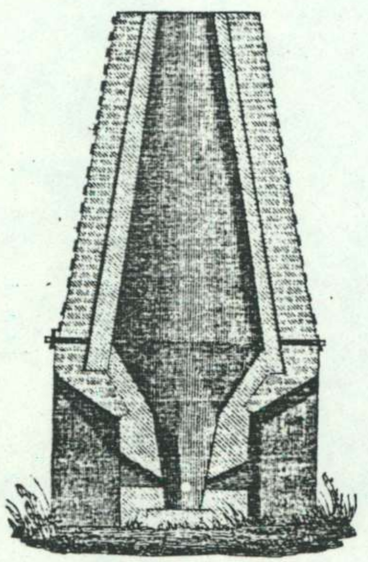



Tapping the gas from below the top.

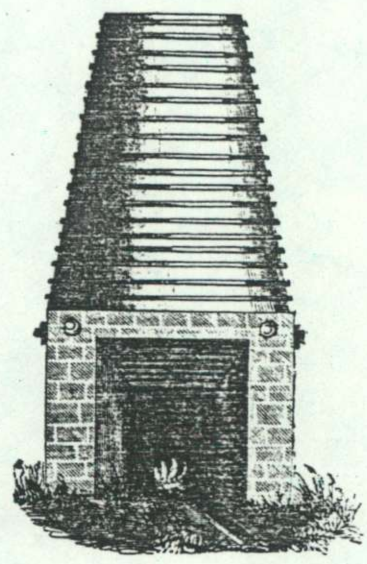
In practice, the pipe containing cold, damp outside air traveled from the bellows up the outside of the blast furnace wall to the top. Here, a small brick chamber conveyed the hot waste gas around the air pipes, heating and drying the air. The somewhat cooled waste gases expelled out the other end of the oven while the heated air was forced (through action of cold air being pumped into the oven) down a slightly larger pipe (warm air expands) that traveled down the inside of the furnace wall to keep it warm, and to the tuyeres. Hot blast ovens were capable of raising blast temperatures to 600° F. Although not generally used in the industry until the 1840-1850 period, a blast furnace at Bennington, Vermont experimented with hot blast in the early 1830's. A circa 1900 photo of the Forestdale furnace ruin clearly shows oven remains at the top, which no longer exist.

## Cupola (Air) Furnaces

Even within the iron industry, the cupola furnace could have more than one definition. One type of cupola furnace (see below) was a cupola-shaped blast furnace, so named for its similarity to the cupola furnace of the foundry. It was



Section and interior of a cupola blast furnace.



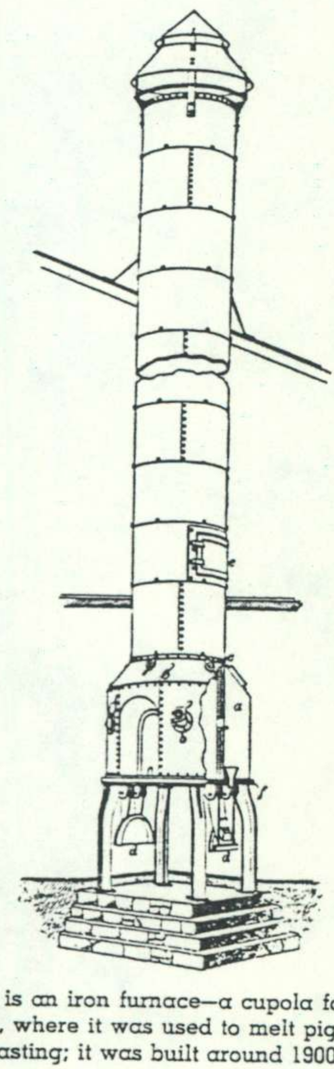
Front view of a cupola blast furnace, at the Great Western Works.

a poor type of blast furnace because the walls were too thin to insulate and hold its heat. Its only advantage over the usual type blast furnace was its relatively inexpensive construction cost.

The foundry cupola furnace was a tall, round furnace that served merely to melt pig and scrap iron for use in manufacture of castings. Cupolas had a high height-to-diameter ratio, sometimes reaching 25 to 30 feet high with only a 4 to

6 foot diameter. Pig and scrap iron (and sometimes even some iron ore to affect the quality iron) mixed with charcoal or coke were loaded through a side door about 10 feet above the hearth. A ring of tuyeres at the hearth provided hot blast that melted everything inside. The molten iron was either cast direct at the foundry or molded into ingots for later use or sale to other foundries. Cupola furnaces were sometimes referred to as air furnaces, to further distinguish them from iron smelting blast furnaces. In some instances, blast furnaces were adapted to operate as cupola furnaces but it usually didn't work well. Cupolas were the standard furnace in Vermont foundries that cast stoves, agricultural implements, pots and kettles (hollow ware), mill gearing, and railroad and machine castings. Advertisements in ca. 1790-1850 newspapers for "pot metal wanted for our furnace" were looking for scrap iron (old iron pots) for melting in the foundry cupola. The cupola furnace essentially relieved the blast furnace of casting; the latter just made the iron while the cupola cast it.

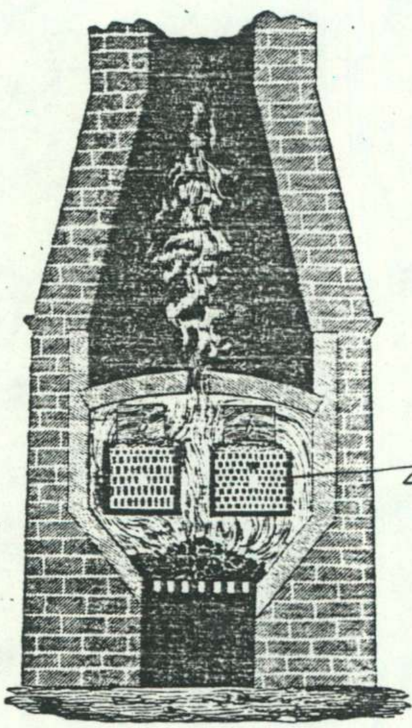
By the late 1800's, cupolas were made of sections of hollow cast iron plates. Water circulated inside the plates to prevent them from melting. The cupolas were 2 to 3 floors high inside the foundry building and could be located from the outside by the tell-tale smoke-belching high chimney that extended above the foundry roof.



This, too, is an iron furnace—a cupola found in old foundries, where it was used to melt pig and scrap iron for casting; it was built around 1900.

## Cementation Furnace

Before Henry Bessemer of England and William Kelley of Kentucky discovered methods of producing large amount of steel quickly and cheaply, most steel was made by foundries in a low-volume time-consuming furnace called the cementation furnace. In this furnace, thin iron bars of wrought iron were heated to just under melting temperature in sealed clay boxes containing loose charcoal dust. Under influence of the heat, carbon in the charcoal was absorbed by the iron, creating an iron bar with a wrought iron core under a steel surface. The action of the carbon on the iron created blotchy patterns looking like blisters, thus the name - blister steel. Much blister steel went into the manufacture of fine



The Cementation Furnace

Iron bars laid up lengthwise, 10 to 16 feet deep into the furnace and baked for 10 to 12 days.

- Furnace for making blistered steel.

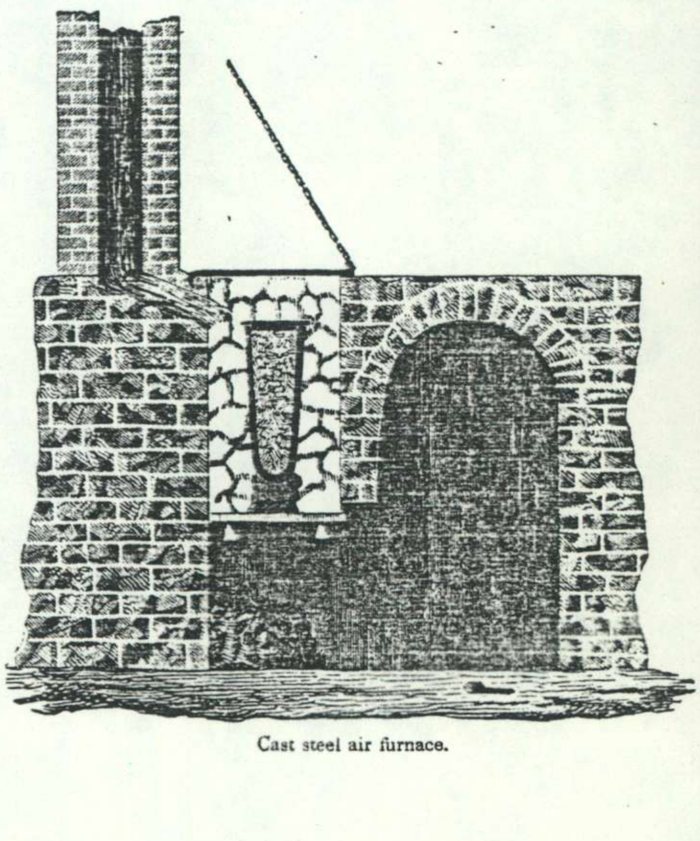
cutlery, springs, and edge tools (axes, chisels, saw blades, files, etc), since the steel jacket allowed the iron to hold a fine cutting edge.

The furnace measured 12 to 15 feet wide and 20 to 25 feet deep. A conical chimney 40 to 45 feet high vented smoke out the foundry roof. The bars were laid up in the boxes 10 to 16 feet long by 2 to 3 feet square. Two such boxes of iron took 10 to 12 days to process. With the Bessemer converter, blister steel went out of fashion although many small rural foundries continued the process for specialized local applications in the manufacture of edge tools and agricultural implements (plows, shears, reapers, etc).

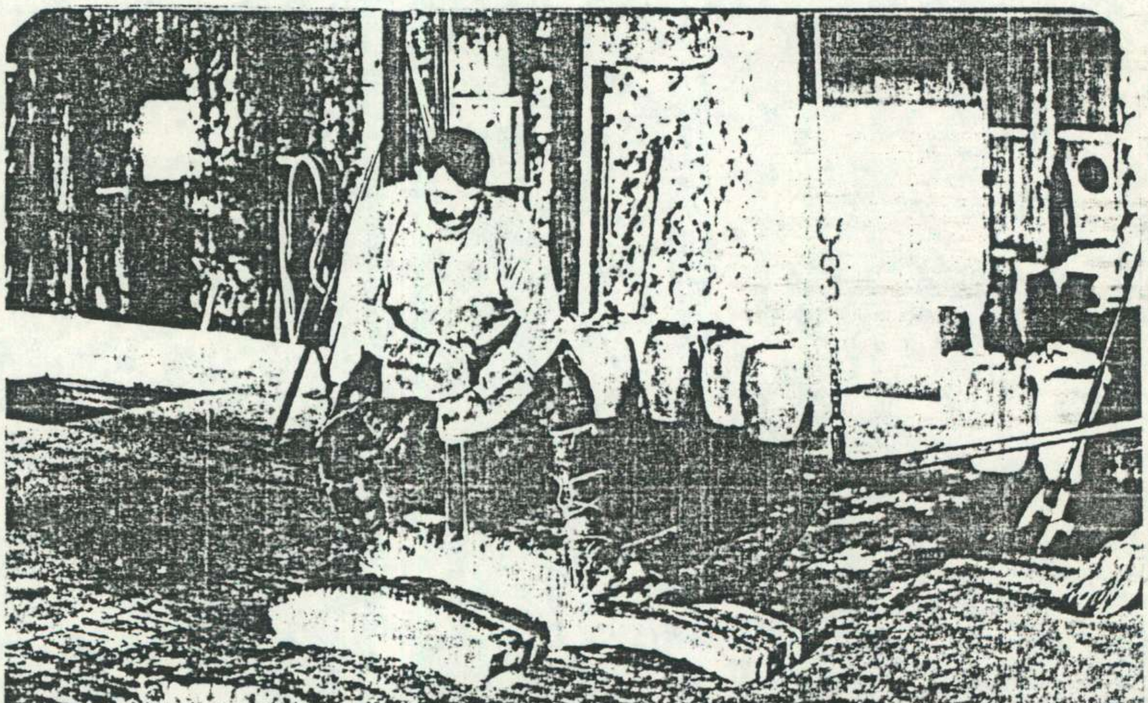
## Cast Steel Air Furnace

The only inovation in steel making between the colonial period and the Civil War was the crucible method. Much more complex and costly than the cementation process, in the crucible method, pieces of blister steel were broken and melted in refractory clay containers to produce a much better quality steel that possesed a uniform internal distribution of carbon. The product was called crucible steel or cast steel.

The crucibles were 5 inches wide by 18 inches deep and were made of a highly refractory clay mixed with charcoal dust. Hot gases were drawn from the furnace hearth through the crucible chamber and vented upward, out the chimney. In some foundries, rows of these furnaces were built into the foundation of the building such that access to the crucibles was through a row of trap doors on the floor. Each crucible contained 50 pounds of steel and took 3 hours or longer to process. The crucibles were carefully lifted with long prongs and the steel poured into preheated molds. Each furnace had its own crucible chamber and chimney, so that a row of chimneys on a foundry roof usually meant a row of air furnaces beneath.



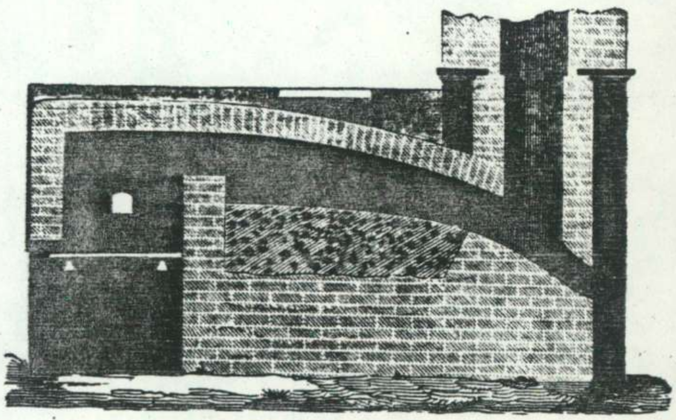
Cast steel air furnace.



*Workman lifting crucibles of steel from the furnace.*

## Heating (Re-heating) Furnace

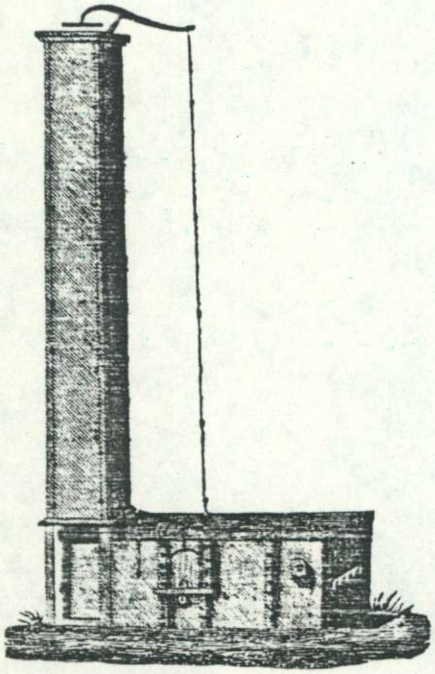
When iron was being worked at the foundry, that is, hammered, drawn, punched, etc., a means was required to keep the iron hot, lest it crack or rupture. The heating furnace was the answer, which was nothing more than a long, narrow heated chamber. In this furnace, hot burning gases were drawn from the hearth at the front end of the furnace, up and through a chamber in which iron rods, bars, or sheets were placed, and vented out a chimney. The heat was sufficient to keep the iron workable without melting or deforming it. While some bars were being heated, others were being worked, so that a number of pieces were processed at the same time. The furnace was generally rectangular in shape, about 8 or more feet wide, depending on the size of the work to be heated, and 5 or less feet deep, so as to maximize the heating effects of the burning gases. Charcoal, coke, or coal was used for fuel; the tall exhaust chimney provided a good draft to 'draw' the flames through the chamber.



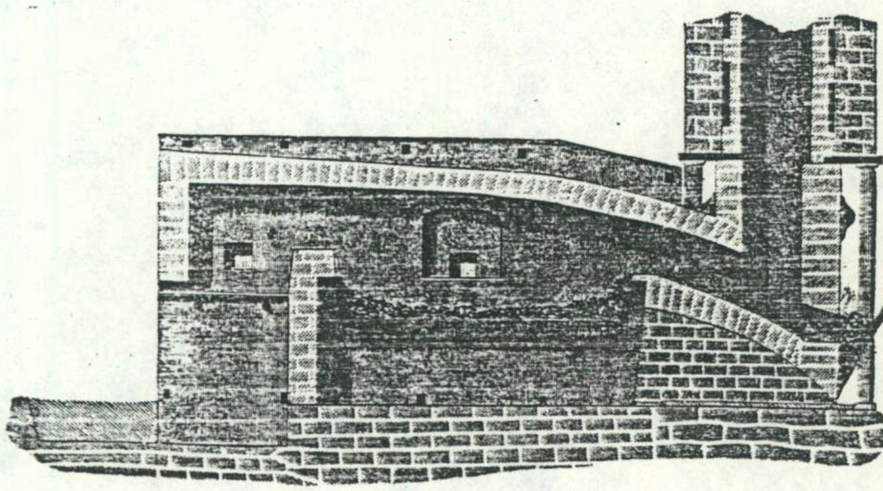
Section of a re-heating furnace.

## Puddling Furnace

Similar in outward appearance to the heating furnace was the puddling furnace. This furnace converted cast (pig) iron from the blast furnace into wrought iron. The major characteristic of the process was separation of iron from fuel. The iron was heated and melted in a chamber physically removed from the hearth area, where carbon-containing charcoal, coke, or coal was burned. As the burning gases were drawn through the chamber, carbon in the molten cast iron was burned away. A worker stirred the molten iron with a long iron rod stuck through a small opening beside the chamber. The stirring exposed carbon-rich cast iron from under the surface to the burning (refining) action of the heat. As the iron lost its carbon, its relative melting point dropped and it started to congeal on the worker's iron rod. It was then formed (puddled) into a ball of iron, removed from the furnace, and hammered into bars. The result, wrought iron, was practically devoid of carbon, was highly malleable, and was sold as bar iron (merchant iron). The worker who stirred and formed the ball was called a puddler.



Elevation of a puddling furnace.



Vertical section of a single puddling furnace.

The puddling furnace was about 12 feet deep by 5 feet high and 5 feet wide. The chimney rose 30 to 40 feet, affording good draw for the furnace. After the furnace is brought up to temperature, which may take some days to stabilize if fired from a cold start, iron is thrown in and all doors sealed. In about 15 minutes the iron should be glowing red; in 30 minutes white, ready to melt; and in 45 minutes, the puddler starts to stir the iron. Iron balls were usually limited to about 15 inches in diameter; that weighing 70 to 80 pounds. The cycle took an hour to complete, from initial charging to drawing out the hot, pasty iron ball.

Puddling furnaces generally replaced bloomery forges throughout the country during the last half of the 19th century. In Vermont, however, bloomeries continued to operate to about 1880 (East Middlebury). Bloomery iron, the direct method of making wrought iron, although a slower and more expensive process, was considered by many at the time superior to puddled iron.

Sources:

W. David Lewis Iron and Steel in America The Hagley Museum, Greenville, Deleware, 1976.

Frederick Overman The Manufacture of Iron Henry C. Baird, Philadelphia, 1850.

David Weitzman Traces of The Past: A Field Guide to Industrial Archaeology Charles Scribner's Sons, New York, 1980.

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Pittsfield, MA 01201

Variability in Design of 19th-Century Charcoal Kilns in Vermont
written and researched by Vic Rolando

Presented to the CNEHA at Troy, NY, November 1, 1986

* The state of Vermont constitutes 9,609 square miles, or less than 0.2% of the area of the United States. Yet, during the summers of 1983, 84, 85, and 86, the sites and ruins of 137 charcoal kilns were located in that small area, part of a state-wide survey of IA sites.

* Basically, the charcoal kilns were constructed of two types of materials; brick and stone, and some a combination of both. Brick-type kilns accounted for 103 kilns, averaging about 28 feet in diameter; * the 18 stone-type and the combination stone-and-brick-type kilns divided evenly in half, nine of each, all measuring from 26 to 35 feet in diameter. * Also found were 15 mound-type remains, measuring from 25 to 40 feet in diameter, and one curiosity, a concrete block-type kiln from the 1950's.

* The kilns were generally found in the south-central part of the state. They date from the 1870's through the turn of the century, well past the peak period of ironmaking activity in Vermont, and thus reflect the making of charcoal for interests outside of the state. * It is well documented that during that period, charcoal makers contracted for millions of bushels of charcoal for ironworks operators as far away as Salisbury, Ct. Additionally, large tracts of mountain land were leased in that same period by such operations as the Richmond Iron Works of Massachusetts, for reduction of the forests to charcoal.

* Of the 103 brick-type kilns, one was confirmed through shallow excavation to have been conical in shape, 2 others may possibly have been conical. * It was the policy of the US Forest Service Service in the 1930's and 40's to dynamite standing kilns on government property to prevent hikers from camping and transients from living in them. The

two questionable conical kiln ruins were found in association * with an iron door typical in configuration to those used in conical-shaped kilns, and are located at sites a few hundred feet from the known excavated conical kiln. But they were thoroughly destroyed by dynamiting, right down to their foundation stones, as excavation attempts proved. * The partially standing remains of most of the stone-type kilns suggest they were of beehive shape, * while the stone-and-brick-combination-type kilns were conical in shape. * This has been determined by comparison with period photographs shared by residents of the old charcoal making areas. * One stone-type kiln was rectangular, measuring 16 feet wide by 37 feet long and 10 feet high. The 1950's era concrete block-type kiln was also rectangular in shape.

Kilns were built anywhere from 1 to 10 at a site. * There were 11 single-kiln sites; six 2-kiln sites; * four 3-kiln sites; seven 4-kiln sites; five 5-kiln sites; * no six- or seven-kiln sites: three 8-kiln sites; * and one 10-kiln site. The largest sites were of brick construction, averaging 4 kilns per site; stone-type and stone-and-brick-combination-type kilns averaged 2 kilns per site.

* The kilns were built at elevations from 660 feet to 2400 feet above sea level. Vermont's lowest elevation is 95 feet, which is the elevation of Lake Champlain, bordering most of the state on the west. It's highest point is Mount Mansfield, * 4393 feet above sea level. Average elevation of the state is 1000 feet. In the area of the most kiln finds, 12 mountains rise to between 3000 and 3800 feet. * Brick-type kilns averaged 1813 feet in elevation at a range of 660 to 2360 feet; the largest concentration of 55 kilns were found between 1500 and 2000 feet. Stone-type kilns averaged 2057 feet, with a range of 1560 to 2400 feet, somewhat higher in elevation than the brick types, but significantly compacted in a tighter range of elevation. The largest

concentration of 10 stone-type kilns were found between the 2000- and 2500-foot level. Mound-type kilns were located at the lower average of 1336 feet, at a range of 700 to 2360 feet; there was no significant concentration at any elevation. Almost all kiln sites are located in proximity to good-flowing streams.

* Anyone familiar with Vermont's higher-elevation landscape is familiar with the rocky nature of the land. Vermont is still known for its marble, slate, and granite industries, but Vermont farmers would rather forget the numbers of stone walls that they have built down through the past 200-year history of the state. Stone-built charcoal kilns reflect, therefore, the adaptive use of a natural resource to answer a need for a practical building material. * The stone-type kilns are built of unfinished stone, but laid up carefully in 3-foot thick walls to prevent as much air as possible from leaking into the interior of the kiln during the combustion process. * Most brick-type kiln sites have since been cannibalized of all usable brick. Stone is such an available resource in Vermont that the best kiln remains in the state are those made of stone.

* Brick-type kilns are laid up in 1-1/2 brick long, or about 1-foot thick walls, which provide a stable enough structure until such factors as the vaulting brick roof, and heating, expansion, and cooling are considered. * Therefore, 28- to 30-foot diameter, 6-inch wide by 1/2-inch thick kiln-girdling flat iron hoops, * held firmly in place by 1-inch bolts, assist in holding the structure together. Except for iron doors, no hardware was found associated with the stone-type kilns, probably because its conical beehive design created a much more stable structure. Other iron hardware found at brick-type kiln sites include 6- by 6-foot doors, * lintels on which the doors slid across, * and cast iron vent-hole linings. Inspection of the few pieces of hardware

that survived World War II scrap drives indicate no visible similarity between dimensions of the hardware, suggesting that hardware for the kilns was made 'on order' at the foundry. But nowhere is the variability in design of hardware for charcoal kilns more obvious * than in the configurations of the circular covers that closed the 6-foot diameter holes at the tops of the kilns. * Probably because of their round, 1/2-inch thick flat shape, they escaped detection of scavengers, * and over a dozen of the artifacts have been found by diligent search in the vicinities of kiln ruins. *

* Vent holes, through which the flow of air into the kiln was controlled, also provide an interesting point in study of variability. * Almost all brick- and stone-type kilns contained vent holes of such a dimension to conveniently allow the insertion of an ordinary red brick to shut the hole completely. Stone-type kilns used a pair of bricks set side by side with a brick-size space between, laid over and under with a large flat stone. Variations in vent holes were found at one site containing five brick-type kilns * that had cast iron vent linings. This site was located about 3 miles from an ironworks, which it serviced. At one stone-type kiln site, * vent hole linings were found that are made of a hard clay material of unknown origin.

* The variability in design of these 19th century charcoal kiln ruins in Vermont reflect the ability of charcoal makers to adapt the needs of the basic kiln design to the resources that were available. The consistent 28-foot inside diameter of the brick-type kilns, for example, indicate a common knowledge of one aspect of the technology. * But the variability in hardware, at these same brick-type kiln sites, testifies to the incividuality of at least one of the number of choices that enterprising Vermont charcoal makers appeared to make the most of. Thank you.

# VERMONT DIVISION FOR HISTORIC PRESERVATION: THE STATE PLAN

## CONTEXT: VERMONT'S CHARCOAL MAKING INDUSTRY (1790-1900+)

**1) How it developed (geopraphic; cultural; social; other influences):** Vermont's charcoal making industry developed in association with the development of its mineral smelting and production industries. Charcoal fueled furnaces (iron, glass, copper), forges, blacksmiths hearths, foundry cupolas, etc. Early charcoal making required no structure; it was made merely by mounding cordwood, covering it with sod, and allowing it to smolder. Much charcoal (and potash) was made by settlers as a by-product of clearing vast acreages of land for agriculture. Kilns supplied charcoal to local furnaces and forges that initially satisfied local needs. Industrial expansion after 1820, stimulated by the Champlain Canal, demanded more charcoal. By Civil War period, charcoal was being made in stone and brick-built kilns with much of it exported out of state. In 1880-1912 all of it was shipped out as Vermont ironworks phased out and charcoal resources in NY, Mass, and Ct became scarce. By ca. 1912, available forests in Vermont were exhausted and charcoal making ended.

Coked Coal process

**2) Limitations of development:** Vermont charcoal making was limited in the early period (pre-1820) by the demand by local metal working industries, which mostly reflected domestic economics. Limitations of middle period charcoal making (ca. 1820 - 1860) still reflected local demand, but charcoal was made on a more regional supply and demand basis; local forests were becoming depleted through settlement and clearing for farmland. Following 1860, charcoal making became an industry unto itself, with charcoal being exported outside the state and forests being rapidly consumed by lumbering interests. Limitations by this period became the resources of the forest stands themselves, which were commercially exhausted by the turn of the century.

**3) Known geographic distributions and patterns:** During the early pre-1820 period, charcoal making generally centered about the iron making industries, then the largest single consumer of charcoal in the state. After 1820, as iron, copper, and glass industries developed, charcoal making chased the forest lines back into the hills. By the 1860's, it was not uncommon for charcoal to come to furnaces from a dozen miles away. As such, earlier charcoal making sites generally were close to developing industrial communities along the Lake Champlain plateau; later charcoal making areas reached well up into the Green Mountain highlands, with many last operations at 2000-foot elevations. Most kilns, however, still remained west of the center line of the Green Mountain range, with concentrations in the north in the Ripton/Middlebury area; the central area at Mt Tabor/Peru/Winhall; and southern at Glastenbury/ Woodford/Stamford/Readsboro.

**4) Historic highlights (i.e., significant events [natural and social], people, technological advances, social trends, etc.):** Largest single-owned charcoal making operation in Vermont was Silas L. Griffith of Danby, whose holdings in late 1880-1890's exceeded 50,000 acres, operating at Mt Tabor and nearby some 35 charcoal kilns, 9 sawmills, and 6 general stores. He was the first to use a telephone in the state, con-

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necting his lodge at Griffith Pond to his office; was an early advocate of using saws instead of axes to cut trees in order to reduce waste. He was a Vermont State Senator but declined candidacy for Governor. His charcoal plus that made farther south supplied fuel needs of ironworks in the Taconic regions of Mass, Ct, and NY until about 1912, when these resouces failed; those ironworks then importing charcoal from as far away as North Carolina (the region's iron industry failed in 1923). Design and efficiency of round and conical kilns in Readsboro were recognized and written up in a technical paper in 1879-1880, published nationally (at least one Readsboro conical kiln located to date).

**5) Time frame:** ca. 1785 to 1912 **(justification):** archival research (see Selected Bibliography).

add shipping sites

**6) Property types known and/or expected:** Mound type kilns: circular gutters; collier huts; coal storage sheds; and oval areas coated with burnt pitch. Stone/brick kilns: stabilizing iron hoops; iron vents; iron top hole liners and doors; square and triangular front doors; lintels; battered, round, and conical foundation remains; road/railroad access and loading platforms; charging embankments; coaling villages (schools, postoffices, workers' housing); offices; saw mills; dams; flumes; stables; blacksmith shops; extensive charcoal-laden black soil.

**7) Information gaps/research questions:** What vegetation predominates in charcoal-laden soil? Where was hardware made for reinforcement and use in kilns (hoops, doors, iron vents, etc)? What was final (pre-collapsed) configuration of stone built kilns (no known photos or sketches)? What generation forest generally stands today? Do any virgin forests remain from prehistoric period? What are the circular, dark areas on the ground in Shoreham located via satellite photos by Dunn of UVM/VAS, but unlocated by ground inspection?

**8) Biases:** Brick and stone kiln remains predominate in numbers over remains located to date of mound type kilns, due to latter having less distinguishable features. Earlier mounds also built closer to furnaces, later disturbed by furnace/industrial expansion, community growth, stream/river erosion. Stone kilns usually in better shape, higher walls than brick, seem to indicate more recent vintage, but brick usually canabalized by locals for use (lighter unit weight, comparable to modern brick, nearer roads/drivable trails); stone kilns not generally canabalized since stone not in high demand for construction (heavy, cumbersome, common everywhere in Vermont countryside).

**9) Relevant constituencies:** U.S. Forest Service; Vermont State Parks; SIA; town, county, and state historical and archeological societies; logging/lumbering associations; National Conservancy - Vermont Chapter; industrial and technological historical societies.

**10) Selected bibliography:** See: Rolando, V.R., 200 Years of Soot and Sweat (unpubl. manuscript) 1985, copy at DHP.

**Prepared by:** Vic Rolando **Date:** August 13, 1985

Curtis J. 9-27-85

VERMONT DIVISION FOR HISTORIC PRESERVATION

VERMONT HISTORIC PRESERVATION PLAN

CONTEXT: Charcoal Making

1) Property types known and/or expected: -Copper making sites - Blacksmiths shops

Q. [Larry Atkin] distinct sites from iron making? Add Shipping sites (Danby) [B.B. & V.R.]

[Peter Hadley] → geographically related?

·Bill Badger] Vic - some are some aren't - Glass works

Archaeological site: Griffith (Mt. Tabor)

2) How it developed (geographic; cultural; social; other influences):

Consensus separate context (possible inclusion under lumber + industry)

3) Limitations of development:

Vic, C.J. Add - Development Coked Coal a factor in obsolesence of Charcoal industry

Bill Badger - Rutland RR. charcoal cars end c. 1910

4) Known geographic distributions and patterns:

5) Historic highlights (i.e., significant events [natural and social], people, technological advances, laws, social trends, etc.):

C.J. Earlier charcoal sites - Middlebury, Brandon?

Col. Abbott - Use of charcoal in copper mines

Polly Darnell - switch from mounds to masonry?

6) Time frame:____________________(justification):

CONTEXT:________________________________________ page 2

7) Information gaps/research questions:

Kelmsley - Ethnic groups in Charcoal? Italians?

C.J. Earlier charcoal sites associated with iron-making?

Polly Parnell switch from mound to masonry kilns.

8) Biases:

9) Relevant constituencies:

10) Selected bibliography:

Prepared by: CJ Curtis Date: 9-27-85

VERMONT DIVISION FOR HISTORIC PRESERVATION

VERMONT HISTORIC PRESERVATION PLAN

CONTEXT: Charcoal Makings

1) Property types known and/or expected:

Shipping sites Danby/Mt. Tabor
Archeological site Village of Griffith, Mt. Tabor
Copper mining sites Blacksmith shops
Glass works Other sites using charcoal

2) How it developed (geographic; cultural; social; other influences):

3) Limitations of development:

4) Known geographic distributions and patterns:

5) Historic highlights (i.e., significant events [natural and social], people, technological advances, laws, social trends, etc.):

6) Time frame:____________(justification):

CONTEXT:______________________________________________ 

7) Information gaps/research questions:

8) Biases:

9) Relevant constituencies:

10) Selected bibliography:

Prepared by: J Curtis Date: 9-27-85

VERMONT DIVISION FOR HISTORIC PRESERVATION

VERMONT HISTORIC PRESERVATION PLAN

CONTEXT: CHARCOAL

1) Property types known and/or expected:

Logging areas
Mining - Iron, copper, glass

2) How it developed (geographic; cultural; social; other influences):

2 stages - local needs
- export product

3) Limitations of development:

COKE DEVEL.

4) Known geographic distributions and patterns:

5) Historic highlights (i.e., significant events [natural and social], people, technological advances, laws, social trends, etc.):

switch from small scale to large scale (stone, brick)

6) Time frame:____________________(justification):

7) Information gaps/research questions:

R.R. Cars (specific type) in car equipment register
~~Social~~

8) Biases:

9) Relevant constituencies:

10) Selected bibliography:

Prepared by: William C. Badger Date: 9/28/85

VERMONT DIVISION FOR HISTORIC PRESERVATION

VERMONT HISTORIC PRESERVATION PLAN

CONTEXT: CHARCOAL

1) Property types known and/or expected:

2) How it developed (geographic; cultural; social; other influences):

add: competition from coked coal coincides with decline of charcoal mfg.

3) Limitations of development:

4) Known geographic distributions and patterns:

5) Historic highlights (i.e., significant events [natural and social], people, technological advances, laws, social trends, etc.):

Rutland RR had charcoal cars until c. 1910

Switch to stone + brick kilns

6) Time frame:__________(justification):

CONTEXT:____________________________________________ 

7) Information gaps/research questions:
Who were charcoal makers? any particular ethnic group

8) Biases:

9) Relevant constituencies:

10) Selected bibliography:

Prepared by: Polly Darnell Date: 9/27/85

42 A

VERMONT DIVISION FOR HISTORIC PRESERVATION

VERMONT HISTORIC PRESERVATION PLAN

CONTEXT: Charcoal making industry

1) Property types known and/or expected:

Rokeby museum has documents related to mound type kilns

Chimney Point

2) How it developed (geographic; cultural; social; other influences):

3) Limitations of development:

4) Known geographic distributions and patterns:

Addison Bridport area

Chimney Point

5) Historic highlights (i.e., significant events [natural and social], people, technological advances, laws, social trends, etc.):

6) Time frame:____________(justification):

CONTEXT: ______________________________________ 

7) Information gaps/research questions:

relation to Port Henry NY iron works
also Crown Point NY

8) Biases:

9) Relevant constituencies:

10) Selected bibliography:

documents at Rokeby museum

Prepared by: Dean Leary Date: 9/27/85

9-27-85

Session 1 Section 6

Iron Manufacture
Mining
Quarrying and Stone Milling

Added Contexts: Iron Foundry work
Glass making (include under Other Industries?)
Charcoal Making (include under Forest Products?)

Attendees: Collamer Abbott
Bill Badger
Almo Cecchini
Warren Cook
Lee Wilkinson
Polly Darnell
Vic Rolando
Bill Kemsley
Thomas Visser
Peter Haller
Larry Atkin
Eric Gilbertson
Curtis Johnson - recorder

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# SOOT, SWEAT – AND HISTORY

*By* ED BARNA
*Photographed by* JERRY LEBLOND

## Vic Rolando Wrote the Book on Vermont's Forgotten Early Industrial Days

FOR AMATEUR archaeologist Victor Rolando, the massive old stone and brick blast furnace near the Neshobe River in Forest Dale has special significance.

Before it fell silent for the last time in 1865, this fire-breathing behemoth sent its roar for miles through the countryside. Molten iron flowed from the arches of its 30-foot-high tower onto molded beds of sand to form axes, draft chains, wagon parts, stoves, kettles, skillets, rods and flat irons.

Rolando knows all these details intimately, from the sources of the iron ore to the shipping manifests for finished products. But this relic means more to him than that. It is the embodiment of a fact he has labored tirelessly to document: that iron-making was as much a part of early Vermont as subsistence farming, sheep raising and quarrying.

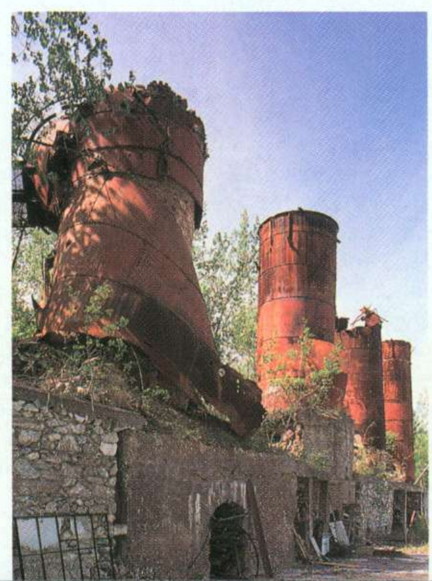
In the course of his long and unpaid work, Rolando has become the acknowledged expert on Vermont's early industrial days, the one person who pulled together the fading history of this period to produce a coherent picture of a Vermont unknown to most people.

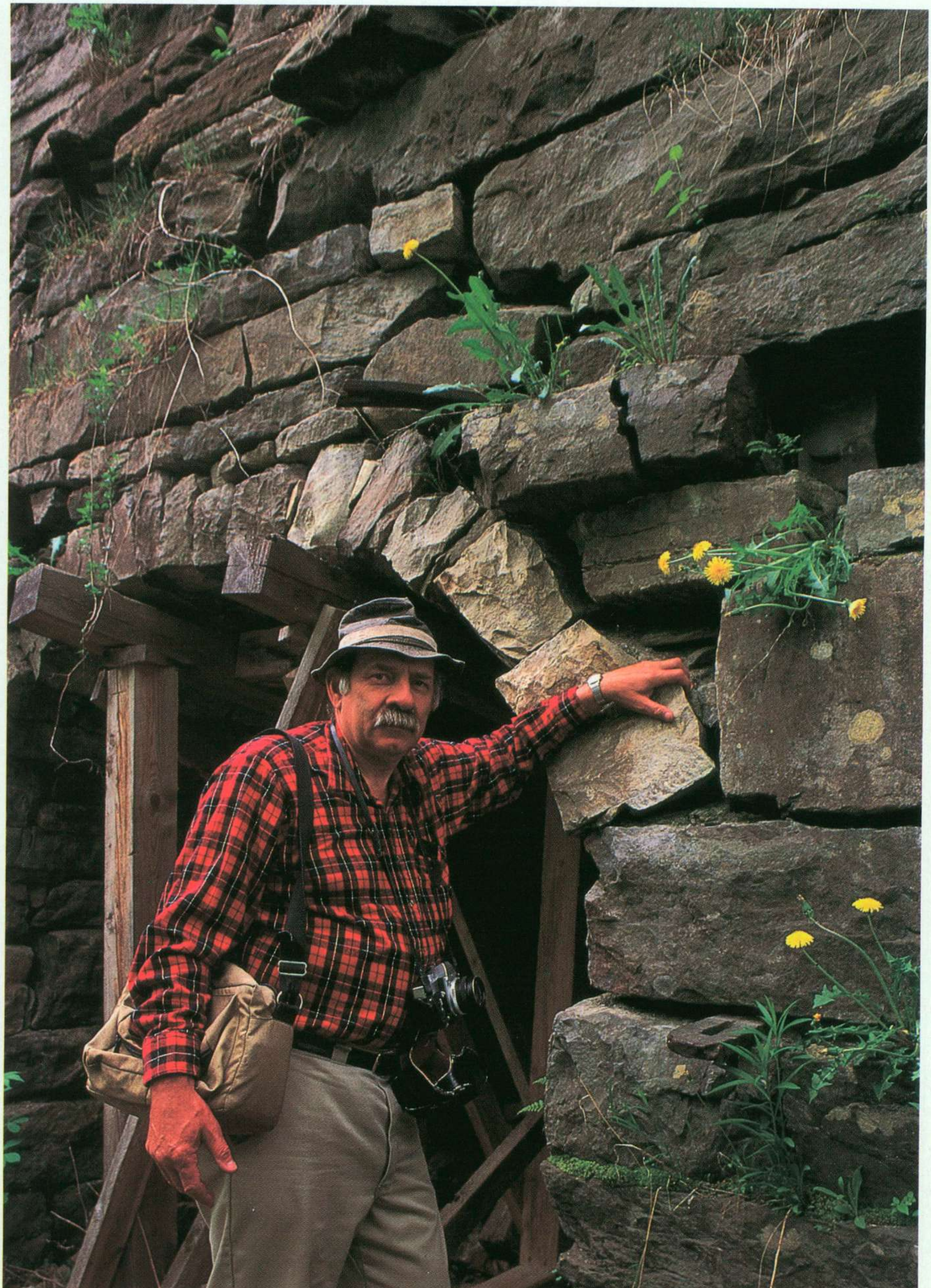
Over the past 20 years, during the many archaeology forays from his home in Pittsfield, Massachusetts, he came repeatedly to the blast furnace in Forest Dale, a village in the Rutland County town of Brandon. The Northern New England Chapter of the Society for Industrial Archaeology, of which Rolando is treasurer, gathered there in 1988 to excavate the abandoned industrial village around the furnace. Vermont's Division for Historic Preservation chose the site as the best place to interpret Vermont's role in the early Industrial Revolution. And Rolando chose a photo of the blast furnace for the cover of his epic 1992 book, *200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries.*

The book was the capstone on Rolando's effort to show that the remains studied by industrial archaeologists, grubby and workaday as they may seem at first glance, are keys to Vermont's identity — just as much as the mansions the iron industry helped finance.

"The complex stories of Vermont's once thriving iron, charcoal and limestone producing industries lay virtually forgotten in forest and field, in libraries and attics, until Vic's exhaustive efforts brought this part of Vermont's heritage to light," wrote state archaeologist Giovanna Peebles in the foreword to Rolando's book. "... There is no question that Vic's devoted and extraordinary efforts — all on a volunteer basis — have immeasurably en-

***Industrial archaeologist Victor Rolando, at the base of the Forest Dale blast furnace. Below, lime kiln in Leicester.***





riched our knowledge."

Rolando's love of industrial history began when he was growing up in the Hudson River Valley around Albany, New York. Gradually he became fascinated with the many abandoned places he found in the area. In high school, he rode his bike to explore old buildings, wharves, and factories. When the weather was bad, he'd hang around the New York State Museum in Albany.

With time, high school, college and career responsibilities eclipsed that early interest. But it returned in the early 1960s: On a Sunday drive, Rolando noticed a street in Richmond, Massachusetts, called Furnace Road. Struck by the name, he drove along it and found an early 19th century blast furnace. Soon he was back in school, getting a degree in history.

But his interest became a passion when he discovered Vermont, a state he describes as a "time capsule" for industrial archaeology. "I would find things in Vermont that predated almost anything I could find in Massachusetts and New York, where most of them evolved into later sites," he said.

Rolando met members of the state's Division for Historic Preservation at a University of Vermont conference in 1978. They warmly welcomed his passion for industrial archaeology. They were interested and helpful; they sent him promised documentation forms instead of forgetting all about them as Massachusetts officials often did. Eventually Rolando decided to focus his research on Vermont rather than Massachusetts and New York.

Soon, he realized he was onto something important. He found that in addition to burning forests for potash, Vermont's settlers had built charcoal kilns all over the mountains, either crude soil-covered piles where dry wood fires drove the gases from green wood, or more efficient stone domes that did the same job. But what did they do with all the charcoal?

Rolando quickly discovered that iron ore — both "bog iron" and higher grade hematite — had been abundant, and that charcoal had been the fuel that fed the ravenous energy appetite of a considerable iron industry in the days before coal and railroads remade the industrial landscape. He found many simple "bloomery" forges, and he was able to document the existence of at least 36 blast furnaces, 12 of which existed as visible remains, and six of which (two in Bennington, one each in East Dorset, Pittsford, Troy, and Forest Dale) were still present as recognizable structures.

The lime kilns were something of a bonus. Informants kept mentioning them, thinking that they were old ironworks, though some lime operations continued into the 1970s. Finally, Rolando decided to document that little-known chapter of Vermont history as well. Lately, he has taken on the challenge of researching the brick industry, whose products were used in both blast furnaces and kilns.

Deceptively unathletic in appearance, Rolando is in fact a relentless trekker, one of those people who can push on and on without food or drink. He has come to know the state's reforested hinterlands as do few others except game wardens, foresters and ginseng hunters. You may have seen him at some remote roadside turnoff, a medium-sized man sporting a hefty mustache and wearing a battered pork pie hat. When he traded his last car in, at 120,000 miles, the dealer handed him $200 and told him to get the thing off the lot. The engine had literally fallen out, thanks to various backroad adventures, and Rolando had held it in with wire and two-by-fours.

After haunting town offices and libraries, questioning older residents, and asking the local children — "they know where things are, even if they don't know what they are" — he has walked countless spirals through the woods, watching intently for bits of ore, slag and charcoal that others overlook. He has followed slag trails up streams until the slag vanishes, then gone overland to find their sources. On the remote hillsides of long-abandoned hamlets, he has spotted the telltale rings of so many collapsed charcoal-burning mounds that he has become bored with finding them.

Just as impressively, Rolando's research has illuminated the social patterns of the iron industry. He uncovered a sort of interlocking directorate of investments, marriages and trade that linked iron families in Vermont with the industry across Lake Champlain in New York State. Ownerships, products made, buyers, transportation routes, are all detailed in the small print of his 296-page book.

Rolando had to organize the amazing array of facts he had accumulated over the years, sort through thousands of photographs, diagrams, reproductions of old advertisements, and maps, and produce a glossary and a detailed index. Getting his encyclopedic account published commercially, or even through a university press, proved an impossible dream. "I'm not a professor at a major university in the Northeast," Rolando notes. "I'm not an eminent archaeologist. I'm writing about something that editors generally don't know what it is, in a state so small they don't know where it is."

In the end, Rolando, then 60, retired in 1992 from his job as a technical editor with General Electric, and moved to Manchester. He established Mountain Publications, obtained a small grant from the Vermont Statehood Bicentennial Commission, and enlisted the support of the Vermont Archaeological Society as nominal publisher. Then he invested $40,000 from a GE job-phaseout program to produce 1,500 copies of the book, of which he has since sold more than a thousand. But making money was never his goal; knowledge and understanding were.

Rolando's efforts won national recognition when the American Association for State and Local History gave him its Award of Merit, perhaps the highest award an amateur historian can achieve, an honor usually reserved for organizations. In nominating him, Castleton State College archaeologist David Starbuck wrote that Rolando's research "unquestionably represents the most thorough inventory ever conducted of the iron, charcoal, and lime industries in any state in this country. In conducting this work, he has greatly helped to sensitize Vermonters to the importance of their industrial heritage and has encouraged all of us to seek out and protect these endangered historical resources."

•

Rolando continues to find new iron production sites, and others may be taking up the work. Lately, he has received so many invitations to speak to

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On June 17-18, visit Arlington's celebration of its early history for Ethan Allen Days: roasts, a historic battle re-enactment, a crafts fair, and an antiques show. Later in the summer on August 12-13th, at Arlington Parks and Recreation, the annual Arlington Arts and Crafts Fair will be held.

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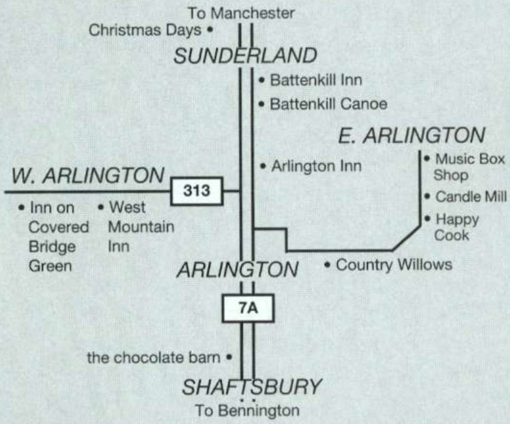




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historical societies, archaeologists, and foresters that he has had to turn some down. No longer is it conceivable that a scrap drive might remove the iron bands from an old blast furnace, as happened in Forest Dale, or that a highway construction crew might dynamite such a structure to get building stones, as happened there in the 1950s.

"I've made my point," Rolando said, "there was a lot of industry here at one time, which I don't think a lot of Vermonters realize."

## For More Information

ROLANDO'S book, *200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries,* is available at Vermont bookstores or by writing to Mountain Publications, P.O. Box 1812, Manchester Center, VT 05255. It costs $32.95 in paperback, $39.95 hardback, plus 5 percent Vermont sales tax.

Rolando did not write it as a guide because he feared that casual souvenir collectors, professional "pothunters" or vandals might damage the historical resources described. But the book gives general directions and methods that a serious student can use in combination with local directions.

The **Vermont Division for Historic Preservation** has on display at the Calvin Coolidge Birthplace in Plymouth Notch a growing collection of cast iron objects made in Vermont furnaces. They will form the nucleus of exhibits at an interpretive center the state plans to build at the Forest Dale blast furnace site, given to the state by Welland Horn, whose family once operated the furnace.

**The American Precision Museum** in Windsor focuses on Vermont's industrial past. This former armory shows how inventors in the lower Connecticut River Valley made the area world-renowned as a source of precision tools, rifles, and other mechanical devices. The museum is open Monday-Friday 9 a.m.-5 p.m., weekends and holidays 10 a.m.-4 p.m., May 20-November 1; tel. (802) 674-5781. Admission charged.

*Writer Ed Barna lives in Brandon, not far from the Forest Dale furnace.*

The SHELDON MUSEUM
News & Notes
Volume III • Number 4 • Fall 1998

# A Local Marriage: Cast Steel and Brooksville Toolmaking

Several local 19th-century industries prospered from new inventions which brought efficiency to their operations and increased the quality of their products. A water-powered saw, allegedly invented by a ten-year-old local boy Isaac Markham, cut marble at Eben Judd's early 1800s' marble works in Frog Hollow. In 1817 David Page installed the second set of power looms in America in his cotton mill on Main Street in Middlebury. Less known, however, is the local development of cast steel, which revolutionized tool manufacturing.

Prior to 1800 tools made of iron or steel could not be made with sharp edges by the manufacturer, and purchasers had to file edges onto them on their own. Even English steel was not suitable for useful tools and a long life. In Middlebury, however, three men developed cast-steel, which made possible the manufacturing of hardened steel tools that aided the development of America in the 1800s.

Local historians H.P. Smith and Samuel Swift report on the event, Smith writing, "Josiah Nichols...was employed in the trip-hammer shop with Daniel Pettibone and Ezekiel Chapman, and in 1802 a patent was taken out in their names; this process was one of great importance and went into general use."

Within a decade a young man named Bezaleel Brooks was acquiring skills which would turn cast-steel into products shipped far and wide. Bezaleel came to Vermont from Connecticut with his uncle, the Reverend Nathaniel Turner, a missionary to the Congregational churches in New Haven Mills.. He was apprenticed to the blacksmith trade, and by 1810 had married Philly Cooke of New Haven and established a blacksmith shop on the River Road in New Haven Mills. Twelve years later he moved his family to Middlebury, where he continued his blacksmith business.

*Brooks Edge Tool Company Forge Shop. Photo c. 1909*

On January 3, 1827 he advertised in the *National Standard* commencing "...the business of making CAST-STEEL AXES and other edge tools..." In 1835 he sold his Middlebury business to move to Moriah, New York, closer to the source of iron ore.

Each of Bezaleel's sons followed in his father's footsteps. The three oldest--Thomas, Jonathan and Milton--were apprenticed to Samuel W. Collins of the Collins Axe Company in Connecticut to learn the cast-steel edge tool business.

In 1843 they purchased William Willson's trip-hammer shop in Beeman's Hollow (New Haven), continuing their father's business under the name "T.M. Brooks and Co.," making axes, adzes and other edge tools. They established their homes there, set up boarding houses, opened a post office, a school, and, eventually, a dry goods store; the hamlet became known as "Brooksville."

Norman Crane Brooks, the fourth son, took over the business in 1861. A reporter from the *Middlebury Register* wrote on January 21, 1873:

> They employ twenty-two high priced hands, mostly piece hands, who make large wages. They pack up ready for the market of the finished product, from twelve to sixteen hundred axes per week. For these they use from ten to fifteen tons of iron and two tons of the best cast steel, per month. In grinding they use up twelve tons of grindstone each month. Their axes are made to order, any desired pattern and style of finish, and are largely marketed in the west."

Fires and declining business led to the company's sale in 1890. The

*Continued on page 4*

# *Winter Exhibit: Thomas Jefferson in Vermont*

In a letter to his daughter Maria, dated May 8, 1791, Thomas Jefferson wrote:

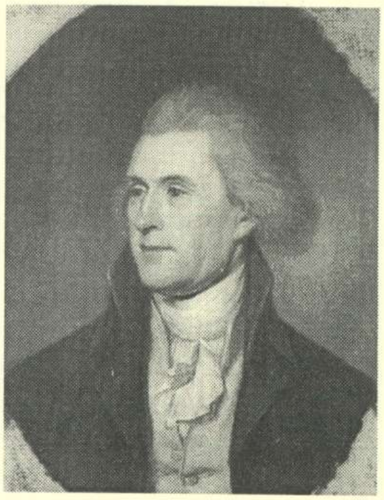
> In about a week I will set out to join Mr. Madison at New York, from whence we shall go up to Albany and Lake George, then cross over to Bennington and so through Vermont to the Connecticut River, down Connecticut River by Hartford to New Haven, then to New York...and expect to be back in Philadelphia about the middle of June.

Indeed, accompanied by Jefferson's slave, James Hemings (older brother of Sally Hemings), they traveled by boat and horseback 920 miles in thirty three days. A spirited journey even by modern standards.

Why did they come to Vermont? Who did they visit?

These questions along with Jefferson's role in Vermont statehood will be explained in an exhibit at the Sheldon Museum using color facsimiles of over 75 original documents, state papers, diaries, letters, maps, newspapers, prints, paintings and photographs. "Travels through Vermont: Thomas Jefferson's Role in Vermont Statehood, 1791," will open in the Cerf Gallery on November 23 and will continue through March 5, 1999. It is being organized by Sydney N. Stokes, Jr., historian and chairman of The Jefferson Legacy Foundation in Ripton, Vermont.

For the exhibit, Stokes has collected documents from many sources, e.g. Pierpoint Morgan Library, New York Public Library, Maryland Historical Society, Massachusetts Historical Society, National Archives, Library of Congress, University of Virginia Library, American Philosophical Society, Lewis Walpole Library and the Bennington Museum. From the office of the Secretary of State in Montpelier, Stokes has obtained copies of 43 printed Acts of Congress signed and attested by Thomas Jefferson between February 25, 1791 and March 2, 1793, along with ten letters from Jefferson to Governor Thomas Chittenden.



*Thomas Jefferson as Secretary of State, about six months after his return from Vermont. Charles Wilson Peale, artist. Courtesy of Independence National Historical Park, Philadelphia.*

These Acts, Stokes says, are perhaps the largest collection of Acts signed by Jefferson as Secretary of State to be found in any state archives.

*You are cordially invited to the*

*Annual Dinner and Meeting*
*of the*
*Sheldon Museum*

*Tuesday, September 29*
*6:30 p.m.*
*Kirk Alumni Center*
*Middlebury College*

*Speaker:*
*Frank Smallwood*
*"Thomas Chittenden:*
*First Governor of Vermont"*

*$20 per person*

*Reply by September 25*
*388-2117*

## *Frank Smallwood to Speak at Annual Meeting*

The author of the 1997 book *Thomas Chittenden: Vermont's First Statesman* will speak at the Annual Dinner and Meeting of the Sheldon Museum on Tuesday, September 29 at Kirk Alumni Center at Middlebury College. (Note: This is a change of date from an earlier calendar listing.) Frank Smallwood will discuss the contributions of Vermont's little known first governor to the stability of the new state.

Thomas Chittenden and his son Noah were among the original proprietors of Middlebury before Thomas became president of Vermont's first governmental body, the Council of Safety and, fifteen years later, governor of the state of Vermont.

Smallwood, a Burlington resident with deep interests in Vermont history and government, is also author of *Free and Independent*. He is the Nelson A. Rockefeller Professor of Government *Emeritus* at Dartmouth College and a former Vermont state senator. He has taught at the University of Vermont and served as Chairman of the Ethan Allen Homestead Trust in Burlington.

## *Historic Barns Tour October 3*

The Museum will hold its second annual Addison County Historic Barns Tour on Saturday, October 3 from 10:00 a.m. to 4:00 p.m. The self-driving tour will take participants to properties in Shoreham and Bridport with barns and other agricultural buildings spanning two centuries.

The buildings on the tour will illustrate how changes in farm building architecture and construction reflected shifts in local agricultural practices and products. Participants will view an early nineteenth century sheep barn, an 1840's barn with gunstock posts, a largely intact nineteenth century barnyard complex, a massive barn which evolved over a century of various uses, the first free stall barn constructed in Vermont, and a 1996 dairy barn.

Experts on barn architecture and restoration will give tours and provide interpretation of the structures, and information on grants for barn preservation will be available. Wool processing and old-fashioned farm activities will be demonstrated at several of the properties.

The cost of the tour is $9 per adult for Sheldon Museum members and $10 for other participants. Preregistration is required. Participants will receive a map and descriptions of the buildings when they register.

## *Education Program Offers Menu of Options*

Teachers this year may choose from a wide variety of educational programs and activities offered by the Museum, geared to students from kindergarten through college. "We have moved away from exhibit-based programs offered primarily during only two periods of the year to a varied menu available year-round, and we are expanding our offerings and outreach to include secondary school students in addition to elementary grades," says Holly Noordsy, the Museum's educator. The popular Christmas program will remain.

Tours, other on-site programs and classroom resources were reviewed during the summer by Martha Santa Maria, an intern who is a secondary school history teacher. Her familiarity with Vermont's Framework of Standards and Learning Opportunities and how teachers use them enabled her to develop a list of the Standards which each of the Museum's educational offerings addresses. Based upon her recommendations, learning kits and programs were strengthened.

This year's education brochure identifies the Standards addressed by each program, which should be of considerable interest to teachers.

In addition to Museum tours and hands-on activities on such themes as "Children's Life," "Itinerant Artist," and transportation, to name a few, offerings include several thematic walking tours of historic Middlebury, and a variety of learning kits with reproduction artifacts, videos, books and other resources for classroom use. New options this year include a combination tour/Research Center visit and Research Center-based programs on "Maps" and "Using Primary Sources for Research."

The Museum will be working closely this fall with the teacher and students in a new class on "The History of the Champlain Valley" at Middlebury Union High School. Following last spring's work with a history class from Mt. Abraham Union High School, this initiative signals a new direction for the Museum's education program.

## *Around and About the Museum*

The Museum welcomes **Mary Ward Manley** as the new **Interim Coordinator of Volunteers and Visitor and Member Services**. She replaces **Liz Bless**, who is serving as **Interim Registrar and Collections Manager** during Peggy Lyons' leave of absence. Mary recently moved to New Haven from Atlanta, where she was Manager of Visitor Services and Associate Head of Adult Programs at the High Museum of Art.

The Sheldon Museum was named Business of the Month in September by **Addison County School-to-Work**. This summer the Museum hosted Martha Santa Maria, a Vermont Teacher/Employer Internship Program employee.

The **VSO "Pops" concert** netted approximately $39,000 despite a smaller audience due to rain.

Volunteers are being sought to decorate **miniature Christmas trees** which will be displayed and raffled in December. Last year's trees drew much admiration from visitors. Trees will be provided by the Museum. Contact Liz Fitzsimmons for more information.

A grant has been received from the **Gertrude Elizabeth Atkins Wolcott and Kate Ann Humble Ebbeler Foundation** to fund the transcription of oral history tapes.

Note that **shutters** have been installed on the Judd-Harris House. They are the original 1829 shutters, which have been restored with a grant from **Walter Cerf.**

Museum Director **Liz Fitzsimmons** is serving as a Mentor to the Northfield Historical Society through a program administered by the Vermont Museum and Gallery Alliance.

*Continued from page 1*

One of the significant results of the Brooks' industry was the stamping of edge tool products. This process enables the identification of the tool's maker as well as the approximate year of production. Bezaleel Brooks' stamps read "B Brooks" and "B Brooks Cast Steel" In 1849 they were replaced by "Brooks & Brothers. " Others have stamps reading "T.M. Brooks & Co.," Brooks Bros" and N.C. Brooks, Brooksville, VT." Labeling, rather than stamping, became common practice in the industry about 1860 and perhaps is the reason that no tools stamped "Brooks Edge Tool Co." (the name the company assumed in 1864) have been located. Descendant Ralph Brooks continues to search for the Brooks tools made possible by the local development of cast steel. Anyone with information should contact him through the Sheldon Museum.

*"B Brooks Cast Steel" fireman's tool*

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*Ralph Brooks is a descendant of the Brooks toolmakers. A resident of Foxboro, MA, he has been researching the edge tool industry for several years. He was instrumental in the erection of the historical marker at the industrial site in Brooksville last year.*

## People and Places from Our Past

*The Middlebury River rose well beyond its banks in East Middlebury in 1937, causing major flooding. A decade earlier heavy rain in November 1927 flooded towns throughout Vermont.*

## *Remembering the 1998 Ice Storm and Floods*

### We Want Your Stories and Photographs!!!

Floods, fires and blizzards are as much a part of local history as are forefathers and foremothers, community celebrations, political events, and businesses and industries. The Stewart Swift Research houses accounts and photographs of Middlebury's nineteenth-century fires, the famous Blizzard of 1888, and twentieth-century floods.

This year's disasters will be historical events for the next century. If you have photographs of the damage caused by the winter ice storm or spring floods, please bring them to the Museum. We would like to make copies of some of them for the archives. If you have a story to relate which brings the fury of nature and its toll on the county to life--or know someone who does--please write an account which can be preserved at the Sheldon Museum for future generations.

*The* Sheldon Museum
1 Park Street
Middlebury, VT 05753
802/388-2117

U.S. POSTAGE
PAID
Permit #28
Middlebury, VT
Non-Profit
Organization

Elsa Gilbertson
Vermont Division/Historic Preserv
135 State Street, Drawer 33
Montpelier, VT 05633-1201

HOURS: *Til October 30:* Monday-Saturday, 10 a.m.-5 p.m. • *Winter:* Monday-Friday, 10 a.m.-5 p.m.& weekends during the holiday season.
*Research Center:* Tuesday-Friday, 1 p.m.-5 p.m. and Thursday, 6 p.m.-9 p.m.

# 19th Century Iron Industry
# Site Components

## Ore Procurement:

1. Quarry or open pit mining; shaft mining; or combinations thereof.
2. Wagons, whimseys, hoists, ore cars/tracks, headframes; horses and/or steam engines for power.
3. Housing for miners/foremen if distant from ore processing site.
4. Storage building(s) for tools, dynamite, etc.

## Ore Preparation:

1. Separator facilities, including ore roasting pits and stamping/crushing/separating facilities to obtain relatively pure, sand-size ore if it was to be reduced in a bloomery forge. Separators required water wheels to drive crushers, and flowing water for separation of ore from unwanted rock.
2. Wood stockpile for ore roasting.

## Ore Reduction:

1. To produce **wrought iron** direct from the ore:
   a. Forge building containing bloomery forges, triphammers, waterwheels or steam engines to drive bellows for forge air blast and triphammers.
   b. Blacksmith shop in or near the forge building for tool repair, etc.
   c. Crushed and separated ore stockpile.
   d. Forge fuel (charcoal) stockpile at or near the forge building.
2. To produce **pig iron**:
   a. Blast furnace with associated water wheel(s) and bellows or blowing cylinders for air blast; heating unit on or near the blast furnace if using hot air blast.
   b. Next to the blast furnace, either a trestle frame from an adjoining hillside, or an elevator unit, to bring ore, fuel and flux to be dumped into the top of the furnace.
   c. Casting house, often enclosing the base area of the blast furnace, with a sand floor where molds (pigs) were formed to receive the molten iron tapped from the furnace, and/or ladles for carrying the molten iron to other castings.
   d. Stockpiles of fuel (charcoal or coal) and flux (e.g., limestone).
3. Disposal areas or means for smelting wastes (slags).

## Fuel Procurement:

1. If charcoal, charcoal-making pits or brick kilns in wooded areas being cut, or kilns at the ore processing site.
2. A house/cabin and small barn for the collier at the kiln location.
3. If coal, anthracite or bituminous coal (or bituminous coke) mined elsewhere and shipped to the blast furnace site.
4. Kilns or ovens for making coke from bituminous coal might be located near the blast furnace.

(continued on back)

Iron Processing (local):

1. For wrought iron billets:
   a. Rolling mill containing heating furnace(s), rolling machines, water wheels or steam engines for power; probable small triphammer.
   b. Factory and storage area for foundry work and manufacturing (e.g., cable, chain, anchors, nails, kegs, etc.)
   c. Fuel (charcoal) stockpiles.
2. For pig iron:
   a. Finery or puddling furnace (for making wrought iron from pig iron).
   b. Steel converter, crucibles or open hearth furnace (usually after 1864).
   c. Foundry and storage area for manufacturing (e.g., hollow ware castings, etc.).
   d. Fuel stockpiles.

Ancillary:

1. For the industry:
   a. Roads (plank for heavy wagons between mines and ore preparation and reduction, and from reduction/processing sites to larger towns or shipping points); railway linkages, canals, docks, depots where appropriate.
   b. River dams at forges, rolling mills and factories.
   c. Saw mill.
   d. Barns, wagons, horses.
2. For labor:
   a. Housing.
   b. Company store.
   c. Grist mill.
   d. Church(es).
   e. Hotel.

---

Iron units of measure:

short (or net) ton = 2000 lbs.
long (or gross) ton = 2240 lbs.
subdivided into hundredweight (20 of 112 lbs. each),
quarters (4 of 28 lbs. each), and pounds.

Example of long ton notation for iron production at a bloomery:

13.15.2.4

| | |
|---|---|
| 13 = long tons (@ 2240 lbs) | = 29,120 lbs. |
| 15 = hundredweight (@ 112 lbs) | = 1,680 |
| 2 = quarters (@ 28 lbs) | = 56 |
| 4 = pounds | = 4 |
| | 30,860 lbs. of iron |

POOR QUALITY ORIGINAL ____

Pg. 1-3

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# CRM

VOLUME 15 • NO. 4
1992


## This Issue




U.S. Department of the Interior
National Park Service
Cultural Resources


# Forging a National Register Multiple Property Nomination: Pennsylvania Iron Furnaces and Steel Mills

William Sisson

In 1989 the Bureau for Historic Preservation, Pennsylvania Historical and Museum Commission, which is Pennsylvania's historic preservation office, began nominating iron and steel industry resources to the National Register of Historic Places. Iron furnaces and steel mills formed the heart of one of the state's most important industries, and they are among the most endangered historic resources in Pennsylvania. The Bureau for Historic Preservation chose to nominate these resources as a multiple property submission. The multiple property format has greatly aided the Bureau for Historic Preservation in evaluating which furnaces and mills are significant and worthy of preservation.

The Bureau for Historic Preservation assembled a staff industrial survey team in 1989 to prepare the multiple property submission in two parts: writing the National Register multiple property documentation form dealing with iron and steel resources in general; and surveying resources and preparing National Register registration forms for individual properties. Bruce Bomberger and this author wrote most of the form. Part of this form covers major trends in the technological, business, labor and community evolution of the industry from 1716 to 1940. This narrative history also places resources in state and national contexts, analyzing how they have state or national significance. The multiple property documentation form also describes the types of iron resources found in the state, including iron furnaces and ancillary production buildings, and iron plantation buildings such as houses, stores,

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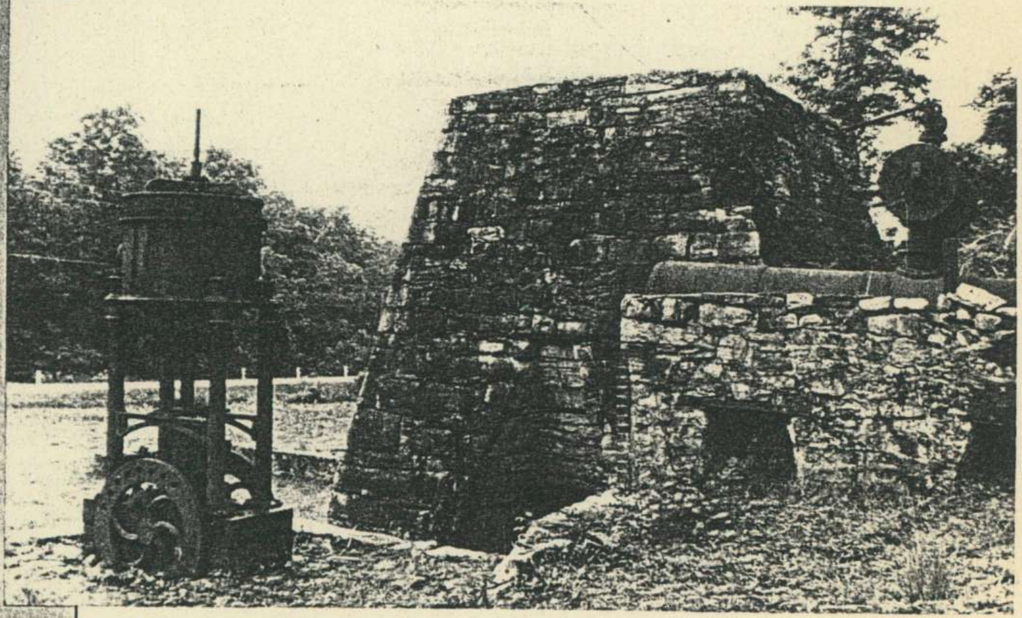


Carrick Furnace, with the blowing engine to the left, the iron furnace stack in the middle, and the boilers to the right. Photo by Diane Reed, Pennsylvania Historical and Museum Commission, 1990.

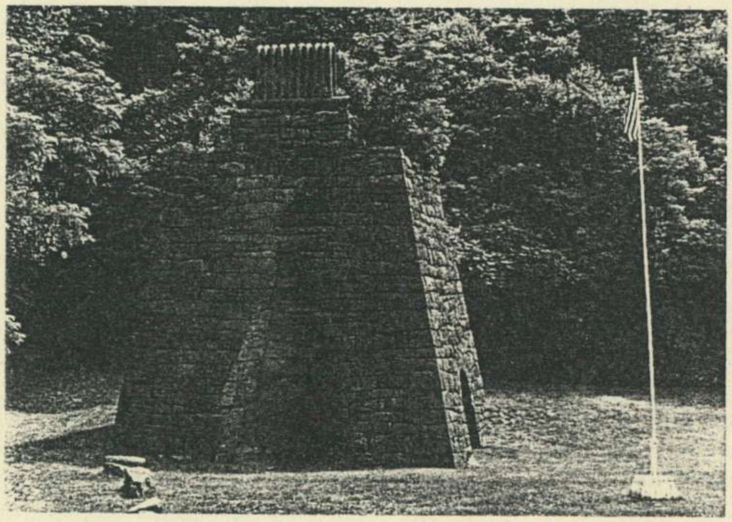

Cultural Resources Management Information for Parks, Federal Agencies, Indian Tribes, States, Local Governments and the Private Sector

# Forging a National Register Multiple Property Nomination: Pennsylvania Iron Furnaces and Steel Mills

*(continued from page 1)*

churches, and farm buildings erected to support work forces at often isolated iron furnaces. The form specifies the areas of significance and National Register criteria under which iron industry resources can be listed. In addition, it defines the levels of integrity these resources must have in order to be listed. Setting integrity thresholds was particularly important for historic archeological sites, since such sites can divulge considerable information about the iron industry.

Diane Reed of the industrial survey team investigated individual iron industry resources and prepared National Register registration forms for eligible properties. She began by reviewing information on iron furnaces and plantations previously listed piecemeal on the National Register, researching primary and secondary sources, and interviewing people knowledgeable about iron industry sites in various regions of the state. She composed a list of 29 iron resources which she visited and for which she completed survey forms, including narrative histories and descriptions, site plans and photographs. Bureau for Historic Preservation staff reviewed the survey forms and found that 22 appeared to be eligible for listing in the National Register. Seven properties were determined not eligible due to lack of integrity or significance. The staff's conclusions concerning eligibility were incorporated in the writing of the multiple property documentation form, as was information from the survey forms. Reed then completed National Register registration forms for the 22 eligible resources. In 1991 these nominations and the multiple property documentation form were approved by the state review board, and the nominated resources were listed on the National Register.



**Stack with original heat exchanger, Eliza Furnace (c. 1846). Photo by Diane Reed, Pennsylvania Historical and Museum Commission, 1989.**

The listed properties run the gamut of iron furnaces and plantations that once operated in Pennsylvania. They include the Robesonia Furnace Historic District in Berks County, which was nominated as representative of iron plantations in southeastern Pennsylvania, for its sophisticated plantation architecture, and as an archeological site that provides information on iron manufacturing. Begun in 1794 and operating until 1927, this iron plantation contains 19th century houses and other buildings featuring high-style architecture seldom found on plantation buildings elsewhere in Pennsylvania. Although the manufacturing facilities were demolished, the remaining building foundations and surface artifacts offer valuable information on how iron was produced at Robesonia. The Carrick Furnace in Franklin County in south-central Pennsylvania was listed on the National Register for its association with the westward movement of the iron industry in Pennsylvania, and as an outstanding example of later 19th century iron furnace technology. Unlike any other furnace in Pennsylvania, the boilers and steam-powered blowing engine, which blasted hot air into the furnace to help smelt iron, survive at Carrick Furnace.

The Bureau for Historic Preservation chose to nominate these resources as a multiple property submission for several reasons. It had determined by 1989 that the Pennsylvania iron and steel industry was highly important in state and national history. A historic context on Pennsylvania industry completed by staff determined that iron and steel manufacturing was one of the five most important industries in the state's history in terms of the number of employees and the value of goods produced.[1] The state's iron and steel furnaces were also critical to the development of the national industry. Pennsylvania led all other states in iron and steel production from the mid-18th through the mid-20th century, and many of the industry's important technological innovations and developments in labor-management relations originated in Pennsylvania. The Bureau found the multiple property documentation form to be an excellent way of documenting the complex and important history of this industry.

The Bureau for Historic Preservation undertook a multiple property submission because many iron and steel industry resources are endangered, and the Bureau and other organizations must set priorities on which resources should be preserved. Scores of iron furnaces have already disappeared, and many that remain are slowly crumbling due to neglect. Since the mid-1980s, steel mills have closed, particularly in the Pittsburgh area, and some mills covering hundreds of acres have been completely demolished. The America's Industrial Heritage Project and the Steel Industry Heritage Task Force, both industrial heritage preservation programs at work in southwestern Pennsylvania, have been trying in recent years to save endangered iron and steel industry resources. Other individuals and historical societies elsewhere in Pennsylvania are involved in similar efforts. Given the scores of remaining historic resources and limited funding available, priorities must be set as to which resources most merit preservation. The multiple property documentation form already completed provides a way of assessing the significance of iron industry resources and designating which properties are worthy of preservation. The Bureau plans to add to the form the types of steel industry resources found in the state, and the

*(continued on page 4)*

# The Farm Creek Section in Central Illinois– Participation in the Geology NHL Theme Study

Ron Deiss

*In 1990, the CRM Bulletin (Vol. 13, No. 1) contained an article by Harry A. Butowsky on the National Park Service's new Geology National Historic Landmark (NHL) Theme Study. The article requested information on sites which influenced the history of the geology in the United States. As a result of this request many sites were recommended for further study in the geology theme study. One of these sites is the Farm Creek Section in East Peoria, IL, located on land operated and managed by the Rock Island District of the U.S. Army Corps of Engineers. The Farm Creek Section was also listed in the National Register of Historic Places on February 6, 1992. The Corps' active role in documenting the significance of this site reflects its commitment to preserving and protecting historic properties under its jurisdiction.*

*For over 95 years geologists have studied the Farm Creek Section revealing information which has influenced the development of historical geology. The knowledge gained from the study of this site not only contributes to our understanding of the natural history of the earth but also helps us to understand the development of the science of historical geology and its important role in American History.*

*This is another in our continuing series of articles that will examine the educational, interpretive and scientific potential of our national parks and other historic sites. Readers of CRM are invited to submit contributions to this series to Harry Butowsky, CRM, (400), National Park Service, P. O. Box 37127, Washington, DC 20013-7127.*

The Farm Creek Section is known to geologists today as a unique property significant in the development of many important geological concepts relating to the study of continental glaciation. The section is located within the Farmdale Reservoir in Tazewell County, Illinois. This reservoir was constructed by the Corps of Engineers to prevent damage from flooding as part of the Farm Creek Flood Control Project.

Archeologically, the Farmdale Reservoir contains much evidence of the prehistoric occupants who inhabited the rough topography left by the last glaciers. A number of prehistoric campsites have been under study for over a decade. During a preliminary survey the significance of the Farm Creek Section was documented by Western Illinois University, Macomb, in *A Cultural Resources Overview and Reconnaissance Survey of Two Dry Reservoirs, Tazewell County, Illinois*. Authors Lawrence A. Conrad, Mark E. Esarey, and J. Joseph Alford recommended the Farm Creek Section for nomination to the National Register of Historic Places due to its importance to Pleistocene studies. They concluded that its significance

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**Forging a National Register Multiple Property Nomination: Pennsylvania Iron Furnaces and Steel Mills**
*(continued from page 3)*

National Register criteria and integrity thresholds that must be met in order to designate steel resources as worthy of preservation.

The Bureau for Historic Preservation also wanted to provide a broad history of Pennsylvania's iron and steel industry for the general public. A number of histories had been written about specific iron furnaces or steel mills, and about the technological, business or labor history of the industry. But no history adequately synthesized these various subjects into a broad, interpretative whole. The Bureau hoped to provide this history and distribute it to the general public. In this way citizens throughout the state could learn the full history of an important industry from their past, and the need to preserve vanishing historic resources. The Bureau for Historic Preservation plans to publish the historical narrative section of the multiple property documentation form for the general public. Thus the multiple property format enables the Bureau to identify and assess iron and steel industry resources, and educate the general public about their history and importance.

**Double workers' house (c. 1845). Robesonia Furnace Historic District. Photo by Diane Reed, Pennsylvania Historical and Museum Commission, 1990.**

[1]This context, *Made in Pennsylvania: An overview of the Major Historical Industries of the Commonwealth*, was written by Bruce Bomberger and William Sisson and published in 1991 by the Pennsylvania Historical and Museum Commission.

William Sisson is the National Register Coordinator for the Bureau for Historic Preservation, Pennsylvania Historical and Museum Commission.

Isaac Tyson, Jr. (1792-1861)

Isaac Tyson, Jr.

1792–1861

**Soldiers Delight Conservation, Inc.**

5100 Deer Park Road

Owings Mills, MD 21117

**PRESS RELEASE: SOUTH STRAFFORD, VERMONT, August 1, 1996**
**concerning ISAAC TYSON, JR.**

One of Vermont's pioneer 19th-Century industrialists, Isaac Tyson, Jr., will soon be inducted into the National Mining Hall of Fame and Museum of Leadville, Colorado. At the Hall of Fame's Annual Banquet to be held on September 8, 1996 in Las Vegas, Nevada, Tyson will join a roster of prior inductees including President and mining engineer Herbert Hoover, rock-drill inventor Simon Ingersoll of Ingersoll & Rand, and controversial labor leader and United Mine Workers of America President John L. Lewis. Tyson is to be honored for his early pioneering achievements in the fields of mining engineering, industrial chemistry, and metallurgy.

Isaac Tyson, Jr., son of a wealthy flour merchant, was born in Baltimore in 1792. One of his most noteworthy accomplishments was the establishment of the domestic chromium mining and chemical industry and the monopolization of the world chrome business until 1850. Although chromium had only been discovered in 1797 in France, by 1810 Tyson had identified heavy, dark rocks from Bare Hills near Baltimore as chromite. He then pursued a lifetime quest to develop chromite and other minerals. Educated in France in geology, mineralogy, and chemistry, Tyson travelled the Mid-Atlantic region seeking serpentine barrens hosting chromite deposits. He purchased, leased, and developed these resources to supply domestic and European markets with this valuable raw material to be used in manufacturing yellow paint pigments. He established chromite mining districts including Soldiers Delight near Baltimore and the State Line District straddling the Maryland and Pennsylvania line. The Wood Mine in Lancaster County, Pennsylvania was the largest domestic chromite mine in existence. By 1845 Tyson successfully patented and manufactured chromium compounds after several failed ventures. His factory later became the world-reknowned Baltimore Chrome Works in Fells Point, operating continuously for 140 years.

Much of Isaac Tyson, Jr.'s influence was seen in Vermont. He pioneered developments in copper, with significant involvement in Vermont's Orange County mines. He was also instrumental in the birth of mine-site smelting in South Strafford, Vermont. Granted a patent in 1827 for the manufacture of copperas, or chemical iron sulfate, Tyson became involved in the operations at Copperas Hill in South Strafford. He became particularly interested in the copper content of the large iron sulfide deposit. He joined in partnership with investors from Boston in this early copper mining and smelting venture and secured local mineral rights. In fact, 1833 found Tyson attempting to smelt copper ores using anthracite coal and a hot blast. This was a first in the United States and coincident with initial domestic patents for similar iron furnaces. To superintend these operations required Tyson to travel to Vermont for extended periods of time. The documented journeys of 1833 and 1834 from Baltimore to Vermont with his young family by steamboat and stage are quite interesting. His local business relationships included both Senator Justin Smith Morrill and Jedediah Harris of Strafford Village.

Tyson also held mineral rights and worked the large copper deposit in South Vershire that later became the famous Ely Mine. His son James Wood Tyson later developed his father's holdings in South Strafford into the Elizabeth Mine which operated as recently as 1958 and was one of the most productive copper mines in the East. Tyson later operated a small copper mine in Waterbury. He was also involved in early manganese mining in Vermont and Virginia, sponsored exploration for copper ores in Cuba, and exploited magnesite deposits located in the serpentine barrens of Maryland and Pennsylvania for the production of epsom salts. He was a leader in other developments in the copper industry that followed and highly involved in the establishment of Baltimore's copper smelting enterprises.

Tyson also established a major iron furnace in Plymouth, Vermont, manufacturing cook stoves and pig iron. The recorded story is that he discovered large deposits of iron ore while crossing the Green Mountains in 1835 near the Black River. He also notices the large tracts of woodland available for charcoal and limestone deposits for flux. He secured these varied resources required to operate an iron furnace and built his efficient, hot-blast charcoal furnace in 1837. He created a manufacturing village and his business representatives operated the furnace successfully for years. Today the hamlet of Tyson, Vermont, named for Isaac Tyson, Jr. is located on the shores of Echo Lake in Windsor County. Tyson Stoves cast during the late 1830's and 1840's are still encountered from time-to-time and feature a ship emblem, a symbol of Tyson's Baltimore roots.

Tyson died in Baltimore in 1861 and not only left behind a variety of successful business ventures to his sons, but also a cadre of practically-trained individuals in the mining and smelting fields. A devout Quaker and abolitionist, Tyson studied constantly and determined to find better methods and materials as a pioneer in his fields. Isaac Tyson, Jr.'s nomination to the National Mining Hall of Fame was sponsored by Mining Historian Johnny Johnsson and Ranger Fraser Bishop of the Soldiers Delight Natural Environment Area of Baltimore County, Maryland. Endorsements of this recognition effort were supplied by a number of individuals and organizations including surviving Tyson descendants residing in South Strafford, Vermont. For an early pioneer from the East to be honored in this way is quite an accomplishment in a field dominated by the West.

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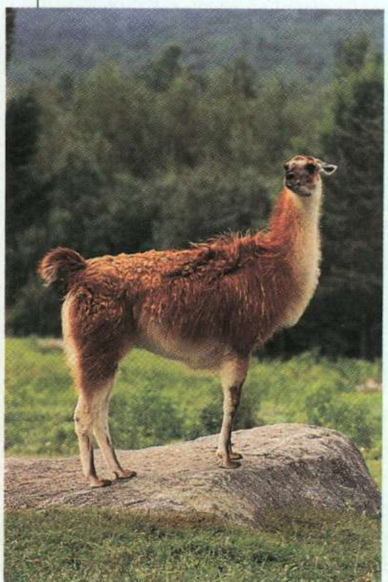
Richard Tyson Wilson
P.O. Box 207
S. Strafford, VT 05070
(802)765-4355

# Vermont Life

Summer 1995 Volume XLIX Number 4



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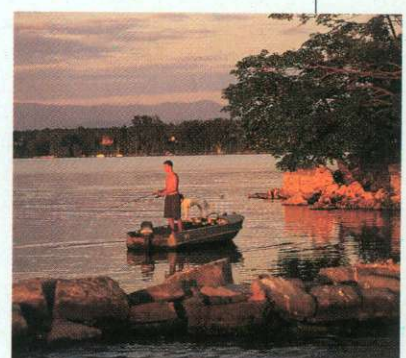
*FEATURES*





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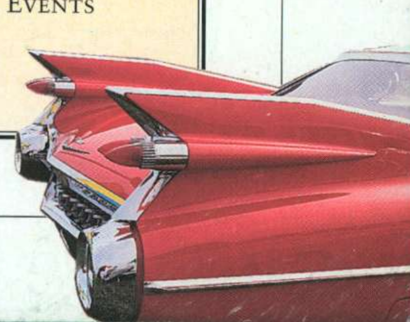
*DEPARTMENTS*





page 76

COVER: *Matt Chandler and crew sail their trimaran off Red Rocks Park in South Burlington. For more of Paul O. Boisvert's Lake Champlain photographs, see page 42.*

*I N S I D E*

# Vermont Life

How many Vermonts are there? Well, we all know there's really only one, but within the borders of that single one, sometimes there seem to be a dozen or more different worlds hiding, especially in summer.

Summer turns Vermonters loose. The state boasts several major festivals every summer, festivals that celebrate jazz, or fishing, reggae music, straw-hat theatre or chocolate — you name it! Sometimes in summer, the state seems to become one large informal festival, celebrating — simultaneously — swimming holes, flower gardens, hiking trails, backyard barbecues, green tomatoes, summer classes, haying, early-morning backyard breakfasts and long, long twilight evenings on the porch.

This issue of *Vermont Life* samples some of that wide-ranging varity. From llama-raising to kayaking on Lake Champlain, our aim is to bring to you the many, many delights of a Vermont summer. Because Lake Champlain dominates much of Vermont's northwest quadrant, we sampled Paul Boisvert's new photo book on the lake, and we also decided to share with you one of the best ways to get close to Champlain — in a kayak. Our lake trip starts on page 42.

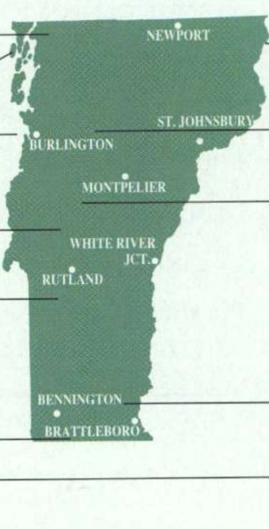
Victor Rolando, historian and researcher, has been exploring Vermont's industrial sites for years and knows that Vermont's past has a lot more in it than farms and cows. Ed Barna's profile of Vic and the significance of his research begins on page 52. Family is important to Vermonters, so we asked Chris Bohjalian to report on some of the many family reunions held in Vermont each summer. His story begins on page 40. And for you summertime construction artists, we have a report on a highly unusual home design workshop, page 36.

From llamas, pushcart meals and home-grown herbs to snappy Vermont comebacks, there's a lot more to sample in this issue. One of my favorites is Mary Miller's recipe for fried green tomatoes in our letters column on page 9. I hope you enjoy *Vermont Life* — and that you find time to enjoy Vermont this summer.

Tom Slayton
EDITOR

**Vermont Places In This Issue**







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# SOOT, SWEAT – AND HISTORY

*By* Ed Barna
*Photographed by* Jerry LeBlond

## Vic Rolando Wrote the Book on Vermont's Forgotten Early Industrial Days

For amateur archaeologist Victor Rolando, the massive old stone and brick blast furnace near the Neshobe River in Forest Dale has special significance.

Before it fell silent for the last time in 1865, this fire-breathing behemoth sent its roar for miles through the countryside. Molten iron flowed from the arches of its 30-foot-high tower onto molded beds of sand to form axes, draft chains, wagon parts, stoves, kettles, skillets, rods and flat irons.

Rolando knows all these details intimately, from the sources of the iron ore to the shipping manifests for finished products. But this relic means more to him than that. It is the embodiment of a fact he has labored tirelessly to document: that iron-making was as much a part of early Vermont as subsistence farming, sheep raising and quarrying.

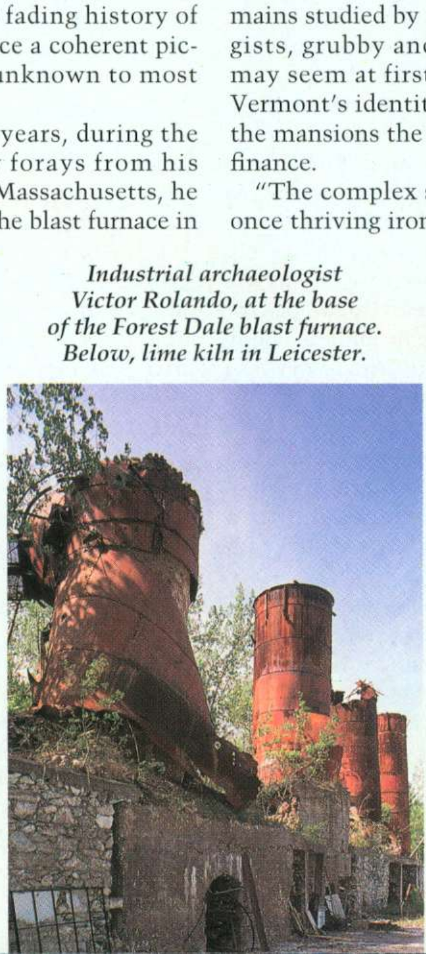
In the course of his long and unpaid work, Rolando has become the acknowledged expert on Vermont's early industrial days, the one person who pulled together the fading history of this period to produce a coherent picture of a Vermont unknown to most people.

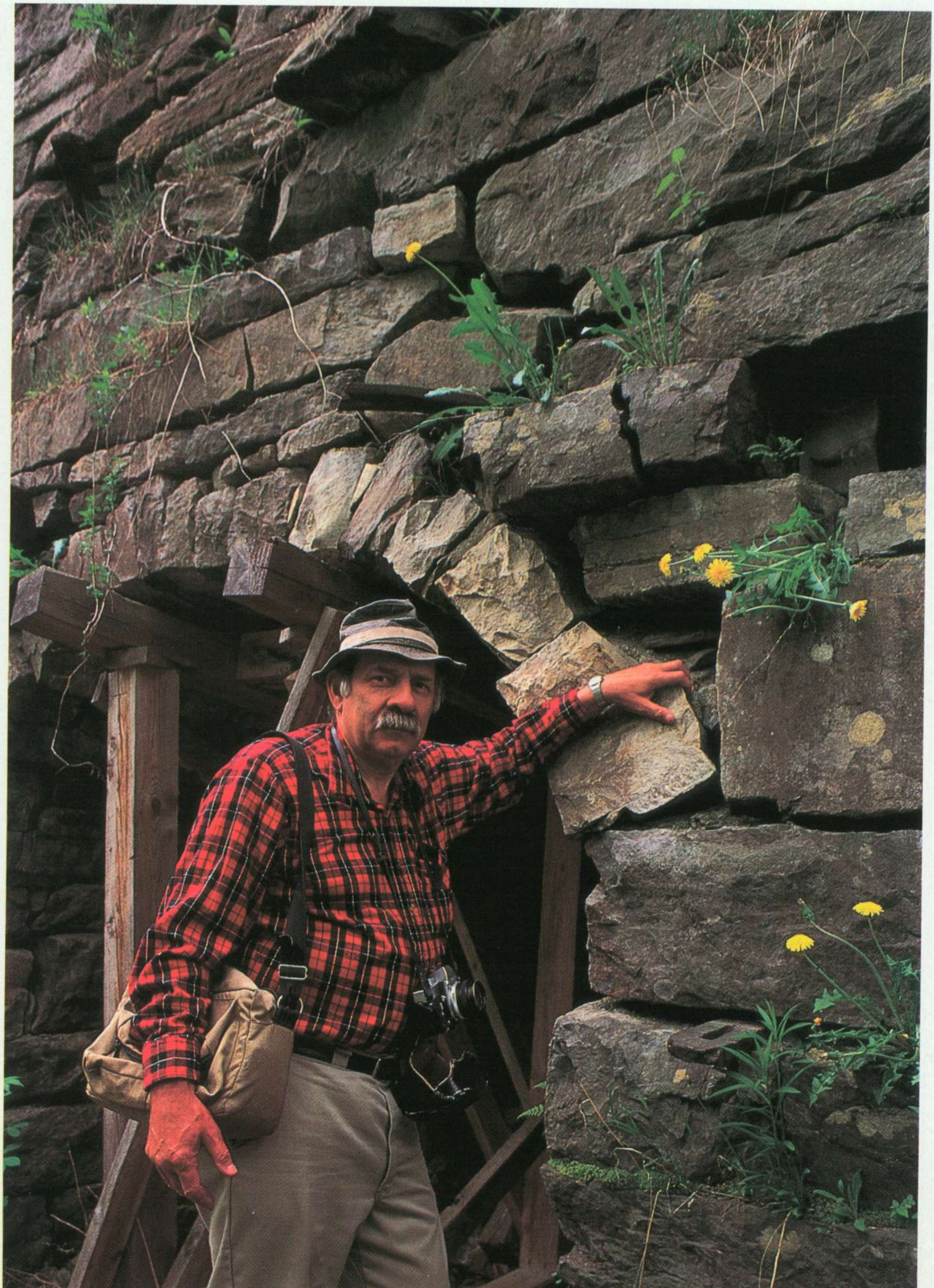
Over the past 20 years, during the many archaeology forays from his home in Pittsfield, Massachusetts, he came repeatedly to the blast furnace in Forest Dale, a village in the Rutland County town of Brandon. The Northern New England Chapter of the Society for Industrial Archaeology, of which Rolando is treasurer, gathered there in 1988 to excavate the abandoned industrial village around the furnace. Vermont's Division for Historic Preservation chose the site as the best place to interpret Vermont's role in the early Industrial Revolution. And Rolando chose a photo of the blast furnace for the cover of his epic 1992 book, *200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries.*

The book was the capstone on Rolando's effort to show that the remains studied by industrial archaeologists, grubby and workaday as they may seem at first glance, are keys to Vermont's identity — just as much as the mansions the iron industry helped finance.

"The complex stories of Vermont's once thriving iron, charcoal and limestone producing industries lay virtually forgotten in forest and field, in libraries and attics, until Vic's exhaustive efforts brought this part of Vermont's heritage to light," wrote state archaeologist Giovanna Peebles in the foreword to Rolando's book. "... There is no question that Vic's devoted and extraordinary efforts — all on a volunteer basis — have immeasurably en-

*Industrial archaeologist Victor Rolando, at the base of the Forest Dale blast furnace. Below, lime kiln in Leicester.*





riched our knowledge."

Rolando's love of industrial history began when he was growing up in the Hudson River Valley around Albany, New York. Gradually he became fascinated with the many abandoned places he found in the area. In high school, he rode his bike to explore old buildings, wharves, and factories. When the weather was bad, he'd hang around the New York State Museum in Albany.

With time, high school, college and career responsibilities eclipsed that early interest. But it returned in the early 1960s: On a Sunday drive, Rolando noticed a street in Richmond, Massachusetts, called Furnace Road. Struck by the name, he drove along it and found an early 19th century blast furnace. Soon he was back in school, getting a degree in history.

But his interest became a passion when he discovered Vermont, a state he describes as a "time capsule" for industrial archaeology. "I would find things in Vermont that predated almost anything I could find in Massachusetts and New York, where most of them evolved into later sites," he said.

Rolando met members of the state's Division for Historic Preservation at a University of Vermont conference in 1978. They warmly welcomed his passion for industrial archaeology. They were interested and helpful; they sent him promised documentation forms instead of forgetting all about them as Massachusetts officials often did. Eventually Rolando decided to focus his research on Vermont rather than Massachusetts and New York.

Soon, he realized he was onto something important. He found that in addition to burning forests for potash, Vermont's settlers had built charcoal kilns all over the mountains, either crude soil-covered piles where dry wood fires drove the gases from green wood, or more efficient stone domes that did the same job. But what did they do with all the charcoal?

Rolando quickly discovered that iron ore — both "bog iron" and higher grade hematite — had been abundant, and that charcoal had been the fuel that fed the ravenous energy appetite of a considerable iron industry in the days before coal and railroads remade the industrial landscape. He found many simple "bloomery" forges, and he was able to document the existence of at least 36 blast furnaces, 12 of which existed as visible remains, and six of which (two in Bennington, one each in East Dorset, Pittsford, Troy, and Forest Dale) were still present as recognizable structures.

The lime kilns were something of a bonus. Informants kept mentioning them, thinking that they were old ironworks, though some lime operations continued into the 1970s. Finally, Rolando decided to document that little-known chapter of Vermont history as well. Lately, he has taken on the challenge of researching the brick industry, whose products were used in both blast furnaces and kilns.

Deceptively unathletic in appearance, Rolando is in fact a relentless trekker, one of those people who can push on and on without food or drink. He has come to know the state's reforested hinterlands as do few others except game wardens, foresters and ginseng hunters. You may have seen him at some remote roadside turnoff, a medium-sized man sporting a hefty mustache and wearing a battered pork pie hat. When he traded his last car in, at 120,000 miles, the dealer handed him $200 and told him to get the thing off the lot. The engine had literally fallen out, thanks to various backroad adventures, and Rolando had held it in with wire and two-by-fours.

After haunting town offices and libraries, questioning older residents, and asking the local children — "they know where things are, even if they don't know what they are" — he has walked countless spirals through the woods, watching intently for bits of ore, slag and charcoal that others overlook. He has followed slag trails up streams until the slag vanishes, then gone overland to find their sources. On the remote hillsides of long-abandoned hamlets, he has spotted the telltale rings of so many collapsed charcoal-burning mounds that he has become bored with finding them.

Just as impressively, Rolando's research has illuminated the social patterns of the iron industry. He uncovered a sort of interlocking directorate of investments, marriages and trade that linked iron families in Vermont with the industry across Lake Champlain in New York State. Ownerships, products made, buyers, transportation routes, are all detailed in the small print of his 296-page book.

Rolando had to organize the amazing array of facts he had accumulated over the years, sort through thousands of photographs, diagrams, reproductions of old advertisements, and maps, and produce a glossary and a detailed index. Getting his encyclopedic account published commercially, or even through a university press, proved an impossible dream. "I'm not a professor at a major university in the Northeast," Rolando notes. "I'm not an eminent archaeologist. I'm writing about something that editors generally don't know what it is, in a state so small they don't know where it is."

In the end, Rolando, then 60, retired in 1992 from his job as a technical editor with General Electric, and moved to Manchester. He established Mountain Publications, obtained a small grant from the Vermont Statehood Bicentennial Commission, and enlisted the support of the Vermont Archaeological Society as nominal publisher. Then he invested $40,000 from a GE job-phaseout program to produce 1,500 copies of the book, of which he has since sold more than a thousand. But making money was never his goal; knowledge and understanding were.

Rolando's efforts won national recognition when the American Association for State and Local History gave him its Award of Merit, perhaps the highest award an amateur historian can achieve, an honor usually reserved for organizations. In nominating him, Castleton State College archaeologist David Starbuck wrote that Rolando's research "unquestionably represents the most thorough inventory ever conducted of the iron, charcoal, and lime industries in any state in this country. In conducting this work, he has greatly helped to sensitize Vermonters to the importance of their industrial heritage and has encouraged all of us to seek out and protect these endangered historical resources."

•

Rolando continues to find new iron production sites, and others may be taking up the work. Lately, he has received so many invitations to speak to

# Enjoy the Villages *of* Arlington, Shaftsbury & Sunderland

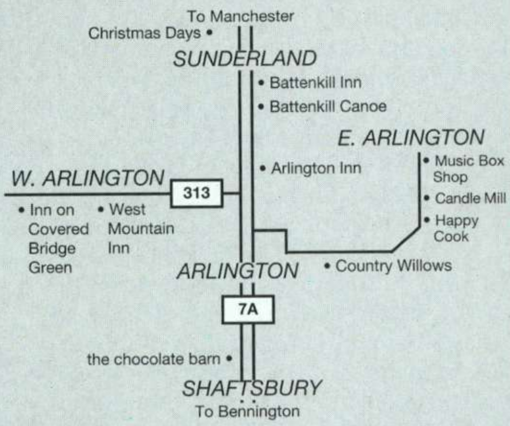


Visit the Vermont that lives in your imagination...visit Shaftsbury, Sunderland and Arlington, hometown of famous American artist and illustrator Norman Rockwell. These villages provided a backdrop against which Rockwell could say, "Vermont is inspiration to my work." He chose this area to settle in from 1939-1953, residing in two different houses on the banks of the famous Battenkill.

The same special world that surrounded Rockwell still exists very much unchanged for visitors to explore today. Picturesque farmland, covered bridges over meandering rivers, scenic bike routes, wilderness hiking paths, country roads lined with wildflowers and boundless natural beauty are here.

On June 17-18, visit Arlington's celebration of its early history for Ethan Allen Days: roasts, a historic battle re-enactment, a crafts fair, and an antiques show. Later in the summer on August 12-13th, at Arlington Parks and Recreation, the annual Arlington Arts and Crafts Fair will be held.

We invite you to bring the Vermont that lives in your imagination to life. Visit our countryside, our shops, our inns, our lodgings and restaurants, or perhaps our Ethan Allen Days events. You'll have an "illustration in your own memory to treasure forever."



historical societies, archaeologists, and foresters that he has had to turn some down. No longer is it conceivable that a scrap drive might remove the iron bands from an old blast furnace, as happened in Forest Dale, or that a highway construction crew might dynamite such a structure to get building stones, as happened there in the 1950s.

"I've made my point," Rolando said, "there was a lot of industry here at one time, which I don't think a lot of Vermonters realize."

## For More Information

ROLANDO'S book, *200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries,* is available at Vermont bookstores or by writing to Mountain Publications, P.O. Box 1812, Manchester Center, VT 05255. It costs $32.95 in paperback, $39.95 hardback, plus 5 percent Vermont sales tax.

Rolando did not write it as a guide because he feared that casual souvenir collectors, professional "pothunters" or vandals might damage the historical resources described. But the book gives general directions and methods that a serious student can use in combination with local directions.

The **Vermont Division for Historic Preservation** has on display at the Calvin Coolidge Birthplace in Plymouth Notch a growing collection of cast iron objects made in Vermont furnaces. They will form the nucleus of exhibits at an interpretive center the state plans to build at the Forest Dale blast furnace site, given to the state by Welland Horn, whose family once operated the furnace.

**The American Precision Museum** in Windsor focuses on Vermont's industrial past. This former armory shows how inventors in the lower Connecticut River Valley made the area world-renowned as a source of precision tools, rifles, and other mechanical devices. The museum is open Monday-Friday 9 a.m.-5 p.m., weekends and holidays 10 a.m.-4 p.m., May 20-November 1; tel. (802) 674-5781. Admission charged.

*Writer Ed Barna lives in Brandon, not far from the Forest Dale furnace.*

# Franconia Stone Furnace Stands As Monument to Iron Industry

By LORNA COLQUHOUN
Union Leader Correspondent

FRANCONIA — The iron industry that flourished here in the last century has long since vanished, but left on the banks of the Gale River is just one reminder of it all, the stone furnace that for more than half a century fueled the New Hampshire Iron Co.

The octagonal stonework is recognized as the sole surving example of post-Revolutionary War furnace used for smelting local iron ore. The only other surviving furnace of this type is located in Harpswell, Pa.

Over the weekend, volunteers and archeologists from the Northern New England Chapter of the Society for Industrial Archeology were at the site of the stone furnace to document information about it and search for further clues about an industry that employed hundreds of local people in the community and changed the course of development of the town.

The study was led by Victor Rolando of Manchester Center, Vt., who authored "200 Years of Soot and Sweat: The History of Vermon't Iron, Charcoal and Lime Industries."

"We're doing a recording," said Jewell Friedman, a member of the Franconia Area Heritage Council. "We're not doing much in the way to preserve it, but to record what we have here."

Interest in the furnace's remains grew during the summer, when the heritage council opened an interpretive center across the river from the furnace. Volunteers opened the center for two hours a day after the Memorial Day weekend and in that time 325 people stopped by to see and learn about the once thriving industry.

Three weeks ago, a group of volunteers, along with Kevin O'Brien, on whose property the furnace is located, climbed ladders to the top of the 32-foot high furnace and removed about 50 trees that were growing from the cracks in the stonework. They also cleared brush from around the furnace, which provides visitors with a clearer view of it from across the river.

On Friday, the first day of the project, the volunteers were clearly seen across the Gale beginning a review of the area. They did not immediately attack the structure itself with tape measures and cameras, but rather walked an area around it, searching the underbrush for clues related to it.

For all that the furnace contributed to the community, including the famous Franconia stoves, little is known about it. The New Hampshire Iron Co., which produced bar and pig iron to produce farm tools and cast iron ware, was begun in 1805 by a group of Salem businessmen who earned their fortunes on the East India trade routes. It ran until at least 1850 and perhaps until 1865. It was sold in 1870 and there was an intention to fire it up again, but fire of destructive kind burned the wooden structure around it and it was never rebuilt.

Among the volunteers tromping through the brush was Allison Edwards of Richmond, Mass., near the Massachusetts border, and the home of a stone furnace of its own.

She and her husband, Bill, are very active in the study of the history of their stone furnace and the way it affected the development of their community.

Unlike Franconia's furnace, Richmond's is not as visible.

"It is a well kept secret, since it is not visible from the road," she said.

The work she and her husband do is a labor of love.

"A lot of industrial archeology is lost, and I think that's a symptom of what happened in our country," she said. "We were so busy making improvements that furnaces would be torn down and no one knew how it existed before that. At least now we'll have a record of what was here."

Another volunteer SIA member on the scene Friday was Woody Openo of Somersworth, a retired architect who did historical research on Sawyer's Mills in Dover a few years ago.

"It's a real beauty, that's what I think," he said of the stone furnace. "It's very impressive."

The heritage council would like to obtain the furnace and the land around it and begin preservation efforts. The current owner is trying to sell the property, including the stone furnace, so the council will probably have to wait until a new owner buys it to take up the question of the stone furnace's future.

# A big-time blast from the past . . .

## . . . now monument to days of ore

By Ralph Jimenez
GLOBE STAFF

FRANCONIA – A crumbling stone tower rises from the banks of the Gale River like a ruin left by Druids or Rapunzel's imprisoner. Four tall beehive archways of quarried granite block pierce the 32-foot-high octagon that stands alone opposite Main Street.

For the motorists who see the tower for the first time – possibly at all only because years of brush have been fallen – the solitary structure is a head-scratcher. Signs at the tiny museum on the opposite bank explain to the curious that they are viewing the last remnant of New Hampshire's iron industry, an era when local miners and founders hauled and "roasted" ore to make cannons, kettles and frying pans.

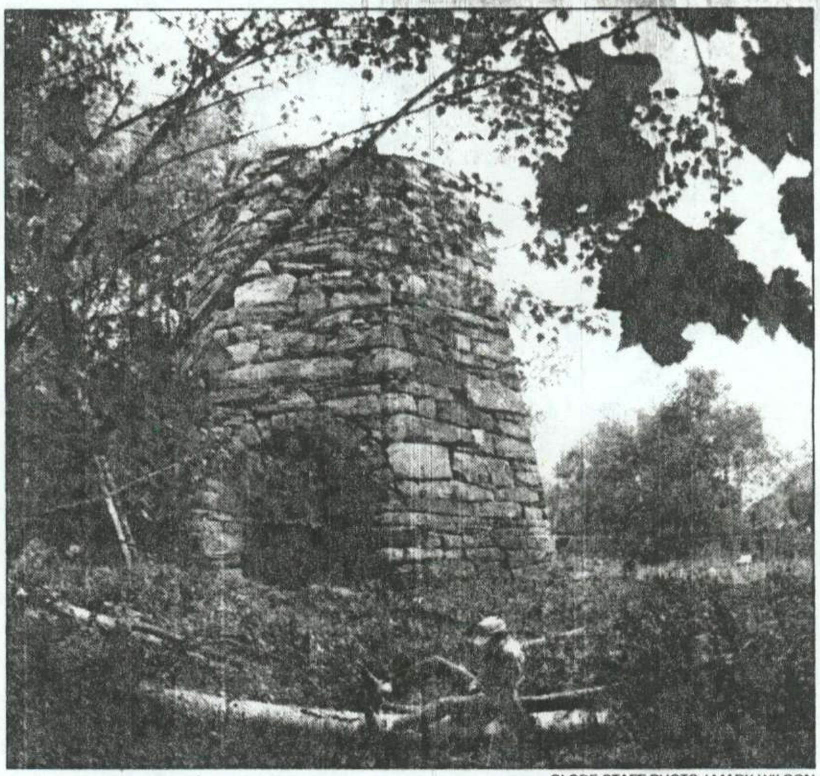
On a recent weekend, a group of industrial archeologists from around New England fanned out around the tower taking measurements and probing the earth. From drill holes in rocks, stone foundations, slag piles and scrap iron they pieced together the past.

Lillian Burns, 94-year-old mother of House Speaker Harold Burns and author of the brief book, "Mining Lore from New Hampshire," watched. "The background for my material was from my husband's people," Burns said of the Whipples of Franconia.

"They made stoves there that were very durable. We had one in our town hall, said Burns, who lives in neighboring Whitefield. The New Hampshire Iron Factory Co. also cast kettles, firebacks, andirons, children's toys and pig iron to be reheated and forged by farmers and blacksmiths,

Franconia's octagonal furnace is the only one of its kind in New England and perhaps in America, said Victor Rolando, the leader of the investigation by the Northern New England Chapter of the Society for Industrial Archeology. Rolando is president of the society's Vermont chapter and author of "200 Years of Soot and Sweat: The History of Vermont's Iron, Charcoal and Lime Industries."

"People have the idea that these things were set up out in the middle of nowhere when they were built but that isn't true," Rolando said as he brushed dirt from firebricks fallen from the interior of the furnace. "Industry and commerce thrived around here. These firebricks came from Perth Amboy, N.J."



GLOBE STAFF PHOTO / MARK WILSON

**This old iron furnace in Franconia was built of stone in the 1800s.**

Franconia's iron age began with the discovery of rich veins of iron on Ore Hill, three miles away in Lisbon in 1790. A refrigerator magnet sticks firmly to a sample of the heavy black ore, up to 70 percent iron.

An early, inefficient type of furnace called a flumery probably went up on the site by 1795. As technology and ownership changed, so did the furnaces on the site. From piles of slag – some glassy and black as obsidian or blue and swirled as agate, others bubbly, coarse and gray – the archeologists also learned that steel was made in small quantities as well.

Water power from a dam upstream powered not only huge sets of bellows that pumped air into the blast furnace but a grist mill, saw mill and bobbin mill as well, said Jewell Friedman, vice president of the Franconia Area Heritage Council and leader of a campaign to preserve the furnace.

Franconia was once a factory town, its tavern, stores and homes owned largely by the iron company. A huge wooden building surrounded the furnace which ran round-the-clock for months at a time. Ore was dumped into its mouth along with lime to mix with and remove impurities to form slag. Charcoal made from nearby kilns fueled the furnace.

The company itself, though incorporated in New Hampshire, was largely owned by captains of industry and commerce from Salem, Mass. "They had made their money in the China trade and were looking for a place to park it where they could earn a good return on it," Rolando said.

"A lot of speculation went on with these things. They operated on and off depending on the market for iron. This furnace was probably rebuilt in 1859 with the hopes that the market would come back," he said.

Rich iron ore is still plentiful. So the furnace may have ceased production, probably around 1865, because local forests had been stripped of wood for charcoal or because it couldn't compete with Pennsylvania and New York's more efficient iron industry, Rolando said.

At the beginning of the research weekend, the archeologists were unsure. An amateur researcher, Roger Aldrich of Franconia, had speculated that due to human error or mechanical failure, the fires had gone out in the furnace leaving a "salamander" on the hearth.

A salamander, a cooled and congealed mass of slag, iron and ore, can be brought back to life with fire, saving the furnace or, on occasion, one can be broken up by firing a cannon into it, Aldrich wrote. Though no cannon had been fired, archeologists found Aldrich was right.

"The last charge still sits on the hearth and the furnace probably was not profitable enough to make removing it worthwhile," Friedman said.

According to research by Duncan Wilkie, a former staff archeologist for the state and now with the state of Vermont, the company earned little profit for most of its life.

"Basically, this furnace was producing pig iron for farmers who paid for it in pumpkins," Wilkie said. "The stockholders weren't too interested in pumpkins so they wanted to change the system to pump out more profit."

Records from 1832 when 50 tons of bar iron sold for $3,250 and "hollow ware" such as kettles sold for 6 cents a pound, list the company's profit at 15½ percent. "A lot of people in New Hampshire don't want to hear about it but by the early 1800s most of New Hampshire's resources, including its water rights, had been bought up by people from Massachusetts," Wilkie said.

The same fate could befall New Hampshire's last blast furnace if it doesn't slowly collapse first. Huge blocks atop it are canted and waiting for frost to topple them. "It's deteriorated rapidly in the past four years," Wilkie said.

The property's current owner hopes to sell both the furnace site and his nearby house, Friedman said. But neither the town nor the heritage council can afford the $225,000 asking price and the owner won't sell just the furnace and surrounding land.

Burns, who has written a poem immortalizing the fictional "Ironclad Jim" who died leading a blasting crew after better ore, said New Hampshire's future lies in saving slabs of history such as the furnace.

Victor R. Rolando
Researcher of Early Vermont Industry
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(802) 362-4382



February 24, 1994

Giovanna Peebles, State Archeologist
Division for Historic Preservation
135 State Street, Drawer 33
Montpelier, Vermont 05633-1201

Dear Giovanna:

Thank you for the new National Register Bulletin No. 36, which I received in yesterday's mail. It reminds me of one project I started and never finished. Maybe someday...

I started sending you FS- type reports last week and had planned to do one a day, and therefore mail one a day. But I've gotten ahead of one a day and figure you have more important things to do than open an envelope from me every day. So enclosed are 8 FS-reports. An accounting of what I've sent and date mailed is as follows:

FS-104(AD) Marsh Lime Kiln--Hancock; 2/16
FS-105(AD) Chaffee Lime Kiln--Granville; 2/20
FS-13(BE) Whipple Lime Kiln--Pownal; 2/17
FS-14(BE) Dorset Mtn Rd Lime Kiln--Dorset; 2/18

The following are enclosed with this letter:

FS-106(AD) Peake Lime Kiln--Shoreham
FS-107(AD) Gibbs Lime Kiln--New Haven
FS-15(BE) Purdy Hill Lime Kiln--Manchester
FS-16(BE) Hopper Brook Lime Kiln--Sandgate
FS-17(BE) Equinox Mtn Lime Kiln--Manchester
FS-18(BE) Readsboro Village Lime Kiln--Readsboro
FS-20(BE) Lawrence Lime Kiln--Sunderland
FS-9(CA) Marl Pond Lime Kiln--Sutton

Note sheet titled "FS-19(BE) vs VT-BE-143" in which there is apparently a numbering mixup. Note also that some site names have changed from that on my 12/26/93 request note to Skinas for FS-numbers (copy attached). I mentioned in the reports which sites I plan no further work until better archival data presents itself and those which I have not yet given up on--still active. I have written all as if I dropped dead tomorrow and someone else could pick up where I left off with all that I knew about the site, including where the information came from.

With this mailing I am about half-way through documenting the lime kiln portion of sites. The reports take from one to three hours each to put together. I am keeping track of hours expended so there should be a hefty donated services report for February.

Vic

The Spring 1994 issue of Vermont Life came out yesterday without the article Ed Barna did about me and my work in Vermont. Not that it was any surprise; Tom Slayton wrote to me a month ago saying there was insufficient advertising to justify another 16-page signature. From my publishing experience at GE, I fully understand the mechanics of publications being printed in 16-page units (some books are done in 32-page units, or as they say in the trade, signatures). Tom said that my article will probably appear in the fall 1994 issue. My feeling is that I will be surprised if it ever appears in Vermont Life at all. By the fall of 1994, I will be old news. And that's the way many other things are going too.

I'm really p_____'d about no reviews of my book being published yet by the SIA, SHA, T&C (SHOT), and CNEHA. They've had review copies since the fall of 1992. T&C requested I review Nick Honerkamp's book about the Chattanooga furnace study the same time they agreed to review my book. In the current issue of T&C 31 books are reviewed including my review of Honerkamp's book. But no review of <u>200 Years</u>.

I looked forward to reviews by such peer groups as those above especially more than those done locally because they are the people on the inside track of the type of things I have been doing in Vermont. I was especially hoping that the reviews would be published during the period of active sales of the book. I never realized I would start to wonder if the reviews will be published during my lifetime!

I should have gone to Columbus, Ohio to receive my AASLH award back in mid-September. My Award of Merit finally arrived in the mail direct from the AASLH a few weeks ago, after apparently being lost in the mail for 4 months! Michael Sherman had planned some kind of a TV bite announcement for the Vermont winners, but the awards for all five Vermont recipients were lost so long that the moment was lost. Better luck for next year's winners.

Not to worry, my archival/field work for Vermont continues. I want to clear out everything pending on sites in the field so that I can get out and explore again come spring (is there going to be a spring this year?). I am finding as I do the FS- reports that a few sites didn't get mentioned in <u>200 Years</u>. I am also finding that there are many that I have good data on and have yet to get out and find. And there are a few that I have, in fact, found physical remains of and have yet to report to you in the VT- category. The latter are my priority for spring.

The Vermont Archeology Week committee invited me to participate last month, some three or four months after they organized. I was wondering if I was ever going to be asked. And, of course, they are optimistically over-extended with ideas and short on helpers. Except they have Kathy Callum as their very enthuiastic leader. I've agreed to be the Bennington County coordinator and am in the process of arranging presentations in Bennington by Phil Lord and

Michael Werner. I am hoping to do something myself that week, maybe with the local elementary school. Someting along lines of a short, simple slide presentation to school kids about the history of a "downtown" block in Manchester Center where a town park is planned, talk about what was there (early mills, a blast furnace, marble mills and a tannery). Then we will all walk the one block from school to the site and see what's there today in the form of foundation walls of the old mills and remains of waterpower systems. With teacher cooperation, I think it should go over well. Maybe get the Conservation Commission's attention too.

I failed to get a day to do my annual "Archeology Day at the State House" this year. Although I contacted David Shütz in mid-January, all dates had already been taken. He said that he also had a long waiting list in case of any cancellation. I've gotten into the habit of looking forward to my special day in Montpelier so I am disappointed that it didn't occur this year. Next (this) year I call Shütz in December (1994).

Am I ever looking forward to spring. The warm weather last week spoiled me, as I got out and shoveled along with the melting. Saw my driveway for the first time in months. The snow along with the bitter cold weather that I know you have also experienced made for the first old-fashioned winter in a long time. We had two or three -30s nights here (probably -40s in Montpelier). Two weeks ago, Donna got asked by her former employer, Hoisington Realty, to return to work for a few weeks, which she jumped at.

I have a meeting with Art Cohn at Basin Harbor March 4 to talk about his plans for some kind of re-creation of an ironworks. I'm not sure what he has in mind, but he asked me last year if a grant proposal was approved for the project, would I be consultant for it. And apparently their proposal was approved. Last year he talked about a working charcoal kiln, but since I don't know what the proposal said, don't quote me on any of this.

I've also been poking Castleton State College and State Parks along on their plans to do some recording at the West Castleton slate mill site. Someone is supposed to be writing a proposal to someone but I've heard nothing to date, thus my letters to Holman Jordan and Russell Reay. David Starbuck has heard nothing yet either. I have offered my assistance to whomever for whatever.

Finally, reservations for presentations are picking up again, two in April already, Whitingham and Swanton. How's that for the two opposite ends of the earth, and 6 days apart. Fortunately, they both want to hear about lime kilns.

Gotta get back to work on reports. Hi to all.

Best to you...

Vic

**Victor R. Rolando**
**Researcher of Early Vermont Industry**
**RR 1 Box 1521-3 Manchester Center, VT 05255**
**(802) 362-4382**



December 9, 1993

Giovanna Peebles, State Archeologist
Division for Historic Preservation
135 State Street, Drawer 33
Montpelier, Vermont 05633-1201

Dear Giovanna:

Enclosed are ten site survey reports that start the effort we discussed a few months ago, that being writing up those sites that in my book have not been definitely located in the field but which we feel should at least have field site numbers assigned. These sites are:

FS-101(AD) Rathbone Blast Furnace, Vergennes
FS-102(AD) Belding/Drake Blast Furnace, Weybridge

FS-8(BE) Sage & Olin Blast Furnace, Bennington
FS-9(BE) "the pup" furnace, Bennington
FS-10(BE) Dorset Village Furnace, Dorset
FS-11(BE) North Village Blast Furnace, Manchester
FS-12(BE) Woodford Blast Furnace, Woodford

FS-26(FR) Fairfield Blast Furnace, Fairfield

FS-52(RU) Keith Blast Furnace, Pittsford
FS-53(RU) Wallingford Blast Furnace, Wallingford

The field site numbers were assigned to me earlier this year by David Skinas in order to provide an "official" site identification number for my article about Vermont blast furnaces in SIA's upcoming issue of IA. It is interesting that in doing that article I discovered, much to my chagrin, that I had completely forgotten to document the Rathbone blast furnace in my book, except for a passing mention of it in the description of a furnace site in Tinmouth.

I will contact David after the holidays for another block of ten field site numbers for more reports. Ten seems to be a comfortable number of reports to write and keep track of at a time. The next batch will pertain to lime kiln sites. I will also submit a time sheet for donated services for October and November, 1993, in a few days.

I recently received, at my insistence, the negatives for my book, which the printer wanted to store at his warehouse in Dover, Delaware. My experience from GE Aerospace with printing houses is that they wish to store customers' negs because that sort of commits publishers to reprint from that same printer rather than from another. But negatives mysteriously turn up damaged or lost in the process: roofs leak, fork truck drivers fork, warehouses burn, and floor supervisors wantonly destroy packages.

Bob West told me last month that when the Rutland Historical Society recently looked into another reprint of their Rutland in Retrospect, they discovered that the printer (Bob Sharp, Rutland) had thrown away the negs without at notifying the historical society in advance. That was enough to motivate me to insist that Dover Litho return my negs, pronto. The large, 3- by 3-foot by 2-inch thick box of negs now lies under my bed, but I want to store it someplace safer. Joe Popecki suggested I store it with VAS archival materials at the UVM Special Collections Library. I'll contact Kevin G. at Special Collections to see if this is all right, but also for advice on how to properly prepare the negs for long-term storage. The negs are presently not separated from each other in any way, which I don't believe is a good idea. I have no plans for a reprint of the book in the near future, but I would hate to see the negs damaged and prevent someone else doing something with them years down the road. Any suggestions?

I hope the holidays find you in good cheer and that all are well at home.

Buon Natalé!

Vic

RECEIVED OCT 1 1992

**Victor R. Rolando**
**Researcher of Early Vermont Industry**
**RR 1 - Box 1521-3 Manchester Ctr, VT 05255**
**(802) 362-4382**

September 30, 1992

Giovanna Peebles, State Archeologist
Division for Historic Preservation
Pavilion Building
Montpelier, Vermont 05602

Dear Giovanna:

Enclosed is a special index and cross reference for you to use for getting into "Soot & Sweat" that is in sequence by site number. I have left off the "VT-" prefixes from the site numbers as I also did in the book, since the "VT-" is common to all site numbers in the state anyway. Notice that the page numbers, in parenthesis, reference any page on which that site is discussed but the site might not be referenced there by site number. In most cases, the main description of the site is in the highest number page(s).

I phoned David Skinas Wednesday morning to let you know that I shall be up Monday morning (Oct 5) to replace any of my books that have defective covers with new copies. I hope to be there in time to sit in on a few minutes of staff, but I cannot stay for the whole morning. I have to do replacement of book copies at the VHS, then swing by UVM to see Bob Sloma on some VAS business. On the way home a stop at the Shelburne Museum for some book copies for their book store and library, thence home.

I hope to have my final donated services report for 1991-92 in hand Monday morning also, but you might want to find out if the value of the books I donated to the Division ($32.95 X 8 = $263.60) can be considered donated service, and also would any percentage of my financial and/or hourly efforts toward publishing the book be considered donated services also, since the book is, in fact, a summary report of 15 years archival and field work in Vermont. I will be home Friday most all day if you want phone me and advise me if any of this is applicable.

I'll be at the CNEHA conference Saturday to sell books and Sunday to present a short paper (and sell books).

Best . . .

Vic

# 200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries

**Cross Reference and Index by Site Number Sequence:**

**Cross Reference and Index by Site Number Sequence (Cont):**

**Cross Reference and Index by Site Number Sequence (Cont):**

**Cross Reference and Index by Site Number Sequence (Cont):**

**Cross Reference and Index by Site Number Sequence (Cont):**

**Cross Reference and Index by Site Number Sequence (Cont):**

**Cross Reference and Index by Site Number Sequence (Cont):**

# Industry and Technology in Antebellum Tennessee: The Archaeology of Bluff Furnace

*R. Bruce Council,*
*Nicholas Honerkamp,*
*and M. Elizabeth Will*

THE UNIVERSITY OF TENNESSEE PRESS / KNOXVILLE

First Edition.

The paper in this book meets the minimum requirements of the American National Standard for Permanence of Paper for Printed Library Materials. ∞ The binding materials have been chosen for strength and durability.

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# Contents

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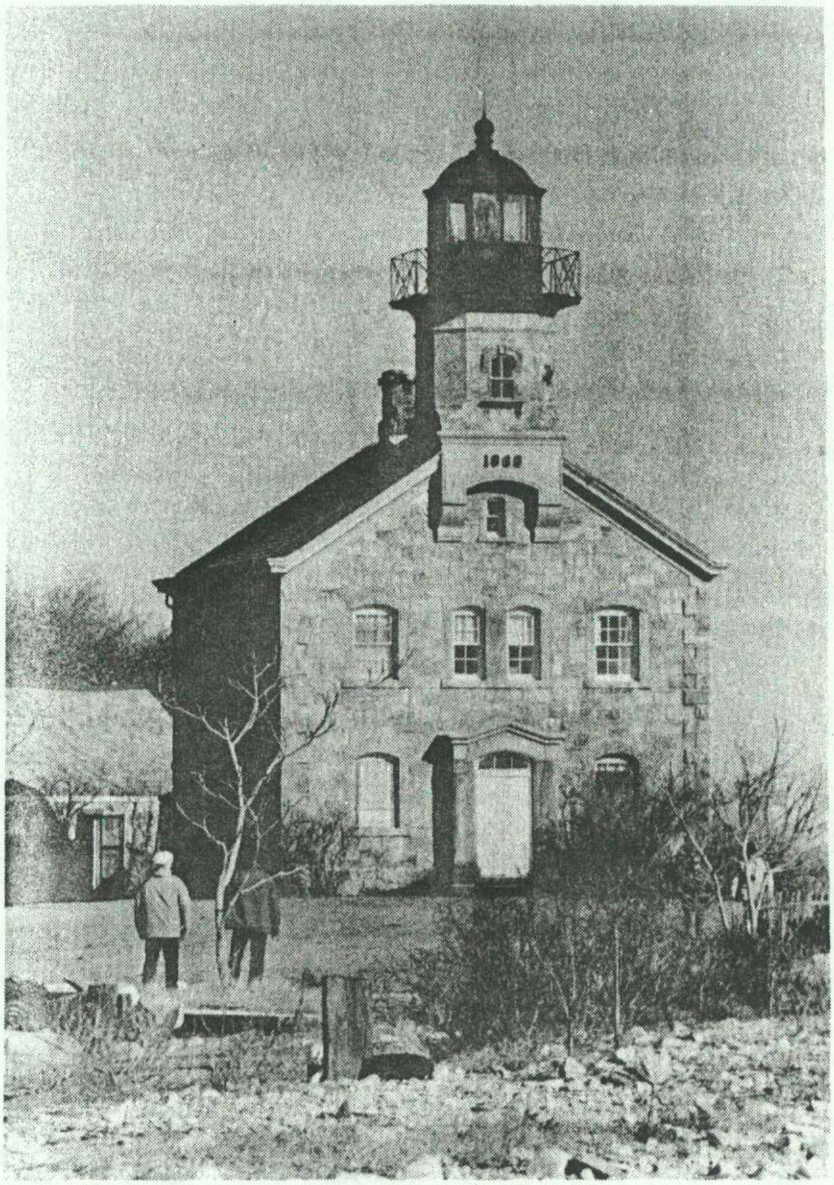


*Norwalk Island Lighthouse, Norwalk, Connecticut. Built in 1868 and listed on the National Register in 1988. See "Historic Lighthouse Stations," page 23. Photo by Norwalk Seaport Association.*

lished by Oxford University Press. Meanwhile, would-be readers of the report should contact the National Technical Information Service, or visit the recently reopened Springfield Armory Museum, whose library has a copy available for on-site perusal.

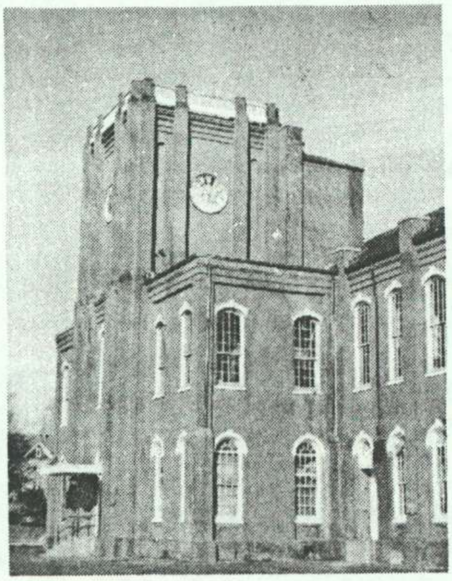
For articles on selected topics within the armory's history, see the profusely illustrated and superbly edited special issue of IA, Vol. 14, -1 (1988). It includes what may be the last-ever photograph (by Pat Malone) of the armory's Mill River ''water shop'' still intact. Its industrial space was leased out in recent years, and the tenants' product (swimming-pool chemicals) caused a devastating fire there in 1988.

Carolyn Cooper
Hamden, CT

**Vermont**

### IA Survey of Vermont Furnaces and Kilns Completes 11th Year

The IA survey of Vermont completes its 11th year with the end of 1989. What started in 1979 as a minimum-level inspection of blast furnace ruins in the state for inclusion in an MA thesis became, by the early 1980s, a serious archival research and field inspection project for ruins/remains of blast furnaces and bloomery forges. The recording of charcoal kiln sites began in 1982, and starting in 1986 lime kiln ruins and remains were included in the survey. To date, 144 iron-, charcoal-, and lime-related IA sites have been recorded and reported to the Vermont State Archeologist; 75+ more sites, either not precisely found or having little-or-no surface remains in evidence, are under continuing study for future recording and reporting. A breakdown of the work accomplished is as follows:



*Part of Water Shops, Springfield Armory, built c1855-1860; burnt 1988. Photo 1986.*

*Blast furnace and bloomery forge survey:*

Blast furnace ruins/remains generally are located in the western part of the state. Visible ruins (obvious furnace ruins, whether standing or collapsed) are at Forest Dale, Pittsford, West Haven, Clarendon, Tinmouth (2), North Dorset, East Dorset, Troy, and Bennington (2). Visible remains (no obvious ruins, but visible slag, charcoal, etc.) are at Highgate, Shaftsbury, Sheldon, New Haven, Tinmouth, Tyson, Brandon, Vergennes, Orwell, and Bennington. Additionally, sites documented in archival sources with questionable or no field evidence (but possible subsurface remains) are at Bristol, Waitsfield, Woodford, Manchester, Weybridge, and St. Johnsbury.

Nearly completely standing furnace ruins are at Pittsford, and at Forest Dale where NNEC and SNEC along with the VAS and other organizations and volunteers held an official recording session this past May. The Forest Dale ruin is associated with a deep, stone-lined waterwheel pit, remains of the head race, stone mounts for draft machinery, and a nearby tenement cellar hole. Various surface depressions and mounds hint at more archeological sites in this area. The site is on a 10-acre tract owned by the Division for Historic Preservation. Outside the state property stand the ironmaster's house (Royal Blake) and other structures that either were once part of the works complex or stood inside the 10-acre tract and were moved outside.

| | Recorded and Reported | | Not yet Reported | | Totals | |
|---|---|---|---|---|---|---|
| | Sites | Ruins | Sites | Ruins | Sites | Ruins |
| **Blast Furnaces** | 23 | 11 | 9+ | ? | 32 | 11+ |
| **Bloomery Forges** | 22 | 3 | 40 | ? | 62 | 3 |
| **Charcoal Kilns** | 55 | 176 | 8 | 9? | 63 | 185 |
| **Lime Kilns** | 44 | 70 | 18 | 22 | 62 | 92 |
| **Totals:** | 144 | 260 | 75+ | 31 | 219 | 291+ |

Notes: Some of the above sites contain more than one component. Recorded iron mines are not included in the above table.

The Pittsford furnace is owned by a descendent of the 18th-century owner of the land on which the original furnace was built (1791; Israel Keith). The present ruin dates from Simeon Granger, who rebuilt the furnace from the apparently razed Keith furnace in 1824. Associated components here are stone walls on both sides of the furnace stack, cellar holes of the works store, charcoal and ore sheds, and standing structures of Simeon Granger's house plus nearby workers' housing.

Both the Forest Dale and Pittsford furnaces and grounds offer a wealth of knowledge and insight into the technology of 19th-century furnace operations in Vermont as well as interpretive social data on ironworker and ironmaster life styles.

Collapsed furnace ruins with significant associated interpretive remains are also at Clarendon, Tinmouth, Troy, and Bennington, all on private property and owned by cooperating property owners (except Troy - owner unknown). The standing ruins at North and East Dorset (NNEC Spring 1983 tour) contain much less visible associated remains than those mentioned above.

No standing or partially standing ruins of any bloomery forges were found in Vermont. Forge sites were identified mostly through archival references and slag finds. Slag found at some forge sites, however, appeared much like that found at some known blast furnace sites, which raised a number of questions regarding kinds of operations carried on here. Forge sites were found distributed in the same relative area as blast furnaces. Although it is felt that the greater proportion of bloomery forge sites in the state have been found and recorded, many more sites await discovery in the state.

The better identifiable forge sites are at Salisbury (2) and East Middlebury, operating and production capacities of which are documented in mid 19th-century ironworks reports by Neilson and Lesley. Most forge sites in the state operated during the 1790 to 1830 period and were apparently small, as judged from remains of slag deposits within their approximately 1000 square-foot areas and the relatively small streams and brooks alongside which they sought water power. These probably supplied purely local needs and were displaced by iron made more cheaply from outside the state with the completion of the Champlain Canal and construction of railroads.

*Charcoal Kiln Survey:*

A total of 131 charcoal kiln ruins/remains have been recorded at 45 charcoal making sites. Of the ruins/remains, 14 are stone-type, 8 are stone/brick-type, and 109 are brick type. All except 5 ruins are round, these being rectangular in shape. Three are brick-type, one is stone, and one is concrete block. Numbers of ruins per site vary from one to eight; the average is two to four per site. The additional sites of 45 mound-type charcoal kilns at 10 sites were found and recorded. The sites are generally in upland areas of the state with a higher concentration in the south-southwest area and a lesser concentration in the west-central area.

Brick-type kilns all measured a nearly consistent 28 feet inside diameter. Wall height varied with the remoteness of the site; those closest to trails, roads, and houses were no higher than ground level, while some a distance from much-used trails had walls up to 4 feet high (Bourn Brook area of Winhall). Wall thickness equaled two brick widths. Vent holes were at ankle, knee, and waist height (appropriately called ankle vents, knee vents, and waist vents). Most kilns were built into embankments to afford access via a bridge to the top charging hole of the kiln, much like a bridge to the top of a blast furnace or lime kiln. Two eight-kiln sites were found: at Bourn Brook, Winhall, and at Old Job, Mount Tabor. The former were in best condition and contained much associated hardware.

The best preserved kiln ruins are those of stone, possibly due to availability of stone throughout the state. Even the most remote brick-type kiln ruins were vandalized for most of their usable brick. Some stone-type kilns had standing wall sections up to 9 feet high. Stone-type kiln ruins resembling "beehive" kilns were found in Stamford, Glastenbury, and Winhall. Some remains at Readsboro suggest kilns made of a stone base with an arching "beehive" roof made of brick (photos exist of these in operation in the Stamford-Readsboro area).

One positive conical brick-type kiln remain was also found in Readsboro with a possibility of two to three others (which were dynamited beyond recognition many years ago by the Forest Service for safety reasons — hikers were camping in them).

Higher concentrations of brick-type kilns were found at Woodford, Winhall, Peru, and Mount Tabor where 78 kiln ruins were found, some with significant quantities and varieties of iron support and reinforcing hardware. They somehow escaped the World War II scrap metal drives. Ruins at Peru, Winhall, and Mount Tabor were generally at 2000 to 2300 feet in elevation. Lesser numbers of brick-type kilns were also found at Danby, Chittenden, and Ripton.

Mound-type kilns were found at Sunderland, Glastenbury, Chittenden, Salisbury, and Ripton. At first the most difficult to recognize in the field, mound-type kilns are now found almost at will, up any draw along the western slope of the Green Mountains between Glastenbury and Winhall. One site on the high western slope of Bloodroot Mountain northeast of Rutland was found to contain remains of 20 mounds. This area was not exhaustively inspected.

Diameters of mound-type kilns varied from less than 20 feet to more than 30 feet. Many were built upon flat ground but some were built into embankments, much like the stone- and brick-type kilns. At many sites, the circular gutter around the kiln was visible. At one site, stones removed from the kiln site resulted in an area of high stone density immediately around the kiln, hinting at first of a stone-type kiln.

With few exceptions, charcoal kilns/mounds sites are within the Green Mountain National Forest.

*Lime Kiln Survey:*

The lime kiln survey started in 1986, the result of finding some of these ruins while in the process of searching for charcoal kilns. A total of 44 lime kiln sites containing 70 kiln ruins/remains have been recorded and reported. This phase of the project is still in progress with 18 out of 22 sites unrecorded from 1988-89 waiting for 1990 action.

The kilns were distributed in "clusters," with the most dense of these generally in the central to southern parts of the state. The highest concentration of lime kiln ruins/remains is at Plymouth, where 11 were found. Other areas are Jamaica, Weathersfield, Clarendon/Tinmouth, Leicester, New Haven, South Burlington/ Colchester, and Swanton. Isolated lime kiln finds were also made at Pownal, Arlington, Danby, Manchester, Dorset, Fair Haven, Brandon, Townshend, Rochester, and Charlotte. Most are single-kiln sites; one site, at Fonda Junction, contains five standing ruins and one collapsed remain.

Early 19th-century lime kiln remains consist of stone-lined cavities built into low embankments in the immediate vicinity of small limestone outcrops, usually built by farmers to burn lime for fertilizer. Later kilns are stand-alone units, some with ornamental openings, such as one Gothic-arch kiln at Jamaica. Kilns operating into the 20th century were made of stone/concrete bases with firebrick-lined, 8- to 12-foot diameter, 15-to 25-foot high steel ovens set upon these bases. At some sites, only the base(s) remain. At others, such as Leicester and Swanton (Fonda Junction), the steel ovens remain, however bent, ruptured, or tipping in most cases. At Winooski, the standing ruin of a four-kiln unit stands that operated into the 1950's, next to two deep quarries that straddle Lime Kiln Road. Under the road, a now-flooded tunnel connects the two quarries. Activity is currently under way to place this site on the National Register.

Almost all lime kiln remains are on private property, some without the owner's knowledge that they existed or what they were. Many have been vandalized for construction stone, are caved in and used for dumping, or mostly destroyed as the result of road construction. The only known lime burning in the state today is a modern facility at New Haven Junction, where no response has been received to an inquiry.

This survey was totally funded by personal expense and carried out on week-ends, holidays, and vacations from full-time work at the GE Ordnance Systems at Pittsfield, Massachusetts. When possible, expenses and effort were recorded and donated to the Vermont Division for Historic Preservation for matching grants, used by the Division for other projects. This survey is the topic of a slide-supported paper to be presented by the author at the Third Annual Conference on New England Industrial Archeology at Plymouth State College, NH, in February 1990. A complete report on the survey will be published by the author in cooperation with the Vermont Archaeological Society sometime in 1990 as part of the Vermont Statehood Bicentennial. Major effort in 1990 is expected to go into the "wrap-up of loose ends" and renewal of efforts toward the thematic National Registration of blast furnace ruins, which was abandoned in 1987 due to work overload.

Vic Rolando
Pittsfield, MA

**Connecticut**

**Eli Whitney's Apprentices Slept Here**

The Connecticut Trust for Historic Preservation recently completed restoration of the 1820s boarding house for single men who worked at the Whitney Armory in Hamden, Connecticut. Removal of grey 20th-century fiber shingles revealed clapboards in surprisingly good condition. Newly painted its (nearly) original white, the building now houses the offices of the Connecticut Trust for Historic Preserva-

FOR Iron Sites File?



# OLD MAP SHOWS BENNINGTON AS 100 YEARS AGO

## Reproduced from Original Preserved in Old Scrap Book

## DEPICTS VILLAGE

### Nearly Entire Community in 1835 Appears to Have Resided On Three Streets

A map of Bennington village as it was 100 years ago should prove of great interest to the people of Bennington of the present.

This map is dated 1835 and where it originally came from, The Banner does not know, but as shown in The Banner it is a combination of two maps which have been preserved in a book which was owned by the late James L. Houghton.

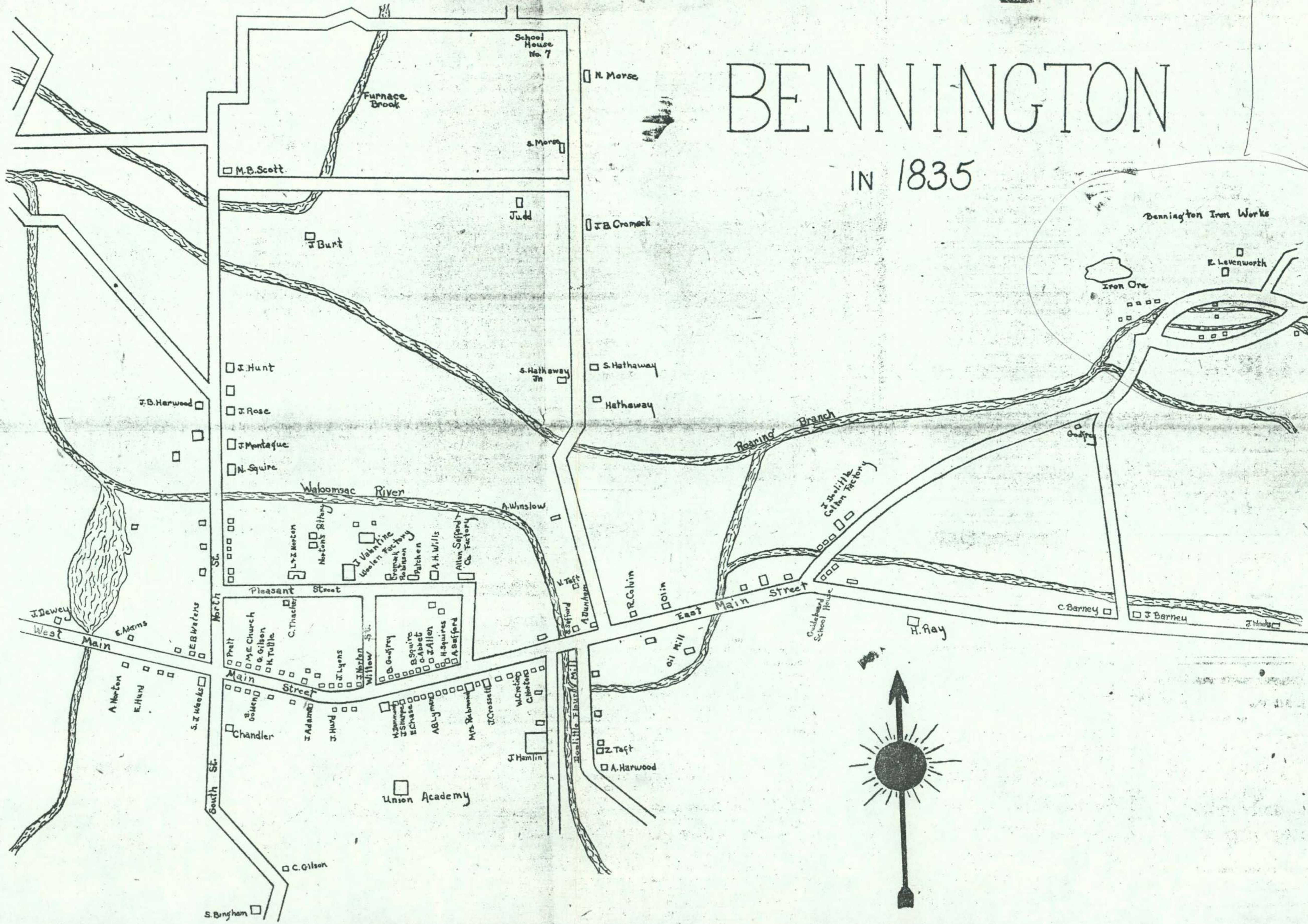
Unfortunately the map shows "East" Bennington only and the Furnace Grove section between the village and the Woodford line. Old Bennington is not included and it was at what is now Old Bennington that some of the principal parts of the town were in 1835.

It was at Old Bennington the county courthouse was located, the postoffice, the hotels and the principal stores. It was there too probably that what might be considered some of the leading citizens and particularly the professional folks resided in 1835, but at that time, the downtown section was beginning to grow and it was not long after, before East Bennington became the principal part of the town in business and population.

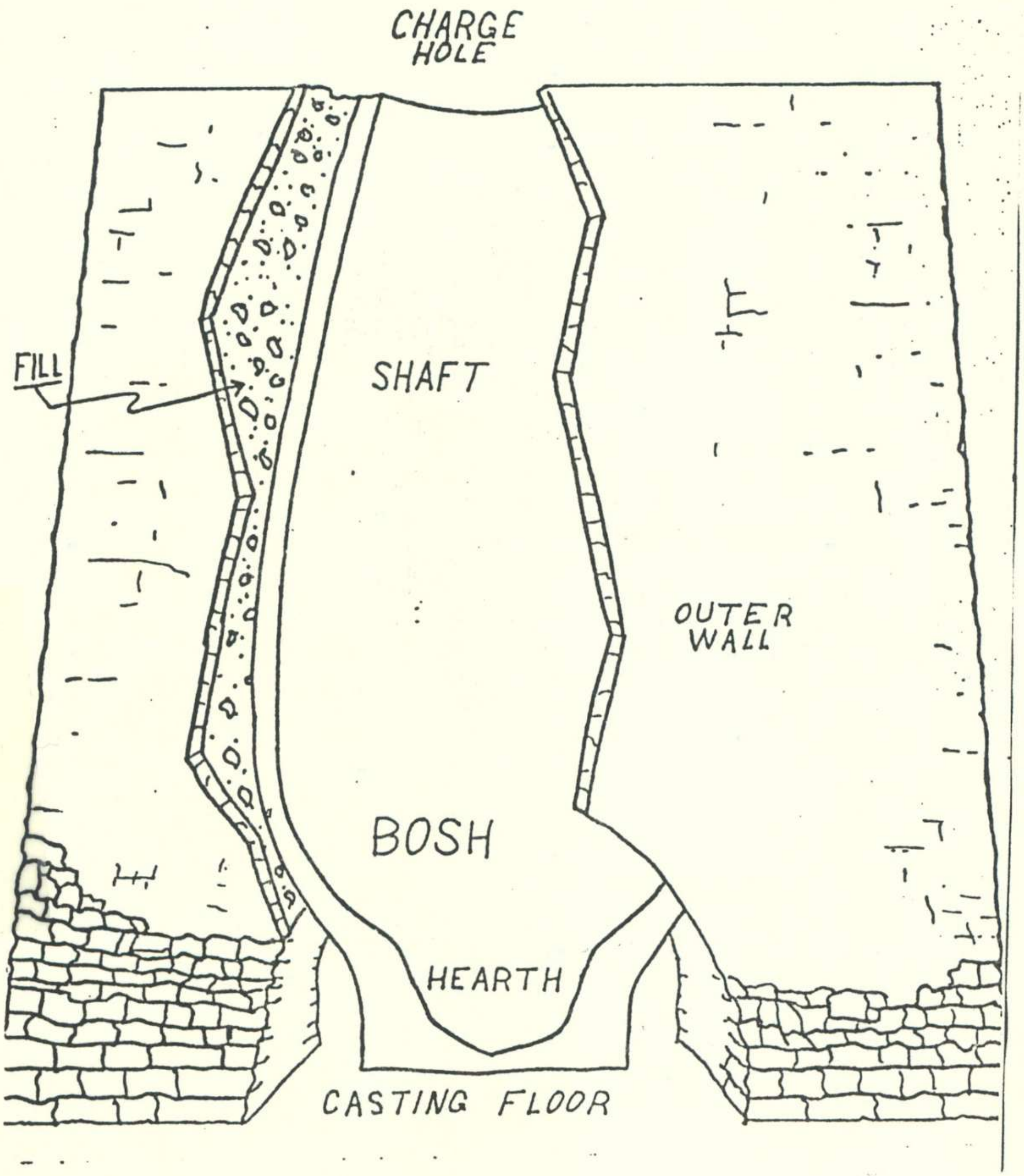
This was many years before the railroad came, but the map shows at least two important business enterprises. They were the Doolittle Flour Mill where the old Cooper shops, now occupied by Welles and Southall, are located and the Bennington Iron Works at Furnace Grove near the Woodford line. These iron works were probably the principal industry in this section at that time and ore was drawn there from various beds of mines in different parts of the town, also from Shaftsbury. Whether the ore from what was later known as the Burden Ore beds in the west part of the town was drawn to these furnaces The Banner does not know, but supposes likely that it may have been.

The village of Bennington in 1835 consisted practically of Main, North and South streets, Pleasant and Willow streets. It was Willow street that was later renamed Valentine street within the memory of the present generation. The map shows a street from east of the Doolittle Flour Mill north across Roaring Branch at the Hathaway bridge and

# Bennington Village One Hundred Years Ago




Map Reproduced From Drawings in an Old Scrapbook Made by James Houghton



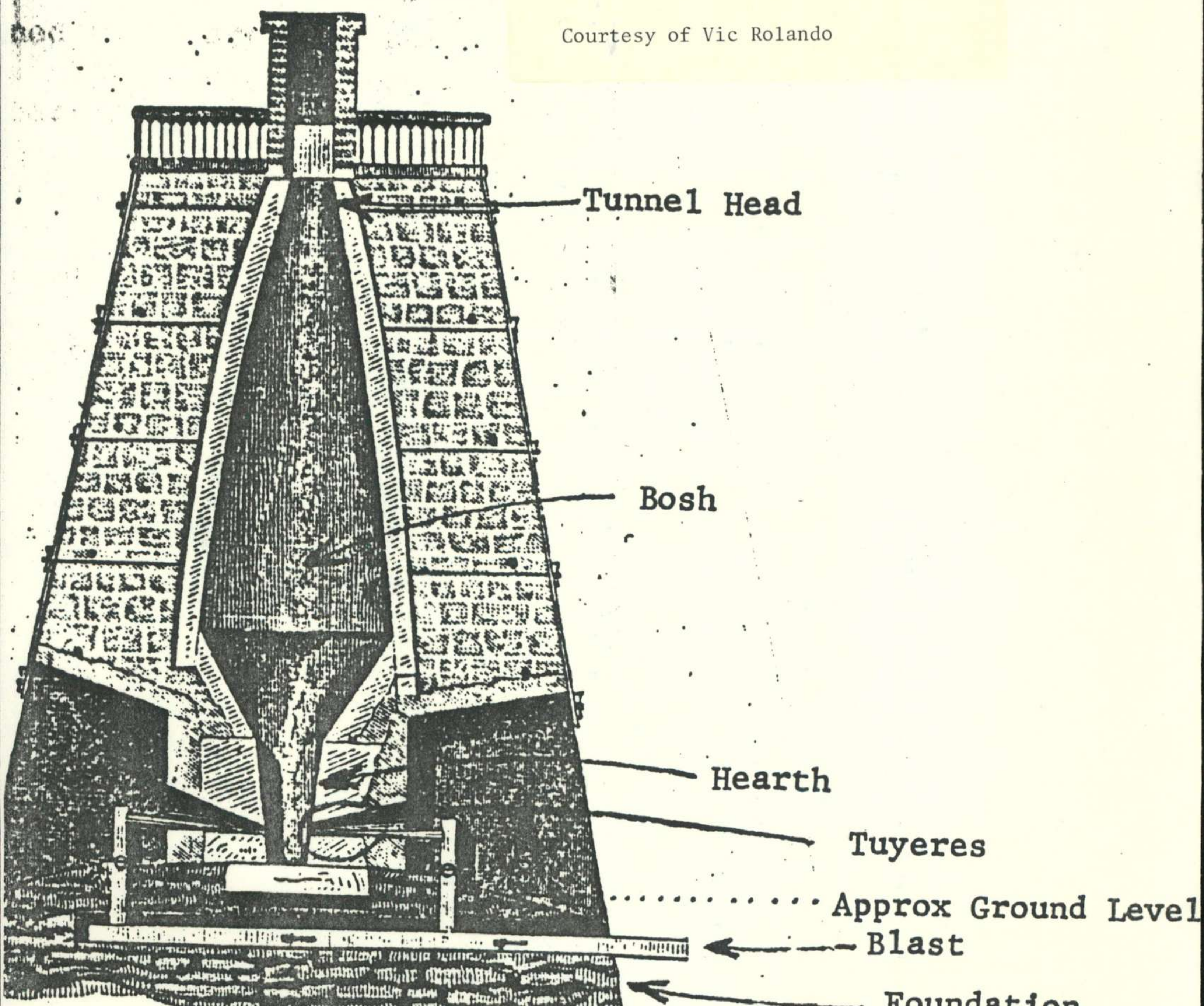

**A cutaway view of an early blast furnace, similar to most pre-Civil War blast furnaces in Vermont.**

FROM: 200 Years of Soot and Sweat: A History of VT Iron and Charcoal Making Industries in Vermont. By Vic Rolando Manuscript on file, DHP, Montpelier. 1984

Courtesy of Vic Rolando

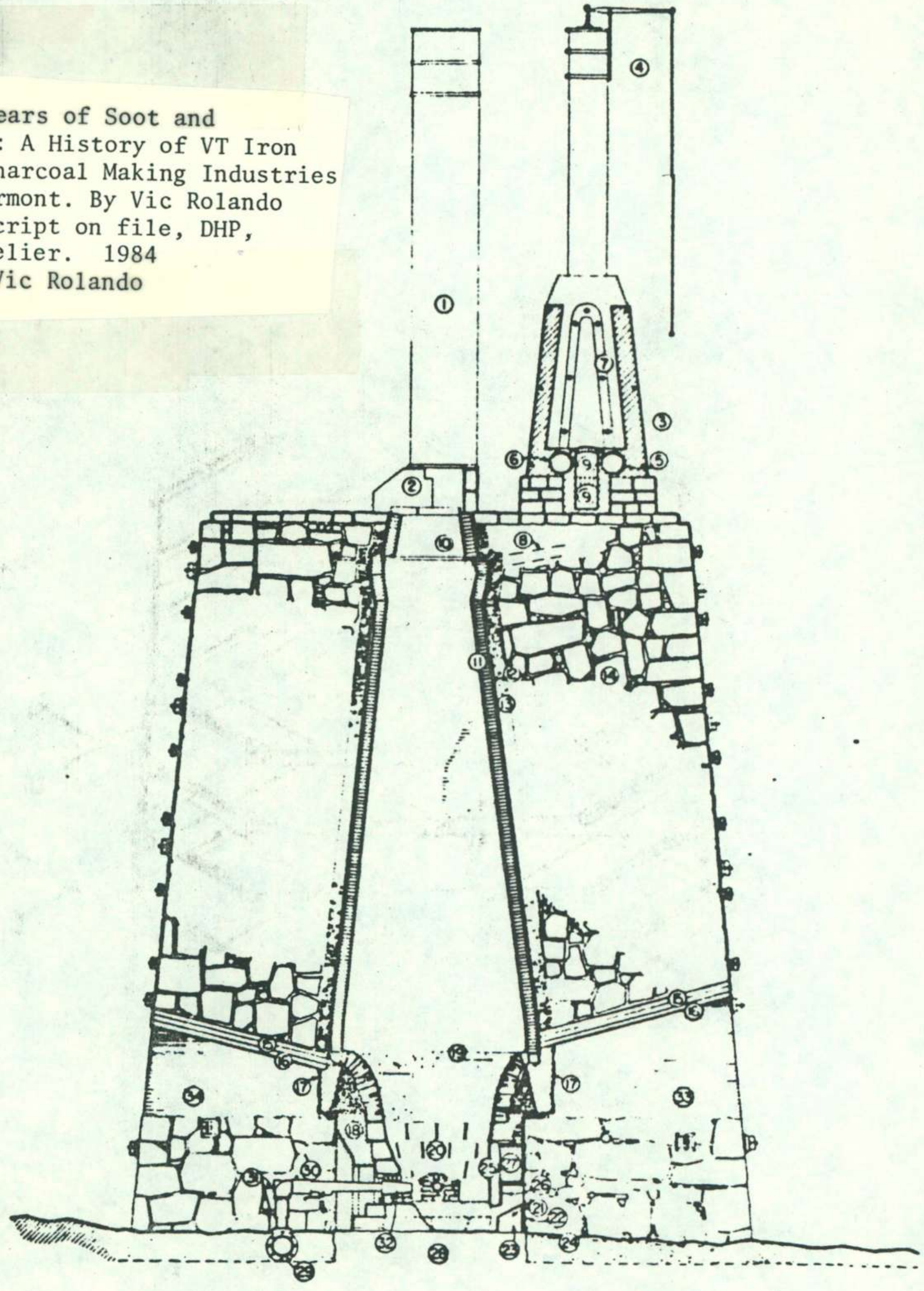
FROM: Forges, Furnaces and
Foundries. Lecture by
Victor Rolando, Presented at
Sheldon Museum, Nov. 1985.

Courtesy of Vic Rolando




Section of a charcoal furnace through the tuyere arches.

FROM: 200 Years of Soot and
Sweat: A History of VT Iron
and Charcoal Making Industries
in Vermont. By Vic Rolando
Manuscript on file, DHP,
Montpelier. 1984
Courtesy of Vic Rolando



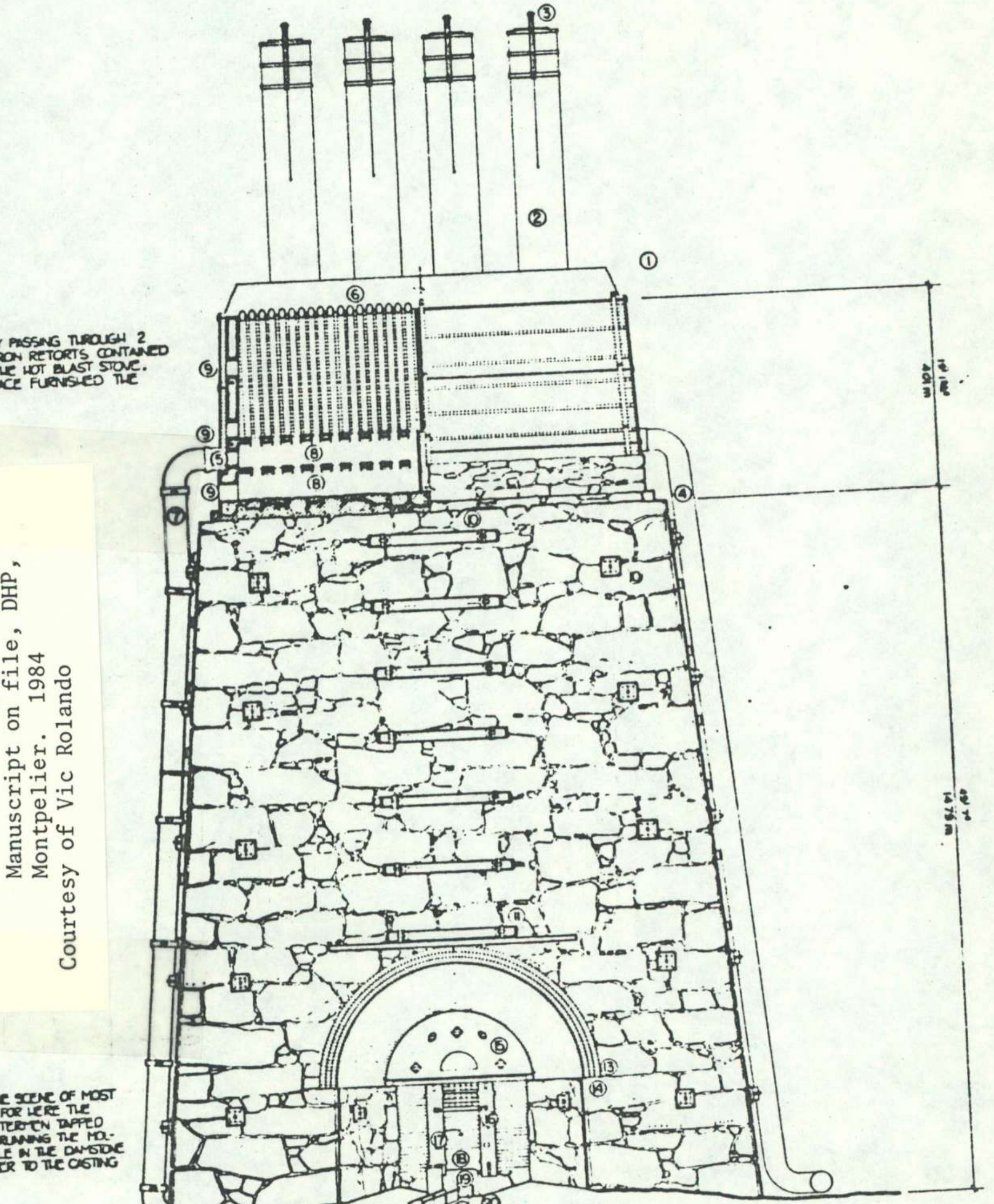
SECTION THROUGH FURNACE

1. BRICK DRAFT CHIMNEY
2. IRON CASTING SUPPORTING CHIMNEY, ALSO RAMP FOR CHARGING CARTS
3. HOT BLAST STOVE - COMMON BRICK SHELL WITH IRON REINFORCING BANDS
4. CHIMNEY WITH DAMPERS
5. CAST-IRON AIR MAIN
6. CAST-IRON AIR MAIN WITH BAFFLE IN PLACE TO DIRECT AIR THROUGH RETORTS
7. CAST-IRON RETORTS - 1 PIECE CASTINGS
8. WASTE GAS FLUE
9. WASTE GAS AIR PASSAGEWAYS, FIRE BRICK
10. TUNNEL HEAD
11. FIRE BRICK LINING
12. FIRE CLAY LAYER
13. RUBBLE FILL
14. STONE MASONRY
15. COMMON BRICK - 2 COURSES
16. FIRE BRICK - 1 COURSE
17. IRON FACE PLATES
18. FIRE BRICK
19. BOSH - WIDEST PART OF THE FURNACE, LINED WITH UNCUT FIRE STONE
20. HEARTH, SANDSTONE BLOCK CONSTRUCTION
21. DAM STONE - HOLDS IRON IN HEARTH
22. WATER-COOLED DAM PLATE - PROTECTS STONE FROM IRON TOOLS
23. TAPHOLE - WHERE IRON RUNS OUT OF HEARTH
24. IRON RUNNER - CHANNEL TO CASTING HOUSE
25. TYMP STONE
26. WATER-COOLED TYMP PLATE - PROTECTION FROM IRON TOOLS
27. FIRE BRICK SUPPORTED ON IRON PLATES BETWEEN BUCKSTAYS
28. BOTTOM STONE - MASSIVE SANDSTONE SLAB
29. BUSTLE OR BELLY PIPE - CARRIES BLAST AIR TO TUYERES
30. BLAST PIPE WITH AIR VOLUME ADJUSTMENT CONTROL
31. POKER ROD TO KEEP TUYERE CLEAR OF SLAG
32. WATER-COOLED TUYERE
33. HEARTH ARCH
34. WEST TUYERE ARCH

3

THE BLAST AIR WAS HEATED BY PASSING THROUGH 2 SETS OF 18 V-SHAPED CAST-IRON RETORTS CONTAINED WITHIN THE BRICK SHELL OF THE HOT BLAST STOVE. WASTE GASES FROM THE FURNACE FURNISHED THE NECESSARY HEAT.

FROM: 200 Years of Soot and Sweat: A History of VT Iron and Charcoal Making Industries in Vermont. By Vic Rolando Manuscript on file, DHP, Montpelier. 1984
Courtesy of Vic Rolando



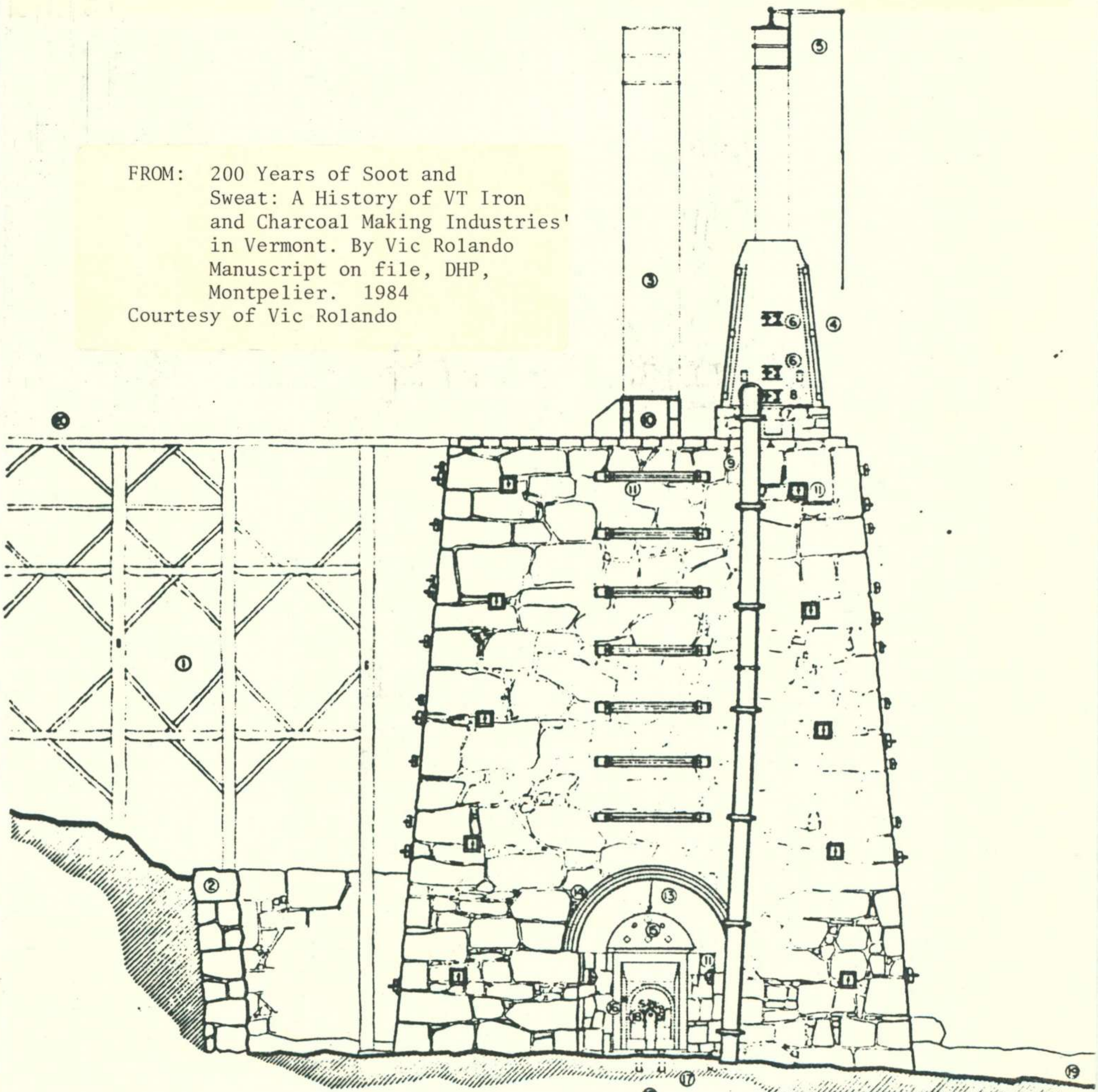
THE HEARTH ARCH WAS THE SCENE OF MOST OF THE FURNACE ACTIVITY, FOR HERE THE FURNACE MASTER AND GUTTERMEN TAPPED THE HEARTH TWICE DAILY, RUNNING THE MOLTEN IRON THROUGH THE HOLE IN THE DAMSTONE AND DOWN THE IRON RUNNER TO THE CASTING HOUSE.

HEARTH ELEVATION

1. HOT BLAST STOVE
2. BRICK CHIMNEYS
3. DAMPERS
4. GALVANIZED SHEET IRON AIR SUPPLY MAIN
5. CAST-IRON AIR MAIN
6. CAST-IRON RETORTS
7. DOWNCOMER
8. WASTE GAS AIR PASSAGES
9. INSPECTION AND CLEANING HATCHES, FITTED WITH IRON DOORS
10. WROUGHT IRON TIE RODS AND ANCHOR PLATES
11. CAST-IRON LINTEL FROM A SOW
12. HEARTH ARCH
13. COMMON BRICK - 2 COURSES
14. FIRE BRICK - 1 COURSE
15. IRON FACE PLATE, BACKED WITH FIRE BRICK
16. IRON BUCKSTAYS
17. IRON PLATES SUPPORTING FIRE BRICK
18. TYMP STONE AND WATER-COOLED TYMP PLATE
19. DAM STONE AND WATER-COOLED DAM PLATE
20. SLAG NOTCH
21. TAP HOLE
22. IRON RUNNER

3

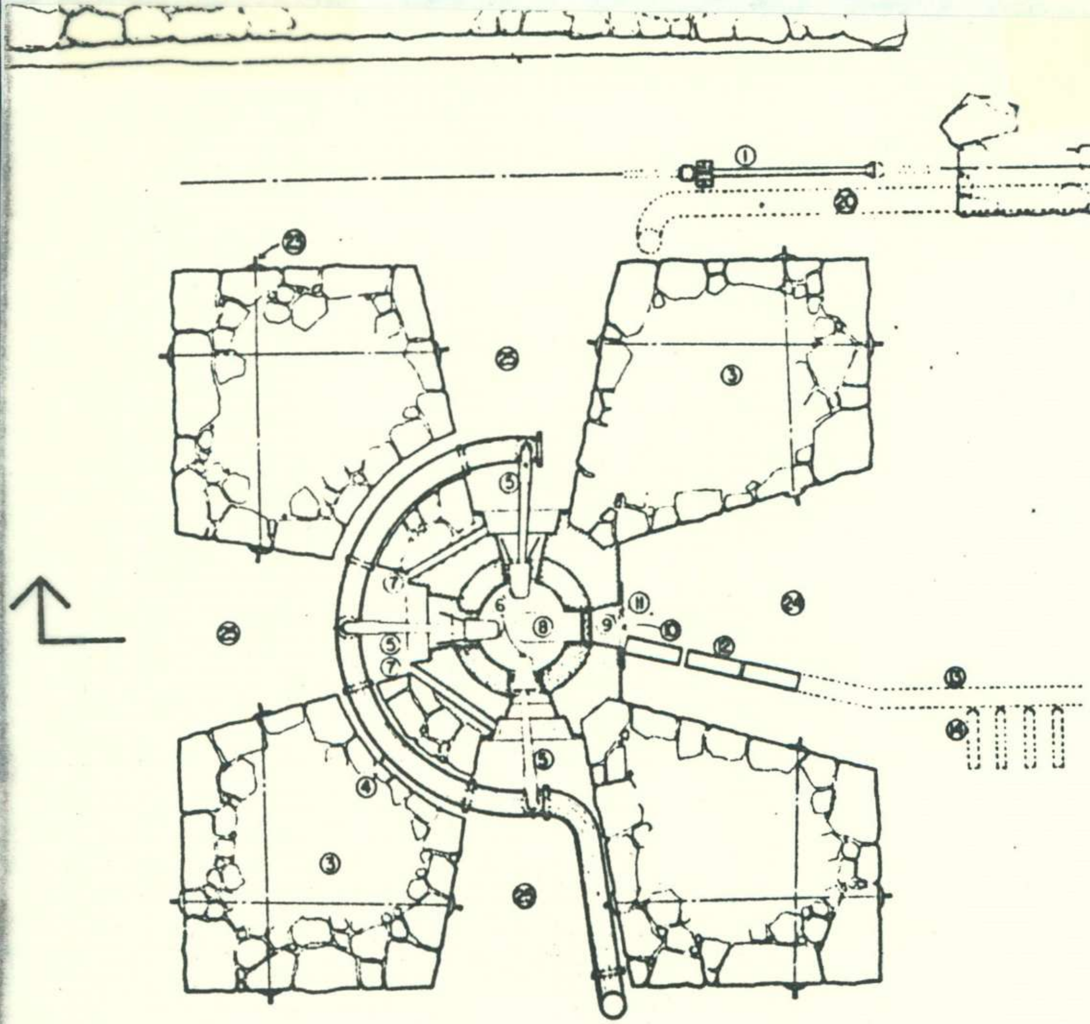
FROM: 200 Years of Soot and Sweat: A History of VT Iron and Charcoal Making Industries' in Vermont. By Vic Rolando Manuscript on file, DHP, Montpelier. 1984
Courtesy of Vic Rolando



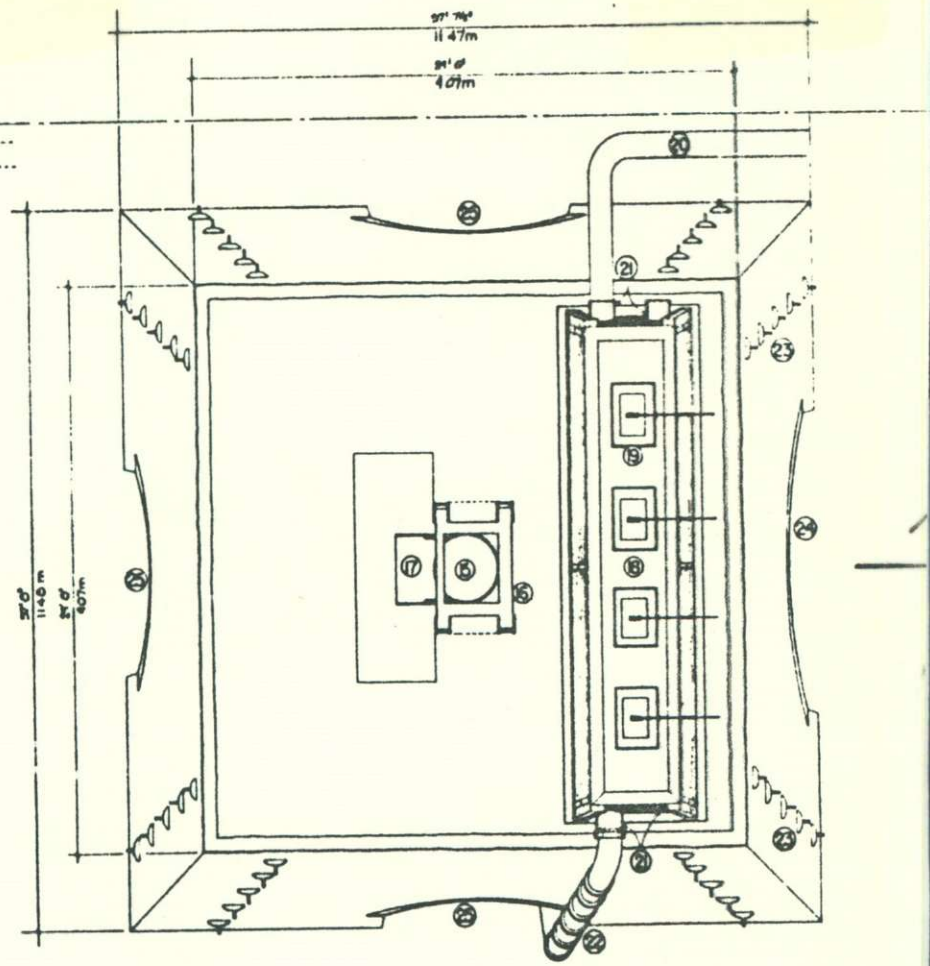
SOUTH TUYERE ELEVATION

1. WOODEN CHARGING BRIDGE
2. RETAINING WALL
3. DRAFT STACK
4. HOT BLAST STOVE - COMMON BRICK SHELL WITH IRON REINFORCEMENT
5. DAMPERS
6. IRON INSPECTION AND CLEANING DOORS
7. WASTE GAS PASSAGEWAYS
8. AIR MAIN WITH BAFFLE IN PLACE
9. CAST-IRON DOWNCOMER
10. TUNNEL HEAD
11. WROUGHT IRON TIE RODS AND ANCHOR PLATES
12. TUYERE ARCH
13. FIRE BRICK - 1 COURSE
14. COMMON BRICK - 2 COURSES
15. IRON FACE PLATE
16. WATER MAIN FEEDING WATER JACKET AROUND TUYERE
17. 'BUSTLE' OR 'BELLY' PIPE
18. BLAST PIPE
19. CASTING HOUSE FLOOR
20. LOCATION OF ORE SAMPS

3




PLAN OF FURNACE




PLAN OF FURNACE TOP

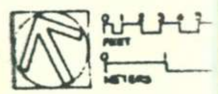
3

FROM: 200 Years of Soot and Sweat: A History of VT Iron and Charcoal Making Industries in Vermont. By Vic Rolando Manuscript on file, DHP, Montpelier. 1984

Courtesy of Vic Rolando

ES IN SOUTH AND WEST TUYERE ARCHES DRAWN
ST PIPE FOUND IN NORTH ARCH.

1. LINE SHAFTING THAT POWERED ORE STAMPS ON CHARGING BRIDGE
2. RETAINING WALL
3. STONE PIERS
4. "BUSTLE" OR "BELLY" PIPE - CARRIED AIR TO TUYERES
5. CAST-IRON BLAST PIPES
6. WATER-COOLED TUYERES - AIR NOZZLES PROTRUDING INTO FURNACE
7. WATER MAINS - SUPPLIED WATER TO COOLING JACKETS AROUND TUYERES
8. HEARTH - CONSTRUCTED OF SANDSTONE BLOCKS IN A BOWL-SHAPE TO HOLD MOLTEN IRON.
9. DAM STONE - HELD MOLTEN IRON IN THE HEARTH
10. DAM PLATE - WATER-COOLED IRON PLATE PROTECTED DAM STONE FROM FURNACEMASTER'S TOOLS
11. SLAG NOTCH - FOR RUNNING MOLTEN SLAG OUT OF FURNACE
12. IRON RUNNER CARRYING MOLTEN IRON TO CASTING HOUSE FLOOR
13. SOW - TROUGH OF MOLTEN IRON
14. PIGS - MOLDS IN SAND FLOOR OF CASTING HOUSE
15. TUNNEL HEAD - TOP OF FURNACE
16. CASTING SUPPORTING BRICK DRAFT STACK
17. IRON PLATES - RAMP FOR CHARGING ORE, CHARCOAL AND FLUX INTO FURNACE
18. HOT BLAST STOVE
19. CHIMNEYS WITH DAMPERS
20. GALVANIZED IRON AIR SUPPLY MAIN
21. CAST-IRON AIR MAINS
22. CAST-IRON DOWNCOMER
23. WROUGHT-IRON TIE RODS AND FACE PLATES
24. HEARTH ARCH WHERE IRON IS TAPPED
25. TUYERE ARCHES



# END OF PROJECT REPORT
# 1986 PROJE  VERMONT SURVEY OF INDUSTRI  ARCHEOLOGY SITES

## A. <u>INTRODUCTION:</u>

This project continued thematic survey throughout the state of Vermont, at reconnaissance level, to identify the following range of historic archeological sites: blast furnaces, iron mines, bloomery forges, foundries, charcoal kilns, and lime kilns. Although most of the sites were recorded on an 'as-located' basis, sites in close proximity to public and/or private development areas were given priority attention.

### 1. HISTORIC CONTEXT OF VERMONT IRONMAKING INDUSTRY:

a. <u>Development trends:</u> The iron industry in Vermont developed in association with other pioneer works (grist and saw mills, blacksmith shops, etc), which reflected the needs of early settlers in Vermont. Ironworks were built near water power, ore beds, and sources of fuel (charcoal); blast furnaces along lower elevation sites near good roads to transport heavy ingots; bloomeries sometimes at higher elevations (i.e. Bristol, Cady's Falls, Lincoln). The works were also influenced by Lake Champlain and the ironworks that developed in New York State. The Lake and later the Champlain Canal changed the character of Vermont ironworks from a larger number of small speculative operations in pre-canal days to costly, high production works. The railroad eventually brought in better iron made cheaper than local works could produce and ended ironmaking in Vermont.

Ironworking, in the form of machine shops (mill gearing, machinery, tools, scales) and medium to heavy foundries (agricultural implements, railroad iron, castings, stoves), expended to reach peak production about 1880-1890, dwindling in numbers and production thereafter.

b. <u>Limitations of development:</u> Vermont ironworks were limited by:

(1) the quantity and quality of its ore (earlier ironworks used bog ore). Later works imported ore from New York State to mix with and improve the quality of locally-made iron.

(2) the length of the winters, which froze streams that powered the works.

(3) the works' remoteness from major industrial centers and seaports nearer to the ocean.

c. <u>Geographic distributions and patterns:</u> Pre-1800 ironworks were distributed near developing population areas that created the demand for raw iron product. With better transportation (road, railroad, and lake barges) industrial demand commenced (1800-1850) and ironworks located closer to fuel, ore, and more reliable water power. Approximately 90% of the ironworks operated to the west of the Green Mountain range and were concentrated in Addison and Rutland Counties.

d. <u>Historic highlights:</u>

(1) Many early ironworks in Vermont were developed by major political figures: Nathaniel Chipman, Ira Allen, and Matthew Lyon.

(2) The first ironworks in the Adirondack Mountain region of New York State imported ore from Basin Harbor (near Vergennes).

(3) A major New York State ironworks, the Crown Point Iron Company was founded by Vermonters: the Penfield and Hammond families of Pittsford.

(4) A blast furnace at East Bennington used preheated blast (hot blast) a year before generally accepted date (1834) for first use at a furnace in New Jersey.

(5) In 1809, Monkton Iron Company at Vergennes attempted use of piston-driven blast machinery, 26 years before accepted date of use in Northeast; first documented successful use in Vermont was 1839 by Conant at Brandon.

(6) Last significant bloomery forges in New England operated in Vermont (1850-1880's): Salisbury, Vergennes, Fair Haven, Lincoln, East Middlebury; then known throughout U.S. industry for high quality wrought iron.

(7) Most all major 1790-1830 Vermont ironworks families inter-related: Austin, Harwood, Lothrop, Page, Dike, Broughton, Bogue, Keith, Sax, Drury, Cooley, Conant, Penfield, and Sutherland; also Colburn and Davey.

2. HISTORIC CONTEXT OF VERMONT CHARCOAL INDUSTRY:

a. Development trends: Charcoal making in Vermont developed in association with the development of its mineral smelting and production industries. Charcoal fueled furnaces (iron, glass, copper), forges, blacksmiths hearths, foundry cupolas, etc. Early charcoal making required no structure; it was made merely by mounding cordwood, covering it with sod, and allowing it to smolder. Much charcoal and potash was made by settlers as a by-product of clearing vast acreages of land for agriculture. Kilns supplied charcoal to local furnaces and forges that initially satisfied local needs. Industrial expansion after 1820, stimulated by the Champlain Canal, demanded more charcoal. By Civil War period, charcoal was being made in stone- and brick-built kilns with much of it exported out of state. By 1880, most of it was shipped out as Vermont ironworks phased out and charcoal resources in New York, Massachusetts, and Connecticut became scarce. Charcoal making in Vermont ended soon after 1900.

b. Limitations of development: Vermont charcoal making was limited in the early period (pre-1820) by the demand of local metal working industries, which mostly reflected domestic economics. Limitations of middle period charcoal making (circa 1820-1860) still reflected local demand, but charcoal was made on a more regional supply and demand basis; local forests were becoming depleted through settlement and clearing for farmland. After 1860, charcoal making became an industry unto itself, with charcoal being exported outside the state and forests being rapidly consumed by lumbering interests. Limitations by this period became the resources of the forest stands themselves, which were commercially exhausted by the turn of the century.

c. Geographic distributions and patterns: During the early pre-1820 period, charcoal making generally centered about the ironmaking industries, then the largest single consumer of charcoal in the state. After 1820, as iron, copper, and glass industries developed, charcoal making caused forest lines to recede into the hills. It was not uncommon for charcoal to be carted a dozen miles to furnaces by the 1860's. As such, earlier charcoal making sites generally were close to developing industrial communities along the Lake Champlain plateau; later charcoal making areas reached well up into the Green Mountain highlands, with many final operations at 2000-foot elevations. Most kilns, however, still remained on the western slopes of the Green Mountain range, with concentrations in the north in the Ripton and Middlebury area; the central area of Winhall, Peru, Mt Tabor, Dorset; and southern at Woodford, Shaftsbury, Glastenbury, Stamford, Readsboro.

d. Historic highlights:

(1) Largest single-owned charcoal making operation in Vermont was Silas L. Griffith of Danby, whose holdings in late 1880-1890's exceeded 50,000 acres, operating some 35-plus charcoal kilns, 9 sawmills, and 6 general stores in and near Mt Tabor. He was the first to use the telephone in the state, connecting his lodge at Griffith Pond to his office at Danby; was an early advocate of using saws instead of axes to cut trees in order to reduce waste. He was a Vermont State Senator but declined candidacy for Governor. His charcoal, plus that made farther south, supplied fuel needs of ironworks in the Taconic regions of New York, Massachusetts, and Connecticut until about 1912, when these resources failed; those ironworks then importing charcoal from as far away as North Carolina (that region's iron industry failed in 1923).

(2) Design and efficiency of round and conical kilns in Readsboro were recognized in a technical paper in 1879-1880, published nationally (the archaeological site of at least one Readsboro conical kiln was located in 1983).

3. HISTORIC CONTEXT OF VERMONT LIME BURNING INDUSTRY:

a. Development trends: Lime burning in Vermont developed in association with the clearing of the land and establishment of farming. Eighteenth century and early nineteenth century lime kilns were built by farmers to provide lime for agricultural purposes; later lime kilns supplied the demands of construction and paper making, although the major kilns at Winooski Park supplied lime for sale to farmers by the U.S. Government until 1971.

b. Limitations of development: Early lime burning in Vermont, which supplied strictly agricultural needs, was limited by physical proximity to limestone quarries. Since these early lime kilns required no blast, water power was of no consequence. By the mid-19th century, lime kiln operations such as those at Leicester, Weathersfield, Highgate, and Winooski located closer to railroads. Lime kilns during this period were large stone-built stack structures (similar in appearance to blast furnaces), requiring major outlays of capital for construction at centralized locations, thus phasing out the smaller, local farmers' kilns. Vermont's final operating lime kilns at Winooski Park operated until 1971 when its U.S. Government contract was awarded to a competitor.

c. Geographic distributions and patterns: Lime kilns in Vermont have always been located in relatively close proximity to limestone deposits. Limestone, which manifests itself in Vermont as varying grades of dolomite for commercial quality marble, or plain limestone for crushing for blast furnace applications or burning for other uses, was early recognized in many places in the State by Zadock Thompson (1853). Thompson identified "Chazy, or Isle la Motte Limestone" and "Trenton Limestone" as being the state's major limestone groups. These groups were located along the eastern shore of Lake Champlain, where major lime kiln operations were established at Highgate (Lime Kiln Point) and Colchester (Winooski Park). Lime kilns were also operating in the Lake Champlain valley at Leicester, Bristol, New Haven; in proximity to marble quarries at Wallingford, Tinmouth, Danby, Clarendon, Dorset, and Manchester; and also at Weathersfield, Jamaica, and Dover in proximity to limestone outcrops.

d. Historic highlights: Research into the lime burning industry in Vermont is still in a very preliminary stage of activity, with location of physical remains the immediate priority. Insufficient investigation into the history of the industry, therefore, contributes little in the way of historic highlights of this industry.

B. METHODOLOGY:

The survey was accomplished through a combination of archival and field research: oral and local traditions, informant information, and published and unpublished material.

1. ARCHIVAL RESEARCH:

a. Library work: Generally available published and unpublished materials were studied for information, however remote or vague, for clues and leads to existence or locations of sites. Specific material studied included: state, county, and town histories, trade journals, business journals, maps, museum and photo collections and papers, newspapers, letters, genealogical and cemetery records, legislative acts, and professional papers.

Libraries visited included Mark Skinner Library, Manchester; Rutland Free Library, Rutland; Sheldon Museum Library, Middlebury; Tyson Library, Plymouth; Griffith Memorial Library, Danby; Vermont Historical Society Library and Vermont State Archives, Montpelier; Bixby Memorial Library, Vergennes; the University of Vermont Bailey-Howe and Special Collections Libraries, Burlington; and Vermont Mapping Program (orthophotos), Waterbury. Also, the New York State Historical Association Library, Cooperstown, NY; State University of New York Library, Albany, NY; Berkshire Athenaeum Library, Pittsfield, Mass; in addition to my personal library and collections of Vermont archival and data stored in my personal computer system.

(1) Reliability of many local histories has proven to be questionable in some cases. Depending on the interest and personal biases of the authors, local histories may or may not have reflected actual industrial activities in the subject county/town/village. This is seen in pages of coverage for religious and social organizations, banking institutions, and prominent families, but vague statements about a 'forge operating in the east part of the town early in the century' without regard to type of forge (bloomery? furnace? foundry?). Statements such as 'there were no industries of significance in this town' conflict with later published histories of the same town which

described many mills and foundries, and with field work that located sites of mills. Additionally, many clues to sites do not come from manufacturing sections of local histories, but in sections dealing with family records, early settlers, and general community development.

2. INFORMANTS AND LOCAL TRADITION:

A number of reliable contacts have been made regards to general or specific information leading to finding sites pertaining to the iron, charcoal, and lime industries in the state:

a. Local informants: This category includes people who own site properties and contributed information on other known or suspected sites or knowledgeable people in the vicinity. The value of slide-illustrated presentations to local historical societies cannot be over emphasized regards to numbers of contacts and quality leads to location of sites. Formal presentations at Middlebury (Sheldon Museum, Summer 1984), Pittsford (Pittsford Historical Society, Spring 1986), Windsor (VAS, Spring 1985) attracted many older and knowledgeable residents who contributed much reliable oral, manuscript, photo, and artifact information. A number of informants also volunteered time to guide me to sites. Correspondence continues with most of these reliable contacts.

b. Professional informants: This informant category includes those who have a professional interest in history/archaeology, beyond members of historical societies or owners of site properties, including:

(1) authors of recently-published histories.
(2) school teachers.
(3) U.S. Forest Service personnel.
(4) staff personnel of:
  (a) Vermont Division for Historic Preservation, Montpelier.
  (b) UVM Consulting Archaeology Program, Burlington.
  (c) Sheldon Museum Library, Middlebury.
  (d) Vermont Historical Society Library, Montpelier.
  (e) Stamford Community Library, Stamford.

3. BACKGROUND RESEARCH:

Potential areas for industrial sites were determined through a combination of archival information, known industrial development patterns, local geology, topography, and mountain trails.

a. Archival information: Information obtained through archival research was duplicated, transcribed, and/or plotted on USGS maps in combination with other associated data to create a job folder, specifically for the site in question. Related site information, such as family connections, incorporation dates, names, and partners, and newspaper advertisements, were also investigated.

b. Industrial development: Through 1850s-period county maps, Beers maps, and business journals such as the annual Walton's Register publications, patterns of industrial development were established and analyzed for trends. Concentrations of ironworks industries indicated, for example, the probability of charcoal kilns in surrounding hills.

c. Local geology: Through state geology reports and maps, the probability of ironworks and lime kilns were determined.

d. Topography: Attention to physical topography revealed clues to location to otherwise undocumented industrial sites. Inspection of streambeds downstream of suspected ironworks or charcoal sites yielded slag or pieces of red brick and charcoal, which when traced upstream, led to location of the sites. Techniques such as this have in time led to development of intuitive skills for locating some types of sites.

e. Trails: Many former roads are today official or unofficial hiking trails. These trails wind through abandoned communities that grew in proximity to saw mills and charcoal kiln operations. Attention to black soil in vicinity to suspected charcoal making areas led to locating many of the kiln sites.

4. WALK-OVER SURVEY:

Once located and verified, the site was inspected at reconnaissance level, for extent of its boundary, remains of visible surface artifacts and features, and potential archeological value, then recorded.

a. Site location and verification: Location and verification of the site was made through obvious structure remains, such as foundation and/or standing blast furnace, charcoal kiln, or lime kiln remains. In absence of obvious remains, evidence of such material as burnt brick and stone, slag, charcoal, firebrick, burned lime, waste iron, iron ore, binding hardware, etc, and such features as collapsed furnace mounds, head and/or tail raceways, flumes, dams and dam cribs, waterwheel pits. charging embankments, etc, were checked for.

b. Site inspection: The site was inspected for the following:

(1) integrity - to what degree is the site undisturbed by later development, vandalism, weathering, etc.

(2) boundary - what is the archaeological boundary of the site as determined by range and distribution of surface artifacts and features, and also by inspection of eroding shores of streams and by shallow (6-inches, max) subsurface inspection.

(3) threats - what are probabilities for development, further vandalism, erosion, etc.

(4) ownership - proximity to property owner; owner interview, if possible, to access local attitude toward site preservation, development plans, etc.

c. Site recording: The site was recorded through use of USGS topographical maps, drawing sketches and ground plans, and photography. Small surface artifacts were reconcealed after recording.

(1) USGS maps - the site was accurately located on USGS topographic quadrangles through identification with local landmarks, such as streams, mountains, roads, standing buildings, etc.

(2) Ground plans - sketch maps were made of the site, indicating all relevant surface features, concentrations of artifacts (slag, charcoal, etc), cellar holes whether known to relate to the site or not, roads and paths, dam sites, etc., and general topography. In some

cases, detailed, scaled sketches were made of remains that were considered of special importance to the integrity or significance of the site, such as uniquely-built furnace archways, hearths, kiln hardware (which might be stolen or vandalized). Compass readings were recorded. In most cases, the site boundary was paced off and dimensions calculated accordingly. When possible, sketch maps were scaled.

(3) Photography - black and white photographs were made of the site from many angles of view, both close up for detail and from a distance to indicate local environment. Small brush and branches might be tied aside or cut, but not sufficient to draw attention. Camera used is a Minolta SLR model SRT101, with normal, long-range, and wide-angle lens, which allow for a wide range of photography under varying situations. In many cases, follow-up photo sessions were made during seasons of less foliage for better photographs. These return sessions also allowed for reinspection of the site, adding surface information that may have been missed during the initial recording and interpretation of additional archival information.

(4) Concealment of artifacts - such large, attention-drawing artifacts as kiln doors and hardware, cast iron vents, etc., were uncovered of accumulation of surface vegetation and debris for purposes of measurement and photography, and were reconcealed beneath brush, leaves, and foliage. In all cases, sites were left appearing as much as possible as found; no attempt was made to 'clear' fallen trees and branches from paths and trails leading to sites. Where possible, further concealment was attempted, and trash found in the site vicinity was collected and carried out.

5. SURVEY REPORT:

Survey reports were submitted to the Vermont Division for Historic Preservation (DHP), which included filled in Archeological Site Survey Forms, an Industrial Archeology Site Survey Form, and a narrative report.

a. Archeological Site Survey Form: This is the standard DHP form for recording archeological sites. All categories and spaces are filled in that apply to the site. Site and F.S. numbers are left blank to be assigned by DHP.

b. Industrial Archaeology Site Survey Form: This form was created to provide additional site information not covered by the Archeological Site Survey Form. It addresses iron furnace, bloomery, and charcoal and lime kiln sites. Where applicable, the form is filled in and included as pages 5 and 6 to the Archeological Site Survey Form.

c. Narrative report: This report includes definitive site location information, a description of the site, history of the site, miscellaneous observations, duplicated USGS and USFS maps with site location, ground plans and sketches, bibliography and sources of further information, and captioned black and white photographs. The report is standalone, that is, it includes all information needed to complete the Archeological Site Survey Form and the Industrial Archeology Site Survey Form.

(1) Definitive site location - site location is defined in terms of USGS topographic quadrangle name, UTM coordinates, county, and town or village.

(2) Site description - a narrative description of the site includes location of the site in the context of its surroundings and environment, a site name, its physical characteristics, range and distribution of features and artifacts, and source of power and/or resources.

(3) Site history - a brief history of the site is provided, including events leading up to the site's establishment, production statistics when known, dates of operation, causes of abandonment, highlights, owners, and relationship with associated works. In some cases, published material was duplicated and included in the narrative.

(4) Observations - visible or suspected threats to the site, potential for further historical/archeological interpretation, etc., are included where applicable.

(5) USGS map - the site is located on current duplicated sections of USGS topographic quadrangles; the site is identified on the map in the same proportion to the sketched ground plan.

(6) USFS map - sites in the Green Mountain National Forest, were indicated duplicated sections of U.S. Forest Service quadrangles.

(7) Ground plans - full page ground plans of the site are provided with the report. The sketch is scaled when possible; all ground plans are sketched in the normal orientation (north at top) and include a north-pointing arrow.

(8) Bibliography - a comprehensive listing of references and sources for all published and unpublished information cited or referenced as part of the report is provided. Addresses and phone numbers of contacts are included.

(9) Photographs - captioned black and white photos depict site condition, artifacts finds, and site environment. Photos are identified by 5-character alphanumeric code (i.e., 86A13) that allows for accurate access to my negative files.

d. Distribution of Forms and Reports: Forms and reports were distributed as follows:

(1) State Archaeologist - original copies of all Forms, Reports, sketches and ground plans, and photographs.

(2) Forest Archaeologist (U.S. Forest Service) - duplicated copy of Reports only, pertaining only to sites within the proclamation boundary of the Green Mountain National Forest.

(3) Librarian, Sheldon Museum Library, Middlebury - duplicated copies of Reports only, of sites only within Addison County.

(4) Rolando files - duplicated copy of all Forms, Reports, maps, and photo negative file.

## C. RESULTS:

The project period commenced October 1, 1985 and ended November 30, 1986. Although work on 25 sites was planned for this project period, actual efforts for the project resulted in 43 sites in eight of the state's 14 counties added to the Vermont Archeological Inventory. Value of donated services totaled $10,487 versus the planned $5,998.00. See pages 10 and 11 of this report for the list of inventory and field site identification numbers of the 43 sites reported.

Almost all the sites surveyed and recorded have the potential for yielding further significant archaeological information regards to their construction, method of operation, technological developments, and relationship of property types across the site. Stabilization of lime kiln structures at Bristol and Amsden could preserve them for future study and possible exhibition as historic industrial sites.

Despite some surface disturbance and scattering of remains, digging and serious subsurface disturbance at most sites appears to be minimal. Visible site disturbance appears to be a function of proximity to well-traveled trails. Sites of brick-type charcoal kilns in along sections of the Long Trail in Mt Tabor betray much evidence of pot-holing. Construction materials, however, also seems to be a factor. Brick-type charcoal kilns, for example, however remote from houses, are relatively stripped of usable brick, whereas stone-type kilns remain in relatively better standing condition. Chimneys of homes in proximity of brick-type kilns contain brick that appears much the same color, texture, and condition as bricks seen in local charcoal kiln remains. The occupant of one house (East Manchester) knew exactly where some charcoal kiln remains existed without acknowledging suspicious bricks in his chimney.

Although some charcoal kiln sites in higher elevations show evidence of disturbance by brick scavengers, or use of brick for fireplaces by campers and sportsmen, the most serious threat to these sites appear to be logging operations. Not all damage is done by the actual logging operation; some by road construction into logging areas, although this also had its reverse benefit. Clues to some undocumented charcoal kiln sites came from pieces of hardware seen in the beds of logging roads in Peru and Woodford (1983). In both cases, the road had been graded to within a few feet of the kiln foundation, accounting for hardware in the roadbed. The Peru kiln ruin, as it turned out, was unknown even to people who had hunted the area for over 20 years. At North Dorset, a staging area for logging vehicles was cleared to within a few hundred feet of a collapsed furnace ruin, but still within the archeologically-sensitive area; part of the waterpower flume system was destroyed. That the property was part of a state park had no effect. At Mt Tabor, on federal property, part of the Ten Kilns site has been disturbed by widening of roads to accommodate large logging vehicles. None of this is intentional destruction, rather there appears to be a lack of communications within the governmental systems. In all cases, site reports had been written and forwarded before the disturbance took place.

Private owners appear more concerned and willing to cooperate with preservation efforts when advised of the historic/archeological value of the site. Whether to increase property values or just personal interest in something not fully understood about the ruins on their property, nearly all property owners have cooperated with recommendations to protect sites from further deterioration through brush clearing or wall support, but attempt no serious restoration/excavation.

Results of this project survey period plus data accumulated in previous years continues to support my theory that industrial activity in Vermont exceeds that generally thought. Vermont is not perceived to have had a significant industrial history. Yet, in terms of numbers of blast furnace, bloomery, and charcoal and lime kiln ruins and sites located and documented to date, Vermont appears to have kept pace (relative to state population and area) with neighboring states, from the immediate post-Revolutionary War period up to the 1850's. Additionally, related genealogical research has shown that the earliest significant ironworks in the Lake Champlain district of New York State were founded by Vermonters.

Data from the 1986 project has added to further understanding how and when ironmaking technology came into Vermont, and how the technology distributed itself within the state. By tracking where pioneer ironmaking families came to Vermont from, migration patterns became apparent that connect 18th-C ironworks operations in eastern and western Massachusetts and in northwestern Connecticut with the establishment of some of the first ironworks in Vermont.

Analysis during the 1986 project year of early 19th-C legislative acts of incorporation has led to development of a preliminary pattern of industrial capital investment flow into Vermont. The pattern shows that many corporation partners were involved in other speculative ventures in Vermont. Names of some partners have also been recognized from ironworks research done years ago in other parts of New England, contributing to understanding the complex economics of early 19th-C speculative exploitation of Vermont's natural resources by Boston's and New York City's budding capitalists.

Results of the 1986 project year also sharpened intuitive skills of locating undocumented industrial sites. Not 100% foolproof, attention to geology and topography contribute toward developing local patterns of charcoal and lime kiln sites. Sites of mound-type charcoal making areas can now be located almost at will in southwestern Vermont, although this has not been intensely pursued due to the non-threatened nature of the area of these sites, as compared to active threats to sites being attended to in other parts of the state.

The following list documents Vermont Archeological Site Survey and Field Site Inventory numbers and site names located and recorded during the 1986 project year. See individual reports for further information on specific sites recorded:

<u>Addison County</u>

| | |
|---|---|
| VT-AD-404 | Richville mills & bloomery forges (2) sites - Shoreham |
| VT-AD-405 | Widow Glynn charcoal mounds (3) sites - Leicester |
| VT-AD-406 | Sawyer's bloomery forge site - Salisbury |
| VT-AD-407 | Salisbury bloomery forge site - Salisbury |
| VT-AD-409 | Bedell lime kiln ruin - Bristol |
| VT-AD-414 | Brooksville Edge Tool Co foundry site - New Haven |
| VT-AD-415 | Wainwright/Davenport foundry site - Middlebury |
| VT-AD-416 | Holley Forge bloomery forge site - Bristol |
| VT-AD-417 | Lewis Creek Farm bloomery forge site - Starksboro |
| FS 85(AD) | Mt Fuller charcoal mounds (?) site - Monkton |
| FS 86(AD) | Bristol Village bloomery forge site - Bristol |

<u>Bennington County</u>

| | |
|---|---|
| VT-BE-105 | Kennedy charcoal kiln (stone) ruin - Stamford |
| VT-BE-106 | Cardinal (Nunge) Brook charcoal kiln (brick) ruins - Stamford |
| VT-BE-107 | Crazy John Stream charcoal kiln (stone) ruins (3) - Stamford |

Bennington County (Cont)
VT-BE-108 Thompson Farm charcoal mounds (2) site - Stamford
VT-BE-109 Barnumville lime kiln ruin - Manchester
VT-BE-110 MD&G RR abandoned right-of-way - Manchester/Dorset

Chittenden County
VT-CH-282 Weston lime kiln ruins (4) - So Burlington
VT-CH-283 Stevens foundry site - Colchester
VT-CH-284 Winooski Park lime kiln site - Colchester

Franklin County
VT-FR-169 Kenfield foundry ruin and site - Fairfax

Rutland County
VT-RU-153 Gibbs & Cooley blast furnace/foundry site - Pittsford
VT-RU-154 Maplebrook Farm lime kiln ruin - Tinmouth
VT-RU-155 Kiln Brook charcoal kiln (brick) ruins (5) - Chittenden
VT-RU-156 Lampman rectangular charcoal kiln (stone) ruin - Chittenden
VT-RU-157 Vt Lime Prod Co lime kiln ruins (3) - Mt Tabor
VT-RU-160 Danby Mtn Road charcoal kiln (brick) ruins (4) - Danby
VT-RU-161 Crow Hill Farm lime kilns (2) ruins - Tinmouth
VT-RU-162 Tinmouth Pond Dam blast furnace site - Tinmouth
VT-RU-163 Palumbo Farm iron mines (2) - Tinmouth
VT-RU-164 Unidentified circular stone-lined feature - Mt Holly
VT-RU-165 S. Bromley Farm lime kiln ruin - Wallingford
VT-RU-166 'The Cobble' lime kilns (2) ruins - Clarendon
VT-RU-167 Crow Hill Farm iron mine - Tinmouth
VT-RU-171 Packard Mill/bloomery forge site - Tinmouth

Washington County
VT-WA- 21 Waterbury Last Block Co saw mill ruins and site - Waterbury
VT-WA- 25 Rice's Forge blast furnace/foundry site - Waitsfield

Windham County
VT-WD- 66 Harold Field's charcoal kiln (concrete block) ruin - Stratton
VT-WD- 67 Janet Greene Farm lime kiln ruin - Dover
VT-WD- 68 W Thayer lime kiln ruin - Jamaica
VT-WD- 69 PA Haven lime kiln ruin - Jamaica
VT-WD- 70 A Howard lime kiln ruin - Jamaica

Windsor County
VT-WN-104 Amsden lime kilns (2) ruins - Weathersfield

Files:
B:EOPRPT.86A
B:EOPRPT.86B

Victor R. Rolando
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Pittsfield, Mass 01201

February 25, 1987

## IRON WORKSHOP NEWSLETTER--JUNE 1987

As you know, over the last few years the SIA's Iron Workshop has held a number of meetings and symposia dealing with the historic iron industry. The workshop's organizers plan to continue this program as well as to develop new directions, such as the Iron Masters' Meeting scheduled for October, a series of iron papers published as one of the special issues of the SIA journal, and participation in the recently initiated SIA/HAER Historic Iron and Steel Sites Survey.

It is now time to update our Iron Workshop mailing list. If you wish to remain on the list, send your correct name and address to Ed Rutsch at RD 3, Box 111, Newton, NJ 07860. Ned Heite is donating his time and computer to maintain membership records, and a complete list will accompany the next newsletter (winter).

When you write, please suggest what you would like to see the workshop address, especially if you are willing to participate in carrying it out. How about, for example, a comprehensive iron bibliography project?

To defray operating costs (postage, xeroxing, etc.), we are asking those of you who can to donate $5, $10, or $15. Checks should be mailed to Ed Rutsch but be made out to "SIA," inasmuch as the workshop has been given a special account by the Society. Such a donation will be greatly appreciated but is not a prerequisite for inclusion on the mailing list.

### IRON MASTERS' SYMPOSIUM (Oct. 10, 1987: Nassawango Furnace, MD)

A working symposium for "Iron Masters," or those involved with research, preservation, and the educational use of the sites of America's historic iron industry, is scheduled for October 10, 1987 at Nassawango Furnace, near Snow Hill on Maryland's eastern shore. Sponsored by Furnacetown Foundation, Inc. and the SIA, the program will include presentations by professionals in the research, stabilization, interpretation, development, and management of historic iron sites. Accompanying the presentations will be a box lunch and a tour of the Nassawango Furnace site. The meeting will conclude with a social hour, dinner, and an after-dinner presentation at a nearby hotel.

For further information concerning the meeting's agenda, fees, and accommodations, please contact its organizers: KATHY FISHER, Director, Furnacetown Foundation, Rt. 12, Old Furnace Rd., P.O. Box 207, Snow Hill, MD 21863 (301) 632-2032; or ED

RUTSCH, Iron Workshop, Box 111, RD 3, Newton, NJ 07860 (201) 383-6355. Please plan to attend, and pass the information on to the Iron Masters at your favorite furnace site.

## SIA/HAER HISTORIC IRON AND STEEL SITES SURVEY

The SIA, working with the National Park Service's Historic American Engineering Record, has initiated a National Iron and Steel Sites Survey having the following goals:

> To complete a comprehensive national review of iron- and steel-making sites in the United States. The initial goal is a state-by-state assessment and survey of all primary iron- and steel-making sites. This will be followed by an inventory survey which will include: (1) an SIA/HAER format record for each site; and (2) photographic documentation. Recommendations for and comprehensive recording of selected sites are one of the goals of this project.

A comprehensive list of our site resources would greatly aid all students of the subject as well as start the process of historic recognition and preservation. All workshop members are urged to participate in the survey by writing WILLIAM LEBOVICH, Iron/Steel Survey Co-Chairman, at the Historic American Engineering Record, National Park Service 429, U.S. Dept. of Interior, P.O. Box 37127, Washington, D.C. 20013-7127. Give him an idea of the sites with which you are familiar and request the site form materials to get started.

## CONFERENCE ON THE HISTORY OF WROUGHT IRON

An international seminar on wrought iron was held July 14-17, 1986 at Ironbridge, England, sponsored by the University of Birmingham and the Ironbridge Gorge Museum Trust. The papers presented included the following:

DEFINITIONS OF WROUGHT IRON: ITS USE IN MEDIEVAL AND EARLY MODERN TIMES--Chairman: David Crossley, University of Sheffield

Douglas Braid, Rolt Memorial Fellow, University of Bath. The Strategic and Economic Importance of Marsh and Lake Ores in the Seventeenth and Eighteenth Centuries.

Dr. Erik Tholander, Royal Institute of Technology, Stockholm, and Dr. Stig Blomgren, Sven Rinman Laboratory, Eskiltuna. Osmundz Iron - The Medieval Swedish Wrought Iron.

Kenzo Igaki, Emeritus Professor, Tohoku Univeristy, High Quality Ancient Wrought Iron in Japan.

J.G. McDonnell, Department of Production and Mechanical Engineering, University of Aston. Anglo Scandinavian Ironwork from Coppergate, York.

Robert D. Smith, Royal Armouries, HM Tower of London. The Construction of Early Ordnance.

WROUGHT IRON IN THE INDUSTRIAL REVOLUTION--Chairman: *Professor Charles K. Hyde, Wayne State University, Detroit

Dr. Barrie Trinder, Institute of Industrial Archaeology, Ironbridge. The Development of the Integrated Ironworks in Eighteenth-Century Shropshire.

Professor Michael Mende, Hochschule fur Bildende Kunst, Braunschweig. Technological Change and Working Conditions in the Forging Industry.

Dr. R. A. Smith, Engineering Department, University of Cambridge. Wrought-Iron Railway Axles and the Origins of the Metal Fatigue Problem.

THE CONSTRUCTIONAL USES OF WROUGHT IRON--Chairman: Stuart B. Smith

C. R. Jones. The Restoration of the Palm Houses at Kew and Bicton.

Teiichi Ohtsuki, Nippon Kokan KK Tokyo. Wrought Iron in Japanese Lighthouses.

Ichiro Takahashi, Yokota Yokotacho Nitagun Shimaneken, Japan. THe use of Wrought Iron on "Tatara" (traditional Japanese blast furnaces) in Medieval and Modern Times.

WROUGHT IRON: ITS MODERN SIGNFICANCE--Chairman: Professor J. R. Harris, University of Birmingham

Stuart B. Smith, The development of the Blists Hill Wrought-Ironworks Project.

Dr. Gerhard Sperl, Erich-Schmid-Institut fur Festkorperphysik der Osterreichischen Akademie der Wissenschaften, Dating by Metallographic Examination.

*David Harvey, Deane Forge, Colonial Williamsburg, Virginia. A Progress Report on the Reconstruction of the American Bloomery Process.

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*SIA member

*Dr. Robert B. Gordon, Department of Geology and Geophysics, Yale University. The Metallography and Mechanical Properties of Wrought Iron.

BLOOMERY IRON MEETING

Bloomery iron was the subject for a March 1987 meeting hosted by Colonial Williamsburg and organized by David Harvey, operator of Williamsburg's bloomery forge. The weekend's highlight was participating in making iron in the Williamburg bloomery under Harvey's kindly interpreter's eye and then watching the product get worked up into tools by smiths at the forge.

Papers and special curator tours and demonstrations included the following: "IN-PROGRESS REPORT ON THE MECHANISM OF THE BLOOMERY PROCESS," Dr. Robert B. Gordon and David Killick, Kline Geology Laboratory, Yale University; "THE MANUFACTURE OF EDGED IRON KNIVES IN MIGRATION PERIOD ENGLAND (7TH-11TH CENTURY A.D.)," Dr. Gerry McDonnel and Dr. S. Murphy, Aston University, Birmingham, UK; "PAST AND PRESENT IRONWORKING IN TANZANIA, EAST AFRICA," S. Terry Childs, Center for Materials Research in Archaeology and Ethnology, M.I.T.; "INDUCED DRAFT IRON SMELTING IN MALAWI, EAST AFRICA," David Killick, Department of Anthropology, Yale University; demonstration of iron working at the James Anderson Blacksmith Shop; tour of the gunsmith shop; "IN-PROGRESS REPORT ON THE LATE BLOOMERIES IN DELAWARE," Ned Heite; "BLACKSMITHING TECHNOLOGY AND FORGE CONSTRUCTION," John D. Light, Historic Sites and Parks, Parks Canada; "IN-PROGRESS REPORT ON THE EXCAVATION OF JOHN DRAPER'S SMITH SHOP ON THE SHIELDS TAVERN SITE," Tom Higgins, Colonial Williamsburg Archaeology; "IN-PROGRESS REPORT ON THE EXCAVATION OF A PROBABLE IRONWORKING SITE AT FLOWERDEW HUNDRED IN VIRGINIA," Ann B. Markell, Lowie Museum of Anthropology, University of California, Berkeley, and the Flowerdew Hundred Foundation; "PROGRESS REPORT ON THE PRELIMINARY EXCAVATION OF THE VIRGINIA MANUFACTORY OF ARMS SITE, RICHMOND, VIRGINIA," Herb Fischer, Historic Landmarks Commission, Virginia Research Center for Archaeology; Film Festival, Iron Making and Forging; demonstration of horseshoeing at the Elkanah Deane Harness Shop; tour of an 18th-century Virginia (Wythe House) kitchen--Everyman's Iron in its cultural context; tour of Wallace Gallery Exhibit--"Patron and Tradesman: Forces that Fashioned Objects"--by Jay Gaynor, Curator of Mechanical Arts; "FREDERICK KLETTE, MASTER ARMOURER AT RAPPAHANNOCK FORGE," by Wallace Gusler, Director of Conservation of Furniture and Decorative Arts, Colonial Williamsburg; firearms exhibit, Wallace Gallery.

NOTE: Papers presented at the Ironbridge and Colonial Williamsburg meetings were made available to participants. For copies of a specific paper, contact Ed Rutsch, who will make copies at cost.

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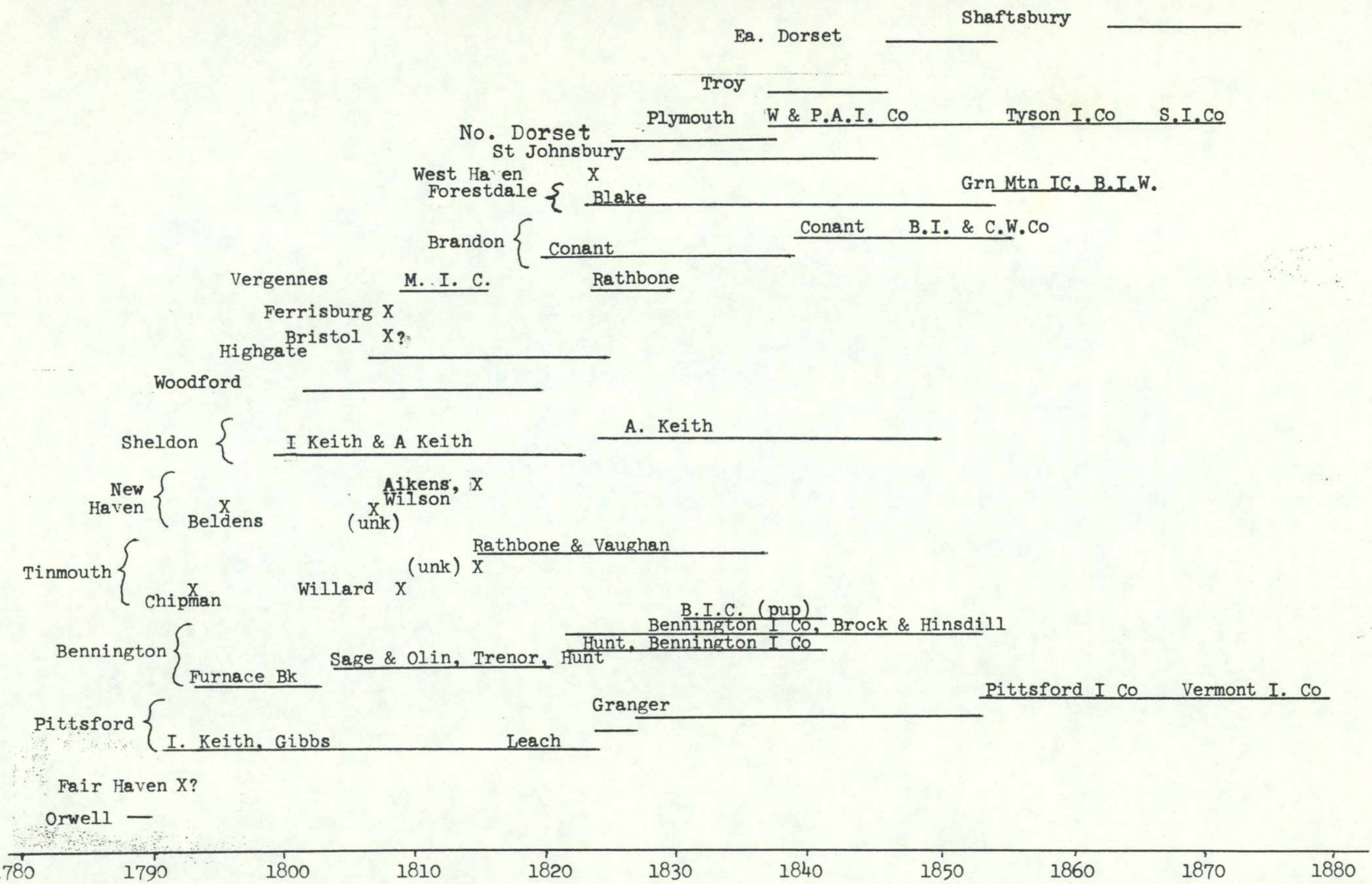
*SIA member


Shaftsbury
Ea. Dorset
Troy
Plymouth
W & P.A.I. Co
Tyson I.Co
S.I.Co
No. Dorset
St Johnsbury
West Haven
X
Forestdale
Blake
Grn Mtn IC, B.I.W.
Conant
B.I. & C.W.Co
Brandon
Conant
Vergennes
M. I. C.
Rathbone
Ferrisburg X
Bristol X?
Highgate
Woodford
A. Keith
Sheldon
I Keith & A Keith
New Haven
X
Beldens
X
(unk)
Aikens, X
Wilson
Rathbone & Vaughan
Tinmouth
(unk) X
X
Chipman
Willard X
B.I.C. (pup)
Bennington I Co, Brock & Hinsdill
Hunt, Bennington I Co
Bennington
Sage & Olin, Trenor, Hunt
Furnace Bk
Pittsford I Co
Vermont I. Co
Granger
Pittsford
I. Keith, Gibbs
Leach
Fair Haven X?
Orwell
1780
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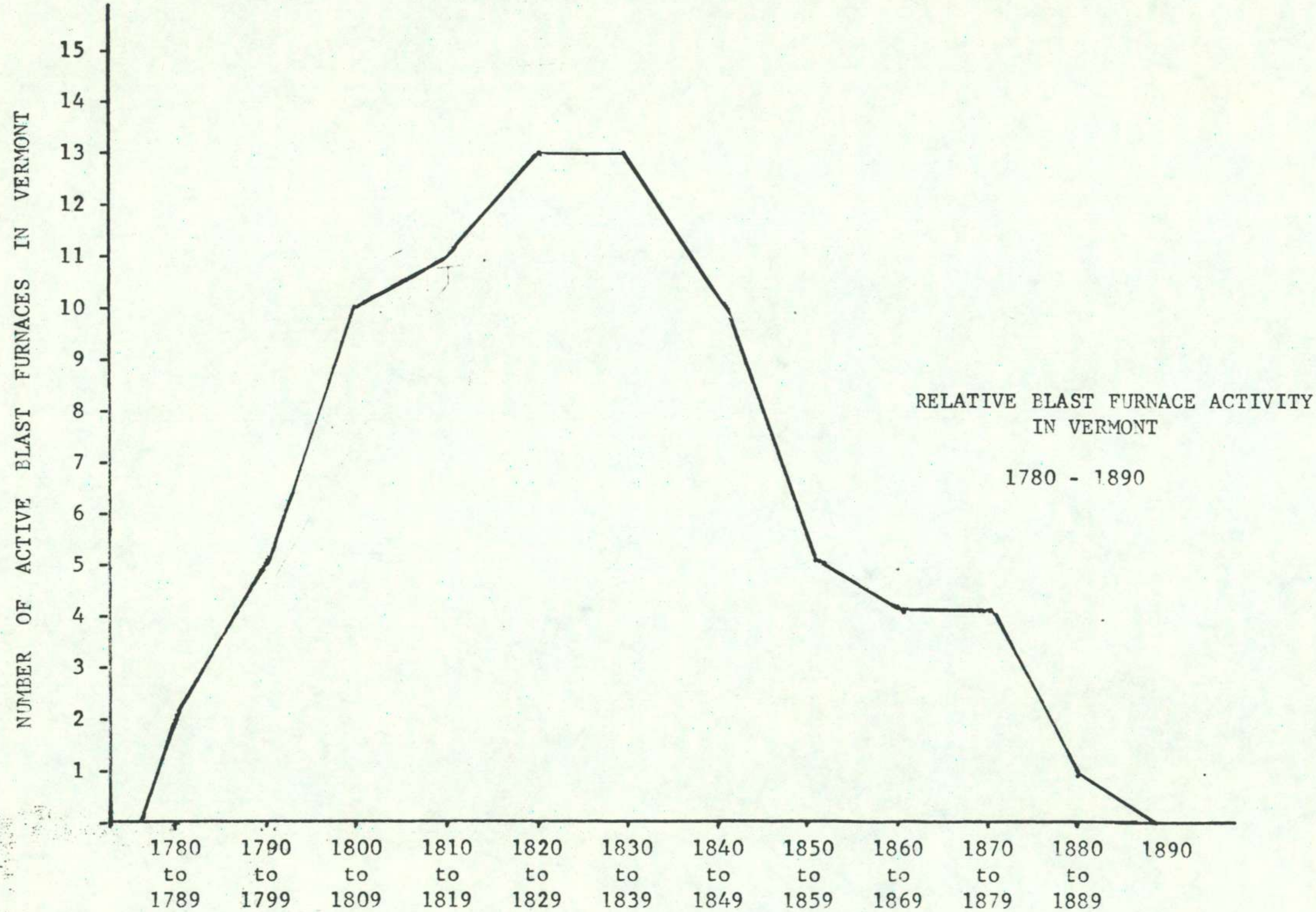
NUMBER OF ACTIVE BLAST FURNACES IN VERMONT
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1780 to 1789
1790 to 1799
1800 to 1809
1810 to 1819
1820 to 1829
1830 to 1839
1840 to 1849
1850 to 1859
1860 to 1869
1870 to 1879
1880 to 1889
1890
RELATIVE BLAST FURNACE ACTIVITY
IN VERMONT
1780 - 1890

SUGGESTED READING LIST - 19th CENTURY IRON AND CHARCOAL MAKING

Updated to March 15, 1986

Ironworks - General:

W. David Lewis Iron and Steel in America Greenville, Del: The Hagley Museum, 1976, 64pp, illus, biblio, index ($3.50). - Excellant.

David Weitzman Traces of The Past: A Field Guide to Industrial Archeology New York: Charles Scribner's Sons, 1980, 227pp, illus, biblio, index ($17.95). - Good for both young people and 'the experts'.

Kenneth Hudson The Archeology of Industry New York: Charles Scribner's Sons, 1976, 128pp. illus, biblio, index ($10.00). - North America and Europe.

William F. Robinson Abandoned New England New York: Little, Brown and Co, for the N.Y. Graphic Society, 1976, 211pp, illus, biblio, index ($19.95). - Poorly written but interesting.

Joseph E. Walker Hopewell Village: The Dynamics of a Nineteenth Century Iron-Making Community Philadelphia: University of Pennsylvania Press, 1966, 526pp, illus, biblio, index ($5.95). - Excellant.

Mary Stetson Clarke Pioneer Iron Works Philadelphia: Chilton Book Co., 1968, 80pp, illus, biblio ($3.97). - Good for young people.

Victor R. Rolando A Survey of Stone Blast Furnaces of New England and Eastern New York State Unpublished Ms., 1977, 141pp, illus, biblio, index. - Somewhat outdated by current research. Copies at UVM Library, Burlington and VHS Library, Montpelier.

J. Lawrence Pool America's Valley Forges and Valley Furnaces West Cornwall, Conn: J.L Lawrence, 1982, 211pp, illus, biblio, index ($15.00). - Self-researched and self-published recent history of Buena Vista blast furnace at West Cornwall, Ct (available through J.L. Pool, Box 31, W. Cornwall, Ct 06796).

Helen Schenck and Reed Knox "Valley Forge: The Making of Iron in the Eighteenth Century" Archaeology (magazine) Boston: Archaeological Institute of America, Vol 39, No. 1, January/February 1986, pp. 26-33, 72., illus. -Excellant!

Ironworks -Vermont:

Richard S. Allen "Furnaces, Forges and Foundries" Vermont Life Winter 1956-57, pp. 2-9, illus. - Somewhat outdated by current research but good reading.

Gina Campoli "Current Research in New England: Vermont - The Troy Furnace Site" Society for Industrial Archeology - New England Chapters Vol. 1, No. 2, October 1980, pp. 11-13. - Field work at the Troy Furnace Site, Vt.

Brandon, Vermont: A History of the Town The Town of Brandon, 1961, biblio, index, ($5.95) pp. 11-13. - Brandon and Forestdale ironworks.

Ironworks - Vermont (cont):

Carl Seaburg and Stanley Paterson Merchant Prince of Boston: Colonel T.H. Perkins, 1764-1854 Cambridge, Mass: Harvard University Press, 1971, Chapter 18 "Short Blast on the Otter" pp. 199-210, biblio, index ($22.50). - Monkton Iron Co., Vergennes, ca. 1808-09.

Christine M. Peleszak The Abandonment of Leicester Hollow BS Thesis, UVM, Burlington, 1984, 111pp, illus, biblio. - Awarded Honors by UVM Dept of Agriculture.

Victor R. Rolando Ironmaking in Vermont: 1775-1890 MA Thesis, The College of Saint Rose, Albany, N.Y., 1980, 132pp, illus, biblio. - Somewhat outdated by current research. Copies at UVM, Burlington; VHS Library, Montpelier; The Rutland Historical Society, Rutland; and Sheldon Museum Library, Middlebury.

___________ "Eighteenth Century Forges" VAS Newsletter Burlington: The Vermont Archeological Society, Inc., No. 27, April 1979, pp. 5-6, illus, biblio. - Overview of 18th-century forge sites in Vt.

___________ "Search for Vermont Furnaces Yields Dramatic Discoveries" VAS Newsletter No. 32, August 1980, pp. 1-4, biblio. - Description of blast furnace; sites at Bennington, Dorset, Forestdale, and Troy, Vt.

___________ "Stone Blast Furnaces in Vermont" VAS Newsletter No. 33, October 1980, p. 6. - List of blast furnace sites located as of 1980.

___________ "Searches Find More Vermont Furnace Sites and a Standing Ruin in 1981" VAS Newsletter No. 38, January 1982, pp. 4-5, biblio. - Sites located at Bennington, Orwell, and North Dorset.

___________ "Current Research in New England: Vermont - Iron and Charcoal Sites" Society for Industrial Archeology - New England Chapters Vol. 5, No. 1, 1985, pp. 13-14. - Background leading to location of ca. 1825 Colburn blast furnace at West Haven, Vt.

Hon. Harvey Munsill, Esq The Early History of Bristol, Vermont The Book Committee of the Bristol Historical Society, (1979?) ($11.75). - "Forges": pp. 107-112. - Forges along the New Haven River and Baldwin Creek in Bristol.

Aleine Austin Matthew Lyon: "New Man" of the Democratic Revolution, 1749-1822 University Park, Penn: The Pennsylvania State University Press, 1981, 192pp, biblio, index ($19.50). - Lyons Works at Fair Haven.

Charcoal Making - General:

Thomas Egleston "The Manufacture of Charcoal in Kilns" Transactions of the American Institute of Mining Engineers Vol. 6, May 1879-Feb. 1880, pp. 373-397. - Copy at UVM Library; includes some Vermont data. An excellant research tool.

Charcoal Making - General (cont):

Jackson Kemper III American Charcoal Making Eastern National Park & Monument Assn., U.S. Dept. of Interior (1960's?) 25pp, illus. - A good little Park Service booklet on making charcoal in mounds.

Rob Woolmington "Coking Charcoal Down in Rattlesnake Gutter" Yankee Magazine December 1979, pp. 80-85, 132-134. - Charcoal kilns in Massachusetts and southern Vermont.

Charcoal Making - Vermont:

Rob Woolmington "The Charcoal Era" Vermont Summer Magazine Bennington: The Bennington Banner, July 7, 1977, pp. 17-20. - Charcoal making areas in southern Vermont.

__________ "Ghost Towns in New England" New England Boston: The Boston Globe, October 23, 1977, pp. 38-40, 42, 44-45. - Abandoned charcoal making towns in southern Vermont.

J.R. Chapin "The Charcoal Burners of The Green Mountains" Outing Magazine April 1885, pp. 4-18, illus. - Charcoal making at Mt Tabor in the 1880's; copy at VHS Library, Montpelier.

Victor R. Rolando "Current Research in New England: Vermont - Charcoal Kilns" Society for Industrial Archeology - New England Chapters Vol. 3, No. 1/2, 1982, pp. 12-14. - Field work in southern Vermont in 1982; copy at VHS Library, Montpelier.

__________ "Current Research in New England: Vermont -Charcoal Kilns" Society for Industrial Archeology - New England Chapters Vol. 4, No. 1, 1984, pp. 3-4. - Field work in southern Vermont in 1983; copy at VHS Library, Montpelier.

__________ "Current Research in New England: Connecticut - The Connecticut Charcoal Company" Society for Industrial Archeology - New England Chapters Vol. 5, No. 1, 1985, pp. 5-6. - Present day charcoal making 'the old way', with modern twists; comparative to Vermont work. Copy at VHS Library, Montpelier.

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B:SRL

## THE SOCIETY FOR THE HISTORY OF TECHNOLOGY

The Society for the History of Technology was formed in 1958 to encourage the study of the development of technology and its relation with society and culture.

An interdisciplinary organization, the Society is concerned not only with the history of technological devices and processes but also with the relations of technology to science, politics, social change, the arts and humanities, and economics. The Society is incorporated in the State of Ohio as a nonprofit educational organization. Its membership is international.

*Technology and Culture*, the official publication of the Society, is included with membership in the Society. Membership is open to individuals, organizations, corporations, and institutions interested in the purposes and activities of the Society (see p. i for membership/subscription rates).

The Society also publishes a series of monographs and holds annual meetings, sometimes with related organizations.

Checks accompanying applications for membership should be sent to The University of Chicago Press, Journals Division, P.O. Box 37005, Chicago, Illinois 60637.



# Technology and Culture

*Volume 27, No. 1* *January 1986*

# Conference Reports

## MEDIEVAL IRON IN SOCIETY—NORBERG, SWEDEN, MAY 6–10, 1985

ROBERT B. GORDON AND TERRY S. REYNOLDS

The origin of iron smelting with the blast furnace is an enigma in the history of Western technology. The earliest written description is from the 15th century,[1] a time when the process was already well established. Hence, new archaeological evidence from Lapphyttan in Sweden of the industrial-scale production of pig iron in blast furnaces in the 13th century—possibly even the 12th—is of more than ordinary interest. Swedish archaeologists have uncovered an iron-manufacturing facility believed to have been in operation between A.D. 1150 and 1350 that includes the blast furnace shown in figure 1, its associated ore store, roasting pits, and waterpower works, and eight hand-blown fineries having provision for tapping slag. Much slag, five different kinds of ore, and a number of iron artifacts were found as well. Operation of a blast furnace here at this time suggests the need for rethinking the history of ferrous metallurgy in medieval Europe.

A conference to present and assess this evidence and to review our understanding of the evolution of the iron industry in medieval times was organized by the Jernkontoret (Swedish Ironmasters' Association) and the Riksantikvarieämbetet (Central Board of National Antiquities). It was held in Norberg, a town in the Bergslagen, the crescent-shaped iron-producing district surrounding Lake Mälaren and Stockholm. Most participants seemed convinced that industrial-scale production of iron of superior quality for international trade was under way in the Bergslagen in the 13th century and that this industry was a significant factor in the subsequent emergence of the modern Swedish nation.

DR. GORDON is a professor of geophysics and applied mechanics and a member of the Council on Archaeological Studies at Yale University. DR. REYNOLDS is director of the Program in Science, Technology, and Society at Michigan Technological University.

[1]John R. Spencer, "Filarete's Description of a Fifteenth Century Italian Iron Smelter at Ferriere," *Technology and Culture* 4 (Spring 1963): 201–6.


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FIG. 1.—View of the Lapphyttan blast furnace looking toward the casting arch. The stream supplying waterpower runs just below the planks in the foreground. The casting floor occupied the space between the stream and the furnace; the blowing arch was on the right. The furnace structure is 4.6 m square at the base, is estimated to have been 3.2 m high and to have had a square shaft made of sandstone. Nothing is left of the hearth, but this is usual with old furnaces; the hearth was broken up after the furnace was blown out so as to recover the bear, the large lump of solid iron that accumulates at the bottom of the furnace. The hearth is estimated to have been 0.3 by 0.5 m.

In prehistoric Sweden (i.e., before ca. A.D. 1050) iron was smelted in hand-blown bloomeries, probably from bog ore.[2] Iron was traded widely through commercial centers such as the one recently excavated at Helgö. After about 1050, population growth, colonization of new lands, and iron manufacture began in the Bergslagen, and it was here that indirect smelting—the use of the blast furnace and finery to make wrought iron—emerged. The explanation for the adoption of the indirect process should be found in the characteristics of the geographical and geological setting and the process metallurgy used, as well as in the skills and social organization required for its operation. These issues were addressed—though somewhat unevenly—by the conference.

The heart of the symposium was a series of twenty-three papers presented by scholars from thirteen countries over a four-day period. In addition to introductory papers by Sven Fornander (Jernkontoret) on the geographical setting of the Bergslagen and Gert Magnusson

[2]A report on the results of recent research on prehistoric ironmaking in Sweden has been published in *Iron and Man in Prehistoric Sweden*, ed. Helen Clarke (Stockholm, 1979).

(Riksantikvarieämbetet) on the excavation of the blast-furnace complex at Lapphyttan, the conference was organized around three themes: waterpower, metallurgical processes, and socioeconomic consequences. The individual papers are available from the Jernkontoret.[3]

*Natural Resources*

The first session focused on waterpower and comprised four papers. The first, by Terry Reynolds (Michigan Technological University), discussed early evidence of the use of waterpower in the production of iron and argued that the large number of waterpower processes that involved the use of linear motion and emerged in or near the Alpine region suggested that the waterpowered iron mill, which also required linear motion, emerged in that region as well. Robert Gordon (Yale University) presented hydrological analyses of the waterpower systems of a number of recently excavated medieval iron mills in Britain and showed that power available at the early mills would have permitted only part-time operation but that the later ones were designed to run on a more nearly continuous or industrial basis. Ninina Cuomo di Caprio (University of Venice) reviewed archaeological data on ancient Italian water mills, comparing their construction to surviving vertical waterwheels in northern Italy and concluding that there had been few changes in construction techniques. Finally, David Crossley (University of Sheffield) discussed what archaeological excavations of waterwheels dating from the medieval period to 1700 reveal about the construction techniques used.

Several papers dealt with aspects of the geographical setting at Lapphyttan. Sven Fornander and Nils Björkenstam (Jernkontoret) showed how ore, fuel, waterpower, and the resources needed for economical transportation are favorably placed in the Bergslagen. Low-phosphorus, rock ore was then available from outcrops, and there were extensive pine and spruce forests producing wood suitable for making charcoal, and streams on which waterpower could be developed conveniently. Much of the transportation of the raw materials to smelting sites was accomplished on sleds in the winter, and Lake Mälaren provided direct access to the Baltic for export of the product.

Climatic conditions, which are important in the use of these resources and may have differed from those that obtain now, were mentioned in several papers but deserve more attention than they have yet received. Data on climate in medieval Europe are increasingly

[3]Jernkontorets Forskningsavdelning, P.O. Box 1721, S-111 87, Stockholm, Sweden.



available. The principal change in medieval times, the onset of cold, wet summers that were so disastrous for agriculture in northern Europe, would have favored the development of the iron industry by accelerating tree growth, facilitating riverine transport, and making waterpower more widely available.

*Ferrous Metallurgy*

The largest segment of the symposium program concerned medieval ferrous metallurgy. The introductory paper by Robert Maddin (Harvard University) covered the technology of iron making in antiquity, focusing on the ingredients used, the furnace arrangements, and the methods of attaining the required temperatures. Several subsequent papers dealt with aspects of early blast-furnace technology that bear on understanding the remains at Lapphyttan and at two other recently excavated Swedish blast-furnace sites described by Inga Serning (University of Stockholm). The conference was enlivened by a lack of agreement among the participants as to whether or not the Lapphyttan furnace was actually a blast furnace—that is, was operated continuously with the intention of producing pig iron. The blast-furnace and the bloomery processes are usually described as distinct, but Gerhard Sperl (Erich-Schmid Institute für Festkörperphysik) pointed out that a nearly continuous transition between them can be found in the historical and archaeological record from the Austrian Alps between 1541 and 1775. This appears in the sequence, *rennofen–stuckofen–flossofen–hochofen*, of furnace types. The proportion of pig iron to bloom iron produced by a *stuckofen* could be varied to meet the demands of the market.

Nils Björkenstam (Jernkontoret) made the point that the blast furnace could not have evolved directly from experience with the high bloomery because bloomeries used high-phosphorus, bog ores; at the low operating temperature of the bloomery, most of the phosphorus goes into the slag, and a good-quality iron can be produced. In the blast furnace, smelting such ores would have resulted in high-phosphorus pig, which would have been unsuitable for conversion to bar iron in the finery. While it may be argued that the furnace at Lapphyttan was primarily producing blooms rather than pig iron, the low iron content of the glassy slag and the presence in it of droplets of cast iron are direct evidence that it was operated as a blast furnace.

The presence of eight fineries associated with one blast furnace is curious. Gert Magnusson suggested that an explanation may be found in King Magnus Eriksson's charter of the ironworkers (*bergsmen*) of 1354. No one could own less than one-eighth of a furnace, and each bergsman was personally responsible for the quality of his refined iron. The blast furnace may have been jointly owned and operated, but the production of the final product would have been carried out by individual craftsmen on their own responsibility.

Was the Swedish blast furnace an indigenous development or did it reach Sweden by some process of technology transfer? It has been argued by some that the blast furnace reached Sweden in late medieval times from Germany and by others that it was developed locally for the trade in Osmund iron in early medieval times. To these possibilities Ronald F. Tylecote (University of London) and Donald Wagner (Carlsbergsfondet, Copenhagen) added the possibility of transfer of the blast-furnace technology from China, where the scale of pig iron production had reached 1.4 kg per capita per year at the time of the construction of the Lapphyttan furnace. Tylecote pointed to the fact that the Swedes were among the first Europeans to establish trade with China (by the 7th century A.D., using a route through Russia) and to the appearance of the waterwheel with a vertical shaft, similar to the type of wheel used in China, in northern Europe in medieval times. Wagner observed suggestive similarities between the construction of the early Swedish blast furnaces and fineries and those used in China and discussed how technical information may have reached Europe through the Arab lands.

Accurately establishing the dates of operation of the Lapphyttan furnace is important in establishing its historical significance. Radiocarbon dates obtained on artifacts found at the site—which center around A.D. 1250–are the principal evidence for establishing when the furnace was built. These are in accord with limited evidence from pottery and other artifacts. But radiocarbon dating does not have the time resolution needed to set a date to within a narrower range than a few hundred years. Thermoluminescence dating of material from the furnace shows that it was last heated sometime between 1270 and 1390. While uncertainties remain, there seems to be little doubt that the furnace at Lapphyttan is substantially older than any other blast furnace known in Europe.

There was a large and growing iron industry active in Sweden by the 12th century. This industry may have already been using rock rather than bog ores. Copper production centered at Falun was under way by the 11th century with bellows-blown shaft furnaces in which some iron would have been produced.[4] The evidence is incomplete, but the possibility of local development of indirect iron smelting out of knowledge of the resources available and experience with both the bloomery and copper smelter seems as likely as the transfer of an exotic technology to the Bergslagen.

[4]Inga Serning, "Prehistoric Iron Production," *Iron and Man* (n. 2 above), p. 56.



A number of papers described the development of ferrous metallurgy in other parts of Europe. Jerzy Piaskowsky (Foundry Research Institute, Cracow) presented analyses of iron objects found in Poland and dated to the 11th to 14th centuries. Elzbieta-Maria Nosek and Wanda Mazur (Museum Archeologiozne, Cracow) reviewed excavations carried out at Muszyna in southern Poland on small iron-working facilities within the border castles and provided metallurgical analyses of the iron artifacts found there. Janos Gömöri (Liszt Ferenc Museum, Hungary) reviewed the spread of the blast furnace in postmedieval Hungary. Radomir Pleiner (Archaeological Institute, Prague) discussed the introduction of the blast furnace in Bohemia. Jean-Francois Belhoste (Ministère de la Culture, Paris) evaluated the diffusion of the blast furnace in western France in the 15th and 16th centuries. Finally, Brian Scott (Ulster Museum, Belfast) discussed the factors behind the failure of the attempts by British entrepreneurs to establish the blast furnace in 17th-century Ireland. Two papers described excavations at specific blast-furnace sites—Dirk Jan de Vries (Rijksdienst voor de Monumentenzorg, the Netherlands), an enigmatic smelting site at Zwolle, and Peter Crew (Snowdonia National Park, Wales), two furnaces in northern Wales.

### *Iron in Medieval Society*

The final session of the symposium dealt with iron in medieval society. Richard Hodges (University of Sheffield), in a paper not read at the meeting, reviewed some of the socioeconomic implications of the very large number of iron objects uncovered by archaeologists and dated to the early medieval period. Hodges argued that written sources give an erroneous impression of iron scarcity in this period, that the production of iron prestige and utilitarian objects reflected the emergence of state societies in Western Europe, and that the rural domestic production of iron retained, even after the emergence of urban smiths, a good deal of autonomy, reflecting the power of the medieval peasantry. Rolf Sprandel (University of Würzburg) reviewed the trade in Swedish iron with other European nations in the late Middle Ages, showing how the superior quality of this iron led to a competitive edge over Spanish and south German iron exporters. Riccardo Francovich (University of Siena) discussed ongoing archaeological excavations of a medieval Tuscan mining village and Lennart Karlsson (Statens Historiska Museum, Sweden) argued that waterpower and iron resources, not religious reasons, determined the location of the Swedish Cistercian abbey of Nyada. Finally, Åke Hyenstrand (Riksantikvarieämbetet) discussed the possible interrelationships between the way town life emerged in Sweden and the evolution of Swedish iron production and manufacturing.

* * *

What do these papers reveal about the introduction of the indirect iron-smelting process at Lapphyttan? The operation of this metallurgical complex would have required both a skilled work force and a social structure that would permit the assembly of raw materials and the sale of the finished wrought iron. Substantial metallurgical expertise had developed in central Sweden in preblast-furnace times. But an increment of skill would have been needed to undertake new tasks required by the indirect process, including the ability to (1) locate and bring together the materials required for construction of the blast furnace, such as the sandstone lining; (2) organize the supplies of ore and fuel and transport these to the smelting site; (3) design and operate the waterpower system which replaced the hand-operated bellows used for the bloomeries; and (4) blend the five different kinds of ore found on the site so as to get the furnace to produce a fluid slag from which the liquid iron could separate.

Operation of the blast furnace was imperfect at least part of the time. Pieces of incompletely reduced ore, bits of charcoal, and droplets of cast iron are embedded in the glassy part of some of the Lapphyttan slag. This shows that some ore and fuel were being wasted and that some of the iron made was lost because of excessive viscosity of the slag. Nevertheless, the large quantity of slag found on the site shows that commercially useful technical competence was attained by the Lapphyttan metallurgists.

What combination of economic, geographical, technical, and social factors induced the bergsmen of Lapphyttan to make their iron by the indirect rather than the direct process is not yet clear. It was not a demand for cast-iron products and probably not scarcity of fuel or ore. Growing reliance on the more structured organization needed to meet the requirements of an export trade based on a reputation for product quality may have been a major factor. There is some evidence that at least one aspect of the organization of iron production established in the Bergslagen in the 13th century persisted through the 19th century in Sweden. On a field trip to the 19th-century iron-smelting village of Olsbenning, Gert Magnusson explained how the blast furnace there was operated on a shared basis by individual producers, each of whom marketed his own pig iron under his own guarantee of quality. Barbro



Bursell, in her book on the Lancashire forgemen of Sweden,[5] observes that, until the 20th century, each finer was economically responsible if the quality of his product did not come up to expectations. One would like to think that the reputation for quality enjoyed by Swedish iron has its roots in so ancient an industrial organization as that at Lapphyttan.

[5]Barbro Bursell, *Träskoadel* (Stockholm, 1975), p. 244.

Bruce E. Seely

1983 "Blast Furnace Technology in the Mid-19th Ct: A Case Study of the Adirondack Iron & Steel Co." Industrial Archeology vol. 7, 1981.

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# IRON & STEEL

There is nothing more fundamental to the man-made physical world than the materials of which its elements are composed, and, likewise, nothing more basic to the smaller world of industrial archeology than the ferrous metals. Other than the static structures of masonry and timber, more industrial-archeological remains are formed of cast iron, wrought, or steel than of any other single material. Looked at another way, the ferrous metals constitute the greatest bulk of that part of our industrial heritage composed of "man-made" or "man-manipulated" material, even including concrete in that category.

Even the 'pure' masonry, timber, or concrete structures almost invariably incorporate ferrous elements in the form of fastenings, hardware, reinforcement, or sheathing. Despite their ubiquitousness, and the broad importance of the ferrous metals to industrial archeology, there exists within the IA community considerable misundertstanding of the nature of the various members of the ferrous family: their physical characteristics and the means by which they are produced (itself an important aspect of industrial archeology).

It must have been his awareness of this same void--although obviously with a more down-to-earth audience in mind--that led George Schuhmann nearly eighty years ago to set down in plain, non-metallurgical language descriptions of the most commercially important of the irons and steels as they related to the operations of a large corporation that dealt extensively with coal, metal, railroads, and the world of heavy industry in general. The fact that Schuhmann's little essay--which is reproduced below--appeared in the Philadelphia & Reading Railway's YMCA organ indicates that it was aimed squarly at the firm's working population, clearly intended to advance its understanding of its work, for the certain benefit of both capital and labor.

Regardless of the author's motive, his account sets forth with such clarity, in such straight-forward terms the essentials of this critical subject, that it was seen to provide ready-made answers to those iron and steel questions that have for so long been so plaguing to so many.

Somewhat more detail, with a historical perspective, will be found in the following:

1) W. K. V. Gale, IRON AND STEEL. Museum Booklet No. 20.04. Ironbridge Gorge Museum (Ironbridge, Telford, Shropshire TF8 7AW, England), 1979. 32 pages, illustrated.

2) ____________, IRONWORKING. Shire Album 64. Shire Publications (Cromwell House, Church St., Princes Risborough, Aylesbury, Bucks HP17 9AK, England), 1981. 32 pages.

3) W. David Lewis, IRON AND STEEL IN AMERICA. The Hagley Museum (Box 3630, Wilmington, DE 19807), 1976. 64 pages, illustrated.

Of additional interest may be:

4) THE MAKING, SHAPING, AND TREATING OF STEEL. This valuable work has been published since 1920 by the United States Steel Co. It treats in full technical detail all the aspects of steel making, including many of the basic bulk finished products such as rails and rolled shapes. The evolution of the elemental processes are covered in an introductory, essentially historical chapter. Chapter bibliographies enhance the usefulness of this outstanding publication. The latest edition (the 10th, 1971) is out of print but should be available in the larger libraries. A new edition is due in early 1985, available from: the Association of Iron & Steel Engineers, 3 Gateway Center, Pittsburgh, PA 15222.

5) The American Iron & Steel Institute (1000 16th St. NW, Washington, DC 20036) has an extensive publications list. Most deal with current technology and affairs but a number touch on historical matters. Request: PUBLICATIONS, FILMS, AND FILMSTRIPS.

# IRON AND STEEL*

By GEORGE SCHUHMANN

General Manager, Reading Iron Company

COMMERCIAL Iron and Steel are metallic mixtures, the chief ingredient of which is the element "Iron," that is, pure iron, of which they contain from 93% to over 99%. The difference between iron and steel is principally due to the composition and proportion of the remaining ingredients.

**Iron Ore** is an oxide of iron (iron rust) containing from 35% to 65% of iron; the balance is oxygen, phosphorus, sulphur, silica (sand), and other impurities. The ore is charged in a blast furnace, mixed with limestone as a flux, and melted down with either charcoal, coke, or anthracite coal as fuel; the resulting metal is what is commercially known as **Pig Iron,** containing about 93% of pure iron, 3 to 5% of carbon (pure coal), some silicon, phosphorus, sulphur, etc. When only charcoal has been used as fuel, the product is known as **charcoal pig iron.** Pig iron is used in foundries for the manufacture of **iron castings,** by simply remelting it in a cupola without materially changing its chemical composition; the only result is a closer grain and somewhat increased strength. Charcoal pig iron has the peculiarity of producing a hard, chilled surface when cast into a metal mold and is therefore largely used in the manufacture of car wheels, chilled rolls, etc.

In the manufacture of **wrought iron** the pig iron is remelted in so-called puddling furnaces, by charging about ½ ton in a furnace, and, while in a molten state, it is stirred up with large iron hooks by the puddler and his helper, kept boiling, so as to expose every part of the iron bath to the action of the flame in order to burn out the carbon. The other impurities will separate from the iron, forming the puddle cinder.

The purer the iron the higher is its melting point. Pig iron melts at about 2100 degrees F., steel at about 2500 degrees, and wrought iron at about 2800 degrees. The temperature in the puddling furnace is high enough to melt pig iron, but not high enough to keep wrought iron in a liquid state; therefore, as soon as the small particles of iron become purified, they partly congeal (come to nature), forming a spongy mass in which small globules of iron are in a semi-plastic state, feebly cohering, with fluid cinder filling the cavities between them. This sponge is divided by the puddler into lumps of about 200 lbs. each; these lumps or balls are taken to a steam hammer or squeezer, where they are hammered or squeezed into elongated blocks (blooms), and, while still hot, rolled out between the puddle rolls into bars 3 to 6 inches wide, about ¾-inch thick, 15 to 30 ft. long. These bars are called puddle bars or muck bars, and, owing to the large amount of cinder still contained therein, they have rather rough surfaces. The muck bars are cut up into pieces from 2 to 4 ft. long and piled on top of each other in so-called "piles," varying from 100 to 2000 lbs. according to the size product desired. These piles are heated in heating furnaces, and when white hot are taken to the rolls to be welded together and rolled out into merchant iron in the shape of either sheets, plates, bars, or structural shapes as desired. When cold this material is sheared and straightened, and is then ready for the market.

Charcoal wrought iron, commonly called **charcoal iron,** is made by remelting charcoal pig iron in a finery or run-out fire, in which the molten metal is exposed to a strong blast, which partly refines the metal by burning out some of the carbon, silicon, etc. The metal is then allowed to run out on the floor, forming a plate about two inches thick, which, after solidifying, is broken up into smaller pieces, and these pieces are then charged into so-called knobbling fires or sinking fires, using charcoal as fuel, where the metal is slowly melted again, the forgeman keeping the mass of charcoal and iron stirred up so as to bring every portion in contact with a strong blast blown in through tuyeres on the sides. This completes the purification of the iron, which forms a lump similar to the sponge in the puddling furnace. This lump of about 200 pounds is then taken out of the fire and forged under a steam hammer into elongated blocks commonly known as **charcoal blooms.** A plant of knobbling fires with their accessories is known as a **charcoal bloomery.** The blooms are afterwards rolled into bars (charcoal bars) similar to muck bars, and then cut up and piled for further rerolling into the shape of sheets, plates, bars, etc.

The process above described is still extensively used in Sweden, from which country large quantities of blooms are imported, but in this country very few, if any, run-out fires are in use at the present time. The common practice here is to melt down (sink) wrought iron or soft steel scrap direct in knobbling fires, using charcoal as fuel. The resulting metal, while much purer and softer than ordinary puddled iron, is usually not as pure and ductile as the Swedish iron, but it is claimed that, owing to its higher cinder contents, it will resist corrosion better than the Swedish iron.

In the manufacture of certain grades of boiler tubes, it is customary to use domestic charcoal iron in the center of the pile and Swedish iron for covers, that is, on the outside. This increases the ductility of the iron and yet maintains a greater resistance against pitting.

After leaving the puddle furnace, or knobbling fire, wrought iron does not undergo any material change in its chemical composition, and the only physical change is an expulsion of a large portion of the cinder; the small cinder-coated globules of iron are welded together, and the subsequent rolling back and forth will elongate these globules, giving the iron a fibrous structure.

**Double Refined Iron** is made by cutting up the finished bars, repiling the pieces on top of each other, then reheating these piles to a welding heat and rolling them out again, which drives the fibres closer together, thus increasing the strength and ductility of the metal.

The word **Steel,** nowadays, covers a multitude of mixtures which are very different from each other in their chemical as well as physical qualities. The ingredient that exerts most influence on these variations is carbon. High grade razor steel contains about 1¼ per cent. of carbon, springs 1 per cent., steel rails from ½ to ¾ per cent., and soft steel boiler plate may go as low as 1-16 per cent. of carbon. Steel which is very low in carbon can easily be welded, but it cannot be tempered; when carbon is above 1-3 per cent. welding is more difficult and can only be done by the use of borax or some other flux or by electric or thermit welding. Steel with carbon above ¾ per cent. can be tempered, that is, when heated to red heat and then quenched in water or other liquid, it becomes very hard and can be used for tools of various kinds, such as saws, files, drills, chisels, cutlery, etc. In tool steel other ingredients are sometimes used to influence its hardness, such as nickel, manganese, chrome, tungsten, etc., the last named playing an important part in so-called "high speed steels," that is, steel tools that will cut metal at a high speed without losing their temper or hardness.

As stated above, pig iron and cast iron contain about 4 per

* Reprinted from The Pilot, official publication of the P. & R. Ry. Dept. Y. M. C. A., Reading, Pa., April, 1906. The chapter referring to charcoal iron has been added since.

cent. of carbon, and wrought iron only a trace of it, while steel is between these two extremes. The manufacture of steel, therefore, refers principally to getting the right proportion of carbon. One method is to take pig iron and burn the carbon out of it, as in the Bessemer and open hearth processes, and the other method is to take wrought iron and add carbon to it, as in the cementation and crucible processes.

In the **Bessemer Process** the molten pig iron is put into a large pear-shaped vessel called the "Converter," the bottom of which is double, the inner one being perforated with numerous holes called "tuyeres" to admit air to be forced in under pressure. The molten iron (from 10 to 15 tons at a time) is poured into the converter while the latter is lying on its side, then the compressed air is turned into the double bottom as the converter rises to a vertical position. The air has sufficient pressure (about 20 lbs. per sq. inch) to prevent the molten metal from entering the tuyeres. The air streams pass up through the molten metal (piercing it like as many needles), burning out the carbon, silicon, etc., accompanied by a brilliant display of sparks and a flame shooting out of the mouth of the converter. The 15 tons of molten pig iron contain nearly ¾ of a ton of carbon, and since this carbon is all burned out in less than ten minutes, this rapid rate of combustion increases the heat of the metal very much; it does not cool it, as one would suppose at first thought. The flame, therefore, at first red, becomes brighter and brighter until it is finally so white that it can scarcely be looked at with the naked eye. A "blow" generally lasts about nine to ten minutes, when the sudden dropping of the flame gives notice that the carbon is all burned out. The metal in the converter is then practically liquid wrought iron. The converter is then laid on its side again, the blast shut off and a certain amount of spiegeleisen or ferromanganese is added in a liquid form so as to give the steel the proper amount of carbon and manganese to make it suitable for the purpose desired. The liquid steel is then poured out into so-called "ingot moulds" and the resulting "ingots" while still hot, but no longer liquid, are rolled out into blooms, billets, or rails without any additional reheating except a short sojourn in so-called "soaking pits." In some steel works where the molten pig iron is taken in large ladle cars direct from the blast furnace to the converter, it is possible to produce rails without adding any fuel to that contained in the molten pig iron, so that the red-hot rail just finished still contains some of the heat given it by the coke in the blast furnace.

The **Open Hearth Process,** sometimes called "the Siemens-Martin process," is similar to the puddling process, but on a much larger scale. The furnaces generally have a capacity of from 40 to 50 tons of molten metal (in some exceptional cases as high as 200 tons); they are heated by gas made from bituminous coal (oil and natural gas have also been used). The gas and the air needed for its combustion are heated to a high temperature (over 1000 degrees) before entering the combustion chamber by passing them through so-called regenerative chambers. Owing to this preheating of the gas and the air, a very high temperature can be maintained in the furnace, so as to keep the iron liquid even after it has parted with its carbon. The stirring up of the molten metal is not done by hooks as in the puddling furnace, but by adding to the charge a certain proportion of ore, iron scale, or other oxides, the chemical reaction of which keeps the molten iron in a state of agitation. While in the Bessemer process only pig iron is used, in the open hearth furnace it is practicable to use also scrap of wrought iron or steel, as the high temperature in the furnace will readily melt same. When the pig iron or scrap contains too much phosphorus, burnt lime is added to the charge; the resulting slag will absorb the phosphorus, thus taking it out of the metal. This dephosphorization by means of burnt lime is called the **basic process** in contradistinction to the **acid process,** where no lime is used, but where care must be taken that the metal charged is low in phosphorus. In this country the basic process is at present used only in connection with open hearth furnaces, while in Europe it is also used in many Bessemer plants, producing the so-called "Basic Bessemer steel."

**Crucible Steel** or **Tool Steel,** formerly called **Cast Steel,** is made by using high grade, low phosphorus wrought iron and adding carbon to it. The oldest method is the so-called "cementation process," in which the iron bars are packed in air-tight retorts, with powdered charcoal between the bars. The filled retorts are put into a cementation furnace, where they are heated to a red heat and kept at that temperature for several days, during which time the iron will absorb about 1½ per cent. of its own weight of carbon. (The process is similar to the case-hardening process familiar to many blacksmiths.) The carbonized bars, called "blister steel," are then cut into small pieces, remelted in a crucible, and from there poured into moulds, forming small billets, which are afterwards hammered or rolled into the desired shapes. The newer method is to put the small pieces of wrought iron direct into an air-tight crucible, mixed with the proper amount of powdered charcoal, and melted down; the iron will absorb the carbon much quicker while in a molten state than when only red-hot as in the cementation furnace. The other ingredients, such as chrome, tungsten, etc., are also added in the crucible.

**Malleable Castings** are produced in the reverse way from the blister steel referred to above, that is, instead of taking wrought iron and adding carbon, castings made of cast iron are made malleable by extracting the carbon. The castings are packed into retorts similar to the cementation retorts, but, instead of charcoal, an oxide of iron, generally in the shape of hematite ore, is packed with them, and kept in a red-hot state for several days. The oxygen of the ore will absorb the carbon in the iron, giving the latter a somewhat steely nature.

**Steel Castings** used to be produced in the same manner, but now steel castings are cast direct from the ladle containing molten steel, which is generally melted in an open hearth furnace, although small Bessemer converters are also sometimes used for this purpose.

While chemically there is not much difference between wrought iron and low carbon steel, there is considerable difference in their physical structures. Owing to the globules of pure iron being coated with cinder in the puddling furnace, the subsequent rolling and reworking, while expelling a large portion of this cinder, always leaves traces of it behind, which gives wrought iron the fibre. Steel having been produced in a liquid form, where the cinder all floated to the top and was removed, the metal is homogeneous, that is, without any grain or fibre. When subjected to many vibrations, or strains due to frequent expansion and contraction, wrought iron will generally yield gradually and give warning to the inspector, while steel is more liable to snap off suddenly. Wrought iron being composed of many fibres, the fibres can break one at a time without directly affecting their neighbors (like the strings in a rope), while a rupture once started in steel will extend more rapidly. Wrought iron will also resist corrosion and pitting longer than steel, no doubt due to higher resisting power of the enclosed cinder, which also causes the corrosive fluid to deflect endwise, thus weakening its action by diffusing it over a larger area and preventing deep pitting. Stay bolts and boiler tubes for locomotives have proven more satisfactory when made of charcoal iron than of steel. Thin sheets, tin plate, corrugated iron covering, wire fencing, pipes, oil well casings, etc., have also proven much more durable when made of wrought iron than when made of steel. On the other hand, in rails, tires, guns, armor plate, etc., steel has proven far superior to iron, owing to its greater strength and hardness, and where corrosion is of minor importance, owing to the rails, etc., generally being worn out long before corrosion has a chance to affect them seriously. When structural steel or iron is used for bridges, etc., it is necessary to protect the metal from serious corrosion by frequent and careful painting, and in the skeletons of high office buildings and other skyscrapers, when completely covered with concrete, etc., so as to thoroughly exclude air or moisture, steel as well as iron will last indefinitely.

Where material is buried in the ground, or exposed to the weather without the careful protection of paint, or where moisture has access to it by other channels, the interior of pipes, for instance, wrought iron will outlast steel by a good margin.

## Fagoted Iron, Busheled Iron, and Knobbled Charcoal Iron.

### 1. Fagoted Iron.

This is produced by piling up pieces of wrought iron scrap, such as bolts, bars, structural material, etc., in a box-like shape, using either old boiler plate or new muck bar as sides and covers. These so-called "box-piles" are then put into a heating furnace, heated to a welding heat, and then either rolled into the shape of the product desired direct, or rolled first into billets and then reheated and rerolled into the finished product. When the scrap used is strictly wrought iron, the finished bars so made are of a good quality, showing a higher ductility than those made from ordinary muck bars, but, unfortunately, it is a difficult matter to get strictly wrought iron scrap without an admixture of steel scrap, and, while the mixed-in soft steel does not reduce the strength or ductility of the metal, it reduces its resistance against corrosion, and therefore it should never be used in the manufacture of material exposed to corrosive influences, such as corrugated iron sheets, pipes, etc.

### 2. Busheled Iron.

Busheled iron is made by taking miscellaneous junk-yard scrap (generally small pieces), sometimes mixed with iron and steel turnings, swarf, etc., and heating same to a welding heat in a furnace similar to a puddling furnace, then forming it into lumps similar to a puddle ball, running same through a squeezer to form an elongated round bloom, which is then rolled out into muck bars, which are afterwards cut up, piled on top of one another, heated to a welding heat, and then rolled out into the desired finished product. Owing to the irregular composition of the scrap, which is often mixed with high carbon and other alloy steels, the material so produced is very unreliable as to its physical qualities and should never be used where either strength or longevity is an object.

### 3. Knobbled Charcoal Iron.

As explained in the chapter on "Charcoal Iron," in the enclosed monograph "Iron and Steel," there are two grades of charcoal wrought iron. The first is made from charcoal pig iron, and the other from wrought iron or soft steel scrap. (Practically all the charcoal wrought iron made in this country is made by the last-named method.) While both steel and wrought iron are used in the latter process, the subsequent manipulation is entirely different from the fagoting or busheling processes described above, in which cases the different pieces of scrap retain their individuality in the pile and are stretched out in rolling, while in the knobbling fire the scrap is melted down drop by drop so that each drop as it sinks into the mass of cinder at the bottom of the fire is coated with cinder similar to the coating of cinder on the iron globules in the puddling furnace. In other words, the metal returns to its original state and forms an entirely different structure from the iron that has been produced by simply heating the scrap to a welding heat and then rolling it out. Because busheled iron is of such an unreliable quality and is the cheapest rolled iron that can be produced at the present time, its shortcomings have been used by the champions of steel as an argument against charcoal iron, by claiming that both processes are practically the same. Busheled wrought iron is a conglomerate of small pieces of iron and steel of different grades, while the iron produced in the knobbling fire is resolved into its original state, so as to cover each drop of iron with its coating of cinder. The lumps produced in the knobbling fire are forged under a steam hammer, then rolled into bars which are repiled, reheated, and rerolled, thus producing a metal of high ductility and uniformity, and at the same time retaining the rust-resisting cinder films, the same as wrought iron made from puddled pig iron.

READING IRON COMPANY.

READING, PA., October 1, 1912.

Published by the Society for Industrial Archeology

Room 5020 National Museum of American History Washington, DC 20560

Frederick Overman
1850 The Manufacture of Iron
Phila: Henry C. Baird

- gives detailed info + graphic descriptions of HOW TO BUILD A Furnace.

- limited printing — Vic Rolando has a copy.

From: SIA Newsletter. New England Chapters 3(1/2) 1982

and improvements. In the last years of operation, grinding has been done only during the period of the spring freshets in April and May. The Parker River has become overgrown, and the flow of water has decreased. Snuff, however, is still being ground on this river, a milling process that emerged with grinding at the L & M in 1804. Soon to be a vanishing industry, for nearly 180 years power from the Parker River has been harnessed to grind snuff in Byfield, Massachusetts.

1. Most of the records are 20th century ledgers and journals that begin 1899-1900. Earlier records, mainly incoming orders for snuff and some machinery repair slips, were unfortunately vandalized. These, left unsorted, were put into 2 boxes for storage. An attempt is underway to find a permanent home for the Byfield Snuff Company Records
2. "In 1691, David Wheeler of Rowley conveyed to his son, Nathan, '30 acres in Newbury'... In 1734, Nathan conveyed to Nathan junior 'one and a quarter acres' on the northeast part of the 30 acres 'at a falls on the river, with conveniences for erecting a mill' and by his will, proved in 1741, gave him his homestead of 35 acres. A saw mill was built and in use until a date later than 1771. This mill and 70 acres adjoining reverted to Samuel and Rebecca Noyes and Sarah Sawyer, children of Nathan Wheeler, who sold it to Joseph Pearson in 1796." An untitled typed sheet. This and other information, including deeds from which much historic information was obtained, is located in the office, along with current company records, of the Byfield Snuff Company, Byfield, Massachusetts.
3. In 1705 the first Benjamin Pearson bought land on the Parker River, and in 1709 he acquired an additional 24 acres with a fulling and sawmill. In "Homestead of Benjamin Pearson," John Currier gives an account of the early Pearson's landholding, the homestead, and its famous elm tree. John A.S. Currier, Ould Newbury: Historical and Biographical Sketches. Boston: Damrell and Upham. 1896. 301-304. (A small group of SNEC members toured this mill during grinding in the spring of 1978.)
4. Patrick Malone, "Recording of the Power System, L & M Mill," October 24, 1981.
5. After the Byfield Company takeover in 1899, all incoming tobacco was stored and the curing process begun in the upriver mill. In 1904 an early concrete warehouse was constructed and a second one in 1909 to house incoming hogsheads of tobacco along with barrels of ground tobacco.
6. Patrick Malone, ibid.
7. After the 1899 consolidation, excess ground tobacco from the L & M Mill was put into barrels each weighing 140 pounds. These were taken to the upper mill, and 5 barrels full of ground tobacco were emptied here into large storage boxes each weighing 700 pounds. The tobacco was left to cure for one year, and in recent times it has sometimes cured for two years.
8. A sawmill on the property was partially converted to grind snuff during this period. One grinding machine was installed, and this was shut down around 1945 when demand no longer necessitated grinding in three mill locations.

*Betsy H. Woodman*
*Woodman Associates Architects*

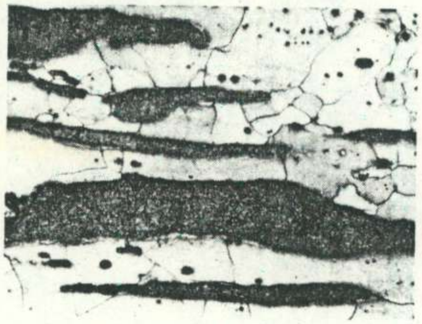
ARTICLE

## Iron and Steel for New England Industry:

Archeological recording of the sites of iron and steel works that supplied 19th century manufacturers in New England would help answer several questions in the history of American technology.

Many questions about the history of manufacturing can only be answered through the study of artifacts and work places. This is particularly true of metallurgical industries of the 19th century. Ironmasters did not write much about their work, and even professional scientists (such as Benjamin Silliman, who visited many ironworks) did not have the means to write technical descriptions of the processes they saw.

Manufacturing could not have grown rapidly in New England in the early 19th century had there not been a local, heavy metallurgical industry already in place. In the 17th century, local New England ironworks had served local needs. (Attempts at larger scale production, as at Saugus, were financial failures in the Colonial economy.) But, by the middle of the 18th century the iron industry began to concentrate in western Massachusetts and Connecticut where water power, ore, and charcoal were all abundant. War time demands stimulated its growth, and by the decade of the 1790s blast furnaces, fineries, forge hammers, and slitting mills were in place and in production, ready to supply all kinds of heavy metal goods. The New England makers of arms, edge tools, nuts and bolts, textile machinery, and other metal products turned to this source for materials, forgins and castings. Eli Whitney, for example, ordered his forge hammers, the ironwork for his water power system, and his initial stock of barrel iron from the works of Forbes & Adams in Canaan, Connecticut.



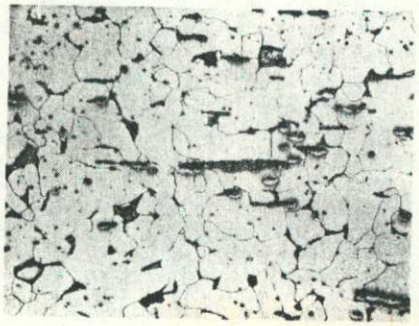


Figure 1. Photographs at the same magnification of the structure of a sample of bar iron made (left) in Litchfield County (Connecticut) and (right) at Marshall's works, Wednesbury, England. The English iron has much finer and more uniformly distributed slag particles. Courtesy of Robert Gordon.

By the early decades of the 19th century, the ironmasters of western New England had established dor themselves a reputation as suppliers of the finest bar iron available in America; their iron, for example, was shipped to the armory at Harpers Ferry for use in preference to that available from Pennsylvania and Maryland.

Yet these ironmakers were soon unable to meet the requirements of their customers. Deliveries of iron became unreliable, and bad quality iron was supplied with the good. Eli Whitney, Jr. complained in 1843 that "it is the most troublesome affair of my business to get suitable Iron for Barrels." The Springfield Armory resorted to sending inspectors to the ironworks to try to improve the quality of the metal supplied for arms-making, but, by the time the Civil War broke out, the Armory had abandoned American suppliers and was entirely dependent on imported English iron, a cause for concern to the government in Washington. In a few decades the New England iron industry had fallen from an established position as suppliers of an essential and superior industrial product to that of a lingering industrial relic.

Why did this take place? It was not due to any shortage of resources; pig iron production continued in western New England until well into the 20th century. Nor was it due to the introduction of the Bessemer process; Bessemer steel did not supplant iron and crucible steel for quality industrial products of the type made in New England until the last decades of the 19th century. The quotation above suggests that the problem was with the quality of the bar iron supplied from about 1830 onwards. The aim of most manufacturers in New England was to increase production through the use of power-driven, self-acting machinery. The operation of this machinery required regular delivery of feedstock of uniform dimensions and properties. Thus, when the Collins Company installed E.K. Root's automated ax-forming machines in 1846, Samuel Collins observed "Root's punching machine requires a better quality of iron." A better quality of iron was in demand, but poorer quality was being supplied. Evidence from archeology can be used to explain why.

The quality of wrought iron can be easily assessed by examination under the microscope. Fortunately, only a small sample is needed, and this can often be removed from an artifact without damaging its appearance. The first indicator of the quality of a sample of bar iron is the form and distribution of the slag particles it contains. Hammering and rolling at the forge where it is made is intended to work as much slag out of the iron as possible and to disperse the rest uniformly as small particles. The second most important factor influencing the quality of wrought iron is the phosphorous content; the presence of more than a trace of phosphorous makes the iron brittle. Phosphorous content can be judged from the appearance of the slag inclusions under the microscope, and it can be measured on the sample with the electron microprobe. Figure 1 shows for comparison the microstructure of gun iron being produced in England and of a sample of Litchfield County (Connecticut) bar iron presented to the Metallurgical Museum of Yale College (and theretore presumably the maker's best), both made about 1855-60. The difference in the slag distribution is clear; microprobe analysis also shows that the phosphorous content of the Salisbury iron is much higher than that of the English iron. Although only a limited number of samples of New England bar iron have been presented for examination so far, the results frequently show variable slag distributions and high phosphorous contents. Such iron would not be suitable for use in sophisticated production equipment such as the barrel rolling mill introduced at the Springfield Armory in 1858. In this machine, shown in Figure 2, a weld must form continuously as the barrel skelp passes through rolls. Inhomogeneities in the metal will result in bad welds.

The laboratory evidence, though still limited, shows that the New England makers of bar iron lost their industrial customers because of inability to make a reliable, uniform material that could be used in production by machinery. To

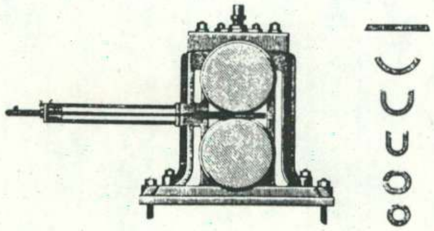
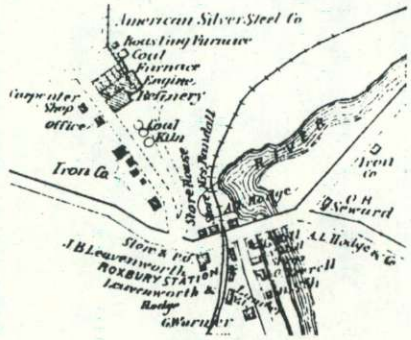


Figure 2. The barrel rolling and welding mill as used at Springfield and other New England Armories in the mid-19th century. The skelp of bar iron is bent up by successive passes through grooved rolls as above on the right and then welded between rolls and a stationary mandrel, as shown on the left. Courtesy of Robert Gordon.

find out why they were unable to do this while English and Scandinavian makers were able, we need to know what sort of physical plant they were using. Census data suggest that by 1830 most of the bar iron manufactured in Connecticut and Massachusetts was made at forges by fining pig. However, no New England forge of the 18th or 19th centuries has been carefully documented yet. Plenty of forge sites are marked on maps of early and mid-19th century New England, but technical details are lacking on maps and in local histories. Three different types of plant were in use at various places and times, the bloomery, the finery, and the wood-fired puddling furnace. To interpret the technology that was in use, we need to know the dimensions and layout of a plant of each of these types and to have samples of the slags left behind from their operation.

Much of what has been said about bar iron is also true of steel. Ironmasters in America found production of quality steel a most difficult problem throughout the first two-thirds of the 19th century. Manufacturers (like the Collins Company or the Springfield Armory), who required high quality steel, had to use imports throughout this period, though they frequently experimented with samples of the domestic article. Samuel Collins, reflecting on the history of his company, remarked that "If we could have been supplied regularly with a uniform quality of superior steel we could have beat the world on Edge Tools ... ." One of the most interesting archeological sites in New England is that of the American Silver Steel Company in Roxbury, Connecticut. It was probably the first integrated steelworks built in North America. As shown by the map in Figure 3, it had a mine, ore preparation facilities, a blast furnace, and a refinery. Examination of samples presented by the Company to the Metallurgical Museum of Yale College in 1867 suggests that the proprietors of this works were attempting to make puddled steel, a technically difficult task but one that was successfully done in Great Britain until the end of the 19th century. The attempt was not successful; the derelict appearance of the works in 1890 and 1970 is shown in Figures 4 and 5. Documentation of this site, which is now under the care of the Roxbury Land Trust, would be a most fascinating contribution to the history of American metallurgical technology.

Figure 3. Map of the site of the American Silver Steel Company plant in Roxbury, Connecticut. Ore was received on the railway shown at the top of the map from adits driven into Mine Hill, roasted, smelted in the blast furnace, and converted to steel in the "Refinery." Courtesy of Robert Gordon.



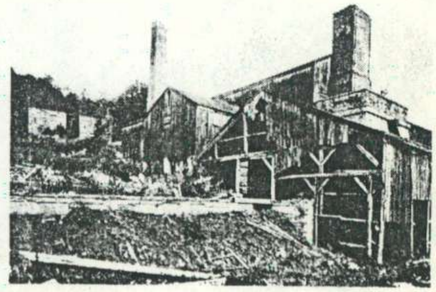



Figure 4. The steel works at Roxbury in the 1890s. The roasting furnaces may be seen in the background. The blast furnace with its brick stack is at the right. Courtesy of Robert Gordon.

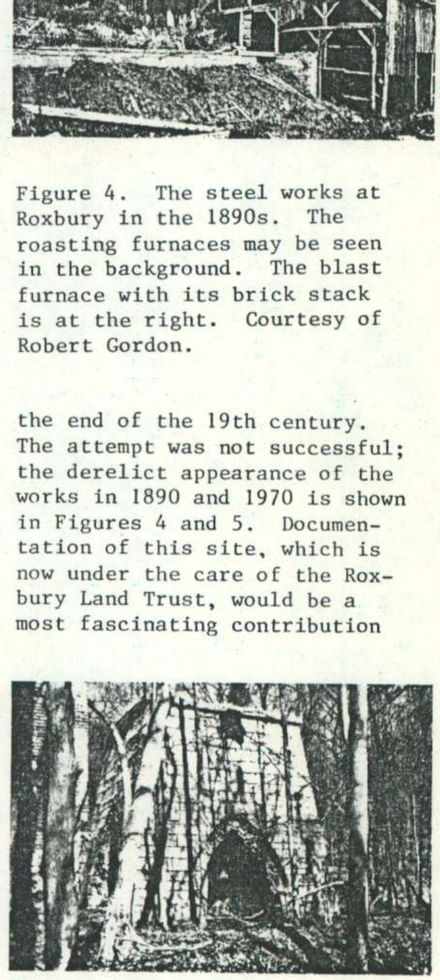


Figure 5. The site of the Silver Steel Company in 1970, showing the remains of the blast furnace. Courtesy of Robert Gordon.

It is remarkable that we know more about the technology for making bar iron and steel in the Roman age of Europe than we know of that used in 19th century New England. One reason is that the blast fur-

naces, because of their size and durability, receive a disproportionate share of attention. Though large, they are by no means the most important part of the equipment required to produce bar iron; conversion of pig to bar iron or steel is technically more demanding but as yet poorly documented in New England.
*Robert B. Gordon*
*Yale University*

CURRENT RESEARCH IN NEW ENGLAND

CONNECTICUT

Metallurgical Archeology at the Whitney Armory Crucible Dump:
In autumn 1979 a Yale University class in archeological field methods partially excavated a dump of used graphite foundry crucibles that is located just outside the Whitney Armory site in Hamden, Connecticut. Makers' marks on some of the crucibles, plus the probable dates of other objects found in the dump, indicate that the dump was used during the 1842-1888 period in which Eli Whitney, Jr. was in charge of the Armory. More recently, metallographic and microprobe analysis has been carried out on some artifacts from the dump and from other places at the Whitney site. These analyses have shown that Whitney, Jr. used his foundry to make pistol frames of malleable iron castings instead of forging them, although forging is the only method described for this in the literature of 19th century small arms technology. They have also corroborated written allusions to Whitney, Jr.'s early shift in materials from wrought iron to steel for the barrels of his guns. A report on this research was given by Carolyn Cooper at the 1982 SIA Annual Conference in Harrisburg.
*Carolyn Cooper*
*Yale University*

Phoenixville:
This past spring and summer a volunteer crew under the direction of John Worrell (Old Sturbridge Village) and David Simmons (U. of Pennsylvania) conducted excavations at several sites relating to the early 19th century mill village of Phoenixville, CT. Preliminary and intensive excavations were undertaken at 3 sites which front on what was then the turnpike from Hartford to Providence: the Latham house, built as company housing by the Sprague Manufacturing Co. in the early 1820s; the Gurley/Taylor house, a non-company house, also built in the 1820s; and a blacksmith shop, in operation from about 1822 to 1836. A portion of the front yard and the front foundations of the Latham house were excavated, yielding considerable information on the construction sequence, landscaping, and early use of the house. Data from this site, a mill official's house, will be compared with that obtained from two nearby company tenements, excavated by the OSV Field School in Historical Archaeology in 1980. These sites, in turn, will offer comparison with the Gurley/Taylor house, built by a blacksmith as part of an expansion of a craft neighborhood near the mills. The house was sold to a fellow blacksmith and then to a poor, single woman, both of whom were attracted to Phoenixville from other towns. A number of areas in and about the Gurley/Taylor house were excavated, revealing several significant changes to the structure early in its use, including the filling in of an unusual stone feature -- possibly a spring house or root cellar -- underneath a portion of what is now the front terrace. Entered from the lower floor of the house, the chamber was capped with cut stones, one of which measures 14 ½ feet in length. The blacksmith shop, which has yielded numerous artifacts relating to the craft, continues to be dug this fall. In addition to these sites, preliminary excavations were undertaken at the Adams house, an 1820s-1830s dwelling which later housed a millinery shop, and the Phoenix mill, a stone textile mill built by the Phoenix Manufacturing Co. in 1823. Artifactual analysis of the domestic sites has begun and is continuing this winter, as is further documentary research. The excavations at Phoenixville will serve as the basis of a dissertation by Simmons on the community and its neighborhoods during the early 19th century.
*David Simmons*
*University of Pennsylvania*

MASSACHUSETTS

Salt Marsh Haying in Newbury, Massachusetts: Site of a one time thriving and profitable salt marsh haying industry, the Newbury marshes in Newbury, Massachusetts are once again returning to their natural state.[1] The drainage ditches, originally cut into their surfaces to drain off excess water so that the hay could be more readily harvested, are fast becoming overgrown.[2] These ditches, when in use, also served to delineate the various plots within a tract of the marsh land. In late August, or early September, depending on the Farmer's Almanac, the tides and weather, the hay was cut and gathered in. Some was taken by wagon directly to the barn. Hay, in outlying regions or on islands located near the salt marsh rivers, was taken by gundelow to a loading dock or loading site. These flat bottomed boats, indigenous to the area, were designed specifically for hauling the loose and heavy hay. From a loading dock, the hay could either be sold or taken by wagon to the barn. Much of it was left on the marsh and was ingeniously

# Eighteenth-Century Ironworking in Sharon, Massachusetts

**by Judith Dolan**

Of the many furnaces and forges that once dotted the eighteenth-century Massachusetts landscape, traces remain of only a few. The colonial iron industry was a small but important element in the economic system, and most towns or counties had their own forges or furnaces. During the seventeenth and eighteenth centuries most iron products were supplied by England; however, these small forges were established to serve the communities' need for tools and their repair. Gradually local artisans began casting holloware products and producing wrought-iron materials. The Massachusetts iron industry, however, did not prosper and expand in the post-colonial period, as did the iron industry in other states, and today only a handful of historical ironworking sites, such as the Saugus Ironworks, have been studied in any detail.

Recently, the Sharon Historical Society sponsored a documentary and archaeological study, through the Center for Archaeological Studies, of one such ironworking establishment. The Ebenezer Man Furnace, known historically as the Stoughtonham Furnace, is located at the southern end of Gavin's Pond in Sharon, Massachusetts. It was built in 1762 by a partnership of nine men, who decided to cast holloware products such as kettles, pots, and pans. One of the original owners of the furnace was Ebenezer Man, for whom the furnace was later named.

The location of the three-acre lot, and specifically the site of the furnace itself, was well suited to accommodate such an industrial enterprise: there were plentiful local supplies of iron ore; Billings Brook, once dammed, provided water power to operate the water wheel; and a steep hillside next to the site provided easy access via a charging bridge to the top of the furnace. The first priority in this enterprise must have been the construction of a stone dam, thus forming what is now known as Gavin's Pond. Along the east side of the dam the wheel pit, sluiceway, and tailrace were built, and adjacent to this the furnace. The last was a substantial structure, approximately 20-25 feet high and 18-20 feet square at the base, tapering by a foot at the top. The outer walls were constructed of cut and fitted granite blocks, and the inner walls of the furnace opening, known as boshes, were lined with firebrick, a refractory material. Between these two walls the space was filled with stone chips, rubble, clay, or cinders, which allowed the furnace lining to expand and contract with the heat. At least two arches were built on the outside of the furnace, one for the leather-clad bellows and another from which furnace workers tapped the iron and guided it into the sand molds.

While in operation the furnace was run continuously, and a casting would be done approximately every twelve hours. Just before the iron was tapped the molds were prepared for the casting of holloware objects and iron bars. When all was ready, the bellows were stopped, the iron was tapped, the slag (impurities) was drawn off the top of the molten iron, and the molds were filled with the hot metal. Once cooled, the holloware objects were finished off and prepared for market. This process of reducing the charcoal, iron ore, and limestone into molten iron required great skill. The founder was responsible for loading the correct proportions of raw materials into the furnace, for preparing the casting beds, and for knowing exactly when the furnace was ready to be tapped. Poorly tended furnaces were highly dangerous and more than one is known to have exploded, causing great property damage and personal harm.


*Site map of the Ebenezer Man Furnace Site at Sharon, Massachusetts. Remnants of the furnace foundation were found in squares 14 and 18 (upper-center of the map).*

POOR QUALITY ORIGINAL LIGHT

pgs 1-11

The Ebenezer Man furnace was actually the center of an industrial complex; it was surrounded by storehouses, dwellings, a trip hammer, and blacksmith shop. The latter two were located at the western end of the dam, about 150 feet from the furnace, and were used to convert cast-iron pigs and bars into wrought-iron objects. The storehouses were built at the top of the ridge, but the exact location of the Ironmaster's house is unknown. A second blacksmith shop and dwelling house, located about one-half mile south of the furnace, were leased from a neighboring landowner, Benjamin Fairbanks. No account books or business records survived to detail the furnace's daily and annual operations, but with the use of a blast furnace, trip hammer, and two blacksmith shops, the complex would have been able to supply the local community with both cast-iron and wrought-iron products.

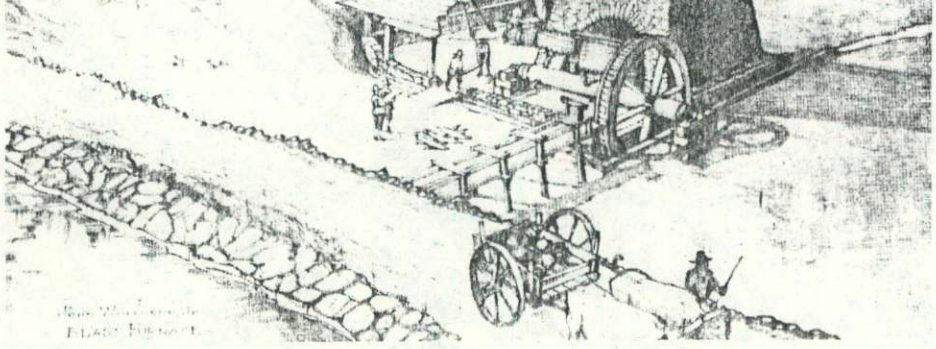
Despite what would seem to be a steady operation, the furnace was apparently not always profitable enough to satisfy the owners. In 1770 the furnace was sold to Richard Gridley, Edmund Quincy, and Joseph Jackson. Within a few years the impending conflict between the English loyalists and the colonists was evident, and the new owners prepared to cast cannon and shot for use by the American forces. Gridley and Quincy owned several mineral rights in the area and secured more to supply the furnace with plenty of iron ore. High-grade ore was also brought up from the New Jersey-Pennsylvania area for use in producing the cannon.

The first cannon produced in America were cast here at the site in 1775. Initially, the traditional two-mold method of casting cannon was used, but this technique later was replaced by an improved process whereby they were cast solid and then bored by machine. A Frenchman, Monsieur de Marasquelles, was instrumental in propagating this new technology throughout the New England iron industry.

In 1777 Uriah Atherton bought the furnace and continued to cast cannon and shot for the remainder of the Revolutionary War. The reasons for the demise of the furnace operation at Sharon are unknown, although it is known that Atherton invested in another furnace in 1780. He may have shut down the Man furnace at this time, taking with him any extra raw materials and tools for use at the new one.

Members of the Sharon Historical Society worked closely with myself and other Boston University archaeologists at the Man furnace site during September and October of 1983. Our excavations uncovered a small portion of the furnace structure that had survived to a height of three feet. We found several samples of the firebrick furnace lining in our test pits, as well as a few nails that had once attached the leather bellows to its wooden frame. A cast-iron wheel was also found that might have belonged to the cannon-boring machine. The only samples of furnace products found were four pieces of shot, ranging in diameter from 1--1¾ inches. The stone-lined tailrace and stone dam are still visible, but the wheel pit and sluiceway have been extensively reworked and thus show nothing of their original construction.

The importance of the Man furnace lies not only in its contribution to the American Revolution, but also in what the study of it can tell us about the development of the ironworking industry in America. The iron industry in Massachusetts during the eighteenth century was characterized by many small furnaces scattered about the countryside, each one serving its local community. The fact that the Sharon Casting Furnace site has survived virtually undisturbed to the present day, unlike so many other early ironworking sites, makes it a perfect target for controlled excavation. The Center plans to continue its work at the site in close cooperation with the Sharon Historical Society to shed more light on an important but little understood aspect of colonial life.



*Artist's reconstruction of the John Winthrop, Jr., Furnace in Braintree, Massachusetts. The features are comparable to those that once existed at the Ebenezer Man site. Reprinted from* Historic Quincy Massachusetts, *edited by William Edwards, Quincy, Massachusetts.*

*Judith Dolan is a graduate student in the Department of Archaeology at Boston University. Her study of the Sharon Casting Furnace site, sponsored by the Sharon Historical Society, is being conducted to help qualify the site for the National Register of Historic Places.*

### Further Reading

*See James Mulholland,* A History of Metals in Colonial America, *University of Alabama Press, 1981, and for a description of ironworking in Massachusetts, see Edward Neal Hartley,* Ironworks on the Saugus, *University of Oklahoma Press, 1957.*

Boston University
Center for
Archaeological Studies

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Spring 1984
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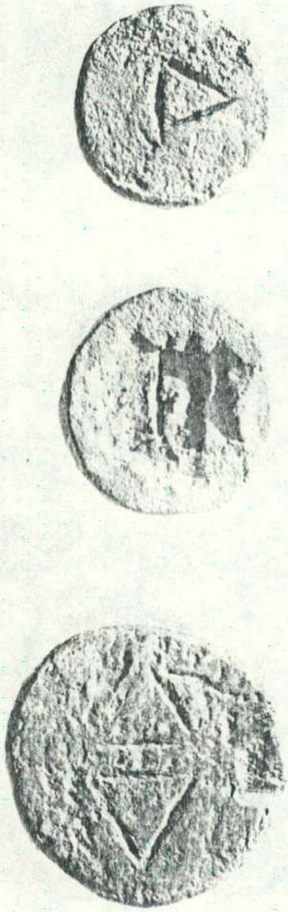
# CONTEXT



*Inscribed Minoan balance weights from Ayia Irini, Keos, Greece. See "On Clay Tablets, Lead Discs, and Ancient Mathematics," page 6.*

## INSIDE THIS ISSUE:



## Excavation at the Golden Ball Tavern

**by Ricardo J. Elia**

During the tense weeks before violence erupted between British and American forces at Lexington and Concord in April 1775, the British commander in Boston ordered two of his officers on a reconnaissance mission to examine the countryside west of Boston. Not certain whether they would receive a friendly or hostile reception, the British officers made their way west along the Boston Post Road, stopping late in the day at an inn in Weston. According to their report to General Gage,

> We stopped at a tavern at the sign of the golden-Ball, with an intention to get a drink and so proceed; but upon going in the landlord pleased us so much, as he was not inquisitive, that we resolved to lye there that night; so we ordered some fire to be made in the room we were in, and a little after to get us some coffee; he told us we might have what we pleased, either tea or coffee; we immediately found out with whom we were, and were not a little pleased to find, on some conversation, that he was a friend to government ....

Isaac Jones, a prominent Weston citizen and landlord of the Golden Ball Tavern, signaled his Tory sympathies to the British officers by offering them tea at a time when many American colonists were boycotting tea as a protest against British colonial policies. During the previous year, Jones had come under increasing pressure on account of his political leanings. He was censured as an "Enemy to his Country" by one revolutionary committee, and in March 1774, in a Weston version of the Boston Tea Party, a mob of about 100 people broke into his residence at the tavern and thoroughly ransacked the house.

Despite his apparent Tory sympathies, Isaac Jones eventually joined the side of the united American colonies against the British. However reluctantly, he probably signed an oath of allegiance to the revolutionary cause soon after the fighting actually began. By 1777, at any rate, he was hauling goods under contract to the American Army. His tavern continued to serve the public throughout the war, and remained an inn until 1793.

Built between 1764 and 1769, the Golden Ball Tavern is a fine example of Georgian-style architecture and is listed on the National Register of Historic Places. The property, acquired in 1963, is owned by the Golden Ball Tavern Trust, which lovingly maintains the house under the guidelines of a special "liberation philosophy." Rather than remove all later alterations and additions in order to create an artificial restored version of the house as it may have appeared in the eighteenth century, the Trust has chosen an "archaeological" approach to presenting the house in which successive changes are preserved and presented as a means of understanding the history and development of the house through time.

Visitors to the tavern can see, for example, how the large original 1760s fireplace and bake oven were converted into a smaller fireplace in the early nineteenth century, and how, still later, the second fireplace was itself bricked in and replaced with a freestanding stove, as a response to the in-

*Continued on next page.*

# VERMONT Life

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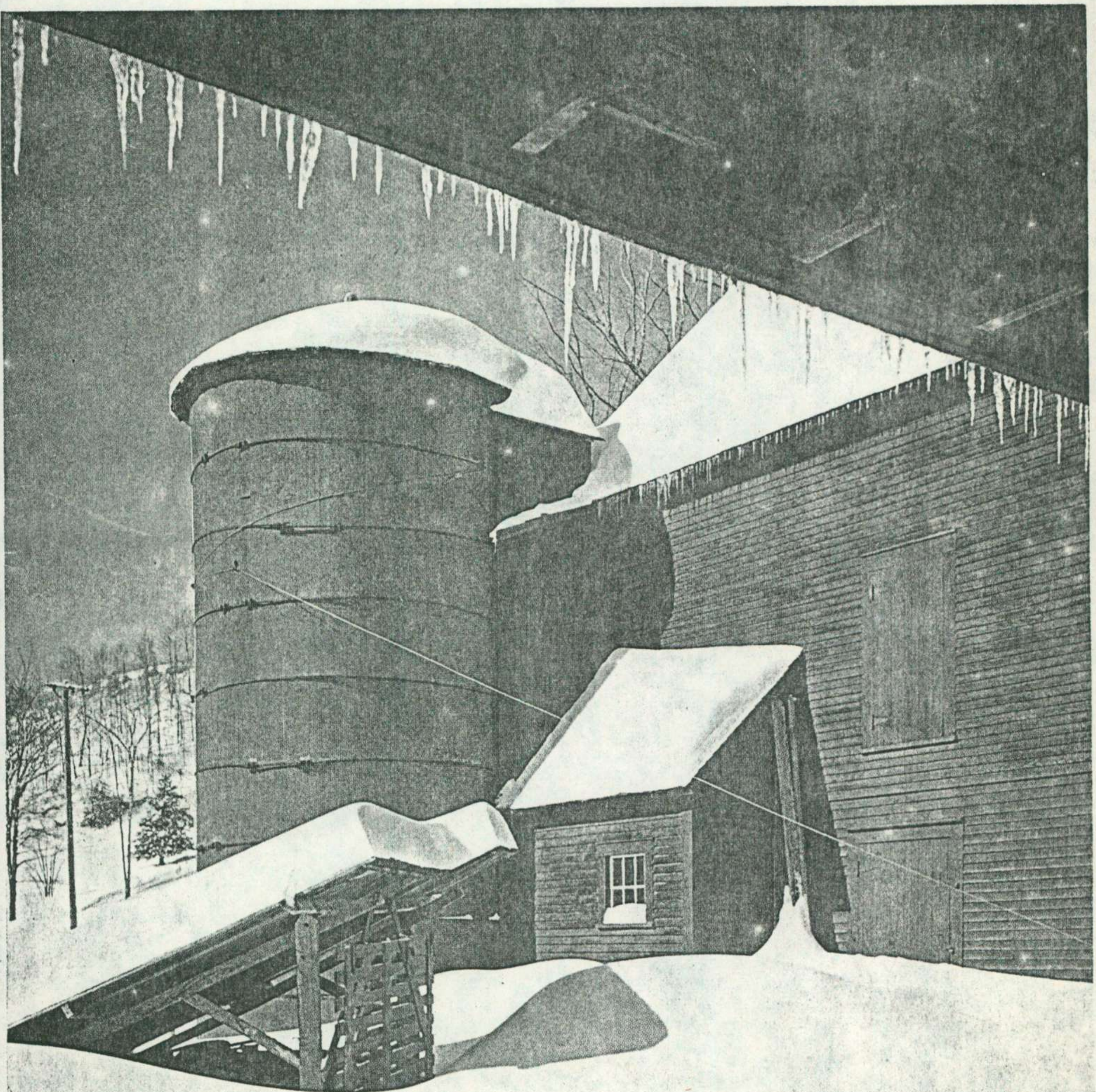
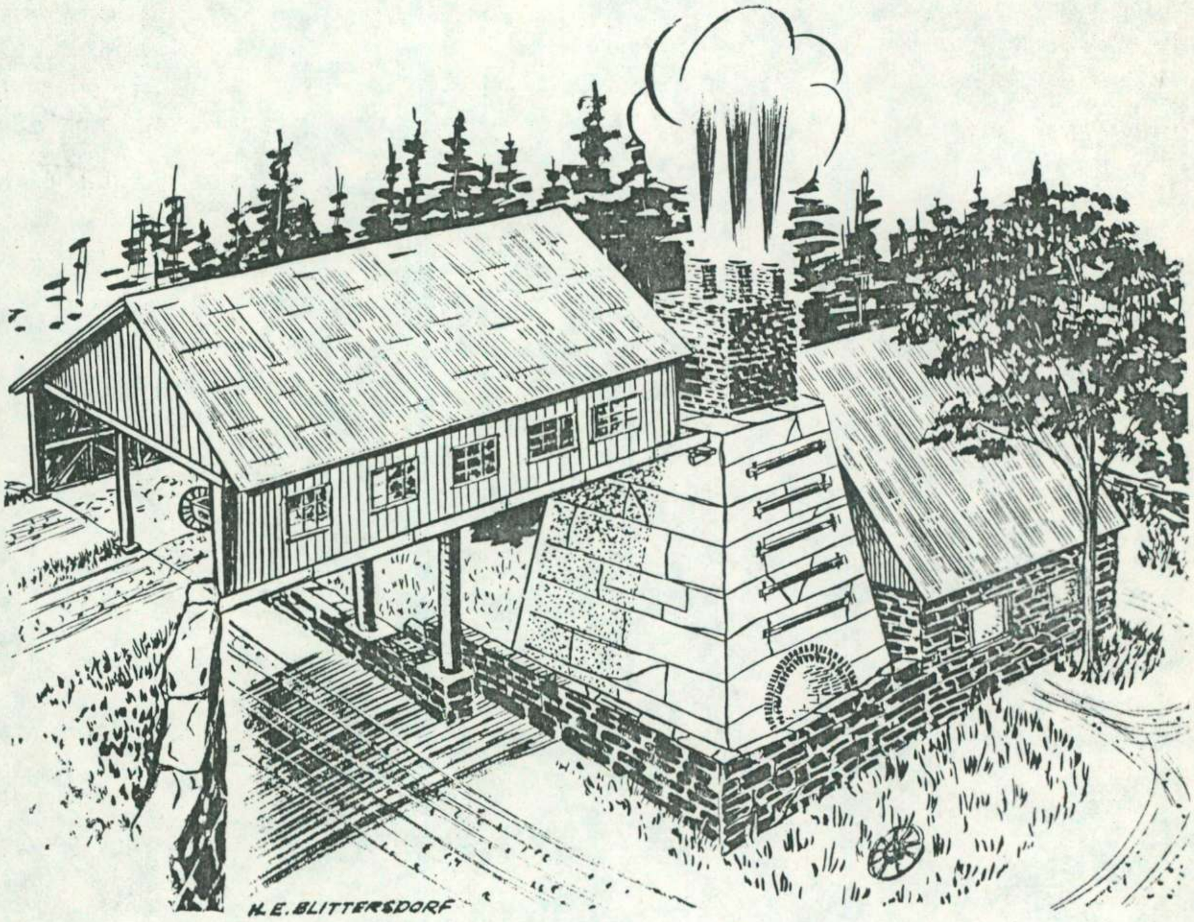
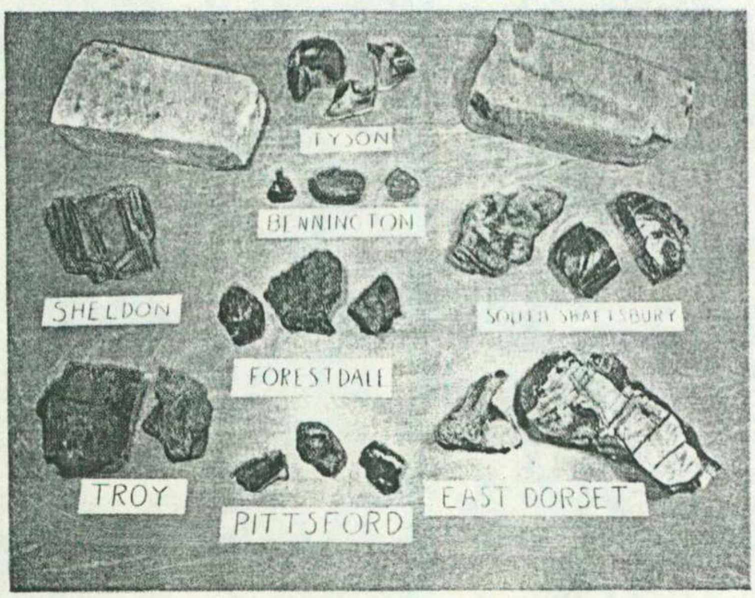


# FURNACES, FORGES AND F(



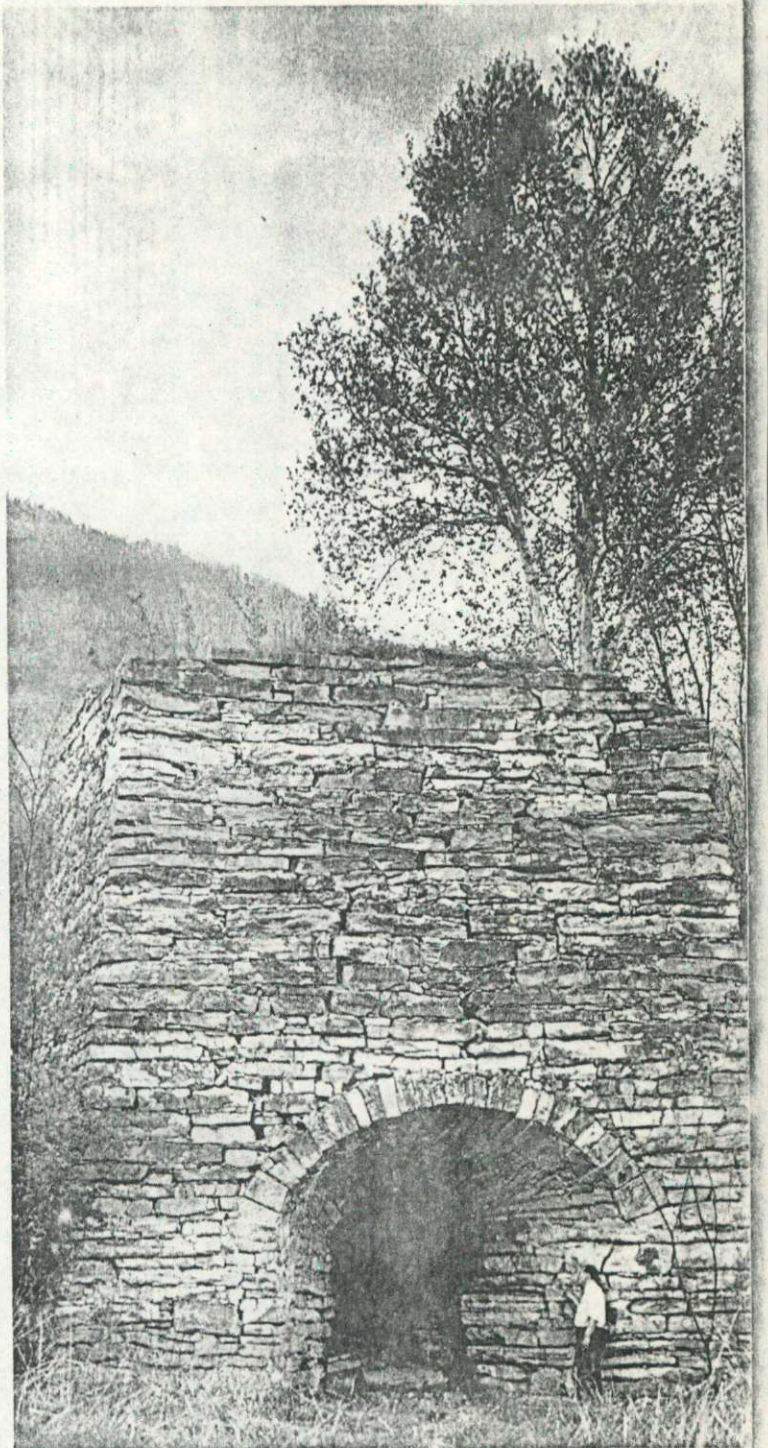

ABOVE: *The old Pittsford Furnace near Pittsford Mills had the good fortune to be built practically atop an iron ore bed.*




LEFT: *These slag and ore samples from the author's collection were gathered at the sites of old Vermont iron works. At top are two special-shaped fire bricks from Pittsford and South Shaftsbury furnaces.*

# OUNDRIES

*Active old foundries and crumbling stone stacks are the reminders today that Vermont 140 years ago led the Nation in the production of iron.*



*Familiar sight to thousands of motorists is the old limestone and marble stack of the Dorset Iron Company at the side of Route 7 near East Dorset, Demming Pond and Mt. Aeolus' slope beyond. Birch trees have an affinity for old iron sites.*

IRON IN VERMONT? A visitor from Minnesota's Mesabi country will scoff at such a thing. But a check of state geology reports and the history books will show that not only was there plenty of iron in Vermont, but that the state once was in the forefront of iron production.

Bog ore was first discovered by pioneer Vermonters in the swampy areas and low spots which had once been covered by the pre-historic "Champlain Sea." There were workable deposits of bog iron in Highgate, Swanton, Sheldon and Ferrisburg, with the biggest bed in Monkton. This ore was not mined, but simply dug out of drained open pits.

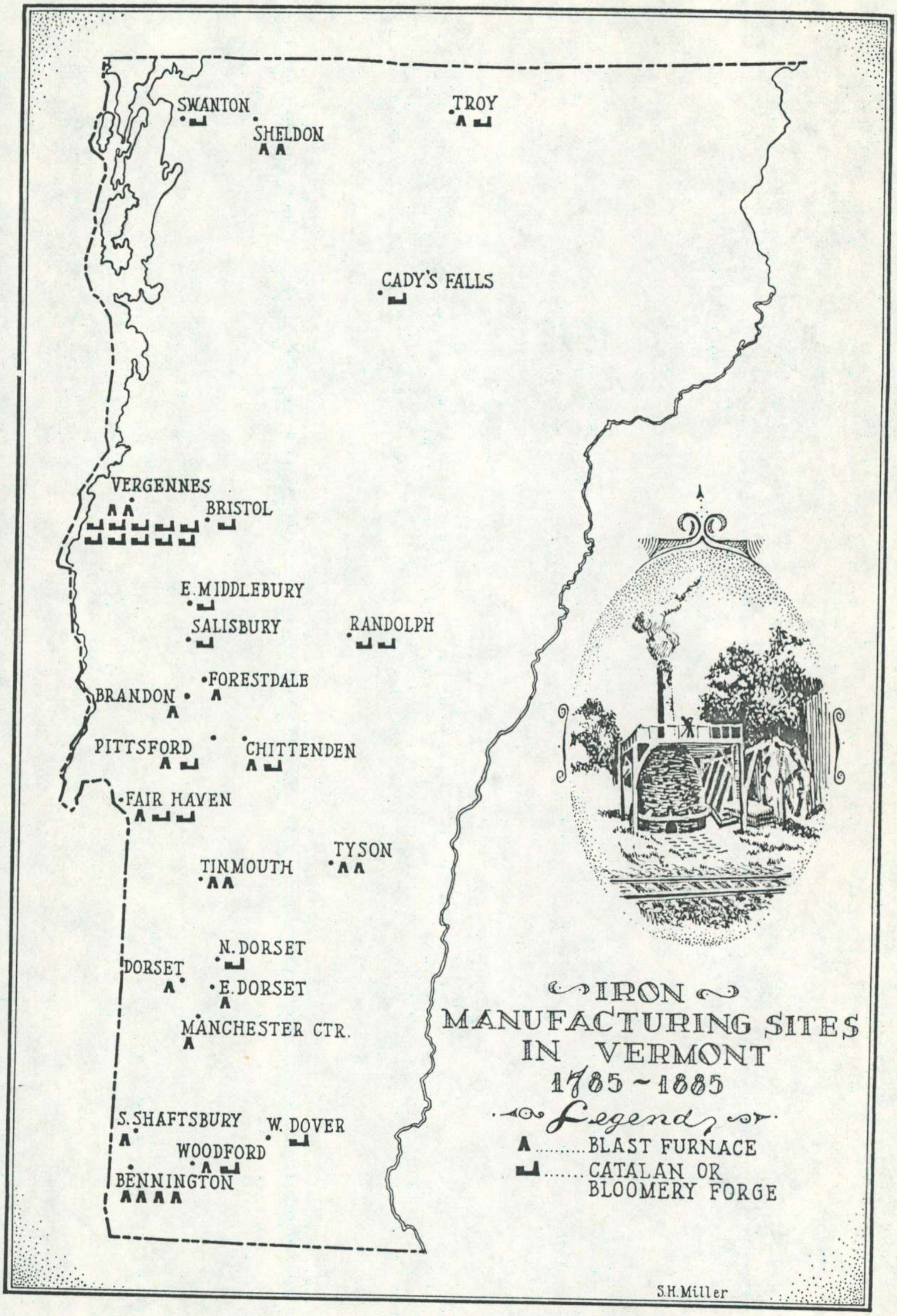
The other main type of Vermont iron is known to geologists as brown hematite. This was harder to get out of the ground. It was usually found in layers of from a few inches to several yards thick, and might extend a few feet, or several miles. Ore of this kind needed real mines, like the ones dug in Chittenden and Bennington where the miners descended sixty feet into a shaft and then picked away at the ore in galleries that extended in several directions.

Possession of an ore bed didn't mean that you had a saleable product. To produce it, you had to build a blast furnace, or a bloomery forge. A furnace was a large,

*By* RICHARD SANDERS ALLEN

*Photography by*

LADISLAV DEJNOZKA


SWANTON
TROY
SHELDON
CADY'S FALLS
VERGENNES
BRISTOL
E. MIDDLEBURY
SALISBURY
RANDOLPH
FORESTDALE
BRANDON
PITTSFORD
CHITTENDEN
FAIR HAVEN
TYSON
TINMOUTH
N. DORSET
DORSET
E. DORSET
MANCHESTER CTR.
S. SHAFTSBURY
W. DOVER
WOODFORD
BENNINGTON
IRON MANUFACTURING SITES IN VERMONT 1785 ~ 1885
Legend
BLAST FURNACE
CATALAN OR BLOOMERY FORGE
S.H.Miller

hollow stack of native stone, tightly mortared and bound with iron bands. Inside, it was lined with special fire brick, designed to withstand terrific heat. The old-time furnaces were a lot like the stone fireplaces that today's do-it-yourself householder builds in his back yard, and were fueled to the best advantage with charcoal, which gives a high clean heat.

In a back yard fireplace you may fan the flames, or get down and puff until you are red in the face. In making iron, the air to intensify the heat was introduced by means of waterwheels, operating big leather bellows to force air into the furnace. In later models, a system of wooden tubs with pistons compressed the air for the same use.

A typical Vermont iron furnace was charged at the top fifteen times a day. A charge consisted of thirty bushels of charcoal, fifteen hundred pounds of ore, and a hundred and fifty pounds of limestone. The limestone acted as a flux to melt and combine with any unburnable matter found in the furnace. This rose to the top of the red-hot mass and was drawn off in the form of slag.

In a fireplace, the important product is the steak that is cooked on top. In the iron furnace it is molten iron, drawn off at the bottom. On the sandy floor beside the bottom of the stone stack a trough was dug to receive the bright, smoking metal as it poured from the furnace. This depression was called the "sow." Connected with it were smaller side ditches which for obvious reasons were called "pigs."

The furnace building itself was a dark and cavernous place that often resembled Dante's Inferno. Big, brawny iron workers moved about with blackened faces and bare chests glistening in the glare of the white-hot pig iron. To keep the furnace in continual blast they worked night and day in twelve hour shifts for periods as long as nine months. Thirsts ran heavy. It has been said that for every ton of iron made, at least a gallon of whiskey was consumed.

Charcoal in vast quantities was needed for the iron making process, and the forests around the furnaces were quickly cut. Farmers with timber holdings went into charcoal-making on the side, and in some regions the smoke from the colliers' oven fires on the hills was always present. A bed of limestone nearby was considered a further asset by the furnaceman.

Pig iron ran about eighty pounds to the bar, and was a mighty important product to early Vermonters. From it could be made kettles, hinges, spikes, forks, hoes, chains, frying "spiders" and all manner of iron implements.

The word "forge" covered several other types of iron works. The most common, of course, was the blacksmith's little heating forge that stood at most village crossroads. On a larger scale were the Catalan forges that actually smelted iron. These worked on an old principle called the *trompe*, by which falling water was made to trap air and deliver it under pressure to a hearth. Naturally, an ideal spot was by a waterfall. In these forges the iron ore was melted and the iron formed in a pasty mass. A big mechanical hammer banged away at this, squeezing out the cinders and resulting in a salable bar of iron called a "bloom." This gave the forge another name, a "bloomery." The first one in northern New York, at Willsboro Falls, used Vermont iron from Basin Harbor across Lake Champlain, Adirondack iron being as yet undiscovered. Later the traffic was reversed and five Vermont bloomeries, (at Vergennes, Salisbury, East Middlebury, Ackworth (Bristol) and Fair Haven), all used York State magnetic ore.

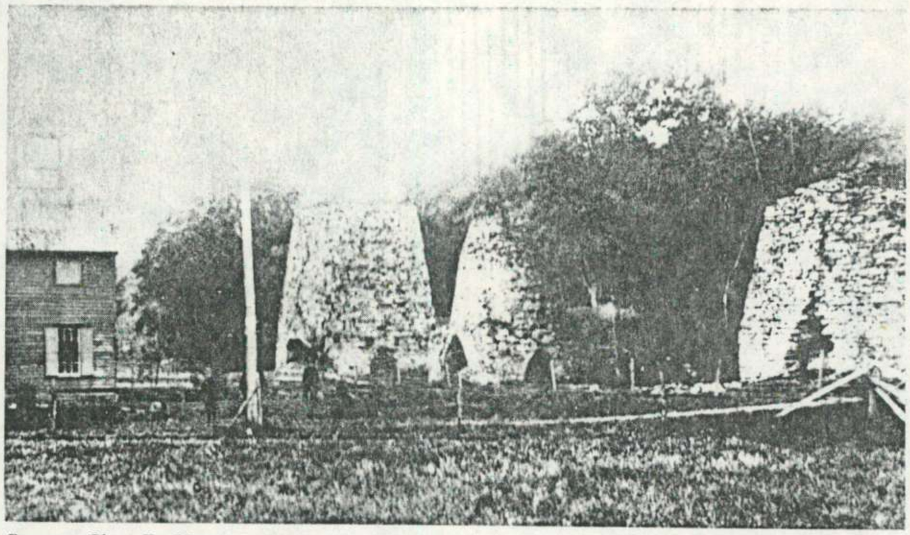
Ethan Allen is sometimes erroneously credited with establishing Vermont's iron industry. Actually, it was another famous Vermonter, Matthew Lyon, who built the state's first iron works at Fair Haven in 1785. In addition to bar iron, Lyon made axes, hoes, ploughs and nails. He even tried to protect native industry by petitioning the State Legislature to impose a duty on nails coming into the state.

Lyon's pioneer venture was followed closely by an iron establishment at Bennington and one in Tinmouth. The Lake Champlain area had the easy-to-get-at bog iron and the industry was centered at Vergennes. There was the big bed in Monkton, and sloops brought other ore from Highgate, Swanton and from the Rogers bed across the Lake in New York. At the falls in Vergennes were two blast furnaces for producing pig iron, and nine forges going full blast to convert it into hammers, anvils, pots and teakettles. These were shipped by boat to Montreal and Troy, and by overland wagon to Boston markets.

In 1813 the Monkton Iron Company at Vergennes was the largest iron works in the United States. The strategic site of the works was a boon to Commodore MacDonough in carrying out his naval campaign for control of Lake Champlain during the War of 1812. He built his fleet in the shipyard across the creek from the iron works, and the company, after supplying his fittings, quickly switched over to war production. They made two tons of cannon shot a day for MacDonough and the Northern Armies. After the threat of invasion was stopped by the defeat of the British fleet in 1814, Benjamin Welles, superintendent of the iron company, remarked:

"MacDonough saved our works, but our works saved his ships by furnishing a large supply of shot. So it is an even bargain." From its preeminence as the nation's largest iron works, the Monkton Iron Company took a swift drop and never recovered from the postwar depression. Various smaller bloomeries and foundries later occupied the site, but conducted only local business.

Israel Keith was a real pioneer in Vermont iron. He came from the bog iron country of tidewater Massachusetts and in 1791, started a furnace enterprise at



Courtesy Chas. R. Harte

*Bennington Iron Works furnaces as they appeared about 1870. The center, smaller stack was called the "Pup." Ironmaster Thomas Trenor burned down a predecessor to one of these furnaces, mistakenly charging it with manganese instead of iron.*

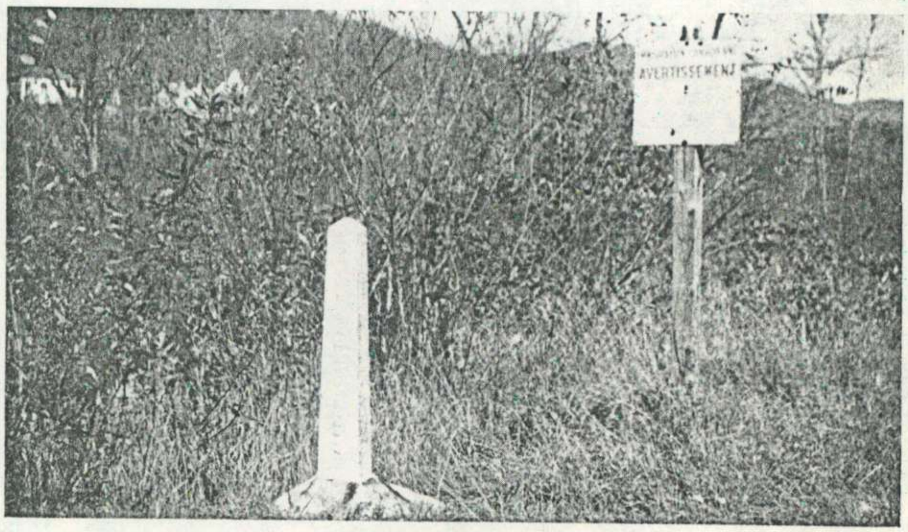
Pittsford, Vermont. Israel bought his land from Ira Allen and paid for it "in iron and holloware" after he got the furnace built. He soon went on north to Sheldon, where he could work the bog ore with which he was more familiar. His furnace on the bank of Black Creek employed a hundred men, and the iron products, bartered for other necessities, became known as "Sheldon Currency." Keith's specialty was potash kettles, for potash-making was a big business at the time. These "kittles" were cast in molds to sizes holding forty-five, sixty, and ninety gallons apiece. Men came as much as two hundred miles for a Sheldon kettle, waited their turns, and loaded the cumbersome castings hot from the mold.

A small portion of the Keith furnace can still be found in the underbrush at Sheldon, forgotten and unmarked. More remains of the successor to his first Vermont iron venture, the well-preserved stack alongside Furnace Brook in Pittsford. This furnace was built in 1828 by the Granger family, long identified with Pittsford iron. The Grangers had been hauling ore six miles from a mine in Chittenden. Then, while excavating for a new furnace, they found their site to be directly *over* a new bed of iron ore. That luck, with good limestone in a quarry nearby, kept Pittsford iron in production for many years. During thirty weeks of 1856, this furnace produced nearly 1600 tons of pig iron.

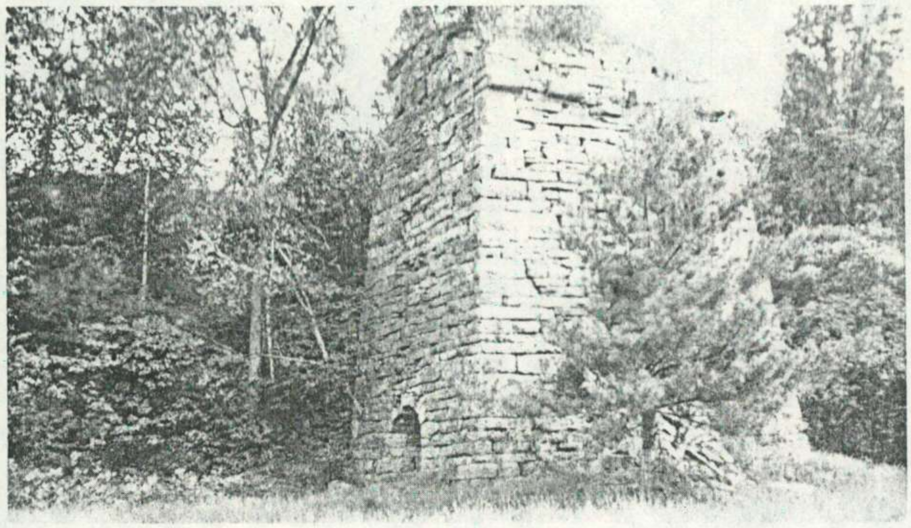
Down in Bennington, William Blodgett commenced furnace operations soon after the Revolution. He had many successors who endeavored to make a go of the iron industry, among them a clothier, an Irish political refugee, a newspaper editor, a French scholar, and a minister. The clothier was Moses Sage, who in 1816 moved to Pennsylvania, where he erected another blast furnace. The place was called Pittsburgh.

The political refugee was Thomas Trenor, a stern, stubborn man with an Irish brogue and an easy temper. He

R. S. Allen




*This marker on the Vermont-Canadian boundary at East Richford, was cast more than 100 years ago by the Orleans Iron Company, Troy, Vermont.*



*The old stone stack of the Green Mountain Iron Company at Forestdale was built in 1854. Two hundred men were employed here, casting pig iron, and later molding ornamental chairs, urns & statues.*

*R. S. Allen*

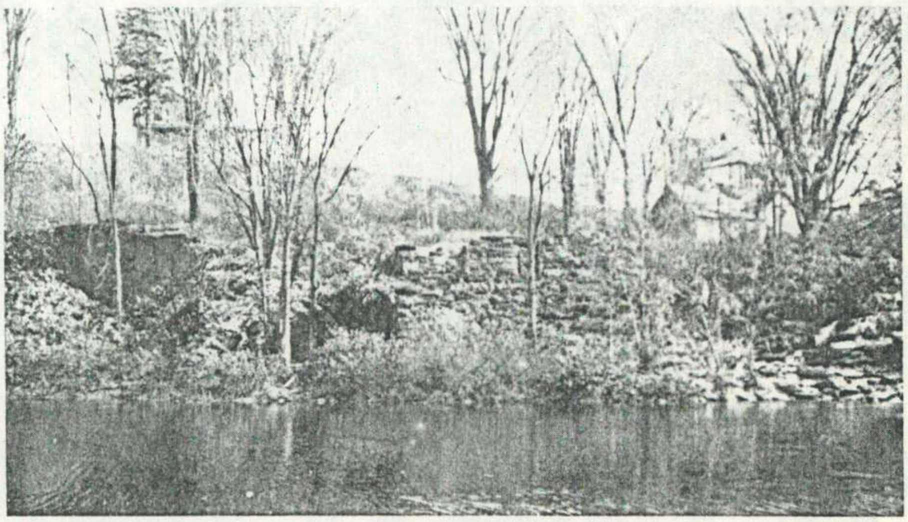
insisted on putting a charge of a new black ore he'd found into his furnace, with the thought that it was a rich vein of iron. The stack commenced to rumble and shake. When the furnaceman tapped it, the liquid stream burst forth with a roar, took fire, and spattered in all directions, burning down the wooden sheds around the stone stack. Mr. Trenor had unwittingly charged the furnace with a deposit of black oxide of manganese, which with iron burns like fury. The ironmaster had to be extremely careful after that, for only half an inch of clay separated iron and manganese in some of his ore beds. Manganese was always the devil in the Vermont iron stockpile, and similar, though not so drastic mistakes happened at Pittsford and Dorset furnaces. A use for manganese was later found in making bleaching powder and in glass manufacture, but at Bennington tons of the stuff were thrown away.

Towns adjacent to Bennington also supported iron furnaces. There was Woodford, where big anchors for navy gun boats were cast during Jefferson's administration, and Shaftsbury, where all the pig iron was shipped to Troy, N. Y. for use by the Burden Company in making practically all the horseshoes used by the Union armies.

Up in Brandon were two furnaces. In Brandon village John Conant made the patent stoves that bore his name, and sold them all over New England and New York. This company later specialized in casting railroad car wheels, a product for which durable Vermont iron was especially suitable. At the other Brandon furnace in Forestdale, to satisfy popular demand, the molders even cast ornamental items like vases, chairs and statues, in addition to their old standby of pig iron.

All this iron activity took place on the western slopes of the Green Mountain Range. On the other side of the state was the small "Somerset Forge" in Dover, which shipped iron blooms to Bennington in competition with the

*R. S. Allen*



*Israel Keith's Sheldon Furnace was located on Black Creek. Iron products made here were used for barter, known as "Sheldon Currency." Huge iron kettles were a specialty.*

local works. There were two forges in Randolph, and one at Cady's Falls in Morristown, whose ore came from the "Gothic Bed" in Elmore.

At Tyson in the town of Plymouth was a substantial iron industry, with furnaces erected in 1837 by Isaac Tyson of Baltimore, Maryland. Tyson built a large blast furnace for pig iron and a small one "for convenience." At one time Tyson Furnace expected to become a leading city of the state. With its self-sufficient iron works, stove foundry, company store, and houses for the workers, it resembled some of the more prosperous "iron plantations" of New Jersey and Pennsylvania, where everything was supplied by and revolved around "the company."

At Troy was the only workable Vermont ore of the magnetic variety. Since the beds stretched for two miles, some Boston promoters bought them and erected the Troy Furnace beside the Missisquoi River. Lack of transportation and distance from markets caused the enterprise to fail. The company is noted chiefly for casting the boundary markers that can still be seen today at many points along the Canadian border.

One by one the iron beds in the state were exhausted, or abandoned because of increased production costs. There are still deposits of good grade iron to be found under the Vermont soil, but as long as iron can be easily scooped up in the open pits of Mesabi, Ungava, and Venezuela, the mineral prospectors will pass them up.

A new hobby has revived interest in the old Vermont iron furnace sites. This centers not on the iron, but on the cast-off by-product, slag. Cut and polished by amateur lapidaries, this makes interesting and inexpensive rings, bracelets and other jewelry settings. Slag ranges from bright blues and greens to white and orange brown, with all shades and combinations in between.

For those interested in seeing some of the old furnace stacks, there are six still standing in the state. Two are visible from Route 9 to the east of Bennington. Perhaps the best-preserved is the limestone and marble stack beside Route 7 south of East Dorset. A little more hunting will bring you to the Pittsford Furnace on the brook above Pittsford Mills, and the Green Mountain Iron Company's old stack still stands under the bank, at the upper end of Forestdale. Local inquiry is necessary to find the remote old Troy Furnace, out of sight of the river road between Troy and North Troy. Portions of other Vermont furnaces still can be found, but archaeological digging would have to be practiced at most of their sites. However, the discerning eye can often pick out a flash of blue or bright green slag in the bed of a brook, disclosing the former presence of one of Vulcan's Green Mountain workshops.

The iron industry in Vermont today is confined to foundries, which were often run in connection with both furnace and forge. In a foundry the metal is heated and cast directly into molds. Modern foundries take bar iron and melt it at high temperatures so that it may be cast into any desired form. Nearly a dozen foundries still do business in Vermont. Typical of them is the Gray Foundry, Inc., of Poultney.

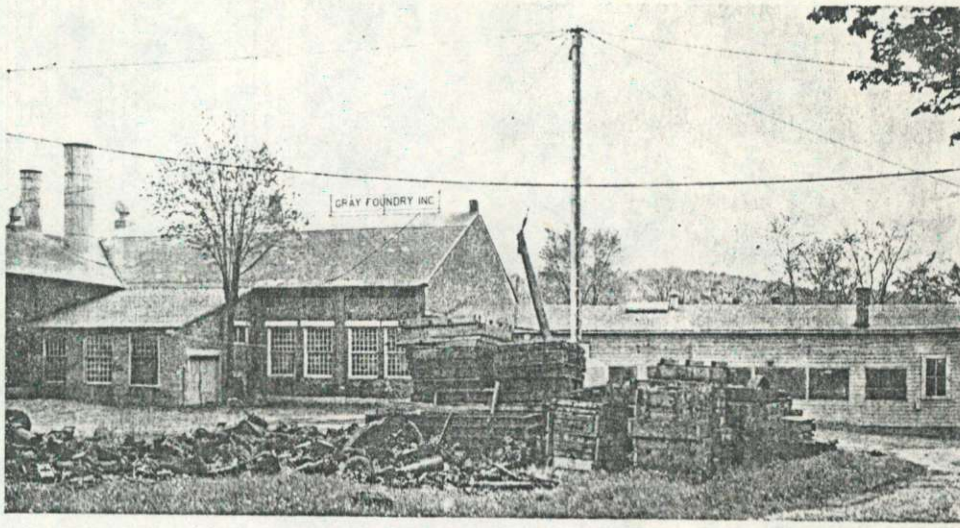
Follow down Furnace Street along the Poultney River and you'll find the Gray Foundry. Its buildings are arranged for utility, not beauty, but on a late winter's afternoon when the furnace is in blast, the leaden sky will be lit up with a glow that gives this plant an aura all its own.

From the squat, square office, a well-worn path leads down to the heart of operations, the main moulding bay foundry. Gone is the gloomy cave of the iron workers of the last century. This is a modern, spacious building with cupola furnaces, electric hoists and cranes. Only the brimstone smell of hot iron remains the same.

Gray's foundrymen prepare molds and pour iron five-and-a-half days a week. Castings range from small blocks to 3000-pound bases for paper-making machinery. The steel stack of the furnace is charged with the proper amounts of York State or Alabama pig iron, scrap iron, coke and flux, and the air blast gets roaring in the cupola. It takes 30,000 cubic feet of air to melt a ton of iron. When the furnace is tapped, the foundry windows reflect the glare, and the place comes alive. Gray's foundrymen, all with at least ten years experience, know their jobs and respect the danger of the material with which they work. Each is ready at the precise moment when the big ladle is poured;—lighting the escaping gases with fire sticks, holding the handle steady, or playing a stream of water on the hot flask or mold. Sparks fly up and scatter on the black sand of the foundry floor. Gushing from the furnace, white-hot iron pours again and again with a plopping noise like thick sour cream from a pitcher. Motions indicate which casting is to be poured next. The little ones are filled from hand ladles and left in smoking rows.

At the end of several hours of such work, all hands stand back and the furnace is dumped. A huge fiery mass cascades to the floor with sparks, coals and thick twisting streams of slag. Water hisses and steams on this residue, the glow fades, and the foundry is done for the day.

Gray Foundry, Inc. is thought to be the third oldest foundry continually in business in the United States, and still produces castings on the same site. It commenced melting iron in 1828 as the Stanley Stove Works. The patent Stanley anthracite stove was a big square ornamental affair, some of which are still to be found in the back rooms of older Vermont houses. The stove business grew with the demand, and later Stanley went into making castings for horse power machines, slate-working machinery and curry combs for the Union cavalry during the Civil War. The foundry was reorganized in 1900 under the direction of A. Y. Gray, and has since born his name. For the past forty years the plant has been run by Norman




G. Knapp, grandson of Mr. Gray, who has kept pace with the times by making a great variety of castings.

"We're classed as a small jobbing foundry," says Gray's president and general manager. "Our business is varied and not concentrated on any one product. In addition to the machinery for slate and marble working, we make castings for paper mill machinery, pumps, machine tools, pipe bending machinery, oil field maintenance machines, and road building machines to name a few. We can make just castings, or the complete machine. And our products go all over the world."

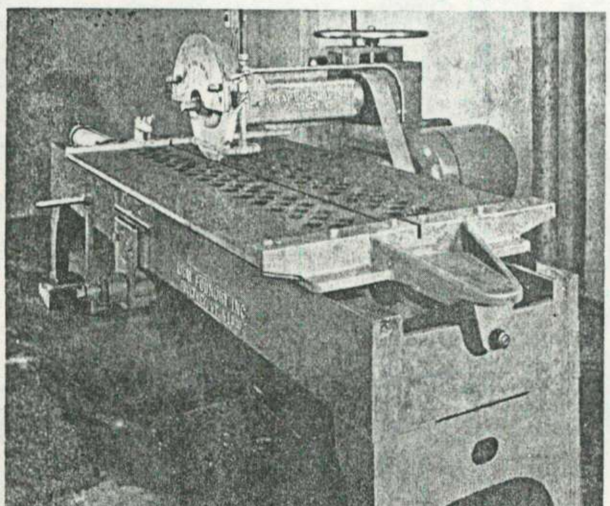
Mr. Knapp's Gray Foundry has risen from the ashes of two disastrous fires, and has had the waters of two floods four feet deep on the main foundry floor. It is a prime example of the survival of a small Vermont family company which has licked the problem of falling markets by diversifying its products and adding new lines. END

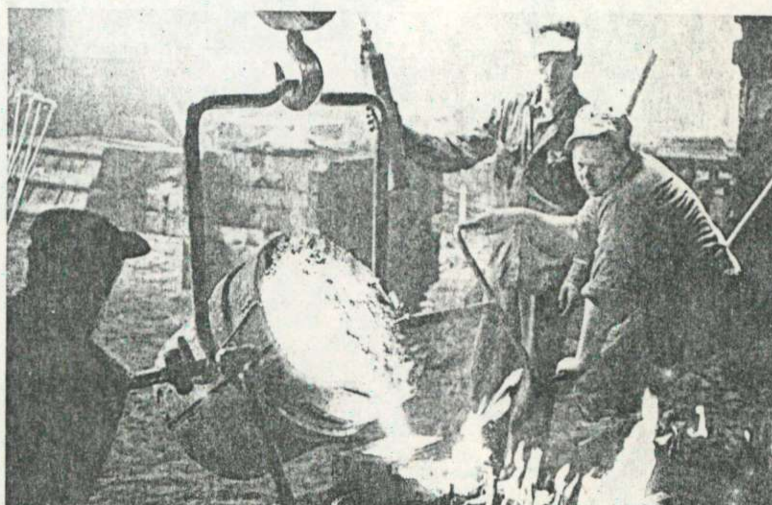
ABOVE: *The Poultney Foundry is one of about a dozen in Vermont. Scrap iron and flasks lie in the foreground.*

ABOVE LEFT: *Norman Knapp heads the 128-year-old Gray Foundry believed to be the third oldest in the Nation.*

BELOW LEFT: *Appropriate to the Poultney slate belt is this Gray Company diamond saw for cutting slate tiles.*

BELOW: *Hoist operator and foundrymen start the pour of molten iron into the runner box of a machine casting.*





blast furnace file

April 2, 1984



Dear Giovanna,

It looks like I shall be coming up sometime either Monday or Tuesday, April 16 or 17th. We won't be making the VAS meeting, possibly coming to Burlington Sunday, staying over to Tuesday eve or Wednesday morn. Many things happening at this end are complicating the trip, so that I won't know for sure until later this week.

What started a few weeks ago as 'idle' curiosity into family relationships between the Penfield and Hammond families of Vt/NY has turned into a full-blown research project. In researching various families connected with the ironworks business, I am finding some amazing things, such as, many of the more prominent ironworks owners in Vermont intermarried with other ironworks-related families. For instance, Penfields are related to Hammonds, who are in turn related to Conants. A Drury (Highgate furnace) married a Keith (Pittsford, Highgate, and Sheldon furnaces), also married a Saxe (Slamon River Furnace, NY). Cloburn (West Haven furnace) married a Davey (Fairhaven works). I'm finding that the originators of the Crown Point Iron Co (Penfields and Hammonds) came from Pittsford. Jacob Saxe, uncle of the poet, was at first part owner, then sole owner of the first blast furnace in the Adirondack North Country. It was built by non other than... (Isreal or Alfred) Keith. The Keiths were also connected with at least one other furnace in NYS. A Colburn built a furnace at West Haven, later a furnace west of Ironville in 1848. And so it goes. I'm finding the answers to many questions I had about ironworks in Vermont by studying the 'family connections'.

At West Haven, there may have been a blast furnace built in 1825. It was located somewhere downstream of Carvers Falls, but since the Poultney River is the VT/NY border, I don't know yet whether the site is in fact in Vt. It'll be the first field trip of '84. Maybe we've found another one! The Colburn that built it maybe the one (or related to ) the Colburn (also spelled Coburn sometimes) furnace at West Moriah. I visited that furnace many years ago, at that time not knowing that Vermont existed, let alone had a blast furnace.

I got some great photos of the standing kilns at No Levittown, Mass (charcoal kilns) and also the lime kilns at Leicester Jct. I'll start writing that up soon. We drove up to Dover (Vt) a few weeks ago trying to find Mrs Stephen Greene's; she has a lime kiln on her property also, per some correspomdence you sent me many years ago. I have since found her mailing address and will get a letter off to her, to see and record it.

Anyway, I have loads of work waiting for me as soon as I get to UVM/VHS libraries. I'll be writing a letter to your Dad tonught also, so I may possibly see his kiln up at Milton. Should be a busy couple days. Can't wait for all this snow to melt. The high roads in the charcoal kiln area are still well snowed in; hopefully I'll have some help beating the bushes this year.

I'll phone up as soon as I get a better date for an appointment.

Ciao!

Vic

-Scotch, Sarah (Family)
-Simpers, Wendy
-Sincerbeaux, Elizabeth
-Smith, Sue (Family)
-Spencer, Anne Felton (Contributing)
-Steele, John M.
-Teague, Virginia
-Thomas, Peter A.
-Varney, Kenneth E. (Life)
-Ward, Richard W.
-Wener, Robert and Faye (Family)
-Wilder, Denise A.

# EIGHTEENTH CENTURY VERMONT FORGES

By Victor R. Rolando

(Last fall, at the invitation of the VAS, I made a presentation at the Annual Meeting on the subject of Vermont's eighteenth and nineteenth century iron making blast furnaces. The presentation was repeated, somewhat updated, to the Rutland Historical Society in February as part of the Bi-monthly Seminars in Archeology. Response to these two very preliminary Industrial Archeology excursions into early industrial Vermont has been very warm and enthusiastic, and I have been encouraged by many of you to put something on paper. What follows is the first of a yet undetermined number of insights into an industry that few understand or realize existed in Vermont. The object of these articles, therefore, shall be to encourage an awareness of these industries through an understanding of why they were there and what they did, in the context of what archeological remains might exist. This first paper concerns eighteenth century Vermont forges. Future papers will cover iron and bog ore, charcoal making, foundries, and blast furnaces. I look forward to your continued encouragement in the form of leads, invitations to visit suspected ironworks sites, newspaper clippings, or just plain interest.)

+ + +

The first iron making industries of Vermont began operation shortly after the end of the American Revolution. These industries responded to a purely local demand for basic domestic and agricultural needs that were the result of a dramatic population growth. From a few thousand people in the 1770's, Vermont's population grew to about 85,000 in 1790, and nearly doubled to 155,000 by 1800 (Thompson 1842:211). One of Vermont's earliest iron entrepreneurs was Col. Matthew Lyon, who built an iron making complex at the upper falls in Fair Haven after petitioning the General Assembly to lay a duty on nails coming into the state, enabling himself to supply all local needs. In addition, Lyon's forges supplied axes, hoes, various agricultural implements, and workable iron bars (Adams 1870:141-42).

Lyon's forges should not be confused with blacksmith's forges, which were much smaller, required less heat, and worked smaller pieces of iron. Neither were Lyon's works connected with blast furnaces, which, under the encouragement of higher temperatures in a significantly larger structure, produced on the order of a ton of cast iron a day. The product of a forge was wrought iron; a relatively low-carbon iron capable of being hammered and shaped. For convenience, it was produced in bars; hence its name--bar iron. Easily handled and transported in approximately 100-pound bars, bar iron was reheated, rolled, slit into rods for drawing into wire; cut and headed into nails, rolled again to make barrel hoops or wheel tires, etc.

The capability of a forge was measured in terms of the number of fires, or hearths, it contained. The hearth was centered in an approximately 15 feet wide by 10 feet deep and one to two feet high brick-lined platform. Small vents led from the bottom of the hearth to one wall of the platform, where air was forced in by waterwheel-powered bellows. The pulsating draft kept the hearth at working temperature. The waterwheel was usually situated just a few feet away, on the outside of the forge building wall. In the hearth, iron ore was continuously added and mixed with hot glowing charcoal until enough of the heavier iron settled to the middle of the hearth in a sort of pasty, red-hot ball.

Because of such physical limitations as the small size of the hearth and the draft-producing bellows, the iron from the forge usually didn't melt. In fact, if it did melt, it would have been useless for the intended purposes of the forge. Even if the heat of the forge could coax the iron to run as free liquid, in this state it would reach such temperatures that it would chemically absorb excessive quantities of carbon from the charcoal, and after removal from the hearth, would be much too hard for hammering or rolling with the methods of the time. By keeping the iron just 'cool' enough not to melt, little if any carbon was picked up by the iron and thus the iron maintained its characteristic malleability.

The ball of iron forming in the hearth was called a bloom. For this reason, many forges show up in the documentation as bloomeries. (The French used the word "loupe", often spelled loop; the Germans used "stuke," or wolf. Wolf furnaces were in fact bloomeries.) The bloom, weighing a hundred pounds as the piece of bar iron it will become, however, required removal of the pieces of solid coal, ash, and stones embedded in or stuck to it. The only way to remove them was to 'squeeze' them out through hammering. Worked quickly before it cooled and hardened, the bloom was removed from the hearth, hammered by rapid strokes of the trip hammer, and returned to the hearth. The cycle was repeated until all visible impurities were removed.

The trip hammer was another waterwheel-powered device in the forge. Replacing the older method of manual hammering, it consisted of an iron hammerhead attached to a 10 to 15 ft. long, strong wooden beam. The hammer end of the beam was raised and dropped on an anvil by action of cams which were attached to the rotat-



April 1979 :5-6

ing waterwheel shaft. The hammer weighed anywhere from 100 to 1,000 pounds. The bellows and trip hammer were turned on and off by hand-operated linkages to gates in the flume. Opening and closing water flow in the flume controlled the waterwheel and the devices it powered.

The anvil, on which the bloom was held with iron tongs, was mounted on the flat end of a large diameter log. The log was buried vertically in the dirt floor of the forge. Long after abandonment of the forge, long after the hearth bricks, tools, hammer, and anvil have disappeared, the subsurface discoloration caused by that anvil seat is a significant archeological clue to the trip hammer's, and probably the entire forge's, existence and location. The waterwheel pit(s), flume, and dam cribbing are other supporting evidences.

Bloomeries were laid so that every two hearths, each tended by an ironworker, were separated by one trip hammer which was used alternately by the ironworkers on each side. If dimensions of the ca.1765 Charlotteburg, New Jersey Middle Forge can be used as a typical example, this two-on-one hearth/trip hammer arrangement took up some 80 by 25 feet (2000 sq. ft.) of floor space. The Charlotteburg site contained two such sets of hearths (fires) and trip hammers in a building measuring approximately 80 by 50 feet (4000 sq. ft.) (Lenik 1974: 9-17).

I do not know the extent of Lyon's eighteenth century forge operations, but in 1794, within ten years of petitioning the Vermont General Assembly and building the dam at the upper falls to power his waterwheels, he sold the "two south fires together with a hammer, anvil, and coal house" (Adams 1870:142). Lyons apparently also used the two-on-one formula. Taking the forge then operating in Tinmouth into account, a considerable number of forge fires are left operating at Fair Haven, making Lyon's Works (as the complex was then known) the center of Vermont's iron producing industry for at least a decade.

In a reference to Nathaniel Chipman building a forge in Tinmouth to produce bar iron in 1781 (Federal Writers' Project 1937:242) is correct, then this might be the birthplace of Vermont's iron making industry. Tinmouth needs further work. Benjamin Wilbur's biography of Ira Allen also hinted at this when he wrote that Ira Allen rode to Tinmouth in 1791, where he signed a contract for the erection of another forge with two fires (Wilbur 1928:6). But another at Tinmouth, or another elsewhere on that same trip?

Ira Allen was connected with many iron making activities to attract investors and speculators into his land holdings, and also to provide some income for Vermont's postrevolutinary cashless frontier economy. In 1789, he was willing to lease iron manufactory sites at the falls in Winooski and Shelburne, and also along the Missisquoi, for seven years free from rent, at the end of which time paying a 'fair price' for the forges. Later that year, he was shipping bar iron to Quebec on rafts, augmenting his lumber business with Canada. By 1790, Ira was authorized by Quebec to ship bar iron to England via Canada without paying the export duty leveled by Quebec.

In 1792, Ira Allen commenced the design of the largest forge he had yet constructed. He obtained the hammer, bellows, etc. from Canaan, Connecticut, near a blast furnace built by brother Ethan thirty years earlier at Lime Rock. In the spring of 1792, Ira signed the contract and specifications for a forge and anchor shop (anchors were big business with our new, growing navy) at Colchester, and a forge building measuring 50 by 40 feet (2000 sq. ft.) in Shelburne (Wilbur 1928:27). Upon completion of these works he immediately leased them out in an attempt to create business in the city that was coming into existence between them--Burlington.

There are references to four forges in Addison County by 1792 (Williams 1794:317), although I know for relative certain only that in Middlebury, built by Jonathan Nichols (Smith 1886:327). This forge, in addition to the trip hammer, had a foundry which produced guns (cannon?). I suspect that eighteenth century forges were also operating in Lincoln, the predecessors to the Ackworth Bloomeries, and also at Vergennes, where the Monkton Iron Company grew to be the largest in the United States during the War of 1812. I am also tracking down a pre-1800 forge in Swanton (Aldrich 1891:405).

At Bennington, bar iron was being made and sold in 1786 at a forge operated by William Blodgett (Sparge 1938:28). But Bennington was to make more of an iron making name by a succession of blast furnaces, even though the first blast furnace in Vermont was built many miles north at Pittsford by Col. Israel Keith in 1791 (Smith and Rosin 1886:741). The blast furnaces are another phase of Vermont's iron making industries, which usually, but not always, followed in the foundations of successful forges. In the process they obliterated archeological evidence of the replaced forges.

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NO. 32 AUGUST, 1980

# VAS newsletter....

A PUBLICATION OF THE VERMONT ARCHAEOLOGICAL SOCIETY, INC.

A notice in the last issue told you that Jim Petersen's monograph was being shipped to you immediately under separate cover. Subsequently, the Board decided to distribute as many as possible at the Spring meeting to save postage, and so I got a lot of inquiring mail. Copies were distributed to members of record at the time of the Spring meeting (May 10) at no charge. If your 1980 dues were paid by that time and you have not received your copy, please notify me at Box 663, Burlington, VT 05402.

Joseph Popecki
Treasurer, VAS

## GEOMORPHOLOGICAL SUMMARY OF THE WINOOSKI SITE

By Peter Beblowski

The Winooski site (VT-CH-46) occupies an area of approximately 43,000 square ~~miles~~ feet of floodplain on the north bank of the Winooski River, one mile downstream from the Routes 2 & 7 bridge over the river, in the town of Winooski VT. The University of Vermont Department of Anthropology's 1978 excavation of portions of the site revealed that it contained multiple components, the most extensive of which date back to the Middle Woodland Period.

The Winooski site's stratigraphy is representative of an alluvial floodplain, with its textural character dominated by fine sands and course silts. Compositionally, the sediments may be described as mature and multi-generational, composed primarily of quartz. The fine grained nature of the site's soil components is indicative of vertical accretion of sediments during overbank flooding - this depositional pattern has probably existed for the past 4,000 years. The site area's seemingly stable sediment accumulation rate of roughly 50 centimeters per thousand years (even with an upper rate of 80 centimeters per thousand years for a portion of the riverbank levee) lends itself to a model of relatively steady-state aggradation.

Sediment accumulation at the Winooski site is influenced by a "downstream control system" which causes the deposition of fine-

➧ 2

## Search for Vermont Furnaces Yields Dramatic Discoveries

By Victor R. Rolando

Wrought and cast iron were made in at least 62 bloomery forge and 18 blast furnace sites in Vermont between 1775 and 1890. During this period, 75 bloomery forges and 28 blast furnaces were fired at these sites (Rolando 1980:107-113). Field investigations made in 1978 and 1979 to locate the surface remains of nine of these forges resulted in a few bits of slag, one flume and one possible dam site. The search for blast furnace sites, however, has netted more dramatic discoveries. Standing ruins of blast furnace stacks exist in Bennington, Dorset, Forestdale, Pittsford, and Troy. Trace ruins are also identifiable in Tinmouth and Plymouth. The remaining sites, which display either questionable or no surface evidence are in Brandon, Fair Haven, Shaftsbury, Sheldon, St.-Johnsbury, Vergennes, and Woodford.

These blast furnaces measure 20 to 30 feet square at the base and 23 to 40 feet high, tapering inward from the base. The outside walls of the earlier furnaces, such as those in Bennington, Dorset, and Troy, are of coarsely laid rough cut (or uncut) stone. Walls of the later blast furnaces at Forestdale and Pittsford are of uniformly laid large finished stone. All walls were laid without mortar or cement.

Each blast furnace was built close enough to a low hill to allow a short bridge to connect the hilltop to the top of the furnace, affording the means of charging the furnace with iron ore, fuel, and flux. Iron ore was mined locally and sometimes mixed with ore from New York State. The fuel was charcoal, made in kilns located in the surrounding forests or at the furnace site. Anthracite coal was considered at Dorset (Neilson n.d.:220), and actually used without success in 1854 at the Forestdale stack (Lesley 1859 b:25). At the Conant furnace in Bradon, a dense peat called lignite ("brown coal") was used to supplement expensive charcoal. To facilitate removal of impurities from the iron, a limestone flux was added to the charge of iron and coal. The limestone combined with the impurities to form slag, visible at most furnace sites as multi-colored "stone".

➧ 2

## 1 ➧ WINOOSKI

grained material on floodplains, lawns, terraces and backswamps. Downstream control of a fluvial system is synonymous with "base level control." The surface of Lake Champlain has been identified as the base level for the aggradational system operable at the Winooski site. It is interesting to note that the sediment accumulation rate perceived at the site paralle's a slow but steady rise which has been projected for Lake Champlain, surface level. This projected use is approximately 80 centimeters per thousand years over the past 4,000 years, and is derived from a straight-line projection from two known points representing lake levels at particular times.

In a downstream aggradational control system, a "sedimentary wedge" is developed which becomes thicker as one approaches the control point, in this case the Lake Champlain shoreline. As a consequence prehistoric human occupation surfaces (sites) of any particular age on the Winooski floodplain are under a thicker mantle of sedimentary material the closer they are to the lake, given no major breaks in the stratigraphic record.

The Winooski site, it must be remembered, is but a small component of a large and complicated environmental system. With no comparative date to shape a geomorphological model around, the conclusions presented above are necessarily tentative. They will be expanded on in the forthcoming Winooski site mitigation report. A more complete geological history of the lower Winooski River Valley, of vital importantance to prehistoric archaeologists, awaits the collection of further data.

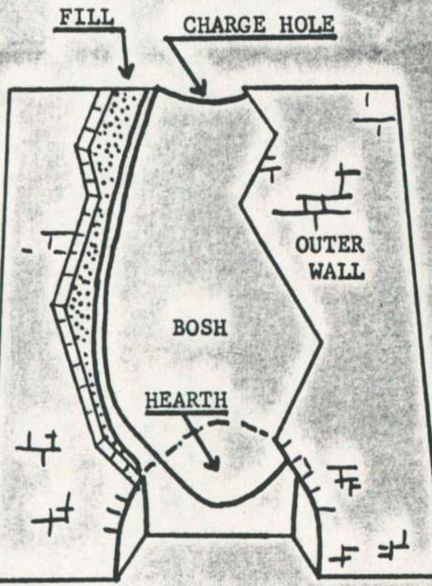
## 1 ➧ BLAST FURNACES

The forced draft for which the blast furnace was named was generated for earlier furnaces by large bellows, driven by waterwheels. Usually operated alternately and in pairs, 4-foot-wide by 20-foot-long bellows were not uncommon at the turn of the nineteenth century. Soon after, these bulky and cumbersome devices were replaced by wooden cylinders and pistons, the forerunners of today's air compressors. The 1839 alteration of Conant's furnace to accommodate two 6½-foot diameter cylinders is the earliest recorded use of these blast machines in Vermont (Lesley 1859 a:77). The cylinder heads were double-acting, with inlets and outlets closed by wood flap valves on leather hinges. (At a contemporary site at Tahawus, New York in 1977, I found the remains of wooden cylinders and pistons and their cast iron piston rods.) The pistons were operated by piston rods made either of cast iron or wood, (wood was used at Hopewell Furnace, Pennsylvania connected and driven from each side of the water wheel. The cylinders were mounted either next to the waterwheel (Tahawus) or on scaffolding above it (Hopewell).

The blast was connected to the furnace hearth through one of the arches at the base of the stack by cast iron nozzles called tuyeres. The tuyeres were usually double-walled and cooled by circulating water to keep them from melting.

Early blast furnaces had one or two arches; later furnaces had four. Early furnaces such as the ca.1820 stack in Bennington, employed corbelled arches with no decorative molded bands. The Dorset and Forestdale furnaces, of slightly later construction, contain splendid wedge-stone arches, while the Pittsford furnace, which operated until the 1880s has a three-tiered molding of mortared brick. The soffit, constructed of red brick underlain by yellow, extends the entire depth of the arch ceiling.

These archways also gave ironworkers access to the hearth, from which the molten iron and slag were periodically drawn off. The hearth sat at the center of the furnace base. It was massively walled and supported with stone and/or brick to support not only the heavy molten iron and slag in it but also the entire bosh, which extended to the top of the furnace. The bosh was the inner stone or brick-lined vertical cavity in which the actual melting took place. Its configuration was like an egg, standing on its wider end. It was at this wide point where the tuyeres were connected and melting temperatures were the highest.




*Cutaway view into a typical blast furnace.*

Early furnace boshes, such as one of those at Tinmouth, were lined with a hard stone possibly schist or gneiss. As the technology advanced, iron characteristics were found to be affected by the nature of the bosh lining, prompting the use of various refractory bricks. Bosh bricks from the ca.1840 Troy, Vermont, furnace appear to be ordinary red bricks; from the ca.1850 Forestdale furnace they are yellow firebrick made in Troy, New York.

Bosh brick is distinctive from decorative brick for its burned and/or glazed end, caused by the extreme heat in the hearth. Glass foundaries, bloomery forges, iron foundary cupola furnaces (air furnaces), lime kilns, and other metal processing furnaces also employ firebrick-lined hearths, as do present-day home heating gas and oil furnaces. Some firebricks were tapered to better fit the circular bosh configuration; all firebricks were mortared.

The space between the inner, circular bosh wall and the outer square furnace wall was filled with rough stone of all shapes and sizes. This fill provided an insulating jacket around the bosh and support to hold the bosh vertical. This fill is visible at the two Bennington furnaces, each of which is partially collapsed. Parts of the Forestdale and Pittsford furnace interiors are also exposed.

The two Bennington furnaces are located on private property off Route 9 at Furnace Grove. They are next to a residence which once served as the ironworks' company store and later as a chair factory. A good waterwheel pit remains next to the eastern stack, and a depression traces the route of the flume from the site of the forge pond to the wheel pit. Otherwise, all surface traces of bloomery forges, charcoal kilns, charging and casting shed, coal and ore houses, and a third smaller 'pocket' furnace (which stood between two stacks) are gone beneath gardens, lawn, roads, and underbrush.

The stack at Dorset stands on private property just west of a by-passed stretch of Route 7 one mile north of the town line. No other surface remains are visible. The Forestdale stack stands in a heavily wooded, state-owned area a few minutes' hike up an old road northeast of the villege. The Pittsford furnace is relatively hidden along Furnace Brook a mile northeast of Pittsford village. No surface remains except fallen arch and bosh bricks and much slag are visible at either of the latter two sites.

The most significant blast furnace site for the quantity and quality of interpretive surface remains is in Troy. This site is located about two and one-half miles north of Route 100 on the east bank of the Missisquoi River. It can be reached by a ten-minute hike through a pasture off River Road. The blast furnace was built in 1837 and abandoned in 1846 (Hemenway - 1877:325). It stands immediately downstream from a falls where a narrow gorge forms a right-angle bend in the river. An approximately 300-foot-long flume cuts diagonally across the inside of this bend, affording a good head at the waterwheel pit, near the stack. The flume is 15 to 20 feet wide and 6 to 10 feet deep, cut through the rock. The dam, which backed the water into the flume, was probably located in the narrow gorge although inspection during a low water period in 1979 failed to reveal any evidence here. Another possible dam location exists upstream, where the flume leaves the river.

The wheel pit is about 20 feet west of the furnace stack. A narrow rock-cut through a low hill between the stack and the pit leads to the speculation that (1) the blast machines were

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either located here, feeding air to a tuyere in a possible arch at the east wall, or (2) the waterwheel shaft came through this cut to power the machines closer to the stack. Locating the archways in the stack would help to interpret various features of the furnace site, but all walls except the southern one are partially collapsed, burying probable arch locations.

Directly east of the stack are stone walls, foundations, and an iron hollow-ware 43 inches in diameter and 23 inches deep, possible a potash kettle cast at the site. A tail race from one of the foundation holes may indicate a wheel pit that powered a bloomery forge or a cupola furnace for remelting and casting stoves, hollow-ware, and boundary markers. (Many of the latter, cast at this furnace, were used along the nearby international boundary.) Glazed firebricks are found in and around this hole. Heavy iron mounting, possibly to support a waterwheel, lie at one corner of the foundation. A small now-dry inlet in one side of the foundation could have fed water to run the wheel, but its connection to the flume or river cannot be found. Slag and waste iron are scattered throughout the immediate furnace area.

During its active ironmaking days, the furnace stack was probably abutted by buildings, in contrast to today's open appearance. These buildings would have protected the blast machines and casting activities around the base of the furnace and the charging operations at the top. The charging house sat directly on the furnace with a tall chimney that vented smoke and stack gases away from the work areas. Foundations on the charging hill behind the furnace indicate that the charging bridge might also have been enclosed. A sketch of a ca.1844 blast furnace at Tahawus, New York, which is contemporary with the Troy furnace in time and wilderness environment, indicates a likely configuration of the immediate furnace structures (Masten 1968:132).

*A ca. 1844 blast furnace complex at Tahawus, New York, a contemporary of the Troy, Vermont furnace. (Masten 1968:132)*

Threading through the rubble of the collapsed furnace walls are the twisted iron straps that held the stack walls together. Their ends are slotted for pins to hold iron end plates snugly against the wall. All pins have been removed, even from the undisturbed wall, but the only end plate was found a few dozen feet downstream, in knee-deep water. The vicinity of the river near the furnace should not be overlooked in a search for artifacts.

The ironworks supported a villege that had a boarding house and post office (Thompson 1842:174). No trace of village cellar holes could be found. They may have been in the relatively smooth pasture that now borders the wooded furnace site. The old road that ran parallel to River Road leads down through the woods to the southeast and uphill out of the woods east of the rail race. The road is indicated on Beers' Atlas, and shows structures in the ironworks vicinity (Beers 1878:50).

Vigilance is one response to threats to archaeological and historic resources. But vigilance must be coupled with accurate identification and an ongoing inventory of sites. Unlike blast furnace sites that were destroyed years ago by later mills in Sheldon, a hydroelectric power station and recently a sewage treatment facility in Vergennes, and industrial development in St. Johnsbury, the Troy furnace site has managed tc escape relatively undisturbed. This is largely to its remote location. The Troy furnace site does, however, fall well within an area of the upper Missisquoi River that is threatened with inundation by the proposed construction of a high dam about two miles downstream. This would place most of the Troy ironmaking site under 25 feet of water.

Assisted by an inventory, the Vermont Division of Historic Preservation, already accomplished for the majority of the bloomery forge and blast sites in Vermont, the UVM contract archaeology team has started initial documentation of this potentially sensitive archaeological site plus an earlier bloomery forge site two miles upstream. This effort also includes the identification of other historic and prehistoric sites at this and five proposed downstream dam sites. The result of this identification effort will allow the Division for Historic Preservation to proceed effectively with compliance with federal and state historic preservation laws.

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# REPORT OF THE STATE ARCHAEOLOGIST

Presented At The VAS Spring Meeting, May 10,1980

By Giovanna Neudorfer

The past six months have been hectic as usual, characterized by various and sundry routine tasks, both the daily and repetitive kind and long-term, never-ending projects such as the predictive model. Some of the activities bore more obvious or immediate fruits than others, and I will briefly summarize a few of the highlights of the winter. I completed draft rules and regulations for all archeology-related matters in the 1975 Vermont Historic Preservation Act. These specify the procedures for permit application and approval for sites both on state-owned lands and under water; for designinating State Archeological Landmarks; for ensuring cooperation with municipalities and state agencies; and so forth. Presently, the rules and regulations are undergoing internal Division review; they should be available for public comment shortly. In February, I presented a procedural and policy summary of the underwater rules and regulations to a small conference of underwater archeologists and scuba divers. Besides putting Lake Champlain on the maps as a major historic sites area, I got some excellent feedback on our proposed underwater program.

Using a scope of work that I prepared, the Villege of Bellows Falls is about to initiate a contract, assisted by a matching grant-in-aid from the Division, to prepare a feasibility plan for developing and protecting the petroglyph site. The study will analyze the possibility of a site overlook in terms of the engineering potential, traffic access, safety, parking and costs. At the same time, the plan will detail methods of fully documenting the site through drawings and photography, outline measures for erosion control and site stabilization, and examine the engineering feasibility of removing the boulder riprap which presently abuts the site.

Past conversations with the Environmental Conservation Agency for conducting an archeological workshop for State Fish and Game personnel developed into a series of regional workshops for all Environmental Agency staff. Assisted by Peter Thomas, we plan to conduct six of these workshops over a four-month period and have expanded the participant list to include interested Soil Conservation Service folks as well as Environmental Agency Staff. Peter and I held the first workshop in Pittsford in mid April. It was well attended, and I think, well received.

Peter Thomas, Art Cohn and I attended a special two-day workshop for our benefit at the New York State Conservation Lab at Peebles Island, Waterford, New York. The purpose of this meeting was to obtain basic information to assist us in developing a plan for an artifact conservation lab in Vermont. Besides providing us with a sound understanding of what a lab would entail in terms of space and necessary equipment, we also were given an introduction to basic conservation procedures which was invaluable in impressing upon us the complexity and sophistication of most conservation processes.

The Vermont Historical Society is in the process of publishing my book on the stone chambers. While the main text of the book will be the same as the article in Vermont History, I have added a foreword by Bill Fitzhugh of the Smithsonian, revised and updated footnotes, an Epilogue, and a large assortment of photographs and tables. This should be availabe by early-to mid-June.

The predictive model takes up most of my "spare" time and I try to spend at least one to two days a week on it. The results, I hope, will be well worth the time and I look forward to sharing it with you in the not-too-distant future.

EDITOR'S NOTE

Due to an oversight, Brian Robinson, was not credited with authoring the article, "Plowed Fields: Diminishing Archeological Resource" in VAS Newsletter, Number 31 (April 1980). Sorry Brian. I hope a future issue will contain a report on your work at VT-FR-69, the Early Archaic site in Swanton.

Bill Bayreuther

Iron Making in Vermont.

# Ironmaking in Vermont: 1775-1890

by

Victor R. Rolando

A thesis submitted to the Faculty of the Graduate School of The College of Saint Rose in partial fulfillment of the requirements for the degree of Master of Arts in History and Political Science.

February, 1980

Albany, New York

## Chapter II

## Ironmaking in Vermont

In the ten-year period following the end of the American Revolution, 16 forges and 3 blast furnaces were erected in Vermont for the production of wrought and cast iron. These were this state's initial ironmaking industries and they signalled the entry of the state into nearly a century of a sometimes successful, but usually frustrating battle with nature, politics, and economics. By 1810, bar and pig iron production totaled 2169 tons for 26 forges and 8 blast furnaces. Thirty years later, 14 forges and 26 blast furnaces were turning out 7398 tons of iron.[18] The fortunes of these works rested on an eighteenth century educated estimate of the probable quantity and quality of a local ore bed; political influence and special interests that ran import tariffs up and down, and took over twenty years to decide to build the canal that economically connected Vermont to the rest of the United States; and finally, the New York and Boston speculators who misjudged a good thing in Vermont by over-investing and expanding the industry beyond its iron making capability, and then abandoning it.

Vermont never was destined to become a major ironmaking region. Its harder magnetite ores contained enough manganese impurity to affect the quality of the cast iron. The mountain streams that afforded the best sites for waterpower were noted for their flash floods which washed away everything in their paths. Forges that had been operating only marginally, but may have been able to ride out a current economic slump to better times, could not afford to rebuild. By the end of the Civil War, James Lesley wrote:

> Besides this (the Green Mountain Furnace), there have been no blast furnaces running in Vermont for some years. There

> stand two in Sheldon, Franklin Co., 9 miles east of St. Albans; one in Troy, Orleans Co; one in Plymouth, Windsor Co., Tysons; two in Bennington, Bennington Co., and two in Dorset on the Western Vermont Railroad, between Bennington and Rutland. The heavy snows make it difficult to get stock and unless such lignite beds, as the one used by Conant Furnace be discovered, elsewhere, the dearness of charcoal and the scarcity of ore will prevent this from becoming a principle furnace district again.[19]

This report presents a directory of all towns, villages, and cities in Vermont in which some referenced documentation mentions or indicates the production of wrought or cast iron from ore. Photographs and maps support the text. Complete documentation in the way of footnotes is attempted in order to aid future researchers to know precisely the source of each bit of data.

There has been no intent for this report to be an exhaustive history of ironmaking in each town although in some cases what is reported here is all that could be found in this limited project. These following abridged histories serve only to describe the location and extent of the ironmaking forge and blast furnace sites. Future research must include such primary sources as deeds, wills, genealogies, patents, court records, etc., before archaeological work is attempted.

Three series of maps were used to determine the existence, location, and time-frame of the ironworks. These were James Whitelaw's 1796 and 1810 maps of the State of Vermont, H. F. Walling's 1857 to 1859 county maps, and the F. W. Beers county atlases of 1869 to 1878. The Whitelaw maps use the Mars symbol ♂ (which in alchemy stood for iron) to indicate ironmaking sites without differentiating between forge and blast furnace in most cases. The Walling maps identify forges and blast furnaces by owner or company name and in addition display dams, flumes, homes, etc. The Beers series is similar to the Walling in content but presents maps on a town and village scale. The

Vermont Historical Society Summer and Fall 1971 issue of Vermont History contains background information on these series in addition to a complete bibliography of all maps pertaining to Vermont (dating back to c1750) and where they are available.

The Whitelaw, Walling, and Beers maps were compared, site by site, directly to each other and to the documentation in town, county, and state histories and gazetteers, ironworks reports, and ironworks-related articles. With this information, the sites were located on current U.S.G.S. topographic quadrangles. Universal Transverse Mercator (UTM) coordinates were measured for each site and this plus other pertinent forge and blast furnace data recorded for presentation in Appendix tables I and II, respectively, in the end of this report.

All towns, whether suspected or confirmed to have made iron are listed in this chapter. Only confirmed sites are listed in the Appendix. Confirmation is determined by on-site artifacts, or an iron-making structure or ruin, or reference documentation that is consistent with other references or with the ironmaking characteristics of the period and location (waterpower, ore, roads, etc.). The towns, villages, and cities are presented in alphabetical order.

Bennington: Here were the sites of an extensive variety of ironmaking industries from 1775 to 1853. In that 78-year period, five blast furnaces and numerous forges turned out cast and bar iron as well as custom-ordered hard and hollow ware. The ore came from local mines near the furnaces, in the northern and western parts of town, and later from Pownal. Charcoal was made in the hills of the surrounding towns and at kilns near the blast furnaces.

There are two early references to eighteenth century forges in

Bennington. One describes a forge erected in 1786 by George Keith on land leased from Eldred Dewey and about a quarter mile east from Dewey's house. It continued in operation into the 1800's and is believed to be the first forge in the vicinity of Bennington.[20] Although there is no mention of bar iron being made at this forge, George Keith was making nails on Mill Street in Bennington in 1775 from ore which he mixed,[21] so that Keith's 1786 forge may have been an expansion of his nail factory to make bar iron.

The other reference is an advertisement in the June 26, 1786 issue of the Vermont Gazette by William Blodgett for the sale of "Best refined bar iron, per ton or less quantity...the above articles will be given for good coal, ore or Pot Metal delivered at the Forge." [22] Pot metal refered to scrap iron. Location of the forge site is undetermined. John Spargo placed it with some probability south of the Lyon's District, which also included today's Furnace Brook, so named for a later blast furnace site. The von Sotzman 1796 map of Vermont indicates a forge with names "Blodgete" and "Deweys" associated with it at what appears to be the Walloomsac River near the middle of today's village of Bennington. This may have been at the mill pond, a thousand feet northwest of the main village intersection (Routes 7 and 9). The 1856 Rice map of Bennington County shows the pond much larger, probably dammed, with a variety of mills including two foundries immediately downstream of the pond. This area coincides closely with the location of the previously-mentioned Keith forge. Both Keith and Blodgett's forge are given 1786 as starting dates and I wonder if maybe Blodgett acquired Keith's forge. These establishments have a history of changing owners many times, sometimes a number of times in the same year and month.

In 1793, Benjamin Fassett and Simeon Hathaway began the construction of a blast furnace along Furnace Brook, so named because it ran past the furnace.[23] Whitelaw's 1796 map of Vermont locates an iron-works along Furnace Brook at a point that appears to be about 1½ miles south of the Shaftsbury town line, where the brook enters a small, narrow valley (figure 9). The site of Bennington's first blast furnace may be within a quarter mile of a proposed highway bypass around the east side of the village of Bennington. That the site was a blast furnace and not a forge (bloomery) is noted by an item in the May 9, 1794 Vermont Gazette which stated that the furnace "is now in blast.... they will begin to cast this day." [24]

Spargo insists in a footnote that this is not the first furnace in Bennington.[25] He does not, however, differentiate between blast furnace and forge, the implication here that Blodgett's is the first furnace, which leads some to believe that Blodgett's was a blast furnace. But where Blodgett advertises bar iron, Fassett and Hathaway advertise hollow-ware, which is made by smelting with a blast furnace. Spargo did not seem to be aware of this crucial difference in his analysis of the word "forge", reading into the word a definition that encompasses a process that produced both cast and wrought iron.[26]

By 1799, the blast furnace of Fassett and Hathaway came under control of Moses Sage, Paul Cornell, and Caleb Gifford, until ore beds in nearby Shaftsbury became unprofitable to work. The blast furnace was probably abandoned in 1803, the year before Sage and his son-in-law Giles Olin commenced operation of a new blast furnace a mile east of the village near the Woodford town line. New ore beds had recently been discovered here.

The new Sage and Olin blast furnace, called Bennington Furnace, commenced operation in 1804 or 1805.[27] Two advertisements by Sage in 1806 offered jobs for woodchoppers and the sale of potash kettles and hollow-ware at the Bennington Furnace. The business continued until 1811 when it was bought by Thomas Trenor who ran the furnace on and off until about 1819.

In 1820 or 1821, the business was acquired by Seth Hunt who took down the original stack to build a new one in 1822 that concentrated on the production of pig iron. This is the easternmost of the two stacks now standing at Furnace Grove, east of Bennington village.

In late 1822, a newly chartered joint stock company called the Bennington Iron Company acquired the entire property, including the former property of Robinson and Lyman just over the line in Woodford. Principal stockholders of the Company were two New York City men: Charles H. Hammond and Nathan Leavenworth. The Bennington Iron Company erected two more blast furnaces; a large one, the westernmost of the two, now standing at Furnace Grove, and later a smaller one about 30 to 40 feet away and between the two stacks. This smaller furnace was referred to as "the pup".

In 1824, a cupola furnace was in operation, remelting the pig iron and casting hollow-ware and ploughs in addition to filling orders for custom work. In 1831, an advertisement noted the addition of a refining forge to the Bennington Iron Company whose two blast furnaces were then making seven tons of pig iron daily (figure 10). This would equate to about 1000 tons a year, about average for blast furnaces in New England at the time.

The Bennington Iron Company failed in 1842 by which time the price of iron had fallen from $66 per ton to $22. Creditors included banks in Bennington and in Troy, N.Y. as well as merchants in Troy

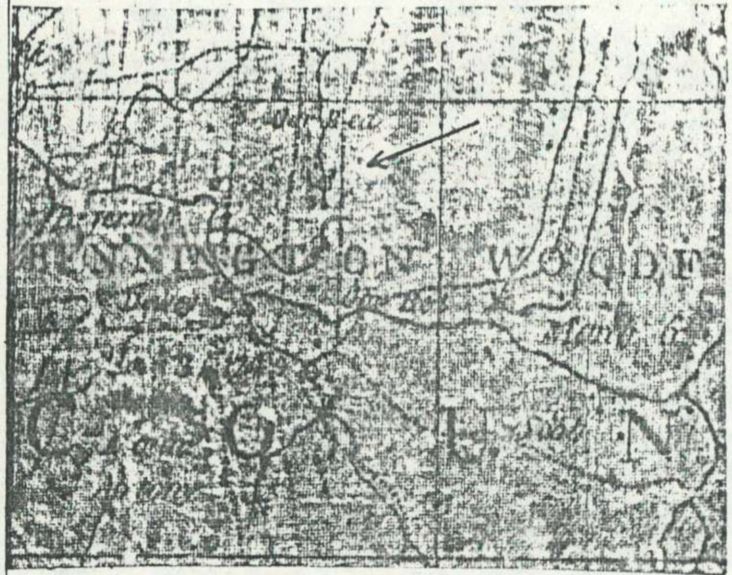

Figure 9 (left). The Town of Bennington in Whitelaw's 1796 map, indicating an ironworks in the northeast part.

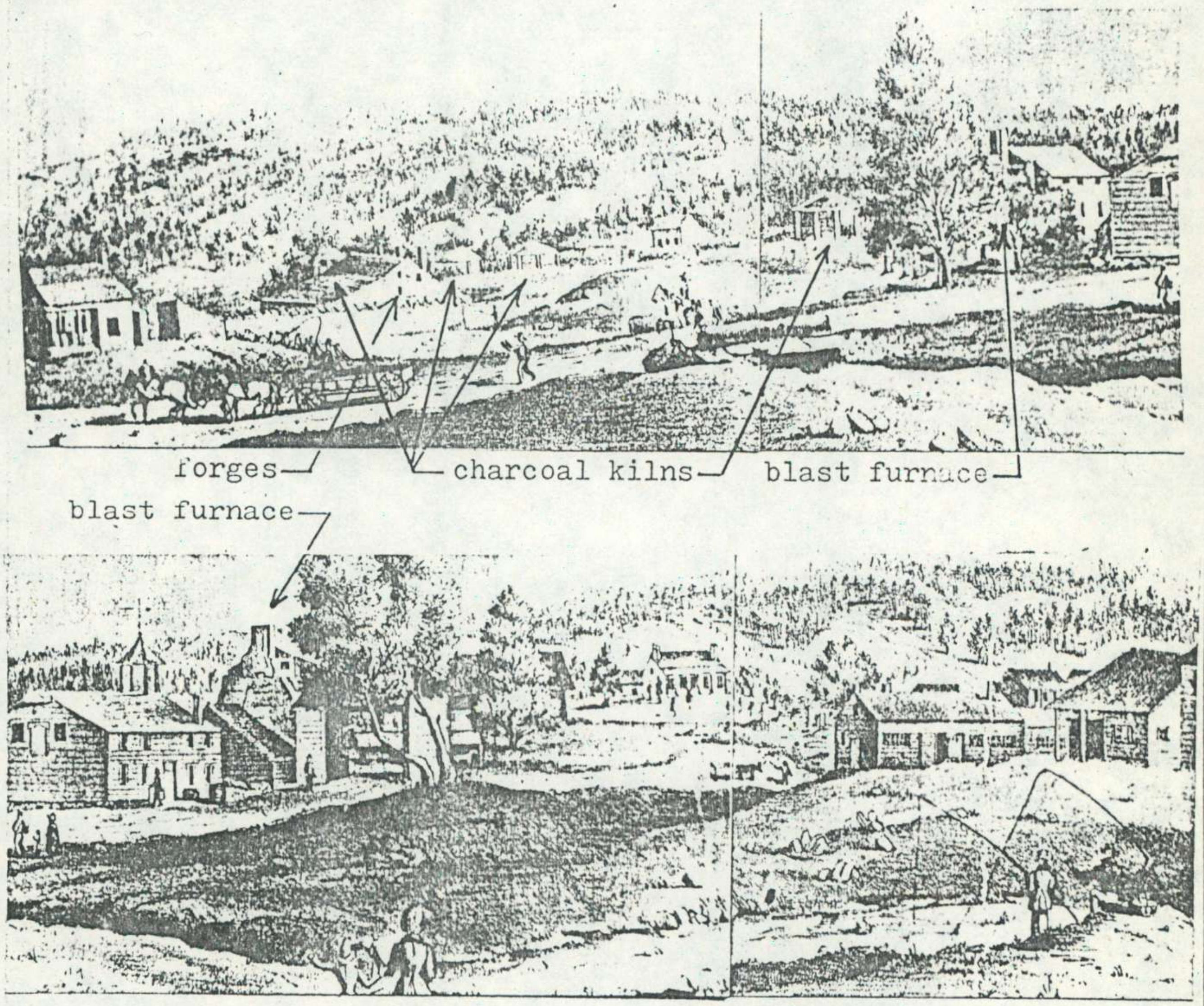


Figure 10. View of the Bennington Iron Company from Hinsdell's 1835 map. The lower photo is a continuation from the upper right side. Roaring Brook branch of Walloomsac River in foreground.

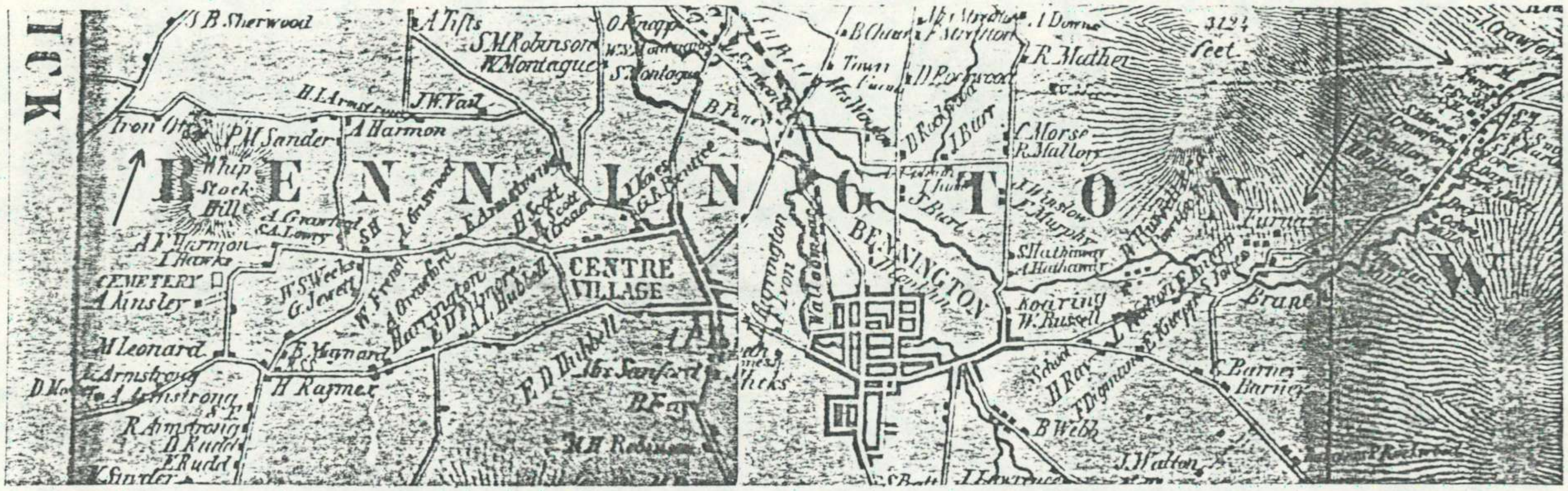


Figure 10A. The Bennington Village area in the Rice and Harwood Map of Bennington County, 1856. Three blast furnaces are still indicated at right, center. Further right (east) over the boundary in Woodford is a forge. At upper left is the iron mine that supplied ore to furnaces in Bennington and Shaftsbury.

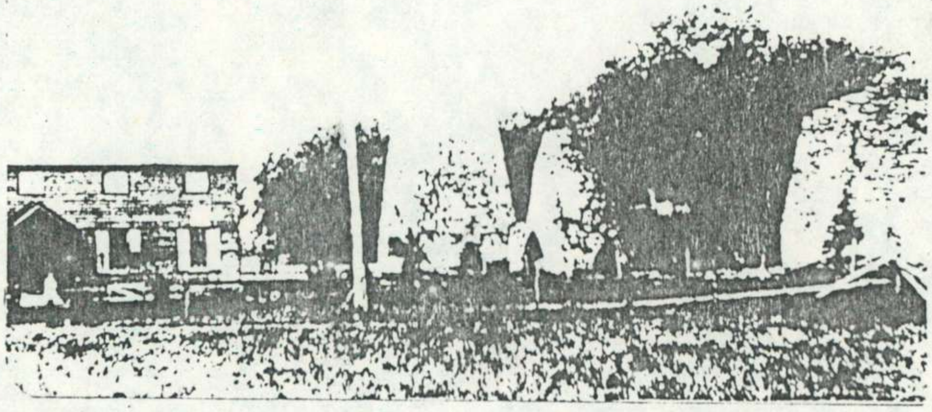

Figure 11. The East Bennington site about 1880, before collapse of the "pup" (center furnace). Photo courtesy R. S. Allen.

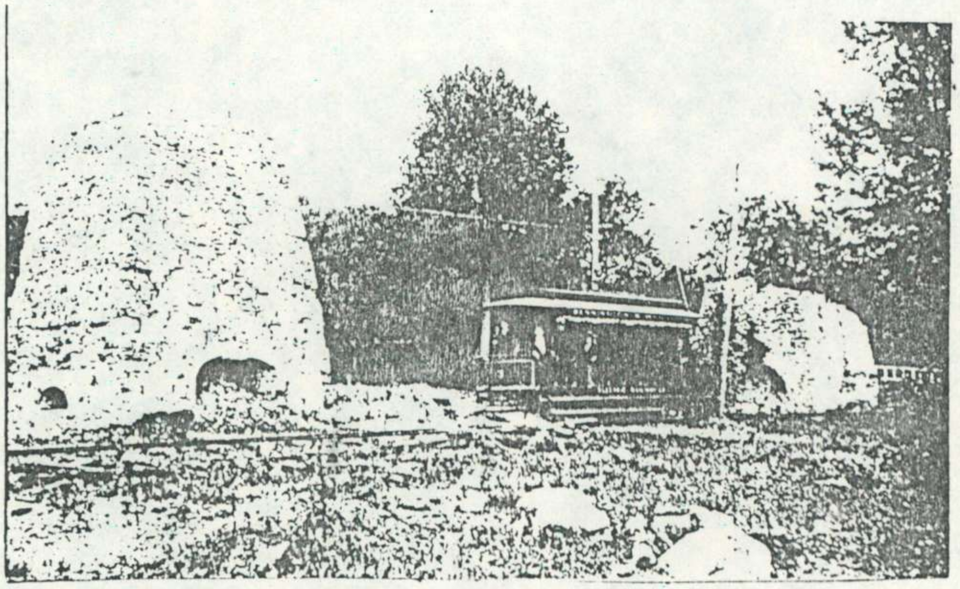

Figure 12. The East Bennington site following the collapse of the "pup", probably in the 1890's. Photo courtesy R. S. Allen.

and Albany, and unpaid employees and farmers. Much litigation followed with the property being eventually acquired by Captain Hamilton L. Shields who leased the furnace to Brock and Hinsdill for three years. They made sufficient profit to renew the lease another three years to 1853, and then lost everything. No part of the ironworks operated after that.[28]

In 1866, the last of the wooden portions of the three furnaces burned. The pup collapsed and was removed in 1890 (figures 11 and 12, before and after collapse of the pup). The largest stack, standing to the west, stood in splendid condition until the early 1900's when the south facade collapsed in the middle of the night with such a roar and tremor to waken nearby residents to fears of an earthquake.[29] Both remaining stacks crumble a few stones at a time every spring (figures 13 and 14).

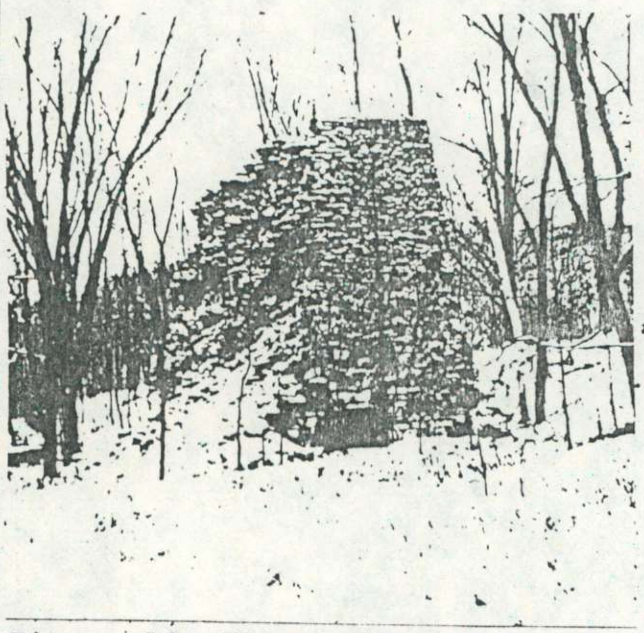

Figure 13. The westernmost stack, in 1955, much the same today. Photo courtesy R. S. Allen.

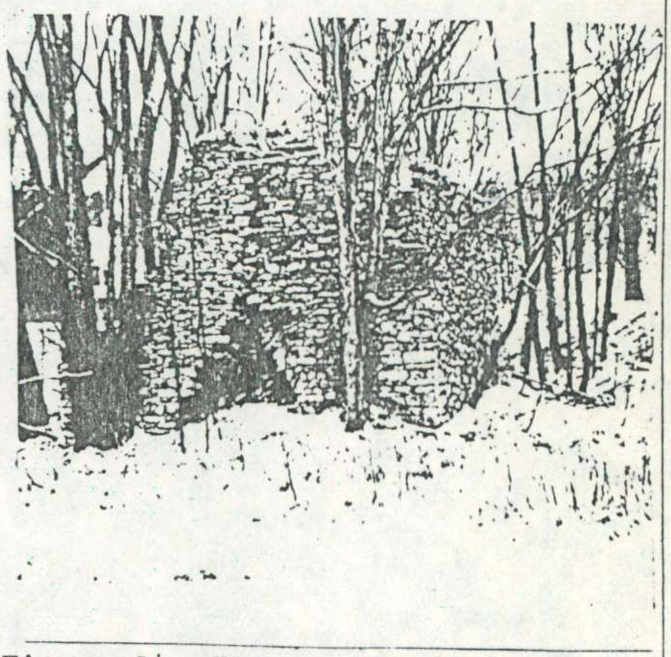

Figure 14. The easternmost stack, in 1955, much the same today. Photo courtesy R. S. Allen.

From: Rolando 1980.

List of sites with assigned survey numbers.

Table 1. Topographic Data: Bloomery Forges

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Bennington | Keith | 1786-1800's | Bennington | unk | unk |
| | Blodgett | 1786- | Bennington | Bennington Village | 18/646070/4748900 |
| Brandon | Blake | 1790-1810 | Brandon | Brandon Village | unk |
| Bristol | Scott #1 | 1791- | Bristol | Lower bridge | 18/65330X/48877XX |
| | Scott #2 | unk | Bristol | Below Scott #1 | 18/65335X/48874XX |
| | Franklin | 1802-1830 | Bristol | Bristol Village | 18/6536XX/4888XXX |
| | Chase | 1832-(1840's) | Bristol | Baldwin Creek | unk |
| | Holley | c1850's | Bristol | East of village | 18/655290/4887600 |
| | Burnham | c1850's? | Bristol | No. of Baldwin Ck. | unk |
| Burlington | Johnson | 1791- | Burlington | unk | unk |
| | Allen | c1796- | Burlington | Winooski River | 18/6436XX/49276XX |
| Calais | unk | c1810 | Plainfield 15' | East Calais | unk |
| Castleton | Slab City Forge | c1796-c1815 | Poultney | Lk Bomoseen Dam | 18/642650/4829300 |
| Colchester | Allen | 1783- | Burlington | Winooski River | 18/6436XX/49276XX |
| Danby | Phillips | early 1800's | Middltn Sp | Tn Rte 2 @ Baker Bk | unk |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Danville | Blanchard | c1810 | St. Johnsby 15' | Joes Brook | 18/7288XX/49177XX |
| Dover | Somerset Forge | 1820-(1832?) | Wilmington 15' | N. of West Dover | 18/672800/4757620 |
| Fairfax | Shepardson's | c1870 | Gilson Mtn | Stones Brook | 18/660470/4947100 |
| Fairfield | Fairfield Forge | 1831- | unk | unk | unk |
| Fair Haven | Lyon's Works | 1785-1815 | Thorn Hill | below upper falls | 18/64025X/482769X |
| F.S. 17(RU) | L. Davey | 1815-1843 | Thorn Hill | below upper falls | 18/64025X/482769X |
| | I. Davey | 1843-(1870's?) | Thorn Hill | below upper falls | 18/64025X/482769X |
| Ferrisburg | Barnum #1 | c1800 | Monkton | Monkton Road bridge | 18/6450XX/48939XX |
| | Monkton Iron Co | 1807-1810's | Monkton | Monkton Road bridge | 18/6450XX/48939XX |
| | Barnum #2 | c1820 | Monkton | Walkers Falls | 18/64417X/48952XX |
| | Fuller | early 1800's | Monkton | Ferrisburg Hollow | 18/640690/4895000 |
| Goshen | Kendall | unk | unk | E. side of mtn (?) | unk |
| Grand Isle | Goodwin | 1827-1838 | Plattsburg 15' | Mill Brook | 18/636XXX/4951XXX |
| Highgate Vt-FR-146 | Drury Blast | 1807- | unk | unk | unk |
| Lincoln | Soper & Pier | c1828-1830 | So Mountain | West Lincoln | 18/65823X/4886740 |

F.S. 50(AD)

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Lincoln (con't) F.S.50(AD) | Burnham | 1830-1860 | So Mountain | West Lincoln | 18/65813X/4886740 |
| | Ackworth #1 | 1828-1830 | So Mountain | West Lincoln | 18/658600/4886600 |
| | Ackworth #2 | 1830-1860 | So Mountain | West Lincoln | 18/658600/4886600 |
| Manchester | Manchester Forge | c1829 | Manchester | along Route 7? | unk |
| Middlebury VT-AD-299 | Middlebury Forge | early 1800's to 1890 | E Middlebry | E Middlebury Vil. | 18/653370/4870130 |
| Middletn Sp | Burnham #1 | c1796-1811 | Wells | Burnham Hollow | 18/6505XX/4815800 |
| | Burnham #2 | 1811- | Wells | Burnham Hollow | 18/6505XX/4815800 |
| | Poultney | c1796 | Middletn Sp | Poultney R @ Train Bk | 18/6540XX/48162XX |
| Milton | Poor Farm Forge | c1820 | Georgia Pl | Lamoille River | 18/647480/4944300 |
| Morristown | Sawyer | 1826-1828 | Hyde Pk 15' | Cady's Falls | 18/689620/4938500 |
| Orwell VT AD 300 | Lyon Blast | 1788- | Orwell | East Creek | 18/634XXX/4851XXX |
| Pittsford | Larned's Forge | c1840 | Proctor | Furnace Brook? | unk |
| Poultney | Joslin & Darling | 1785- | Poultney | East Poultney | 18/6457XX/48208XX |
| Pownal | Noble | c1796-(1810 plus) | Pownal | W of Green Mtn Pk | 18/6442XX/47348XX |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Proctor | Sutherland Falls | c1800-1840 | Proctor | Sutherland Falls | 18/658480/4836170 |
| Randolph | Randolph Forge #1 | (1800's-1850's)? | Randolph 15' | unk | unk |
| | Randolph Forge #2 | (1800's-1850's)? | Randolph 15' | unk | unk |
| Richmond | Sears | 1780's-1800's | Huntington | Huntington River | 18/66XXXX/4914XXX |
| UTCA 20 ST. Johnsbury | Paddock forge | 1818 - 1828 | St. J. 15' | | |
| Salisbury | Sawyer | 1791- | E Middlbry | Leicester River | 18/653XXX/4862XXX |
| | Salisbury Bloomry | 1840's-1857 plus | E Middlbry | Leicester River | 18/653250/4862050 |
| Shelburne | Burritt | 1792-(1820's?) | Mount Philo | Shelburne Falls | 18/642100/4914380 |
| Shoreham | Knopp | c1790- | Orwell | Richville | 18/6387XX/48590XX |
| | Shoreham | c1797- | Orwell | Richville | 18/658510/4859160 |
| Starksboro | Fergusson & Sayles | 1819-1871 plus | Bristol | Starksboro village | 18/655100/4898760 |
| | Ferguson & Bushnl | c1820 | Bristol | E. of village | 18/6556XX/4898800 |
| | East Mtn | c1840 | Bristol | Upper Lewis Creek | 18/656XXX/4895XXX |
| Swanton | Barney #1 | 1799-1816 | E. Alburg | Goose Island | 18/647760/4975890 |
| F.S. 12 (FR) | Barney #2 | 1816-1821 | E. Alburg | Goose Island | 18/647760/4975890 |
| | Barney #3 | 1821-1824 | E. Alburg | Goose Island | 18/647760/4975890 |
| | Barney #4 | 1849-1868 | E. Alburg | Goose Island | 18/647760/4975890 |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Tinmouth | Chipman | 1781 or 85- | Middltn Spg | near Chipman Lake | 18/6583XX/48085XX |
| | Allen | 1791- | Middltn Spg | unk | unk |
| Troy | Stebbins/Phelps | 1834-1841 | Irasburg 15' | E of Troy village | 18/7058XX/49766XX |
| Vergennes | Spencer | 1786- | Pt Henry 15' | E side Otter Creek | 18/6394XX/48917XX |
| | Stevens | 1799- | Pt Henry 15' | W side-above falls | 18/6395XX/48915XX |
| VT-AD-146 | Monkton Iron Co | 1808- | Pt Henry 15' | W side-below falls | 18/63925X/489160X |
| | White's Bloomery | c1850 | Pt Henry 15' | W side-below falls | 18/63925X/489160X |
| Wallingford | Miller | 1780's-1835? | Wallingford 15' | Route 7 in village | 18/663620/4814850 |
| Westford | Stanton | 1795-c1809 | Essex Ctr | Westford Center | 18/657900/4941360 |
| | Camp | -c1809 | Essex Ctr | Westford Center | 18/658000/494167X |
| Weybridge | Belding | 1795-(1800) | Middlebury | Belding Falls | 18/646000/4879050 |
| Williston<br>F.S. 70 (CH) Old CCAS F.S. # | Spafford | c1810 | Essex Jct | Allen Bk @ I-89 | 18/65388X/49216XX |
| Windsor | unk | 1820's-1830's | Claremont | Windsor Village | unk |
| Woodford | Woodford H. #1 | c1800 | Bennington | Woodford Hollow | 18/652610/4750840 |
| | Woodford H. #2 | c1856 | Bennington | Woodford Hollow | 18/652610/4750840 |

YOUNGSTOWN STATE UNIVERSITY
YOUNGSTOWN, OHIO 44555

April 28, 1980

Victor R. Rolando
34 Howard St.
Pittsfield, Mass. 01201

Dear Mr. Rolando:

The two papers you requested are in press and won't be available until fall probably. "Slag as an Interpretive Tool in Historic Blast Furnace Research" will be in the fall issue of Historical Metallurgy. I've put your name on my list of interested "slagologists" and will send copies when they appear. In the meantime here is a reprint, which if you have not already seen, should be right down your alley; I've also sent along three of my related articles.

Let me know what's happening in your studies.

Sincerely,

John White

JOHN R. WHITE, Ph.D.
Professor of Anthropology

No charge.

JRW/csd

# Slag, cinder, and bear

LESTER A. ROSS

G. R. MORTON AND JOYCE WINGROVE

In archaeology, and indeed in modern ironmaking terminology, the terms "slag" and "cinder" are used in a somewhat loose manner and the two terms are frequently used in the same context. In addition, the term "bear" appears to be restricted to coke blast-furnace practice only, although in the authors' opinions bear material was present in charcoal blast-furnaces and to a lesser extent in bloomery hearths.

The object of this paper is to consider the properties and structures of some of these products, to relate them to the processes, and to make recommendations for future terminology.

In iron-smelting operations, slag can be considered as the molten silicate complex formed by the combination of impurities and earthy matter agglomerated with the ore, fuel, and fluxes either in or added to the charge. Slags are formed from molten silicates which act as carriers for other impurities, either in solution or suspension. All slags are in the molten condition when in the furnace hearth. Slags are also formed in refining operations, in which case some of the metal from the charge, or fluxes specially added for the purpose, combine with the impurities in the charge, fuel, and fluxes to form a silicate slag complex.

In many metallurgical operations, drossy solid material collects on the top of the molten slag or metal, and when removed it resembles a mass of infusible or partially fused material, often intermixed with slag. Since this material has never reached a molten nor free-flowing condition in the furnace, it should be termed cinder.

Stead[1] defines a blast-furnace bear as "a solidified mass of metal or conglomerate below the hearth or floor level of a blast furnace, found after the furnace has been blown out after long service". When a blast furnace is blown out, the whole of the liquid mass below the level of the tapping hole eventually becomes solid and constitutes the bear, which is also known by other names, such as "old horse", "sow" and "salamander". In furnaces where the product is molten pig iron it is only when the furnace is being blown in that molten slag can come into contact with the refractory material of the hearth. When a well of metal has formed it must be the iron and not the slag which is responsible for the attack on the brickwork, and as a result of this attack bear is formed. Details of slag, cinder, and bear in relation to the furnace hearth are shown in Fig. 1.

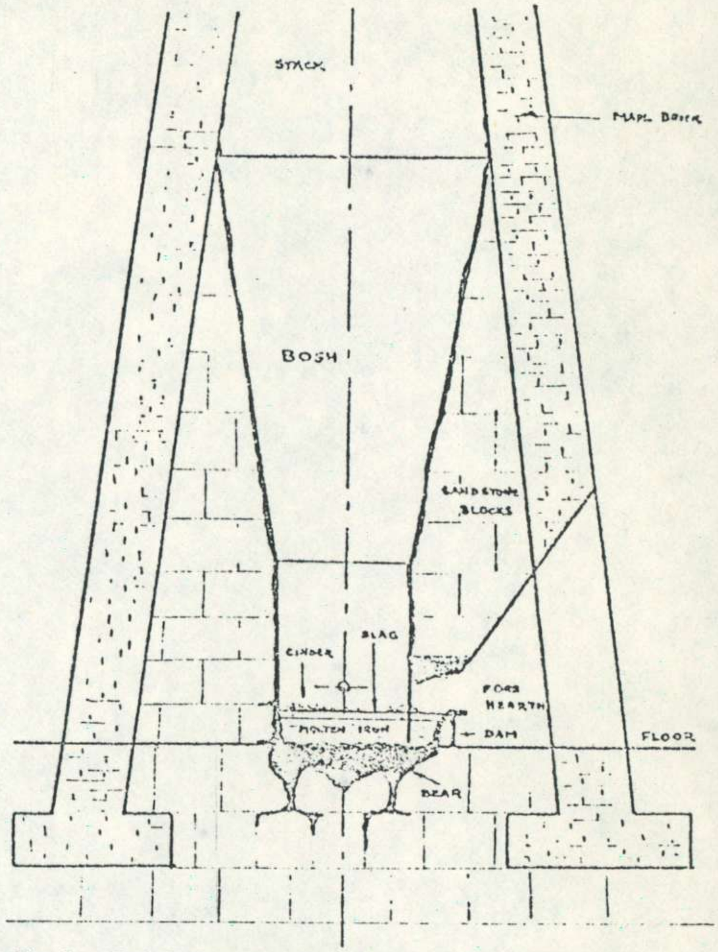


Fig. 1 — Sketch showing sites of formations of slag, cinder, and bear in the blast-furnace

## TYPES OF SLAG

The main types of slag found as a result of ironmaking operations can be conveniently classified according to the amount of iron lost to the slag. In the early bloomery process and in slag produced by the conversion of pig iron to the form of bar, the iron loss was generally high and the slag contained in the order of 30-50% Fe, whereas in early blast-furnace slags the iron loss to the slag was as low as 2-4%. In modern blast-furnace slag this iron loss is less than 1%. It is therefore convenient to classify slags by consideration of the iron lost to the slag, and in the following manner:

1. Bloomery slags, in which the iron acted as a flux to the gangue material of the ore, thus causing high iron loss to the slag. The bloomery process was the only smelting operation in which some of the iron contained in the charge acted as a flux, and the iron content of the slag was in the order of 40-50% of the slag.

2. Slags from processes relating to the production of malleable bar by refining pig iron in the forge, where the iron loss was high. Little is known of several of these processes, but they have been considered in some detail by Morton and Mutton[2]. These are subdivided as follows:

(i) Charcoal finery

(ii) Charcoal chafery

(iii) Coke/coal refinery

(iv) Coke/coal finery

(v) Coke/coal chafery

(vi) Puddling furnace (usually known as tap cinder)

(vii) Balling and reheating furnace

3. Blast-furnace slags, where the iron loss was low.

(i) Charcoal furnace
 (a) where sufficient $Al_2O_3$ was present in the ore to act as a flux
 (b) where a small quantity of lime was added to the charge.

(ii) Slag from blast-furnaces where coke or coal, or a mixture of coke and coal, was the fuel used and where the air blast was not preheated (cold-blast slag)

(iii) Slag from blast-furnaces where coke or coal, or a mixture of coke and coal, was the fuel used and the air blast was preheated (hot-blast slags).

(iv) Modern blast-furnace slags.

The authors are at the College of Technology, Wolverhampton.

Morton and Wingrove[3,4] have considered the bloomery process and the slags produced during the Roman era in detail, and later bloomery slags are now under consideration. Since the operating temperatures of the bloomery were low, little or no special flux such as lime could be added, since this would not have produced a fluid slag, and in order to neutralize the acids present in the ore, some of the iron present was taken up by the slag, thus lowering the efficiency of the process. These high iron-bearing slags were fluid at temperatures in the order of 1150°C and were based on the compound fayalite ($2FeO.SiO_2$). Excess FeO was necessary to provide for slag-metal reactions in the hearth and, dependent upon the composition of the ore, some other compounds such as spinels could form on solidification. In solid slags these minerals are found embedded in a glass matrix.

Owing to the variable nature of the ore, it would be expected that slight variations in temperature and ore composition could make a considerable difference to the viscosity of the slag as tapped from the furnace. Differences in viscosity can often be seen on the surface of the slag found on excavation, which may show runnels or be quite smooth. When fractured, these slags show a clean grey-black compact structure, often with a large number of gas blow-holes. The size of the blowholes is dependent upon the rate of cooling: fast cooling gave a fairly uniform distribution of small holes whereas slow cooling produces a random orientation of large holes congregating towards the last cooled surface. Where such slags have been exposed to atmospheric conditions for a very long period of time, slight surface discoloration resulting from the production of the higher oxide ($Fe_2O_3$) may be seen. Occasionally very porous sponge-like slags very much lighter than normal bloomery slags are found, and this condition might be caused by the molten slag absorbing a high gas content which would be evolved and trapped on cooling. Typical analyses of bloomery slags are given in Table I, and microstructures in Figs. 2 and 3.

Forge Slag (Produced from refining pig iron)

A study of the forge slags in group 2 form a part of the present research programme at the Wolverhampton College of Technology. Slags from the charcoal finery and charcoal chafery are being studied in some detail, and results are not complete. Virtually no information has yet been obtained on slags from groups (iii), (iv), and (v). These are related to processes where attempts were made to use mineral coal or coke for heating purposes. All slags in this group were fluid at furnace operating temperatures and were tapped as a molten magma.

**Fig. 3 — Microstructure of Stoney Hazel slag**
Magnification × 100

The conversion of pig iron into the form of malleable bar (wrought iron) in the charcoal finery and chafery has been considered in detail by Morton[7], and the fuel transition from charcoal to coal by Morton[8] and Morton and Mutton[9]. From the variety of processes covered by this group it would be expected that the characteristics of the slags would also vary. Nevertheless, those examined to date appear to contain the compound fayalite, which in itself is high iron-bearing. As with bloomery slags, the fayalite is associated with a glass phase, but in these slags oxides of iron other than wüstite could be present, and the iron in the slag can be in the order of 50% of the slag. It follows therefore that slags in this group are likely to be somewhat similar in appearance to bloomery slags, but perhaps more compact. Other differences may be found, and these will be the subject of a further paper on completion of the section of the work now being undertaken. Typical analyses of slags in this group are given in Table II.

BLAST-FURNACE SLAG (Low iron loss)

The higher temperatures attained in the blast-furnace permitted the formation of slags containing silicates of lime and alumina instead of silicates of iron as in the bloomery process, thus leaving more iron available for reduction and providing slags low in iron.

TABLE I  Analyses of Bloomery Slags, %

| | Roman | | | Medieval | | |
|---|---|---|---|---|---|---|
| | 1[5] Ashwicken | 2 Worcester | 3[6] Gt. Casterton | 4 Nun's Well | 5 Rushall | 6 Stoney Hazel |
| $Fe_2O_3$ | 7.70 | 10.57 | 3.20 | 6.90 | 4.30 | 3.20 |
| FeO | 62.10 | 61.85 | 46.10 | 47.50 | 45.50 | 56.90 |
| $SiO_2$ | 21.20 | 16.15 | 26.20 | 24.20 | 24.70 | 24.20 |
| CaO | 0.40 | 3.05 | 7.00 | 1.10 | 5.60 | 2.50 |
| MgO | 1.40 | 1.25 | 1.10 | 0.30 | 2.60 | 0.90 |
| MnO | 0.50 | 0.24 | 0.70 | 2.50 | 0.80 | 0.13 |
| $Al_2O_3$ | 3.20 | 5.86 | 9.50 | 14.50 | 13.60 | 8.90 |
| $P_2O_5$ | 1.72 | 0.03 | 2.30 | 1.60 | 0.60 | 0.71 |
| S | | n.d. | | n.d. | n.d. | 0.22 |
| $TiO_2$ | | | 0.45 | | | |
| Fe | | | | 1.20 | 1.40 | 1.90 |
| Total | 98.22 | 99.00 | 96.55 | 99.80 | 99.10 | 99.56 |

| Group | (i) | (i) | (ii) | (ii) | (iii) | (iv) | (vi) |
|---|---|---|---|---|---|---|---|
| | Powick | Ipsley | Back-barrow | Ipsley | Little Aston[10] | Little Aston | Staffs. |
| FeO | 65.10 | 69.10 | 33.20 | 58.80 | 56.59 | 45.20 | 58.67 |
| $Fe_2O_3$ | 9.10 | 11.20 | 8.60 | 9.90 | | | 17.00 |
| $SiO_2$ | 11.20 | 7.70 | 20.02 | 17.80 | 12.50 | 22.62 | 11.76 |
| CaO | 3.10 | 2.50 | 4.20 | 2.60 | 3.20 | nil | 2.88 |
| MgO | 0.29 | 0.10 | 1.94 | 0.22 | 0.54 | 0.15 | 0.29 |
| MnO | 3.83 | 0.58 | 0.74 | 2.50 | 0.24 | 0.06 | 0.57 |
| $Al_2O_3$ | 3.50 | 5.70 | 10.60 | 4.90 | 7.92 | 13.38 | 2.84 |
| $P_2O_5$ | 2.59 | 1.80 | 1.00 | 2.01 | 0.51 | n.d. | 4.27 |
| S | 0.10 | 0.08 | 1.83 | 1.05 | 2.47 | 0.08 | 3.11 FeS |
| $TiO_2$ | 0.23 | 0.10 | | | | | |
| Fe | 0.75 | 0.88 | 17.20 | 0.70 | | | |
| C | | | | | 13.89 | | |
| $H_2O$ | | | | | 1.40 | | |
| Alkali | | | | | 0.74 | | |

The development of blast-furnace slags over the years can be directly related to this ability to obtain higher and higher air blast volumes and pressures. The effect of increasing blast on the operating temperature made possible a change in the fuel used from charcoal to coke, and to coke-coal mixtures, which led to the ability to use lime in greater quantities as a flux. Blast-furnace slags can therefore be divided into groups according to the nature of the blast, the fuel used, and the quantity of lime added as flux (Table III). This ability to use more lime as a flux also allowed more sulphur to be taken up by the slag, which meant that poorer-quality ores (i.e. those with higher sulphur content) could be successfully smelted.

All these slags have definite identifiable visual, chemical, and mineralogical characteristics. Early blast-furnace slags are glassy and, as the lime content increases, the slag takes on a more stony appearance, even to the point of slaking after many years of exposure to atmospheric conditions. The visual characteristics of these slags are given in Table IV.

It is to be expected that the chemical analyses of the slags will vary according to the nature of the gangue material associated with the ore, but in the charcoal blast-furnaces the ratio of the sum of the bases to acids is always such that the resultant slag has a glassy appearance. Table V shows the analyses of charcoal blast-furnace slags. The appearance of cold-blast coke furnace slags, on the other hand, is markedly affected by the rate of cooling; rapid cooling retains a glass whereas slow cooling produces a calcium silicate stony mass. Thus cold-blast slags tapped from the furnace into cast-iron slag bogies will show a glassy surface where the melt was in contact with the bogie, and this turning to stone a short distance from the surface. Hot-blast slags are generally stony and unless very rapidly cooled show little glass.

## Cinder

The definition of cinder suggests that drossy material insoluble in the molten slag at a particular temperature might be taken into solution with progressive increase in temperature. It therefore follows that bloomery cinder will differ in constitution from that found on the top of charcoal blast-furnace slags, and this again will differ from that found on slag from later blast-furnace processes where still higher temperatures were obtained. In the bloomery process the slag was either tapped off into a slag pit via a runner from the hearth taphole (i.e., tap slag[15]) or left in the hearth and removed

TABLE III Analyses of Blast-Furnace Slags, %

| | Charcoal blast-furnace | | | Coke/coal blast-furnace | |
|---|---|---|---|---|---|
| | Cannock 1561-1650 | Charlcot 1700-1792 | Duddon 1736-1866 | Tipton[11] c1850 coke cold-blast | Ebbw Vale[12] c1850 hot-blast |
| $SiO_2$ | 47.90 | 52.50 | 56.40 | 39.52 | 43.55 |
| $Al_2O_3$ | 23.20 | 20.17 | 12.40 | 15.11 | 20.40 |
| CaO | 11.90 | 17.00 | 14.60 | 32.52 | 28.85 |
| MgO | 7.20 | 4.57 | 3.60 | 3.49 | 1.10 |
| MnO | 3.30 | 1.86 | 9.80 | 2.89 | 0.25 |
| FeO | 4.40 | | 2.60 | 2.02 | 3.74 |
| $Fe_2O_3$ | | 4.30 | | | |
| $P_2O_5$ | 0.10 | 0.32 | | | 0.35 |
| S | 0.10 | 0.01 | | 2.15 (CaS) | 0.65 |

| Group | A | B | C | D | E |
|---|---|---|---|---|---|
| Colour | Mainly light to dark grey. Some opaque milky green and some bottle-green patches | Lightish milky grey-green | Milky grey-green to turquoise | Greyish-white chalky appearance. | Light to medium grey. |
| Texture | All pieces show glaze. Some patches completely vitrified. Some pieces of unburnt charcoal present. | All pieces highly glazed. Many completely vitrified patches. Some pieces of unburnt charcoal present. | Outer (top) surfaces cement-like. Large proportion of striated glass. Some outer separation of clear green-brown glass. | Mostly rather soft and slaked, due to weathering.<br>No glassy phase visible | Hard, concrete-like. |
| Porosity | Variable, gas holes mainly small, though some up to 1 cm dia. Well distributed. | Greater than A, with average pore size larger. Well distributed. | Outer (top) surfaces pin-pointed with many mainly small holes. | Gas holes largely invisible, but in places medium-sized, even, and closely spaced. | Low, except in darker pieces, where there are closely spaced small to medium-sized holes. |
| Rust | Present in fair quantity on the most porous pieces. | Present in fair quantity in many porous pieces. | None visible. | Infrequently visible | Infrequently visible. |
| Smell (on fresh break) | None | None | $H_2S$ | Strong smell of $H_2S$ | Sulphur. |

General remarks: For all glassy slags the glassy appearances decrease with increasing porosity, and the colour lightens in most cases.

The diameters of the gas holes are stated: very small—pin-head to 1mm; small—1-3mm; medium—3mm-1cm.

TABLE V Analyses of charcoal blast-furnace slags, %

| | Cannock 1561-1650 | Rievaulx[13] 1577-1790 | Sharpley Pool 1652 | Rockley[14] 1652-1736 | Charlcot 1700-1763 | Duddon 1736-1866 |
|---|---|---|---|---|---|---|
| $SiO_2$ | 49.66 | 45.30 | 49.30 | 45.90 | 52.50 | 56.40 |
| $Al_2O_3$ | 23.16 | 22.48 | 11.40 | 19.07 | 20.17 | 12.40 |
| CaO | 11.92 | 22.80 | 22.80 | 18.40 | 17.00 | 14.60 |
| MgO | 7.16 | 3.69 | 12.00 | 9.19 | 4.57 | 3.60 |
| MnO | 3.29 | 1.17 | 0.84 | 2.95 | 1.86 | 9.80 |
| FeO | 4.37 | | 2.70 | | | 2.60 |
| $Fe_2O_3$ | | 3.72 | | 2.43 | 4.30 | |
| $P_2O_5$ | 0.073 | 0.055 | trace | 0.50 | 0.32 | |
| S | 0.10 | | trace | | 0.01 | |
| Sulphide | | 0.032 | | 0.102 | | |
| Sulphate | | 0.19 | | 0.058 | | |

.160

when cold as "furnace bottoms". The upper surface of these furnace bottoms might well include drossy material which is, in effect, cinder and the two terms "cinder" and "slag" should not be confused. They are structurally different and also differ in chemical and mineralogical composition. Cinder found on the top of slags tapped from the blast-furnace, particularly from those of the charcoal era, includes many readily identifiable constituents such as charcoal, prills of iron, glassy slag, oxides and sulphides of iron, and many other insoluble phases. Details of cinder found on the top of pieces of slag taken from the Cannock site are shown in Fig. 4.

### Blast-Furnace Bear

At the site of Cannock charcoal blast-furnace, Morton[16] found a number of slagged hearthstones and a mass of bear approximately 18 in dia. and 3 in thick. The bear material was heavy and had the appearance of slag produced in the charcoal finery forge rather than the bottle-green slag usually made at Cannock and other charcoal blast-furnaces. It was apparent that the bear was formed by contact of molten iron and slag with the silica stone of the furnace hearth, and that its structure would be related to the reactions occurring between the metal, slag, and refractory, and the tramp materials held in suspension in the molten mass. A section through this sample of bear (Fig. 5) shows the high iron-bearing mass with entrapped charcoal, metallic iron prills, and other materials. Adhering to the underside were larger pieces of pig iron and partially slagged refractory material from the hearth. On fresh fracture the colour appeared a lighter grey than that of forge slags, and x-ray analysis confirmed the matrix to be a mixture of crystalline anorthite ($CaO.Al_2O_3.2SiO_2$) and cristobalite. The presence of anorthite in its crystalline form confirms the slow rate of cooling to which the bear would have been subjected on the

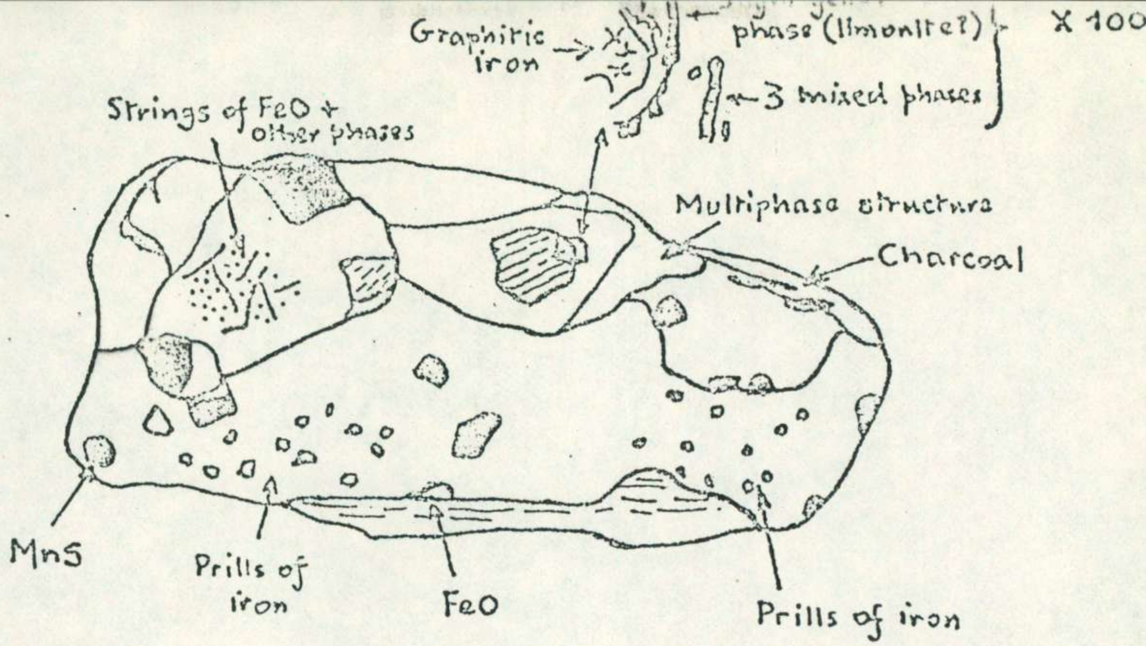


Fig. 4 – Cannock cinder

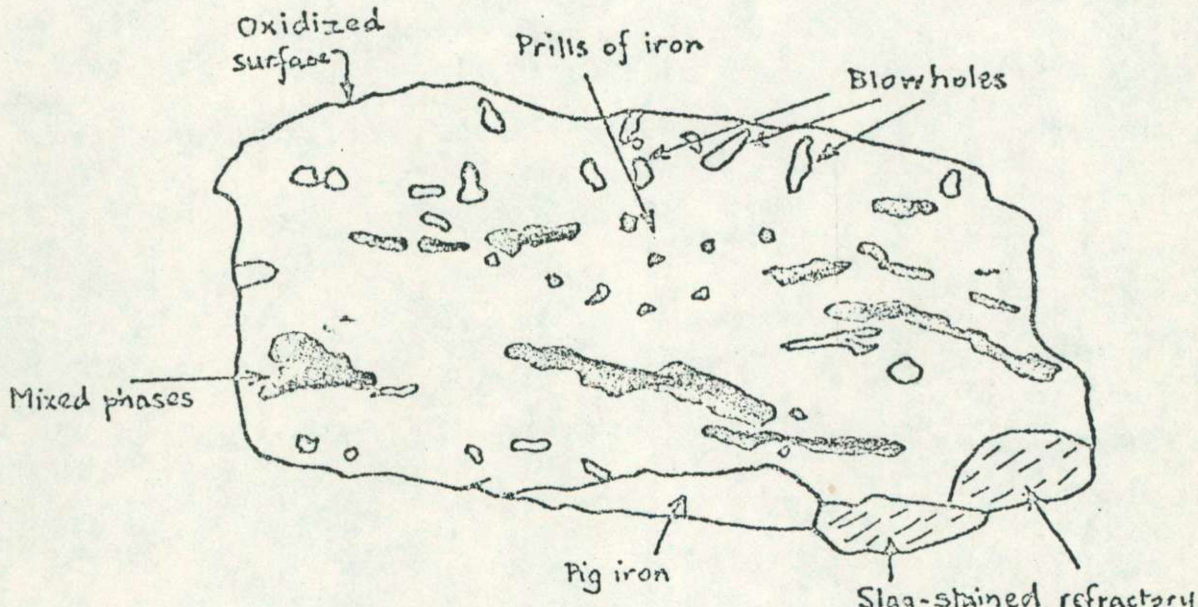


Fig. 5 – Section through Cannock cinder

blowing out of the furnace. The other material has become entrapped in this matrix.

The type of bear from coke blast-furnaces considered by Stead was formed over a long period of years, during which time the bottom linings were more or less fluxed away and replaced by a metallic agglomerate in which a large and varied number of substances collected. This mass contained a mixture of metal, kish, and partially fused brickwork, in which sulphides of iron and manganese, masses of oxides and silicates of iron, and other compounds were present. Details of typical bears are given in Figs. 6 and 7, each of which would weigh many hundreds of tons[17]. Bear of this type were common in coke blast-furnaces where the operating temperature was high (> 1500°C) and the campaign lasted many years (4-5 years +).

Since the melting temperature of the refractory material in the hearth was far above that of the liquid iron, it follows that the main action on silica and firebricks was due to chemical attack and not by simple fusion. In addition it must be noted that, when a furnace is blown in at the beginning of a new campaign, the only time that molten slag is in contact with the hearth is prior to the first tap. It is therefore the metal which is mainly responsible for the attack on the brickwork, and every class of silica brick and firebrick gives way to the action of the liquid iron. Stead also points out that all pig irons contain manganese, which is highly reactive with silica, and produces a fusible manganese silicate, green in colour. He gives the reactions:

$$2Mn + SiO_2 \rightarrow 2MnO + Si$$

$$2MnO + SiO_2 \rightarrow 2MnSiO_3$$

This green discoloration is frequently seen on the side walls of early charcoal furnaces. Alumina in the refractory materials will be fluxed away with the manganese silicates and iron will also form the silicate fayalite ($2FeO.SiO_2$). In this

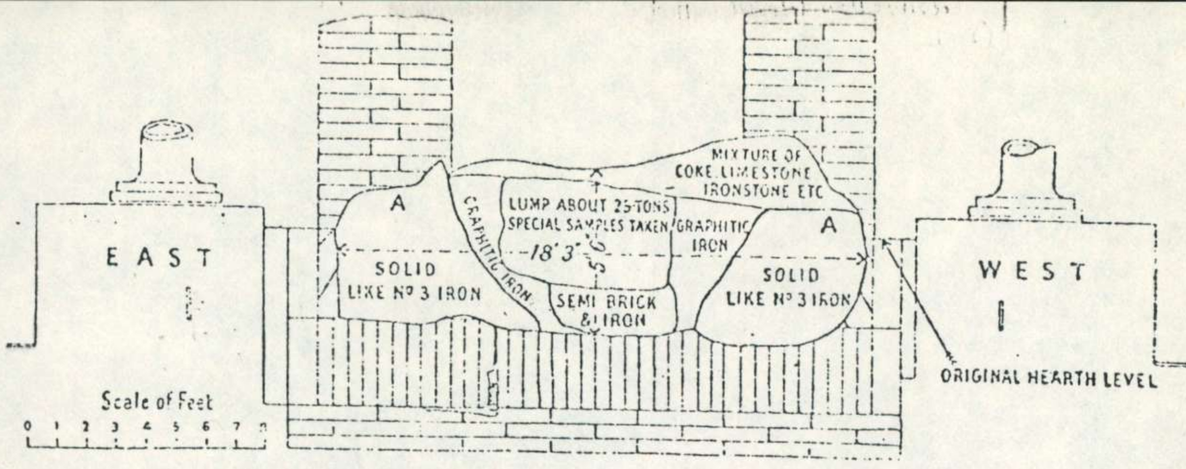


Fig. 6 — No. 3 furnace bear, as removed July-October 1917. The bear was removed in five distinct and separate formations: two central lumps with two annular masses round them and a top layer of partly reduced material

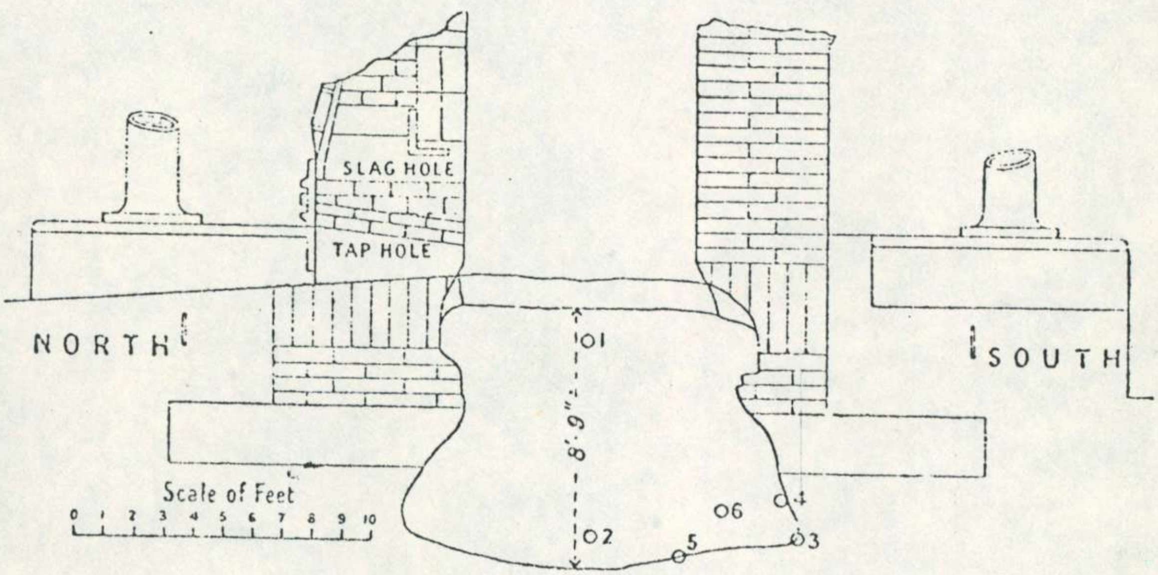


Fig. 7 — Ormesby No. 4 furnace bear, removed November 1914-April 1918

manner the bear builds up and, because it rests below the level of the iron notch, it is not removed on tap.

In the charcoal blast-furnace, the operating temperature being low (< 1450°C) and the campaign approximately 9 months, a somewhat different bear would form. The bear found at Cannock was readily differentiated from the normal working slag.

### Bear material from bloomery hearths

With the still lower operating temperature of the bloomery hearth (< 1350°C) and the working cycle of approximately 12 h, it follows that the bear material might be limited only to the attack of the slag on the refractory material in the region of the hearth and sidewalls. Since in the bloomery furnace the reduced iron was never molten in the hearth, virtually all the attack on the lining must have come from the molten slag, at temperatures in the order of 1100-1250°C. Bloomery furnace linings were usually made from clay minerals, probably in the form of an agglomerate of kaolinite and free quartz grains. At about 500°C, water of crystallization would be driven off from the clay, leaving amorphous $SiO_2$ and $Al_2O_3$, and it would be with these that slag reactions would occur.

A sample of bear material 2-3 in thick was obtained from Rockley bloomery, and examined visually, microscopically, and subjected to x-ray analysis. The appearance of the working surface was rough and eroded. Immediately below the surface the structure was quite hard and the colour dark grey, with considerable porosity. The remainder of the cross-section was more dense and had a wide greenish glassy band running through it (Fig. 8).

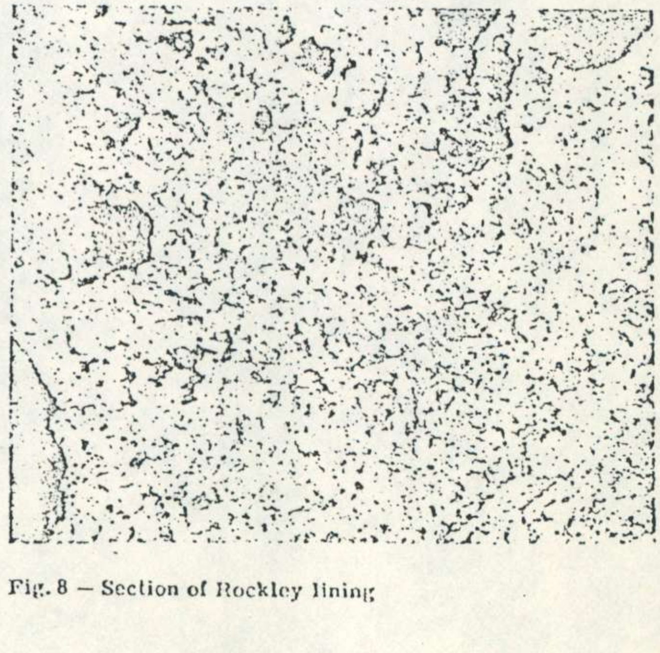

Fig. 8 — Section of Rockley lining

refractory background. A section from the centre of the sample showed a few large laths of fayalite in a refractory matrix. Thin sections showed, in addition, many feathery dendrites of mullite, and near the working face there were areas opaque to polarized light. X-ray analysis confirmed the presence of fayalite, mullite and probably some anorthite. Spectrographic analysis showed Al, Ca, Fe, Mg, and Mn as major elements, with only traces of the alkalis Na and K.

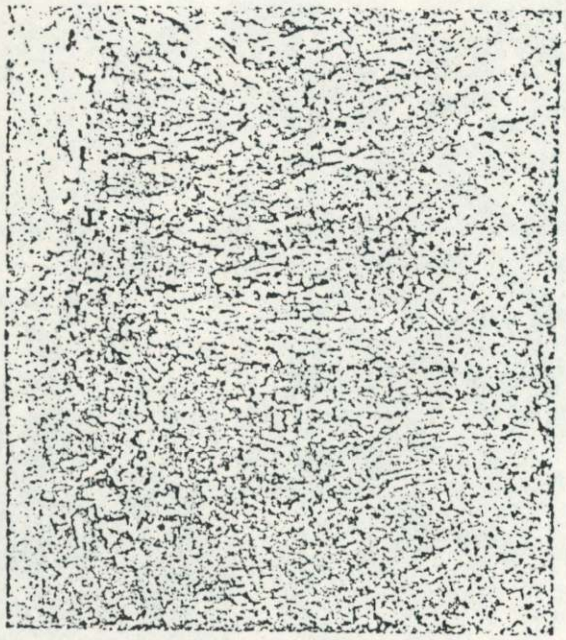

Fig. 9 — Rockley bloomery slag
Magnification × 100

It is therefore clear that when the clay lining of a bloomery furnace is fired at 1000°C, FeO from the slag penetrates the lining to form fayalite with the amorphous silica. The depth of penetration of fayalite continues for a distance of at least 1½-2 in. The presence of glass away from the working surface may be due to the small amount of alkali present in the clay acting as a flux for the formation of low-melting glasses. Nearer the working surface these would dissolve into the

## SUMMARY AND RECOMMENDATIONS

Slag, cinder, and bear are three distinct and identifiable materials. Slag is a molten product of smelting, cinder an infusible or partially fused mass produced at a particular temperature of furnace operation, and bear a material resulting from reaction of molten smelting products with the refractory lining of the furnace hearth. These terms should not be confused, and attempts have been made in the paper to clarify the present uncertain state. It is therefore recommended that terms for each material should be put forward for national and international acceptance, and towards this end members of the Historical Metallurgy Group should be requested to criticize constructively the suggestions made.

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POOR QUALITY ORIGINAL LIGHT

1967 ... Bull. Hist. Metall. Group, Vol. 3, no. 2, pp. ...

# Technical note



## The efficiency of the bloomery process

G. R. MORTON AND JOYCE WINGROVE

The efficiency of iron extraction in the bloomery is generally defined as the proportion of the iron content of the prepared ore charged into the furnace which is extracted as metallic iron; thus

$$E\% = \frac{e}{T} \times 100$$

when e = weight of iron extracted,

T = total weight of iron in ore.

In practice various considerations affect the iron yield of the operation. Since in the bloomery process there is no added flux, some iron is used to flux the gangue material in the ore and this iron cannot be extracted as metal. In addition, some iron is lost by reaction with the clay lining, and this iron also cannot be extracted. The operator has no control over such losses.

Some iron enters the slag as wustite (FeO), which then takes part in decarburizing slag-metal reactions, and the quantity of this dissolved FeO may be considerably controlled by the worker in order to obtain a good yield of iron.

The maximum theoretical efficiency would be achieved if all the iron were extracted excepting for that used in fluxing the gangue material of the ore.

The writers have shown that bloomery slags comprise three main phases: fayalite ($2FeO.SiO_2$), glass, and wustite (approximately FeO)—see Fig. 1. Other phases may be present in small amounts, but can be neglected for the purposes of this note. The authors further showed that the quantities

Fig. 1 — Bloomery slag: dark = glass, grey = fayalite, light = wustite Magnification × 100

of the main phases can be calculated from the chemical analysis of the slag, using the simplified argument set out below.

The composition of the glass phase approximates to the mineral anorthite ($CaO.Al_2O_3.2SiO_2$) and, since there is almost invariably an excess of $SiO_2$, the total amount of anorthite formed is limited by the proportions of lime and alumina present, the quantity being such as to exhaust the oxide present in smaller molecular ratio. The excess $SiO_2$ then reacts with wustite (as FeO) to form fayalite.

The maximum efficiency from the process would be obtained if all the remaining iron compounds from the ore were reduced to iron. This would in fact only occur if the rate of reaction with carbon within the furnace was such as to reduce the available oxides of iron completely to pure iron, with no excess carbon available for carburization of the metal. These ideal conditions in fact never occur, and pure iron is obtained by decarburization in the hearth, slag/metal reactions occurring with wustite dissolved in the slag.

The writers have considered the mechanism of reduction in the bloomery hearth, and a study of this mechanism gives an indication of the amount of wustite in solution with the slag required to take part in decarburizing slag/metal reactions.

It seems likely that reduction of the ore proceeds both by direct and indirect reduction, viz.:

1. Reduction by solid carbon, added as charcoal

$$2FeO + C \rightarrow 2Fe + CO_2$$

2. Indirect reduction by CO.

Although charcoal arriving at the tuyeres will react initially to form $CO_2$, the reaction

$$CO_2 + C \rightarrow 2CO$$

will proceed at the temperatures above 1000°C prevailing in the hotter parts of the furnace. Thus succeeding indirect reduction reactions will occur as the CO passes up through the furnace and the charge descends:

(a) $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

(b) $Fe_3O_4 + CO \rightarrow 3FeO + CO_2$

(c) $FeO + CO \rightarrow Fe + CO_2$

In order for these reactions to proceed excess CO must be present. At temperatures below about 500°C, the reaction

$$2CO \rightarrow C + CO_2$$

take place rapidly, depositing carbon as finely divided lampblack, which coats and impregnates the partially reduced ore and leads to direct reduction reactions:

(a) $6Fe_2O_3 + C \rightarrow 4Fe_3O_4 + CO_2$

(b) $2Fe_3O_4 + C \rightarrow 6FeO + CO_2$

(c) $2FeO + C \rightarrow 2Fe + CO_2$

Visual evidence of the occurrence of solid-state reduction can be seen in Figs. 2 and 3.

The operation will be most efficient when the reduction rates (both direct and indirect) are such that the amount of excess CO, and therefore the carburization of the iron, is a minimum. In practice some CO will always pass out with the waste gas, and the $CO/CO_2$ ratio of this gas will thus give an indication of the reduction efficiency.

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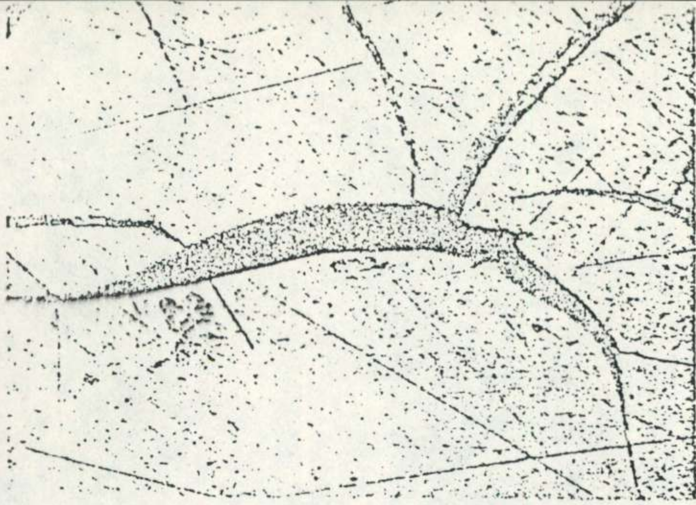

Fig. 2 — Internal fissures in ore

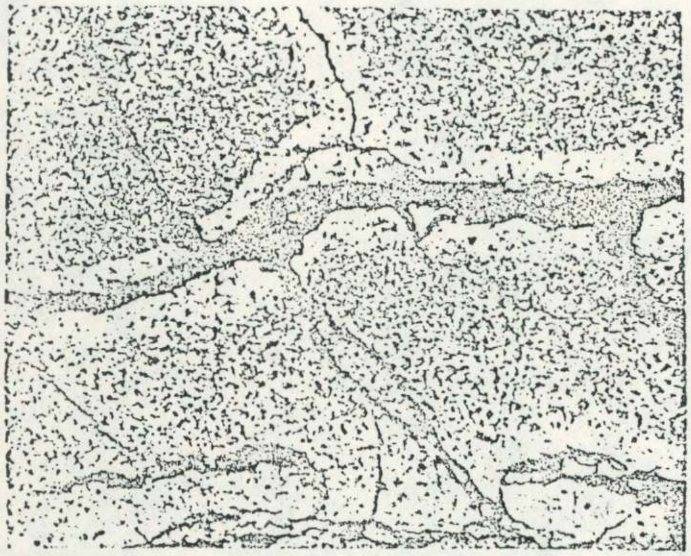

Fig. 3 — Internal reduction

It can be seen from the above outline of the complex reduction mechanism that the skill of the operator in controlling the course of the reaction had an important bearing on the efficiency of extraction. The main aim was to produce slag containing a minimum amount of wustite consistent with the production of pure decarburized iron, thus minimizing the iron loss to the slag. The control of temperature, rate of addition of charcoal and of ore, and estimation of slag com-

An unavoidable lowering of yield from the bloomery occurs as a result of slag attack on the furnace lining. These were generally of clay mineral, probably in the form of an agglomerate of kaolinite and free quartz grains. At about 500°C water of crystallization would be driven off, leaving amorphous $SiO_2$ and $Al_2O_3$. During the running of the furnace, wustite in the slag would readily attack the refractory, forming fayalite with the amorphous silica. Thus, according to the physical form of the attack, extra slag could be formed by this means, or iron could be lost by the penetration of fayalite into the refractory. This latter has in fact been observed, as the typical fayalite lathes penetrating the furnace lining show (Fig. 4).

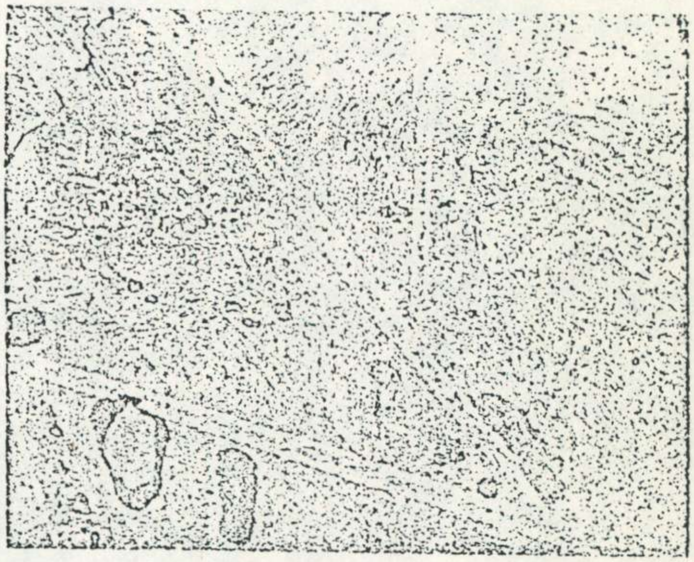

Fig. 4 — Fayalite laths in clay lining

## SUMMARY

The efficiency of a bloomery reduction process may be defined as the proportion, expressed as a percentage, of the iron content of the ore (including gangue) which is extracted as metallic iron. This is governed by a number of factors which control the iron loss. These are (i) the amount of iron needed to flux the gangue material of the ore; (ii) the amount of wustite in the slag, some of which is needed for slag/metal reactions in order to produce pure iron; and (iii) refractory attack of the furnace lining by the slag. The iron loss can be reduced by skilful working of the furnace to produce a slag containing a minimum of wustite at the end of the operation. Thus a study of the mineralogical constitution of any given slag will give an indication of the efficiency of operation during the corresponding furnace run.

# Preliminary Archaeological Examination of Ohio's First Blast Furnace: The Eaton (Hopewell)[1]

JOHN R. WHITE

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# PRELIMINARY ARCHAEOLOGICAL EXAMINATION OF OHIO'S FIRST BLAST FURNACE: THE EATON (HOPEWELL)[1]

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*Abstract.* The Eaton (Hopewell) Furnace located near Struthers, Ohio was built in 1802–1803. The first blast furnace west of the Alleghenies and the first industry of any kind in the Western Reserve, it went out of blast circa 1808 due to a combination of factors and fell into ruin. Historical sources on the Eaton are scarce and informational sources are vague, but archaeological excavations carried out in 1975, 1976, and 1977 have led to some interesting findings concerning early blast furnace operations. Subsequent chemical and metallurgical analyses of furnace artifacts and specimens provided insights into the level of efficiency of the operation and the quality of the raw materials, products, and byproducts. Foremost among these findings is the fact that the Eaton's use of bituminous coal in combination with charcoal was the earliest use substantiated in the New World.

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The Eaton-Hopewell Furnace (33MH9) is located in Yellow Creek Gorge just 200 m downstream from manmade Lake Hamilton in Mahoning County, between the cities of Struthers and Poland, two suburbs of Youngstown, Ohio. It lies midway up a steep slope with an incline in excess of 45 degrees. The slope soil is classified as Dekalb very stony loam, 25% to 50% slopes (DkF), characteristic of very steep valleys in Mahoning County (Lessig *et al* 1971, p. 78).

The furnace, built in 1802–1803, was the earliest blast furnace west of the Alleghenies and the earliest industry of any kind in the Western Reserve. It operated with only one major interruption until about 1808, when, due to a combination of factors including an inefficient blast process, a shortage of readily available hardwood for charcoal, and an accidental blow-out, it went out of blast. Very little is known about the operation years. What few accounts I have found written in local histories (Butler 1921, p. 658) are somewhat repetitive (even in their errors), suggesting that they were gleaned from the same primary and insubstantial source.

Prior to excavation, very little of the furnace was observable and, like the remainder of the site, was either destroyed or buried under 175 years of erosional overburden. Only the tuyére arch and a small 1.75 m rim segment of the inner chimney of refractory sandstone were visible. Evidence, including old photographs, indicated that little more of the furnace than this was exposed for at least the last 75 years. The cover vegetation was so dense with elm, sycamore, wild grape, sumac, and poison ivy that it took 4 full days just to clear the area for gridding.

Excavations covering 3 seasons were carried out by a crew consisting of 15 Struther's High School seniors, 5 university archaeology students and recent graduates, and a more or less steady supply of university volunteers. The site was divided into 7 major excavation zones, 4 of which were of prime importance. This division served 2 purposes: it allowed for simultaneous sampling and investigation in different areas of the site, and it facilitated deployment of the field crew over the relatively restricted and precarious land area.

## FURNACE ZONE

The Furnace zone consisted of the furnace structure itself and the fill within its perimeters. Overburden often reached a depth of more than 2 m. Because of

[1]Manuscript received 30 January 1979 (#79-8).

the striking visual remains and great local interest, continuous efforts were made to clear this zone. The end of the first season saw almost the entire furnace structure uncovered to its full remaining size. Excavation revealed the remains of the entire bosh area and firepot or hearth, measuring 180 cm in height from

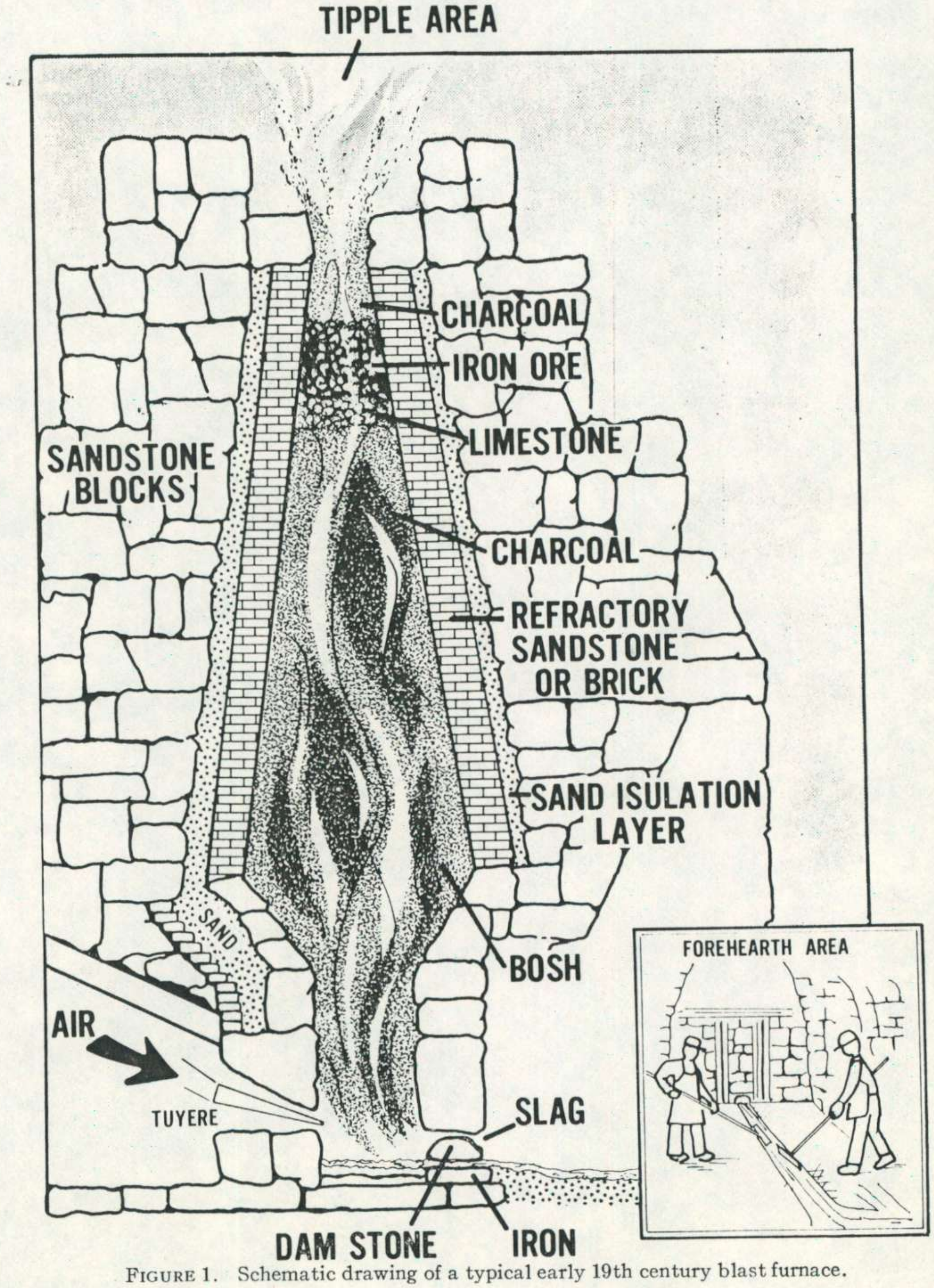


FIGURE 1. Schematic drawing of a typical early 19th century blast furnace.

base to bosh and varying in width between 1.7 m and 1.9 m. The bosh, which is the widest point of the furnace and the structural feature that allows for the support of the charge, measured a maximum of 2.7 m in diameter. (See fig. 1 for a schematic of a typical early blast furnace.) Based on these specifications, an estimated production rate of 2 to 3 tons of cast iron per day seems reasonable.

The inner chimney lining was made from shaped blocks of refractory sandstone that were cemented with a hard mortar colored to a brick-red. Examination of this mortar showed a constituency quite similar to that of the samples of sand and soil analyzed from the site (table 1). In a laboratory experiment, red sand from the hearth opening (Sample 2) was mixed with water and baked. This process resulted in the creation of a friable concretion not as hard as but not very different from the color and texture of our mortar sample. This finding leads us to believe that the furnace builders expeditiously welded their sandstone blocks together with mortar made from local sand or mud and water. The intense heat and pressure produced by the furnace operation hardened and colored the mortar. The chimney interface was patinated with a thick incrustation of slag, and the tap hole itself was clotted with the remains of the furnace's last cast, a part of which upon cessation of the blast had been allowed to cool within the firepot. Remains of the cast, which consisted of a pudding-like conglomeration of charcoal, slag, ore, and iron, were discovered in the form of a long runner extending from the tap hole some 4 m out onto the casting floor. The runner was covered with 100 cm of erosional soil. This finding suggests that the incompletely cooked cast erupted onto the casting floor as a result of a furnace lining failure.

## FURNACE WALL

The outer furnace wall was composed of large hand-chiseled blocks of native sandstone, some weighing several hundred pounds. The furnace was built into the gorge slope with the natural sandstone cliff constituting an integral part of its construction. The insulating space between the heavy outer wall and the refractory inner chimney was filled with sand that was subsequently oxidized to a bright red-orange by the intense heat generated by the furnace. This sand, though dramatically different in color, proved to be quantitatively and qualitatively identical to samples taken from other areas of the site (table 1). These sands were local in origin and resulted from weathering and erosion of the contiguous sandstone cliff. When the furnace subsequently collapsed, the oxidized sand spilled out over the immediate casting floor area and served as a clear red demarcation between the lower cultural levels on which it sits and the post–1808 sandy loam overburden on top of it.

## CASTING FLOOR (ZONE A)

*Zone A* was the designation given to the relatively flat and featureless area immediately adjacent to and south of the furnace. It was determined to be the casting floor, the place where the raw molten iron or *loupe* was set into various molds. This zone represented the area of maximum furnace activity. The entire zone measured approximately 14 x 18 m in area and was cleared to a depth of between 10 and 100 cm revealing a flat sandy floor. The top several centimeters contained a heavy concentration of rock spalls and fragments. Within this spall level were found several artifacts shaped like large, thick dog biscuits

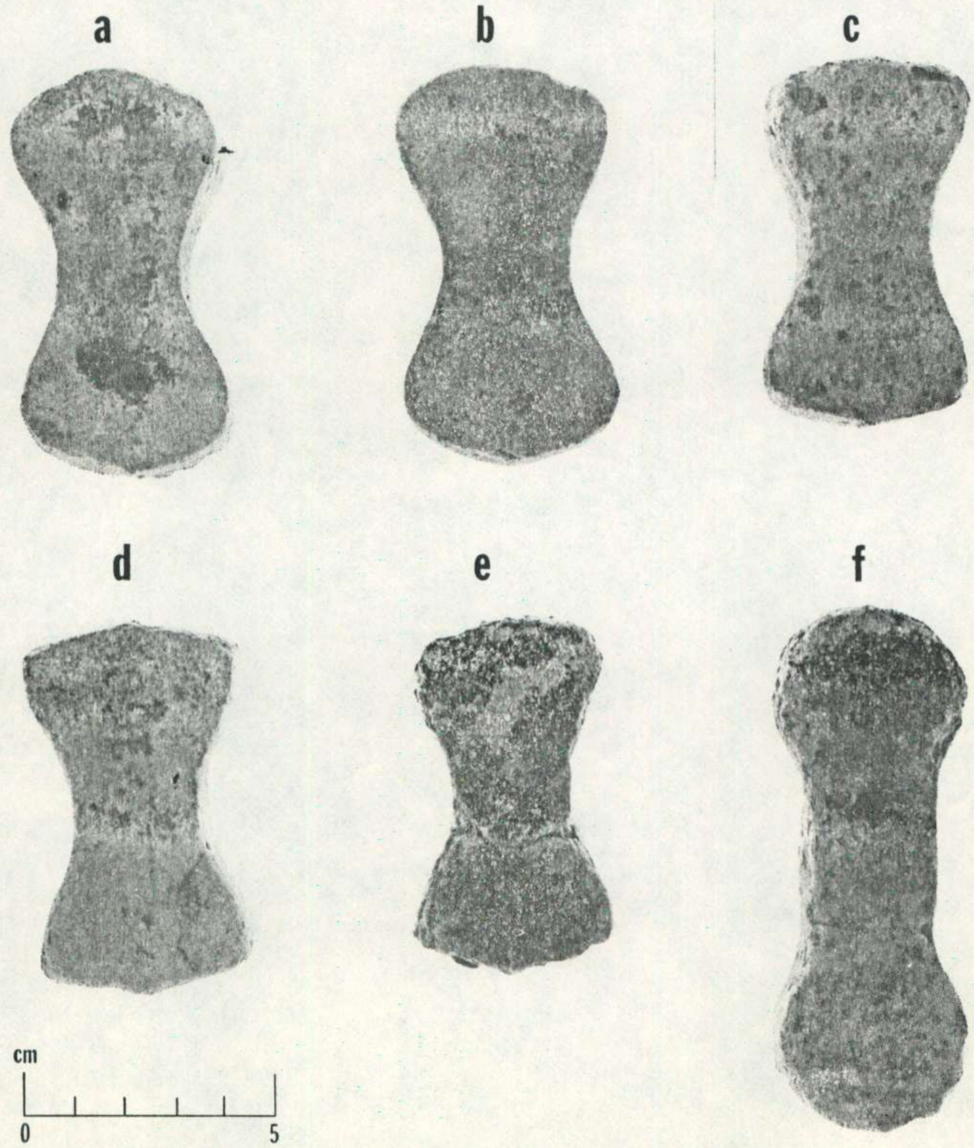


FIGURE 2. Hydraulic mortar bricquets recovered from the site indicate post-1907 activity.

(fig. 2). These artifacts were determined to be bricquets used for testing the tensility of hydraulic mortors (American Society for Testing and Materials 1963, p. 505). These devices were used by engineers during the construction of Hamilton Dam and hence were ideal dating indicators for the spall level as modern or post-1907. The spalls themselves could well represent the result of energies put to the finish-shaping of the enormous sandstone blocks used in the dam. While no evidence was found of a casting floor shed in this area, such a structure would have been a necessity because even the smallest amount of precipitation coming into contact with the molten iron would cause a violent reaction.

Most of the artifacts that were found came from *Zone A*. These included stove parts, fireback fragments, fragments of assorted heavy iron tools, spikes, heavy pins, staples, utensil pieces such as Dutch ovens, trivets, and pans; and byproducts of the manufacturing process including sprues and scrap iron. Some artifacts were so encrusted with rust that identification was impossible. Several artifacts were made from wrought iron and must have been brought to the site from elsewhere because there is no evidence, historical or archaeological, of the Eaton's having a forge or facility for their production. One of these wrought iron artifacts was a large staple that may have been part of the casting shed. The more ubiquitous items included chunks of slag and kidney ore. Two basic methods were used to clean these artifacts: (1) more delicate pieces were cleaned by electrolysis; (2) the hardier, bulkier artifacts were muffled and sandblasted. This is a new, efficient and far speedier process (White 1976).

Less than 30 cm below the sand level, we found an extremely rocky talus level composed of huge slabs and blocks of sandstone that had, through the centuries, detached themselves from the cliff side. Apparently, the furnace builders created the necessary flat casting floor by filling and covering the talus interstices with sand until a level working surface was achieved. Immediately southeast of the flat casting floor was a massive slag heap that sloped steeply from the perimeter of the casting floor to the creek level 11 m below. A cut made into this slag heap at its top revealed evidence that the furnace had undergone some major repair and relining during its use. Relining was done in a piecemeal or patchwork manner rather than by a complete overhauling. Fragments of discarded refractory sandstone were found sandwiched between layers of slag and cinder. The slag heap probably served as the general disposal area for all discarded material.

## OTHER ZONES

*Zone B* was the designation given to a small terrace roughly 6 x 6 m in area located about 8 m downslope east from the furnace mouth. It was here that the original mechanism for supplying the blast was located. Excavations revealed a stone wall or footing and an almost square, flat sandstone slab floor measuring 160 x 158 cm along its sides. This structure was all that remained of the blowing shed or wheelhouse. The overshot wheel turned in the area between the walls and raised and lowered the bellows that rested atop the square slab floor.

The least investigated of the major excavation areas was *Zone C*. This is the designation given to the tipple area approximately 10 m up the cliff face from the bosh. Work was undertaken here to determine what we could about the charging process. We found more fragments of kidney ore, charcoal, and coal in this area than we had anywhere else on the site. This is as it should be, since it was from this spot that the charges of fuel, iron ore, and flux (limestone) were supplied to the furnace. The abundance of high quality bituminous coal in this zone led us to believe that the Eaton (Hopewell) used a combination of charcoal and raw coal as fuel. Chemical analysis of the cast irons by scientists at Youngstown Sheet and Tube company and other laboratories supported this conclusion because the finished iron contained larger amounts of sulfur than expected with simple charcoal reduction, i.e., between 0.060% and 0.22% by weight (White 1978). This fact tends to reduce the effectiveness of those arguments by historians and archaeologists who proclaim that archaeology cannot add anything of a hard factual nature to our knowledge of our historical past. No extant record of the Eaton (Hopewell) mentions this use of charcoal in combination with raw coal; in fact, coal used in this manner was the earliest reported for the New World (White 1978).

## ANALYSES

The Eaton (Hopewell) coal was analyzed and found to be of a relatively efficient, high grade, and bituminous type, averaging out as 4.06% ash, 38.04% volatile material, and 52% sulfur. By comparison, the Eaton (Hopewell) charcoal ranged between 1.94% and 7.30% in ash content, between 40.02% and 44.58% in volatile material, and between 0.01% to 0.02% in sulfur content.

Eaton (Hopewell) iron ore is a variety known as *kidney* or *reniform ore*, getting its name from its physical characteristics, i.e., it is generally kidney-shaped and reddish brown in color. Extremely dense, it occurs in both pockets or layers and as float material in Yellow Creek. While higher quality iron ore exists (today the mills use taconite pellets with 60–65% iron), the Eaton (Hopewell), with its ferrous oxide ($Fe_2O_3$) between 47.9% and 58.6%, is considered good especially for its time.

The most ubiquitous byproduct of the ironmaking process is *slag*, which is the lithic material created when the limestone flux mixes with impurities or nonferrous materials in the iron ore. This slag, less dense than the molten iron, floats on the iron and is skimmed off and discarded. Old ironmasters had a maxim: "Take care of the slag and the steel will take care of itself," which exemplified the importance of this phase in the operation. Low viscosity and high sulfur-removing capacity are the prime characteristics of blast furnace slags (Muan and Osborn 1964, p. 148). The Eaton (Hopewell) were relatively consistent in this desulfurizing ability, having between 0.30% and 0.50% sulfur. As is characteristic of blast furnace slags, the thermodynamically stable oxides of magnesium ($MgO$), aluminum ($Al_2O_3$), silica ($SiO_2$), and calcium ($CaO$) were present. Slag colors included blue, green, glassy black, and turquoise. The content figures were roughly comparable for each of the different colors. Analysis of Eaton (Hopewell) slags indicated that the furnace was run at a temperature between 2150 °F and 2250 °F (1177–1232 °C) (White 1977). As a point of comparison, modern furnaces work at approximately 2800 °F (1538 °C). Earlier blast furnaces did not get respectively cooler as there is a minimum effective temperature for ironmaking of 2200 °F (1204 °C).

We have learned a considerable amount about early iron production in an area that prides itself as one of the world's largest steel producing centers, but this is only a preliminary report and many questions still remain. Classification and analysis of the artifacts and specimens from the site is almost completed, as is the final site report containing more complete descriptions of site settings, geology and archaeology. Undoubtedly, publication of our final monograph will serve to raise even more questions, but archaeology can answer some hard questions about those periods and aspects of our historical past traditionally neglected by the record keeper and the historian.

*Acknowledgments*. I am indebted to Youngstown Sheet and Tube company for its contributions of time, equipment and expertise. The highest thanks must be reserved for Frank Galletta, research engineer, without whom much of the analyses could not have been done. Finanacial support for the project came from the Gund Foundation, the Youngstown State University Graduate Research Council, and the Struthers Board of Education.

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# X-Ray Fluorescent Analysis of an Early Ohio Blast Furnace Slag

JOHN R. WHITE

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Vol. 77 No. 4, July, 1977

THE OHIO JOURNAL OF SCIENCE 77(4): 186, July, 1977

*BRIEF NOTE*

# X-RAY FLUORESCENT ANALYSIS OF AN EARLY OHIO BLAST FURNACE SLAG[1]

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OHIO J. SCI. 77(4): 186, 1977

In the summers of 1975 and 1976, archaeological excavations were carried out at the Eaton-Hopewell Furnace near Struthers, Ohio. These excavations were carried out primarily to recover information on early ironmaking in the Western Reserve. The Eaton-Hopewell Furnace, considered to be the earliest blast furnace west of the Alleghenies, was built in 1802 and lasted for 10 years until 1812. The excavations lasted a period of 10 weeks and led to the recovery of hundreds of artifacts and several major structural features. Among the more ubiguitous cultural remains recovered from the site were the fragments of heavily incrusted iron scrap and slag.

The slag phase in ironmaking has always been a critical one as indicated by the industrial maxim "take care of the slag, and the steel will take care of itself". Nowadays, the steelman is a technologist, enlisting the aid of a wealth of accrued information in slag chemistry, his predecessor in the early 19th century was more an artisan, guided by a feel for his trade. Now, as then, the slag characteristics of concern to the metallurgist are its fusibility (the slag should be completely liquid at ironmaking temperatures) and fluidity (the liquidus should have relatively low viscosity, that is, favorable diffusion properties). Muan and Osborn (1964) add to these the properties of optimum composition and a high sulfur-removing capacity. Analysis of slag for the information it can provide is especially important in the historical or archaeological context where there is a absence or paucity of written information.

Fragments of slag (9) were selected from various stratigraphic levels and from different horizontal locations. The samples consisted of slags of different colors and textures and were analyzed by specialists at the Youngstown Sheet and Tube Company in Youngstown, Ohio using a Vacuum X-ray Quantometer. The instrument was calibrated using previously analyzed samples of modern blast furnace slags of known constituency. In the case of the Eaton slags, the critical calibration was for $SiO_2$ where the range was in the 50 percentile. Modern test samples in this high silica range are not common but samples are available.

Slags produced through a charcoal blast furnace normally are of a viscid character and have a high silica content. Lord's (1884) early work on Ohio iron manufacturing and his analysis of slags from charcoal furnaces in the Hanging Rock region seem to bear this out. The Eaton-Hopewell slags were no exception. X-ray fluorescent analysis of 9 specimens of slag indicated a high percentage of $SiO_2$ ranging between 51.6 and 58.0 and with an average of 54.5 (table 1).

The Eaton-Hopewell slag is apparently typical of slags produced in the blast furnace environment. At the low oxygen pressures prevailing, only those oxides which are very stable thermodynamically were present. The oxides of magnesium (MgO), aluminum ($Al_2O_3$), silica ($SiO_2$), and calcium (CaO) were the most important. Manganese (MnO) also was present in appreciable quantities (table 1).

The sulfur-removing ability of blast

[1]Manuscript received October 1, 1976 and in revised form as a note April 1, 1977 (#76-77).

TABLE 1
*Percentage composition by X-ray spectroscopy of Eaton-Hopewell slags.*

| Specimen* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Color | Blue | Green | Black (glassy) | Tur-quoise | Green-Tur-quoise | Green (glassy) | Black | Grey-Black (porous) | Green-Black-(porous) |
| Constituents | | | | | | | | | |
| MgO | 6.1 | 6.1 | 5.1 | 6.2 | 3.3 | 2.70 | 2.90 | 2.40 | 4.30 |
| $Al_2O_3$ | 15.3 | 16.2 | 14.8 | 16.3 | 14.5 | 15.00 | 13.10 | 14.40 | 16.30 |
| $SiO_2$ | 51.6 | 51.8 | 53.5 | 53.2 | 55.3 | 55.80 | 55.00 | 56.00 | 58.00 |
| S | 0.4 | 0.5 | 0.3 | 0.4 | 0.4 | 0.35 | 0.28 | 0.38 | 0.28 |
| CaO | 18.2 | 16.6 | 20:2 | 15.4 | 19.0 | 17.80 | 19.30 | 16.20 | 10.50 |
| MnO | 3.2 | 4.1 | 2.6 | 4.1 | 2.9 | 2.86 | 3.74 | 3.05 | 4.40 |
| $TiO_2$ | 0.7 | 0.7 | 0.5 | 0.7 | 0.6 | 0.61 | 0.60 | 0.60 | 0.70 |
| FeO | 0.5 | 1.0 | 0.4 | 0.6 | 0.6 | 0.66 | 1.94 | 2.32 | 1.75 |
| $\frac{CaO+MgO}{SiO_2+Al_2O_3}$ (desulfurization index) | .36 | .33 | .37 | .31 | .32 | .29 | .33 | .26 | .20 |

*Specimens 1, 2, 3, and 4 were collected from the surface of the slag pile. They were selected specifically by color and/or texture. Specimen 5 was recovered from the tipple area at a depth of 20 cm. Specimens 6 and 8 were recovered from the casting floor area at a depth of 25 cm. Specimen 7 was recovered from the slag pile at a depth of 75 cms. Specimen 9 was recovered from the slag pile at a depth of 120 cm.

furnace slags increases in the order $SiO_2 < Al_2O_3 < MgO < CaO$. The optimum compositional ratio for desulfurization has a low $SiO_2$–$Al_2O_3$ content and a high CaO–MgO content. The desulfurization index can be determined by dividing the combined percentages of CaO and MgO by the combined percentages of $SiO_2$ and $Al_2O_3$. To a point, at least, the higher the index, the greater the sulfur retaining capacity. The index for Eaton-Hopewell slags was between a very low 0.20 and 0.37 (average 0.31). For comparison purposes, slags from 8 other historic blast furnaces (dating from 1650 to 1850) were analyzed. These ranged from a low index of 0.28 (from Hammersmith on the Saugus, the earliest blast furnace in the United States) to a high of 0.54 (from the original Hopewell in Berks County, Pennsylvania). In terms of desulfurizing property, the Eaton-Hopewell slag could not be considered particularly effective even for its time.

The need for effective sulfur retention capacity is more critical in those situations where coke or raw coal were used as a fuel than in cases where charcoal was relied upon. Just such a need may have been called for at the Eaton-Hopewell Furnace but history has left no written record of the fuel used. It has been common to credit the "Mary" Furnace in Lowellville, Ohio with being the first blast furnace in the United States (built in 1842) to use coal in the melting of iron ore. Archaeological findings and subsequent metallurgical analysis leads to the inevitable conclusion that this historical footnote will have to be modified. Archaeological excavations undertaken in the tipple area of the Eaton-Hopewell Furnace (located on the cliffside above the blast furnace) turned up an abundance of high quality bituminous coal mixed with fragments of charcoal and kidney ore. In addition, analysis of the finished Eaton-Hopewell irons revealed larger amounts of sulfur (between 0.060% and 0.22%) than one might expect with simple charcoal reduction (White 1976). In short, the Eaton-Hopewell Furnace used combination of charcoal and raw coal as fuel. Its date almost 40 years earlier than the "Mary" supports the site's claim as representative of a transition stage between the sole use of charcoal and the sole use of coal.

Fortunately, the very same qualities that develop optimum desulfurization also provided for low viscosity. CaO and MgO aid in the breaking down the

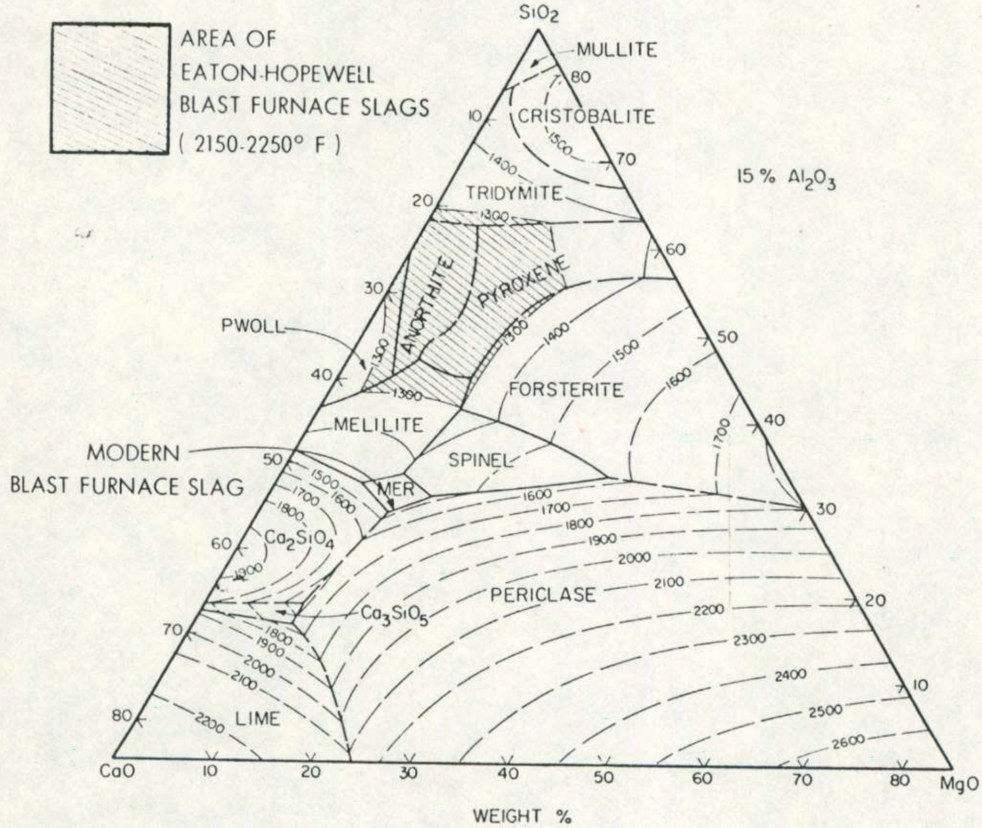


FIGURE 1. Phase relations at liquidus temperatures in the 15% $Al_2O_3$ plane of the $CaO$–$MgO$–$Al_2O_3$–$SiO_2$ system, showing position of Eaton-Hopewell Furnace slags in relation to those of a modern blast furnace. Temperature in degrees Celcius.

polymerized silicon-aluminum-oxygen tetrahedra. To a point (at which very low $SiO_2$ content leads to the formation of merwinite or periclase crystals suspended in the liquidus) viscosity decreases with the increase of CaO and MgO.

Using the 15% $Al_2O_3$ plane of the $CaO$-$MgO$-$Al_2O_3$-$SiO_2$ tetrahedron designed by Osborn and co-investigators (1954), the Eaton-Hopewell slags were found to fall within the isotherms of 1300°C. This is appreciably cooler than the temperature of modern blast furnace slags (fig. 1). Technical analyses such as these give archaeologists and historians insights into early industry and they may ultimately supply the critical clues on pioneering operations which lasted only a short time.

*Acknowledgments.* The author wishes to thank Youngstown Sheet and Tube Company for their cooperation and contributions of time and expertise. Particular thanks must go to Frank Galletta, John Stubbles and Dick Huber for their analysis, and comments. In addition, my sincerest thanks to Daniel Mamula and Dominic Russo of STEEP for the opportunity to excavate the site.

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August 1, 1979

Mr Sanborn Partridge
62 Ormsbee Avenue
Proctor, Vermont 05765

Dear Sandy,

I believe I've found my way to the bottom of the so-called 'blast furnace' in Proctor (in a manner of speaking). The enclosed should be of interest to you. I find it hard to believe that someone would construct a blast furnace where the illustration shows it. Iron may have been made here, but I have only found references to 'bar iron', a product of forges and trip hammers, not blast furnaces. Forges also had waterwheels to operate bellows. Blast furnaces were usually (but not always) built a distance from water so as to reduce the chances of molten iron contacting water, and thus producing superheated steam, scalding everyone in the vicinity.

I'll be in Montpelier at the VHS and State Library the coming Friday, August 10. The next day, I'll be in Troy (Vermont, that is) to do some continuing field work at a blast furnace site there.

Keep well...

Vic

Victor R. Rolando
34 Howard Street (NEW ADDRESS!)
Pittsfield, Mass 01201

(413) 443-1461

# Letters To The Editor

The Herald welcomes letters from readers on all timely subjects. Writers must include their names and addresses, but these will be withheld from publication on request. Please make your letters short.

## ANOTHER FOUNDRY

To the Editor of The Herald: It may not be so well known to many in this vicinity that there existed another forge and iron furnace in what was known as Sutherland Falls, now Proctor, during the early part of the last century.

I have a photograph made of a painting, now in the possession of the Vermont Historical Society, which was made in 1859, which does show the furnace and the building housing the forge. It stood approximately at the north end of the so-called "Johnson's mill," then a deep gulley about 75 feet below the present floor level of the mill.

The pictures also shows the flume which carried the water from the mill dam to the wheel, which was dislocated by the disastrous flood of 1840. The water wheel which operated the bellows stood a short distance north of the furnace. The west side of the furnace seems to have been integral with the cliff on the west side with a driveway above and to the west of the furnace.

The forge or foundry stood on a higher elevation to the east of the furnace, and beside the mill pond. The water came from above Sutherland Falls on Otter Creek past a grist and carding machine, which stood near the head of the falls.

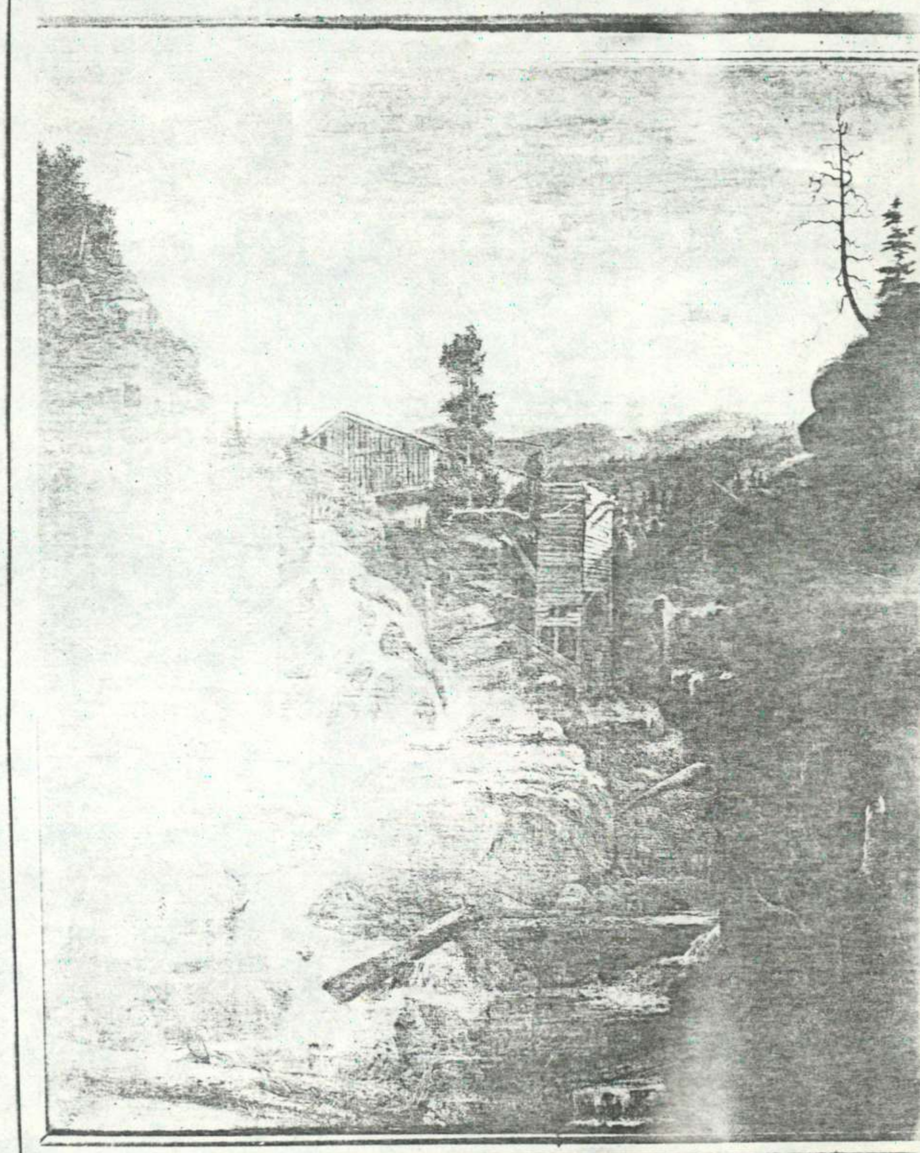
The earliest land records show its existence as far back as 1809. From that time onward it passed through many vicissitudes, ending financially bankrupt after the disastrous flood of 1840, when two decrees of foreclosure by the Court of Chancery, one in 1843 and the other in 1845, were granted to Abel Penfield of Pittsford who had a financial interest in the venture.

An attempt to mine iron ore was made on the so-called "ore hill" on the high bluff north of the Humphrey homestead, but it was of a very inferior quality. Record has it that some iron ore was brought from Crown Point, N. Y. for smelting in the furnace.

The charcoal used in the furnace may undoubtedly have come from some kilns located on the bluff to the west of the so-called Garden of Eden, where indications are that such kilns were located.

OTTO T. JOHNSON

Proctor, Jan. 2, 1957



STATE OF MICHIGAN



WILLIAM G. MILLIKEN, Governor

**DEPARTMENT OF NATURAL RESOURCES**

HOWARD A. TANNER, Director



Box 30028
Lansing, MI 48909

~~XXXXXX~~
517/322-1319

April 6, 1979

Mr. Victor Rolando
Parsonage, Apt. 3S
Nassau, NY 12123

Dear Sir:

I saw the note about your interest in slag analysis in the November 1978 issue of the SIA newsletter. I am in charge of the artifacts excavated from the site of Fort Michilimackinac which had a French occupation from about 1715 to 1761 and a British occupation from 1761 to 1781. I am currently doing research into the possibility that trace element analysis of some of our iron artifacts might be used to determine their origin.

My interest is, therefore, tangential to yours, but in my research I have found a couple of things which may be useful to you. First, Professor John R. White, Dept. of Sociology/Anthropology, Youngstown State University, Youngstown, Ohio 44555. His office telephone is 216/742-3442 and home 216/783-2484. He has excavated a furnace in Ohio and has used slag analysis to help show that it was partially coal fired. He has published two articles, "Archaeological and Chemical Evidence for the Earliest American Use of Raw Coal as a Fuel in Ironmaking" J. of Archaeological Sci., Vol. 5, No. 4 (Dec. 1978), pp. 391-393 and "X-Ray Fluorescent Analysis of an Early Ohio Blast Furnace Slag" The Ohio J. of Sci., Vol. 77, No. 4 (July 1977), pp. 186-188.

Secondly, enclosed is some membership information on the Historical Metallurgy Society. I have recently received a complete set of the back issues of their journal. I have not had time to study them carefully, but they seem to be a treasure trove of information. There are several articles on slag analysis. There is also a French journal, but since I do not read French it has not been of much help to me. Revue d'Histoire de la Siderurgie, 54 Jarville, Nancy, France.

I hope this information proves to be of some help to you. If you should come across a metallurgist who is interested in doing the chemical analysis of some iron samples, I would appreciate knowing about him.

Sincerely,

MACKINAC ISLAND STATE PARK COMMISSION

Loren Daniel Lillis

Loren Daniel Lillis
Archaeology Lab Director

LDL:ajw

Enclosure

The Society's origins lie in concern over the steady reduction in the number of surviving early blast furnaces, which was expressed in a letter to the Journal of the Iron and Steel Institute in 1962. This brought together enough interested people for the Historical Metallurgy Group to be constituted informally and to produce its first Bulletin in 1963. Subsequent years brought large increases in membership, which in mid-1970 was approaching 400, and valuable links with the Iron and Steel Institute and with the Institute of Metals.

At the beginning of 1974 the Group became the Historical Metallurgy Society, affiliated to the newly formed Metals Society.

The Society has three inter-related purposes; it maintains its original object of encouraging the recording of early metallurgical sites and selecting examples for preservation, but it has extended its interests to the fostering of all aspects of metallurgical history, ferrous and non-ferrous, whether by documentary or field research, in this country or abroad; it has been able, from time to time, to make small grants in aid of research and publication. Its second function complements the first; publication of the Journal (formerly the Bulletin of the Historical Metallurgy Group), twice each year, provides a medium for short articles, and in particular, for up-to-date reports on work in progress, providing members with information which might otherwise not be seen until the eventual publication of completed research reports; occasional papers are also published from time to time. The third function is to hold annual conferences; these began with one in Wolverhampton in 1965, and have subsequently been held in Sheffield, the Forest of Dean, the Lake District, Cornwall, South Wales, Leeds and Staffordshire,* giving members the opportunity of hearing papers both of national and local interest, and of extensive visits to sites in these regions.

New members are very welcome, whatever the aspect of their interest in the history of metals. Among the present membership are metallurgists, economic historians, archaeologists, and many with a wide general interest in history and technology. The latter may find that the activities of fellow-members are of interest; for instance the archaeologists in the Society always welcome helpers in field-work, whose range can be seen from past issues of the Bulletin. In particular, excavations have been carried out on Roman works in Sussex, and early modern sites in the Lake District and in the Weald. The Wealden Iron Research Group has been formed by members with interest in the south-east, and welcomes assistance.

Anyone wishing to join The Historical Metallurgy Society should write for details and a form of application to the Hon Secretary, K C Barraclough, 19 Park Avenue, Chapeltown, Sheffield S30 4WH.

Details of available back-numbers of the Bulletin/Journal and other publications may be obtained from the Hon Treasurer, C R Blick, 16 Sycamore Crescent, Bawtry, Doncaster, DN10 6LE.

* and now - Sheffield, South Wales, Scotland, Teesside and Mid-Wales

November, 1978

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13th June 1979

MET/OPN/HAH

Dear Mr. Rolando,

My attention has been drawn to a note in a recent S.I.A. publication, in which you express an interest in the examination of slags. There has indeed been much interest in the relationships between slag constitution and its origins. Iron and steel makers have for many years exercised effective control over their processes by selecting a slag composition to give the required interactions with the ore, or the melt, which is to be refined.

It is now known that solidified slags may be glassy, crystalline, or a mixture of both structures. The slag composition (and structure if crystalline) certainly enables assessment to be made of its melting point, and perhaps if its source. Its physical appearance (when allowance is made for weathering and similar deterioration) is also of importance - for instance, charcoal furnace slags often enclose unburnt charcoal, or characteristic ash. The distinction between slags of different origin cannot be 100% definitive, but by the critical appraisal of results from the several "analytical" techniques currently available, a fairly high degree of confidence may be established. (I use "analytical" to include conventional chemical analysis, X-ray discriminatory techniques, mineralogical studies, electron microscopy, and similar techniques).

From the point of view of providing an effective aid to the industrial or to the classical archaeologist, slag technclogy is I believe at an exciting stage of development. Indeed, I have at this moment a Ph.D. student who is examining and characterizing ancient ferrous process slags, using the varied techniques already mentioned. We are fortunate in having access to the National Collection of Archaeological Slags, which is housed not too far from here by the Ironbridge Gorge Museum Trust (with whom we have a close working arrangement).

Mr Rolando
Nassau
U S A

13th June 1979

I attach a short list of some significant published work on ironmaking slags, which you may find to be a useful introduction. I shall be pleased to hear from you in more detail, so that more pertinent information may be exchanged. I am,

Yours sincerely,

Nicholson

O P Nicholson
Lecturer in Metallurgy and Materials

Encl. References

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DEPARTMENT OF METALLURGY AND MATERIALS

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13th June 1979

*Journal of Archaeological Science* 1978, 5, 391–393

# Archaeological and Chemical Evidence for the Earliest American Use of Raw Coal as a Fuel in Ironmaking

John R. White[a]

The archaeological discovery of bituminous coal in the tipple area and the subsequent analyses of specimens of the iron ore, charcoal, limestone, slag, and cast iron from the Eaton (Hopewell) blast furnace built in 1802 indicate that raw coal was used in combination with charcoal as a fuel in American iron smelting at least thirty years before it was used alone. Further, its use in this combinatory manner marks the earliest as yet attested to in the New World.

*Keywords:* EATON FURNACE, UNITED STATES, AMERICA, INDUSTRIAL REVOLUTION, 1802, METALLURGY, SPECTROGRAPHY, CHEMISTRY, BITUMINOUS COAL, SLAG, CAST IRON, IRONMAKING, BLAST FURNACE, SMELTING.

History credits the Pioneer blast furnace in Pottsville, Pennsylvania with being the earliest blast furnace in America to use raw coal (anthracite) successfully as a fuel in the smelting of iron. This occurred in 1839 (Warren, 1973; Hogan, 1971). Prior to that time charcoal was the sole fuel used in American furnaces because it has some distinct advantages as a fuel in ironmaking: (1) the furnace consumes considerably less charcoal than coke per ton of pig iron; (2) only one-third as much limestone per ton of pig iron is required in a charcoal furnace; (3) the amount of blast required is only about 66% of that for a coke furnace with the same productive capacity; and (4) the "critical temperature" may be lower in a charcoal furnace than in a coke furnace. Materials collected during archaeological excavations at the Eaton (Hopewell) Furnace site in 1975 and 1976, and their subsequent chemical analysis, show that this historic "fact" will have to be modified. Evidence presented herein indicates that raw coal was used in combination with charcoal some 30 years before it was used alone, and the Eaton Furnace marks the earliest substantiated use in this way.

The Eaton (or Heaton) Furnace (later called Hopewell by its owners) was built in 1802–03 and is located near Youngstown, Ohio, in the city of Struthers. This early smelting operation, which went out of blast sometime before 1812, was the first blast furnace west of the Allegheny Mountains and the first furnace of any kind in an area which, by the 1860's, was one of the largest iron-producing areas in the world.

The first indication that raw coal had been an integral part of the Eaton ironmaking process came with the archaeological excavation of the furnace tipple or loading area. Excavation revealed the presence of four primary charging materials: charcoal, limestone, iron ore, and bituminous coal—all but the coal fully expected. As the tipple area would normally be expected to yield samples of the materials being introduced into the furnace, the recovery, in the upper levels, of almost as many samples of coal as charcoal

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was considered a significant archaeological discovery. Normally such an occurrence would be sufficient support for the conclusion that both items were used, in combination, as reducing agents. However, in order to provide independent non-archaeological support for this hypothesis, the various materials from the site were submitted to metallurgical and chemical evaluations with the following findings.

The ore used at the Eaton is of the type referred to as *reniform* or *kidney* ore, a concretionary ore consisting of masses of impure carbonate of iron, often discoidal or ellipsoidal in form. The ore is generally composed of concentric layers or shells made distinct by weathering. The shape and deep red-brown colour is responsible for the name. The $Fe_2O_3$ content of the samples tested varied between 44·0% and 58·6%, with an average of 51·3%. Loss on ignition ranged between 25·0% and 32·5%. None of the specimens, chosen from various depths and areas of the site, contained measurable amounts of sulphur.

The Eaton charcoal varied in ash content between 1·94% and 7·3%, with an average of 4·42%; and had a sulphur content which ranged between 0·01% and 0·02%, with an average of 0·015%.

The native limestone used as a flux was of a relatively poor quality having a higher than desirable silica ($SiO_2$) content (as high as 33·8%) and a relatively low calcium (CaO) content (27·5%). Premium blast furnace fluxes are usually selected for a low silica–high calcium ratio (McGannon, 1964). In none of the samples was a measurable amount of sulphur found.

Slag, by far the most ubiquitous evidence of the ironmaking process, was taken from various stratigraphic levels and areas of the site, including the site's large slag heap. Colour and texture were also considered in choosing the test sample. Since slag is probably the single most revealing material to the reduction process, the specimens were subjected to both spectrochemical and wet chemical (titrimetric) analysis. Samples of slag were examined independently in five different laboratories: Youngstown Sheet and Tube Company; United States Steel Corporation; Inland Steel Company; Wheeling Pittsburgh Steel Corporation; and the Lone Star Steel Company.

A high sulphur-removing capacity is considered a primary slag asset to the metallurgist (Muan & Osborne, 1964). The sulphur-removing capacity of blast furnace slags increases in the order $SiO_2 < Al_2O_3 < MgO < CaO$. The optimum composition index for desulphurization has a low $SiO_2$–$Al_2O_3$ content and a high CaO–MgO content. To a point at least, the higher the index the greater the sulphur-removing capacity. The index for Eaton (Hopewell) slags varied between an exceedingly low 0·20 and 0·37, with an average of 0·31. When compared to slags from eight other historic furnaces, dating from 1650 to 1850, the Eaton material did not fare well as a desulphurizing slag, even for its time (White, 1977). The sulphur content of the tested samples varied between 0·23% and 0·55%, with an average of 0·35%.

Specimens of the Eaton cast iron were very much in abundance at the site where they occurred as fragments of finished (though usually flawed) products, casual droppings, or *sprues*. Spectrographic and titrimetric analysis established a range of sulphur between 0·055% and 0·17%. One specimen characterized as having "poor reproducibility" had a sulphur content of 0·22%. The average for all samples was 0·086%.

It is evident that even the minimum sulphur containment (0·055%) in the finished iron plus the smallest sulphur content of the slag (0·23%) adds up to farmore sulphur in the original mix than would be possible with the constituents generally conceded to have gone into the reduction process, i.e., minus the raw coal.

An analysis of the coal specimens taken from the site indicates a high quality bituminous coal with a relatively low ash and sulphur content. The sulphur content varied between 0·52% and 0·79% with an average of 0·63%.

The only possible source for the sulphur found in such levels in the finished iron and the by-product slag is the bituminous coal. Archaeological findings and chemical analyses confirm that the Eaton (Hopewell) Furnace used a combination of charcoal and raw coal as the reducing medium.

When one gives thought to it, the idea for an intermediate step between iron reduction using charcoal alone and reduction using solely raw coal is quite logical. Coal, of which there are two general classes: bituminous, a soft coal from which the gas can be expelled leaving a denser product, or *coke*, which approximates pure carbon; and anthracite, a hard coal containing very little gas in its natural state and which is like a "natural" coke, was known as a fuel long before it saw use in ironmaking. Its utility as a reducing agent may have been recognized when the hardwood necessary for charcoal came into short supply or the process of charcoal-making became too expensive. Conservative iron-masters may have been hesitant to switch completely to a novel way of doing things and instead eased into the new era by mixing the old (charcoal) with the new (raw coal). Evidence from the Eaton (Hopewell) indicates it was done as early as the first decade of the 1800's in North America.

**Acknowledgements**

I thank Frank Galletta for his patience, insights, and expert spectroanalyses, Bob Pristera for the wet chemical analyses, and the Youngstown Sheet and Tube Company for its constant support. Dan Mamula and Dominic Russo, Co-directors of S.T.E.E.P., supplied funds, equipment, and student help to the successful accomplishment of the excavations. Archaeological work was supported by both a Gund Foundation and a Youngstown State University research grant.

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*BRIEF NOTE*

# X-RAY FLUORESCENT ANALYSIS OF AN EARLY OHIO BLAST FURNACE SLAG[1]

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OHIO J. SCI. 77(4): 186, 1977

In the summers of 1975 and 1976, archaeological excavations were carried out at the Eaton-Hopewell Furnace near Struthers, Ohio. These excavations were carried out primarily to recover information on early ironmaking in the Western Reserve. The Eaton-Hopewell Furnace, considered to be the earliest blast furnace west of the Alleghenies, was built in 1802 and lasted for 10 years until 1812. The excavations lasted a period of 10 weeks and led to the recovery of hundreds of artifacts and several major structural features. Among the more ubiguitous cultural remains recovered from the site were the fragments of heavily incrusted iron scrap and slag.

The slag phase in ironmaking has always been a critical one as indicated by the industrial maxim "take care of the slag, and the steel will take care of itself". Nowadays, the steelman is a technologist, enlisting the aid of a wealth of accrued information in slag chemistry, his predecessor in the early 19th century was more an artisan, guided by a feel for his trade. Now, as then, the slag characteristics of concern to the metallurgist are its fusibility (the slag should be completely liquid at ironmaking temperatures) and fluidity (the liquidus should have relatively low viscosity, that is, favorable diffusion properties). Muan and Osborn (1964) add to these the properties of optimum composition and a high sulfur-removing capacity. Analysis of slag for the information it can provide is especially important in the historical or archaeological context where there is a absence or paucity of written information.

Fragments of slag (9) were selected from various stratigraphic levels and from different horizontal locations. The samples consisted of slags of different colors and textures and were analyzed by specialists at the Youngstown Sheet and Tube Company in Youngstown, Ohio using a Vacuum X-ray Quantometer. The instrument was calibrated using previously analyzed samples of modern blast furnace slags of known constituency. In the case of the Eaton slags, the critical calibration was for $SiO_2$ where the range was in the 50 percentile. Modern test samples in this high silica range are not common but samples are available.

Slags produced through a charcoal blast furnace normally are of a viscid character and have a high silica content. Lord's (1884) early work on Ohio iron manufacturing and his analysis of slags from charcoal furnaces in the Hanging Rock region seem to bear this out. The Eaton-Hopewell slags were no exception. X-ray fluorescent analysis of 9 specimens of slag indicated a high percentage of $SiO_2$ ranging between 51.6 and 58.0 and with an average of 54.5 (table 1).

The Eaton-Hopewell slag is apparently typical of slags produced in the blast furnace environment. At the low oxygen pressures prevailing, only those oxides which are very stable thermodynamically were present. The oxides of magnesium (MgO), aluminum ($Al_2O_3$), silica ($SiO_2$) and calcium (CaO) were the most important. Manganese (MnO) also was present in appreciable quantities (table 1).

The sulfur-removing ability of blast

[1]Manuscript received October 1, 1976 and in revised form as a note April 1, 1977 (#76-77).

TABLE 1

*Percentage composition by X-ray spectroscopy of Eaton-Hopewell slags.*

| Specimen* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Color | Blue | Green | Black (glassy) | Turquoise | Green-Turquoise | Green (glassy) | Black | Grey-Black (porous) | Green-Black-(porous) |
| Constituents | | | | | | | | | |
| $MgO$ | 6.1 | 6.1 | 5.1 | 6.2 | 3.3 | 2.70 | 2.90 | 2.40 | 4.30 |
| $Al_2O_3$ | 15.3 | 16.2 | 14.8 | 16.3 | 14.5 | 15.00 | 13.10 | 14.40 | 16.30 |
| $SiO_2$ | 51.6 | 51.8 | 53.5 | 53.2 | 55.3 | 55.80 | 55.00 | 56.00 | 58.00 |
| S | 0.4 | 0.5 | 0.3 | 0.4 | 0.4 | 0.35 | 0.28 | 0.38 | 0.28 |
| $CaO$ | 18.2 | 16.6 | 20.2 | 15.4 | 19.0 | 17.80 | 19.30 | 16.20 | 10.50 |
| $MnO$ | 3.2 | 4.1 | 2.6 | 4.1 | 2.9 | 2.86 | 3.74 | 3.05 | 4.40 |
| $TiO_2$ | 0.7 | 0.7 | 0.5 | 0.7 | 0.6 | 0.61 | 0.60 | 0.60 | 0.70 |
| $FeO$ | 0.5 | 1.0 | 0.4 | 0.6 | 0.6 | 0.66 | 1.94 | 2.32 | 1.75 |
| $\frac{CaO+MgO}{SiO_2+Al_2O_3}$ (desulfurization index) | .36 | .33 | .37 | .31 | .32 | .29 | .33 | .26 | .20 |

*Specimens 1, 2, 3, and 4 were collected from the surface of the slag pile. They were selected specifically by color and/or texture. Specimen 5 was recovered from the tipple area at a depth of 20 cm. Specimens 6 and 8 were recovered from the casting floor area at a depth of 25 cm. Specimen 7 was recovered from the slag pile at a depth of 75 cms. Specimen 9 was recovered from the slag pile at a depth of 120 cm.

furnace slags increases in the order $SiO_2 < Al_2O_3 < MgO < CaO$. The optimum compositional ratio for desulfurization has a low $SiO_2$–$Al_2O_3$ content and a high $CaO$–$MgO$ content. The desulfurization index can be determined by dividing the combined percentages of $CaO$ and $MgO$ by the combined percentages of $SiO_2$ and $Al_2O_3$. To a point, at least, the higher the index, the greater the sulfur retaining capacity. The index for Eaton-Hopewell slags was between a very low 0.20 and 0.37 (average 0.31). For comparison purposes, slags from 8 other historic blast furnaces (dating from 1650 to 1850) were analyzed. These ranged from a low index of 0.28 (from Hammersmith on the Saugus, the earliest blast furnace in the United States) to a high of 0.54 (from the original Hopewell in Berks County, Pennsylvania). In terms of desulfurizing property, the Eaton-Hopewell slag could not be considered particularly effective even for its time.

The need for effective sulfur retention capacity is more critical in those situations where coke or raw coal were used as a fuel than in cases where charcoal was relied upon. Just such a need may have been called for at the Eaton-Hopewell Furnace but history has left no written record of the fuel used. It has been common to credit the "Mary" Furnace in Lowellville, Ohio with being the first blast furnace in the United States (built in 1842) to use coal in the melting of iron ore. Archaeological findings and subsequent metallurgical analysis leads to the inevitable conclusion that this historical footnote will have to be modified. Archaeological excavations undertaken in the tipple area of the Eaton-Hopewell Furnace (located on the cliffside above the blast furnace) turned up an abundance of high quality bituminous coal mixed with fragments of charcoal and kidney ore. In addition, analysis of the finished Eaton-Hopewell irons revealed larger amounts of sulfur (between 0.060% and 0.22%) than one might expect with simple charcoal reduction (White 1976). In short, the Eaton-Hopewell Furnace used combination of charcoal and raw coal as fuel. Its date almost 40 years earlier than the "Mary" supports the site's claim as representative of a transition stage between the sole use of charcoal and the sole use of coal.

Fortunately, the very same qualities that develop optimum desulfurization also provided for low viscosity. CaO and MgO aid in the breaking down the

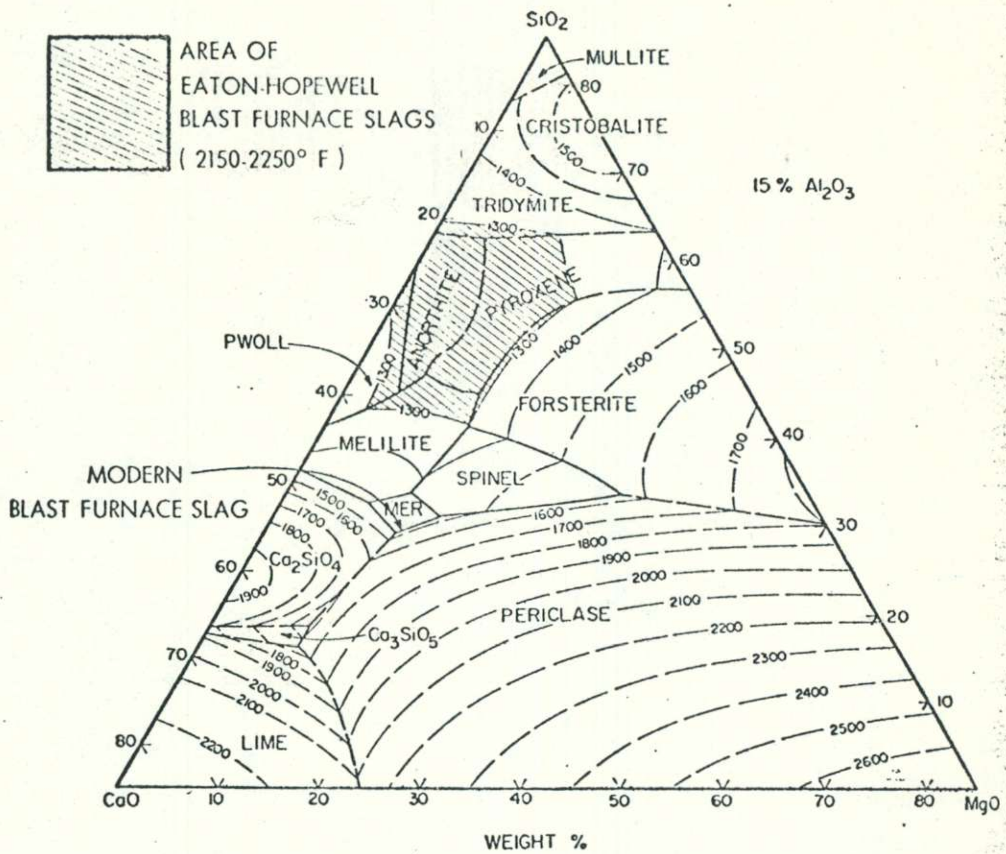


**Figure 1.** Phase relations at liquidus temperatures in the 15% $Al_2O_3$ plane of the CaO–MgO–$Al_2O_3$–$SiO_2$ system, showing position of Eaton-Hopewell Furnace slags in relation to those of a modern blast furnace. Temperature in degrees Celcius.

polymerized silicon-aluminum-oxygen tetrahedra. To a point (at which very low $SiO_2$ content leads to the formation of merwinite or periclase crystals suspended in the liquidus) viscosity decreases with the increase of CaO and MgO.

Using the 15% $Al_2O_3$ plane of the CaO-MgO-$Al_2O_3$-$SiO_2$ tetrahedron designed by Osborn and co-investigators (1954), the Eaton-Hopewell slags were found to fall within the isotherms of 1300°C. This is appreciably cooler than the temperature of modern blast furnace slags (fig. 1). Technical analyses such as these give archaeologists and historians insights into early industry and they may ultimately supply the critical clues on pioneering operations which lasted only a short time.

*Acknowledgments.* The author wishes to thank Youngstown Sheet and Tube Company for their cooperation and contributions of time and expertise. Particular thanks must go to Frank Galletta, John Stubbles and Dick Huber for their analysis, and comments. In addition, my sincerest thanks to Daniel Mamula and Dominic Russo of STEEP for the opportunity to excavate the site.

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SLAG



although Warwick, an exceptional furnace, often made forty tons a week before the close of the Revolution.[53] The first furnaces established in the twenties made from fifteen to twenty tons weekly.

The operation of the furnace—a chemical operation—was fairly simple, although its management often involved great difficulties. It was kept filled continuously with alternate layers of charcoal, ore, and limestone.[54] These materials were usually not weighed before being charged, but simply measured in baskets or buckets. The practice of weighing began with the use of anthracite coal in the smelting of iron, which came much later than the period under discussion. The gaseous products escaped at the top of the stack. At the tuyère of the furnace the ore melted and dropped down to the hearth below. The cinder, or slag, floated on top of the molten iron and was drawn off from time to time.[55] The slag was the result of the action of the limestone flux upon the impurities of the ore. About twice a day, sometimes oftener, the molten iron was run into the casting bed of sand,[56] which was prepared for its reception by molds occasionally made from mahogany wood patterns,[57] but usually from other wood patterns. Some imaginative early ironmaster compared the casting bed to a sow and her litter of suckling pigs. Thus, the main stream or feeder from the furnace was called the sow, while the side gutters were called pigs, a term which is in use today. Before the iron became cold, the pigs were separated from the sow and the latter broken up into smaller pieces. The amount of ore necessary to make a ton of pig iron varied, depending on the type of ore, the construction of the furnace, and skill of the manager. About two tons of ore usually made a ton of cast iron.

The "blowing in," or the starting, of a furnace was difficult. The stack was first filled with charcoal and lighted from the top. After several days, when the fire had burned down and reached the tuyère opening, the furnace was refilled with charcoal. The fire now worked back to the top. The blast was then applied, and ore and flux put in from the tunnel head in gradually increasing quantities. After a

[53] Schoepf, *Travels*, I, 202. Warwick and Reading furnaces produced some 800 tons of pig iron annually even before the middle of the century, which was equal to the output of the largest English furnaces of the same period. Acrelius, *New Sweden*, p. 168.

[54] From two to three hundredweight of limestone was used each day by the average furnace to flux the ores of their impurities. Drinker to Blackledge, p. 83.

[55] Coleman *vs.* Brooke, *Alden's Appeal Record*, pp. 205, 221. The journey of the ore through the furnace from the time it was put in until it reached the hearth took from forty to sixty hours.

[56] *Ibid.*, pp. 160, 165.

[57] Schoepf, *Travels*, I, 199.



few days, slag and iron ran into the hearth below. The proportion of ore and flux to charcoal was gradually increased until the furnace was working normally. The slag varied in color. That of a fine sky-blue color denoted the presence of manganese. Gray slag indicated high grade iron, rich in graphite carbon. Dark slag showed that the iron was low in graphitic carbon.

Beside pig iron, the early Pennsylvania furnaces cast hollow ware, such as pots, pans, skillets, sugar kettles, Dutch ovens, stoves, and firebacks. The process was similar to that of casting pig iron. Different molds, of course, had to be used. When the molten iron was tapped into the pig beds, a part of it was delivered into large ladles, and in turn was poured into small ladles and then into the molds for castings. Many of the decorated stove plates with their biblical and classical scenes, scriptural quotations, mottoes, hearts, and flowers,[58] still remain, bearing testimony to artistic yearnings of these early artisans in iron. The verses and mottoes in a form of German and the Germanized spelling of English names reveal the origin of many of these early workers.

The burdening of the furnace—the determination of the proper proportions of ore, flux, and fuel for the furnace charge—was considered a "gift" of the old time furnace worker. The results obtained, in view of lack of knowledge, were remarkable. The modern laboratory method with its quick and accurate analyses has done away with such guesswork, or trial and error, but there is still the necessity for judgment, experience, and a certain intuition which successful furnacemen must have.

The number of workmen needed to operate the furnace was not large. Two founders, two keepers, two guttermen, two or three fillers, who filled the furnace with alternate charges of charcoal, ore, and limestone, a "potter" who made the hollow ware, an ore roaster, and a few laborers included them all.[59] The "founders," who regulated the furnace, made the sand molds, and cast the iron, together with the potter were the only skilled workmen employed at the furnace. Frequently the potter was an itinerant worker, working a few weeks at one furnace and then traveling on to another. As the work of iron-making had to be carried on night and day, the workers labored in two twelve-hour shifts.

[58] The collection of stove plates at Doylestown is described in H. C. Mercer, *The Decorated Stove Plates of the Pennsylvania Germans* (Doylestown, 1899), and in his *The Bible in Iron* (Doylestown, 1914).

[59] Drinker to Blackledge, p. 83.

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# THE STORY
# of
# THREE TOWNS

## *Westport, Essex and Willsboro, New York*

*By*

Morris F. Glenn

## CHAPTER 2

## SISCO FURNACE

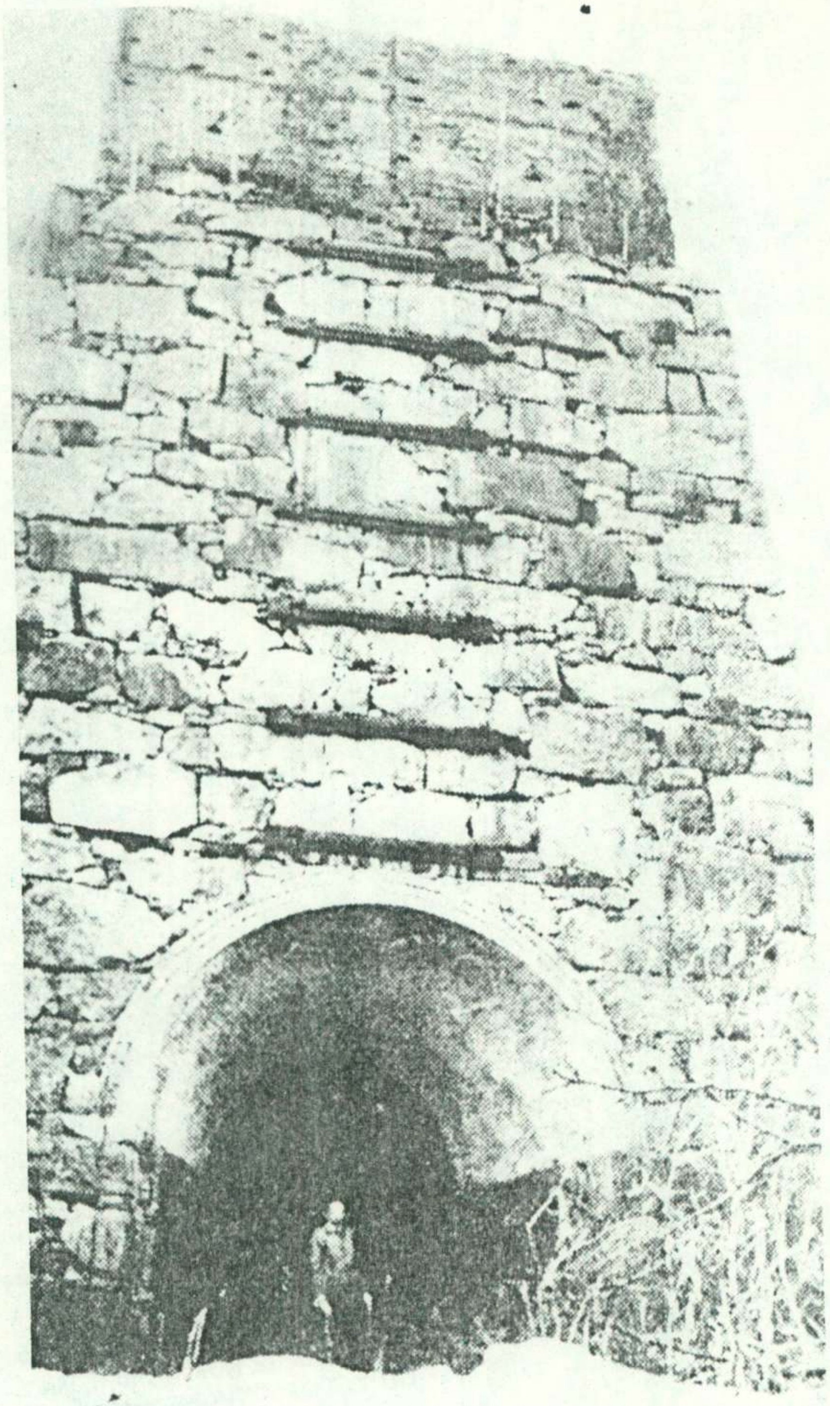
The Sisco Blast Furnace was the most important industrial plant ever to be located in Westport. It cost $100,000 to build. For comparison, a blast furnace could be built for about $1,500 to $2,000 in 1840 as reported by the Indiana Geological Survey in *Native Iron Ores and 19th Century Ironworks*. The Sisco Furnace represented the best technology that money could buy in the late 1840's. It was used as an example of current technology in most of the technical journals and books of the era. For example, the most respected ironmaker's text of the 1800's entitled *A Treatise on Metallurgy* by Frederick Overman used the Sisco Furnace as a basis for his description of parts of a blast furnace.

At this point we should say that the blast furnace itself was a revolution in the history of ironmaking. It produced much more iron than local Catalan forges and was continuous in operation. This meant that it had to be mechanized. Other forges were either mountain forges or Catalan forges and were old-fashioned when compared to the Sisco Furnace. Few observers in early Westport realized the advance in technology that the Sisco Furnace represented, particularly since few profits were realized from its operation. But as a student of the history of technology, this writer can't emphasize enough on these next few pages that the Sisco Furnace and its sister furnace at Port Henry influenced not only the state-of-the-art on Lake Champlain but of the entire United States.

The furnace was located on the Sisco farm which was about one mile north of the center of the village of Westport. The small bay was also known as Sisco Bay. Today it is shown on the USGS map as Furnace Point. On an 1850's map, it is shown under the name of Ralph A. Loveland, who was then in charge of the business. It is indeed strange that the furnace was not shown on this map or any other contemporary map. In the *Atlas of Essex* County, the property is shown as owned by W. H. Conger, a Westport businessman.

The furnace was built by Mr. Francis H. Jackson of Boston who already owned part interest in the Port Henry Iron Company. The Port Henry furnace was the only other advanced blast furnace in Essex County, and this is where Jackson probably got his ideas for the Westport operation. The Sisco Furnace was reportedly started in 1845 and finished in 1847. It was completely rebuilt in 1856 just one year before it ceased operation.

Jackson built his own home there in 1848. He also built a dozen workmens' houses, a large house for his bookkeeper, offices, a store, a long row of giant coal kilns and a large wharf. At one time over a hundred people resided there, and the place was given the name of Jacksonville as shown on a map. Caroline Royce in *Bessboro* reports there was never a post office there even though the community had its own mail bag. In 1857, the property was sold by Jackson.



Blast furnace built at Tahawus about same year as Sisco. It was 48 ft. high whereas Sisco stood about 60 ft.



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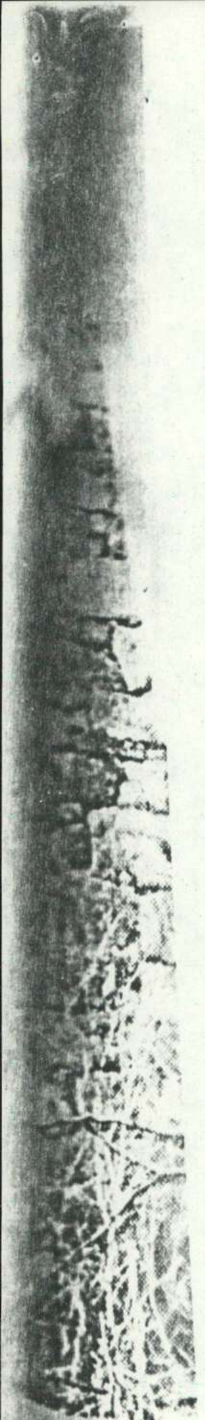


me year as Sisco.
about 60 ft.

The building effort necessary to construct the furnace probably involved most of the businesses and craftsmen in Westport. Building a furnace was an exacting project and required the very best builders. One of these men was Abe Sherman, grandfather of Gordon Sherman, Sr. He worked at many jobs during his life but we narrowed down his work on the Sisco furnace to the woodwork rather than the masonry. He was paid $1 a day for his work.

These skilled workmen cut stone for the furnace stack, burned limestone for mortar and made bricks for the lining. Heavy timbers to support the ore and iron were cut in local forests, taken to a sawmill and then hauled to the site. All of the stone had to be dressed to some extent because the sheer weight of the structure required a tight fitting outer shell. The space between the outer shell of stone and the inner shell of brick was filled by crushed rock to insulate and support the boshes. Remember the outer cover was a square pyramid like shape and the interior was a rounded, flour-mill shaped structure. Although the facing stones, arch stones and corner stones required great precision, the best craftsmen worked on the hearthstones and were considered the greatest artists. The hearthstone was trapezoidal in shape and formed the inverted cone at the bottom of the boshes where the iron collected. It was so important that a wood model was made by the furnace designer. The measurements of the Sisco furnace hearthstone are given in a later paragraph of this text. A wooden crane was necessary to construct the Sisco furnace. It had to be higher than 60 feet and over 54 feet wide. Although made of wood, it was reinforced with iron bolts and straps. It is difficult to imagine how a stone structure the size of a four story building was constructed with only man and animal power.

The following materials relating to the Jacksons came from *Henry and Mary Lee - Letters and Journals*. The July 6, 1846, letter is the only eyewitness account of the furnace site. This material is found in the collection of Gordon Sherman, Westport Historian.

> The following passages are from letters of Dr. Jackson to Miss Anna C. Lowell....
>
> At this time Cousin Frank and Cousin Sarah Jackson and their little children, Jim and Lily (Cousin Lily Winson), were living at Westport, N. Y., where Cousin Frank was in charge of the Ironworks.
>
> In November, 1848, Uncle Frank and Aunt Sarah Lee, just married, were living at Stonysides, still lived in and loved by their family to the third generation,...
>
> July 6, 1846
>
> If you come through Lake Champlain in the daytime, I hope you will see my son Frank's place. It is in Westport, about two or three hours' sail on this side of Burlington. You probably will stop in the Village of Westport, which is in a bay; and on the north of the

> bay you see his furnace, a large stone building down on the lake, while on the bank above you see his neat row of houses for the operatives, and above them his own house. As the ground rises gently from the bluff on the lake, and as there are many trees interspersed among the houses, you have a pretty, quiet scene exhibited.
>
> November 1, 1848
>
> .... We had a very pleasant journey to Frank's this autumn, enjoyed the gorgeous beauties of the Vermont Mountains in their bright red, yellow and russet attire, and found everything very comfortable at Westport. F.'s wife and two children were in excellent health and very happy. His affairs are going as well as anybody's in these hard times....

J. Elliot Cabot to his sister, Mrs. Henry Lee, Jr.

> November 11, 1852
>
> As for Frank, I thought I knew him pretty well before, but I very soon found I had under-valued both the depth and the breadth of his understanding, and I came to love more and more his great and magnanimous heart. -- I have no criticism to make on his way of life, for I did not find any evil effects upon him; there is nothing morbid or contracted, and tho' one might wish he could have developed more fully, and made the mark on the world that he might, yet take him as he is, how many men are there whose life on the whole one could call more successful than his? I can think of but very few...

Winslow Watson in his *History of Essex County* notes that:

> In 1847, Lee and Sherman effected a sale of twenty thousand tons of iron ore to F. H. Jackson of the Sisco furnace at Westport. This was the first sale made of ore to be used in the furnaces. (p. 403)

This ore was reported to be Moriah ore. But in *History of the Iron Industry of Essex County* by Frank S. Witherbee, only one bed was reported owned jointly by these two men, and it was the "Sanford, or Old Bed Mine." Individually and with other partners, they owned an interest in many ore beds in the area. They bought the Sanford Bed in 1846 and they sold it to S. H. and J. G. Witherbee in 1851 for $4,000. The Port Henry Furnace, in which Jackson had an interest, owned the Sanford Bed so it is probable that his ore came from there.

Teams or wagons hauled the ore directly from the mine. In another part of his book, Winslow Watson cites a different location for the ore as follows:

> The ore used was chiefly from the Cheever bed, and in part from a bed two or three miles west of the village of Westport, and owned by the proprietors of the furnace, who are also owners of the Goff ore bed in Moriah. (p. 463)

That commentary requires a bit of explanation and this writer is not certain if the sources of the ore will ever be known. For example, the bed to the west of town owned by the proprietors of the furnace would be the Jackson Bed where only a small amount of ore was removed (see Watson, p. 411). But in *Bessboro*, it is called the Ledge Hill Mine located just west of the Mountain Spring Road, back of the McMahon place. Caroline Royce reported, "The ore was soon found to be titaniferous, and therefore not available for use in the furnace, but large quantities of the Moriah ore were manufactured." Watson also infers that the Goff Bed was owned by the same owners. However, as near as this writer can ascertain, about the only time that this mine was used was during the brief tenure when George W. Goff owned the Sisco Furnace. The Goff mine adjoined the Cheever mine and was supposedly the same ore but in a smaller quantity. This also means that the furnace had to operate some time after 1857.

About 1869, Winslow Watson wrote that the Sisco Furnace was then owned by the Champlain Ore and Furnace Company, but that the works had not operated for a long period. The last year that any production was reported, according to *The Iron Manufacturers Guide*, was for 31 weeks in 1857 when 3,741 tons of iron were produced. The yearly total before then was around 4,200 tons. This compares with 5,321 tons from the Port Henry Furnace, the only other advanced blast furnace in the area. It is interesting to compare this production with the Willsboro Iron Works that only produced 1,000 tons of iron in 1855 but was operated at a profit for 20 more years. Caroline Royce in *Bessboro* writes about Sisco that "it is said to have cost one hundred thousand dollars and with the well known ingratitude so often found in costly building, never returned to its builders one-tenth of the price." This is the best remembered quote about the Sisco Furnace and unfortunately, the figures upon which it is based may never be known.

The Sisco furnace produced pig iron or more properly called "white iron," according to the previously mentioned *Guide*. In *An Introduction to the Metallurgy of Iron and Steel* by H. M. Boylston, white iron is described as:

> Pig iron and cast iron in the fracture of which little or no graphite is visible, so that the fracture is silvery and white.

This book mentions the Port Henry furnace as the most advanced of the time. Pig iron was strictly industrial iron and had to be processed in another furnace called a puddling furnace. Thus it was a two step operation to turn this metal into plows and other farm tools. This was another disadvantage for the Sisco furnace because its competition, the Catalan furnaces at Willsboro and Highlands Forge, directly produced wrought iron. Whereby much of the metal

at Willsobro and Highlands Forge was used at the plant to produce a large variety of goods, the Sisco Furnace is only reported to have produced metal. Most of this probably went into the national market, and in the iron depression of the '50's it had to end production. This may be one of the reasons that the Sisco furnace failed and that it could never be operated at a profit after 1857.

Steam power was used at Sisco in several ways. It operated the forced air devices to drive blast engines and also raised the ore, flux, and coal to the top of the furnace. According to the previously mentioned *Guide*, the Sisco furnace switched from charcoal for fuel in 1853 to anthracite or hard coal. It thus became the first furnace on the Lake to burn this fuel and was followed by the Port Henry Furnace in 1854. J. M. Swank in *History of the Manufacture of Iron in All Ages* cites this conversion as one reason production of iron was increased in New York after 1850. The conversion created a whole new set of requirements at the Sisco furnace. The extensive charcoal kilns were no longer used, and this cleaned up the air of the entire village since the kilns gave off a considerable amount of gas when they were burning. They certainly would not be approved under today's air pollution laws. But in place of the kilns, canal boats had to unload and store large stacks of hard coal. Split Rock Mountain and areas west of the Boquet were the most likely areas where charcoal wood was obtained, and by the 1850's all sources close to Westport were probably utilized. This was most likely the main reason that the furnaces switched over to coal. Pennsylvania coal was used at Sisco and that had to have been expensive, even though it burned hotter in the furnace and produced more metal. The operation of the coal kiln is described under the chapter on the Willsboro Iron Works, and charcoal burning is described in the chapter on Highland Forge.

The Sisco blast furnace was made of stone according to Caroline Royce. Most blast furnaces of that day were also made of stone as shown by the graphic on Tahawus. The stack was the heart of the system, even though the peripherals occupied more ground space and largely hid the furnace when it was in operation. The Sisco furnace was 42 feet high, which was about average for a furnace of that day, and extended about 54 feet along the ground. Thus, the device used to raise the ore and coal which was dropped into the top of the furnace had to be at least that high or higher. It was operated by steam power and was probably operated on an inclined ramp because of the heavy weight of the ore, flux and coal rather than as an elevator. There was a large two story shed roof completely surrounding the furnace. The floor of the first floor was covered with sand, and just before the molten iron was tapped a series of ditches were formed from the mouth of the furnace radiating outward. At right angles to these ditches, a wooden mold was sunk by hand into the sand and removed, thus leaving a depression of uniform size and shape. The uniform depressions looked like a row of pigs lined up feeding from a sow. Therefore, the ditches were known as the sows and the uniform bars were known as pigs -- or pig iron. The pigs were easily broken from the sows by a narrow neck, and the pig of iron was a uniform product for further processing. The name still persists today, even though sophisticated machinery is now used. A tap hole was located on the side of the furnace higher than the moulding arch

where the cinders flowed out. Vast piles of cinder surrounded the furnace and were probably dumped into the Lake. The bottom of Sisco Bay is most likely covered with this cinder even today.

To describe the rest of the Sisco Furnace we must start at the bottom and work our way up. First of all, there was the hearth upon which the rest of the furnace was built. The inside of the furnace did not mirror the outside shape of the furnace but was shaped like an old fashioned flour mill. For those who do not remember what that shape looked like, refer to graphic showing a bosh. The narrow top was called the throat and the wide sloping central walls, the boshes. The widest part of the boshes of the Sisco furnace was 13 feet according to the *Iron Manufacturers Guide*. The narrow bottom part was what we earlier called the hearth. Overman in a *Treatise on Metallurgy* described the hearth of Sisco Furnace as being a square 2 feet 10 inches wide and 18 inches high. On page 516, he noted the Sisco tuyere entered the hearth 18 inches above the bottom and 20 inches below the point where the boshes begin.

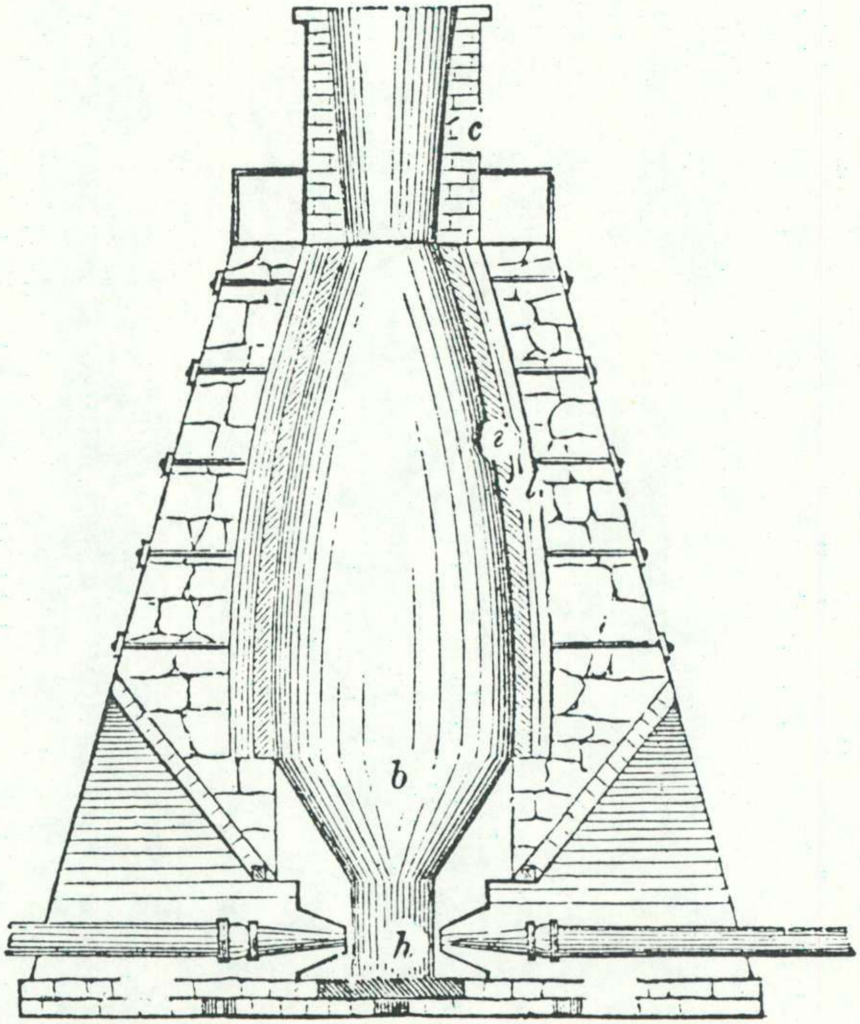
There were at least two archways at the base of the furnace as shown on the picture of the Tahawus. One of these was used to remove the molten iron and was called the Casting Arch. The other arch, known as the Blast Arch, was used to permit entry for the tuyere, through which the air blast was blown. As blast furnaces grew increasingly sophisticated, more tuyeres were added; but, only two arches are mentioned on the Sisco furnace. The blast machines were located near the steam plant and the air was carried to the Blast Arch by iron pipes. There were regulator boxes just outside of the furnace where the ironmaster could regulate the flow of air to the furnace.

The process of making iron is very colorful on a clear night and presented Westport residents with quite a show unsurpassed even today. The following is a description from Joseph Hergesheimer's book, *The Three Black Pennies*, of an early furnace.

> It had ... grown dark with annoying rapidity .... At the same moment a brighter, flickering radiance fell upon the road, the thick foliage of the trees. The blast was gathering at Shadrach Furnace. A clear, almost smokeless flame rose from the stack against the night blue sky. It illuminated the rectangular, stone structure of the coal house on the hill, and showed the wet and blackened roof of the casting shed below. The flame dwindled and then mounted, hanging like a fabulous oriflamme on a stillness in which ... one could hear the blast forced through the furnace by the great leather bellows.

It was quite a show and one that early Westport residents certainly availed themselves of on warm, clear summer evenings. The setting of sky, lake, and pyrotectics from the furnace were an unequalled sight.

To fire up the furnace, coal was placed in the hearth and it was gradually filled up to the boshes with burning coal. When half-full




Illus. of parts of a blast furnace. (The boshes are shown at b, air-blast from pipes at h in hearth and l is lining. The two arches are located on either side--see p. 22.)

of burning coal, ore and flux were added. When drops of molten iron were seen dropping to the bottom, the damstone was put in place with fire clay to keep the molten iron from running out of the furnace. It took a week to get the furnace in full operation to full capacity and the blast going at full force. A well regulated furnace made from 16 to 18 tons per week when in full blast. The Sisco furnace exceeded normal production by a large amount. The following description is attributed to Judge Hatch.

> We now find ourselves situated in a pleasant village of about one thousand inhabitants plentifully supplied with all the necessities of life and many luxuries, having now a variety of factories, among others a furnace which makes from six to nine tons of iron per day.

This production increased in later years as we noted in an earlier paragraph so Judge Hatch was rightfully proud of his local furnace. The quantity of iron produced certainly was never a factor in its downfall. In fact, it seems production was on the increase when it closed (refer to earlier production figures).

Dr. George F. Bixley, former editor of the *Plattsburgh Republican* wrote a series of articles on the iron industry entitled "The History of the Iron Ore Industry on Lake Champlain." He visited many of the ironworks on the Lake, and his description of the high degree of mechanization of the Crown Point plant seems to describe what the Sisco Furnace must have looked like when it was operating. On reading about the size of the furnace the reader must remember this furnace was built about 40 years after the Sisco furnace.

> A walk of a mile toward a lurid gleam in the east, most of the distance over as good plank sidewalks as Plattsburgh can boast of, brings us to the spot. ... A blast furnace should always, if possible, be visited by night, for everything about it then shows to the most striking advantage, and if he who comes in upon one for the first time, out of the darkness of night, does not experience a new sensation, then he is played out and incapable of one. The ponderous machinery, the bright streams of light, the intense heat, the strange figures of the workmen, now lighted up with a brighter than noon day blaze, and then flittering about in the sombre shadows of the huge walls: all make up a strange, weird scene. ....
>
> Away up aloft, under the high roof, you can dimly see the ponderous "walking beam" working up and down upon its center. It is a mere reed, thirty feet in length and weighs 28,000 pounds. At one end a piston rod connects it with the steam cylinder 52 inches in diameter and into this the rod plunges fourteen times every minute, nine feet six inches, as the steam forces the huge piston up and down within. At the other end, a similar rod works in the same manner in the "blowing cylinder," which is eight-four inches in diameter. This

is filled with air, and here is where the blast comes from which blows the fire and melts the iron in the furnace. The engine has a capacity of 350 horse power. There is pressure to thirty pounds of steam and the blast pressure is from four to five and one-half pounds.

Passing over into another building we find the boilers, sixteen of them, each forty feet long, with a diameter of three feet, six inches.

....

We pass along into another compartment and the heated atmosphere indicates that here is the furnace, a huge circular brick structure, sixty feet high and largest diameter sixteen feet. Great coils of pipes connect it with other portions of the establishment, and water circulates about through other pipes freely. This is about how it all is; in order to separate the iron from the rock impurities with which it is always found, it must be melted, rock and all. Then the next thing is to separate the iron from the melted rock or cinder. In order to do this there must be a hot fire, and in order to get a hot fire there must be a strong blast of air.

....

But here it is not sufficient, so an artificial blast is created by the aid of a steam engine, as we have already described, and this blast furnishes the heat which is the motive power of the engine. Thus we see it is a circular, reciprocating, back-action arrangement, which when it once gets in motion, must be kept so. Into the top of this furnace is dumped first a certain quantity of iron ore, and another of "transition limestone," which is used as a flux, which, when melted mixes readily with the melted rock and facilitates its separation from the iron. The same proportion of these three materials is constantly adhered to and the furnace is kept filled up nearly full, these materials being put in at the top... The coal rattles down its sides into what looks like the crater of a volcano or the mouth of the burning pit itself. You are thirty feet away, and yet the fuel gases choke you and the heat from the mouth of the monster scorches your face, as if it would not be denied the pleasure of swallowing you up... Then the ore and limestone flux follow.

Upon the platform again, and at the signal we descend. Suppose the chain should break sometime when these immense loads are going up? Then, by an ingenious arrangement, the motion of an elliptical spring, which is always kept bent to its fullest tension by the weight of the platform and its load, but which would immediately upbend, should the chain break, an iron of strong iron teeth spring at each side and "mesh" into an iron rack, arresting in an instant the descent. Here we are upon the ground again, after passing the tank holding 200 tons of water, which serve with a thirty foot head to keep the surroundings of the furnace cool.

On

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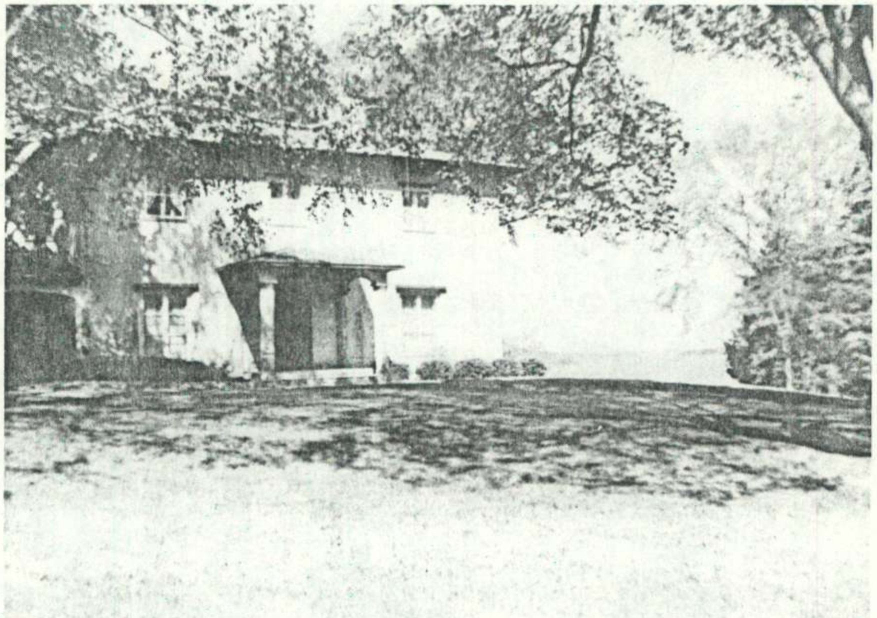
Stre



One of remaining houses in old Town of Jacksonville

Ruins of cellar holes of one of workmen's houses on Main Street, Jacksonville.

> They are about to blow off the cinder. As the ore and rock melt inside, the rock or slag rises like froth to the top of the molten mass and must be drawn off. The hold which is at the right level is punched out, and the ruddy stream pours forth and crawls along like a great red dragon.
>
> A stream of water from a hydrant played upon it, causes it to expand in a strange manner, as if it was humping its back angrily at the interruption. Another interval and the iron is ready to be drawn off. A lower orifice is opened, and the molten iron pours down a gutter and side ways into trasverse short ones in a large bed of sand, forming the "pigs." The inside of the building is brilliantly lighted up and the faces of the workmen glow as if they were demons. Thirty tons of pure iron are melted into pigs here every day in the year. Blast furnaces run day and night, week in and week out for years without interruption, for when they stop it costs thousands of dollars to start them again. The red stream becomes weaker, for ensues the most brilliant sight of all. The fire glows as it issues from the orifice, with a most intense whiteness, and the sparks fill the huge room full, while the lurid light streams far out upon the lake.
>
> The steamboat bell sounds, we hasten to the dock just in time for the boat, and as she moves off down the lake, we take one last lingering look at this still glowing building, and its reflection in the waters of the lake, at the very foot of the walls, illuminating with a weird light all the objects in the vicinity, after which we turn in to dream of all sorts of infernal horrors through the few remaining hours of the night, as the good steamer *Adirondack* plows her way northward through the lake.

The history of the old furnace after Jackson sold it is largely unknown. We know, as mentioned earlier, that George Goff operated the furnace on the ore from his Goff Bed, but no official production was ever reported to national reporters. Goff reportedly hired over 100 men at one time to operate the ore bed, haul the ore, and operate the furnace. This was a larger work force than Jackson ever had. Goff was making money in the ore business but he probably lost a great deal of money on the Sisco venture. The reason for the failure of the Sisco Furnace when compared with the spectacular success of its sister Port Henry Furnace is a mystery. At one point, Sisco was either owned or operated by a Port Henry industrialist by the name of Silas H. Witherbee who hired a team of experts to run the furnace. He was one of the directors of the world famous Cedar Point Iron Company, owner of Witherbee, Sherman and Company, and had a reputation of being able to produce iron from anything that would melt. When he could not make iron at a profit in Westport, other operators were forewarned.

There is just not enough known about the old furnace to determine the cause of the Sisco failure. At some point before it was torn down, it was owned by a large company who bought many Champlain Iron works after the depression of the 1850's. However, it was eventually torn down and the stone was used to build houses in the area. When Caroline Royce wrote *Bessboro*, stone from the walls of the furnace were to be found in the house of Mr. Robertson Marshall. The bookkeeper's house was then occupied by a Mrs. Hall. Earlier, when Witherbee operated the furnace, Mr. Victor C. Spencer lived there. The massive foundation was still in existence, the wharf was being used by pleasure boats, and most of the workmen's houses had disappeared. All of the modern equipment was probably dismantled and taken for use at the Port Henry Furnace. Today there are very few ruins left of the former town of Jacksonville. On the left as one approaches the point there are about eight cellar holes in a neat row in the woods and a commercial summer camp on the right. There is one lovely brick house from the former town, owned by the Prescotts, located at the junction of this road.

## Addenda

The *1860 Census of Industry* gave the following production for the Sisco Furnace that year.

| | |
|---|---|
| Used 4,249 | tons of ore |
| 429,200 | bu. of coal |
| $29,936 | spent for above |
| 60 | H.P. steam engine |
| 26 | men employed (at $30 a month each) |
| 2,456 | tons of pig iron produced |
| $44,208 | sale price of iron |

# CHAPTER 18

## HIGHLANDS FORGE

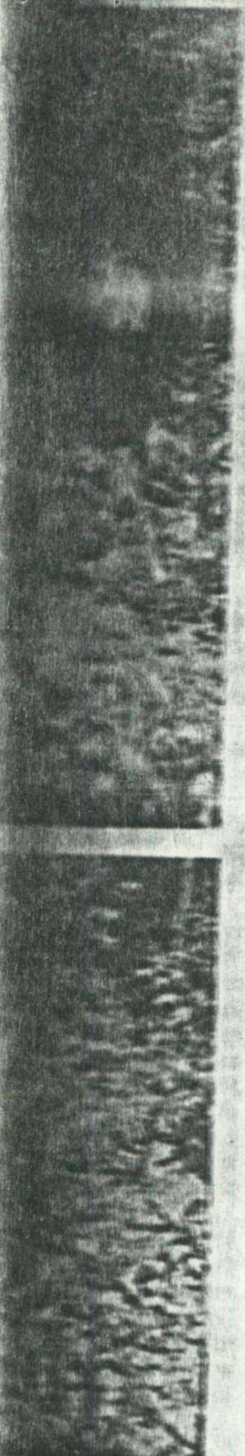
Highlands Forge was located on Howards Brook at the mouth of Warm Pond, now called Highlands Forge Pond on the U.S.G.S. map of the area. In the *Iron Manufacturer's Guide of 1855*, it was called "Highlands Bloomery." Howards Brook has also been called Higby Brook after Levi Higby of Willsboro who served as Postmaster at Port Kendall near the outlet of the Brook into the Lake. It was listed in the *Guide* as having a Port Kendall P. O. Box. Just as a sidelight, Higby, the Postmaster and one of the most important men in the area at that time, was only paid wages of $9.46 in 1851 and took in revenues of only $12.05. Some of the Higby history at Port Kendall is reported by Alice Higby Downs in *History of An Old House*. On page 61 she mentions that Ransom Higby started up the iron trade in Port Kendall. The forge at Port Kendall was evidently operated for several short periods of unknown duration. She goes on to say that Higby reportedly sold most of his lands to a dishonest purchaser except for 80 acres on Higby Brook where a saw mill was later built.

Highlands Forge was located 1½ miles upland from Lake Champlain above Port Kendall, seven miles south of Keeseville, and about four miles north of Willsboro. Koert Burnham noted to this writer that Highlands Forge was patented to Robert Boyd on February 4, 1796, especially to control the water power available from the fall of Long Pond and Warm Pond to the main lake. Earlier maps show Long Pond as Rattlesnake Pond. Koert Burnham also advanced the date when forge and sawmill operations began at Highlands Forge. He established the existence of a vertical sawmill and forge well before 1837. The almost simultaneous development of iron works throughout the Lake Champlain area about 1802, which is discussed in the chapter on Willsborough Iron Works, tends to validate this earlier development.

At that time, it was just one of many active forges and furnaces that were scattered throughout Essex County. Now only the name and crumbled ruin recount it as the location of an Adirondack forge. Just as Split Rock graphite mine is representative of the forgotten mines of the area, Highlands Forge is the prime candidate to serve as an example of the forgotten iron work of the area. There are no pictures and no recorded visits to the forge; the only aid to reconstruct what it must have looked like comes from a seven line description in the aforementioned *Guide* and a four line description by Winslow Watson in 1857. Dr. C. S. Smith of M.I.T., a noted metalurgist, also suggested an educated study of the ruins would reveal a lot of information about its mode of operation. From such sketchy information, it is indeed difficult to reconstruct a picture of what the forge site and equipment looked like. But there is just enough information about the equipment and enough ruins left at Highlands Forge to go to industry sources written during that era and ascertain how that type forge was generally equipped and how it operated. This writer went to such sources and included in this chapter material describing Highlands Forge as it must have existed.

Falls of
Howard
Brook

Ruin of old
forge
building



The early farmers in the area depended upon the forges as a source of their metal; thus, forge owners were men well known in the local area. The men who built the forges were the more adventurous businessmen of their day. The most important forge to be located at Highlands Forge was built and operated by such an individual, A. G. Forbes. He was a charcoal burner, amateur geologist and metalurgist, ironsmith, metal craftsman, and a businessman. He must have been extremely self reliant to operate a successful forge for 20 years, 1837 to 1857, in such a relatively isolated location. There may be many reasons that A. G. Forbes went out of business. The bottom line of his 1850 report to the *Census of Industry* showed a very small profit. His account was as follows:

600 tons of ore for $3,000 ($5 a ton)
80,000 bu. of charcoal for $4,000
8 men employed at $360 a mo.
$12,600 total income

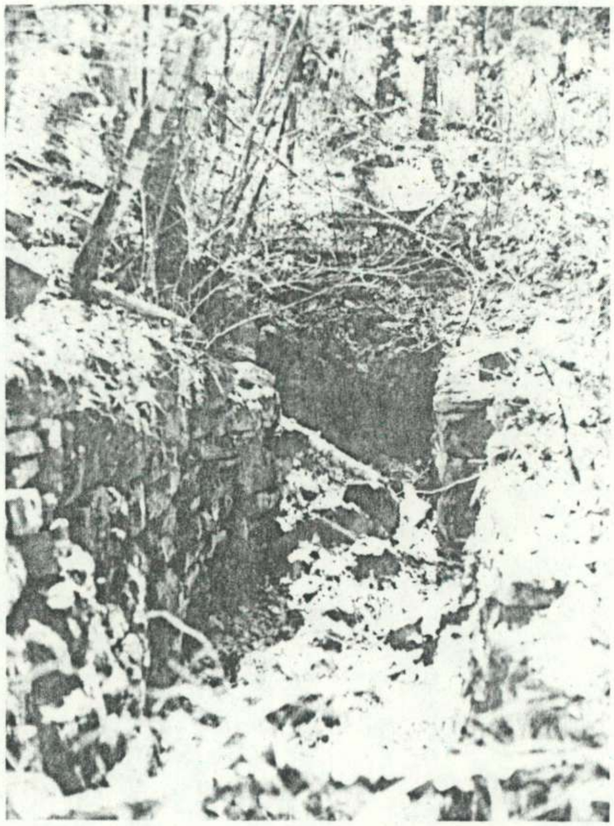
analysis of costs

| | |
|---|---|
| $3,000 | ore |
| 4,000 | charcoal |
| 4,320 | labor |
| $11,320 | |
| 12,600 | income |
| $ 1,280 | profit |

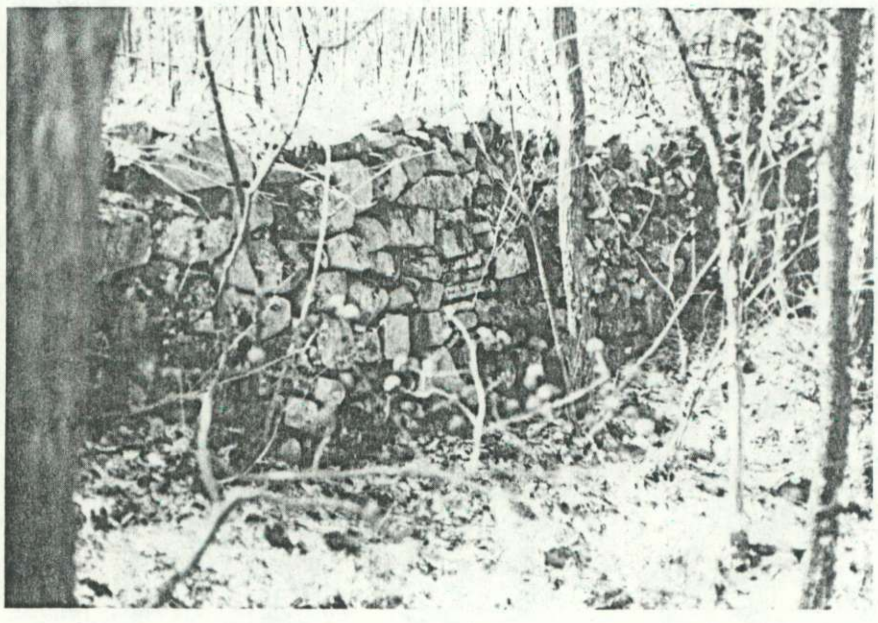
His profit would have been greater if he had paid standard wages. Sisco Furnace in Westport paid $25 per month and the average Champlain furnace only paid $1 a day. The most expensive labor was generally paid $30 a month. Therefore, Forbes paid $15 a month for each employee over the normal wages. He could have saved over $1,440 per year by paying standard wages. This would have allowed a profit of over $2,000 on $10,000 and would have been a respectable profit on his labor. We can only guess at the reason for the failure of his forge a few years later. Forbes paid the standard price for ore and charcoal and received a standard price for his iron; so, labor costs must have been the deciding factor. We also can only guess at the reason for these high labor costs. He might have employed many relatives or skilled labor might have required greater pay to work at Highlands Forge.

For a moment, just imagine his economic position. There were no local ore bodies of commercial size so most of his ore was reportedly loaded onto boats at Moriah, although Koert Burnham reports some of the ore was produced locally. This was reported to have mined from both Lot 109 and Lot 111 on a mountain to the northwest of Highlands Forge. Moriah ore was transported to Port Kendall and there loaded onto wagons. These wagons had to drive past one deserted forge located at the foot of the mountain in the village. This in itself speaks volumes for A. G. Forbes' business acumen. Each haul up the steep hill was an event with the heavily loaded wagons. But this haul was part of the secret of his success. The drop in water (470 feet +) over the same distance represented water power which was needed to operate the bellows to forge the iron and the large wooden hammer to form the blooms. If we made a horse power

Well for
Water
Wheel



Storage Dam



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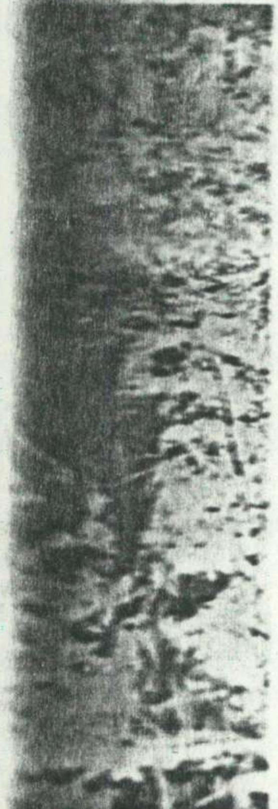
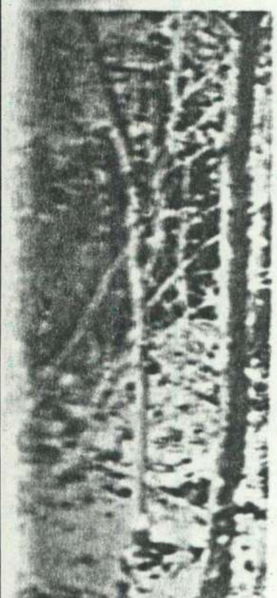




(H.P.) balance sheet to measure the advantage of his location, it would read something like this:

| Power Expended | Power at Mill |
|---|---|
| H.P. to load ore from mine to boat | Water Wheels (100,000 bushels of charcoal per year) |
| H.P. to load boats | |
| Wind Power to move the boat | |
| H.P. to unload boats | |
| H.P. to get wagons up the hill | |
| H.P. to unload wagons | |

The above tabulation also shows the premium placed upon water power for industry in 1837-57. The horse power of A. G. Forbes' water wheels are not known, but they must have been efficient wheels to offset the costs in the "power expended" column above. The ruins of Highlands Forge indicate at least two large water wheels and possibly other smaller wheels. Koert Burnham remembers a description given to him of the wheel when he was very young by an old farmer at Highlands Forge. He said that the wheel was a 60 foot water-wheel and told of seeing a man killed on the wheel one winter when he was attempting to clear the top of the wheel of ice. This would indicate the wheel must have been an undershot wheel. End mounts for the axle of the wheel and a trough for the bottom of the wheel are in an excellent state of preservation. The trough measures about 33 feet long by 6 feet 4 inches wide and 6 feet deep. This would indicate that the paddles or buckets were 6 feet wide. Slits are also constructed into the side of the trough in such a manner as to suggest that they were used to mount supports for the axle of the wheel.

Another curious aspect of the business was the general association of saw mills with the iron forges with dams serving a double duty. It is not known if this was needed to satisfy some operation ancillary to the forge or if the proximity of the water power made the setting up of a mill beneficial. This applied in general to all Iron works of that era; for example, at the Ringwood Ironworks, there was located one saw mill, and one grist mill and at the Charlotteburg Ironworks there were two saw mills.

The arrangement of the industrial plant at Highlands Forge would take a technical historian many chapters to relate. The ruins are in an amazing state and have not been disturbed by succeeding uses. They are located in the valley made by Howards Brook. The steep slopes of the Brook were bypassed for agricultural uses, and the Brook was not large enough to destroy the remains during periods of high water. It offers an interesting site for a detailed historical study.

Koert Burnham has studied the ruins and given much thought to the former uses of the structures. His reconstruction of the site is given as follows:

The water power for the site was stored by both Long Pond and Warm Pond. There was a small dam at the mouth of Long Pond with a number of planks stacked in a slot. When more water was needed at the forge, one or more planks could be removed to release water. There was a saw mill and a forge between Long Pond and Warm Pond to take advantage of that drop in water. There was another dam, the same as the one at Long Pond, located at the mouth of Warm Pond. Just below the mouth of Warm Pond were two more small forges with small eight foot dams. There are still some remains and cinders scattered about from these forges. Going further down the stream, we encounter the remains of a large stone dam which impounded water necessary for the short term operation of two large forges located just below the dam. It was about 300 feet across and its height varied with the terrain. The forge on the right bank of the valley was the one where the undershot wheel must have been. Water came to this wheel from the dam in a flume. There are fairly complete remains of the stonework of the wheel but almost nothing of the forge building. There is a pile of charcoal at the top of the rise where the working level of the forge must have been located. The foundation of a large forge is located near the waterfall on the left side of the valley. The drop in water from the dam to the ruin is about 40 feet. Water was also carried to this forge by a flume. The foundation indicates a building about 24 feet square. It was reported to be a three story building with the top two stories constructed of wood. Other details of this building are not known. But it would appear to house the large forge in the area.

A map dated 1837 shows there were at least six more sawmills located on the stream to Port Kendall. Port Kendall is reported to have been called Port Misery by the ore bargemen because of the harsh northern winds. These winds were unbroken over the long reach of the lake and made the task of unloading the ore barges a miserable job.

Highlands Forge used over 100,000 bushels of charcoal per year as fuel to heat the forge and melt the iron ore. Thus charcoal production was an important part of the process. Production of the charcoal, like the rest of the process of ironmaking, was a laborious task. Even though timber was close at hand, inspection of a map of Highlands Forge shows the hilly nature and indicates the difficult task of moving the timber or finished charcoal. Gangs of woodcutters first felled suitable trees, cut them into proper lengths, and carted them to a burning area. These were usually remote areas located on an isolated farm as only the large furnaces had charcoal ovens. Here the logs were stacked in conical piles in a dry sheltered area. The pile was covered by earth and damp leaves. The damp leaves were necessary to keep the dirt in place once the burn began. A small chimney or flue was left in the pile and burning wood chips were dropped down this chimney to ignite the cone of wood.

Fires were usually set from early May until late December, thus avoiding the winter weather and strong winds that could ruin the charring process. Weather was the charcoal master's clock. The trees had to be cut in the coldest months when the sap had retreated. This wood was also considered to be harder and it dried faster thus producing stronger charcoal. This strength was caused by the soluable chemical residues left in the wood of the tree by the retreating sap.

Production of charcoal was a job calling for expertise; it was not a job for beginners. Small openings had to be located in the sides of the cone of wood. This provided a proper draft and, as the winds changed, the location of the holes had to be changed. Without proper care, either ash or partly burned wood would be the result of the fire. Usually from three to ten days was required depending upon the size of the cone, technique of the charcoal master, weather, and the kind of wood. If the site was remote, the burner had to camp out or maintain a small cabin nearby. Even today, a trek through the woods will reveal a deserted charcoal burner's cabin. Some burners preferred a pile of rocks and wood forming a conical hut, which is curious, since the piles of wood were also conical.

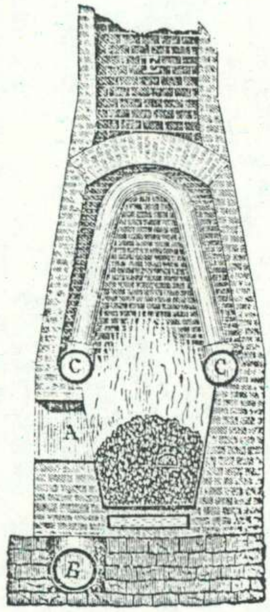
The end product of the fire was nearly pure carbon which, after a cooling period, was hauled to the forge only as needed. There were probably only small piles of charcoal maintained at Highlands Forge. Most charcoal masters preferred to have the coal remain at its burn location rather than move it into large piles. It was transported to the forge in iron bedded wagons.

Highlands Forge was of a primitive type since it was described by the 1855 *Guide* as having two bloomery and one forge fires. The bloomery fire was a modified Catalan. It was sometimes called a mountain forge. It was a simple device and produced reasonably uniform results. Frederick Overman in the *Manufacture of Iron* describes a Catalan forge as:

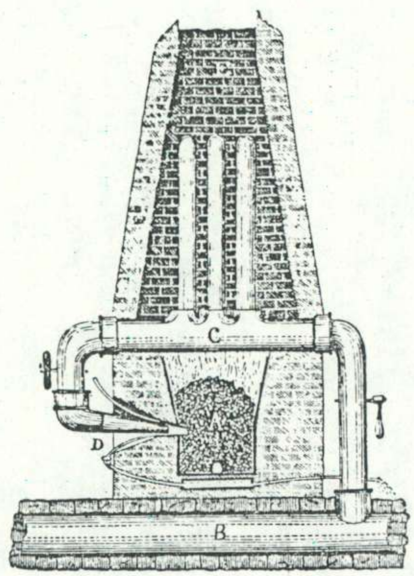
> ... the whole is a level hearth of stonework from six to eight feet square at the corner of which is a fireplace from 24 to 30 inches square and from 15 to 18 inches in depth.

It generally looked like a large barbecue pit mounted on a brick platform with a sloping shed type roof for a cover. The chimney was generally 20 feet in height.

There was also a number of blacksmith fires at Highlands Forge for working metal into shapes and usable instruments. It was likely many such products were fabricated in order to make a living at the forge. The blooms certainly did not produce enough profit to keep the forge going during the depression of the 1850's. Koert Burnham has collected a large sample of tools fabricated at the forge. They are mostly hammers in various degrees of completion. It is also said that the forge was known for fabrication of Highland plows and Highland stoves. The plows would have been made of wrought iron from the loup and hammered into shape on a blacksmith's anvil. The stoves would require a foundry operation. This would mean some of the iron was carburized and then poured into stove molds.




Side view of bloomery




Front view of bloomery

The use of the Catalan Forge is a two-step operation: first, the deoxidization; and second, the reduction of the ore. Once the ore arrived at Highlands Forge, it was laid in large pyramidal piles on top of logs, intermixed with brush, logs, and layers of charcoal, and then "roasted" for several days. Too little fuel caused poor roasting as did too much fuel. The proper amount was determined by experience only; no written rules were handed down. This custom of piling the ore seems to be an exclusively Champlain custom. Larger furnaces used kilns but there is no evidence of such at Highlands Forge. This roasting produced a friable, crumbling mass which was pulverized by large flat hammers. It was always reduced to a powder before it was put into the hearth.

A description of this roasting process can be found in the August 27, 1875, *Plattsburg Sentinel*. After the ore was roasted, it was put into long troughs with grates in the bottom. Water was passed through these troughs and its flow was adjusted so that the iron ore sank to the bottom because of its greater specific gravity. The gangue would be carried out of the trough as the ore sank through holes in the bottom of the trough. It was periodically collected and carried to the forge in wheelbarrows.

The forge was first filled with charcoal, and when fully ignited by a blast of air it was then covered with the pulverized ore and scattered evenly over the glowing fire. Charcoal and ore were then added for a period of about two hours or until what was called "the loup" was formed in the hearth. The iron was a pasty mass at the bottom of the hearth. Workmen then tested the glowing mass by a push and pull with tools. If it felt like lead, then the mass was pulled in front of the blast of air. By a continual raising and turning, the iron would become uniformly heated. In from three to four hours, the loup of iron and scoriae would be finished. The blast of air entering the hearth was turned off and the whole ball of material was removed from the hearth. The metal was a mixture of fiberous iron, cast iron, and steel. Outside the furnace was located a bench where the ball was laid and the scoriae was removed with wooden mauls.

The next step in production was to take the ball of iron and some scoriae to the trip hammer. According to the 1855 *Guide*, Highlands Forge had "one hammer driven by water," the sound of which could be heard across the breadth of Warm Pond, but the ruins of Highlands Forge suggest several hammers. Here another expert entered the picture, the hammer-man. It was his job to pound the iron until it was drawn to an oblong and square sided "bloom." The term "bloom" comes from the word "blum" or flower. Koert Burnham has found the iron hammer-head of one of the Highland Forge hammers. It is about eight inches with a wedge end for fitting into a wooden hammer arm. The end of the hammer is shaped like a peening hammer. It was obviously never used for finishing operations as that required a flat faced hammer. It was probably used exclusively for shingling the porous loup of iron to remove the cinder trapped inside and other hammers were used for finishing. A hammer described in the August 27, 1875, *Plattsburg Sentinel* was also run by an undershot wheel, weighed five tons and operated at a rate of 80 strokes per minute.

The iron hammer-head was mounted at the tip end or head of a long beam of wood called the "stale." It was generally made of beech and pivoted on an iron collar at a point near its center. At the opposite end from the hammer-head was the tail which received the blows of the cams mounted on the axle of the water wheel. As the water wheel turned, these cams forced the tail of the stale down, thus raising the hammer-head. Then the hammer dropped as the cam passed on. Each cam repeated the action and the hammer master regulated the water flowing over the water wheel, thus regulating the wheel.

A new fire was lit and the forge fire was run at full blast for the purpose of reheating the bars drawn from the bloom to perfect them by further hammering. They had to be reheated since they had grown cold on the hammer. To protect the bars from again melting or burning, ore was sprinkled over them to form a protective coating. This ore melted, thus forming the basis of the next loup. Therefore, only a small amount of time was lost in the reheating process.

In the average furnace, it would take about 50 bushels of charcoal to produce 100 pounds of iron. The Highlands Forge produced about 100 tons of blooms per annum, which was a relatively small amount of production. Cost of the production was averaged at $40 a ton in 1851 from this type of forge. Such forges were much less costly to build than blast furnaces and rolling mills such as the one built at Boquet, but the iron produced was more costly. Wages of the workmen worked out to about $10 per ton in 1851. As mentioned earlier, the cost of labor at Highlands Forge was one of the highest in the area. These forges were best when used with magnetic ores.

The Catalan method produced wrought iron which was a very different product from the pig iron produced by the blast furnaces. The wrought iron blooms produced were superior for making nail plates for nail factories and large quantities of Adirondack blooms were converted into that article. Even though it cost more to produce them than the competitive puddled iron from the local blast furnaces, it was preferred by many users. Local farmers could take the product, put it into their home forges, and make plows and other farm implements. Charcoal iron was also a favorite product with farmers since it had the reputation for high quality. Wrought iron was also called bar iron since this was the shape in which it was commonly sold.

The blast of air for the furnace was probably provided by two bellows worked by the water wheel although the blast required by a Catalan furnace was quite small -- only about one pound per square inch. Thus a common device called a water box was used to obtain a blast of air for small forges. Where a good head of water could be obtained, it was dropped through a pipe into a box-like shaped receptical. This box was one-half water and one-half air. Air rushed into the box along with the dropping water, was forced out under a small pressure, and then was piped into the furnace through tubes called tuyeres (pronounced twee-airs). This method was usually sufficient for a Catalan forge.

Highlands

Outlet of Warm Pond

In general, the 1840's was a boom decade for Adirondack iron forges. According to Peter Tenin in *Iron and Steel in Nineteenth Century America*, this was ended by a depression in the early 1850's. The depression was one of the causes of A. G. Forbes going out of business at Highlands Forge. In addition, this was also the period of a general deforestation of the area, so he had to go further and further for charcoal. During this period, over one-half of the production in the United States changed over from charcoal as a fuel to coke while steam replaced water power as a dominant economic factor. After this period, the demands of the railroads for rails and the Civil War caused renewed activity in the United States, but production at Highlands Forge was over. No attempt was ever reported to reopen Highlands Forge, and in 1857 it thus became a candidate for our "forgotten Adirondack Iron Work."

In *Personal Reminiscences 1840 - 1890* by Lucius Chittenden who visited the shores of Lake Champlain is a good description of the devastation of Adirondack timber.

The Adirondack Region - A Warning to the Destroyer -- A Plea for the Perishing

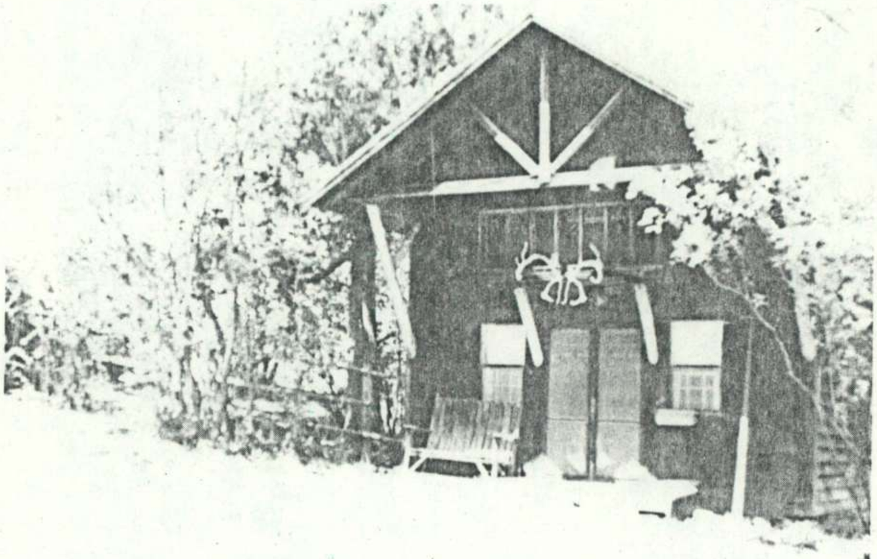
> The vandalism originated in the Champlain Valley ... The smoke of coal-pits covered the land. The trees were swept away as if some gigantic scythe-bearer had moved over it. In a few years there was no charcoal to be had at paying prices. Then the furnaces ceased operations, and where the forest had stood were huckleberry plains, where the berries were picked by Canadian-French "habitans." One may travel in that region now for miles and not find a tree large enough to make a respectable fish pole.

He was speaking of the area around the AuSable where there were several forges. But Highlands Forge was probably similar at least for a few years.

In describing the mountain forge, Dr. John Percy in *Metallurgy-Iron and Steel*, stated that in comparatively few locations could such a forge produce a profit. He gave the following analysis:

> In mountainous regions, abounding in rich iron-ores and wood suitable for charcoal, and still inaccessible to railways, the Catalan process may hold its ground; but certainly not in localities, however advantageous with respect to ore, fuel, and waterpower, where it is unprotected by high rates of carriage or other circumstances from competition with iron smelted and manufactured by modern process. Its advantages are, that the outlay and floating capital required for a forge are inconsiderable, and the consumption of charcoal is comparatively small.

Even in the Lake Champlain area, most operators realized that it was an uneconomical production method. In the *Plattsburg Sentinel*, August 27, 1875, issue, it was reported:



Old P. O. and Tavern at Highlands Forge

Willsboro Point from Pinnacle Rock

Opinion is expressed among our best iron makers that the Catalan Forge is a thing of the past even though it produces most Adirondack iron. About 40,000 tons for 2½ million dollars was produced with about 25% of it coming from this part of New York. Two new Catalan forges were built in the last year.

So we find even though the experts around Lake Champlain were aware of more economical methods of production, such forges were still being built around Plattsburgh in 1875.

The Highlands Forge industrial plant was an important structure to the entire region during its day and provided employment for many men. Much more than just acquisition of iron ore was involved. A whole catalogue of supplementary goods and services was needed to provide and maintain the large number of tools, mauls, sledges, utensils, and other equipment necessary to produce iron. Also, the human needs of the workers and their families were met by trips to Willsboro and Keeseville. The small communities at Highlands Forge and Port Kendall were intimately connected to the operation of the Forge and saw mills. When operations ceased, it was a severe blow to the community. Port Kendall is today smaller than it was in 1853 and Highlands Forge remains about the same size. There are in existence many foundations and cellars on the road from Port Kendall up the Brook, but only three houses exist along that road today. In fact, the name Port Kendall no longer appears on maps.

Without the advantages of A. G. Forbes' water power and management, the bloomery at Port Kendall closed sometime in the late 1840's soon after opening. There are no descriptions of its physical plant so a "historic reconstruction" such as we have performed on Highlands Forge is impossible for this Forge. Just enough was known about Highlands Forge that we are reasonably assured that the description included in this chapter has a sound basis in history.

Today, Highlands Forge is owned by Koert Burnham and several partners. His home, Highlands, occupies the former site of A. G. Forbes' home as shown on the 1856 map of Essex County. Other structures from A. G. Forbes' era still stand nearby. For example, a building that once housed the old Highlands Forge Post Office is located in the front yard of Highlands and an old one-room schoolhouse is located on a nearby rise. The view from Highlands is unsurpassed anywhere. It offers a view of Lake Champlain as well as that of towering mountains. It is indeed a unique and historic location.

THE CONNECTICUT BLAST FURNACES
AND FURNACE PRACTICES

C.F. HARTE

THE EARLY IRON INDUSTRY OF
CONNECTICUT

20 FEBRUARY 1935

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# THE EARLY IRON INDUSTRY OF CONNECTICUT*

## Part II.

## THE CONNECTICUT BLAST FURNACES AND FURNACE PRACTICE

By Charles Rufus Harte, Member The Connecticut Society of Civil Engineers, Inc.,

### Introductory

While the establishment, by John Winthrop, Jr., of a blast furnace and forge at East Haven in 1658 made Connecticut one of the pioneer colonies in the matter of smelting iron, it was by no means a pioneer field she entered. Long before, man had discovered what minerals, properly heated with charcoal in a comparatively shallow fire, gave him a pasty "loop",† which, when hammered to work out much of the melted mineral matter, became a "bloom" of tough and malleable wrought iron, or, with a deeper fire, yielded, from the same materials, the hard and comparatively brittle cast iron. This latter, however, had the advantage that, at a temperature which only made the wrought iron soft, it melted and flowed almost like water, permitting the casting of objects it was difficult, if not impossible to forge in wrought iron. He had also learned that by reheating the cast iron with charcoal, it could be converted to wrought iron, and that, indeed, in many respects this was the best way to obtain the latter, particularly in large quantity.

And so, when Winthrop established the first iron works in Connecticut, and undertook to smelt the bog ores of North Haven, he had, to guide him, not only his previous experience in Massachusetts, where he had started the Braintree and Lynn plants, but also the traditions of an old technique, which, while almost entirely the result of trial and error, had produced, in the past, very satisfactory results.

*Presented at 51st Annual Meeting, The Connecticut Society of Civil Engineers, Inc., New Haven, Conn., February 20, 1935.

†It would seem that the formation of the pasty mass, which quite possibly occurred the first times in altar fires, was anything but welcome to either the Germans or the French, for they called it by the name of the beast of the forest most hated and feared, the wolf. The English, however, seem to have no such antipathy, for instead of translating the French "loup", they merely anglicized it to "loop".





### The Metallurgy of the Blast Furnace

It is a fortunate fact, that of the many minerals containing iron, those which have a sufficiently high percentage of the metal, and are themselves sufficiently abundant to be considered iron ores, — an ore being a compound from which the metal can be produced in commercial quantity, at a cost permitting its sale at a commercially obtainable price, — are either oxides, or, by comparatively simple treatment, can be converted to oxides, for these latter, suitably heated with carbon, readily give up their oxygen to it, leaving spongy metallic iron.

In the forge this is practically the extent of the reactions; the resulting gases at once escape into the air, while the mineral matter associated with the ore, and known as the "gangue", melts, part remaining in the forge as cinder, and part filling the pores in the spongy iron, from which some is later removed by hammering or squeezing.

The reduction of the ore, however, is but the first step in a series of reactions, in the case of the blast furnace. The function of the latter is not only to deoxidise the iron, as is done in the forge, but also to carburise and melt it; and to convert the gangue into a fusible slag which, as far as practicable, will carry off all undesirable matter, the process depending upon a general, though not invariable principle underlying most metallurgical operations: that if both reduced and oxidised substances are melted together, the reduced substances will unite in one group, and those oxidised in another, but the two groups will remain entirely separate.

The blast furnace is essentially a tall container, filled to the top with fuel, ore and flux, with the lower part of the contents maintained at an intense heat by a blast of air, which furnishes the oxygen to burn the fuel, and then, by the products of that combustion, aided by the heat produced, first effects the reactions which must precede the melting of the iron and the slag, and then becomes "tunnel-head gas", burned in the early days to get rid of it, but later utilised to heat the blast and to generate steam.

The solid contents of the stack, eaten away at the bottom by the burning of the fuel and the melting of the other constituents, move slowly downward, the top of the column, by the more or less continuous addition of fresh material, being kept close to a fixed level, the "stock-line". As the ore descends, it is first reduced to spongy iron, as in the forge; then, continuing down into regions of increasing heat, but still solid, it slowly absorbs carbon, thus lowering its point of fusion from the 2786 degrees Fahrenheit required for pure iron, until at about 2200 degrees it melts, taking up, as the temperature continues to increase, more carbon, until it has absorbed a total of nearly 5 per cent, together with such silicon, manganese and phosphorus as have also been reduced, and such sulphur — as iron sulphide — as has not been converted to calcium sulphide, the compound collecting in the bottom of the hearth as a molten mass of that material of rather widely varying composition known under the general name of "pig-iron".

In the meantime, the limestone, the amount of which, in the early days was determined by the combined results of experience, experiment, and then an "informed guess", has burned to lime, part combining with the iron sulphide present, to form calcium sulphide and free the iron, the rest uniting with the silicious matter of the gangue, and the ash, to make a fusible silicate of lime with more or less magnesia and alumina, which, on melting, collects all the oxidised material and the calcium sulphide, and settles on top of the much heavier molten iron, to flow out over the "cinder notch", as soon as it reaches that level.

The various reactions are controlled by mixing different ores, by varying the proportion of flux used, and by changing the temperature of the hearth, to all of which the resulting metal is very sensitive. That the early iron-masters — and not so early ones at that, for it is only within comparatively recent times that the assistance of the chemist has been accepted — working almost entirely by rule-of-thumb methods, were able to turn out the quality of iron that they did, is little short of miraculous.

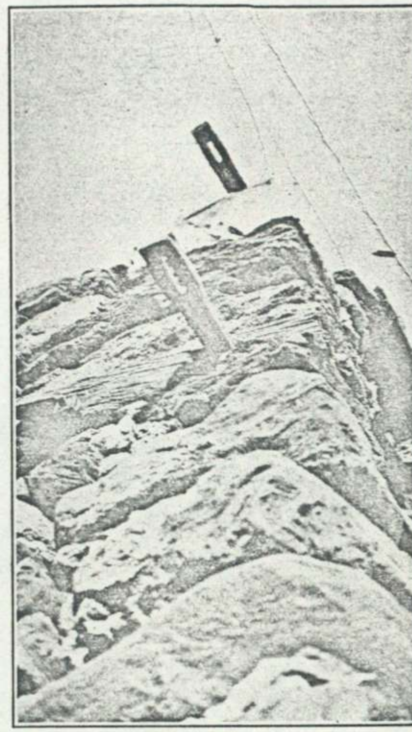
## The Earlier Furnaces

Today, at the outlet of Lake Saltonstall, there is not a trace of Winthrop's furnace, nor have there been found any details of its construction in any of the records examined. Thanks, however, to an old sketch once in the possession of the Barnum - Richardson Company, we know in a general way what the Lakeville furnace of 1762 was like, and as it it very similar to some European furnaces of about 1600, and as iron smelting was a craft of long standing, with all the traditions and all the conservatism of such an industry, it seems fair to assume that no material changes were made in the furnaces in the intervening period. If this assumption is correct, a reasonably accurate description of the pioneer Connecticut furnace, and of those which followed it in the succeeding one-hundred or one-hundred-and-fifty years, is as follows:

The outer shell was of dry rubble masonry, and was approximately 20 feet high, with a base about 20 feet square, and practically vertical



sides, and to facilitate charging the fuel and ore, and to prevent loss of heat, it was placed with its top on a level with the top of the bank against and into which it was built. Embedded in opposite sides were horizontal timbers in pairs, each pair tied together by iron rods passing through masonry and beams, and having in their slotted ends wedges which, bearing against the wood, could be tightened to take care of any shrinkage of the latter as it was dried out by the heat; the frame thus formed served to bind the masonry together and protect it from cracking. In front there was a rude archway about 10 feet high and as



Corner of Mt. Riga furnace. Note timber tie beams, slotted tie rods, and rough character of masonry.

many wide; and on one side there was another similar but smaller opening, about 6 feet high and wide.

Inside this outer structure, and separated from it by a sealed air space, was the furnace proper. At the bottom, on a heavy foundation of sandstone, was the hearth, or crucible, about 24 inches square in section, its sandstone walls, 2 or 3 feet thick, flaring outward a little in their 4 or 5 feet of height. An opening at the front was topped by a stone curtain-wall, the "tymp", in front of which two side walls and a fore-stone, the "dam", formed the "fore-hearth", which was practically an extension out into the big archway of the lower part of the hearth. The side walls and part of the dam were considerably higher than the bottom of the tymp, but a short section of the former, the "cinder notch", although still somewhat higher than the bottom of the tymp, was lower than the rest of the fore-hearth, so that when the molten slag reached this level, it flowed over into a channel leading to one side of the floor of the casting house, the escape from the furnace of any gases being prevented by the tymp, projecting below the surface of the slag.

Near the top of the hearth an opening in its wall into the small archway permitted the blowpipe to deliver the blast to the fire, while another hole, in the base of the dam, kept closed at other times by a plug of fire-clay, was the outlet by which the molten iron was "tapped off" into the pig-bed, on the side of the casting house opposite the slag-bed. The molten iron, kept from oxidation by the slag which lay on top of it, was allowed to accumulate for about six hours; this resulted in the production of approximately one-half a ton of iron, or about as much as would fill two ordinary water-pails, and filled the fore hearth nearly to the level of the cinder-notch.

Above the hearth, resting on it and extending up to the top of the outer stone masonry, was an egg-shaped structure, large end down. The furnaces of a somewhat later date had heavy cast iron bars built into the outer walls, to form a seat on which this inner masonry rested, to guard against unequal settlement; whether Saltonstall and the other early furnaces had such castings, which would have had to come from one of the Massachusetts furnaces or from abroad, or whether their inner shells simply rested on ledges in the outer stonework, was not learned.

When these stacks first began to use firebrick is not clear. Mr. John Birkinbine, a noted authority, says*—

> "The 'inwalls' (were) built of shale or slate - - , The bottom, the crucible (or hearth), and the boshes, were built of sandstone, nicely jointed, the masonry being carried out against the buttresses or corners of the stack, which were in many instances braced by heavy timbers and iron rods, to preserve the masonry from injury by expansion."

*"American Blast Furnace Progress", in Mineral Resources of the United States, 1883 and 1884." Page 290.



The old Lime Rock furnace, and those at Stafford, Falls Village and Joyceville all show stone lining at the top, although the last named one has boshes of brick, but as, according to Lesley*, it was in blast as late as 1854, it is probable that, whatever its earlier make-up, the brick now in the boshes are of comparatively recent date. The interior of the Mt. Riga stack, another old-timer, is completely filled with rubbish, and could not be reached for examination, but as it is said to have been rebuilt in 1845, and to have been in blast as late as 1856, (Lesley), it is very unlikely either that any of the old lining is left, or that, if present, it could either be identified or correctly dated.

The maximum diameter, which was from 8 to 10 feet, occurred at mid-height, or thereabouts, usually at a point sometimes called "the top of the boshes", and sometimes simply "the bosh", "the boshes" being that portion of the furnace between the top of the hearth and, in most cases, this section of greatest diameter. These terms were not fully standardized, however, and, at least in 1856, the point of maximum diameter, and "the bosh", or "the top of the boshes", were not always synonymous. Lesley records Sharon Station as:—

> "built in 1854, 9 feet bosh, swelling in the cylinders to 10 feet, and 23 feet high."

Of Mt. Riga he says:—

> "an old furnace, built about 1800. It was rebuilt in 1845, 8 feet across the top of the bosh by 30 high, but across the bilge, six feet above the top of the bosh it is 16 feet wide."

Wherever the point of beginning, the boshes, starting with a circular section at the top, sloped down, gradually changing shape and contracting, to connect smoothly with the square top of the hearth.

The portion above the bosh, "the shaft", had throughout its length a circular section, reducing from the same diameter at its base as the bosh to about 3 feet at the top, "throat", or "round-top", as it was variously called. To protect it against the wear and tear of charging, the throat at first had a stone curbing, but later a heavy cast-iron cover-plate, with a charging hole 18 inches to 2 feet in diameter and central with the shaft, took its place. Because of the difficulty of procuring such a plate at that time, there being no other furnaces near to cast it, Saltonstall undoubtedly was curbed, but somewhat later the use of a plate became practically universal.

*J. P. Lesley, "The Iron Manufacturer's Guide". Page 30.

The blast was produced by a pair of bellows, very similar to the ones which up to quite recently could be seen in any blacksmith's shop, but much larger, and "blown" by means of a water-wheel. Dr. James Thacher, who was one of its owners, describing, in 1804, the Federal furnace in Plymouth County, Massachusetts, a stack which, built in 1794, of stone, was 20 feet high and 24 feet square, with an interior diameter of 10 feet, and walls 7 feet thick, wrote*:—

> "In another arch on one side there is a small aperture for the insertion of pipes of two large bellows 22 feet long and 4 feet wide, which being kept in constant alternate motion by the agency of a water-wheel 25 feet in diameter, a powerful current of air is exerted, and being impelled upon the surface of the fuel, the fusion of the metal is greatly accelerated."

The "trompe", a very efficient device which is essentially a water-operated air-injector, a stream of water flowing through a small throat at the top of a larger vertical tube sucking air through a series of holes just below the throat, and delivering it through a wind-box at the bottom, as a damp but steady blast at a pressure depending on the head of the water, while used extensively abroad, and, to a lesser extent, in New Jersey, North Carolina and Tennessee, particularly for forges, does not seem to have been employed at all in the Connecticut iron industry. It is interesting to note, however, that in 1901 there was installed at the site of the present "Tunnel" hydro-electric power plant on the Quinebaug River, just above Norwich, Connecticut, a Taylor Hydraulic Air Compressing Company trompe of 1365 horse power, which, until June, 1917, supplied compressed air for power to several factories in Norwich.

The blast itself, at a pressure little if any over one-half pound per square inch, was introduced into the fire through a clay "tuyere", or nozzle, the outside diameter of which was appreciably less than that of the opening in which it was centered, leaving an annular space through which nearly as much outside air as was delivered by the nozzle itself was fed the fire by injector action, with a roaring which was one of the characteristic sounds of these early furnaces, when in action. The nitrogen which forms 80 per cent of the air, plays no chemical part in the furnace, but transfers heat, absorbing it as it blows through the zone of active combustion, to give it out again as it goes, unchanged, up through the charge. The oxygen, however, first combines with the carbon of the fuel to form carbon dioxide, producing great heat; then

*Jas. M. Swank: "History of the Manufacture of Iron." Page 93.



immediately is reduced to carbon monoxide by the hot and oxygen-hungry carbon just above the zone of combustion; then helps in the reduction of the iron ore; and finally, as a mixture of carbon monoxide and dioxide, reaches the top of the stack mixed with the nitrogen, forming the "tunnel-head gas".

The high proportion of carbon monoxide makes this gas a serious menace to the men at the top, and for their protection it was drawn off by a side flue or tunnel, connecting with a chimney or "tunnel-head", and for a long time it was burned to get rid of it. This flaming top was as characteristic of these early stacks as the roar of the open tuyeres. Describing its appearance, Mr. Richard Peters, Jr., says:—*

> "A translucent flame interspersed with glowing sparks rose and fell from the open tunnel-head in harmony with the pulsations of the blast. By day it was suspended over the furnace top like a mystical oriflamme, and at night it served as a beacon, lighting up the country-side."

What shelter the men had was largely incidental to the protection of property. Since if in the pig-bed the molten iron came in contact with any appreciable amount of moisture over and above that necessary to give the moulding sand the consistency required to pack properly, there was certain to be a serious steam explosion, with consequent wrecking of the bed, to say nothing of injury to the men, there had to be some sort of casting house to keep out the rain, but for a long time this was little more than an open shed over the pig-bed and the slag-bed. The bellows, too, had to be sheltered from the sun as well as from the rain on account of their leather sides; and if any casting other than that of pigs was done at the furnace, there had to be some sort of a pattern shop and storage loft; as a rule this was the extent of the housing at the base of the stack. At the top there was even less. Although the tunnel-head carried most of the furnace gases well above the charging floor, flare-backs occured every now and then, and a "top-house", or any similar structure which might be set on fire, and in turn burn the charging bridge and floor, was long considered too great a risk, and the top-men had little or no cover.

Up to just what time this picture remained reasonably correct is not now possible to state, at least from any of the material so far discovered. No documentary evidence has been found, while the fact that stacks were relined and rebuilt again and again has largely masked any infor-

*Richard Peters, Jr.:—"Two Centuries of Iron Smelting in Pennsylvania." Page 7.

mation which might otherwise have been uncovered in the field. But while the time element in uncertain, not only as to this early period, but also until well towards the beginning of the Civil War, the steps in the developments which occurred as the old conservatism died away, and changes began to be made in traditional proceedings, are quite apparent. They are so inter-related, however, that often it is quite difficult, if not impossible, to tell just what was cause and what was effect.

## The Furnace Lines and The Blast

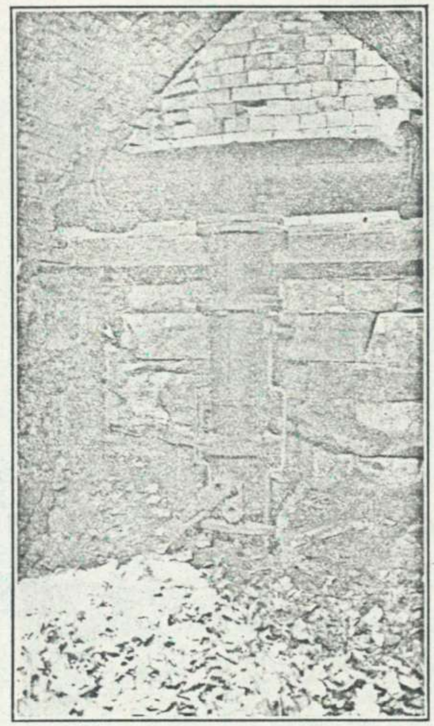
A considerable period of time elapsed before the early iron-masters realized that the change in shape from the egg-like form of the furnace as it was built, to that found when it was "blown out", carried an important lesson; not until 1839 is John Gibbons, an Englishman, credited with recognizing the functions of the inside shape; but before that time the fact that after operating for a while the "egg" would be filled out in places by material which had stuck to its walls, while elsewhere it had been melted or worn away, had led to modifying both shaft and boshes to frustrums of cones; to changing the section of the hearth from square to round; and had pushed the bosh down to a point about one-third of the height from the bottom.

As a result of these newer lines the charge moved more freely and rapidly, and this, together with the increase in size to meet growing demand for more and more iron, required a correspondingly greater air supply for the furnace, for it takes nearly five tons — 150,000 cubic feet — of air to reduce one ton of iron from the ore. This necessity was first met by putting a second tuyere opposite the original single one in one side; then by adding a third one at the rear; and finally, by increasing the number of tuyeres to five, one at the rear, and two each in each of the side archways.

The single tuyere was connected directly to the bellows by a duct of wood or tin, a leather section making a flexible joint which facilitated the temporary withdrawal for repairs, of the portion of the piping in the archway. For more than one tuyere, a "bustle-pipe", partly encircling the stack, was used, the duct from the bellows feeding into it, while dropper pipes at the archways supplied the separate nozzles. At first this bustle pipe was of tin or light sheet iron, and was hung on the outside walls, above the archways,—the Roxbury stack still has some of the supporting rings in place,—but it was soon moved inside, between the inner body and its housing masonry, well above the tuyere openings, cast iron pipe being used, with part of the joints bell-and-spigot



and part flanged. The rear dropper was single; if there were twin tuyeres on the sides, a large vertical main from the bustle pipe branched into two droppers, each of the same size as the one at the rear. To each of these droppers, which had individual dampers so the connected lines could be cut off without interfering with the other tuyeres, was attached, by a slip joint to facilitate removal, a short, vertical pipe, the "tuyere-stock", or "boot-leg", which in turn was connected to the horizontal "blow-pipe", or "belly-pipe", carrying at its other end the tuyere itself.

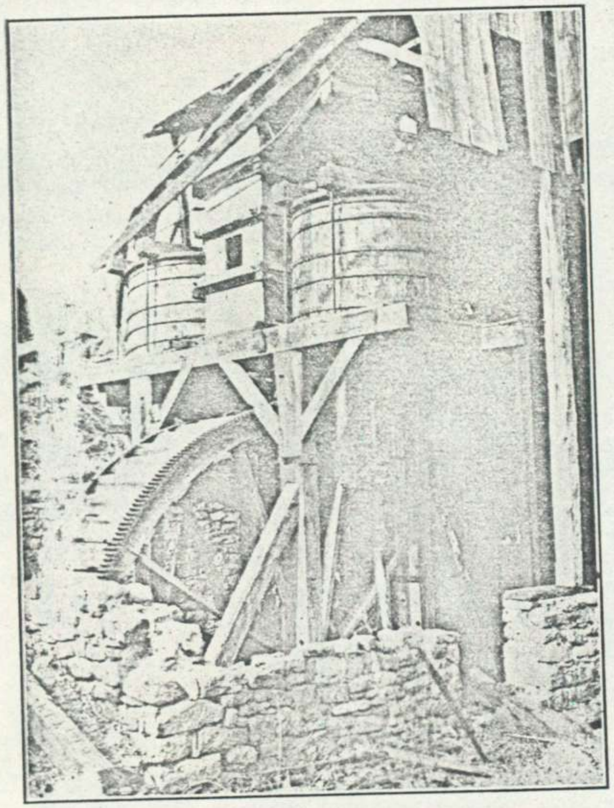


Bustle-pipe, dropper, and tuyere stock for rear tuyere, Sharparoon furnace. Note peep-hole and cover, damper stem where clamping rod is attached, and the sandstone hearth blocks.

At the lower end of the tuyere stock an opening on the center-line of the belly-pipe was normally closed by a swinging cap with a mica-covered peep-hole through which the fire and the condition of the tuyere was watched. When, as often happened, partly melted material tended to block up the latter, the cap was swung to one side, an iron bar run in, and the obstruction cleared away.

## The Wooden Tub Blowing Machines

For a time the increased volume of blast required was obtained by increasing the size of the bellows, but when the latter began to exceed 20 feet in length, it was evident that some other device was necessary, and attention was turned to the blowing apparatus which had been invented, in 1550, by one Hans Lobsinger, an organ builder of Nuremburg, Germany. This had three particularly noticeable parts so like



Hopewell furnace (Pennsylvania) blowing machine, with square wind-box or equalizer between tubs.
Courtesy Mr. Lewis Dalrymple Bradbury

tubs that they had at once been called by that name, and even today, although the resemblance disappeared long ago, the cylinders of blowing engines of the reciprocating type are still called "blowing tubs". The two mains "tubs" of the Lobsinger machine, operated by a water wheel, pumped the air into a third and larger cylinder, the equalizer, or wind-box, the free but loaded piston of which, while rising and falling with



the pulsations of the pumping cylinders, maintained a steady outflow at uniform pressure.

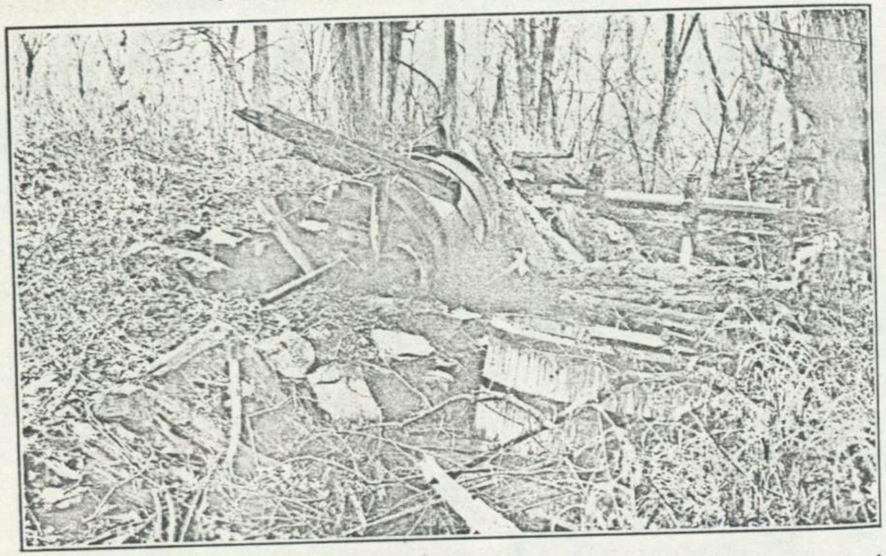
The first American installation was at the Hopewell furnace, near Birdsboro, Pennsylvania, about 1771. This machine was the sole dependence of the plant until 1880, when an unusually severe winter froze up the water-wheel, and other means had to be used to tide over the emergency; apparently the old machine was soon returned to service, however, and it continued in operation thereafter until the furnace closed down permanently in 1883. Recently, through the generosity of Mrs. Edward Brooke of Birdsboro, one, if not the, owner of the property, the complete old blowing gear, in working order, has been set up in the museum of the Franklin Institute at Philadelphia. Undoubtedly this unit is very similar to some of the vertical Salisbury machines, and in view of the fact that so far no pictures, and but one outline sketch of any of the latter have been found, and there are practically no remains, it is particularly fortunate that through the courtesy of Mr. Lewis Dalrymple Bradbury, recently Manager of Advertising of the Birdsboro Steel Foundry and Machine Company, it is possible to show a photograph of the Hopewell unit as it stood shortly after the furnace had closed down.

Just when or where in the Salisbury district the first such installation was made has not been learned, although it seems probable that the date was not far from 1835. Pynchon* illustrates, as a typical Salisbury unit, a vertical machine similar to the one at Hopewell, and as the furnace he describes in detail is Canaan No. 3, it is probable that his blowing gear was of that plant also. Incidentally, Mr. W. A. Barker of Kent, whose father, Mr. James Barker, was long the superintendent at Kent furnace, says that one of the Canaan blowing sets, quite likely that of No. 3, was one, if not the, best in the state.

Today, except at Kent, there is very little left of any of these machines. At that furnace the tubs were horizontal, and, it would seem from the appearance of the masonry foundations, horizontal gear was used at Lime Rock, Roxbury and Van Deusenville as well. Buena Vista, (at Huntsville), Beckley, Canaan No. 3, Sharon Valley and Wassaic apparently were vertical, while what the others were, at least so far as judging from present conditions is concerned, is any-one's guess. Whichever way the blowing tubs themselves stood, however, the equalizer had to be vertical.

*W. H. C. Pynchon:—"Iron Mining in Connecticut" Connecticut Magazine, Vol. 5, Page 232.

The Kent blowing plant, the only one of the water-driven sets of which today there remains anything to speak of, was operated by a breast wheel 17 feet in diameter and 12 feet wide, with a bucket ring consisting of a tight back of 2 inch plank; side rings — and probably one in the middle — 9 inches wide, measured radially, made up of segments cut from 3 inch plank, two layers thick, bolted together and breaking joints at the ends; and front boards of 2 inch plank 12 inches wide fitted tightly to the back with which they made an angle of approximately 26 degrees, with the front chamfered on the inside to form an edge and the ends let into the side — and the center — if so be there was one — rings. If these front boards extended the full 12 feet of width,



Kent furnace blowing machinery today. Note tail-rod extending from cylinder-head of tub, the relief holes at top of equalizer (in the foreground), and the water-wheel shaft and spiders in background.

there were 50 buckets; if there was a center-ring the buckets were 6 feet long, and there were 100.

The bucket ring was carried at the ends of 3 sets of rectangular wooden spokes, 5½ inches wide by 5 inches parallel to the shaft, 10 to each set, with outer ends notched into and bolted to the rings; the inner ends bolted in pockets in cast iron spiders 41 inches in diameter, held by 8 keys each on an iron shaft which for some undiscovered reason had one-half of its 14 feet of length octagonal, 9 inches face to face, and the other half round, 9 inches in diameter. The keys are rectangular, 1¼ inches wide by ¾ inches deep, and are seated in keyways in the



hubs of the spiders and in the round section of the shaft, but simply rest on the flat faces of the octagonal portion of the latter. The cranks, one at each end of the shaft, are 90 degrees apart, and drove the tub pistons through wooden connecting rods with iron end-fittings.

The blowing cylinders, 50 inches inside diameter by 5 feet stroke, were built up of a large number (approximately 100) of narrow pine staves, 2 inches average width by 2 inches deep, bound together by iron straps with tightening bolts. The heads were built up of two layers of pine plank 1 inch thick, laid at right angles to each other, bolted together, and were clamped on the cylinder by tie-rods through the ends of paired beams at each head, which, lying across the heads on either side of the piston rod, extended out just far enough so the rods cleared the side of the tub. Both the Kent and the Cornwall Bridge machines, the only ones of which any of the wooden parts remain, were double-acting, each head having both an inlet and an outlet, closed by wood flap valves, with leather hinges.

At Kent the inlets were square and the outlets were round; at Cornwall Bridge all outlets were round, but two heads had square inlets, and two had them oval. The heads at this latter furnace were much the heavier, consisting of two layers of 3 inch plank, and while there were a few bolts near the circumference, the layers for the most part were pinned together with trenails. It is rather interesting to note that at Cornwall Bridge, except for the four cylinder heads, and one piston built just like them but without openings, not another part was found of the blowing unit.

The piston was built up like the tub head, but the thickness at the edge of the Kent pistons was doubled by a ring of segmental sections of 1 inch plank on each side; it was made air-tight in the cylinder by packing consisting of narrow strips of leather laid tightly side by side across the piston's edge, the ends being turned down on the face, to which they were nailed. Graphite was used as a lubricant, but at best they maintained a doleful moaning. Mr. Bolles wrote, with no little moderation:—*

> "The - - mournful groaning - - affects the unaccustomed ear rather curiously."

It might well do so, for one of the old furnace men said that on a still night it sounded "next door" at his father's house, some 2 miles away.

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*J. A. Bolles, in an article in the New Milford Gazette of March 25, 1887, quoted in Atwater's History of Kent.

Mr. John Birkinbine, writing about 1884, says:—

> "The wooden blowing tubs were cylindrical or rectangular in form, from 5 to 7 feet in diameter, or square, and from 2 to 5 feet stroke. They were formed from segments or strips cut from 1 inch boards, generally pine, glued and doweled together and then turned or planed to smooth surfaces. There are examples of both cylindrical and rectangular wooden tubs still in use. These tubs, when lined with apple or other hard wood, were very durable. - - Large wooden pistons with leather edging were fitted in the tubs and connected with square wooden piston rods working in square stuffing boxes."

Both Kent and Cornwall Bridge had round cylinders and piston rods. Kent's piston rods were of iron, 3 inches in diameter; those at Cornwall bridge may have been of wood, for the hole in the cylinder head is 4½ inches diameter, and in it was some graphite packing in fair condition. (1935). At Kent, to prevent the weight of the piston from unduly wearing the lower half of the cylinder, the piston rod was extended through the piston and out through the rear cylinder head as a tail-rod; the fact that there were no tail rods at Cornwall Bridge — the rear heads having no opening for one — may well indicate that it was a vertical set, although Pynchon's sketch shows tail-rods on a vertical machine.

The equalizer cylinder at Kent, 65 inches in diameter inside, and somewhat more than 51 inches long — the bottom is sunk in the mud and is inaccessible — was made up of staves the same average width — 2 inches — as those of the blowing tubs, but they were 3½ inches thick, measured radially; they were bound together by the same type of adjustable straps. The inlet and outlet, which were at the bottom, and not visible, undoubtedly had some kind of valves, but this could not be determined with any certainty. A series of small holes, in slanting lines, near the top, evidently were to serve as relief openings in case the piston was forced dangerously near the top by some interference with the blast beyond it and there was a resultant build-up of pressure.

While there are wheel shafts similar to the one at Kent at the sites of several old blowing plants, the only other furnace which has anything left of the wheel itself is Buena Vista, where there are the remains of a breast wheel 5 feet 6 inches wide and 20 feet in diameter. This wheel had a wooden shaft 24 inches in diameter, but all trace of the cranks and connections are gone. Its bucket ring had 60 buckets, and was carried at the ends of two sets of 12 spokes each, each spoke being 9 inches wide, parallel with the shaft, and 3 inches thick. The spokes were mortised into the shaft and were strapped and bolted to the cheek plates of the bucket ring, which latter except in width and diameter was practically a duplicate of that at Kent. Besides the remains of the wheel, there are a few sill timbers in the wheel-pit, and clinging to the wheel is the delivery end of the flume, but of the tubs or their supports there is nothing; it seems probable, however, that this was a vertical unit.



### Steam Blowing Gear

Until it was realized that the gases from the top of the furnace could be burned successfully for the purpose, it was felt by the Salisbury iron-masters that the cost of the fuel in their district more than offset the advantages of freedom from interruption by reason of drought or flood possessed by steam-operated blowing engines, and, in fact, until further demands for greater production forced such an increase in the diameter of the stack that the old water-operated plants could neither give the required volume nor the pressure necessary to reach with the blast the center of the zone of fusion, there was little real need for such a change.

In 1842, however, Wilhelm Faber du Faur was granted his American patent covering the use of the tunnel-head gases for generating steam, and shortly thereafter steam blowing-engines began to appear, particularly where mineral fuels were used, and a high-pressure blast was a necessity. In a few instances, where a water-blown set was superseded, the old wooden tubs were used, but practically all of the new units had new iron tubs. In the Salisbury district there is but one installation of which there is anything remaining, that at the Maltby furnace, near Millerton, New York. This had a single cylinder engine geared to the crank-shaft operating the two horizontal iron tubs. Copake, originally water-blown, but later converted to steam, now has nothing-whatever left of the blowing gear, but photographs kindly loaned by Miss Helen Miles of Twin Lakes, daughter of the noted Salisbury iron-master William A. Miles, owner of Copake for many years, show a single cylinder horizontal Corliss engine geared to the crank-shaft of a pair of vertical tubs of iron.

The large amount of dust in the gases, which for a long time were used without any attempt at cleaning them, made a large flue boiler desirable and the usual ones employed were very long Lancashire type of small diameter. This, however, is largely hearsay, for there is but one of the steam-blown furnaces that has not been stripped of all its equipment. At Maltby, however, the boiler is still in place, just above the level of the top of the furnace and behind the stove, a common flue bringing the hot gases to a point where dampers turned them to the oven or to the boiler or both as desired.

## The Heated Blast

The development of the railroad brought new demands on the Salisbury furnaces, for the Salisbury iron, and especially that from ore of the Ore Hill Mine, was particularly adapted to the making of chilled cast-iron car wheels. All of the early furnaces had been blown with air at outside temperature, and to the older iron-masters, William Henry's experiments at Oxford, New Jersey, in 1834, with the heated blast that James Neilson of Glasgow claimed to have used with great success, and for which, in 1828, he had obtained a patent, seemed little short of sacrilege; as late as 1837 Dr. Shepard,* urging the employment of hot blast, stated that there was then no furnace in Connecticut making use of it. Shortly afterwards, however, installations began, and of 33 furnaces listed by Lesley as comprising those in the Salisbury district in 1859, 26 were using hot — or at least heated — blast, although 6 of these at times also ran on cold blast.

As with so many of the other features of these furnaces, there is today very little to tell the story of the early heaters in any detail. Described broadly, the air from the blowing tubs was put through a series of cast iron pipes surrounded by hot gases from the furnace top, and so was raised to a temperature which, in the first installations, was about 250 degrees Fahrenheit. This limit was gradually increased, however, until it reached a maximum of about 900 degrees, above which point the cast iron pipes tended to deteriorate very rapidly and seriously.

The "oven" or "stove" pipes, oval in section, were formed into "U's", with the long diameter of the oval in the plane of the legs. At Copake they were suspended, but apparently in the majority of cases they stood up, inverted. They have been described as being nested, and also as being connected in series. J. A. Bolles said of the Kent oven:—

> "The water power from the dam operates these bellows, which send big blasts of air through a long pipe connecting with the furnace. From the main pipe the air flows into a bed pipe and thence into a tier of siphon pipes, fifteen in a tier, forty-five in all. The pipes of each tier are curved like an ox-bow, and the three tiers are connected with each other by means of three bed pipes. The air,

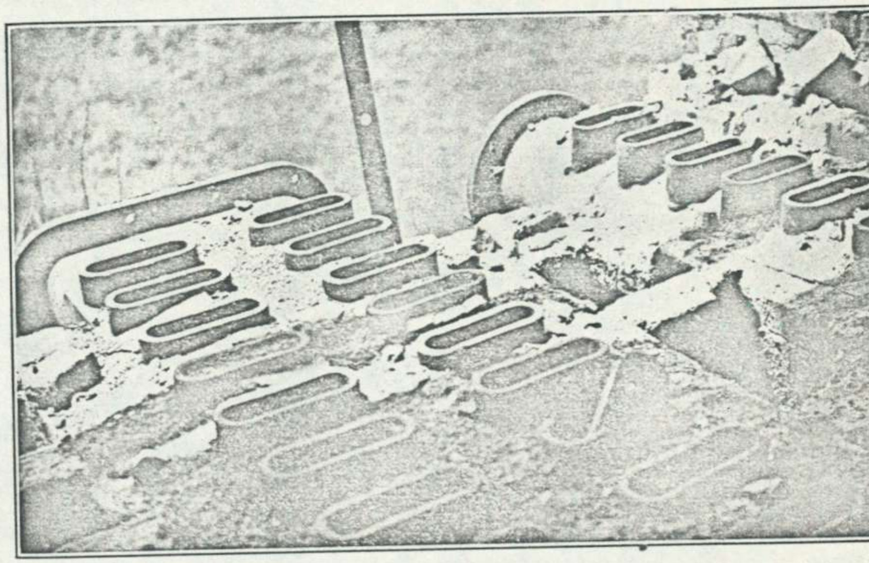
*Charles Upham Shepard:—"Mineralogy of Connecticut". Foot-note on Page 26.



> as it is carried over and over in these siphon pipes, so as to be thoroughly exposed to the heat of the furnace, becomes very hot, and it is estimated that its pressure, as it comes down from the siphon pipes upon the fire, cannot vary much from one pound to the square inch."

At Maltby, the only furnace where there is enough material left to give any sort of an idea of the arrangement, they seem to have been in pairs, the two U's of each pair in series, but the pairs themselves in parallel.

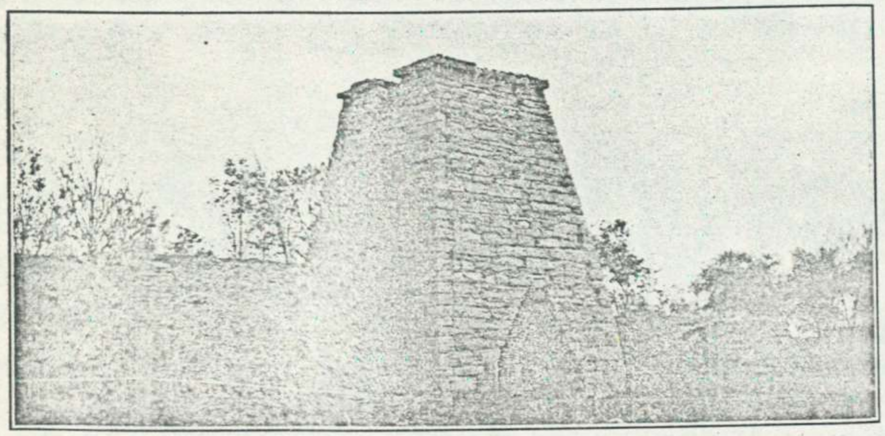
There was another type of oven-pipe used elsewhere, of which no traces were found in the field, nor does there seem to be anything on



Maltby furnace manifolds in oven floor. Note flue openings between, up which hot gases came.

record to indicate that the "pistol-pipes" — so called because they looked something like enormous single-barrelled pistols — were employed in this district, except for the possibility that the mention in the Proceedings of the United States Charcoal Iron Workers Association of "web" pipes used at Kent may have referred to them. These pipes were like a "J" inverted, with the end of the hook closed, and a partition — which might well have been called a web — extending almost to that end, the blast going up on one side and returning on the other. Whether the base of the pipe forked, and there was a nipple for each of the branches, or whether a single nipple had a partition which matched with the one in the "pistol" and was continued through the bed pipe could not be discovered. Bolles' description of the oven pipes at Kent as "curved like an ox-bow" would seem to indicate that at that time — 1887 — Kent had U pipes, and as this was just about the same time as the other reference it is probable that "web-pipes" were not the same as "pistol-pipes", but there was nothing to indicate what else they may have been.

The Maltby oven, seated on top of the stack, was of brick, 9 feet square, 8 feet high to the springing-line of the semi-cylindrical top, and 12½ feet high at the crown of the arch. Bedded in the floor, parallel to the axis of the top, were 3 cast iron manifolds, the two outer ones round, 10 inches inside diameter, each having on its top, with their long axes at right angles to the axis of the manifold, 15 oval nipples,



Beekman steam-blown furnace with top of oven on ground just showing at left.

spaced 6½ inches center to center, each 2⅜ inches high, 8 inches long, and 3¼ inches wide, over all. The middle manifold, 21½ inches wide by 10½ inches deep inside, had two such rows of nipples, 14 inches center to center of rows, while from center of outside row to center of nearest side manifold was 32 inches. The pipes — though none were found at Maltby — probably had bell-and-spigot joints, as did the fragment of an oven pipe found in the brook at Macedonia, and if the U's, 32 inches center to center of legs, had the same clearance at the top that they had at the side wall, they were between 10 and 11 feet high.

A damper in a duct leading also to the boiler, when opened, allowed the hot gases to go first into two large transverse arched passages under the oven floor, then into three similar but smaller ducts parallel to the manifolds, and finally through a series of holes in the bottom between the manifolds, into the oven, where, after circulating around the pipes, they went out a hole in the top to a chimney with a top damper. The blast apparently went first into both ends of one of the side manifolds, then through one set of U's to the center manifold which served merely as a receiver, then to the other side manifold by way of the other set of U's, and then, heated, passed out at both ends of this last manifold into two downtakes which went to the side tuyeres, the bustle-pipe, with the dropper for the rear tuyere at its mid-point, being connected to both of these down-takes.



The remains of the ovens are but little less scanty than those of the blowing apparatus. At Maltby and at Kent they were on top of the stack, but apparently having the oven on the ground, as at the Beekman, New York, steam-blown furnace, was not uncommon practice, for Bolles, in his article on the Kent furnace, speaking of the oven, says:—

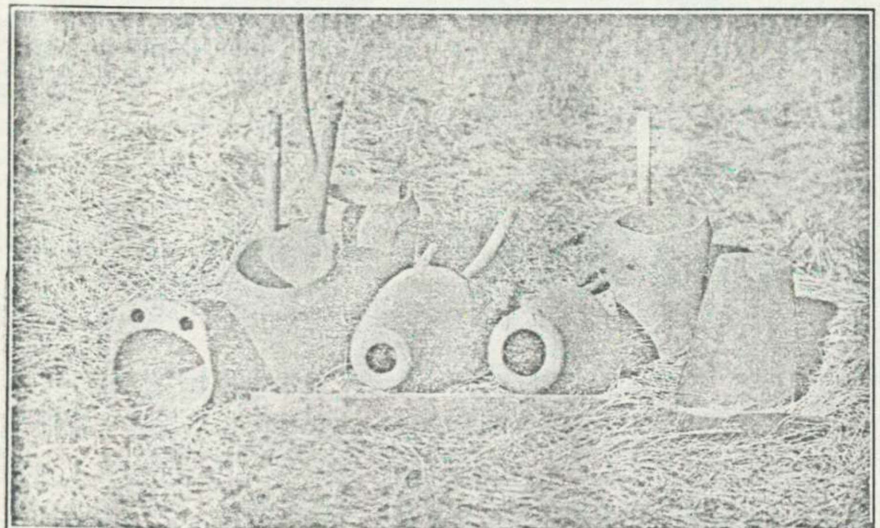
> "The latter is placed on top of the stack instead of to one side of it, as is the rule in many iron works."

Whether the stoves were stripped of their piping as soon as they went out of service because at the time there was a good market for cast iron scrap, and in the wreckers' zeal the ovens themselves were destroyed, or whether there was some less obvious happening, the fact remains that except at Maltby, Beekman and Kent, not a trace of an oven could be found, nor, if we except a bit of oven-pipe discovered in the brook at Macedonia, of any fittings.

## The Water-Cooling System

Starting with a so-called "hot" blast of but about 250 degrees Fahrenheit, the temperature was gradually raised to enable the furnaces to meet the demand for greater production, until the blast was leaving the oven at 900 degrees or even a little higher. Long before this latter stage was reached, however, the tin, and in some cases wooden, piping, which had served for the low-pressure cold blast, had given place to cast iron, and for the old clay nozzles had been substituted water-cooled tuyeres. These latter, a foot in length, 6 inches in diameter at the nose, and 9 inches diameter at the rear, had nose openings varying from 2⅞ inches inside diameter to 3⅜ inches, increasing to 4 or 5 inches diameter at the back, to receive the forward end of the blow-pipe. Cooling was effected by circulating water either through passages cast in the walls, in the Lancashire type, or, in the Scotch type, through a coil of pipe around which the tuyere was cast. Maltby had Lancashire tuyeres; Macedonia, Scotch. The outlet discharged into an open cup on top of a vertical drain pipe, so it could be seen at a glance whether or not the circulation was all right.

The success of the water-cooled tuyeres led to the replacement of the massive stone hearth by water-cooled segmental iron plates held together to form a cylinder by iron clamping rings, and lined with a single course of fire-brick. A number of the old furnaces did not make this change, but Canaan No. 3 was built with a water-cooled

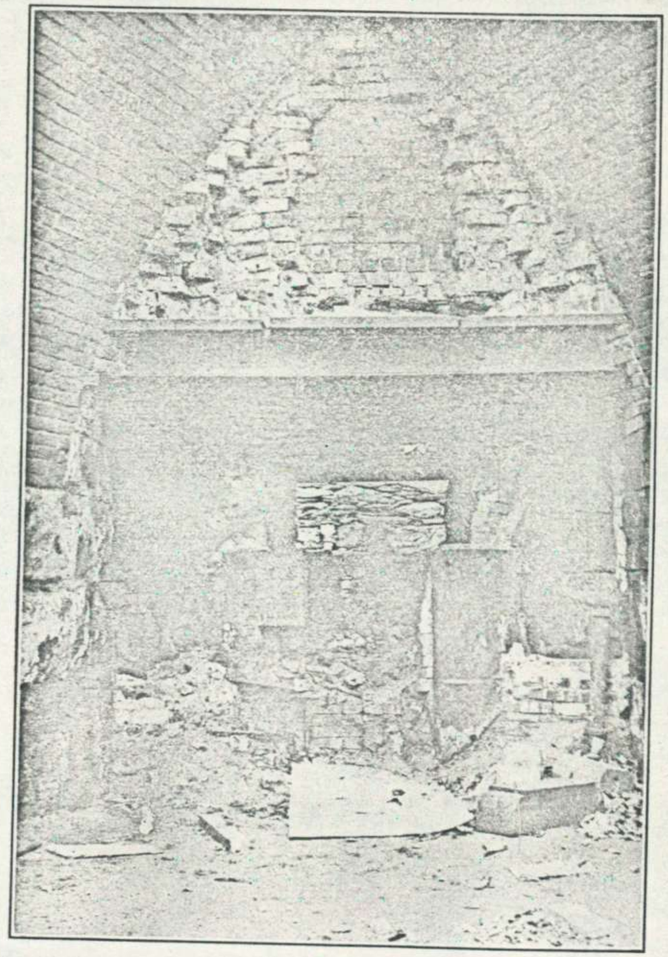


Lancashire type water-cooled tuyeres, Maltby furnace.

hearth, and Richmond, Copake — always in the fore-front in progressiveness, — and Maltby were among those which made the substitution. Today, at Canaan and at Richmond only a little of the piping remains, but at Copake and at Maltby both piping and hearth are in fair condition. As with the tuyeres, some of the hearth-plates had water-passages, and others cast-in piping, through which the water circulated, and similarly, an open discharge served as a tell-tale. At many furnaces the fore-hearth had already disappeared, tapping-hole and cinder-notch being pierced through the hearth walls. With the advent of the water-cooled hearth, the cinder-notch was also water-cooled; the tapping-



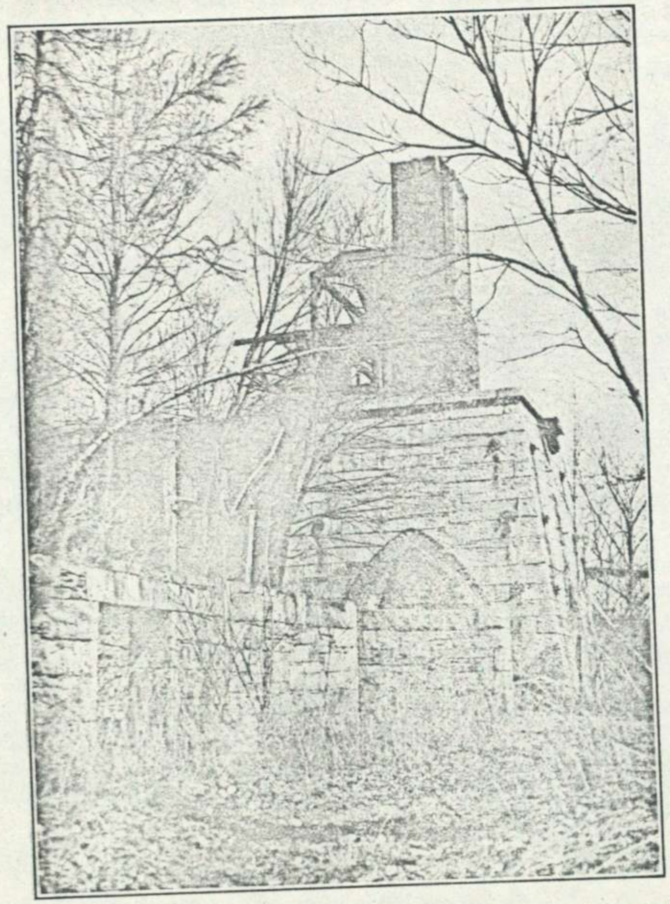
hole, however, was built in fire-brick, the probability of a serious explosion in case of leakage into the molten iron, making water-cooling of the tapping-hole too dangerous a proceeding.



Fore-arch of Copake furnace. Note water cooled hearth and bosh plates, also, right and left, the tell-tale cups for watching the circulation.

## The Outer Appearance

With these other developments came changes in the external appearance of the stack. The ragged dry rubble pile, with its timber-and-tie-rod binding system, and its irregular archways, characteristic of Mt. Riga and of Joyceville, gave place to stacks, first of rubble in mortar, as at Maltby, and then of various grades of ashlar, the Sharparoon Lake stack at Dover Furnace, and the Roxbury furnace being good examples of the best work. Copake, another example of fine facing, was robbed of its cut stone by "progressive" Tri-State Park authorities to make a brook retaining wall.



Roxbury furnace. Note fine ashlar masonry, brick arches, and heavy wall plates at ends of tie rods.

These stacks all had tie-rods through the masonry, as had their predecessors, but the wedges in the slotted ends, instead of bearing against wooden beams, were seated on massive round, square or diamond shaped cast iron wall-plates, often heavily ribbed for reinforcement. To facilitate operations the archways, especially the front one, were materially increased in size, and instead of the ragged openings, these



were now Gothic arches in brick, with the masonry neatly fitted to them. At Bulls Falls, and the unfinished Dover stack, an arched narrow passageway through the masonry connected side and rear archways, so the operatives could pass from one to the other without the necessity of going outside and around.

?

WHITE'S DOVER

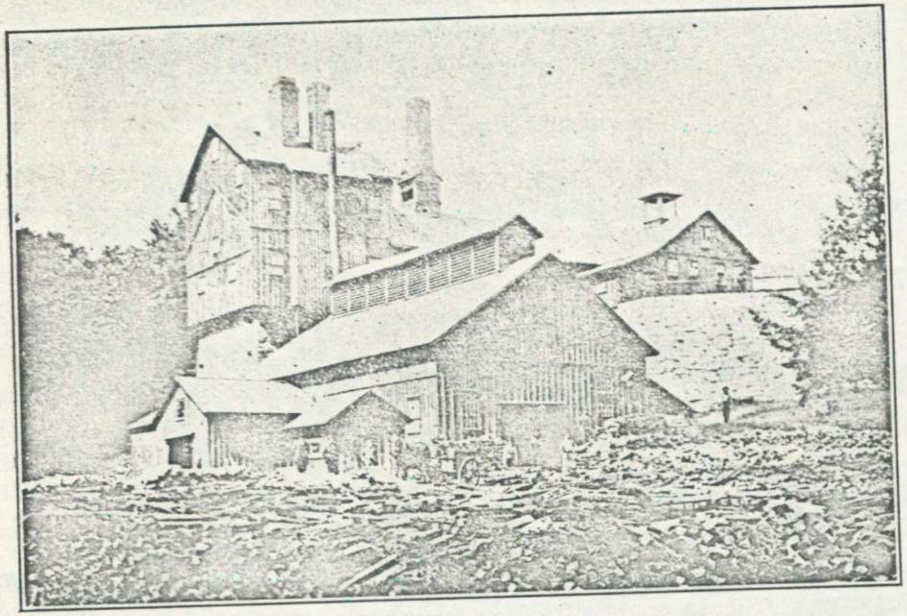
There still remained considerable modesty as to the boshes; the portion at the end of the archway was concealed by one or more curtain walls, stepped back, if there were more than one, as the slope of the boshes drew inward. These curtain walls rested on cast iron lintels, some square, others of I section, while at the Bulls Falls stack there were two semi-circular girders of tee section, 4 inches wide across the flange, 8 inches deep, and spanning 9 feet in the clear.

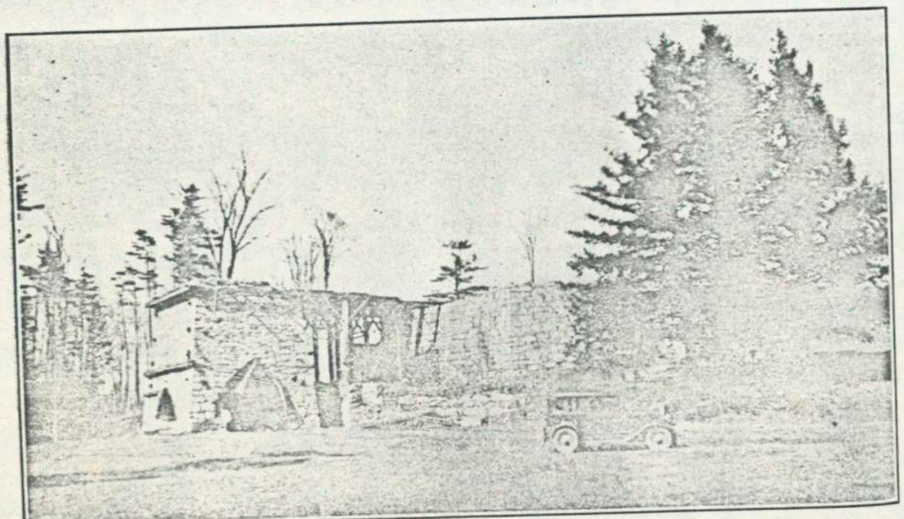
It was being realized, too, that reasonable protection for the workmen, instead of making them "soft", resulted in better efficiency. Putting tuyeres on three sides of the furnace had made it necessary to move the stack out from the bank into which the early ones had been built, in turn requiring a bridge to span the gap so that the stock could still be kept approximately on a level with the charging floor. Gradually the sheds on the bank had been extended onto the trestle, and when there began to be diversion of the tunnel-head gases this shelter was carried out to the stack and enlarged, as a "top-house", until it took at least two good looks to determine where the furnace itself was located. The casting-house had become a closed structure; the forehearth, reduced little by little, had finally completely disappeared, tapping-hole and cinder-notch being pierced in the walls of the hearth itself; and a great iron hood, with a chimney from it carried well above the top-house, took off such fumes and gases as escaped when the furnace was tapped off.

Elsewhere than in this territory there was a growing tendency to strip the lining of its bulky outside covering, and rely on radiation and various types of cooling devices to keep the thin walls of refractory brick from burning through, but the Salisbury district apparently did not get beyond the stage of the completely exposed and water-cooled hearth.

## Furnace Operation and Control

Starting the blast furnace, — "blowing in" — was rather more of an undertaking than it might seem at first thought. The massive character of the structure, and the poor conductivity of the materials of which it was built, made it essential that the fire should be brought up to full intensity gradually, to prevent uneven expansion and consequent





Richmond furnace; views from practically the same point; upper about 1870; lower, 1934.
Man in door of casting house, top view, is Mr. Alfred Perdrizet, who kindly loaned the
picture. Round pipe at other end of casting house came from hood seen in acr way in
lower view. Notice in upper cut how the stack is housed in.



injury. The stack first was filled with charcoal, which was lit at the top, and then, only fuel being charged, the fire was allowed to burn gradually until it had worked down to the tuyeres. With the furnace full of glowing charcoal, the blast was started, gently at first, gradually increasing to full strength; at the same time ore and flux was charged, also gradually increasing the amount until normal operating conditions were reached. At the end of the run similar care was used in "blowing out"; the "burden", or proportion of ore and flux to the fuel was gradually cut down until finally the ore was replaced with all the old scrap iron about the plant; and when that was melted and tapped off the hearth was opened and what was left inside cleaned out.

The relative amounts of ore, flux and fuel charged were dependent on the compositions of the first two; the amount charged, on the size of the stack. Kent, producing about 14 tons of iron daily, using for the most part Salisbury limonite, charged 1100 to 1400 pounds of ore, 30 bushels (600 pounds) of charcoal, and 250 to 350 pounds of limestone per hour. Oxford, New Jersey, running on magnetite and producing 2 tons of iron per day, charged 175 pounds of ore, 210 pounds — 10½ bushels — of charcoal, and 50 pounds of limestone per hour. In percentages, Kent charged 58 per cent ore, 28 per cent fuel and 14 per cent flux; for Oxford, the respective figures were 40 per cent, 48 per cent, and 12 per cent. In terms of ore, Kent used 48 per cent fuel and 24 per cent flux; Oxford 120 per cent fuel and 29 per cent flux.

At first the charge was measured with comparatively little accuracy; the materials were shovelled into boxes and baskets, and the personal equation had not a little to do with how well they were filled, for they were carried and dumped, by hand. Later, when scales had been introduced, and the materials were weighed, wheelbarrows were employed, and were unloaded by bumping them violently against a stop-log just in front of the throat. The charge, shooting to the far side, tended to segregate, the fines forming an incline where they had landed, while the larger material, rolling down this, went to the opposite side. In consequence the working was very uneven, the heavy resistance of the fines, on their side, all but stopping the blast, which, on the other hand, blew too freely through the lumps. Frequent levelling off the top helped somewhat, but at best the results were not good.

The next improvement was the use of a tube or "tremie", extending from the top down nearly to the stock-line. This was better, but it still had the disadvantage that the fine material piled up directly under the tube, while the coarse rolled to the in-walls, forming there an easy passage for the blast, but leaving the center choked. To obviate this the tremie was replaced by an iron cone, hung, point up, a little above the stock-line. The charge, dumped on this "bell", was automatically thrown to the sides, where the fines stayed, the lumps rolling down and to the center, where it was desirable that the resistance should be least. This took care of the distribution, but by this time the pressure of the blast had been increased to a point that made it necessary to stop it during charging, to protect the men from gas. The final step was to restore the tube and use with it a moveable bell which could be drawn up tightly against the bottom of the former. In that position the top could be opened and the tube filled without serious gas escape; the top was then closed and the bell lowered, when the charge flowed over its sides to the sides of the stack. It is not clear how far the Salisbury furnaces went in this matter. Lesley, — 1859 — says that Copake:—

> "uses a cone or 'tremie' let down 4 feet into the tunnel head."

and that Northeast, at Millerton, New York:—

> "uses a cone (tremie) 3 feet deep."

The Beekman steam furnace is said to have had an automatic charging system, the cars, hoisted by a small engine, dumping themselves into a hopper at the top, and it naturally would be expected that there was an equally up-to-date system for completing the stock disposition. The large majority of the Salisbury stacks, however, had bridges from ground at practically the same level as the charging floor, in turn implying wheel-barrow or cart handling.

The iron-master controlled the output of his furnace in several ways. By a choice of ores and suitable proportioning, he could get a mixture which lent itself to further treatment; then, by varying the temperature in the hearth, by changing the proportion of fuel to that of ore and flux, and by varying the proportion of flux to ore, and so varying the composition of the slag, he was able to control to a very considerable extent the composition of the iron itself. The higher the working temperature, the more powerful the deoxidizing action of the furnace, and the more silicon, manganese and phosphorous reduced to be taken up by the iron; also the stronger the tendency for iron sulphide, rather than go into the iron, to become calcium sulphide and go off in the slag, particularly if the latter was rich in lime, or "basic"; this tended to produce gray iron, for the higher the silicon content of the iron, the greater the tendency of some of the carbon to become graphite; sulphur in the iron, on the contrary, opposes the formation of graphite, and so tends to produce white iron.



The hearth temperature was raised by one or more of three methods; —by:—

1. Reducing the burden — the proportion of ore and flux to fuel.
2. Making the slag more basic, that is, richer in lime. This raised the fusion point of the slag, and so held the iron subject for a longer time to the high temperature.
3. Raising the blast temperature. Obviously, with cold blast this was not possible.

Of these, the third gave the quickest results, but frequently the conditions which made it desirable to raise the hearth temperature also caused very lean furnace gas, and in such cases, unless there was some auxiliary means of getting the desired heat, the scheme could not be employed. Reducing the burden, or increasing the lime content of the slag took more time because of the slow downward movement of the charge, but the higher proportion of fuel or limestone tended to make a coarser mixture, and by cutting down the resistance to the blast a quicker reaction was had than would naturally be expected.

Until the chemist became one of the furnace's regular staff, and a laboratory part of the equipment — and with many of these furnaces that time never was reached — how the stack was "running", that is, what kind of iron it was producing, was determined in advance of tapping off, and with remarkable accuracy too, by the appearance of the fire through the tuyere peep-holes, by the consistency of the melted slag as it flowed over the cinder-notch, and by its appearance after it had cooled. Regarding the latter, Turner* says:—

> "With an excess of lime, as is usual for the production of an open grain iron, such, for instance, as a No. 1 grade, the slag is difficulty fusible, and when solidified, is white in colour, light, and soft in texture, and when it comes in contact with water it readily slakes. With intermediate grades, such as No. 4, the slag is more hard and compact, and usually has a grey colour, with more or less of a greenish or bluish shade, caused by a small quantity of ferrous oxide, and probably also by sulphide of manganese. It is this class of slag which is chiefly employed for road metal, and for the production of slag bricks; not infrequently also definite crystals are met with in these slags. When the furnace is making white iron, the slag produced is dark in colour and very fluid; it contains unreduced iron in the form of ferrous oxide, and on account of its great fluidity, when

*Thomas Turner:—"The Metallurgy of Iron." Page 175.

melted, and its power of attacking the furnace lining, is known as a "scouring slag".

## The Charcoal Iron Grades

Charcoal iron from the Salisbury district was graded in 7 steps. An anonymous writer in Railroad Gazette*, speaking of Salisbury iron as of 1877, and with particular reference to the product of the Barnum-Richardson Company, said:—

"This iron is graded as Nos. 1, 2, 3, 4, 4½, 5 and 6. No. 1 is the softest grade, of which very little is made. It will not chill, and is used for cheap ordinary castings. No. 2 is the softest or lowest grade which is produced in any quantity. It will not chill, and is used for making malleable castings in air furnaces, and is mixed with old wheels and hard high grades of iron for car wheels. No. 3 is a somewhat harder iron and will chill slightly in the tread of a wheel, and is much used with harder iron in the manufacture of car wheels. No. 4 is a still harder iron and will chill about ⅛ inch deep in the tread of car wheels. No. 4½ is much used for malleable castings in cupola furnaces and also for car wheels, mixed with lower grades or softer iron. It will chill about ¾ inch deep. No. 5 mottled, and No. 6, white, iron are both very hard and will chill to almost any desired depth. In fact, No. 6 has the character of chilled iron all through. These grades are used with softer iron for wheels, and also for chilled rolls.

Nos. 2 and 5 are also used a great deal for making plow castings; the harder iron is mixed with that of the lower grade to give the latter the requisite hardness. By using two different grades of iron, the manufacturer is able to modify and control the quality of the castings as may be required, getting the tensile strength by the use of the softer iron, and the hardness with the high iron, whereas if but one kind was used, there would be no means of making castings of any other quality than that produced by the grade of iron used.

The quality or grade of the iron produced depends largely upon the temperature of the furnace at the time it was manufactured, somewhat upon the ore used, and also on the state of the weather, and probably on some other causes not fully understood. When the furnace is running cold it produces hard or high grades of iron, and softer irons are produced by a high grade of temperature. When it

*Railroad Gazette.—"Salisbury Iron". November 23, 1877. Page 515.



is desired to produce hard iron, therefore, an increased amount of iron is added with a given amount of fuel, or if soft iron is required less ore is charged.

When the iron is cast into pigs several test pieces are made, which are then broken, and from an inspection of these, and also from a careful examination of the pigs themselves, the grade or number of the iron is determined."

It will be noted that at that date — 1877 — nothing is said regarding any chemical analysis. Inspection was of the color of the fresh fracture, and of the grain, the gray iron having a very coarse crystalline structure, becoming finer as the iron became harder. The "chill", the sudden cooling by casting in iron moulds — or, for test, on an iron plate — caused the graphitic carbon mechanically mixed with the iron so treated to go into chemical combination at the surface chilled, thus increasing its hardness.

Forty years later, the Salisbury Iron Corporation, successor to the Barnum-Richardson Company, was grading by chemical analysis and composition, which doubtless accounts for the use of the lower grades for more important service than in 1877. Their handbook* gives a table of chemical compositions, together with some comments on the purposes to which each grade is best adapted:—

"The seven standard grades of Salisbury Iron analyze as follows:—

| Number | Silicon % | Manganese % | Sulphur % | Phosphorous % |
|---|---|---|---|---|
| 1 | 1.75 to 3.00 | 0.95 to 1.30 | 0.03 | 0.19 to 0.28 |
| 2 | 1.35 to 1.75 | 0.90 to 1.30 | 0.08 | 0.19 to 0.28 |
| 3 | 0.90 to 1.35 | 0.70 to 1.00 | 0.03 | 0.19 to 0.28 |
| 4 | 0.60 to 1.00 | 0.55 to 0.80 | 0.03 | 0.19 to 0.28 |
| 4½ | 0.50 to 0.60 | 0.45 to 0.55 | 0.03 | 0.19 to 0.28 |
| 5 | 0.35 to 0.50 | 0.25 to 0.45 | 0.03 | 0.19 to 0.28 |
| 6 | Very hard, silvery iron of low silicon and manganese. | | | |

No. 1, 2 and 3 are used for making strong close grain castings as required in machinery and other castings used in hydraulic and steam pressure work. These grades, while close grained and strong, are soft enough to machine easily. A 25 per cent mix of No. 2 with ordinary charcoal iron will produce a good even chill for rolls.

No. 4 is used in the highest grade chilled work in rolls, special car

*Dr. Richard Moldenke: — "Charcoal Iron". Page 61.

wheels and dies. This grade is especially valuable in making heavy machinery requiring the utmost resistance to constant vibration.

No. 4½, 5 and 6 are special use irons adapted to mixture control, particularly for air furnace practice. Both No. 5 and 6 are very hard and will chill to almost any required depth.

Every cast of Salisbury Iron is numbered, analyzed and graded with the utmost care."

It took comparatively little experience to teach the difference between the extremes; on the one hand, the brilliant incandescence of the fire and the hot sluggish-flowing slag that spelled gray iron, and, on the other hand, the comparatively dull fire and the very fluid slag accompanying white iron; but to distinguish, as could many of the old furnace-men, almost between the individual grades while the iron was in the making, was a somewhat different matter. Not only could many of the experienced men predict most accurately what the next cast would be; once any trouble that had interfered with the output had been cleared up, it was astonishing how little "off-iron" was run before the stack was brought back to the grade on which it had been working.

## Furnace Mishaps

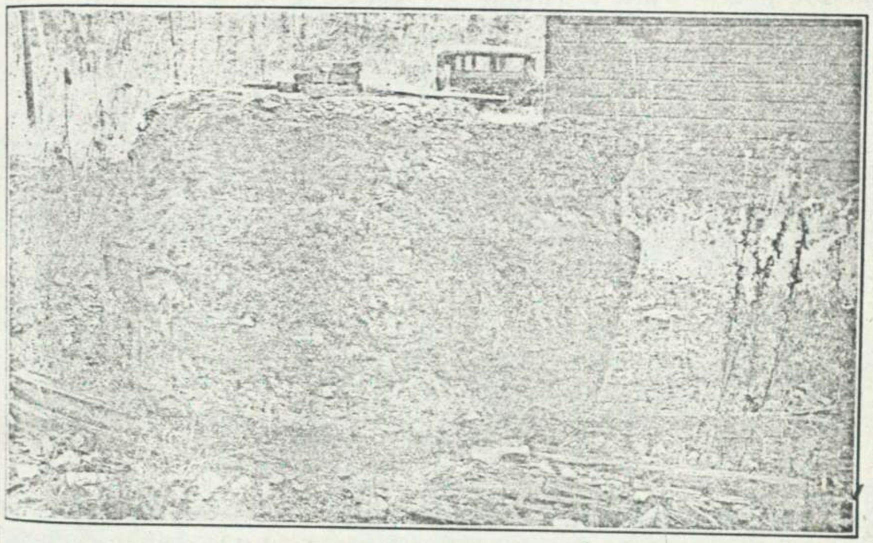
The rate of descent of the stock, as shown at the top of the furnace, was one of the most important signs in the operation of the latter, any irregularity indicating some sort of obstruction farther down. The outward flare of the "inwalls" or sides of the shaft, was supposedly such as would prevent any choking from the swelling of the ore which occurred as it was reduced, but too often material wedged itself from side to side in an arch or "bridge", thus "hanging up" the portion of the charge above it. If the obstruction was not too bad it sometimes could be started by "jumping", or stopping and starting, the blast suddenly, for even with a pressure of but half a pound to the square inch, under normal conditions its sudden stop was equivalent to loading the "arch" with at least an additional ton of weight.

If the obstruction was near the top it often could be broken down by ramming it with a long iron bar driven through from above, but if it did not at once yield, more radical measures had to be taken, and that right speedily, for below it there was a steadily growing open space, to make the blow from its drop when it did release, increasingly dangerous. At the same time, if the temperature of the lower mass was not kept fairly high there was the danger that it might solidify, or "freeze", which usually meant the destruction of at least the hearth, and might



as in one classic case, result in the abandonment of the entire furnace, its interior a hopeless mass of solidified slag and iron.

Failing to break down an arch from above, the next step was to empty the hearth as far as practicable, and then, if it could not be got at from one of the tuyere openings, cut a hole in the side of the stack and attack it with drills, with blasting powder, or even with dynamite. In the early days a sovereign remedy for a bad bridge was to break out the hearth, clear out everything that could be withdrawn, and then literally shoot it down, using a small mortar and solid shot. With the commercial production of kerosene and other petroleum products, the oil blow-pipe proved a most valuable substitute for the blasting, which



Great salamander from Richmond furnace. Note prints of two tuyeres which were blocked by it.

always was a serious menace to the stack itself. Thrust through a hole just below the obstruction, a good blow-pipe could melt out any but the most obstinate of blocks.

A consequence of a hang-up often having very serious consequences were the slips which occurred when the obstruction yielded. Frequently these did nothing more than cause an outburst of gas or "explosion" at the tunnel head, although if the latter offered too much resistance, and part came out at the throat, it made matters decidedly unpleasant on the charging floor. A severe slip, however, was apt to shake the stack to at least an undesirable extent, and if it brought up low down it sometimes burst through bosh walls or hearth, or forced a sudden out-flow of slag and iron from the fore-hearth of an open-front furnace, not infrequently causing serious injury or death to the men about it.

A minor slip, forcing a comparatively small amount of unfused material below the level of the blast, usually did little mischief, as the molten iron and slag there promptly dissolved the mass. Little by little, however, material, associated with the ore and infusible at the furnace temperature, tended to gather at the bottom of the hearth. As a rule, in an entire season the collection was not large enough to cause trouble, and the "salamander", or "bear", as it was variously called, was readily removed after the stack had been blown out. If, however, a large amount of the unfused charge was forced down into the hearth, or if, by reason of some accident, the hearth itself became chilled, there was the possibility of that nightmare of the iron-master, a frozen hearth. At Richmond Furnace stack there is mute witness to such a tragedy; a salamander which filled the hearth to a point somewhat above the tuyeres, and as there are clear prints of the noses of four of the five nozzles, it is evident that in this case the blast was nearly if not quite shut off. Another great salamander lies in a hole in front of the Beekman steam-blown stack; and at almost every furnace small "bears" can be found. A mishap related to the salamander, usually the result of a breakdown of the cooling system, was the "gobbing up" of a tuyere by partly melted material which fused on to the nose and closed it; a fine example of this form of trouble was found in the brook at the Macedonia furnace, a tuyere hopelessly fused into a mass of slag and iron.

## Casting

In the early days the fore-hearth was a storage reservoir to hold the molten iron, not only until there should be enough to fill the pig bed, but also to permit the casting of kettles, fire-backs, stoves and similar articles, the iron being dipped out with small ladles, and poured into moulds made on the casting floor, between the pig-bed and the portion used to receive the slag; not until the cupola had come into general use for casting was this practice entirely abandoned.

The pig-bed consisted of a layer of some kind of sand carrying enough loam or clay so that it would hold a sharp edge when slightly damp, but not enough to have it bake to tile with the heat of the molten iron. It was prepared either by using patterns, or by excavating. In the first case much of the sand was shovelled to one side, leaving a level layer at least 3 or 4 inches deep, on which were laid down the patterns for the "pigs" and the "sows"; the rest of the sand was then shovelled back over them and rammed down to the level of the tops of the patterns, after



which the latter were carefully withdrawn. The use of patterns was practically a necessity if, as was often the case, the pigs were to be "branded", that is, to have, in raised letters on their backs, the name of the furnace where they were cast. This was done in New Jersey by the Andover and the Speedwell furnaces*, and a cast iron bar from the Livingstone furnace at Ancram, New York, now used as a hitching post by Mr. H. Van Valkenburgh of Ancram, has on it "N. York (an anchor) 1793", but no branded pigs from any of the Salisbury furnaces have as yet been seen.

If no patterns were to be used, the entire amount of sand was leveled and rammed, after which the forms were dug in it. In either case the finished bed was full of grooves like a series of great rakes, the teeth being the moulds for the pigs, the backs those for the sows, while a still larger trench, the "main runner", connected with one end of each sow and ran up to the tapping hole. A sand dam was placed in the main runner just beyond each sow; when the litter nearest the furnace was poured its dam was removed, allowing the next to fill, and so to the end. The tapping hole was opened by drilling out its fire-clay plug, and the iron was allowed to flow until the escape of the blast showed that the hearth was practically empty. The early small tapping holes were stopped as soon as the furnace "blew", — that is, the blast began to escape at this point, — by a ball of fireclay on the end of a stout stick, with which it was rammed into the hole and then followed up with several other balls until the hole was filled. Later, the larger amount of iron to a "cast" made it necessary to have a tapping hole too big to be stopped this way, and there were developed "mud-guns" consisting of a magazine of clay balls, and a power device to force them home, the gun being held by several men at first, and later swung from a crane.

An interesting fact about the sand-cast pigs, now largely forgotten because today pigs are for the most part machine cast, is that while everything else about the furnace was weighed in gross tons of 2240 pounds each, they had a ton of their own, of 2268 pounds, the extra 28 pounds being an allowance for adhering sand.

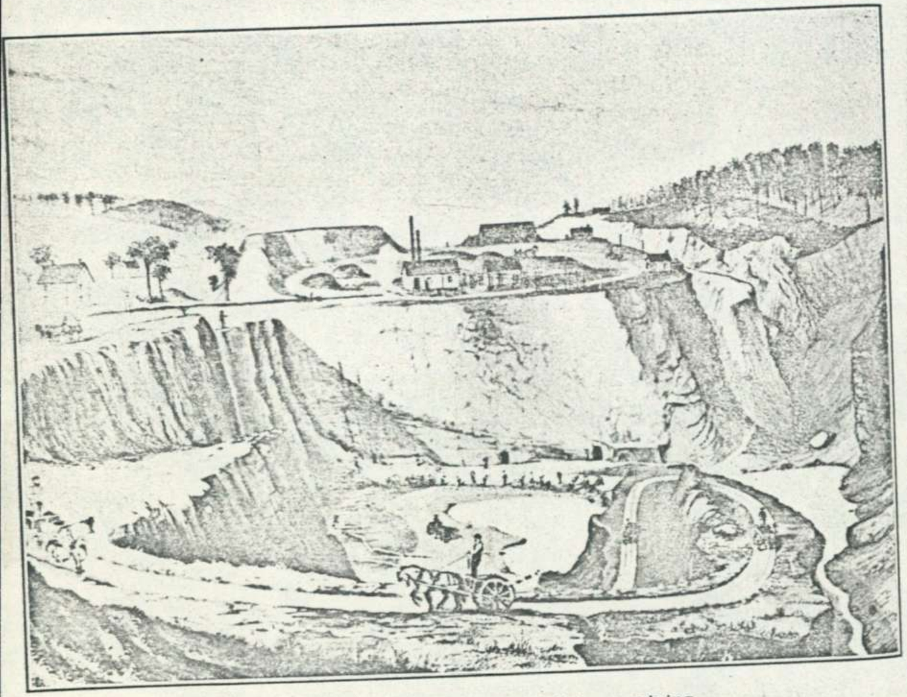
## The Mines

Until the use of the furnace gas made it commercially practicable to employ steam blowing engines in the Salisbury district, the ruling consideration in the location of a furnace was the water-power; and the other elements, because there was no shortage of fuel, ore or flux, nor

*Charles S. Boyer:—"Early Forges and Furnaces in New Jersey."

lack of market, played comparatively little part. Wherever practicable the ore was obtained from a mine on the road to the probable chief market, so the wagons which teamed the finished product could come back with the ore. This was the reason for some of the connections between mines and furnaces which today seem rather peculiar, as, for example, the fact that Bulls Falls, Kent and Macedonia used so much ore from the Clove and Quaker Hill beds, the answer being that they were on teaming roads to Poughkeepsie.

For a long time the mining was by open cut, the excavated ore being



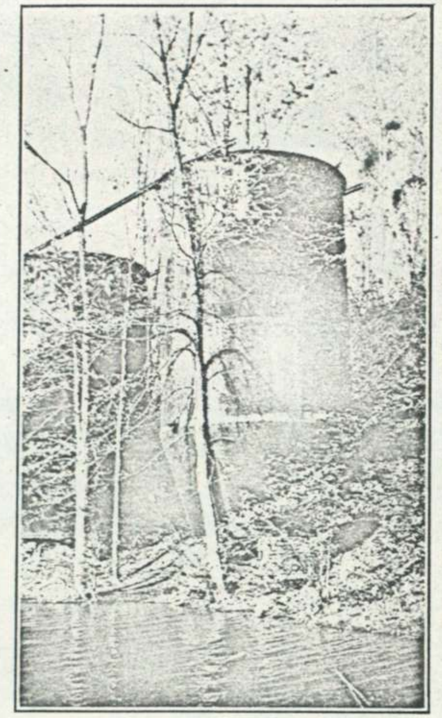
Pen-and-ink sketch showing Salisbury mining.
Note drifts at floor level in back wall.
Courtesy Mr. Malcolm D. Rudd

drawn out by teams, up roads cork-screwed to reduce the grade; a pen-and-ink drawing in the possession of Mr. Malcolm D. Rudd of Lakeville, to whose courtesy we are indebted for the privilege of reproducing it, giving a very good illustration of how it was done.

Later, cable-hauled drag-scrapers were used as long as they could be operated economically, and then the ore was followed by shafts and drifts, the little cars used underground being either dumped into larger ones which were then hauled to the top, or coupled into trains, to be



similarly drawn up. Many of the workings were deep and extensive; Mr. Edward Buchanan Manning, for many years in charge at Maltby, said that the open pit work at that bed was carried nearly 100 feet below the general surface, and that the shafts went down below the pit floor at least as much further. In some cases, particularly in Massachusetts, steep inclined railways were employed, the cars being hoisted up by cable. There is very little left at any of these mines except the hole, barring that one at Boston Corners, New York, where the old incline, the head-house, and a crusher still stand in ruins.



Ore roaster, Amenia mine.

There was not a great deal of water to contend with, as a rule, and drainage was one of the lesser troubles, but in the time that has elapsed since the pumps stopped, the water has accumulated until today almost every pit has become a lake, Indian Pond mine being the only exception among the limonite beds. The Roxbury siderite mine was entirely shaft and drift work, and while, due to the fact that some of the workings descend as they go in they are flooded, it still is possible to go through much of the work.

The ore had comparatively little treatment before smelting. It was crushed to a fairly small size and washed, sometimes at the mine, and sometimes at the furnace, the ore going from the crusher in a stream of water through either flat or rotary screens which separated it into two groups, the pieces much above an inch in diameter going back to be broken smaller.

Comparatively few of the mines or furnaces roasted the ore. The great Amenia pit had a battery of three vertical cylindrical roasters of boiler iron lined with fire-brick; West Cornwall passed its hot gases through piles of ore in its yard; while Roxbury roasted its siderite in a pair of square masonry kilns.

In the earliest days the ore was carried from mine to forge or furnace in saddle-bags, on the backs of horses or mules; later, carts were used, and Atwater* says, of the Bulls Falls Iron Works:—

> "The majority of the iron was taken in two and four horse teams to Poughkeepsie, thirty miles away, where it was probably shipped down the Hudson to New York, the teams going one day and returning the next, stopping at Quaker Hill for a load of ore. This, when it arrived was weighed in a very primitive way. Chains would be placed around the axles near the wheels, large steelyards would be put in place, and the load would be drawn up on a windlass. Twenty to twenty-five teams were kept in constant use and from fifteen to twenty tons of iron was put into pigs daily."

The advent of the railroad greatly simplified matters in some ways, but deprived some of the smaller, less efficiently operated mines of the advantage their location had given them, and in a number of cases caused their abandonment. On the other hand, some of the Salisbury mines were able to ship ore to Pennsylvania for a time after their home market was gone. This was the case at the Maltby mine; the furnace went out of blast about 1884, but the Thomas Iron Company operated the mine until 1893, sending the ore to their plant at Hokendauqua, Pennsylvania, near Allentown.

## The Length of "Blast"

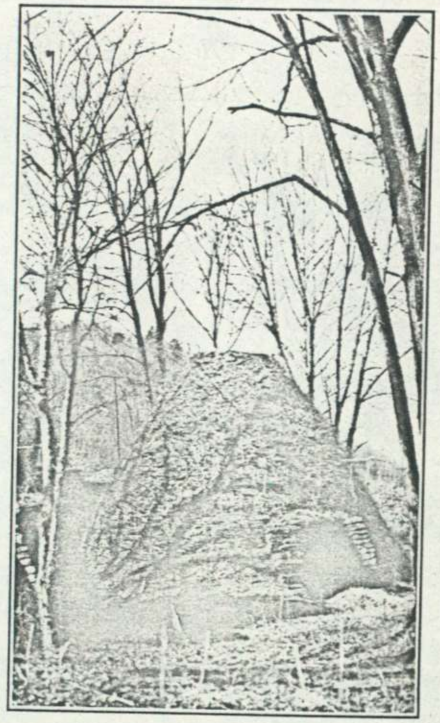
The earlier furnaces ran but a short blast. With little radiation the lining became exceedingly hot, and this, coupled with the lack of any real refractories, combined to make its life but a few weeks. Better lines and construction increased this period, but for many years every-

*Francis Atwater:—"History of Kent, Connecticut." Page 82.



thing was at a standstill throughout the winter. Birkinbine* says:—

> As most of the blast furnaces were located in a section of the country where winter interfered with outdoor work, and as their construction was such that the interior was rapidly destroyed, the practice of making one "blast" every year was followed. Wood would be cut during the winter, and as soon as the weather permitted of doing so, hearths would be leveled among the cut timber, wood would be hauled to these hearths, and there piled into meilers



Charcoal kiln, Wassaic.

> covered with loam and earth and fired. After about two weeks of carbonization the charcoal would be drawn, and hauled by wagons to the furnace. When a sufficient quantity of charcoal had accumulated to insure regular supply, the furnace was blown in, and except for some accident, low stage of water, or other disturbing cause, it would be continued in blast until all the charcoal which had been

*John Birkinbine:—"American Blast Furnace Progress" in "Mineral Resources of the United States, 1883 and 1884". Pages 292 - 293.

made in the coaling season was consumed. This generally permitted the furnace to be active eight or nine months in each year."

Eventually the housing-in of the stacks, and the construction of great charcoal sheds made all-the-year operation possible. Toward the end of the period of smelting iron in the district, with the local fuel sources largely exhausted, charcoal was brought in from the south by train. Always a menace because of the possibility that the meiler or kiln had not been completely quenched, and that there lingered a spark which only needed a little air to start a glorious fire, there occasionally were cases where trains were involved, and Mr. Alfred Perdrizet of East Canaan, for many years with the Barnum - Richardson Company tells of seeing such a string of burning charcoal cars which came down the grade from the East Canaan railroad station to furnace No. 3 like a great comet, luckily going clear to the end of the side-track and off it into the fields, where it burned out without further damage.


## Acknowledgement

Starting with many pleasant anticipations, the authors have found the investigations necessary for the preparation of these papers of increasing interest as the work has progressed, and they have been particularly pleased with the enthusiasm shown, and the assistance given, by all who have known of their quest.

To Miss Helen Miles and Messrs. Malcolm D. Rudd, Richard Peters, Jr., Lewis Dalrymple Bradbury, S. L. Nicholson, S. L. Eastburn, Charles Hodge, and E. Irvine Rudd the authors are particularly indebted for aid; they only regret that the limits of the paper make it impracticable to also list individually the large number of other persons who so kindly co-operated.

Undertaken as a joint project, it had been expected that the material on Connecticut's iron industry, which had been jointly gathered, would be jointly worked up, but the fact that the senior author first was out of the state for a long time, and is now abroad, has necessitated two papers; it should be clearly borne in mind, however, that while this section of the story bears but one name as author, a great part of the labor of accumulating the facts was done by Mr. Keith.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By the same author:

History of the First Fifty Years of the Connecticut Society Civil Engineers. 1934.
The American Standards Association. Proc. 1934.
Some Engineering Features of the Old Northampton Canal. Proc. 1933.
And others.

# HISTORY

OF

# RUTLAND COUNTY

## VERMONT

*WITH ILLUSTRATIONS AND BIOGRAPHICAL SKETCHES OF SOME OF ITS PROMINENT MEN AND PIONEERS*

EDITED BY

H. P. SMITH AND W. S. RANN

---

SYRACUSE, N. Y.

D. MASON & CO., PUBLISHERS

1886 k

Roach Quarry, Wells and Poultney..roofing
McGrath & Rogers, Wells and Poultney.. "
Temple and Heffernan, Wells .......... "
W. J. Evans (three quarries), Wells..... "
Hugh J. Williams, Pawlet............. "
M. Welch, " ............. "
J. Warren, " ............. "
Norton Brothers (two quarries), Pawlet.. "
H. D. G. Goslin, Pawlet.......... "
Kinnie, Hunt and Co., " .......... "
Jones and Ellis, " .......... "
Robert J. Jones, " .......... "
Vermont Slate Co., " .......... "
H. J. Williams, " .......... "
Roberts and Jones (Tabor Quarry), Pawlet.................................... "
The Brownell Slate and Flagging Co., (four quarries), Pawlet............... "
Warren Slate Co. (two quarries), Pawlet.. "
H. Dillingham, West Pawlet............ "
H. W. Hughes (four quarries), West Pawlet..................................roofing
Rising and Nelson (four quarries), West Pawlet.................................. "
Jones and Griffith, West Pawlet......... "
Lake Bomoseen Slate Co., West Castleton ..........................mill stock
Knapp and Prouty, Poultney... "
W. W. Martin, " ... "
Premium Purple Slate Co., " .....roofing
The Boyce Quarry, " ..... "
Jones, Roberts and Edwards, Poultney, mill stock
Ripley and Stanley, (two quarries), Poultney .......................... "
Captain Wm. H. Jones, Poultney ..... "
Jones and Parry, " .......roofing
Lloyd and Jones, " ....... "
Bolger Brothers, " ....... "
R. Hanger, Blissville .........billiard beds, etc.

A few other quarries are in process of opening, but not yet developed, which promise future profit.

Analysis of slate in Rutland county, Vt., and Washington county, N. Y., by Professor J. Francis Williams, of Rensselaer Polytechnic Institute, Troy, N. Y.:—

| | SEA GREEN. | UNFADING GREEN. | PURPLE. | RED SLATE OF GRANVILLE, N.Y. |
|---|---|---|---|---|
| Silica | 65.02 | 64.71 | 62.37 | 73.93 |
| Protoxide of iron | 5.44 | 5.44 | 4.21 | 1.74 |
| Peroxide of iron | 2.99 | 7.23 | 7.66 | 10.17 |
| Alumina | 16.02 | 7.84 | 13.40 | 5.16 |
| Manganese Oxide | 0.31 | 0.30 | 0.20 | 0.10 |
| *Calcium Carbonate | 1.38 | 3.00 | 2.50 | 1.25 |
| Calcium Sulphate | 1.31 | 1.55 | 0.16 | 1.06 |
| Phosphoric Acid | trace | trace | trace | trace |
| Alkalies (Sodium) | 4.16 | 6.92 | 7.20 | 3.92 |
| Water | 1.37 | 1.38 | 1.50 | 1.24 |
| *Magnesia | 2.00 | 1.63 | 0.90 | 1.43 |

Peroxide of iron is probably the coloring matter. These analyses show that the bulk of slate deposits is made up chiefly of silica and alumina, and was therefore at one time ordinary clay.

## IRON.

Beds of hematite (limonite) iron ore are found in many localities within this county, some of which have been worked, producing a superior quality of what was called "charcoal iron," charcoal being used for fuel in reducing the ores. In close proximity to these ore beds are large deposits of yellow ocher (limonite) which has been and is now being mined for paint material.

An extensive bed of limonite exists in the southeast part of Tinmouth near the north end of Tinmouth Pond, which was successfully worked for about thirty years. This deposit was called the "Chipman Bed." This bed was abandoned some forty years ago, and has not been worked since.

About two miles north of the Chipman Bed is another deposit of ore which was opened and worked seventy-five years ago. This ore was excellent and iron of superior quality was made from it. This bed is now abandoned. There is a deposit of iron ore situated about one mile east of South Wallingford village that has been worked, but is now abandoned. The iron ore was of inferior quality, owing to the large percentage of manganese present. The following is an anaylsis of iron made from this ore, by Prof. Olmstead:—

| | |
|---|---|
| Metallic iron | 88.71 |
| Metallic manganese | 11.28 |
| | 99.99 |

The manganese made the iron hard and brittle.

A furnace for smelting iron was built in Pittsford in the fall of 1791 by Israel Keith, from Easton, Mass. The ore was mostly brought from Chittenden, a distance of about two miles. A good quality of iron was made and found a ready sale. On the 4th of July, 1795, Mr. Keith sold the furnace property to Nathan Gibbs, Cornelius Gibbs, Edward Kingman and Luke Reed; and in 1797 Nathan Gibbs purchased his associates' interests and took upon himself the sole management of it. He enlarged the works and continued the business till about the time of his death in 1824. After the death of Mr. Gibbs the furnace passed into the hands of Andrew Leach, who sold it to Simeon Granger & Sons in 1826.

The furnace was burned in 1827, but was rebuilt soon afterward and the business was conducted by "Simeon Granger & Sons" till the death of the father in 1834, when the two sons, Lyman and Chester, took charge of the works. In 1837 Lyman sold his interest to Edward L. Granger, another brother. C. & E. L. Granger continued the business until the death of the junior member of the firm in 1846, when George W. Hodges was admitted as a member of the firm, and the furnace business was conducted in the name of "Granger, Hodges & Co." till 1852.

After a partial suspension of business a stock company was formed and incorporated by an act of the General Assembly as the "Pittsford Iron Company." This company did a brisk business for a short time, but soon suspended, not being able to compete with other companies elsewhere possessing superior facilities for the manufacture of iron.

In 1865 the name of the company was changed to the "Vermont Iron Company," which was composed of entirely new members, who repaired the furnace and again put it in operation; but it was found to be an unprofitable business, and consequently was again suspended, and has remained so to the present time.

Iron was discovered in Brandon in 1810 and soon after a forge was built and bar iron of superior quality was manufactured for several years. In 1820 John Conant, esq., built a furnace for reducing the ore. It is to the energy and enterprise of Mr. Conant that Brandon is indebted for an impetus then given to its business which added materially to its growth and prosperity.

In 1850 the furnace property, ore beds, kaolin mines, etc., were purchased by the "Brandon Car Wheel Company," who for a number of years manufactured a superior quality of cold blast charcoal iron. The iron furnace has not been in operation for a number of years.

Three miles northeast of the Granger furnace, not far from the west line of Chittenden, are beds of limonite. That known as the "Mitchel Bed" has been worked quite extensively and the greater portion has been of excellent quality. The Mitchel Bed furnished much of the ore for the Granger furnace.

The yellow ocher (limnite), kaolin and manganese (psilolemane) ore, were each successfully worked while the iron furnace was in operation. Many tons of the manganese were shipped to England. The ocher is still mined to a moderate extent as a paint material by the "Brandon Kaolin and Paint Co.," of which G. W. Prime is president; C. H. Forbes, secretary. The ocher is also mined for paint material by the "Original Brandon Paint Co." No iron beds or blast furnaces are worked at the present time within the county.

A thick deposit of sulphate of iron, or iron pyrites, exists at Cuttingsville, which has been mined and used quite extensively in the manufacture of copperas. For nearly forty years these beds have been abandoned; the buildings in which the copperas was manufactured have been taken down and removed. With the exception of the mine but few traces of the works are to be seen.

## CLAYS.

Clays suitable for brick are found in several localities within the county. Good bricks are manufactured in Rutland by John McIntire; also by Albert Davis. Their yards and kilns are just south of the village. A good quality of brick is also made at Brandon.

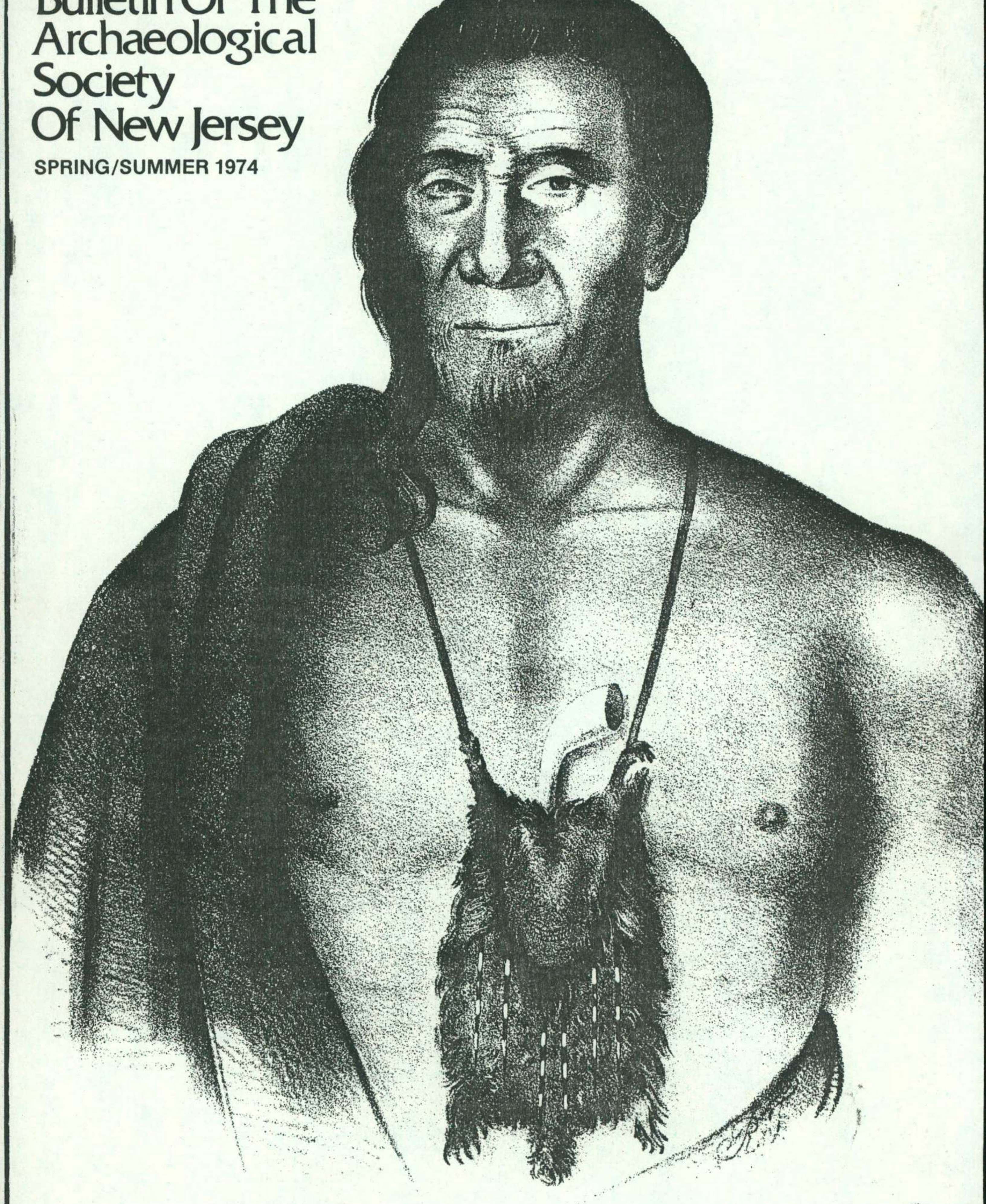
The bricks used in the construction of the United States court-house and post-office at Rutland were made from clay hauled from Pittsford and were pressed and burned at Rutland.

Fire-clay is found in Brandon and at one time was used in the manufacture of fire-brick and stone-ware. A deposit of fire-clay of excellent quality is found near the east line of Rutland, which is worked to some extent by the "Rutland Fire-clay Co.," of which R. L. Perkings is manager and A. W. Perkings, treasurer.

The writer desires to state that he has gladly availed himself of information wherever it could be obtained, relating to the subject matter contained in the foregoing chapter. Much relating to geology has been derived from the following works, viz.: *Vermont Geological Reports*, 2d vol., 1861. *Dana's Manual of Geology*, 3d edition, 188–. Prof. Archibald Geike's *Elements of Geology*, London. *Proceedings of the Middlebury Historical Society*, vol. I, part

# Bulletin Of The Archaeological Society Of New Jersey

SPRING/SUMMER 1974



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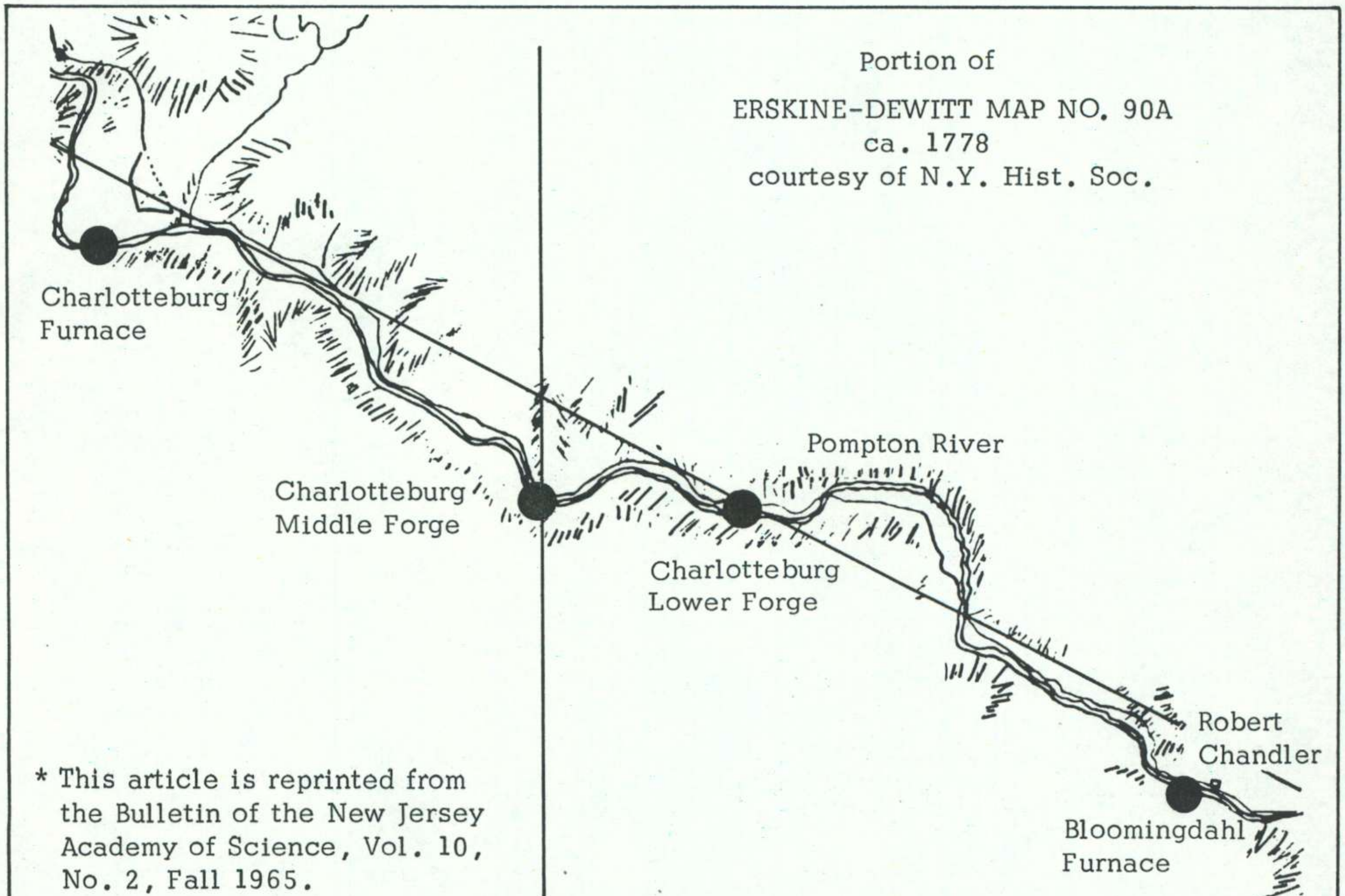
EXCAVATIONS AT

# Charlotteburg Middle Forge

Edward J. Lenik




* This article is reprinted from the Bulletin of the New Jersey Academy of Science, Vol. 10, No. 2, Fall 1965.

The ruins of Charlotteburg Middle Forge stand in a quiet, unspoiled section of Passaic County as a silent reminder of the iron industry of bygone days. Two hundred years ago, the sound of the trip hammer rang through the woodlands of the Highland area, and the shouts of sweating men-at-work resounded over the countryside.

The site of the forge is on a long narrow island in the Pequannock River. Today, the term "island" applies only at times of high water or flooding of the present river channel, which lies on the south side of the site. A normally dry channel borders the north side of the site. The island is 80 to 125 feet wide and approximately 500 feet in length. It is situated in a steep and narrow gorge on the south side of state route number 23, in West Milford Township, just east of the Smoke Rise entrance.

The objectives of archeological investigations at Charlotteburg Middle Forge have been two-fold: First, to learn something about the actual construction and operation of this 18th century ironworks. Secondly, to find some clue or evidence of what caused cessation of operations with its resulting loss of productive capacity for the Revolutionary War effort.

The first stated objective has been greatly facilitated by the existence of historical documents relating to the area. Numerous maps, letters, news paper advertisements, and reports give us a good picture of the life and times of Charlotteburg. Perhaps the most significant document is a report (New Jersey Archives, First Series, vol. 28 (1772), p. 247 et seq.) submitted by four appraisers to Governor William Franklin of New Jersey in 1769. This report shows the extent and character of the ironworks at Charlotteburg, Ringwood, and Longpend. That portion which specifically refers to Middle Forge is as follows:

Sir,

In compliance with your Excellency's request communicated to us by letter of the 27th of June last, we proceeded on Monday the 2nd inst. to view the iron-works erected by Peter Hasenclever, Esq; within this Province, and began with those of Charlottenburgh, on the west branch of the Pequanock River, which is the boundary between the counties of Morris and Bergen. We there found a very fine blast furnace erected in 1767...On the same stream, about three miles lower, is a very fine forge and four fires, and two hammers for converting pig-iron into bar-iron, and is, according to the information we received from the overseer, and workmen, capable of making 250 tons of bar-iron yearly, single handed, and from 300 to 350 ton double handed. The dam here is upwards of twenty feet high, and is remarkably substantial and well secured: Here are also the necessary coal-houses, dwelling-houses, store-houses, workshops, and stables. About a mile...

We are,

Your Excellency's most humble servants,
Stirling
James Grey
Theunis Dey and
John Schuyler

Newark, July 8, 1769

The reader should endeavor to keep the above description in mind as the story of the excavation is unfolded in the ensuing paragraphs. It has been a challenging and rewarding task to find, examine, and interpret all evidence in relation to this appraiser's report.

Now we come to our most difficult question: What happened to the Charlotteburg ironworks? What caused this giant of industry to shut down its operations? Attempts to solve this mystery by means of historical records have been fruitless. Diligent research has failed, at this point, to turn up any specific evidence which would tell us what happened. Several authorities have stated that the works at Charlotteburg were destroyed presumably by Tories, in 1776 (Swank 1892; Heusser 1928; Boyer 1931). Another has written that it was destroyed by direction of the Home Company, that is, the London Company (Tuttle 1870). Still another indicates it was abandoned in 1772 (Bayley 1910), but documentary evidence indicates that this statement is incorrect. The last recorded reference to Charlotteburg, found to date, appeared in the New York Journal on February 2, 1775 (New Jersey Archives, Vol. 31 (1775) ). This was an advertisement placed by Daniel Neal, living at Charlotteburg ironworks, seeking information regarding his brother. Thus it would appear that the works was in existence at this time. It must be noted, however, that the above theories have their basis in legend, or rumor, rather than in fact.

At this point, let us examine the actual finds uncovered in excavation at Middle Forge. This site was rediscovered in 1961. Surface investigation revealed evidence of a cellar hole, the side of a coal house, a forge hearth in an advanced state of ruin, two wheel pits, and a possible raceway. This was clear and sufficient evidence to establish the location of Middle Forge, and actual excavations were soon undertaken. The search was greatly aided by a map of the area drawn by Robert Erskine (Fig. 1).

Several test pits were dug first to determine the original floor level, and to locate building perimeters. Approximately 18 inches of top soil and river gravel, deposited by floods over the past 185 years, covered the forge work area. In order to expedite the removal of tons of earth from the mill races and some portions of the floor area a backhoe was engaged in the Fall of 1961. Of course, each shovel-full was carefully examined for artifacts even though only top soil and river gravel was removed in this manner.

Patiently digging week in and week out, the archaeological crew uncovered all of the main features of the forge building. Basing conjectures partly on historical data, partly on the lay of the land, and partly on pure hunches, these features plus innumerable artifacts were unearthed. The four forge hearths and two hammer sites which are mentioned in the report to Governor Franklin were, in due course, laid bare.

A brief description of the main features of the forge, along with some of the important artifacts which were found, is outlined in the following paragraphs. The reader should, however, refer to the accompaning drawing for specific details and an over-all view.

The mill race on the south side of the site was filled with mud. Two parallel 9" x 9" oak beams, 7 feet apart and mortised at 2-foot intervals, were found at the bottom of the race. One cross member was also found. The bottom of the race was sheathed with 1" x 10-12" oak planks beyond the cross member. The purpose of this mill race planking was undoubtedly to minimize the effect of water turbulence caused by the wheels. Portions of a cut stone wall were found along the north side of the race only. A 50-pound spoon-shaped forging, and a small 10-pound casting were found at section "D" of the race.

The mill race on the north side was filled with sand, and had side walls of cut stone spaced $7\frac{1}{2}$ feet apart. The bottom of this race also contained 1" x 10-12" oak plank sheathing at a depth of 37 inches from the top of the wall. Iron spikes and nails were found throughout.

In terms of construction, the forge hearths designated as Numbers 1, 2, and 3 in the accompanying drawing, were exactly alike. These forges were made of cut stone bonded with mortar, and were the same size. Excavation revealed the exact location of all three of these hearths within the building proper. Actually, very little of their physical structure remains; approximately three feet of the base of each is all that is left. (These hearths, if intact, would look much like giant blacksmith forges.) The tuyere opening, or air inlet, from the bellows for each hearth also was located. Each forge undoubtedly had a crucible formed of iron plates. In fact, a complete hearth plate weighing approximately 300 pounds, and showing evidence of exposure to extreme heat, was recovered from forge Number 3.

Forge hearth Number 4, on the other hand, is almost completely different from the others. Its construction appears crude by comparison and it is larger in size. Again, all that remains is a mere outline of stones.

The exact location of the two hammers also was found in the course of excavations. A bed of scoria (slag) was uncovered at each location which showed the size and shape of many of the beams which made up the hammer assembly. A hammer consisted of a 400 to 600 pound iron block fastened to the end of a wooden beam so that it had a free movement up and down. This beam, held in great wooden "ledges," was raised by cams on the water wheel shaft. After the hammer was raised, it was allowed to fall by gravity on the anvil. Two holes where the anvil blocks were situated were clearly in evidence. Found at the bottom of each hole, in a remarkable state of preservation, were hugh interlocking oak beams which served as reinforcing.

Innumerable artifacts were recovered from all areas and from various levels. The most important of these may be summarized and grouped as follows.

| | |
|---|---|
| **Tools:** | |
| Shovel blades | 3 |
| Hoe | 1 |
| Trowel | 1 |
| Harness buckle | 1 |
| Hammer-headed chisels | 5 |
| Pick | 1 |
| Wedges, various sizes... (approx.) | 25 |
| Jaw of blacksmith tongs | 1 |
| **Personal Items:** | |
| Shoe | 1 |
| Button | 1 |
| Bowl of a clay smoking pipe | 1 |
| Clay pipe stem fragments | 6 |
| **Castings:** | |
| Fragment of pig iron with date "1770" | 1 |
| Fragment of pig iron with letters "CH" | 1 |
| **Other Items:** | |
| Potsherds | 5 |
| Glass fragments | 3 |
| Alcony | 1 |
| Bellows nozzle (possible) | 1 |

A great many hand-forged spikes, nails and pins of various sizes were found. Also recovered was one complete iron pig weighing 69 pounds, plus many assorted fragments. An interesting and unusual feature revealed was a cache of several 6 to 8 inch pig fragments which were stacked neatly inside forge hearth Number 4. Another curious feature was the presence of fine screened sand in many areas. Finally, a profusion of slag, charcoal, brick, mortar, bar stock, strap iron and plate iron of various sizes was found scattered throughout the site. The many fragments of plate iron may have come from the forge crucible plates or the loop-and-drag plates (an iron-plated path leading from the forge to the hammer) which were on the floor.

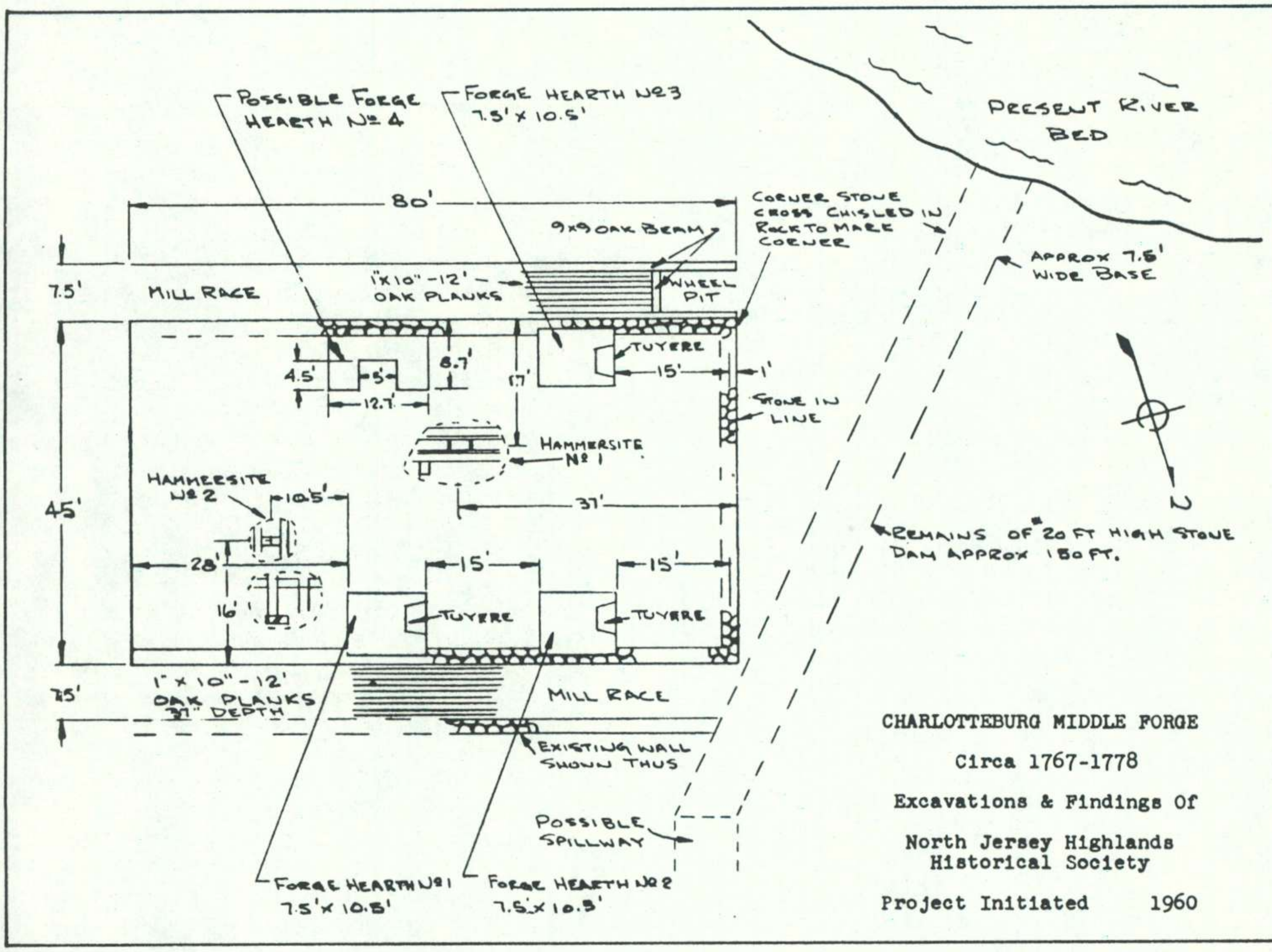
From the foregoing archaeological data it is possible to draw some conclusions regarding the fate of Charlotteburg Middle Forge. The preponderance of evidence favors the theory that the works was destroyed by violence. For example, the large quantity of artifacts recovered lends support to the belief that the works was not abandoned. Items such as tools, pig iron, and bar stock were much too valuable to be left behind.

Furthermore, the appearance of much of the iron uncovered seems to indicate a violent suspension of activity while the material was in process. A prime example of such a condition was noted by Malone (1962) who described the appearance of a 40-pound piece of pig iron which was found and concluded that it was in the process of being melted at the time the operation was halted.

If the conclusion is correct—that the works were deliberately destroyed —then the next question to be asked is by whom? Numerous raids by British, Hessian, Tory, and robber bands are known to have been made throughout the North Jersey area. Hence, the specific group and/or its leader that destroyed Charlotteburg may never come to light. The concensus of opinion, however, seems to favor the Tories as the culprits.

Although the possible suspects are many, this writer puts forth the name of Captain James Gray as the most likely. It is noted at the outset, that this is a theory based upon conjecture rather than specific fact.

As stated previously, James Gray was one of the appraisers appointed to inspect the ironworks of the London Company at Charlotteburg, Long Pond, and Ringwood. Therefore, he was thoroughly familiar with their operation as well as the surrounding geographical area. Furthermore, Gray himself operated an ironworks at Little Falls con-




CHARLOTTEBURG MIDDLE FORGE
Circa 1767-1778
Excavations & Findings Of
North Jersey Highlands Historical Society
Project Initiated 1960

sisting of a forge with three fires and one hammer (New Jersey Archives, Vol. 27 (1770), p. 321). In fact Boyer (1931) states that "the ore for this forge was carted from Ringwood and Charlotteburg mines ..." Thus, Gray would also have an intimate knowledge of iron-making and would realize its tremendous importance to the Revolutionary War effort.

With the coming of the Revolutionary War, Gray chose to remain loyal to the British. He reported for duty to Sir Henry Clinton at New York in 1777, and was given the command of a foraging troop of horses. Soon, Captain James Gray was leading disastrous raids around Acquackanonk and other areas as well. In fact, Gray's Company is known to have plundered around Chatham and Pine Brook (Brooks, 1962).

The Charlotteburg Ironworks was perhaps the most remote and vulnerable of the London Company's holdings. It was set apart some 13 miles from Long Pond and Ringwood. The latter works was the headquarters of Robert Erskine, where together with Long Pond, he had enough men to make quite a respectable militia regiment. Hence, while operating in the Pine Brook area, it would have been quite logical for Gray to make a lightening raid on Charlotteburg to destroy this important Revolutionary arsenal.

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END OF PROJECT REPORT
1986 PROJECT VERMONT SURVEY OF INDUSTRIAL ARCHEOLOGY SITES

A. INTRODUCTION:

This project continued thematic survey throughout the state of Vermont, at reconnaissance level, to identify the following range of historic archeological sites: blast furnaces, iron mines, bloomery forges, foundries, charcoal kilns, and lime kilns. Although most of the sites were recorded on an 'as-located' basis, sites in close proximity to public and/or private development areas were given priority attention.

1. HISTORIC CONTEXT OF VERMONT IRONMAKING INDUSTRY:

a. Development trends: The iron industry in Vermont developed in association with other pioneer works (grist and saw mills, blacksmith shops, etc), which reflected the needs of early settlers in Vermont. Ironworks were built near water power, ore beds, and sources of fuel (charcoal); blast furnaces along lower elevation sites near good roads to transport heavy ingots; bloomeries sometimes at higher elevations (i.e. Bristol, Cady's Falls, Lincoln). The works were also influenced by Lake Champlain and the ironworks that developed in New York State. The Lake and later the Champlain Canal changed the character of Vermont ironworks from a larger number of small speculative operations in pre-canal days to costly, high production works. The railroad eventually brought in better iron made cheaper than local works could produce and ended ironmaking in Vermont.

Ironworking, in the form of machine shops (mill gearing, machinery, tools, scales) and medium to heavy foundries (agricultural implements, railroad iron, castings, stoves), expended to reach peak production about 1880-1890, dwindling in numbers and production thereafter.

b. Limitations of development: Vermont ironworks were limited by:

(1) the quantity and quality of its ore (earlier ironworks used bog ore). Later works imported ore from New York State to mix with and improve the quality of locally-made iron.

(2) the length of the winters, which froze streams that powered the works.

(3) the works' remoteness from major industrial centers and sea-ports nearer to the ocean.

c. Geographic distributions and patterns: Pre-1800 ironworks were distributed near developing population areas that created the demand for raw iron product. With better transportation (road, railroad, and lake barges) industrial demand commenced (1800-1850) and ironworks located closer to fuel, ore, and more reliable water power. Approximately 90% of the ironworks operated to the west of the Green Mountain range and were concentrated in Addison and Rutland Counties.

d. Historic highlights:

(1) Many early ironworks in Vermont were developed by major political figures: Nathaniel Chipman, Ira Allen, and Matthew Lyon.

(2) The first ironworks in the Adirondack Mountain region of New York State imported ore from Basin Harbor (near Vergennes).

(3) A major New York State ironworks, the Crown Point Iron Company was founded by Vermonters: the Penfield and Hammond families of Pittsford.

(4) A blast furnace at East Bennington used preheated blast (hot blast) a year before generally accepted date (1834) for first use at a furnace in New Jersey.

(5) In 1809, Monkton Iron Company at Vergennes attempted use of piston-driven blast machinery, 26 years before accepted date of use in Northeast; first documented successful use in Vermont was 1839 by Conant at Brandon.

(6) Last significant bloomery forges in New England operated in Vermont (1850-1880's): Salisbury, Vergennes, Fair Haven, Lincoln, East Middlebury; then known throughout U.S. industry for high quality wrought iron.

(7) Most all major 1790-1830 Vermont ironworks families interrelated: Austin, Harwood, Lothrop, Page, Dike, Broughton, Bogue, Keith, Sax, Drury, Cooley, Conant, Penfield, and Sutherland; also Colburn and Davey.

2. HISTORIC CONTEXT OF VERMONT CHARCOAL INDUSTRY:

a. Development trends: Charcoal making in Vermont developed in association with the development of its mineral smelting and production industries. Charcoal fueled furnaces (iron, glass, copper), forges, blacksmiths hearths, foundry cupolas, etc. Early charcoal making required no structure; it was made merely by mounding cordwood, covering it with sod, and allowing it to smolder. Much charcoal and potash was made by settlers as a by-product of clearing vast acreages of land for agriculture. Kilns supplied charcoal to local furnaces and forges that initially satisfied local needs. Industrial expansion after 1820, stimulated by the Champlain Canal, demanded more charcoal. By Civil War period, charcoal was being made in stone- and brick-built kilns with much of it exported out of state. By 1880, most of it was shipped out as Vermont ironworks phased out and charcoal resources in New York, Massachusetts, and Connecticut became scarce. Charcoal making in Vermont ended soon after 1900.

b. Limitations of development: Vermont charcoal making was limited in the early period (pre-1820) by the demand of local metal working industries, which mostly reflected domestic economics. Limitations of middle period charcoal making (circa 1820-1860) still reflected local demand, but charcoal was made on a more regional supply and demand basis; local forests were becoming depleted through settlement and clearing for farmland. After 1860, charcoal making became an industry unto itself, with charcoal being exported outside the state and forests being rapidly consumed by lumbering interests. Limitations by this period became the resources of the forest stands themselves, which were commercially exhausted by the turn of the century.

c. Geographic distributions and patterns: During the early pre-1820 period, charcoal making generally centered about the ironmaking industries, then the largest single consumer of charcoal in the state. After 1820, as iron, copper, and glass industries developed, charcoal making caused forest lines to recede into the hills. It was not uncommon for charcoal to be carted a dozen miles to furnaces by the 1860's. As such, earlier charcoal making sites generally were close to developing industrial communities along the Lake Champlain plateau; later charcoal making areas reached well up into the Green Mountain highlands, with many final operations at 2000-foot elevations. Most kilns, however, still remained on the western slopes of the Green Mountain range, with concentrations in the north in the Ripton and Middlebury area; the central area of Winhall, Peru, Mt Tabor, Dorset; and southern at Woodford, Shaftsbury, Glastenbury, Stamford, Readsboro.

d. Historic highlights:

(1) Largest single-owned charcoal making operation in Vermont was Silas L. Griffith of Danby, whose holdings in late 1880-1890's exceeded 50,000 acres, operating some 35-plus charcoal kilns, 9 sawmills, and 6 general stores in and near Mt Tabor. He was the first to use the telephone in the state, connecting his lodge at Griffith Pond to his office at Danby; was an early advocate of using saws instead of axes to cut trees in order to reduce waste. He was a Vermont State Senator but declined candidacy for Governor. His charcoal, plus that made farther south, supplied fuel needs of ironworks in the Taconic regions of New York, Massachusetts, and Connecticut until about 1912, when these resources failed; those ironworks then importing charcoal from as far away as North Carolina (that region's iron industry failed in 1923).

(2) Design and efficiency of round and conical kilns in Readsboro were recognized in a technical paper in 1879-1880, published nationally (the archaeological site of at least one Readsboro conical kiln was located in 1983).

3. HISTORIC CONTEXT OF VERMONT LIME BURNING INDUSTRY:

a. Development trends: Lime burning in Vermont developed in association with the clearing of the land and establishment of farming. Eighteenth century and early nineteenth century lime kilns were built by farmers to provide lime for agricultural purposes; later lime kilns supplied the demands of construction and paper making, although the major kilns at Winooski Park supplied lime for sale to farmers by the U.S. Government until 1971.

b. Limitations of development: Early lime burning in Vermont, which supplied strictly agricultural needs, was limited by physical proximity to limestone quarries. Since these early lime kilns required no blast, water power was of no consequence. By the mid-19th century, lime kiln operations such as those at Leicester, Weathersfield, Highgate, and Winooski located closer to railroads. Lime kilns during this period were large stone-built stack structures (similar in appearance to blast furnaces), requiring major outlays of capital for construction at centralized locations, thus phasing out the smaller, local farmers' kilns. Vermont's final operating lime kilns at Winooski Park operated until 1971 when its U.S. Government contract was awarded to a competitor.

c. Geographic distributions and patterns: Lime kilns in Vermont have always been located in relatively close proximity to limestone deposits. Limestone, which manifests itself in Vermont as varying grades of dolomite for commercial quality marble, or plain limestone for crushing for blast furnace applications or burning for other uses, was early recognized in many places in the State by Zadock Thompson (1853). Thompson identified "Chazy, or Isle la Motte Limestone" and "Trenton Limestone" as being the state's major limestone groups. These groups were located along the eastern shore of Lake Champlain, where major lime kiln operations were established at Highgate (Lime Kiln Point) and Colchester (Winooski Park). Lime kilns were also operating in the Lake Champlain valley at Leicester, Bristol, New Haven; in proximity to marble quarries at Wallingford, Tinmouth, Danby, Clarendon, Dorset, and Manchester; and also at Weathersfield, Jamaica, and Dover in proximity to limestone outcrops.

d. Historic highlights: Research into the lime burning industry in Vermont is still in a very preliminary stage of activity, with location of physical remains the immediate priority. Insufficient investigation into the history of the industry, therefore, contributes little in the way of historic highlights of this industry.

## B. METHODOLOGY:

The survey was accomplished through a combination of archival and field research: oral and local traditions, informant information, and published and unpublished material.

### 1. ARCHIVAL RESEARCH:

a. Library work: Generally available published and unpublished materials were studied for information, however remote or vague, for clues and leads to existence or locations of sites. Specific material studied included: state, county, and town histories, trade journals, business journals, maps, museum and photo collections and papers, newspapers, letters, genealogical and cemetery records, legislative acts, and professional papers.

Libraries visited included Mark Skinner Library, Manchester; Rutland Free Library, Rutland; Sheldon Museum Library, Middlebury; Tyson Library, Plymouth; Griffith Memorial Library, Danby; Vermont Historical Society Library and Vermont State Archives, Montpelier; Bixby Memorial Library, Vergennes; the University of Vermont Bailey-Howe and Special Collections Libraries, Burlington; and Vermont Mapping Program (orthophotos), Waterbury. Also, the New York State Historical Association Library, Cooperstown, NY; State University of New York Library, Albany, NY; Berkshire Athenaeum Library, Pittsfield, Mass; in addition to my personal library and collections of Vermont archival and data stored in my personal computer system.

(1) Reliability of many local histories has proven to be questionable in some cases. Depending on the interest and personal biases of the authors, local histories may or may not have reflected actual industrial activities in the subject county/town/village. This is seen in pages of coverage for religious and social organizations, banking institutions, and prominent families, but vague statements about a 'forge operating in the east part of the town early in the century' without regard to type of forge (bloomery? furnace? foundry?). Statements such as 'there were no industries of significance in this town' conflict with later published histories of the same town which

described many mills and foundries, and with field work that located sites of mills. Additionally, many clues to sites do not come from manufacturing sections of local histories, but in sections dealing with family records, early settlers, and general community development.

2. INFORMANTS AND LOCAL TRADITION:

A number of reliable contacts have been made regards to general or specific information leading to finding sites pertaining to the iron, charcoal, and lime industries in the state:

a. Local informants: This category includes people who own site properties and contributed information on other known or suspected sites or knowledgeable people in the vicinity. The value of slide-illustrated presentations to local historical societies cannot be over emphasized regards to numbers of contacts and quality leads to location of sites. Formal presentations at Middlebury (Sheldon Museum, Summer 1984), Pittsford (Pittsford Historical Society, Spring 1986), Windsor (VAS, Spring 1985) attracted many older and knowledgeable residents who contributed much reliable oral, manuscript, photo, and artifact information. A number of informants also volunteered time to guide me to sites. Correspondence continues with most of these reliable contacts.

b. Professional informants: This informant category includes those who have a professional interest in history/archaeology, beyond members of historical societies or owners of site properties, including:

- (1) authors of recently-published histories.
- (2) school teachers.
- (3) U.S. Forest Service personnel.
- (4) staff personnel of:
  - (a) Vermont Division for Historic Preservation, Montpelier.
  - (b) UVM Consulting Archaeology Program, Burlington.
  - (c) Sheldon Museum Library, Middlebury.
  - (d) Vermont Historical Society Library, Montpelier.
  - (e) Stamford Community Library, Stamford.

3. BACKGROUND RESEARCH:

Potential areas for industrial sites were determined through a combination of archival information, known industrial development patterns, local geology, topography, and mountain trails.

a. Archival information: Information obtained through archival research was duplicated, transcribed, and/or plotted on USGS maps in combination with other associated data to create a job folder, specifically for the site in question. Related site information, such as family connections, incorporation dates, names, and partners, and newspaper advertisements, were also investigated.

b. Industrial development: Through 1850s-period county maps, Beers maps, and business journals such as the annual Walton's Register publications, patterns of industrial development were established and analyzed for trends. Concentrations of ironworks industries indicated, for example, the probability of charcoal kilns in surrounding hills.

c. Local geology: Through state geology reports and maps, the probability of ironworks and lime kilns were determined.

d. Topography: Attention to physical topography revealed clues to location to otherwise undocumented industrial sites. Inspection of streambeds downstream of suspected ironworks or charcoal sites yielded slag or pieces of red brick and charcoal, which when traced upstream, led to location of the sites. Techniques such as this have in time led to development of intuitive skills for locating some types of sites.

e. Trails: Many former roads are today official or unofficial hiking trails. These trails wind through abandoned communities that grew in proximity to saw mills and charcoal kiln operations. Attention to black soil in vicinity to suspected charcoal making areas led to locating many of the kiln sites.

4. WALK-OVER SURVEY:

Once located and verified, the site was inspected at reconnaissance level, for extent of its boundary, remains of visible surface artifacts and features, and potential archeological value, then recorded.

a. Site location and verification: Location and verification of the site was made through obvious structure remains, such as foundation and/or standing blast furnace, charcoal kiln, or lime kiln remains. In absence of obvious remains, evidence of such material as burnt brick and stone, slag, charcoal, firebrick, burned lime, waste iron, iron ore, binding hardware, etc, and such features as collapsed furnace mounds, head and/or tail raceways, flumes, dams and dam cribs, waterwheel pits, charging embankments, etc, were checked for.

b. Site inspection: The site was inspected for the following:

(1) integrity - to what degree is the site undisturbed by later development, vandalism, weathering, etc.

(2) boundary - what is the archaeological boundary of the site as determined by range and distribution of surface artifacts and features, and also by inspection of eroding shores of streams and by shallow (6-inches, max) subsurface inspection.

(3) threats - what are probabilities for development, further vandalism, erosion, etc.

(4) ownership - proximity to property owner; owner interview, if possible, to access local attitude toward site preservation, development plans, etc.

c. Site recording: The site was recorded through use of USGS topographical maps, drawing sketches and ground plans, and photography. Small surface artifacts were reconcealed after recording.

(1) USGS maps - the site was accurately located on USGS topographic quadrangles through identification with local landmarks, such as streams, mountains, roads, standing buildings, etc.

(2) Ground plans - sketch maps were made of the site, indicating all relevant surface features, concentrations of artifacts (slag, charcoal, etc), cellar holes whether known to relate to the site or not, roads and paths, dam sites, etc., and general topography. In some

cases, detailed, scaled sketches were made of remains that were considered of special importance to the integrity or significance of the site, such as uniquely-built furnace archways, hearths, kiln hardware (which might be stolen or vandalized). Compass readings were recorded. In most cases, the site boundary was paced off and dimensions calculated accordingly. When possible, sketch maps were scaled.

(3) Photography - black and white photographs were made of the site from many angles of view, both close up for detail and from a distance to indicate local environment. Small brush and branches might be tied aside or cut, but not sufficient to draw attention. Camera used is a Minolta SLR model SRT101, with normal, long-range, and wide-angle lens, which allow for a wide range of photography under varying situations. In many cases, follow-up photo sessions were made during seasons of less foliage for better photographs. These return sessions also allowed for reinspection of the site, adding surface information that may have been missed during the initial recording and interpretation of additional archival information.

(4) Concealment of artifacts - such large, attention-drawing artifacts as kiln doors and hardware, cast iron vents, etc., were uncovered of accumulation of surface vegetation and debris for purposes of measurement and photography, and were reconcealed beneath brush, leaves, and foliage. In all cases, sites were left appearing as much as possible as found; no attempt was made to 'clear' fallen trees and branches from paths and trails leading to sites. Where possible, further concealment was attempted, and trash found in the site vicinity was collected and carried out.

5. SURVEY REPORT:

Survey reports were submitted to the Vermont Division for Historic Preservation (DHP), which included filled in Archeological Site Survey Forms, an Industrial Archeology Site Survey Form, and a narrative report.

a. Archeological Site Survey Form: This is the standard DHP form for recording archeological sites. All categories and spaces are filled in that apply to the site. Site and F.S. numbers are left blank to be assigned by DHP.

b. Industrial Archaeology Site Survey Form: This form was created to provide additional site information not covered by the Archeological Site Survey Form. It addresses iron furnace, bloomery, and charcoal and lime kiln sites. Where applicable, the form is filled in and included as pages 5 and 6 to the Archeological Site Survey Form.

c. Narrative report: This report includes definitive site location information, a description of the site, history of the site, miscellaneous observations, duplicated USGS and USFS maps with site location, ground plans and sketches, bibliography and sources of further information, and captioned black and white photographs. The report is stand-alone, that is, it includes all information needed to complete the Archeological Site Survey Form and the Industrial Archeology Site Survey Form.

(1) Definitive site location - site location is defined in terms of USGS topographic quadrangle name, UTM coordinates, county, and town or village.

(2) Site description - a narrative description of the site includes location of the site in the context of its surroundings and environment, a site name, its physical characteristics, range and distribution of features and artifacts, and source of power and/or resources.

(3) Site history - a brief history of the site is provided, including events leading up to the site's establishment, production statistics when known, dates of operation, causes of abandonment, highlights, owners, and relationship with associated works. In some cases, published material was duplicated and included in the narrative.

(4) Observations - visible or suspected threats to the site, potential for further historical/archeological interpretation, etc., are included where applicable.

(5) USGS map - the site is located on current duplicated sections of USGS topographic quadrangles; the site is identified on the map in the same proportion to the sketched ground plan.

(6) USFS map - sites in the Green Mountain National Forest, were indicated duplicated sections of U.S. Forest Service quadrangles.

(7) Ground plans - full page ground plans of the site are provided with the report. The sketch is scaled when possible; all ground plans are sketched in the normal orientation (north at top) and include a north-pointing arrow.

(8) Bibliography - a comprehensive listing of references and sources for all published and unpublished information cited or referenced as part of the report is provided. Addresses and phone numbers of contacts are included.

(9) Photographs - captioned black and white photos depict site condition, artifacts finds, and site environment. Photos are identified by 5-character alphanumeric code (i.e., 86A13) that allows for accurate access to my negative files.

d. <u>Distribution of Forms and Reports:</u> Forms and reports were distributed as follows:

(1) State Archaeologist - original copies of all Forms, Reports, sketches and ground plans, and photographs.

(2) Forest Archaeologist (U.S. Forest Service) - duplicated copy of Reports only, pertaining only to sites within the proclamation boundary of the Green Mountain National Forest.

(3) Librarian, Sheldon Museum Library, Middlebury - duplicated copies of Reports only, of sites only within Addison County.

(4) Rolando files - duplicated copy of all Forms, Reports, maps, and photo negative file.

## C. <u>RESULTS:</u>

The project period commenced October 1, 1985 and ended November 30, 1986. Although work on 25 sites was planned for this project period, actual efforts for the project resulted in 43 sites in eight of the state's 14 counties added to the Vermont Archeological Inventory. Value of donated services totaled $10,487 versus the planned $5,998.00. See pages 10 and 11 of this report for the list of inventory and field site identification numbers of the 43 sites reported.

Almost all the sites surveyed and recorded have the potential for yielding further significant archaeological information regards to their construction, method of operation, technological developments, and relationship of property types across the site. Stabilization of lime kiln structures at Bristol and Amsden could preserve them for future study and possible exhibition as historic industrial sites.

Despite some surface disturbance and scattering of remains, digging and serious subsurface disturbance at most sites appears to be minimal. Visible site disturbance appears to be a function of proximity to well-traveled trails. Sites of brick-type charcoal kilns in along sections of the Long Trail in Mt Tabor betray much evidence of pot-holing. Construction materials, however, also seems to be a factor. Brick-type charcoal kilns, for example, however remote from houses, are relatively stripped of usable brick, whereas stone-type kilns remain in relatively better standing condition. Chimneys of homes in proximity of brick-type kilns contain brick that appears much the same color, texture, and condition as bricks seen in local charcoal kiln remains. The occupant of one house (East Manchester) knew exactly where some charcoal kiln remains existed without acknowledging suspicious bricks in his chimney.

Although some charcoal kiln sites in higher elevations show evidence of disturbance by brick scavengers, or use of brick for fireplaces by campers and sportsmen, the most serious threat to these sites appear to be logging operations. Not all damage is done by the actual logging operation; some by road construction into logging areas, although this also had its reverse benefit. Clues to some undocumented charcoal kiln sites came from pieces of hardware seen in the beds of logging roads in Peru and Woodford (1983). In both cases, the road had been graded to within a few feet of the kiln foundation, accounting for hardware in the roadbed. The Peru kiln ruin, as it turned out, was unknown even to people who had hunted the area for over 20 years. At North Dorset, a staging area for logging vehicles was cleared to within a few hundred feet of a collapsed furnace ruin, but still within the archeologically-sensitive area; part of the waterpower flume system was destroyed. That the property was part of a state park had no effect. At Mt Tabor, on federal property, part of the Ten Kilns site has been disturbed by widening of roads to accommodate large logging vehicles. None of this is intentional destruction, rather there appears to be a lack of communications within the governmental systems. In all cases, site reports had been written and forwarded before the disturbance took place.

Private owners appear more concerned and willing to cooperate with preservation efforts when advised of the historic/archeological value of the site. Whether to increase property values or just personal interest in something not fully understood about the ruins on their property, nearly all property owners have cooperated with recommendations to protect sites from further deterioration through brush clearing or wall support, but attempt no serious restoration/excavation.

Results of this project survey period plus data accumulated in previous years continues to support my theory that industrial activity in Vermont exceeds that generally thought. Vermont is not perceived to have had a significant industrial history. Yet, in terms of numbers of blast furnace, bloomery, and charcoal and lime kiln ruins and sites located and documented to date, Vermont appears to have kept pace (relative to state population and area) with neighboring states, from the immediate post-Revolutionary War period up to the 1850's. Additionally, related genealogical research has shown that the earliest significant ironworks in the Lake Champlain district of New York State were founded by Vermonters.

Data from the 1986 project has added to further understanding how and when ironmaking technology came into Vermont, and how the technology distributed itself within the state. By tracking where pioneer ironmaking families came to Vermont from, migration patterns became apparent that connect 18th-C ironworks operations in eastern and western Massachusetts and in northwestern Connecticut with the establishment of some of the first ironworks in Vermont.

Analysis during the 1986 project year of early 19th-C legislative acts of incorporation has led to development of a preliminary pattern of industrial capital investment flow into Vermont. The pattern shows that many corporation partners were involved in other speculative ventures in Vermont. Names of some partners have also been recognized from ironworks research done years ago in other parts of New England, contributing to understanding the complex economics of early 19th-C speculative exploitation of Vermont's natural resources by Boston's and New York City's budding capitalists.

Results of the 1986 project year also sharpened intuitive skills of locating undocumented industrial sites. Not 100% foolproof, attention to geology and topography contribute toward developing local patterns of charcoal and lime kiln sites. Sites of mound-type charcoal making areas can now be located almost at will in southwestern Vermont, although this has not been intensely pursued due to the non-threatened nature of the area of these sites, as compared to active threats to sites being attended to in other parts of the state.

The following list documents Vermont Archeological Site Survey and Field Site Inventory numbers and site names located and recorded during the 1986 project year. See individual reports for further information on specific sites recorded:

Addison County

| | |
|---|---|
| VT-AD-404 | Richville mills & bloomery forges (2) sites - Shoreham |
| VT-AD-405 | Widow Glynn charcoal mounds (3) sites - Leicester |
| VT-AD-406 | Sawyer's bloomery forge site - Salisbury |
| VT-AD-407 | Salisbury bloomery forge site - Salisbury |
| VT-AD-409 | Bedell lime kiln ruin - Bristol |
| VT-AD-414 | Brooksville Edge Tool Co foundry site - New Haven |
| VT-AD-415 | Wainwright/Davenport foundry site - Middlebury |
| VT-AD-416 | Holley Forge bloomery forge site - Bristol |
| VT-AD-417 | Lewis Creek Farm bloomery forge site - Starksboro |
| FS 85(AD) | Mt Fuller charcoal mounds (?) site - Monkton |
| FS 86(AD) | Bristol Village bloomery forge site - Bristol |

Bennington County

| | |
|---|---|
| VT-BE-105 | Kennedy charcoal kiln (stone) ruin - Stamford |
| VT-BE-106 | Cardinal (Nunge) Brook charcoal kiln (brick) ruins - Stamford |
| VT-BE-107 | Crazy John Stream charcoal kiln (stone) ruins (3) - Stamford |

Bennington County (Cont)

| | |
|---|---|
| VT-BE-108 | Thompson Farm charcoal mounds (2) site - Stamford |
| VT-BE-109 | Barnumville lime kiln ruin - Manchester |
| VT-BE-110 | MD&G RR abandoned right-of-way - Manchester/Dorset |

Chittenden County

| | |
|---|---|
| VT-CH-282 | Weston lime kiln ruins (4) - So Burlington |
| VT-CH-283 | Stevens foundry site - Colchester |
| VT-CH-284 | Winooski Park lime kiln site - Colchester |

Franklin County

| | |
|---|---|
| VT-FR-169 | Kenfield foundry ruin and site - Fairfax |

Rutland County

| | |
|---|---|
| VT-RU-153 | Gibbs & Cooley blast furnace/foundry site - Pittsford |
| VT-RU-154 | Maplebrook Farm lime kiln ruin - Tinmouth |
| VT-RU-155 | Kiln Brook charcoal kiln (brick) ruins (5) - Chittenden |
| VT-RU-156 | Lampman rectangular charcoal kiln (stone) ruin - Chittenden |
| VT-RU-157 | Vt Lime Prod Co lime kiln ruins (3) - Mt Tabor |
| VT-RU-160 | Danby Mtn Road charcoal kiln (brick) ruins (4) - Danby |
| VT-RU-161 | Crow Hill Farm lime kilns (2) ruins - Tinmouth |
| VT-RU-162 | Tinmouth Pond Dam blast furnace site - Tinmouth |
| VT-RU-163 | Palumbo Farm iron mines (2) - Tinmouth |
| VT-RU-164 | Unidentified circular stone-lined feature - Mt Holly |
| VT-RU-165 | S. Bromley Farm lime kiln ruin - Wallingford |
| VT-RU-166 | 'The Cobble' lime kilns (2) ruins - Clarendon |
| VT-RU-167 | Crow Hill Farm iron mine - Tinmouth |
| VT-RU-171 | Packard Mill/bloomery forge site - Tinmouth |

Washington County

| | |
|---|---|
| VT-WA- 21 | Waterbury Last Block Co saw mill ruins and site - Waterbury |
| VT-WA- 25 | Rice's Forge blast furnace/foundry site - Waitsfield |

Windham County

| | |
|---|---|
| VT-WD- 66 | Harold Field's charcoal kiln (concrete block) ruin - Stratton |
| VT-WD- 67 | Janet Greene Farm lime kiln ruin - Dover |
| VT-WD- 68 | W Thayer lime kiln ruin - Jamaica |
| VT-WD- 69 | PA Haven lime kiln ruin - Jamaica |
| VT-WD- 70 | A Howard lime kiln ruin - Jamaica |

Windsor County

| | |
|---|---|
| VT-WN-104 | Amsden lime kilns (2) ruins - Weathersfield |

Files:

B:EOPRPT.86A
B:EOPRPT.86B

Victor R. Rolando
33 Howard Street
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February 25, 1987

RECEIVED MAY 7 1992

**Victor R. Rolando**
**Researcher of Early Vermont Industry**
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May 4, 1992

Eric Gilbertson, Director
Division for Historic Preservation
Pavilion Building
Montpelier, Vt 05602

Dear Eric:

In 1984 I had the opportunity of touring the just-restored Clove Furnace at Harriman, N.Y., along with members of the Iron Researchers Committee (an arm of the SIA). The Clove furnace is the furnace stack that can be seen a few hundred feet east on the NYS Thruway, just south of the Harriman exit. I took many notes at the time of the visit, even them having Forest Dale on the back of my mind, and used those notes to generate the material in the letter to you.

The Clove Furnace was built in the 1850s, to replace an older furnace that still stands uphill about a mile farther east. Clove furnace operated by steam power and burned coke versus charcoal for fuel. The furnace probably went out of operation in the 1870-80 period and the entire area became part of the Harriman Estate (New York State Governor Averill Harriman, et al.). The family preserved the two stacks instead of destroying them.

The land on which the Clove furnace stands was donated to the Orange County Historical Society in the mid-1970s; they in turn contracted Roland Robbins for Consultant (you might like to know that back around 1978-79 they asked me if I was interested!). Since I had visited the stack many times in the 1960s-70s, in the days I was traveling all over New York State and western Massachusetts and Connecticut looking for these kind of things, I have a good idea of the 'before and after' experience of the furnace stack and grounds.

At one of my last visits before the restoration, I remember inspecting the remains of the charging bridge from the adjacent high embankment (40-50 feet high), which consisted of a few rotted boards on steel beams. Back then I didn't dare make the approximately 15-foot walk on one of the 6-inch wide beams to the top of the stack for fear of the 40-foot drop to the bottom. In 1984, the charging bridge had been rebuilt of strong planks laid on the original steel beams. It and the area about the top of the stack was closed in with a high, strong chain link fence. At the top of the furnace you could look down into the throat of the furnace through a protective, transparent plexiglass/lexan platform, around which was a tile walkway. The plastic platform afforded both the interesting view into the furnace - top down - and protection to the interior of the stack from weathering. There ware some small vents around the base of the platform for ventilation but I remember thinking that they weren't big enough. The day we visited (mid-November), the whole inside looked like a giant terrarium, meaning that much vapor coated the inside walls of the transparent window at the top of the stack. The furnace-top platform was about 1½ feet high and probably 10 feet square, effectively covering the entire top opening of the stack. It cannot be walked on, but one could lean on it to view through it and into the stack. The fence and walkway was on a built-up stone/gravel layer, reinforced at the edges with the chain-link fence about a foot from the outside edges of the top of the stack. Walking over the charging bridge and strolling about the top of the stack are an experience.

What used to be the office at Arden Farms, the dairy owned by the Harriman family, was included in the little Clove Furnace Park at the bottom of the stack. This office building shows up on some early views of the works (Beers, Orange County, NY). Again, having been in the building many years before when it was still the dairy company office, I know that the Orange County Historical Society spared no expense to convert it into an excellent museum. The museum depicted in detail, the almost daily trials and tribulations of the stabilizing of the stack, planning the exhibits, archeological work, and the reconstruction of the charging bridge and the platform atop the stack. At the time, there were probably a hundred 8-by-10 color photos of the entire operation, up to the final opening. The display is a must for you and the Forest Dale architect to see.

Archeological excavation was still in progress in 1984. As part of the restoration, the furnace base was excavated, exposing foundation walls of buildings that once stood there (engine house, casting house, etc.). I discussed some aspects of the restoration at Clove Furnace with Ed Rutsch, one of the founders of the SIA and a renown authority on blast furnaces. Ed felt that enough furnaces had been directly excavated about their bases, but what is not generally known was what was under the fringes of the sites; these parts then were under the parking lots, hiking trails, etc. He felt that although the Clove Furnace mini-park was exciting, that most sagging furnace structures were so far beyond rehabilitation as to make them costly beyond gain, and the possible work required direct to the masonry would probably result in the stack different that what existed in the first place. Ed felt that money might be better spent on stabilizing the existing stack (minimal cost) and building a new replica that might even work. Have the replica next to the original so people could see one operating and how it really looked. Ed used for example of this the Plymouth Colony Restoration, which was apparently not built directly on the site as a bona fide restoration, but next to the site, thus preserving the site itself.

The mailing address for the museum is: Clove Furnace Historic Site, Arden, NY, 10910. Phone number is: (914) 351-4696. Museum hours are 9 a.m. to noon, and 1 to 4 p.m., Monday through Friday. I checked these times by phone with the museum on April 30. The walkway to the top of the furnace and the museum exhibit of the restoration process are still there.

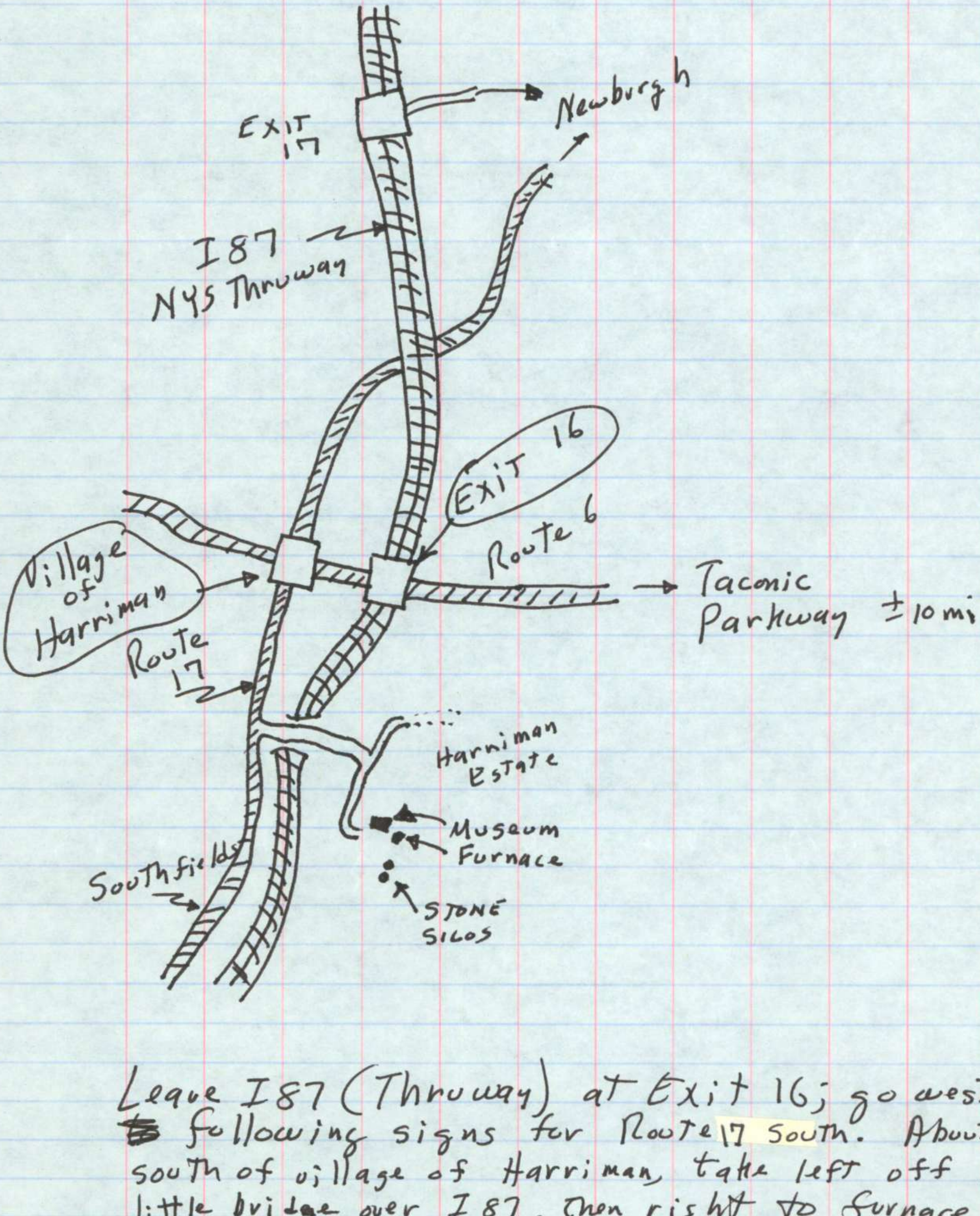
When Route 73 at Forest Dale was reconstructed (in the 1950s?), it cut across to the north of the original road. That road still exists in part, about 100 feet away. It's too bad that happened, of course, because it probably affected, if not entirely destroyed, remains of the buildings that stood at the top of the embankment and were central to the operation of the furnace. If the highway garages are in fact abandoned, I would recommend they be carefully disassembled and removed. When Audrey Porsche and I traced the boundary of the Division's furnace property last fall, we found the line to include a lot of the top of the embankment that has been backfilled and used by the highway department. The garages didn't appear to be on Division property but not by more than a couple of feet in one case. From inspection of the edges of this embankment, it appears that some four to six feet of fill covers the original ground in the direct vicinity of the garages and this might, to some degree, be protecting the original surface area up there.

In addition to describing the blast furnace at Forest Dale, the 1961 History of Brandon (pg. 48) goes on to describe "At the top of the cliff is another and much shorter tower of similar type. Upon the upper level, one sees the outlines, in foundation stones, of a number of sizeable wooden buildings..." In a map drawn for me a few years ago by Mary Kennedy of Forest Dale, a "small casting furnace" is shown at the edge of the embankment near the garage. What all this is about another furnace atop the embankment has puzzled me down through the years unless it was a stone structure that was connected with the south end of the charging bridge. I doubt cast iron from the furnace would be hauled uphill to be cast at another furnace. The mystery could be solved by careful removal of the fill at the garage and exposure of the original ground surface. It would also be nice if we could get the State to reroute the highway back around to the original bed but I guess that would be expecting too much, wouldn't it.

If you do decide to visit Clove Furnace, let me know if you would like and I will try to join you down there.

All best,

Vic Rolando




Leave I87 (Thruway) at Exit 16; go west on Route 6 ~~&~~ following signs for Route 17 South. About 2 to 3 miles south of village of Harriman, take left off Route 17 onto little bridge over I 87, then right to furnace & museum.

RECEIVED OCT 1 1992

Victor R. Rolando
Researcher of Early Vermont Industry
RR 1 - Box 1521-3 Manchester Ctr, VT 05255
(802) 362-4382

September 30, 1992

Giovanna Peebles, State Archeologist
Division for Historic Preservation
Pavilion Building
Montpelier, Vermont 05602

Dear Giovanna:

Enclosed is a special index and cross reference for you to use for getting into "Soot & Sweat" that is in sequence by site number. I have left off the "VT-" prefixes from the site numbers as I also did in the book, since the "VT-" is common to all site numbers in the state anyway. Notice that the page numbers, in parenthesis, reference any page on which that site is discussed but the site might not be referenced there by site number. In most cases, the main description of the site is in the highest number page(s).

I phoned David Skinas Wednesday morning to let you know that I shall be up Monday morning (Oct 5) to replace any of my books that have defective covers with new copies. I hope to be there in time to sit in on a few minutes of staff, but I cannot stay for the whole morning. I have to do replacement of book copies at the VHS, then swing by UVM to see Bob Sloma on some VAS business. On the way home a stop at the Shelburne Museum for some book copies for their book store and library, thence home.

I hope to have my final donated services report for 1991-92 in hand Monday morning also, but you might want to find out if the value of the books I donated to the Division ($32.95 X 8 = $263.60) can be considered donated service, and also would any percentage of my financial and/or hourly efforts toward publishing the book be considered donated services also, since the book is, in fact, a summary report of 15 years archival and field work in Vermont. I will be home Friday most all day if you want phone me and advise me if any of this is applicable.

I'll be at the CNEHA conference Saturday to sell books and Sunday to present a short paper (and sell books).

Best . . .

Vic

# 200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries

**Cross Reference and Index by Site Number Sequence:**

| Site No. | Site Name/Town/Page |
|---|---|
| Addison County | |
| AD-16 | Huntley Island charcoal mound, Leicester (170, 174) |
| AD-146 | Monkton Iron Company, Vergennes (12, 38, 42, 73, 93-98, 172) |
| AD-299 | East Middlebury Iron Works, Middlebury (22-24, 50, 73, 88, 90-92, 172) |
| AD-300 | Orwell furnace, Orwell (73, 88-89) |
| AD-314 | Dragon Brook charcoal kilns, Ripton (156, 170, 173) |
| AD-315 | Widow's Trail charcoal kilns, Ripton (170, 173) |
| AD-318 | Huntley lime kilns, Leicester (221, 227, 245-247) |
| AD-338 | Billings charcoal kilns, Ripton (170, 174) |
| AD-339 | Eagle Forge, Middlebury (73, 90) |
| AD-340 | Little Otter furnace, New Haven (73, 102-103) |
| AD-341 | Keewaydin Camps charcoal mounds, Salisbury (170, 174) |
| AD-348 | Adler Brook-east charcoal mounds, Ripton (153, 170, 174) |
| AD-351 | Adler Brook-west charcoal mounds, Ripton (153, 170, 174) |
| AD-355 | Green Mountain Lime Company, New Haven (221, 222, 227, 244-245) |
| AD-356 | Sandusky charcoal/coke area, Granville (170, 174) |
| AD-395 | Worth Mtn. charcoal mounds, Goshen/Hancock (168, 170, 174) |
| AD-404 | Richville forge, Shoreham (73, 106-107) |
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| AD-406 | Sawyer's Forge, Salisbury (73, 89) |
| AD-407 | Salisbury Forge, Salisbury (24, 73, 88, 89-90) |
| AD-409 | Bristol lime kiln, Bristol (214, 216, 227, 242-243) |
| AD-414 | Brooks Edge Tool Company, New Haven (40, 50, 73, 100-102) |
| AD-415 | Wainwright/Davenport Foundry, Middlebury (42, 47, 73, 92-93) |
| AD-416 | Holley forge, Bristol (73, 106) |
| AD-417 | Lewis Creek Farm forge, Starksboro (73, 107) |
| AD-430 | North Ferrisburg forge, Ferrisburgh (73, 104) |
| AD-431 | Doreen's forge, Ferrisburgh (73, 103-104) |
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| AD-494 | Lyman-Martell lime kilns, New Haven (214, 227, 243-244) |
| AD-FS50 | Ackworth bloomeries, Lincoln (73, 88, 104-105) |
| AD-FS85 | Mt. Fuller charcoal area, Monkton (170, 173) |
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| AD-CK01 | Cobble Mountain charcoal area, Hancock (170, 174-175, 245) |
| AD-IW01 | Downing forge, not located (73, 88) |
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| " | National Horse Nail Company, Vergennes (24, 50, 74, 98-100) |
| AD-IW04 | Belding/Drake furnace, Weybridge/New Haven (74, 100) |

**Cross Reference and Index by Site Number Sequence (Cont):**

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**Furnaces, Forges, and Foundries**

A brief description of the various furnace names, dimensions, and applications to the early iron industry.

This paper was initially written for "Exploring Local Industry, Middlebury 1800–1990" presented by The Sheldon Museum, Middlebury, Vermont, on November 8–10, 1985

Updated and revised May 28, 1998

by

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Furnaces, Forges, and Foundries

Contents

Furnaces, Forges, and Foundries

## Introduction

The iron industry was, and still is, fraught with technical terms and expressions that appear to sound alike, but each describe a specific industrial process. Such things as a blast furnace, air furnace, cupola furnace, heating furnace, pocket furnace, etc., all tend to confuse. Historians generally lumped all these expressions under the all-inclusive category of the "forge," leaving it to later generations of historians to sift through the words and try to figure out exactly what was going on at the ironworks.

The word "forge" can be a noun or a verb; it can be a place where iron was worked (noun) or it can be the working of iron (verb). In its strict definition, a forge was a place where iron was hammered, whether by hand or machine, whereas a furnace was a place where molten iron was dealt with. So what, then was Jason Davenport of Middlebury, Vermont, advertising in the August 7, 1849 issue of the *Middlebury Galaxy* when he said that he had on hand for sale "forge castings" (Rolando 1992:93)?

Working iron usually meant heating, melting, hammering, molding, rolling, drawing, and shearing. The latter three were normally associated with foundry operations. Historians also called a place where iron was being made a forge, which additionally included such operations as smelting, casting, puddling, reducing, etc. A forge, therefore, can be interpreted to mean almost anything connected with the iron industry, depending on the time period of the published material and the technical background of the writer and/or historian. The forge could, therefore, have been a full-scale blast furnace operation; it could have been a blacksmith's shop. The word "forge" should be approached carefully and skeptically.

Early histories abound with statements that :"At an early time a furnace operated in the town . . . " with no further information. Depending on such other factors as proximity to water power, iron ore, fuel, and market, the :"furnace" could have been a blast furnace; it could have been a small farrier's shop. Follow-up field work usually uncovers the secret, although a knowledge of the furnace structure and dimensions is important for interpreting the remains in addition to being able to recognize the site when it is seen.

The 19th century witnessed the final transition of the iron industry from the technically stagnant Middle Ages through the frenzied Industrial Revolution and into the 'modern' 20th century. During that 100-year period, the industry experienced so many technical improvements that many blast furnaces were obsolete a mere dozen years after they were built. A correct description of the industry and its furnace artifact for the 19th century is therefore impossible since no period is typical of the entire century.

The 1840s has been chosen for this period of description for a few reasons. For one, the 1840s was the period when the works' owners were comparing notes, sharing technical knowledge, and learning that "secret processes" were hindering not only the general growth of the industry but also their individual success. Owners were staring to recognize that iron making was a chemical process and that almost insignificant variances in furnace design and construction materials made significant changes to the quality and character of the final iron product. By the 1840s, the iron industry in Vermont was in transition, numbers of iron-making blast furnaces and bloomeries were decreasing while the manufacture of agricultural implements was increasing.

A few blast furnaces continued to operate in Vermont after the 1840s. The Green Mountain Iron Company stack at Forestdale to 1865 and the Vermont Iron Company stack at Pittsford to the 1870s (maybe 1880s?). But the 1840s generally mark the high water mark of blast furnace activity in Vermont. It is a good sample period.

## The Charcoal Blast Furnace

By the mid-1800s, blast furnaces fueled by anthracite (coke) were appearing in the Northeast. Anthracite was tried unsuccessfully at two places in Vermont. The abundant local forests, however, provided sufficient fuel for Vermont's blast furnaces. The charcoal blast furnace was generally 35 feet high and set 30 feet square at the base on a foundation 32 feet square and extended some 6 to 10 feet below ground. The walls of the stack sloped inward with height so that this 35-foot high stack was 15 feet square at the top, approximately a quarter the area of the base (figure 1). The outside walls were made of hard, dense stone, capable of withstanding the weight of everything above without cracking. This outside wall was sometime mortared. The inside walls, where the heat of the furnace reduced the ore, were made of a refractory quality stone, usually sandstone, although by the 1840s some type of refractory bricks (firebricks) were starting to appear.

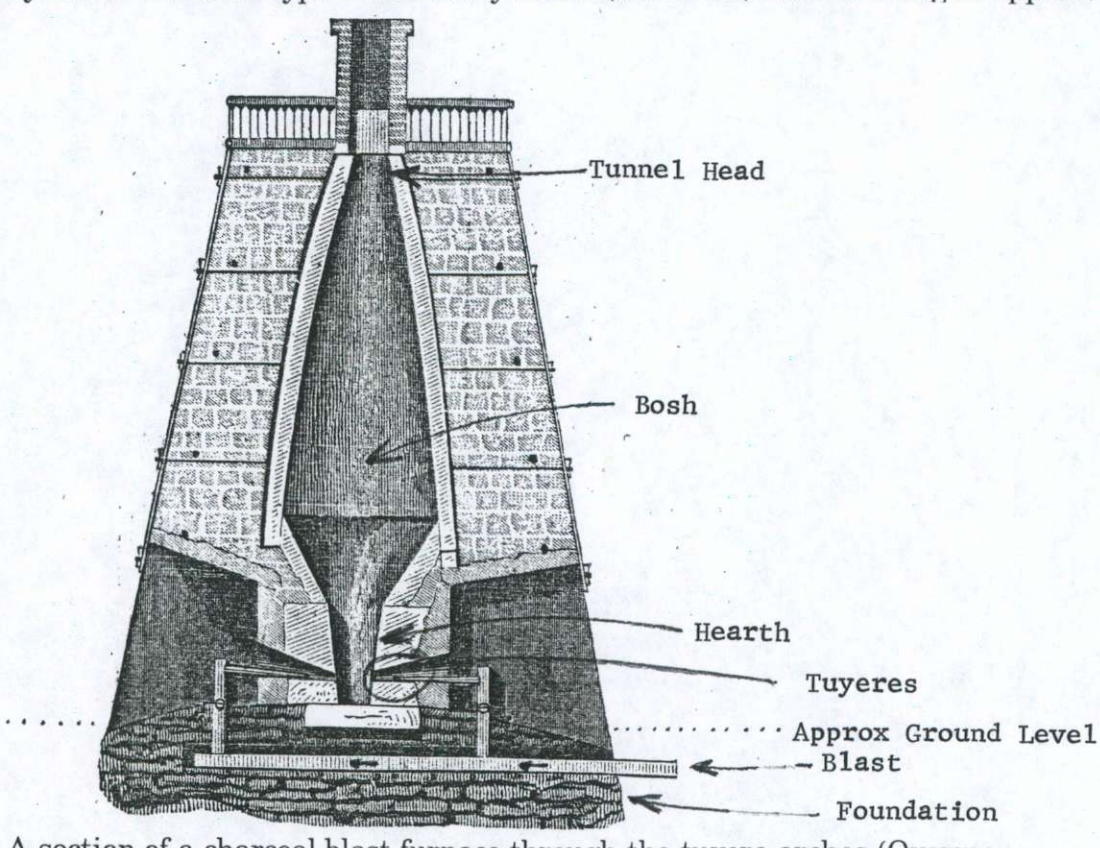



Figure 1. A section of a charcoal blast furnace through the tuyere arches (Overman 1850:153).

## Furnaces, Forges, and Foundries

As the name implies, the charcoal blast furnace was fueled by charcoal and its high temperatures were created by the forced blast of air. The blast was continuous, although at of a pressure of only ¼ to ½ pound per square inch, it was none-the-less of high volume, pumped by large bellows or air cylinders that were driven by a huge waterwheel. The blast was introduced into the furnace interior through cast a iron nozzle called a "tuyere" (pronounced: too-wee'-r), located inside the three tuyere arches. The fourth archway, the largest of the four, was the work arch, where ironworkers maintained the hearth and periodically tapped slag and molten iron from the furnace interior.

The blast furnace had one sole purpose, which was to reduce iron ore to molten iron that when cooled, became a relatively hard, high-carbon cast iron. The blast furnace ran night and day without stop, except for malfunctions. Continuous blasts lasted several months, sometimes 15 to 18 months. In Vermont, however, frozen winter streams limited blasts from spring to fall. The life of the firebrick usually defined the length of the blast. During the blast, all fuel, flux, and ore had to keep coming to the top of the furnace stack while molten slag and iron were drawn from the bottom. Nothing was allowed to interrupt the rhythm of wagons arriving and leaving, roads had to be kept clear, no holidays or weekends stopped the process (Rolando 1992:24-35).

### Ore Roasting Oven

After the iron ore was mined and crushed, separated, and washed, but before it was prepared for charging into the blast furnace, it was sometimes roasted. The process of roasting the ore removed such impurities as sulfur, hydrogen, chloride, arsenic, and phosphorous. These were drawn off as gas, and in the case of sulfur, also reduced the chance of explosion inside the blast furnace. Although called roasting ovens, they had all the external appearances (as also did some lime kilns) of a short, 12- to 18-foot high blast furnace (figure 2).

Raw ore mixed with charcoal was loaded into the oven through the large opening at the top, a fire of wood or charcoal started at the bottom, and the whole mass smoldered, roasting away water and gas. When complete, the bottom grates were pulled out and the treated ore shoveled into waiting wagons. An oven of 50 tons initial capacity yielded 30 tons of roasted ore every 24 hours. (The process is very similar to that employed at lime kilns.)

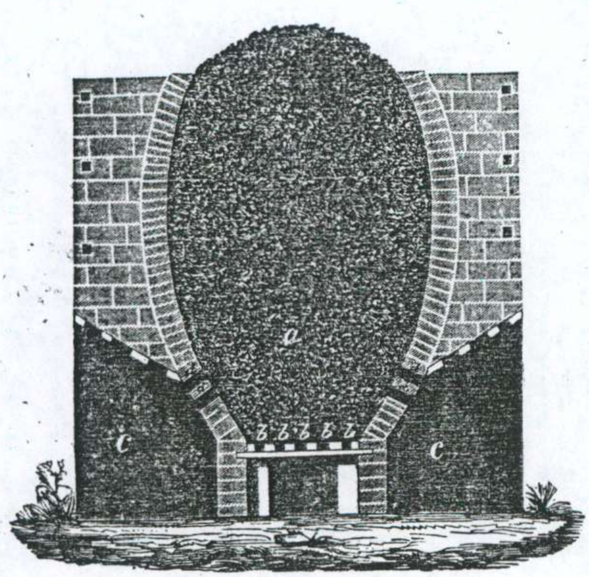


Figure 2. A section through an ore roasting oven (Overman 1850:41).

Hot Blast Oven

A significant technical improvement to the blast furnace made in the early 19th century was that of preheating the blast. This was found to significantly increase the smelting temperature and reduce the charcoal-to-iron ratio. Initial heating ovens were small stoves that stood next to the base of the blast furnace through which passed thin-walled pipes carrying outside cold air from the bellows to the tuyeres. The pipes were heated by fire in the stove fueled by charcoal or wood. In time, the ground-based stove was replaced in favor of utilizing the heat of the waste gases exiting the top of the furnace stack (figure 3).

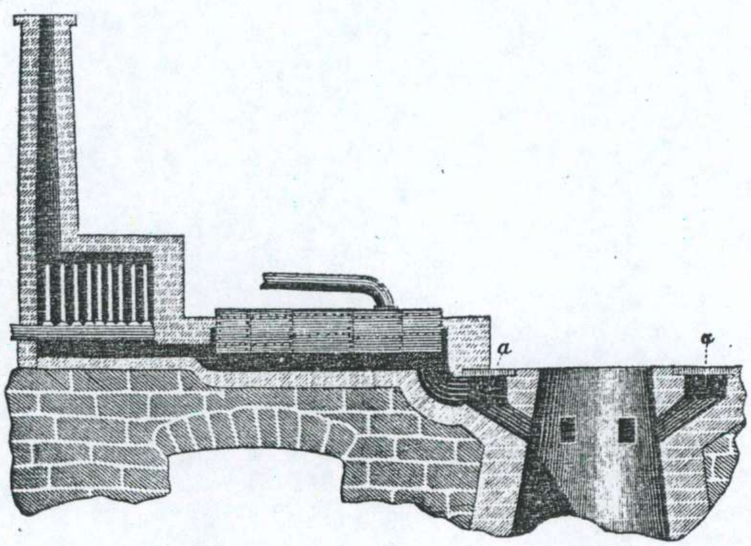



Figure 3. A hot blast oven atop the blast furnace stack, showing how hot exhaust gas was tapped (Overman 1850:450).

In practice, the pipe containing cold, damp outside air traveled from the bellows up the outside of the blast furnace wall to the top. Here, a small brick chamber (stove) conveyed hot waste gas around the air pipes, heating and drying the air. The somewhat cooled waste gases expelled out the other end of the oven while the heated air was forced (by cooled air being pumped into the oven) down a slightly larger pipe (warm air expands) called a down-comer that traveled down inside the furnace (between the outer and inner walls) to keep it warm. At the bottom, another pipe that circled the hearth called a bustle pipe conveyed the heated air to the three tuyeres. Hot blast ovens were capable of raising air blast temperatures to 600° F. Although not generally used in the industry until the 1840-50 period, a blast furnace at Bennington, Vermont, experimented with hot blast in the early 1830s. A circa 1900 photo of the Forestdale furnace ruins clearly shows oven remains (which no longer exist), at the top of the stack.

## Cupola (Air) Furnace

Even within the iron industry, the cupola furnace should have more than one definition. One type of cupola furnace (figure 4) was a cupola-shaped blast furnace, so named for its similarity to the cupola furnace of the foundry. It was a poor type of blast furnace because the walls were too thin to insulate and hold its heat. Its only advantage over the usual type blast furnace was its relatively inexpensive construction cost.

The foundry cupola furnace was a tall, round furnace that served merely to melt pig and scrap iron for use in manufacture of castings. This cupola had a high height-to-diameter ratio, sometimes reaching 25 to 30 feet high with only a 4 to 6-foot diameter. Pig and scrap iron (and sometimes even some iron ore to affect the character of the iron) mixed with charcoal or coke were loaded through a side door about 10 feet above the hearth. A ring of tuyeres at the hearth provided hot blast that melted everything inside. The molten iron was either cast direct at the foundry or molded into ingots for later use or sale to other foundries. Cupolas were the standard furnace in Vermont foundries that cast stoves, farming implements, pots and kettles (hollow ware), mill gearing, and railroad and machine castings. Advertisements in ca. 1790-1850 newspapers for "pot metal wanted for our furnace" were looking for scrap iron (old iron pots) for melting in the foundry cupola. The cupola furnace essentially relieved the blast furnace of casting; the latter just made iron while the cupola cast it.

By the late 19th century, cupola furnaces were made of sections of hollow cast plates. Water circulated inside the plates to prevent them from melting. The cupolas were 2 to 3 floors high inside the foundry building and could be located from the outside by the tell-tale smoke-belching high chimney that extended above the foundry roof (figure 5).

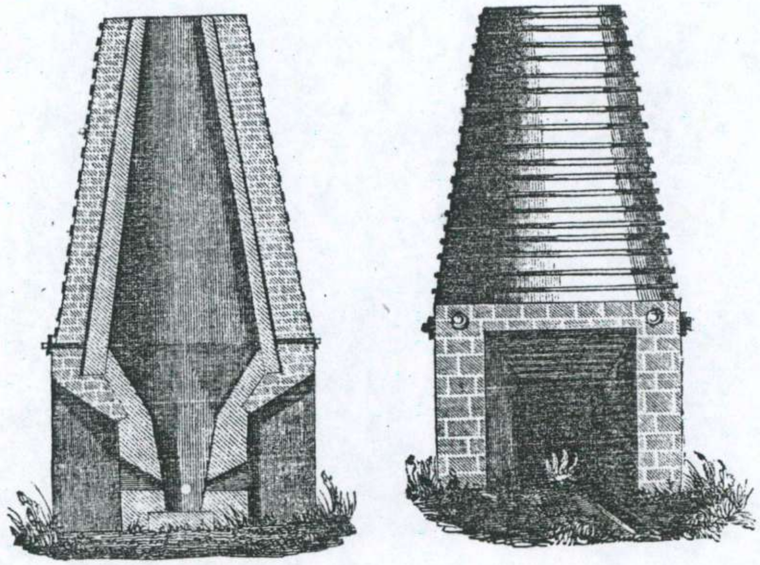


Figure 4. A section and interior (left), and front view (right) of a cupola blast furnace (Overman 1850:163).

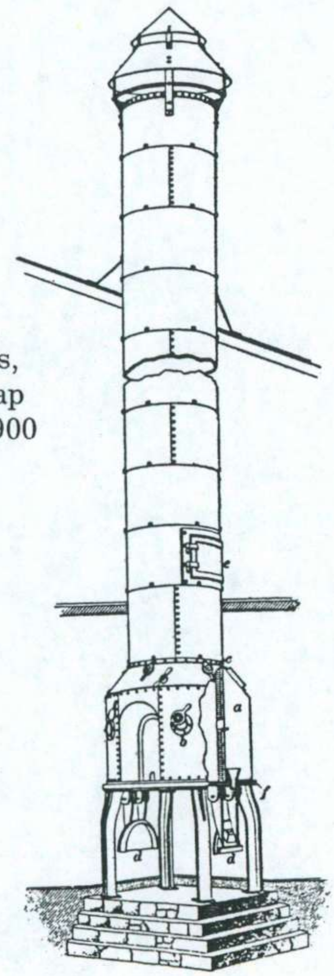


Figure 5. This, too, is an iron furnace, a cupola furnace found in old foundries, where it was used to melt pig and scrap iron for casting; it was built around 1900 (Weitzman 1980:165).

## Cementation Furnace

Before Henry Bessemer of England and William "Pig Iron" Kelley of Kentucky discovered methods of producing large quantities of steel quickly and cheaply, most steel was made by foundries in a low-volume time-consuming furnace called a cementation furnace. In this furnace, this iron bars of wrought iron were heated to just under melting temperature in sealed clay containers that contained loose charcoal dust. Under the influence of heat, carbon in the charcoal was absorbed by the iron, creating an iron bar with a wrought iron core under a steel surface. The action of the carbon on the iron created blotchy patterns looking like blisters, thus the name of blister steel. Much blister steel went into the manufacture of fine cutlery, springs, and edge tools (axes, chisels, saw blades, files, etc.), since the steel jacket allowed the iron to hold a fine cutting edge.

The furnace measured 12 to 15 feet wide by 20 to 25 feet deep. A conical chimney 40 to 45 feet high vented smoke and gas out the foundry roof. The iron bars were laid up in 10–

to 16-foot long by 2- to 3-foot square clay containers (figure 6). Two such containers of iron took 10 to 12 days to process. With the Bessemer converter, blister steel went out of fashion although many small rural foundries continued the process for specialized local applications in the manufacture of edge tools and framing implements (plows, shears, reapers, etc.).

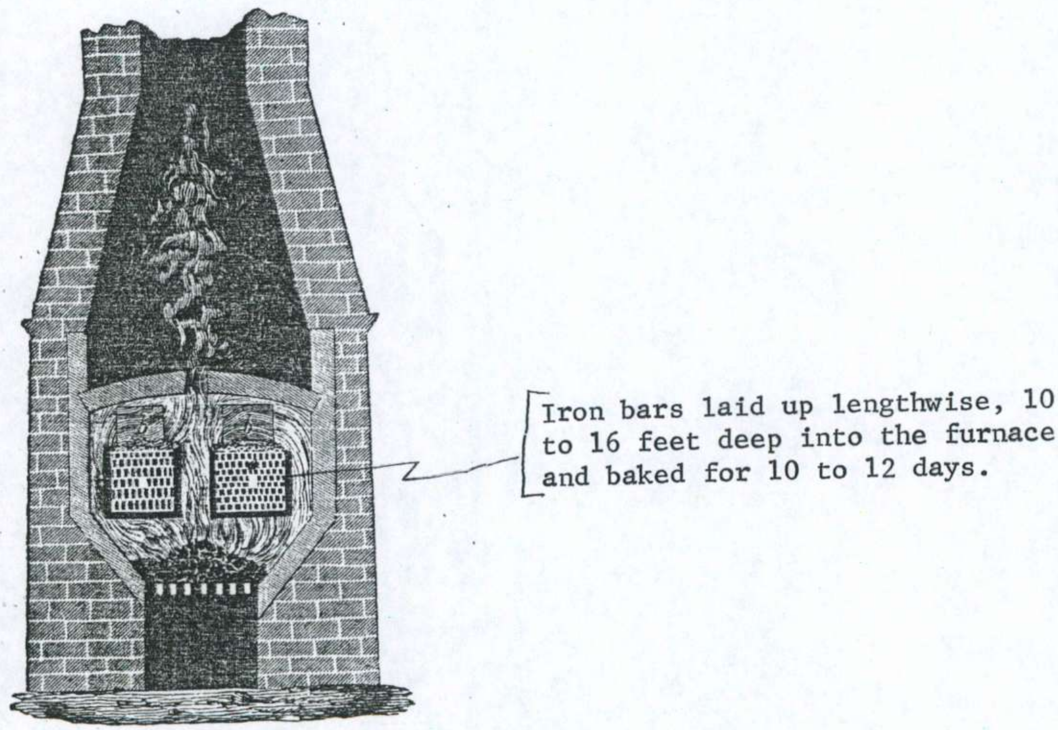



Figure 6. A cementation furnace for making blister steel (Overman 1850:471).

## Cast Steel Air Furnace

The only innovation in steel making between the colonial period and the Civil War was the crucible method. Much more complex and costly than the cementation process, in the crucible method, pieces of blister steel were broken and melted in refractory clay containers to produce a much better quality steel that possessed a uniform internal distribution of carbon. The product was called crucible steel or cast steel.

The crucibles were 5 inches wide by 18 inches deep and were made of a highly refractory slay mixed with charcoal dust. Hot gases were drawn from the furnace hearth through the crucible chamber and vented upward, out the chimney (figure 7). In some foundries, rows of these furnaces were built into the foundation of the building such that access to the crucibles was through a row of trap doors in the floor (figure 8). Each crucible contained about 50 pounds of steel and took 3 hours or longer to process. The crucibles were carefully lifted with long prongs and the steel poured into preheated molds.

Each furnace had its own crucible chamber and chimney, so that a row of chimneys on a foundry roof might mean a row of air furnaces beneath.

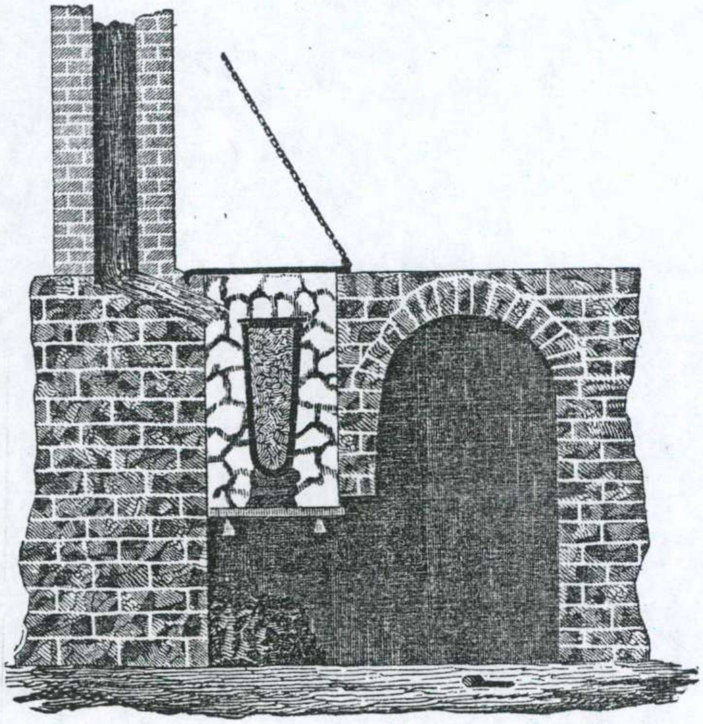


Figure 7. A cast steel air furnace showing the crucible in place in its compartment (left, center) under the door (Overman 1850:476).

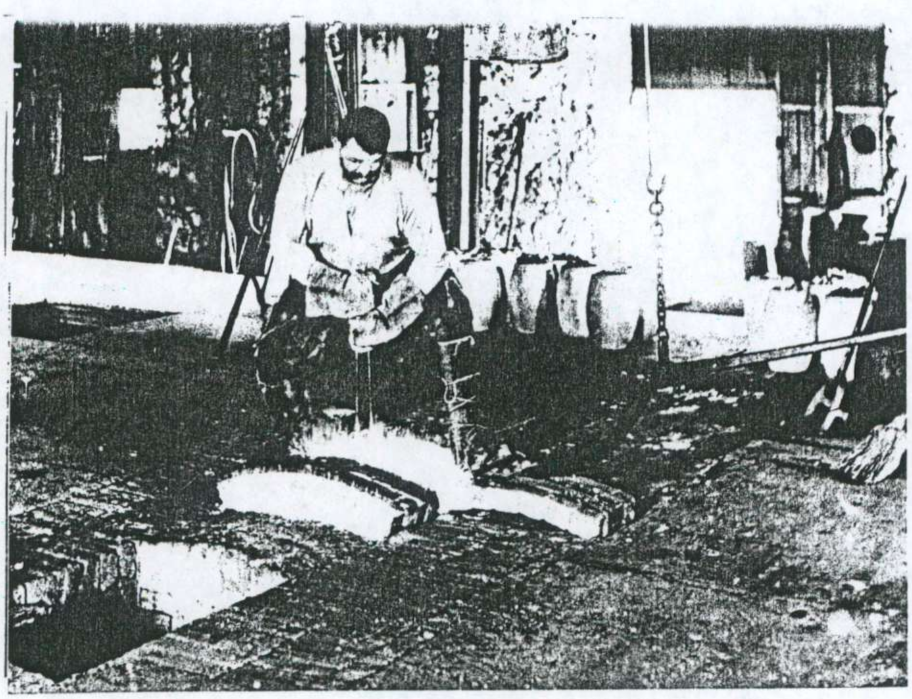


Figure 8. An iron worker lifting a crucible of steel from the furnace (Lewis 1976:36).

## Heating (Re-heating) Furnace

When iron was being worked at the foundry, that is, hammered, drawn, punched, etc., a means was required to keep the iron hot, lest it crack and/or deform. The heating furnace was the answer, which was nothing more than a long, narrow heated chamber (figure 9). In this furnace, hot burning gases were drawn from the hearth at the front end of the furnace, up and through a chamber in which iron rods, bars, or sheets were placed, and vented out a chimney. The heat was sufficient to keep the iron workable without melting or deforming it. While some bars were being heated, others were being worked, so that a number of pieces were processed at the same time. The furnace was generally rectangular in shape, about 8 or more feet wide, depending on the size of the work to be heated, and 5 or less feet deep, so as to maximize the heating effects of the burning gases. Charcoal coke, or coal was used for fuel; the tall exhaust chimneys provided good draft to "draw" the flames through the chamber.

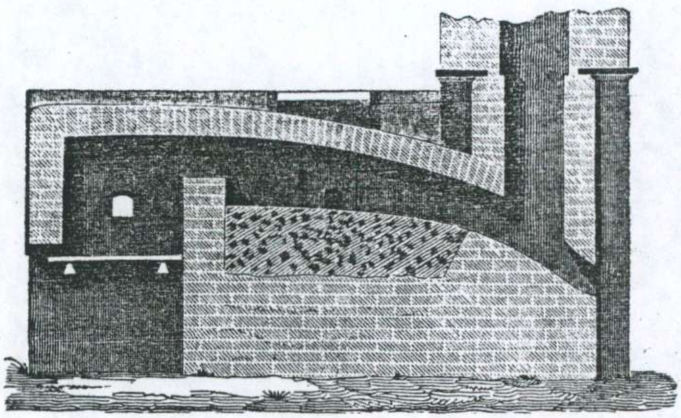


Figure 9. A section through a reheating furnace (Overman 1850:372).

## The Bloomery Forge

The availability of forests to provide fuel for making charcoal did as much to dictate location of the bloomery forge site as did the site's proximity to waterpower. Bits of slag in Near Eastern deserts betray an ancient catastrophic loss of local forests for making charcoal, at a time when the primitive methods of iron making consumed 70 pounds of charcoal for every pound of iron produced (Fleming Jul/Aug 1983:66).

Contrary to popular thought, unlimited hardwood forests were not everywhere available in the American Colonies to supply charcoal. The expensively high ratio of charcoal consumption to iron bar production caused many to consider bloomery forges as wasteful. One of these areas was Pennsylvania, where few bloomeries existed. There the blast furnace came into use instead from almost the birth of this frontier industry. The reverse was true in New England, where bloomeries thrived (Bining 1973:65). Colonial New England iron was therefore made primarily in bloomeries (Pearse 1876:101).

Vermont was no exception; there were many more bloomeries than blast furnaces.

Many of the early New England ironworks contained "complete works"—both blast furnace and bloomeries—rather than just one type of forge. These New England works were generally categorized as follows (Bining 1973:28): (1) smelting furnaces reduced crushed rock-bearing ore into pigs, with unlimited charcoal supply; (2) refinery forges imported pig iron from New York, Pennsylvania, and Maryland furnaces and converted it into bar iron; (3) bloomery forges reduced directly from bog ore (without an intermediary furnace operation) into blooms—but much inferior to those refined from pigs; (4) "bog ore" furnaces reduced bog ore and mainly cast holloware.

Few records dealing with the operations of forges in colonial America have survived but it is assumed the forge procedures and design in Vermont followed the English pattern. Generally, the English forge had two hearths (called fires in the 1780s and 1790s) to each trip-hammer. Plans of the forge at the 17th-century ironworks at Saugus, Massachusetts, contained this ratio. The 1765 forge at Charlotteburg, New Jersey (figure 10), had two sets of this 2-to-1 hearth-to-trip-hammer arrangement, each set using about 2,000 square feet of floor space (Lenik 1974:10). Ira Allen contracted for a forge at Tinmouth in 1791 with two fires. A year later he contracted for another forge in Shelburne measuring 50 by 40 feet, or 2,000 square feet (Wilbur vol. 2 1928:6, 27). Matthew Lyon sold his "two south fires together with a hammer, anvil, and coal house" at Fair Haven in 1794 (Adams 1870:142). It seems, therefore, that Vermont's earliest bloomeries, at least, followed somewhat in the pattern of English and colonial American bloomeries.

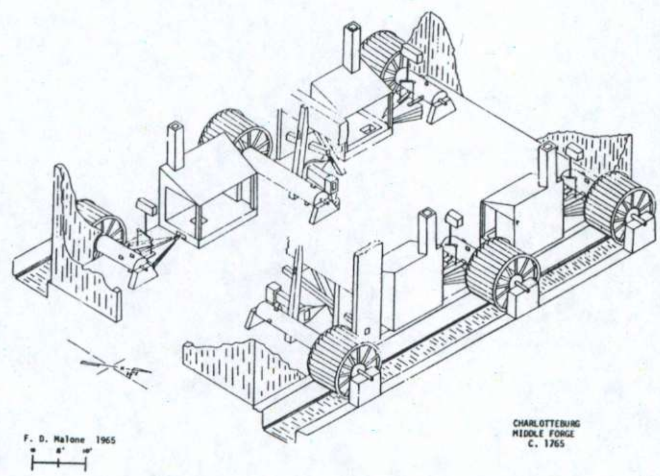



Figure 10. Ground plan of a bloomery forge at Charlotteburg, New Jersey, about 1765; typical in both layout of apparatus and area as those built by Ira Allen in Vermont during the 1780s (Lenik 1974:10).

Vermont bloomeries in the early 1800s were the latest improved version of the old Catalan forge (Overman 1850:245). No longer a small cup-shaped device, it had evolved to a 6- to 8-foot-square stonework table called the hearth, with a place for the fire 24 to 30 inches square, recessed 15 to 18 inches deep into one corner of the hearth. The hearth was 3 to 4 feet high. Through the back wall was an iron nozzle called the tuyere, which directed the preheated draft that was provided by the wooden bellows and waterwheel (figure 11). These were early predecessors to the Champlain Forge, which reduced magnetic ores. The Lake Champlain region, both the Vermont and New York sides, was regarded industry-wide as containing the best-known deposits of the time.

To reduce the ore in a bloomery, first the hearth was lined with charcoal, then coarse iron ore placed against the wall of the hearth opposite the tuyere, the fire set, and the draft gently directed against the ore. Charcoal and ore were added as the process continued, 400 pounds of ore being a common charge. Charcoal was piled 2 to 3 feet high against the back wall above the hearth. After 1½ to 2 hours the charge was reduced to a hot (but not red-hot) mass, pasty in consistency, like taffy or cold molasses. It was the skill and experience of the bloomer that made the critical difference whether the soft iron mass could be separated from enough charcoal and non-iron elements to result in a bloom of marketable value. Poor iron, with too high a ratio of non-iron elements remaining in the product, resembled no more than one large chunk of slag. The resulting bloom was therefore subject to considerable variation, depending on whether the bloomer considered the economy of charcoal or ore the object. By manipulating the tuyere to save charcoal he obtained a small yield of iron; or, he obtained more iron by burning more charcoal.

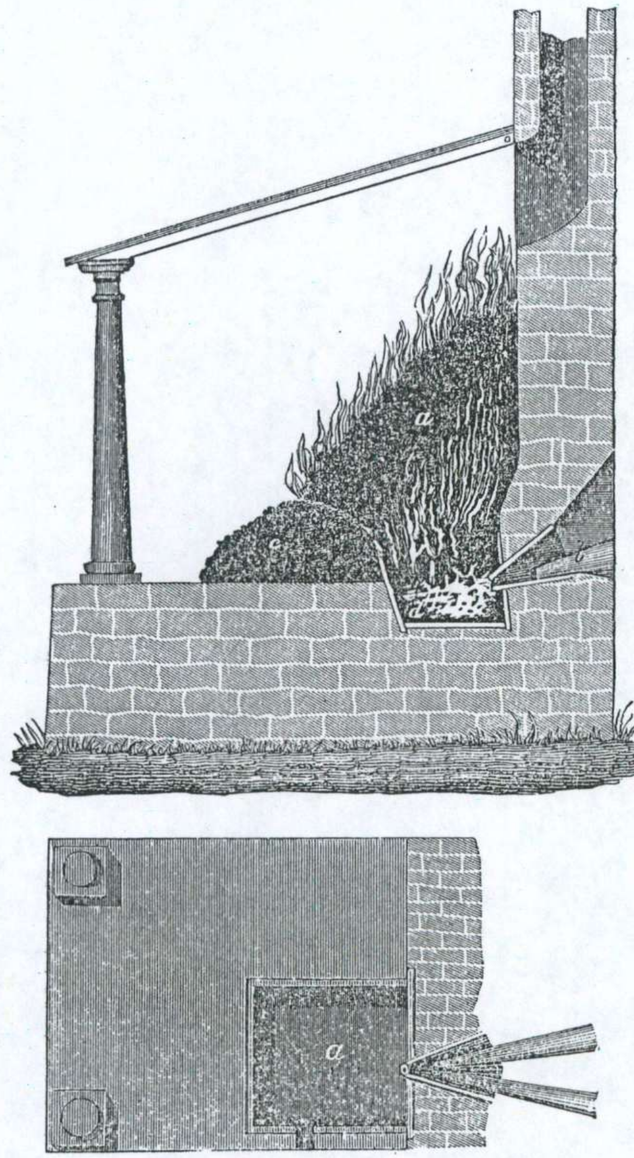



Figure 11. Vertical section of bloomery fire (top); plan at hearth level (bottom). Hearth at point "a" (Overman 1850: 246).

Good bloomers worked the iron mass in the hearth with long iron tools, slowly applying moderate draft, and turning and folding the charge (much like a baker kneading dough). The bloomer's job was to concentrate the iron within the charge into a coherent ball of iron, working out pieces of stone and non-iron material. Some of the non-iron material might melt and run out of the charge as droplets of slag, but usually the charge looked like one large mass of debris, except to the eye of the expert bloomer. When he judged the time had come, the bloomer separated the last significant parts of the slag from the charge and lifted what had now become a bloom out of the hearth with heavy, long-handled iron tongs. If the bloom was no larger than a basketball in size, it may have weighed about 100 pounds (not including the weight of the tongs) and could be lifted out by a single bloomer. But if the hearth capacity was larger, the bloom might weigh up to 500 pounds. That size bloom required lifting by two or more workers with specially large tongs that were sometimes connected waist-high by chains to an overhead support beam. The iron workers could then swivel the bloom up and out of the hearth to an adjacent anvil where the bloom was worked on by a trip-hammer to squeeze out the non-iron particles, returned to the hearth for further heating, then underwent repeated hammering. The process eventually shaped the bloom into a long, thick bar, which could be rolled into smaller bars and cut into individual 1-cwt pieces (merchant iron). Waste material left in the hearth, although much of it contained iron, was cleaned out and discarded. The hearth was recharged before it cooled and the process repeated.

The bloomery process obviously wasted much good iron, especially at bloomeries that operated before 1800, when American bloomers had not fully developed the necessary skills and hearths had not incorporated the latest technology. The British made sure the American Colonies did not have access to the latest developments from Europe. Slag from many early bloomeries contained so much reworkable iron that some of the slag heaps were later "mined" and remelted.

Slag from many early- to mid-19th-century Vermont bloomery sites is likewise dark and heavy, loaded with wasted iron. Not shiny and light in weight like slag from blast furnaces, bloomery slag is dull-looking, appearing like something from outer space. Hefting a piece in one hand while holding a similar-size rock in the other will immediately betray the difference in weight, the heavier being the slag.

Despite later improvements, the bloomery process remained an apparently inefficient one. Yet it remained popular because the bloomery forge required a much smaller initial investment of money and labor than that of building a blast furnace. Whereas the blast furnace, once fired, had to remain in continual day-and-night operation, month after month, the bloomery cycle ended with each final removal of the bloom from the hearth. The bloomery consumed much less fuel and time to come to temperature as compared to the large blast furnace, which took days to slowly bring up to operating temperature. The bloomery could more easily respond to fluctuations in the supply of ore and fuel, and to demands of the market. And since the domestic needs of blacksmiths who were making horseshoes and door hinges could be better met by the direct ore-reduction process of the bloomery, these small ironworks tucked away in mountain hollows became more significant contributors to the market needs of early Vermont than did the blast furnace.

On an average, it took 4 tons of ore and 300 bushels of charcoal to make a ton of iron. In Vermont bloomeries, where the rich magnetic ores were worked, a ton of iron in the 1840s cost about $40 to make. An ironworker earned an average of $10 per ton (Overman 1850:247-248).

There are numerous references to trip-hammers and trip-hammer shops throughout town and county histories. Trip-hammers were large, ponderous, and noisy hammers that might have been associated with a forge, but could also have been involved in other activities, including welding, plating, hammering edges on axes and knives, or stamping out small pieces of copper, iron, bronze, or leather for various mechanical, decorative, or architectural needs. Stamping didn't require much hammering force and as such, the hammers were quite small, on the order of 10- to 40-pound hammerheads and anvils. They were all waterpowered, but being small operations, could have been set up in modest shops near any small streams.

Most trip-hammers were associated with blacksmith shops or small foundries.

Hammers usually did not involve any furnace beyond a small charcoal hearth to heat metal, which made it easier to plate, edge, or stamp. Welding required an intense heat, enough to bring the metal to a cherry-red brightness before hammering, requiring a larger, bellows-driven heating furnace. Small welds, such as for wagon wheel rims, could be done by the blacksmith's rhythmical hammer. Larger welds for repairing cracked or broken castings were relegated to the trip-hammer at the forge. Both were noisy and scattered many sparks, much to the amusement of spectators.

The hammers used at the forge had hammerheads weighing from 50 to 400 pounds (figure 12). For drawing small-diameter iron, such as for nail rod, a hammerhead of 50 pounds was sufficient. Forging 60- to 100-pound blooms required a hammerhead of 300 to 400 pounds. These heads were made of strong-quality cast iron and were secured to the business end of the helve by wooden wedges. The other end of the helve was acted on by the waterwheel (Overman 1850:336-339).

In the usual arrangement, a cam wheel driven by the waterwheel struck forcibly downward on the helve, which, pivoting on a horizontal pin near its middle, raised the hammerhead end. The closer the pivot pin was located to the cam wheel end of the helve, the higher the hammerhead would be raised (much like adjusting a seesaw), and thus more striking force on the anvil would be obtained. But then a more powerful waterwheel was required (putting the heavier person at the short end of the seesaw), due to the additional torque now added to the hammer. Hickory or oak was most commonly used for making the helve.

The anvil, upon which the hammer worked the iron, equaled the hammerhead in weight. It was attached to the cut end of a 4-foot-diameter log that extended lengthwise 6 to 8 feet into the ground. Under that, a platform of pilings secured the anvil to a stable platform. At many forge sites long since abandoned or destroyed by fire, the location of the anvil is still marked by its deeply buried foundation. With that located, the rest of the forge remains can be approximated and found.

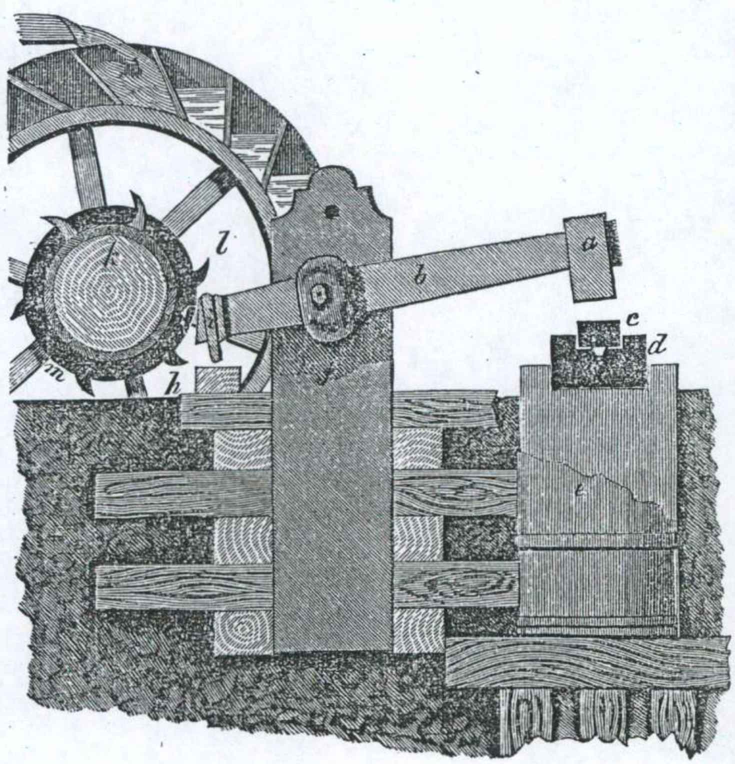



Figure 12. Tilt hammer and foundation pilings (left) and helve ring (center). The helve ring served as the strong fulcrum on which the full weight of the helve rested (Overman 1850:335).

The cam wheel did not merely raise the hammerhead to let it drop to the anvil. When striking its end of the helve, it caused the opposite (bottom) edge of the helve to bounce off a large piece of timber. This bounce im-parted to the hammerhead the effect of a recoil and dramatically increased its striking force on the anvil. The faster the hammering speed (either by increasing the rotational speed of the waterwheel or by additional cams on the cam wheel), the greater the hammering force due to increased recoil action.

Hammers of this type were called German forge hammers, but they were commonly known in Vermont as trip-hammers or tilt hammers, from the actions of the mechanisms. A variation of the forge hammer that was more common in Europe had the cam wheel raising the hammerhead at that end, and was known as the T-hammer. By the 1840s, when most water-driven hammers were being replaced by steam hammers, bloomeries in Vermont were still utilizing the cheap and abundant water resources of the state. Only in foundries and heavy machine shops did steam, and later hydraulic, hammers make their appearance.

The process of hammering blooms was known in some sectors of the industry as shingling. It was usually used more in terms of hammering to remove (or squeeze out) solid bits of impurities such as slag, small stones, or unburned charcoal, rather than hammering the bloom into a uniformly shaped bar. A type of hammerhead with a beveled face called a squeezer was sometimes employed for shingling. An "iron and shingle mill," therefore, did not refer to the manufacture of house shingles.

Another process of producing wrought iron was to refine pig iron from the blast furnace and convert it in the puddling furnace. Refining meant cleansing the pig iron of most of its carbon and other impurities. It was called a puddling furnace because the pig iron was melted in a reverberatory-shaped chamber and worked in "puddles" into pasty balls, similar to the bloomery process. The puddling process took advantage of a major difference between wrought and cast iron: how their carbon content inversely affected their respective melting points. Cast iron, with a higher carbon content, melted at a lower temperature, about 2,100° F, whereas practically carbon-free wrought iron melted at about 2,500° F (Schuhmann, 1906). The heat in the puddling furnace was maintained high enough to melt the pig iron, but just short of the melting point of wrought iron. Additionally, by burning charcoal in one hearth and drawing the hot flaming gases over and through an adjoining hearth containing the pig iron, the iron was melted and its carbon burned away. Physical separation of the iron and charcoal in this horizontal-type furnace prevented charcoal carbon from replacing burned-away carbon. In the foundry, this separation-type furnace was known as an air furnace.

Puddlers stirred the molten iron with long iron rods that reached into the furnace through little holes in its side walls. The stirring action continuously brought higher-carbon iron from below the surface to be exposed to the carbon-consuming flames. As the carbon content of the iron was reduced, and therefore its melting point dropped, the iron commenced to congeal (come to nature). Lumps of this purified iron were removed from the furnace and worked at the hammer much like the bloom of the bloomery process. The puddling furnace product, however, was much more pure than that of the bloomery. The resultant iron bars hammered from puddled iron were called puddle bars or muck bars. They were cut into pieces 2 to 4 feet long, piled in stacks weighing upward to a ton, reheated in another furnace specially designed for this purpose (called a heating furnace), and each piece was finally rolled into merchant bars.

With the development and proliferation of puddling furnaces, a controversy arose regarding the quality of wrought iron made by the direct method—the bloomery—and the indirect method—puddled pig iron from the blast furnace. In the 1850s, when the two operations were operating neck-in-neck for supremacy, the consensus was in favor of the bloomery. One reason was that bloomeries produced in smaller quantities. This was an age when small quantity was still considered superior to large; only 25 years later the theme would switch to "big is better." The puddling furnace, which was consuming much more charcoal per ton of merchant bar, would evolve into an efficient process capable of turning out a most superior wrought iron from the most questionable grades of pig iron.

One significant improvement to the Catalan forge was made in the Adirondack bloomeries during the early 19th century. It consisted of preheating the blast, which was never done with the earliest Catalan forges (Swank 1892:107). The improvement seems to have been copied at the Fair Haven Iron Works; an 1866 description of the bloomeries includes three arched pipes for preheating the blast above each bloomery hearth (Neilson 1866:227). Since it was an American improvement, it became known as the American Bloomery, although in the New York and New England area it was called the Champlain Forge (figures 13 and 14) (Egleston Sept. 1879:515). "The Catalan Forge in this country took the form of the Champlain Forge, which had the blast heated by the waste flames from the forge. These waste flames heated a coil through which the blast was blown, thereby cutting down the fuel requirement. The Champlain Forge, of considerable importance in the development of the early iron industry in the northern Appalachian areas, was capable of producing an iron with an almost complete absence of phosphorus and sulfur" (Kirk and Othmer vol. 8 1952:25).

Physical details of the Champlain Forge were described in 1879 as follows:

> The furnace in which the ore is reduced and the bloom is made consists of a series of cast-iron plates, 2 to 3 inches in thickness, securely fastened together, forming a rectangular opening, which, at the bottom, varies from 24 to 30 inches, at right angles to the tuyere, and 27 to 32 inches parallel to it. On the back side, parallel to the tuyere, it is 28 to 36 inches high. On the front this plate is cut down to from 15 to 19 inches, to make a place for a small platform, or shelf, called a fore plate. The bellows space, where the operation of reduction is carried on, is thus rectangular in shape, and is called the firebox. Its walls are usually vertical, except the fore and skew plates, which are generally inclined, but sometimes they are made to incline outward at the rate of 1 inch in 7.
>
> Each one of the plates forming the sides of the furnace had a name and a special duty. They are sometimes made of more than one piece, and are not always of exactly the same shape, nor are they always put together in exactly the same way in different works, but the variations are not very essential. Their size varies also with capacity of the furnace, but their office is the same in all. Those plates most exposed to the direct action of the fire are usually cast with holes in them, into which pieces, called repair pieces, are made to fit, so that they can easily be removed and replaced when worn out (Egleston Sept. 1879:518–519).

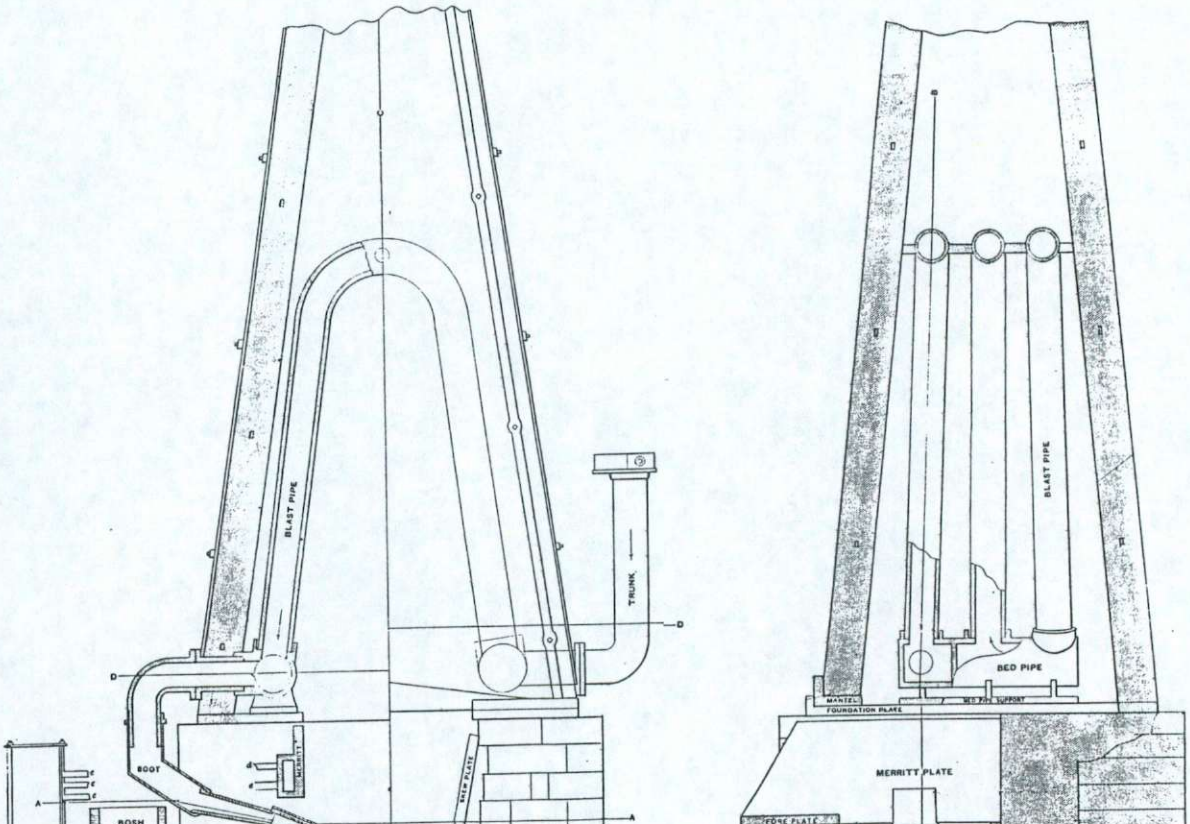



Figure 13. A three-pipe variety Champlain Forge, used at Saranac, New York, but typical of that which operated at East Middlebury (Egleston Sept. 1879: plate 4).

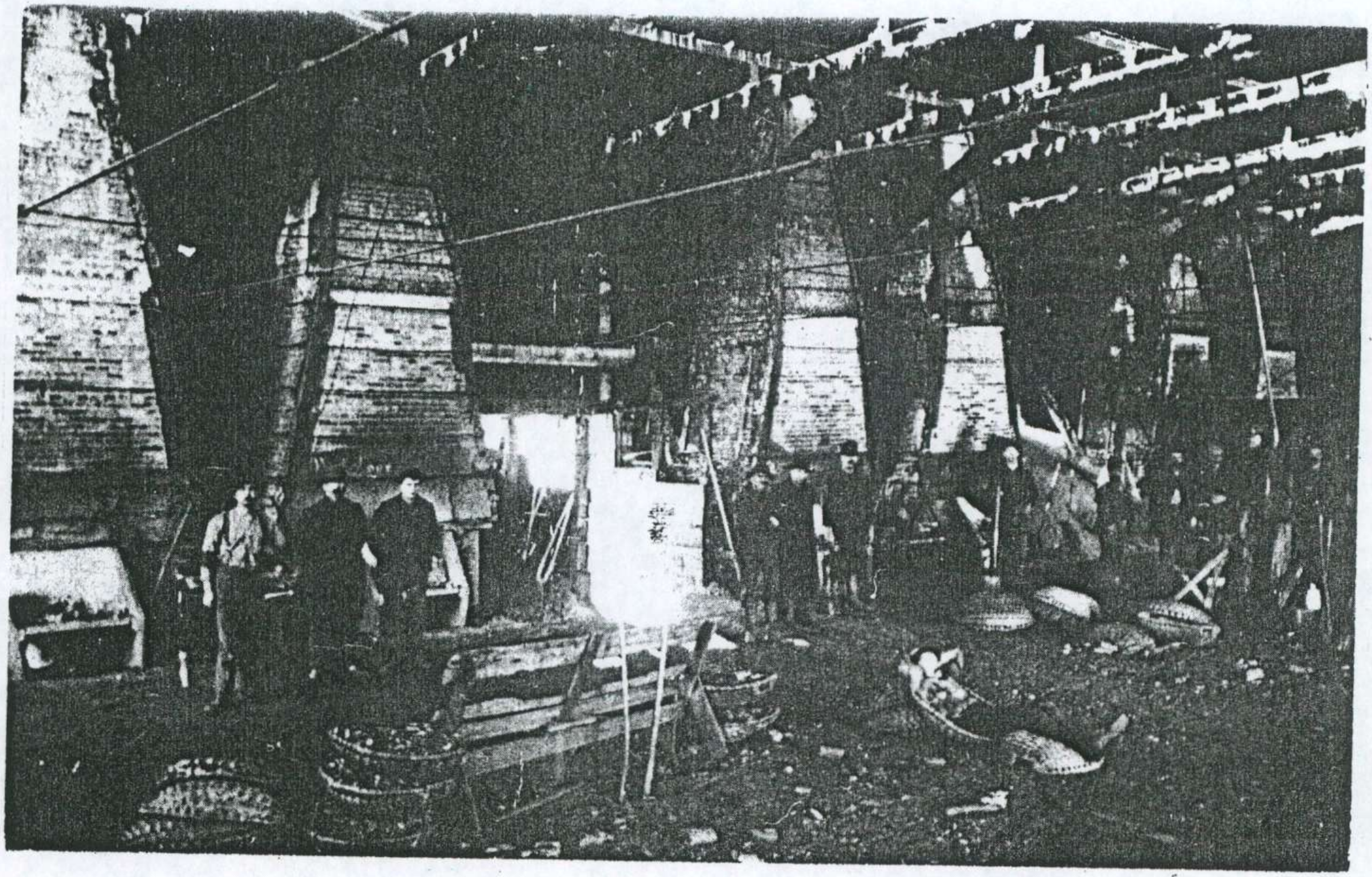


Figure 14. Interior view of the forge at Jay, New York, in 1888, but probably very similar in appearance to that at East Middlebury, Vermont, in the 1880s. Notice that forge hearths were built on the dirt floor. Man at right-foreground is lying in a charcoal basket (courtesy Adirondack Museum).

Another contemporary report described the hearth area varying from 27 by 30 inches to 28 by 32 inches, with the height from 20 to 25 inches above the tuyeres and 8 to 14 inches below:

> In the East Middlebury forges this bottom plate is 4 inches thick and has within it a hollow space of 4 inches. The side plates, which slope gently inward in descending, and rest on ledges on the bottom-plate, are 1¼ inches thick. A water box, measuring 12 by 8 inches, is let into the twyer-plate [sic], and a stream of cold water circulates through this box and through the bottom plate, as well as around the twyer [sic]. The length of the hearth, from the twyer plate to that opposite, is 24½ inches, and the breadth from front to rear is 29 inches. The twyer enters 12 inches above the bottom, and is inclined downwards at such an angle that the blast would strike the middle of the hearth. The opening of the twyer has the

form of the segment of a circle, and is 1 inch high by 1¾ inches wide. In front of the furnace, at 16 inches from the bottom, is placed a flat iron hearth, 18 inches wide. The side plate beneath it is provided with a tap hole, through which the melted slag or cinder may be drawn off from time to time. The iron plates used in the construction of these furnaces last for 2 years.

At East Middlebury . . . the estimated consumption of charcoal was 270 bushels to the ton of blooms, a result which is the mean of the figures obtained at the New Russia [N.Y.] forges. Some of the ores here used contain a little phosphate of lime, and it was observed that when too hot a blast was used, although the production of metal was rapid, the iron from these ores was hot-short, while with the cold blast, formerly employed, the iron, although produced more slowly, was never hot-short. The force of the blast at these forges was equal to 1¾ pounds and even 2 pounds to the inch. Mr. Pearson, the director of the East Middlebury forges, made, in the autumn of 1867, experiments on several tons of the iron sands from Seven Islands [Sept-Îles, Québec] and succeeded in obtaining from them about ⅝ths of their weight of good iron. He, however, found it necessary in order to treat these fine sands, to reduce very much the force of the blast. . . . It appears to be from ignorance of this fact, that the bloomers of New York had always rejected the fine sandy ore separated during the process of washing, as being unsuited for treatment in the bloomery fire (Hunt 1870:277–280).

Tools required at a typical Champlain Forge (Egleston Sept. 1879:536) were:

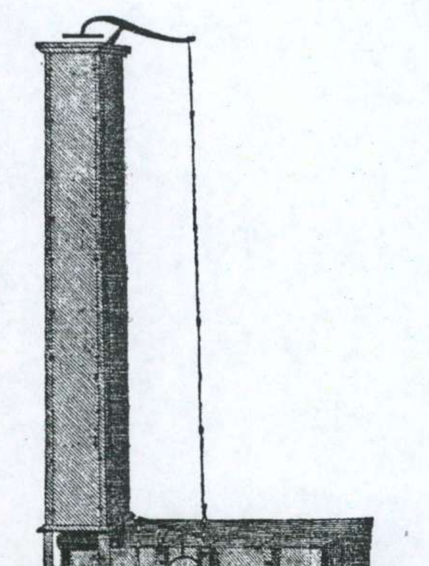
| | | |
|---|---|---|
| Bloom tongs | Foss hook | Sledge, 3 pound |
| Turn-bat | Cinder bar | Hammer, 1½ pound |
| Billet tongs | Tapping bar | Fore bar |
| Ore shovel | Furgen | Anvil |
| Fire shovel | Wringer | Piggin |

The U.S. Census of 1860 recorded three bloomery forges still operating in Vermont, the only report of such forges yet in operation throughout New England. The bloomeries reported an output of 1,400 tons of blooms. Neilson's 1866 report notes, however, that Vermont did not become the solitary producer of blooms until 1864, the last year that the bloomery fires ran at the Franklin Forge, New Hampshire. The only other bloomery then in New England was at Falls Village, Connecticut, which by that time had not run for some years (Neilson 1866:232–236). Vermont bloomeries were replaced by larger specialized operations such as the National Horse Nail Company at Vergennes. Some of the smaller forges continued supplying local blacksmith and foundry needs until cheaper puddled iron from outside the state closed them down. In the post-Civil War period bloomeries continued at East Middlebury, Fair Haven, and Salisbury. By the time the East Middlebury bloomery closed in 1890, the significance of Vermont's superior Lake Champlain magnetic ores had already passed into history (Swank 1892:113).

## Puddling Furnace

Similar in outward appearances to the heating furnace was the puddling furnace. This furnace converted cast (pig) iron from the blast furnace into wrought iron. The major characteristic of the process was separation of iron from fuel. The iron was heated and melted in a chamber physically removed from the hearth area, where carbon–containing charcoal, coke, or coal was burned. As the burning gases were drawn through the chamber, carbon in the molten cast iron was burned away. A worker stirred the molten iron with a long iron rod stuck through a small opening in the side wall of the furnace. The stirring exposed carbon–rich iron from under the surface to the burning (refining) action of the heat. As the iron lost its carbon, its relative melting point dropped and it started to congeal on the worker's stirring rod. It was then formed (puddled) into a ball of iron, removed from the furnace, and hammered into a bar. The result, wrought iron, was practically devoid of carbon, was highly malleable, and was sold as bar iron (merchant iron). The ironworker was stirred the ball was called a puddler.

The puddling furnace was about 12 feet deep by 5 feet high and 5 feet wide. The chimney rose 30 to 40 feet, affording good draw for the furnace (figure 15). After the furnace is brought up to temperature, which might take days to stabilize if fired from a cold start, iron is thrown in and all doors sealed. In about 15 minutes the iron should be glowing red; in 30 minutes white, ready to melt; and in 45 minutes, the puddler starts to stir the iron. Iron balls were usually limited to about 15 inches in diameter and weighed



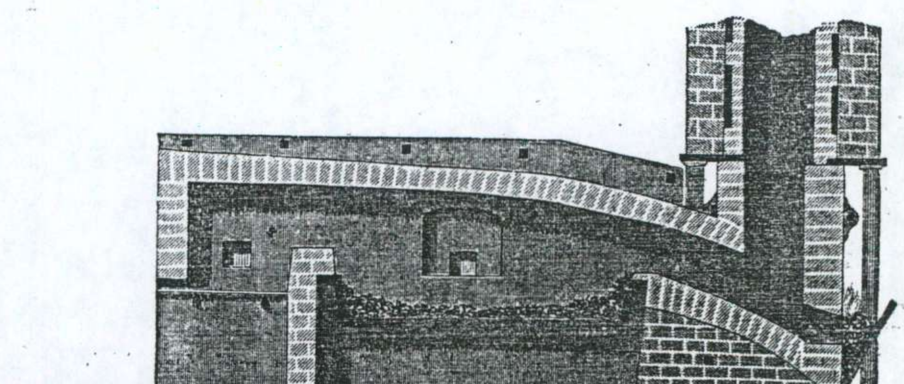


Figure 15. Puddling furnace elevation (left) and vertical section (right). Notice similarity to figure 9 (Overman 1850:260, 264).

70 to 80 pounds. The cycle took an hour to complete, from initial charging to drawing out the hot, pasty iron ball.

Puddling furnaces generally replaced bloomery furnaces throughout the country during the last half of the 19th century. In Vermont, however, bloomeries continued to operate to about 1880 (East Middlebury). Bloomery iron, the direct method of making wrought iron, although a slower and more expensive process, was considered by many at the time to be superior to puddled iron.

## Pocket Furnace

Pocket furnaces are the most deceptive category of furnaces encountered in text. Mid-19th century histories abound with references to "pocket furnaces" with no further explanation as to what they are. A pocket furnaces was referred to operating at Beeman's Hollow (New Haven, Vt.) sometime before 1830 along with trip and blacksmith shops (Smith 1880:146). Since a blacksmith shop is mentioned separately, the pocket furnace can't be construed to have been the blacksmith shop.

A book published by U.S. Steel in 1949 includes an illustration of a diminutive blast furnace with the caption "Pioneers made iron whenever possible, as in this wilderness blast furnace. Note foot-operated bellows." (figure 16). Shown is what appears to be a scaled-down version of a blast furnace, complete with binders, bellows, and casting archway. Charcoal and iron ore are shown being dropped into the top and what appears to be white-hot molten iron is flowing from a tap hole near the bottom.

An letter to U.S. Steel a few years ago as to the source of the illustration and its explanation resulted in nothing more than "Mr Fisher [the book's author] is no longer with U.S. Steel." I am left with my own thoughts and guesses as to what this is.

My best guess, assuming it actually existed and operated as shown made pig iron, that is) might have been a "testing furnace," for determining the quality of the ore before erecting a full-sized blast furnace. I have not found anywhere in any technical literature anything that hints of testing the ore in a diminutive furnace. More likely, ore was shipped to an operating full-size blast furnace and smelted there.

The pocket furnace remains a mystery.

Figure 16. Pocket Furnace? (Fisher 1949:18).

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NO. 32 AUGUST, 1980

# VAS newsletter....

A PUBLICATION OF THE VERMONT ARCHAEOLOGICAL SOCIETY, INC.

A notice in the last issue told you that Jim Petersen's monograph was being shipped to you immediately under separate cover. Subsequently, the Board decided to distribute as many as possible at the Spring meeting to save postage, and so I got a lot of inquiring mail. Copies were distributed to members of record at the time of the Spring meeting (May 10) at no charge. If your 1980 dues were paid by that time and you have not received your copy, please notify me at Box 663, Burlington, VT 05402.

Joseph Popecki
Treasurer, VAS

## GEOMORPHOLOGICAL SUMMARY OF THE WINOOSKI SITE

DOC 17201

By Peter Beblowski

The Winooski site (VT-CH-46) occupies an area of approximately 43,000 square ~~miles~~ feet of floodplain on the north bank of the Winooski River, one mile downstream from the Routes 2 & 7 bridge over the river, in the town of Winooski VT. The University of Vermont Department of Anthropology's 1978 excavation of portions of the site revealed that it contained multiple components, the most extensive of which date back to the Middle Woodland Period.

The Winooski site's stratigraphy is representative of an alluvial floodplain, with its textural character dominated by fine sands and course silts. Compositionally, the sediments may be described as mature and multi-generational, composed primarily of quartz. The fine grained nature of the site's soil components is indicative of vertical accretion of sediments during overbank flooding - this depositional pattern has probably existed for the past 4,000 years. The site area's seemingly stable sediment accumulation rate of roughly 50 centimeters per thousand years (even with an upper rate of 80 centimeters per thousand years for a portion of the riverbank levee) lends itself to a model of relatively steady-state aggradation.

Sediment accumulation at the Winooski site is influenced by a "downstream control system" which causes the deposition of fine-

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## Search for Vermont Furnaces Yields Dramatic Discoveries

DOC 17202

By Victor R. Rolando

Wrought and cast iron were made in at least 62 bloomery forge and 18 blast furnace sites in Vermont between 1775 and 1890. During this period, 75 bloomery forges and 28 blast furnaces were fired at these sites (Rolando 1980:107-113). Field investigations made in 1978 and 1979 to locate the surface remains of nine of these forges resulted in a few bits of slag, one flume and one possible dam site. The search for blast furnace sites, however, has netted more dramatic discoveries. Standing ruins of blast furnace stacks exist in Bennington, Dorset, Forestdale, Pittsford, and Troy. Trace ruins are also identifiable in Tinmouth and Plymouth. The remaining sites, which display either questionable or no surface evidence are in Brandon, Fair Haven, Shaftsbury, Sheldon, St.-Johnsbury, Vergennes, and Woodford.

These blast furnaces measure 20 to 30 feet square at the base and 23 to 40 feet high, tapering inward from the base. The outside walls of the earlier furnaces, such as those in Bennington, Dorset, and Troy, are of coarsely laid rough cut (or uncut) stone. Walls of the later blast furnaces at Forestdale and Pittsford are of uniformly laid large finished stone. All walls were laid without mortar or cement.

Each blast furnace was built close enough to a low hill to allow a short bridge to connect the hilltop to the top of the furnace, affording the means of charging the furnace with iron ore, fuel, and flux. Iron ore was mined locally and sometimes mixed with ore from New York State. The fuel was charcoal, made in kilns located in the surrounding forests or at the furnace site. Anthracite coal was considered at Dorset (Neilson n.d.:220), and actually used without success in 1854 at the Forestdale stack (Lesley 1859 b:25). At the Conant furnace in Bradon, a dense peat called lignite ("brown coal") was used to supplement expensive charcoal. To facilitate removal of impurities from the iron, a limestone flux was added to the charge of iron and coal. The limestone combined with the impurities to form slag, visible at most furnace sites as multicolored "stone".

➧ 2

## 1 ➧ WINOOSKI

grained material on floodplains, lawns, terraces and backswamps. Downstream control of a fluvial system is synonymous with "base level control." The surface of Lake Champlain has been identified as the base level for the aggradational system operable at the Winooski site. It is interesting to note that the sediment accumulation rate perceived at the site paralle's a slow but steady rise which has been projected for Lake Champlain, surface level. This projected use is approximately 80 centimeters per thousand years over the past 4,000 years, and is derived from a straight-line projection from two known points representing lake levels at particular times.

In a downstream aggradational control system, a "sedimentary wedge" is developed which becomes thicker as one approaches the control point, in this case the Lake Champlain shoreline. As a consequence prehistoric human occupation surfaces (sites) of any particular age on the Winooski floodplain are under a thicker mantle of sedimentary material the closer they are to the lake, given no major breaks in the stratigraphic record.

The Winooski site, it must be remembered, is but a small component of a large and complicated environmental system. With no comparative date to shape a geomorphological model around, the conclusions presented above are necessarily tentative. They will be expanded on in the forthcoming Winooski site mitigation report. A more complete geological history of the lower Winooski River Valley, of vital importantance to prehistoric archaeologists, awaits the collection of further data.

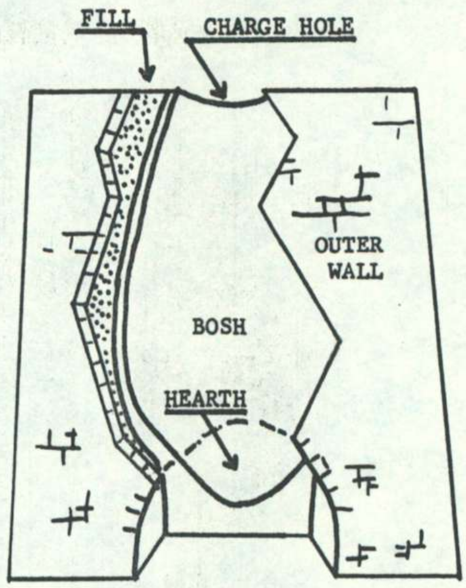
## 1 ➧ BLAST FURNACES

The forced draft for which the blast furnace was named was generated for earlier furnaces by large bellows, driven by waterwheels. Usually operated alternately and in pairs, 4-foot-wide by 20-foot-long bellows were not uncommon at the turn of the nineteenth century. Soon after, these bulky and cumbersome devices were replaced by wooden cylinders and pistons, the forerunners of today's air compressors. The 1839 alteration of Conant's furnace to accommodate two 6½-foot diameter cylinders is the earliest recorded use of these blast machines in Vermont (Lesley 1859 a:77). The cylinder heads were double-acting, with inlets and outlets closed by wood flap valves on leather hinges. (At a contemporary site at Tahawus, New York in 1977, I found the remains of wooden cylinders and pistons and their cast iron piston rods.) The pistons were operated by piston rods made either of cast iron or wood, (wood was used at Hopewell Furnace, Pennsylvania connected and driven from each side of the water wheel. The cylinders were mounted either next to the waterwheel (Tahawus) or on scaffolding above it (Hopewell).

The blast was connected to the furnace hearth through one of the arches at the base of the stack by cast iron nozzles called tuyeres. The tuyeres were usually double-walled and cooled by circulating water to keep them from melting.

Early blast furnaces had one or two arches; later furnaces had four. Early furnaces such as the ca.1820 stack in Bennington, employed corbelled arches with no decorative molded bands. The Dorset and Forestdale furnaces, of slightly later construction, contain splendid wedge-stone arches, while the Pittsford furnace, which operated until the 1880s has a three-tiered molding of mortared brick. The soffit, constructed of red brick underlain by yellow, extends the entire depth of the arch ceiling.

These archways also gave ironworkers access to the hearth, from which the molten iron and slag were periodically drawn off. The hearth sat at the center of the furnace base. It was massively walled and supported with stone and/or brick to support not only the heavy molten iron and slag in it but also the entire bosh, which extended to the top of the furnace. The bosh was the inner stone or brick-lined vertical cavity in which the actual melting took place. Its configuration was like an egg, standing on its wider end. It was at this wide point where the tuyeres were connected and melting temperatures were the highest.




*Cutaway view into a typical blast furnace.*

Early furnace boshes, such as one of those at Tinmouth, were lined with a hard stone possibly schist or gneiss. As the technology advanced, iron characteristics were found to be affected by the nature of the bosh lining, prompting the use of various refractory bricks. Bosh bricks from the ca.1840 Troy, Vermont, furnace appear to be ordinary red bricks; from the ca.1850 Forestdale furnace they are yellow firebrick made in Troy, New York.

Bosh brick is distinctive from decorative brick for its burned and/or glazed end, caused by the extreme heat in the hearth. Glass foundaries, bloomery forges, iron foundary cupola furnaces (air furnaces), lime kilns, and other metal processing furnaces also employ firebrick-lined hearths, as do present-day home heating gas and oil furnaces. Some firebricks were tapered to better fit the circular bosh configuration; all firebricks were mortared.

The space between the inner, circular bosh wall and the outer square furnace wall was filled with rough stone of all shapes and sizes. This fill provided an insulating jacket around the bosh and support to hold the bosh vertical. This fill is visible at the two Bennington furnaces, each of which is partially collapsed. Parts of the Forestdale and Pittsford furnace interiors are also exposed.

The two Bennington furnaces are located on private property off Route 9 at Furnace Grove. They are next to a residence which once served as the ironworks' company store and later as a chair factory. A good waterwheel pit remains next to the eastern stack, and a depression traces the route of the flume from the site of the forge pond to the wheel pit. Otherwise, all surface traces of bloomery forges, charcoal kilns, charging and casting shed, coal and ore houses, and a third smaller 'pocket' furnace (which stood between two stacks) are gone beneath gardens, lawn, roads, and underbrush.

The stack at Dorset stands on private property just west of a by-passed stretch of Route 7 one mile north of the town line. No other surface remains are visible. The Forestdale stack stands in a heavily wooded, state-owned area a few minutes' hike up an old road northeast of the villege. The Pittsford furnace is relatively hidden along Furnace Brook a mile northeast of Pittsford village. No surface remains except fallen arch and bosh bricks and much slag are visible at either of the latter two sites.

The most significant blast furnace site for the quantity and quality of interpretive surface remains is in Troy. This site is located about two and one-half miles north of Route 100 on the east bank of the Missisquoi River. It can be reached by a ten-minute hike through a pasture off River Road. The blast furnace was built in 1837 and abandoned in 1846 (Hemenway - 1877:325). It stands immediately downstream from a falls where a narrow gorge forms a right-angle bend in the river. An approximately 300-foot-long flume cuts diagonally across the inside of this bend, affording a good head at the waterwheel pit, near the stack. The flume is 15 to 20 feet wide and 6 to 10 feet deep, cut through the rock. The dam, which backed the water into the flume, was probably located in the narrow gorge although inspection during a low water period in 1979 failed to reveal any evidence here. Another possible dam location exists upstream, where the flume leaves the river.

The wheel pit is about 20 feet west of the furnace stack. A narrow rock-cut through a low hill between the stack and the pit leads to the speculation that (1) the blast machines were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MASTEN, ARTHUR H.
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NEILSON, WILLIAM G.
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THOMPSON, ZADOCK
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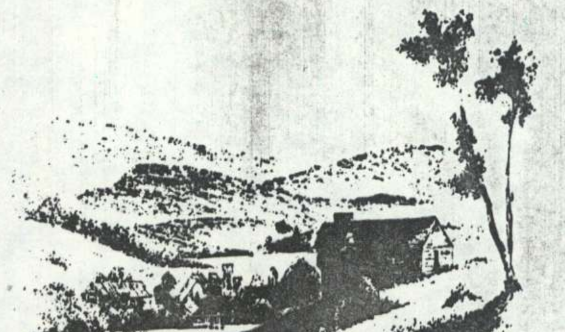
either located here, feeding air to a tuyere in a possible arch at the east wall, or (2) the waterwheel shaft came through this cut to power the machines closer to the stack. Locating the archways in the stack would help to interpret various features of the furnace site, but all walls except the southern one are partially collapsed, burying probable arch locations.

Directly east of the stack are stone walls, foundations, and an iron hollow-ware 43 inches in diameter and 23 inches deep, possible a potash kettle cast at the site. A tail race from one of the foundation holes may indicate a wheel pit that powered a bloomery forge or a cupola furnace for remelting and casting stoves, hollow-ware, and boundary markers. (Many of the latter, cast at this furnace, were used along the nearby international boundary.) Glazed firebricks are found in and around this hole. Heavy iron mounting, possibly to support a waterwheel, lie at one corner of the foundation. A small now-dry inlet in one side of the foundation could have fed water to run the wheel, but its connection to the flume or river cannot be found. Slag and waste iron are scattered throughout the immediate furnace area.

During its active ironmaking days, the furnace stack was probably abutted by buildings, in contrast to today's open appearance. These buildings would have protected the blast machines and casting activities around the base of the furnace and the charging operations at the top. The charging house sat directly on the furnace with a tall chimney that vented smoke and stack gases away from the work areas. Foundations on the charging hill behind the furnace indicate that the charging bridge might also have been enclosed. A sketch of a ca.1844 blast furnace at Tahawus, New York, which is contemporary with the Troy furnace in time and wilderness environment, indicates a likely configuration of the immediate furnace structures (Masten 1968:132).




*A ca. 1844 blast furnace complex at Tahawus, New York, a contemporary of the Troy, Vermont furnace. (Masten 1968:132)*

Threading through the rubble of the collapsed furnace walls are the twisted iron straps that held the stack walls together. Their ends are slotted for pins to hold iron end plates snugly against the wall. All pins have been removed, even from the undisturbed wall, but the only end plate was found a few dozen feet downstream, in knee-deep water. The vicinity of the river near the furnace should not be overlooked in a search for artifacts.

The ironworks supported a villege that had a boarding house and post office (Thompson 1842:174). No trace of villege cellar holes could be found. They may have been in the relatively smooth pasture that now borders the wooded furnace site. The old road that ran parallel to River Road leads down through the woods to the southeast and uphill out of the woods east of the rail race. The road is indicated on Beers' Atlas, and shows structures in the ironworks vicinity (Beers 1878:50).

Vigilance is one response to threats to archaeological and historic resources. But vigilance must be coupled with accurate identification and an ongoing inventory of sites. Unlike blast furnace sites that were destroyed years ago by later mills in Sheldon, a hydroelectric power station and recently a sewage treatment facility in Vergennes, and industrial development in St. Johnsbury, the Troy furnace site has managed to escape relatively undisturbed. This is largely to its remote location. The Troy furnace site does, however, fall well within an area of the upper Missisquoi River that is threatened with inundation by the proposed construction of a high dam about two miles downstream. This would place most of the Troy ironmaking site under 25 feet of water.

Assisted by an inventory, the Vermont Division of Historic Preservation, already accomplished for the majority of the bloomery forge and blast sites in Vermont, the UVM contract archaeology team has started initial documentation of this potentially sensitive archaeological site plus an earlier bloomery forge site two miles upstream. This effort also includes the identification of other historic and prehistoric sites at this and five proposed downstream dam sites. The result of this identification effort will allow the Division for Historic Preservation to proceed effectively with compliance with federal and state historic preservation laws.

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(Cont. on pg. 3)

**VICTOR R. ROLANDO**
**RESEARCHER OF VERMONT INDUSTRY**
33 HOWARD STREET
PITTSFIELD, MASS. 01201
(413) 443-1461

July 6, 1987

RECEIVED JUL 8 1987

Giovanna Peebles, State Archaeologist
Division for Historic Preservation
58 East State Street
Montpelier, Vermont 05602

Dear Giovanna:

As you hopefully know by now, I am coming up to meet with Nancy Boone this Thursday (July 9) morning, to discuss where I go with what I've got so far on the NR effort. I also want to spend some time, if possible, in the State Geologist's office, looking into the whereabouts of former State Geologist Elbridge Jacobs' papers.

Back in the 1950's, Jacobs published a short article in the VHS Proc about blast furnaces in Vermont. His information, I have been able to find out, came from a 'manuscript' sent to him at his request from a friend, Charles Rufus Harte. Harte did a lot of ironworks research in Connecticut in the 1930's and 40's. Problem is, Jacobs, thanks to Harte, published data on blast furnaces in places and at dates in Vermont that I have been unable to confirm either historically or archaeologically.

I have been unable to find any record of the 'manuscript' that Harte sent to Jacobs; all the Harte names in the New Haven CT phone books apparently have no relation or knowledge of Charles R Harte. Harte, in a letter to Richard S. Allen in the 1950's siad that he had no copy of what he sent to Jacobs and took no responsibility for the accuracy of the content since he obtained all the information from town and county histories. But to this day, I have been unable to find the sources in any Vermont town and/or county history. So the mystery continues.

I thought that maybe, there might be some Jacobs Papers yet in the State Geologist's office, that I might be able to research. Life would be easier if I found out that the problems were due to misprints, but that is not likely. The Jacobs article in the VHS Proc in the 50's apparently raised a minor furor, witness the defensive nature of Harte's response to Rick Allen's query on just that question. Harte probably took his secret to the grave (I believe he died in the late 50's).

for Thurs afternoon

Anyway, the reason for all this is, could you phone the State Geologist' office for me to sort of 'grease the skids' so I can find out if there are any Jacobs papers there? Might anyone at that office know if his papers are elsewhere? I understand Jacobs taught at Norwich University; maybe his papers (if any) are there? If you can help me with a phone call, I will appreciate it. If you are too busy, I understand and can let this go to another time.

Thank you.

Vic

# 1984 BLAST FURNACE AND CHARCOAL KILN SURVEY

## 10/01/83 - 08/31/84

## COMPLETION REPORT

During the period October 1, 1983, to July 31, 1984, the 1984 Blast Furnace and Charcoal Kiln Survey project produced reports on eight charcoal kiln sites in Bennington County, a furnace in Rutland County and a stone-lined pit of uncertain origin in Rutland County. Both background research and site visits are involved in producing the reports.

Research results relating to this 1984 survey project were incorporated into a detailed, long manuscript submitted to the Division for Historic Preservation in April, 1984. The results of this year's survey are important because they serve to articulate new information about one of the subsystems of iron manufacture (charcoal making) with existing information about blast furnaces, ore mining and forges in Vermont. In addition, background research relating to the iron industry in Vermont generated an important hypothesis which will guide future data collection: Vermont iron makers were related to each other by marriage ties. Family connections formed the basis of capitalizing industry expansion and perhaps supplied industrial expertise for the expansion.

In addition to the Blast Furnace Inventory, a survey of metal truss bridges produced reports on and photographs for 23 iron truss bridges in Vermont.

## SITES ADDED TO STATE ARCHEOLOGICAL SITE INVENTORY

October 1, 1983 - July 31, 1984

| | | |
|---|---|---|
| 10/03/83 | Vt-BE-50 | Heartwellville Stone Kiln |
| 10/03/83 | Vt-BE-51 | Heartwellville Brick Kiln |
| 11/08/83 | Vt-BE-52 | Heartwellville Conical Kiln |
| 05/10/84 | Vt-BE-53 | Coty Kilns |
| 05/14/84 | Vt-BE-54 | Dutch Hill Charcoal Kilns |
| 04/30/84 | Vt-BE-55 | Cowan Brook Charcoal Kiln |
| 07/84 | Vt-BE-56 | Sterba Reservoir Charcoal Kilns |
| 05/27/84 | Vt-RU-99 | Colburn Furnace |
| 06/84 | Vt-RU-98 | Stone-Lined Pit |

STATE OF VERMONT

*AGENCY OF DEVELOPMENT AND COMMUNITY AFFAIRS*

TWX 710-225-8100

MONTPELIER, VERMONT 05602

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Housing & Community Affairs 828-3217

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Historic Preservation 828-3226
Vermont Travel Division 828-3236
Vermont Life Magazine 828-3241

MILTON A. EATON, SECRETARY

February 9, 1984

Mr. Victor Rolando
33 Howard Street
Pittsfield, Massachusetts 01201

Dear Vic:

Thanks for your last letter and sorry to hear about the disappointment on the non-purchase of the furnace property. As Grace said, maybe it wasn't meant to be. You may want to get in touch with the new owner of the furnace at some point so you can do a little P.R. and make sure she doesn't demolish the whole thing. If and when you visit with her, you might want to drop off a copy of the site survey form and maybe the relevant write-up out of your book. A person's lack of interest is often a product of lack of information; the more knowledgable one is, the greater the interest.

I completely understand your desire to keep your Vermont work informal and unscheduled. We were simply giving you "equal opportunity" to submit a project proposal. Just know that your work is invaluable, and I am proud to tell people about the Rolandos' gratis blast furnace and charcoal kiln work. From time to time, people walk in off the street and ask for money to carry out some "research" project or other. I then proceed to tell them that a number of people are doing very important research (i.e. the Rolandos) and have never received a dime from us. And they should follow suit . . .

If you have reason to visit with Mr. Nelson Jaqway in the near future or if you have his address, I'd appreciate it if you could give him/send along the enclosed information. (Teachers need to be educated, too.) I never heard of Nelson before, but he may appreciate the enclosed information, especially as an educator. Also, I just want to emphasize that you should steer him and his students away from any digging or moving stones around. This gives kids the idea that they can dig anywhere/any time. Good student activities (including grades 4 to 6) which I've recommended in the past might include deed and historic research on the furnace, drawing and photographic activities and site mapping with tape and compass. There are all kinds of new skills to be learned just from the above few ideas.

Mr. Victor Rolando
Page 2
February 9, 1984

Forgive me for the "educational" tone of the last paragraph. I always get zealous/excited when I hear anything about kids digging or otherwise physically disturbing a site.

Speaking of digging (and referring to your next-to-the-last letter), if anyone is entitled to do any testing at the kiln sites, it's you and Grace. Technically, you're supposed to have a permit from the Division (us) if you want to do any excavating or "field investigations" on State lands. If you plan to do anything at Emerald Lake State Park, let's go through the permit process. It's not complicated. For testing on private land, I recommend obtaining the landowner's permission, which I know you'd do anyway. Although excavations on Federal land require a Federal permit, you're not exactly "excavating." I think we have noted in each individual site file if you've done any testing at any given site. Correct me if I'm wrong. If I'm wrong, you might want to write a brief one or two page report on which sites you've tested, how many test pits, where located, what you were looking for, and what you found (or didn't find).

All my best to you and Grace and thanks for your great letter.

Sincerely,

DIVISION FOR HISTORIC PRESERVATION

Gio

Giovanna Peebles
State Archeologist

GP/cjd

Enclosures

3F

31 October 1984

NOV 5 1984

Giovanna Peebles, State Archeologist
Division for Historic Preservation

Dear Giovanna:

Enclosed are my donated services for October; first fiscal month of 1985. Let me elaborate on some of the items therein.

I have completed trascription of Asa Chapmsn's Teaming Book. It afford a unique insight into the transactions of loads of ore coming in (and who and where they came from), and loads of bar iron being shipped out. I have already plotted the data, and have some interesting correlations of the reducing efficiency of the works (East Middlebury) and other contemporary forges of the period.

With Bob West's help, I have finally obtained a photo of the Tyson Furnace. It is probably the only one ever taken of it. The furnace went out of operation in 1872; the photo probably taken shortly after since there is no smoke in the photo - no sign of industrial activity. The photo was taken from what appears to be the exact perspective as Myron Dimmick's painting of it, which leads me to believe that maybe Myron painted it from the photograph? None the less, the photo is a valuable archeological resource, since I can now plot exatcly where the furnace and out-buildings were. A section of the road (Dublin Road) shows in the photo, as does a corner of the District 12 School House, for reference. A good find. Mrs Chiolone, from whom I obtained the photo, wanted $10 for it; it is worth it - it is an 8 X 10 glossy, all ready for the publisher.

When we left Burlington last weekend, we stopped at Chittenden and located the mine on Wset Road. First of all, I don't believe there was any blast furnace here, for a few reasons; there is no local source of water power, for one thing. There is a very small run of water that issues from a well house a few hundred feet to the northwest, but can't conceiveably be enough to power anything. The burned stones don't look anything like slag that I've seen. They do appear burned, and I've taken some samples of it so I'll bring them up to the meeting at Greenwood Lake next week - maybe the 'experts' can help me. Some mine operations roasted the ore, to remove some impurities, such as sulphur, but I don't know that this happened here - at least, I didn't think that sulphur was a problem with ore from this area. We tried to find the other mine, but the road got very rough and we had to turn around. It was also getting late and very overcast. We did locate much charcoal along that raod, however. There is a Kiln Brook that flows out of the mountains here; possibly rising at what is known as 'the basin' where charcoal was made for the furnaces at Brandon and Forestdale. We haven't done any field work here yet; maybe next season.

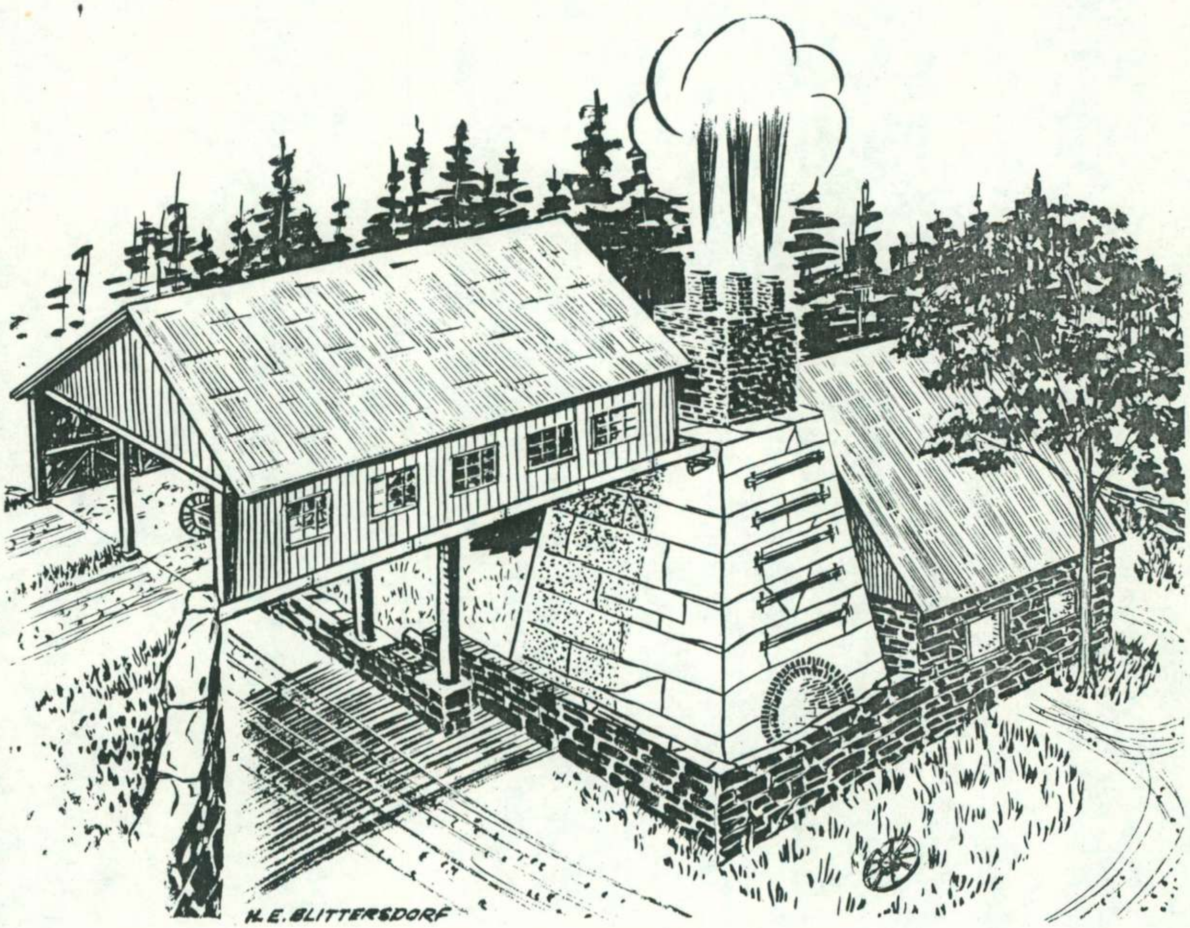
no specific site

Upon re-reseraching some data I obtained from Rick Allen many years ago, I discovered that his 'connecting furnace' at Dorset village is in fact a smelting furnace, according to Zephine Humphrey's history of Dorset. I don't know where Rick got that connecting furnace stuff from - he's led me astray a few times before also. I got out to Dorset Village last weekend, found nothing where I looked, but feel that if there was a furnace there, it might be a bit farther downsteam, where there were many large, barking dogs. I'll follow this up at some later date, when I have a better idea exactly where the site is. If it's there, I'll find it.

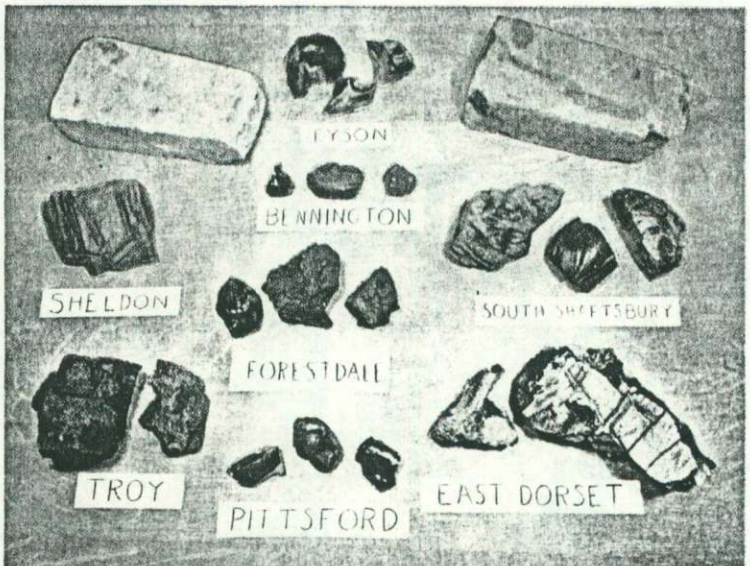
All else appears to be improving. Keep your fingers crossed for me.

Vic

# FURNACES, FORGES AND F




ABOVE: *The old Pittsford Furnace near Pittsford Mills had the good fortune to be built practically atop an iron ore bed.*




LEFT: *These slag and ore samples from the author's collection were gathered at the sites of old Vermont iron works. At top are two special-shaped fire bricks from Pittsford and South Shaftsbury furnaces.*

(original in color)

# FOUNDRIES

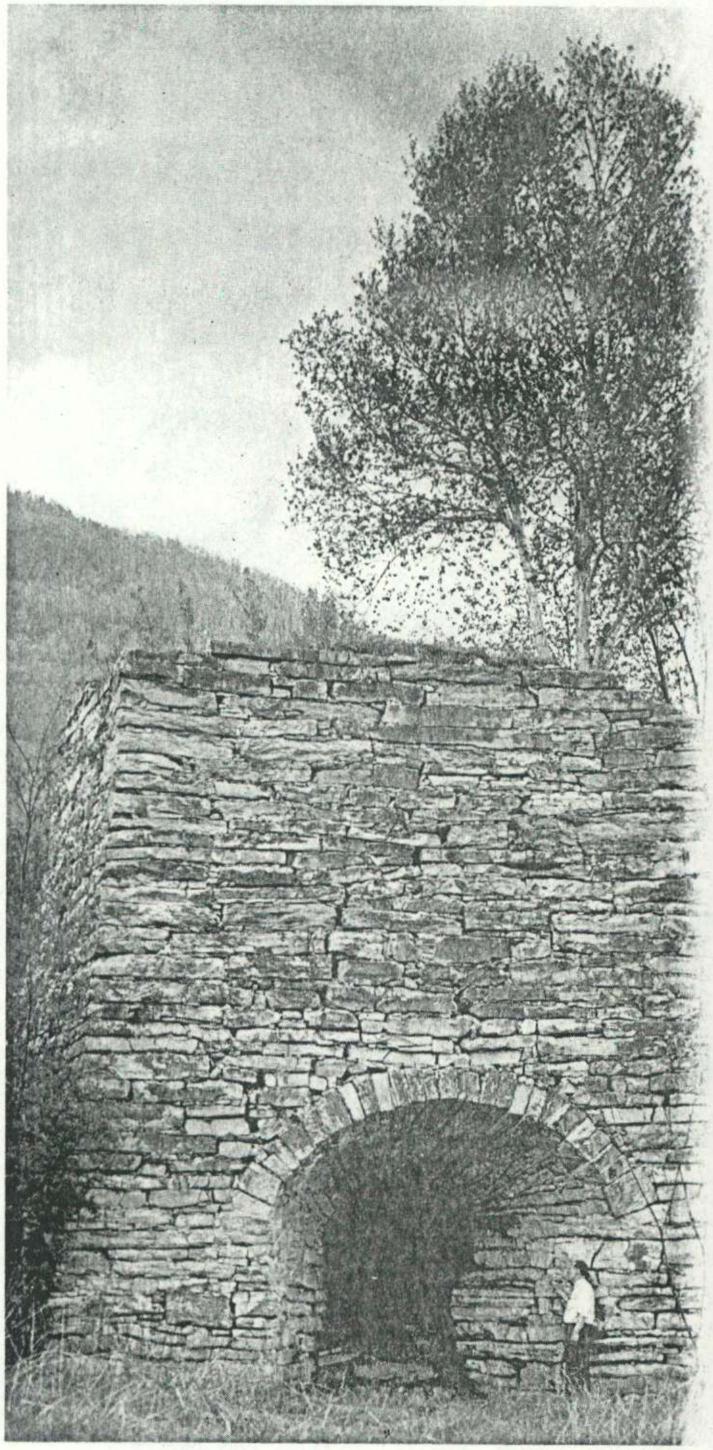
*Active old foundries and crumbling stone stacks are the reminders today that Vermont 140 years ago led the Nation in the production of iron.*

IRON IN VERMONT? A visitor from Minnesota's Mesabi country will scoff at such a thing. But a check of state geology reports and the history books will show that not only was there plenty of iron in Vermont, but that the state once was in the forefront of iron production.

Bog ore was first discovered by pioneer Vermonters in the swampy areas and low spots which had once been covered by the pre-historic "Champlain Sea." There were workable deposits of bog iron in Highgate, Swanton, Sheldon and Ferrisburg, with the biggest bed in Monkton. This ore was not mined, but simply dug out of drained open pits.

The other main type of Vermont iron is known to geologists as brown hematite. This was harder to get out of the ground. It was usually found in layers of from a few inches to several yards thick, and might extend a few feet, or several miles. Ore of this kind needed real mines, like the ones dug in Chittenden and Bennington where the miners descended sixty feet into a shaft and then picked away at the ore in galleries that extended in several directions.

Possession of an ore bed didn't mean that you had a saleable product. To produce it, you had to build a blast furnace, or a bloomery forge. A furnace was a large,



*Familiar sight to thousands of motorists is the old limestone and marble stack of the Dorset Iron Company at the side of Route 7 near East Dorset, Demming Pond and Mt. Aeolus' slope beyond. Birch trees have an affinity for old iron sites.*

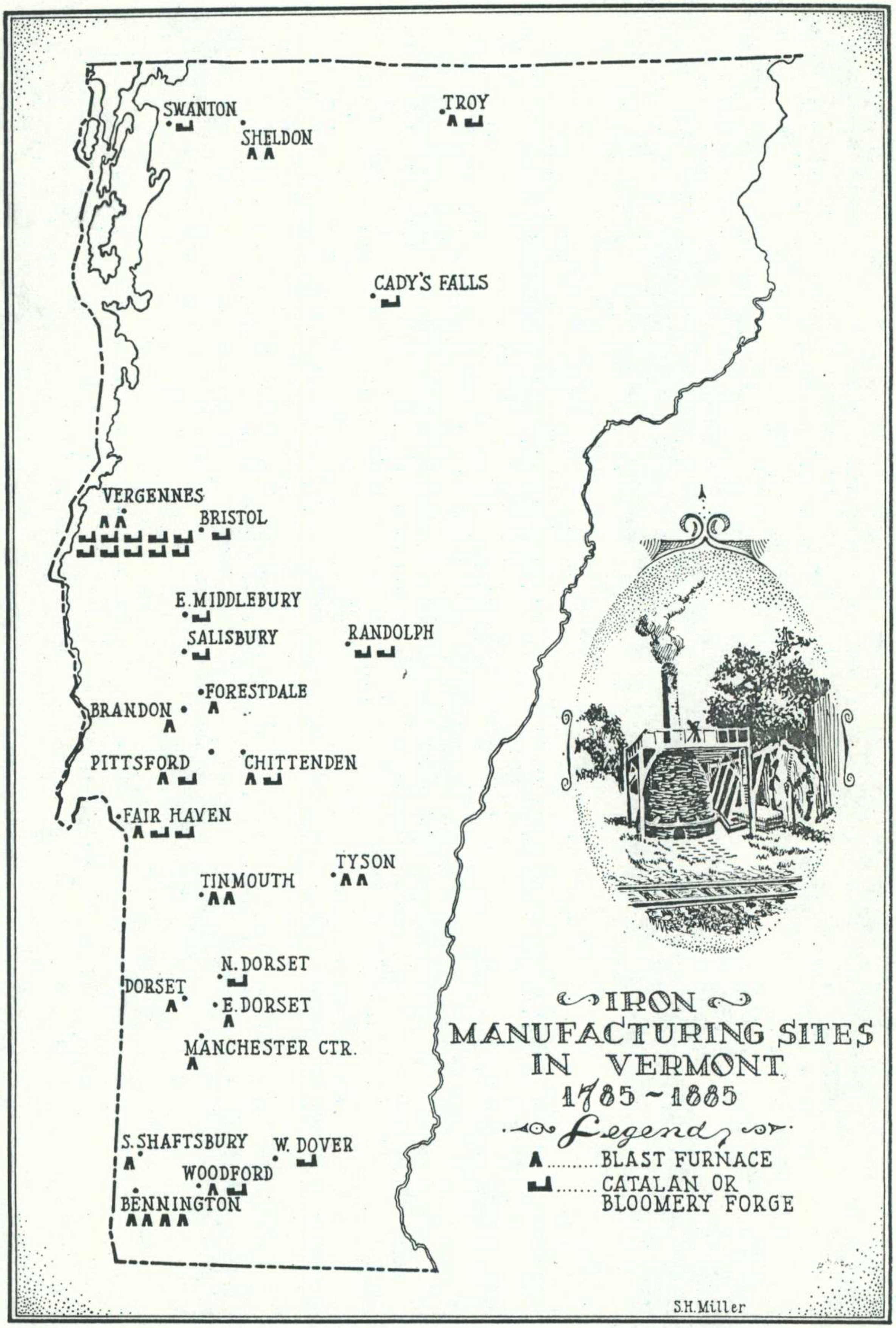
By RICHARD SANDERS ALLEN

Photography by

LADISLAV DEJNOZKA

Vermont Life

Winter 1956-57


SWANTON
TROY
SHELDON
CADY'S FALLS
VERGENNES
BRISTOL
E. MIDDLEBURY
SALISBURY
RANDOLPH
FORESTDALE
BRANDON
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CHITTENDEN
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TINMOUTH
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DORSET
E. DORSET
MANCHESTER CTR.
S. SHAFTSBURY
W. DOVER
WOODFORD
BENNINGTON
IRON MANUFACTURING SITES IN VERMONT 1785 ~ 1885
Legend
BLAST FURNACE
CATALAN OR BLOOMERY FORGE
S.H. Miller

hollow stack of native stone, tightly mortared and bound with iron bands. Inside, it was lined with special fire brick, designed to withstand terrific heat. The old-time furnaces were a lot like the stone fireplaces that today's do-it-yourself householder builds in his back yard, and were fueled to the best advantage with charcoal, which gives a high clean heat.

In a back yard fireplace you may fan the flames, or get down and puff until you are red in the face. In making iron, the air to intensify the heat was introduced by means of waterwheels, operating big leather bellows to force air into the furnace. In later models, a system of wooden tubs with pistons compressed the air for the same use.

A typical Vermont iron furnace was charged at the top fifteen times a day. A charge consisted of thirty bushels of charcoal, fifteen hundred pounds of ore, and a hundred and fifty pounds of limestone. The limestone acted as a flux to melt and combine with any unburnable matter found in the furnace. This rose to the top of the red-hot mass and was drawn off in the form of slag.

In a fireplace, the important product is the steak that is cooked on top. In the iron furnace it is molten iron, drawn off at the bottom. On the sandy floor beside the bottom of the stone stack a trough was dug to receive the bright, smoking metal as it poured from the furnace. This depression was called the "sow." Connected with it were smaller side ditches which for obvious reasons were called "pigs."

The furnace building itself was a dark and cavernous place that often resembled Dante's Inferno. Big, brawny iron workers moved about with blackened faces and bare chests glistening in the glare of the white-hot pig iron. To keep the furnace in continual blast they worked night and day in twelve hour shifts for periods as long as nine months. Thirsts ran heavy. It has been said that for every ton of iron made, at least a gallon of whiskey was consumed.

Charcoal in vast quantities was needed for the iron making process, and the forests around the furnaces were quickly cut. Farmers with timber holdings went into charcoal-making on the side, and in some regions the smoke from the colliers' oven fires on the hills was always present. A bed of limestone nearby was considered a further asset by the furnaceman.

Pig iron ran about eighty pounds to the bar, and was a mighty important product to early Vermonters. From it could be made kettles, hinges, spikes, forks, hoes, chains, frying "spiders" and all manner of iron implements.

The word "forge" covered several other types of iron works. The most common, of course, was the blacksmith's little heating forge that stood at most village crossroads. On a larger scale were the Catalan forges that actually smelted iron. These worked on an old principle called the *trompe*, by which falling water was made to trap air and deliver it under pressure to a hearth. Naturally, an ideal spot was by a waterfall. In these forges the iron ore was melted and the iron formed in a pasty mass. A big mechanical hammer banged away at this, squeezing out the cinders and resulting in a salable bar of iron called a "bloom." This gave the forge another name, a "bloomery." The first one in northern New York, at Willsboro Falls, used Vermont iron from Basin Harbor across Lake Champlain, Adirondack iron being as yet undiscovered. Later the traffic was reversed and five Vermont bloomeries, (at Vergennes, Salisbury, East Middlebury, Ackworth (Bristol) and Fair Haven), all used York State magnetic ore.

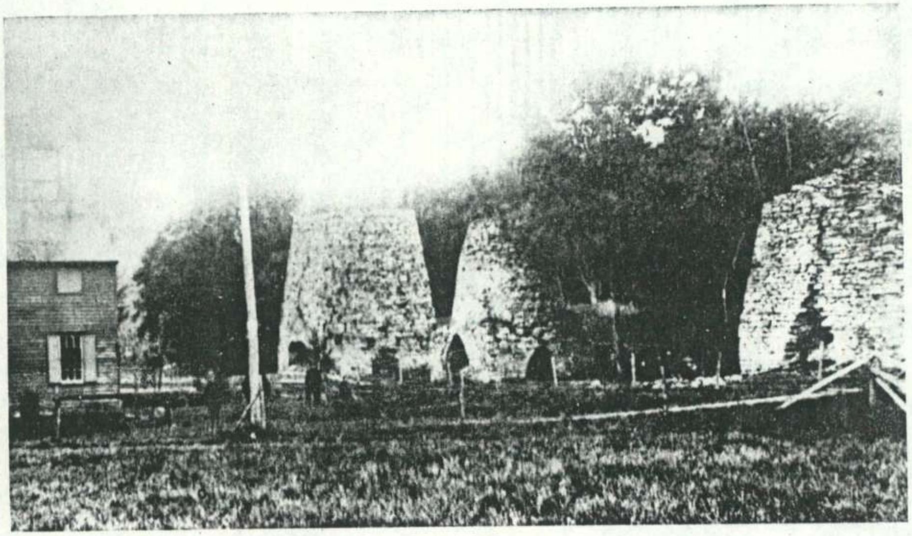
Ethan Allen is sometimes erroneously credited with establishing Vermont's iron industry. Actually, it was another famous Vermonter, Matthew Lyon, who built the state's first iron works at Fair Haven in 1785. In addition to bar iron, Lyon made axes, hoes, ploughs and nails. He even tried to protect native industry by petitioning the State Legislature to impose a duty on nails coming into the state.

Lyon's pioneer venture was followed closely by an iron establishment at Bennington and one in Tinmouth. The Lake Champlain area had the easy-to-get-at bog iron and the industry was centered at Vergennes. There was the big bed in Monkton, and sloops brought other ore from Highgate, Swanton and from the Rogers bed across the Lake in New York. At the falls in Vergennes were two blast furnaces for producing pig iron, and nine forges going full blast to convert it into hammers, anvils, pots and teakettles. These were shipped by boat to Montreal and Troy, and by overland wagon to Boston markets.

In 1813 the Monkton Iron Company at Vergennes was the largest iron works in the United States. The strategic site of the works was a boon to Commodore MacDonough in carrying out his naval campaign for control of Lake Champlain during the War of 1812. He built his fleet in the shipyard across the creek from the iron works, and the company, after supplying his fittings, quickly switched over to war production. They made two tons of cannon shot a day for MacDonough and the Northern Armies. After the threat of invasion was stopped by the defeat of the British fleet in 1814, Benjamin Welles, superintendent of the iron company, remarked:

"MacDonough saved our works, but our works saved his ships by furnishing a large supply of shot. So it is an even bargain." From its preeminence as the nation's largest iron works, the Monkton Iron Company took a swift drop and never recovered from the postwar depression. Various smaller bloomeries and foundries later occupied the site, but conducted only local business.

Israel Keith was a real pioneer in Vermont iron. He came from the bog iron country of tidewater Massachusetts and in 1791, started a furnace enterprise at



*Bennington Iron Works furnaces as they appeared about 1870. The center, smaller stack was called the "Pup." Ironmaster Thomas Trenor burned down a predecessor to one of these furnaces, mistakenly charging it with manganese instead of iron.*

*Courtesy Chas. R. Harte*

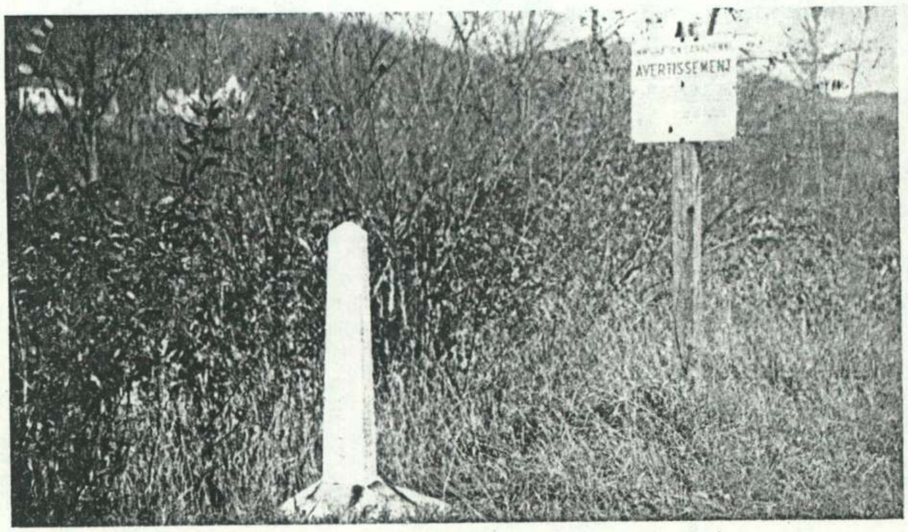
Pittsford, Vermont. Israel bought his land from Ira Allen and paid for it "in iron and holloware" after he got the furnace built. He soon went on north to Sheldon, where he could work the bog ore with which he was more familiar. His furnace on the bank of Black Creek employed a hundred men, and the iron products, bartered for other necessities, became known as "Sheldon Currency." Keith's specialty was potash kettles, for potash-making was a big business at the time. These "kittles" were cast in molds to sizes holding forty-five, sixty, and ninety gallons apiece. Men came as much as two hundred miles for a Sheldon kettle, waited their turns, and loaded the cumbersome castings hot from the mold.

A small portion of the Keith furnace can still be found in the underbrush at Sheldon, forgotten and unmarked. More remains of the successor to his first Vermont iron venture, the well-preserved stack alongside Furnace Brook in Pittsford. This furnace was built in 1828 by the Granger family, long identified with Pittsford iron. The Grangers had been hauling ore six miles from a mine in Chittenden. Then, while excavating for a new furnace, they found their site to be directly *over* a new bed of iron ore. That luck, with good limestone in a quarry nearby, kept Pittsford iron in production for many years. During thirty weeks of 1856, this furnace produced nearly 1600 tons of pig iron.

Down in Bennington, William Blodgett commenced furnace operations soon after the Revolution. He had many successors who endeavored to make a go of the iron industry, among them a clothier, an Irish political refugee, a newspaper editor, a French scholar, and a minister. The clothier was Moses Sage, who in 1816 moved to Pennsylvania, where he erected another blast furnace. The place was called Pittsburgh.

The political refugee was Thomas Trenor, a stern, stubborn man with an Irish brogue and an easy temper. He

*R. S. Allen*



*This marker on the Vermont-Canadian boundary at East Richford, was cast more than 100 years ago by the Orleans Iron Company, Troy, Vermont.*

*The old stone stack of the Green Mountain Iron Company at Forestdale was built in 1854. Two hundred men were employed here, casting pig iron, and later molding ornamental chairs, urns & statues.*

*R. S. Allen*

insisted on putting a charge of a new black ore he'd found into his furnace, with the thought that it was a rich vein of iron. The stack commenced to rumble and shake. When the furnaceman tapped it, the liquid stream burst forth with a roar, took fire, and spattered in all directions, burning down the wooden sheds around the stone stack. Mr. Trenor had unwittingly charged the furnace with a deposit of black oxide of manganese, which with iron burns like fury. The ironmaster had to be extremely careful after that, for only half an inch of clay separated iron and manganese in some of his ore beds. Manganese was always the devil in the Vermont iron stockpile, and similar, though not so drastic mistakes happened at Pittsford and Dorset furnaces. A use for manganese was later found in making bleaching powder and in glass manufacture, but at Bennington tons of the stuff were thrown away.

Towns adjacent to Bennington also supported iron furnaces. There was Woodford, where big anchors for navy gun boats were cast during Jefferson's administration, and Shaftsbury, where all the pig iron was shipped to Troy, N. Y. for use by the Burden Company in making practically all the horseshoes used by the Union armies.

Up in Brandon were two furnaces. In Brandon village John Conant made the patent stoves that bore his name, and sold them all over New England and New York. This company later specialized in casting railroad car wheels, a product for which durable Vermont iron was especially suitable. At the other Brandon furnace in Forestdale, to satisfy popular demand, the molders even cast ornamental items like vases, chairs and statues, in addition to their old standby of pig iron.

All this iron activity took place on the western slopes of the Green Mountain Range. On the other side of the state was the small "Somerset Forge" in Dover, which shipped iron blooms to Bennington in competition with the

*R. S. Allen*

*Israel Keith's Sheldon Furnace was located on Black Creek. Iron products made here were used for barter, known as "Sheldon Currency." Huge iron kettles were a specialty.*

local works. There were two forges in Randolph, and one at Cady's Falls in Morristown, whose ore came from the "Gothic Bed" in Elmore.

At Tyson in the town of Plymouth was a substantial iron industry, with furnaces erected in 1837 by Isaac Tyson of Baltimore, Maryland. Tyson built a large blast furnace for pig iron and a small one "for convenience." At one time Tyson Furnace expected to become a leading city of the state. With its self-sufficient iron works, stove foundry, company store, and houses for the workers, it resembled some of the more prosperous "iron plantations" of New Jersey and Pennsylvania, where everything was supplied by and revolved around "the company."

At Troy was the only workable Vermont ore of the magnetic variety. Since the beds stretched for two miles, some Boston promoters bought them and erected the Troy Furnace beside the Missisquoi River. Lack of transportation and distance from markets caused the enterprise to fail. The company is noted chiefly for casting the boundary markers that can still be seen today at many points along the Canadian border.

One by one the iron beds in the state were exhausted, or abandoned because of increased production costs. There are still deposits of good grade iron to be found under the Vermont soil, but as long as iron can be easily scooped up in the open pits of Mesabi, Ungava, and Venezuela, the mineral prospectors will pass them up.

A new hobby has revived interest in the old Vermont iron furnace sites. This centers not on the iron, but on the cast-off by-product, slag. Cut and polished by amateur lapidaries, this makes interesting and inexpensive rings, bracelets and other jewelry settings. Slag ranges from bright blues and greens to white and orange brown, with all shades and combinations in between.

For those interested in seeing some of the old furnace stacks, there are six still standing in the state. Two are visible from Route 9 to the east of Bennington. Perhaps the best-preserved is the limestone and marble stack beside Route 7 south of East Dorset. A little more hunting will bring you to the Pittsford Furnace on the brook above Pittsford Mills, and the Green Mountain Iron Company's old stack still stands under the bank, at the upper end of Forestdale. Local inquiry is necessary to find the remote old Troy Furnace, out of sight of the river road between Troy and North Troy. Portions of other Vermont furnaces still can be found, but archaeological digging would have to be practiced at most of their sites. However, the discerning eye can often pick out a flash of blue or bright green slag in the bed of a brook, disclosing the former presence of one of Vulcan's Green Mountain workshops.

The iron industry in Vermont today is confined to foundries, which were often run in connection with both furnace and forge. In a foundry the metal is heated and cast directly into molds. Modern foundries take bar iron and melt it at high temperatures so that it may be cast into any desired form. Nearly a dozen foundries still do business in Vermont. Typical of them is the Gray Foundry, Inc., of Poultney.

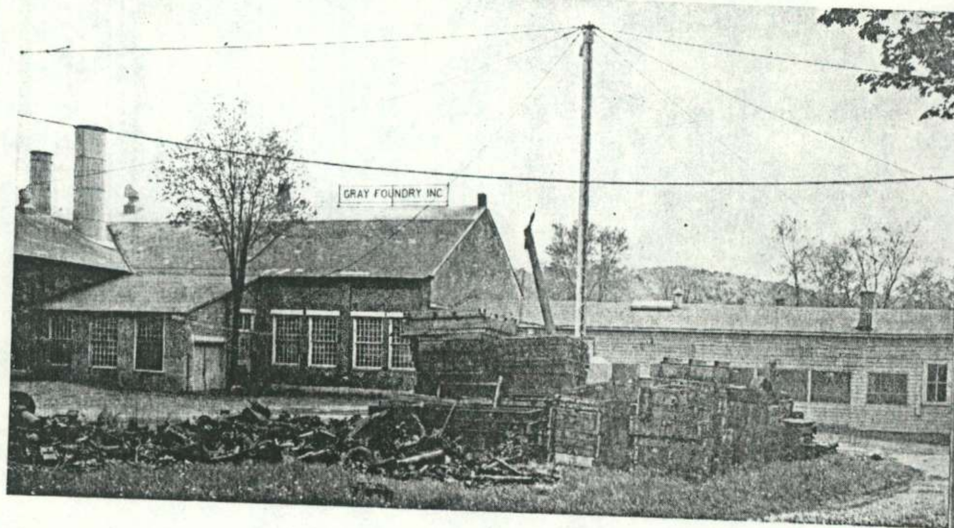
Follow down Furnace Street along the Poultney River and you'll find the Gray Foundry. Its buildings are arranged for utility, not beauty, but on a late winter's afternoon when the furnace is in blast, the leaden sky will be lit up with a glow that gives this plant an aura all its own.

From the squat, square office, a well-worn path leads down to the heart of operations, the main moulding bay foundry. Gone is the gloomy cave of the iron workers of the last century. This is a modern, spacious building with cupola furnaces, electric hoists and cranes. Only the brimstone smell of hot iron remains the same.

Gray's foundrymen prepare molds and pour iron five-and-a-half days a week. Castings range from small blocks to 3000-pound bases for paper-making machinery. The steel stack of the furnace is charged with the proper amounts of York State or Alabama pig iron, scrap iron, coke and flux, and the air blast gets roaring in the cupola. It takes 30,000 cubic feet of air to melt a ton of iron. When the furnace is tapped, the foundry windows reflect the glare, and the place comes alive. Gray's foundrymen, all with at least ten years experience, know their jobs and respect the danger of the material with which they work. Each is ready at the precise moment when the big ladle is poured;—lighting the escaping gases with fire sticks, holding the handle steady, or playing a stream of water on the hot flask or mold. Sparks fly up and scatter on the black sand of the foundry floor. Gushing from the furnace, white-hot iron pours again and again with a plopping noise like thick sour cream from a pitcher. Motions indicate which casting is to be poured next. The little ones are filled from hand ladles and left in smoking rows.

At the end of several hours of such work, all hands stand back and the furnace is dumped. A huge fiery mass cascades to the floor with sparks, coals and thick twisting streams of slag. Water hisses and steams on this residue, the glow fades, and the foundry is done for the day.

Gray Foundry, Inc. is thought to be the third oldest foundry continually in business in the United States, and still produces castings on the same site. It commenced melting iron in 1828 as the Stanley Stove Works. The patent Stanley anthracite stove was a big square ornamental affair, some of which are still to be found in the back rooms of older Vermont houses. The stove business grew with the demand, and later Stanley went into making castings for horse power machines, slate-working machinery and curry combs for the Union cavalry during the Civil War. The foundry was reorganized in 1900 under the direction of A. Y. Gray, and has since born his name. For the past forty years the plant has been run by Norman




G. Knapp, grandson of Mr. Gray, who has kept pace with the times by making a great variety of castings.

"We're classed as a small jobbing foundry," says Gray's president and general manager. "Our business is varied and not concentrated on any one product. In addition to the machinery for slate and marble working, we make castings for paper mill machinery, pumps, machine tools, pipe bending machinery, oil field maintenance machines, and road building machines to name a few. We can make just castings, or the complete machine. And our products go all over the world."

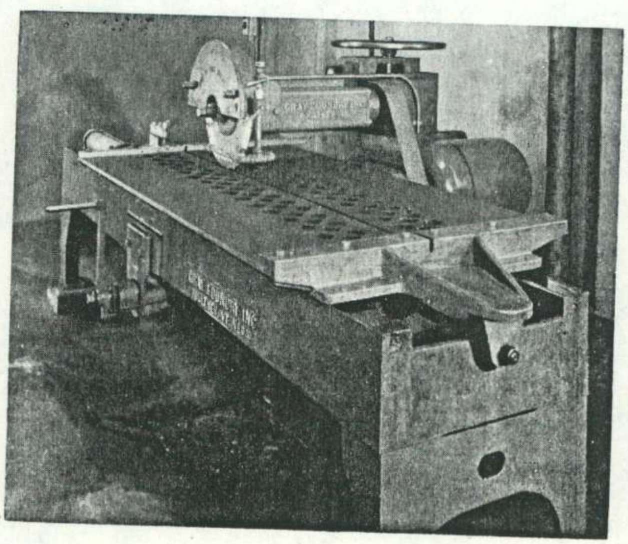
Mr. Knapp's Gray Foundry has risen from the ashes of two disastrous fires, and has had the waters of two floods four feet deep on the main foundry floor. It is a prime example of the survival of a small Vermont family company which has licked the problem of falling markets by diversifying its products and adding new lines. END

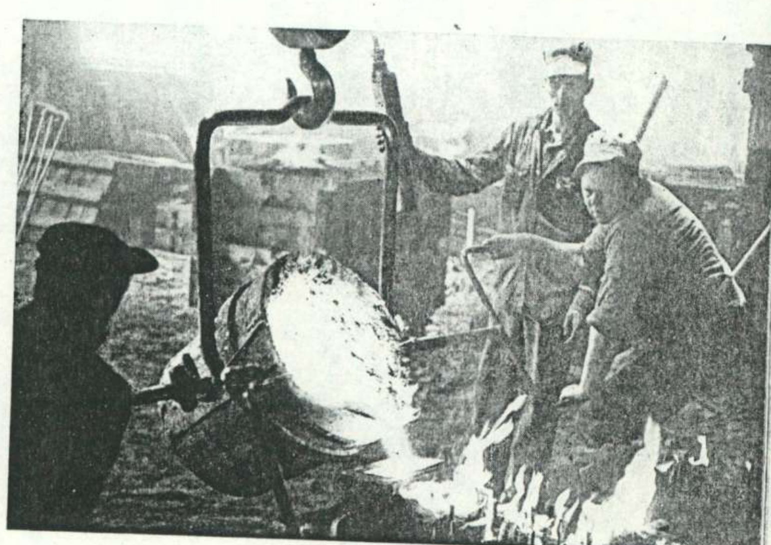
ABOVE: *The Poultney Foundry is one of about a dozen in Vermont. Scrap iron and flasks lie in the foreground.*

ABOVE LEFT: *Norman Knapp heads the 128-year-old Gray Foundry believed to be the third oldest in the Nation.*

BELOW LEFT: *Appropriate to the Poultney slate belt is this Gray Company diamond saw for cutting slate tiles.*

BELOW: *Hoist operator and foundrymen start the pour of molten iron into the runner box of a machine casting.*





# GE editor digs history

## *Victor Rolando probes for ironworks*

By Linda Carman

Victor Rolando started collecting unusual rocks when he was in Southern California in the service, so he was in the habit of poking around in the dirt.

When he picked up an aquamarine-colored chunk in Richmond, he thought he'd found a rare gem.

Now he thinks he may have been right, after all. The slag from the Richmond ironworks — because that's what it was — sparked an enthusiasm that takes almost the time and effort of a second job.

Rolando's quest for ironworks, and information about them, has led him to tramp through the overgrown hills of Vermont, write for journals documenting his efforts, and speak to historical societies about his findings.

**Weekends in Vermont**

He spends most weekends in the wooded Green Mountains of Vermont, which he says provide better hunting grounds than the Berkshires and where he and his wife Grace, a registered nurse at Berkshire Medical Center, spent the past two summers searching for the remains of charcoal kilns. They found about 90 ruins at dozens of sites, located by researching town and county histories, consulting old maps and old-timers, and exploring back roads and backwoods.

"I don't know whether I've got a nose for it or what," said Rolando, adding that after a while they began to recognize characteristics of kiln-building terrain and tell-tale signs such as pieces of broken brick or very black soil on the downhill side.

Rolando said they found most ruins just a few feet from trails and old logging roads, but they had some surprises. Camping on Mount Tabor, they discovered they had unknowingly pitched their tent the previous day so it straddled a kiln foundation.

This past summer, Rolando was delighted to find variant kiln remains, a larger than usual kiln with stone walls and a conical kiln. They also found what may be the ruins of a 1790 forge and furnace with connections to Ira Allen, brother of the more famous Ethan, and builder of many forges as well as founder of the University of Vermont.

Most remnants are meager, the most complete having brick walls 3 to 4 feet high forming circular ruins some 28 to 30 feet in diameter. These kilns were originally 20 to 25 feet high and designed for 25 to 45 cords of wood.

**50 bushels per cord**

The most efficient ones yielded 50 bushels of charcoal per cord. Most kilns collapsed from neglect, but others were dynamited during the 1930s as safety hazards while hiking trails were being laid out in the vicinity. Brick was turned into fill for road base, and iron went to scrap drives during World War II, according to an article Rolando had published by the the Society for Industrial Archaeology's New England chapter.

In pursuing their project, the Rolando's were granted volunteer status by the Forest Service and were assigned to work independently under the informal direction of the Forest Service archaeologists.

Rolando mapped and sketched the sites, then referred the information to the state archaeologists.

"We find out all there is to find out," he explained, "then it's their decision whether to do anything for the protection of the site."

Roland's walking and sketching in the woods is part of filling in a bigger picture, the industrial history of the region. And it's part of a view that considers historic preservation as including the workplace as well as the battlefield and the mansion.

"Little by little, we're trying to reconstruct what was going on in New England and New York in the iron industry, from the period of settlement up to the electrification of the industry in the early 1900s. Here it was a rural industry, and we're putting it together," he said.

Although charcoal was generally used as to fuel blast furnaces, the peak period of charcoal production, 1880-1900, was after the end of major ironmaking, he said. By 1910, most available forests in the vicinity had been harvested for lumber or charcoal, and the kilns were closed.

**The Richmond operation**

Berkshire County ironworking in Richmond lasted longer than in Lanesboro, which could not compete when Richmond got rail service to haul its pig iron to Troy, while railless Lanesboro still depended on oxen. Richmond started in 1830 and continued until 1923, after the railroads switched from cast iron wheels to steel, which was beyond local capabilities.

The Richmond ironworking, was a far-flung operation in the 1880s and 1890s, he says. It had 700 people on its payroll, owned furnaces in Cheshire and Van Deusenville, and leased land for charcoal all over Vermont, New York state, and Massachusetts.

In the course of his explorations, Rolando does very little excavation, and informs the University of Vermont archaelogical team of his finds. "I locate, and let them dig," he said.

Sometimes, nothing pans out. Once he spent two hours combing the Hoosic River behind the Green Mountain race track in Pownal, Vt., in search of a forge he had seen indicated on a 1796 map. After digging little holes to investigate whether the site had been filled, he determined that the river is now many hundreds of feet out of its earlier course. Rolando finds much of significance in his investigations, or, as he prefers to call it, "stories."

He looks at the water system, roads and railroad system to see what they did with the slag. He looks in the refuse to see who made the bricks, because furnaces lined with high-quality hearth brick could be expected to make iron for distant, important enterprises. Many in Vermont use only fieldstone, and as a consequence their product was considered usable only locally.

The quality of the iron produced can also be gauged by the quality of the slag, he said. Bright clean slag like Richmond's turquoise byproduct shows high-quality iron, he said, whereas some slag is crusted, indicating that the furnace was not hot enough to burn out impurities.

"There are a lot of clues," he said.

Although Berkshire County had nine major blast furnaces — North Adams, Cheshire, Lanesboro, Lenox Dale, Richmond, West Stockbridge, Van Deusenville and Housatonic — that produced cast iron high in carbon, usually known as pig iron, other ironworking with bar or wrought iron was being done in forges.

"Ironworking used to be as common as today's auto body shop," he said.

**Editor at GE**

Rolando, a native of Albany, N.Y., quips that he has better credentials for his avocation than for his profession — he is publications production editor at the General Electric Co. here, where he has worked since 1957. He received an associate's degree in electronics from Hudson Valley Community College in 1957, a bachelor's degree in American History from Empire State College in Albany in 1974, and a master's degree in 1980 from the College of St. Rose, where his thesis topic was, unsurprisingly, "Ironmaking in Vermont," 1775-1890.

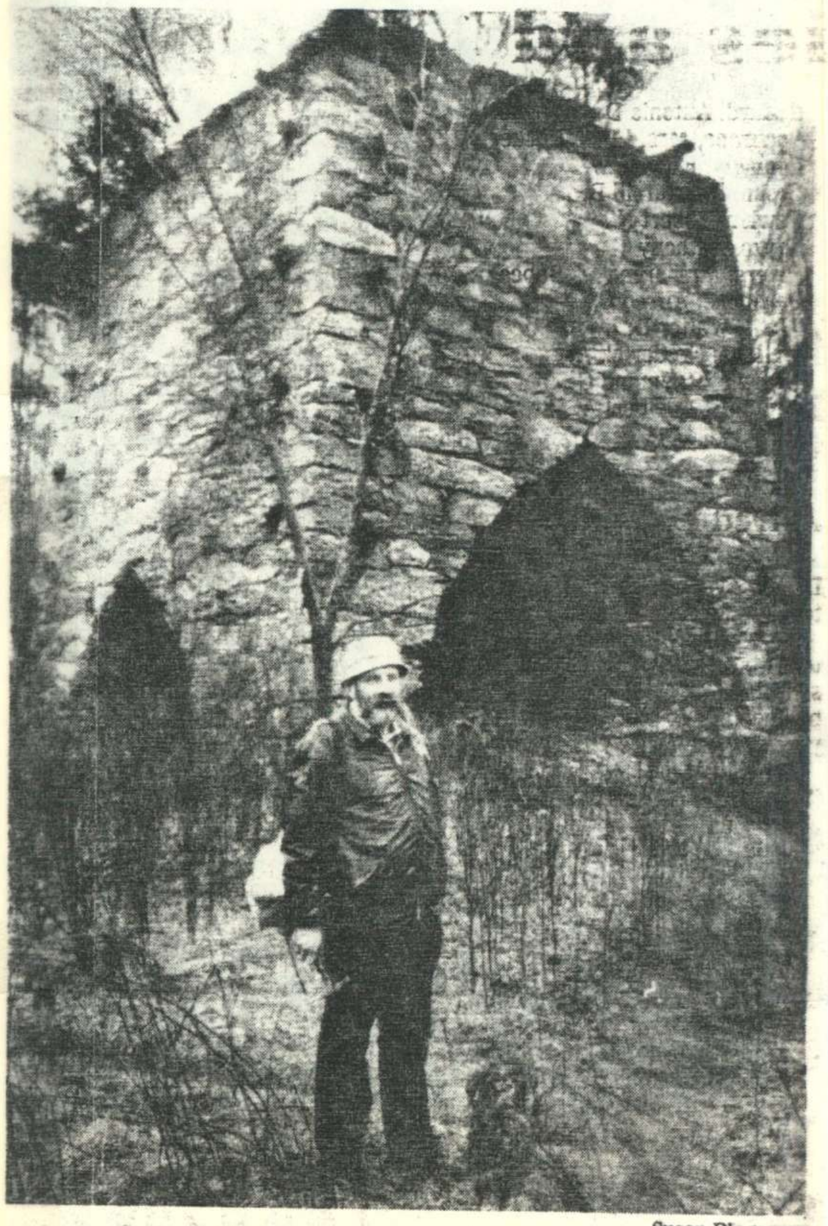
He has spoken on his research to the Lenox Historical Society, the Berkshire County Historical Society, and most recently, Oct. 15, to the Vermont Archaeological Society's annual meeting in Burlington. He is treasurer, and his wife is secretary, of the Northern New England chapter of the Society for Industrial Archaeology.

**Disagrees with Celtic theory**

Rolando strongly disagrees with the highly-publicized theories of Celtic origin for stone structures in Vermont, maintaining that the structures are merely root cellars constructed by early settlers.

He dismisses the possibility of Celtic origin by maintaining that if the Vikings, in their brief settlement in Newfoundland, left debris and disturbed the ground, surely any stone-hauling Celt would have done the same.

"Did not at least one Celt drop and lose one tool during the time the structures were built," he inquires, rhetorically. "Did they return all their dead to Europe?"



Susan Plageman

**BLAST FURNACE** remains in Richmond is one of the areas investigated by Victor Rolando in his archaeological research throughout New England.

27 Dec 83

Dear Giovanna,

In a few days, I will be forwarding to you a Xeroxed copy of my manuscript. I have updated it as far as I intend to for the time being and have run off three copies: one each for Bob West, yourself, and me. Bob still feels there is an excellent chance for getting it published. I am content now to wait and see. We are now putting together an illustration package – that may take another couple months. For your copy – it contains much new and different material than was in my thesis. Please treat it like unpublished manuscript, but please do feel free to use the information in it as you see fit. As soon as we get an illustration package put together, I'll try to make a good copy of that also, for you.

Checking some old 1856 Bennington County maps against current USGS maps, I noticed that town lines in that, and in Beers were not where they are today (Stamford, Readsboro, Woodford area). I don't know whether it means that the maps were made in error, or ~~more~~ more current surveys re-established the boundaries elsewhere. Anyway, I rechecked the kiln site (on the 1856 map) along Rte 8 barely inside Stamford that I had reported to you the fall of '82 as probably being buried under new Route 8. At that time, I estimated the kiln location on the basis of where the town line is today marked on Rte 8. As it happens, the actual site is about 1/8 to 1/4 mile further up the hill, and well into Readsboro, and precariously ~~close~~ close to the Dutch Hill Ski Area. We drove up there yesterday to check it out, found a 'niche' cut into the side of the hill near where I estimate the site to be and on the correct side of the road, but buried under a foot to 1½ feet of snow, so it'll have to wait till spring before I can resume search for this one. I have yet to find a kiln identified on any ca 1850's county maps – I'd like to find out what they are identifying on the map as 'coal kiln' – a marl, stone, brick kiln, or what.

Dec 26th, yesterday, when we were trudging in the snow at Dutch Hill, struck me as being the latest in the year I've done any field work in Vermont. Then it occurred to me that at the other extreme, Jan 2, 1983, I was up in Swanton with Grace, poking around Goose Island at the Barney forge site, at the other end of the state. I guess I'm realizing that season no longer holds any bounds on my field work in Vermont. 1983 has been a good, rewarding year for me.

Nelson Jaquay, on whose property one of the furnace ruins are on in Tinmouth, phoned me a few days ago to report that the land on which another, partially collapsed ruin sets at the ~~north~~ north end of town, is on a 114 acre piece of land now in the hands of a real estate office for development. I have some names he gave me and I'm going to pursue the hope that I might be able to buy the furnace land only, if not, maybe the entire 114 acres. We'll see. If we can get those furnace sites on the Nat Reg this year, maybe I can get something going on some of the sites. Also, at E. Dorset, the tenant next to the stack, John Harris, has moved away, and the ~~owners~~ owners, Mr & Mrs Dennis Conroy have moved back from Florida. They are modernizing the house with the intention of selling the property (house, furnace, etc) sometime in the spring. Grace & I stopped by last week to remeasure the furnace (I'm trying to detect shifting, settling, etc) and found the Conroy's busily remaining the house. The furnace was full of trash and I suspect they use it as an outside incinerator. I don't think they will any more - because I told them the heat could destabilize the stack. ~~It~~ It's only ten to 12 feet away from the house and towers over it.

I don't remember if I told you about the pieces of slag-looking material I found up a dirt road a mile NW of Stamford Village last month. I believe I have traced it to the Houghton Chemical Co, which operated in Stamford village (in Beers). I'd known about the chemical company for some time because one of their products was acids and oils, extracted from wood, the remains being charcoal. But further research has revealed that they also manufactured iron: I don't know exactly what that "iron" is, possibly some iron required for chemical purposes, but the size of the chunks of slag I have, if connected to the chemical company, reveal some kind of a major furnace. Also, the Beers shows an "Iron Ore" area about a half mile NE of the company. Houses today stand on the site of the chemical company, & I haven't been able to locate the ore site from Rte 8. There's a stream (Roaring Brook) that runs through the chemical company area, so I'll inspect it as soon as the ice thaws, for some addt'l matching pieces of slag, or whatever.

Anyway, as you can see, I am still keeping busy between house construction, Grace, G.E., and field work in Vermont (not necessarily in any particular order). As I said earlier, 1983 has been a good year, I've accomplished much, and I feel very good about myself. Regardless of what happens with the manuscript in 1984, I still have much work waiting for me in Vermont, especially in Stamford-Readsboro-Woodford - re: kilns, and also in Bristol-New Haven - re: an elusive blast furnace site - (When you get the copy of the manuscript, be sure to read the section in Chapter 4 about Bristol.)

Please know that Grace & I wish you, David, and Josh and the girls all the happiest, healthiest, and successful 1984.

Vic

PS. We read in the local paper about Gina's wedding so get ~~her~~ her a gift and a hug from the two of us, about an hour before the wedding. Don't give her anything too technical to do for the next month or so.

From: Rolando 1980.

List of sites with assigned survey numbers.

Table 1. Topographic Data: Bloomery Forges

| Town | Forge Name | Dates | Quadrangle | Location | ~~UTM Coordinates~~ |
|---|---|---|---|---|---|
| Bennington | Keith | 1786-1800's | Bennington | unk | unk |
| | Blodgett | 1786- | Bennington | Bennington Village | 18/646070/4748900 |
| Brandon | Blake | 1790-1810 | Brandon | Brandon Village | unk |
| Bristol | Scott #1 | 1791- | Bristol | Lower bridge | 18/65330X/48877XX |
| | Scott #2 | unk | Bristol | Below Scott #1 | 18/65335X/48874XX |
| | Franklin | 1802-1830 | Bristol | Bristol Village | 18/6536XX/4888XXX |
| | Chase | 1832-(1840's) | Bristol | Baldwin Creek | unk |
| | Holley | c1850's | Bristol | East of village | 18/655290/4887600 |
| | Burnham | c1850's? | Bristol | No. of Baldwin Ck. | unk |
| Burlington | Johnson | 1791- | Burlington | unk | unk |
| | Allen | c1796- | Burlington | Winooski River | 18/6436XX/49276XX |
| Calais | unk | c1810 | Plainfield 15' | East Calais | unk |
| Castleton | Slab City Forge | c1796-c1815 | Poultney | Lk Bomoseen Dam | 18/642650/4829300 |
| Colchester | Allen | 1783- | Burlington | Winooski River | 18/6436XX/49276XX |
| Danby | Phillips | early 1800's | Middltn Sp | Tn Rte 2 @ Baker Bk | unk |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | ~~UTM Coordinates~~ |
|---|---|---|---|---|---|
| Danville | Blanchard | c1810 | St. Johnsby 15' | Joes Brook | 18/7288XX/49177XX |
| Dover | Somerset Forge | 1820-(1832?) | Wilmington 15' | N. of West Dover | 18/672800/4757620 |
| Fairfax | Shepardson's | c1870 | Gilson Mtn | Stones Brook | 18/660470/4947100 |
| Fairfield | Fairfield Forge | 1831- | unk | unk | unk |
| Fair Haven | Lyon's Works | 1785-1815 | Thorn Hill | below upper falls | 18/64025X/482769X |
| F.S. 17 (RV) | L. Davey | 1815-1843 | Thorn Hill | below upper falls | 18/64025X/482769X |
| | I. Davey | 1843-(1870's?) | Thorn Hill | below upper falls | 18/64025X/482769X |
| Ferrisburg | Barnum #1 | c1800 | Monkton | Monkton Road bridge | 18/6450XX/48939XX |
| | Monkton Iron Co | 1807-1810's | Monkton | Monkton Road bridge | 18/6450XX/48939XX |
| | Barnum #2 | c1820 | Monkton | Walkers Falls | 18/64417X/48952XX |
| | Fuller | early 1800's | Monkton | Ferrisburg Hollow | 18/640690/4895000 |
| Goshen | Kendall | unk | unk | E. side of mtn (?) | unk |
| Grand Isle | Goodwin | 1827-1838 | Plattsburg 15' | Mill Brook | 18/636XXX/4951XXX |
| Highgate UT-FR-146 | Drury (Blast furnace) | 1807- | unk | unk | unk |
| Lincoln F.S. 50 (AD) | Soper & Pier | c1828-1830 | So Mountain | West Lincoln | 18/65823X/4886740 |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | ~~UTM Coordinates~~ |
|---|---|---|---|---|---|
| Lincoln (con't) F.S. 50 (AD) | Burnham | 1830-1860 | So Mountain | West Lincoln | 18/65813X/4886740 |
| | Ackworth #1 | 1828-1830 | So Mountain | West Lincoln | 18/658600/4886600 |
| | Ackworth #2 | 1830-1860 | So Mountain | West Lincoln | 18/658600/4886600 |
| Manchester | Manchester Forge | c1829 | Manchester | along Route 7? | unk |
| Middlebury UT-AD-299 | Middlebury Forge | early 1800's to 1890 | E Middlebry | E Middlebury Vil. | 18/653370/4870130 |
| Middletn Sp | Burnham #1 | c1796-1811 | Wells | Burnham Hollow | 18/6505XX/4815800 |
| | Burnham #2 | 1811- | Wells | Burnham Hollow | 18/6505XX/4815800 |
| | Poultney | c1796 | Middletn Sp | Poultney R @ Train Bk | 18/6540XX/48162XX |
| Milton | Poor Farm Forge | c1820 | Georgia Pl | Lamoille River | 18/647480/4944300 |
| Morristown | Sawyer | 1826-1828 | Hyde Pk 15' | Cady's Falls | 18/689620/4938500 |
| Orwell UT-AD-300 (Blast furnace) | Lyon | 1788- | Orwell | East Creek | 18/634XXX/4851XXX |
| Pittsford | Larned's Forge | c1840 | Proctor | Furnace Brook? | unk |
| Poultney | Joslin & Darling | 1785- | Poultney | East Poultney | 18/6457XX/48208XX |
| Pownal | Noble | c1796-(1810 plus) | Pownal | W of Green Mtn Pk | 18/6442XX/47348XX |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | UTM Coordinates |
|---|---|---|---|---|---|
| Proctor | Sutherland Falls | c1800-1840 | Proctor | Sutherland Falls | 18/658480/4836170 |
| Randolph | Randolph Forge #1 | (1800's-1850's)? | Randolph 15' | unk | unk |
| | Randolph Forge #2 | (1800's-1850's)? | Randolph 15' | unk | unk |
| Richmond | Sears | 1780's-1800's | Huntington | Huntington River | 18/66XXXX/4914XXX |
| UT-CA-20 St Johnsbury | Paddack Forge | 1818-1828 | St J 15' | Sleeper River | |
| Salisbury | Sawyer | 1791- | E Middlbry | Leicester River | 18/653XXX/4862XXX |
| | Salisbury Bloomry | 1840's-1857 plus | E Middlbry | Leicester River | 18/653250/4862050 |
| Shelburne | Burritt | 1792-(1820's?) | Mount Philo | Shelburne Falls | 18/642100/4914380 |
| Shoreham | Knopp | c1790- | Orwell | Richville | 18/6387XX/48590XX |
| | Shoreham | c1797- | Orwell | Richville | 18/658510/4859160 |
| Starksboro | Fergusson & Sayles | 1819-1871 plus | Bristol | Starksboro village | 18/655100/4898760 |
| | Ferguson & Bushnl | c1820 | Bristol | E. of village | 18/6556XX/4898800 |
| | East Mtn | c1840 | Bristol | Upper Lewis Creek | 18/656XXX/4895XXX |
| Swanton | Barney #1 | 1799-1816 | E. Alburg | Goose Island | 18/647760/4975890 |
| F.S. 12 (FR) | Barney #2 | 1816-1821 | E. Alburg | Goose Island | 18/647760/4975890 |
| | Barney #3 | 1821-1824 | E. Alburg | Goose Island | 18/647760/4975890 |
| | Barney #4 | 1849-1868 | E. Alburg | Goose Island | 18/647760/4975890 |

Table 1. Topographic Data: Bloomery Forges (con't)

| Town | Forge Name | Dates | Quadrangle | Location | ~~UTM Coordinates~~ |
|---|---|---|---|---|---|
| Tinmouth | Chipman | 1781 or 85- | Middltn Spg | near Chipman Lake | 18/6583XX/48085XX |
| | Allen | 1791- | Middltn Spg | unk | unk |
| Troy | Stebbins/Phelps | 1834-1841 | Irasburg 15' | E of Troy village | 18/7058XX/49766XX |
| Vergennes | Spencer | 1786- | Pt Henry 15' | E side Otter Creek | 18/6394XX/48917XX |
| | Stevens | 1799- | Pt Henry 15' | W side-above falls | 18/6395XX/48915XX |
| VT-AD-146 | Monkton Iron Co | 1808- | Pt Henry 15' | W side-below falls | 18/63925X/489160X |
| | White's Bloomery | c1850 | Pt Henry 15' | W side-below falls | 18/63925X/489160X |
| Wallingford | Miller | 1780's-1835? | Wallingford 15' | Route 7 in village | 18/663620/4814850 |
| Westford | Stanton | 1795-c1809 | Essex Ctr | Westford Center | 18/657900/4941360 |
| | Camp | -c1809 | Essex Ctr | Westford Center | 18/658000/494167X |
| Weybridge | Belding | 1795-(1800) | Middlebury | Belding Falls | 18/646000/4879050 |
| Williston F.S. 70(CH) | Spafford | c1810 | Essex Jct | Allen Bk @ I-89 | 18/65388X/49216XX |
| Windsor | unk | 1820's-1830's | Claremont | Windsor Village | unk |
| Woodford | Woodford H. #1 | c1800 | Bennington | Woodford Hollow | 18/652610/4750840 |
| | Woodford H. #2 | c1856 | Bennington | Woodford Hollow | 18/652610/4750840 |

Table 2. Topographic Data: Blast Furnaces with assigned site survey numbers ✓

| Town | Blast Furnace | Location | UTM Coordinate | Quadrangle |
|---|---|---|---|---|
| Bennington | Fassett & Hathaway<br>Sage (1799) | Furnace Bk | ~~18/~~6483XX/4752XXX | Bennington |
| | Sage & Olin<br>Trenor (1811)<br>Hunt (1820) | E Bennington | ~~18/~~6506XX/474935X | Bennington |
| ✓ UT-BE-10 | Hunt<br>Benn Iron Co (1822)<br>*Brock & Hinsdill (c1846) | E Bennington | ~~18/~~650650/4749300 (east stack) | Bennington |
| ✓ UT-BE-11 | Benn Iron Co<br>*Brock & Hinsdill (c1846) | E Bennington | ~~18/~~650649/4749300 (west stack) | Bennington |
| | Benn Iron Co<br>Brock & Hinsdill (c1846) | E Bennington | ~~18/~~650650/4749300 (the pup) | Bennington |
| Brandon<br>✓ F.S. 16 (RU) | Conant | Brandon Vil | ~~18/~~653700/4851100 | Brandon |
| ✓ UT-RU-41 | *Grn Mtn I Co (ON NATIONAL REGISTER) | Forestdale | ~~18/~~656900/4854800 | Brandon |
| Dorset<br>✓ UT-BE-35 | Curtis | NoDorset | ~~unk~~ | Dorset |
| ✓ UT-BE-9 | *Draper<br>Dorset Iron Co (1864)<br>Draper (1870) | S Dorset Pd | ~~18/~~661550/4787600 | Manchester |
| Fair Haven<br>F.S. 17 (RU) | Lyon's Works | upper falls | ~~18/~~64025X/482769X | Thorn Hill |
| Pittsford<br>✓ UT-RU-57 | Keith<br>Gibbs & Co (1795)<br>Leach (1824)<br>Granger (1826)<br>* Vermont Iron Co (1865) | Furnace Bk | ~~unk~~<br>18/661030/4842550 | Proctor<br>Proctor |
| Plymouth<br>✓ UT-WN-51 | @Tyson | Tyson Vil | 18/685450/4814900 | Ludlow |
| St Johnsbury<br>✓ UT-CA-20 | Paddock Iron Works | NE St Jbry | 18/737800/4923200 | St Johnsbury |

Table 2. Topographic Data: Blast Furnaces (con't)

| | Town | Blast Furnace | Location | UTM Coordinate | Quadrangle |
|---|---|---|---|---|---|
| | Shaftsbury | Douglass & Bangs | unk | unk | unk |
| ✓ UT-BE-36 | | @H.Burden & Sons | S Shaftsbury | 18/645260/4755660 | Bennington |
| ✓ UT-FR-68 | Sheldon | Keith #1 | Sheldon Ctr | 18/662460/4974700 | Enosburg F. 15' |
| ✓ UT-FR-67 | | Keith #2 | Sheldon Ctr | 18/662459/4974700 | Enosburg F. 15' |
| | Tinmouth | @Willard & Perry | at the dam | 18/659550/4817050 | Middletn Spgs |
| ✓ UT-RV-76 | | *(unidentified) | N of dam | 18/659480/4816860 | Middletn Spgs |
| ✓ UT-RV-77 | | *Rathbone & Vaughan | N of Rte 140 | 18/658530/4812570 | Middletn Spgs |
| ✓ UT-OL-3 | Troy | *Boston & Troy Iron Co. Orleans Iron Co. (1847) | River Rd | 18/704870/4979450 | Irasburg 15' |
| ✓ UT-AD-146 | Vergennes | Monkton I Co | below falls | 18/63925X/489160X | Pt Henry 15' |
| | | @Rathbone | below falls | 18/63925X/489160X | Pt Henry 15' |
| | Woodford | Robinson & Lyman Hunt & Quimby (1822) | E part | 18/651XXX/4749XXX | Bennington |

NORTHERN NEW ENGLAND CHAPTER

of the

SOCIETY FOR INDUSTRIAL ARCHEOLOGY

Spring Meeting

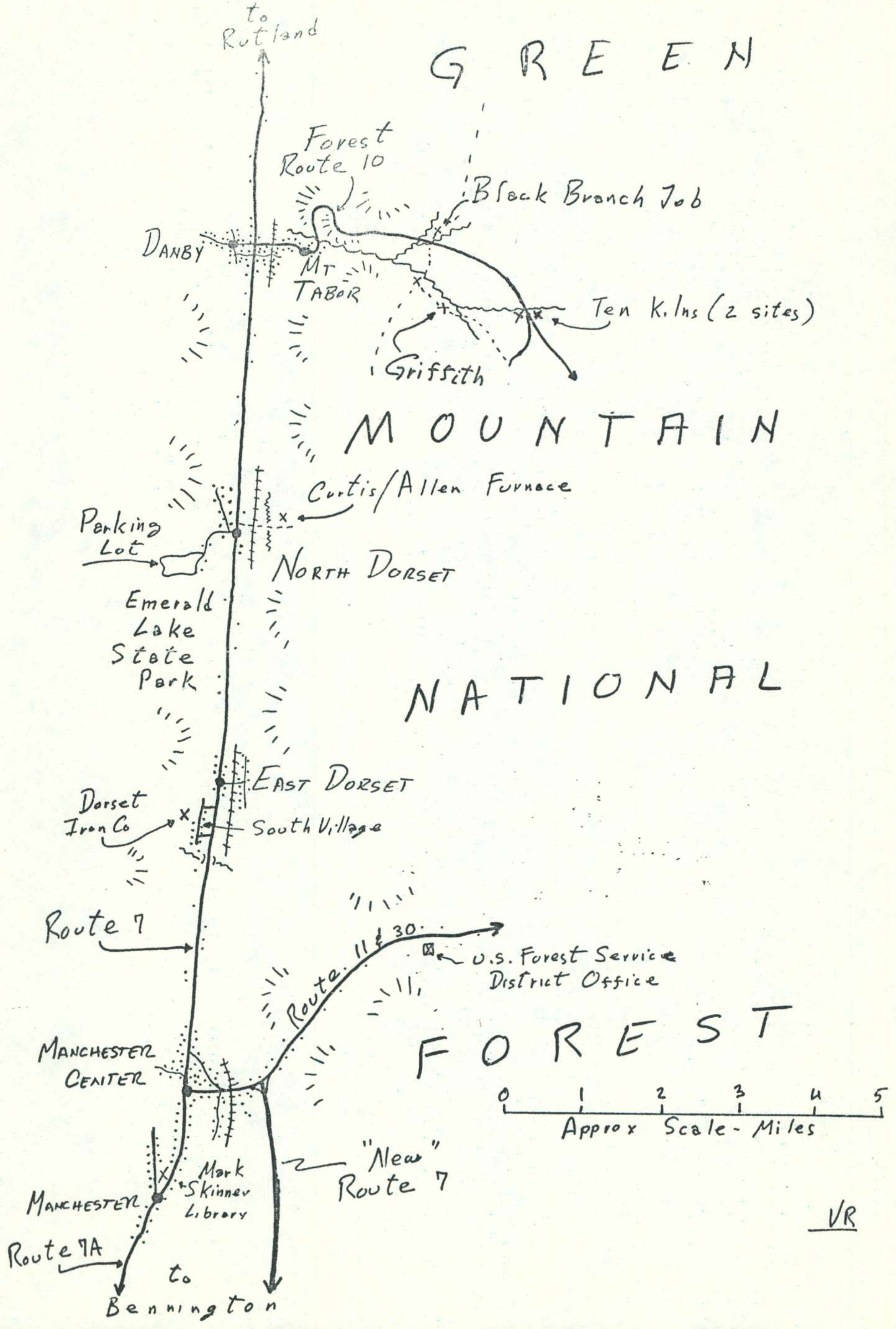
May 7, 1983

Tour of ironworks-related sites
in Dorset and Mt. Tabor, Vermont.

Researched and compiled

by

Vic Rolando



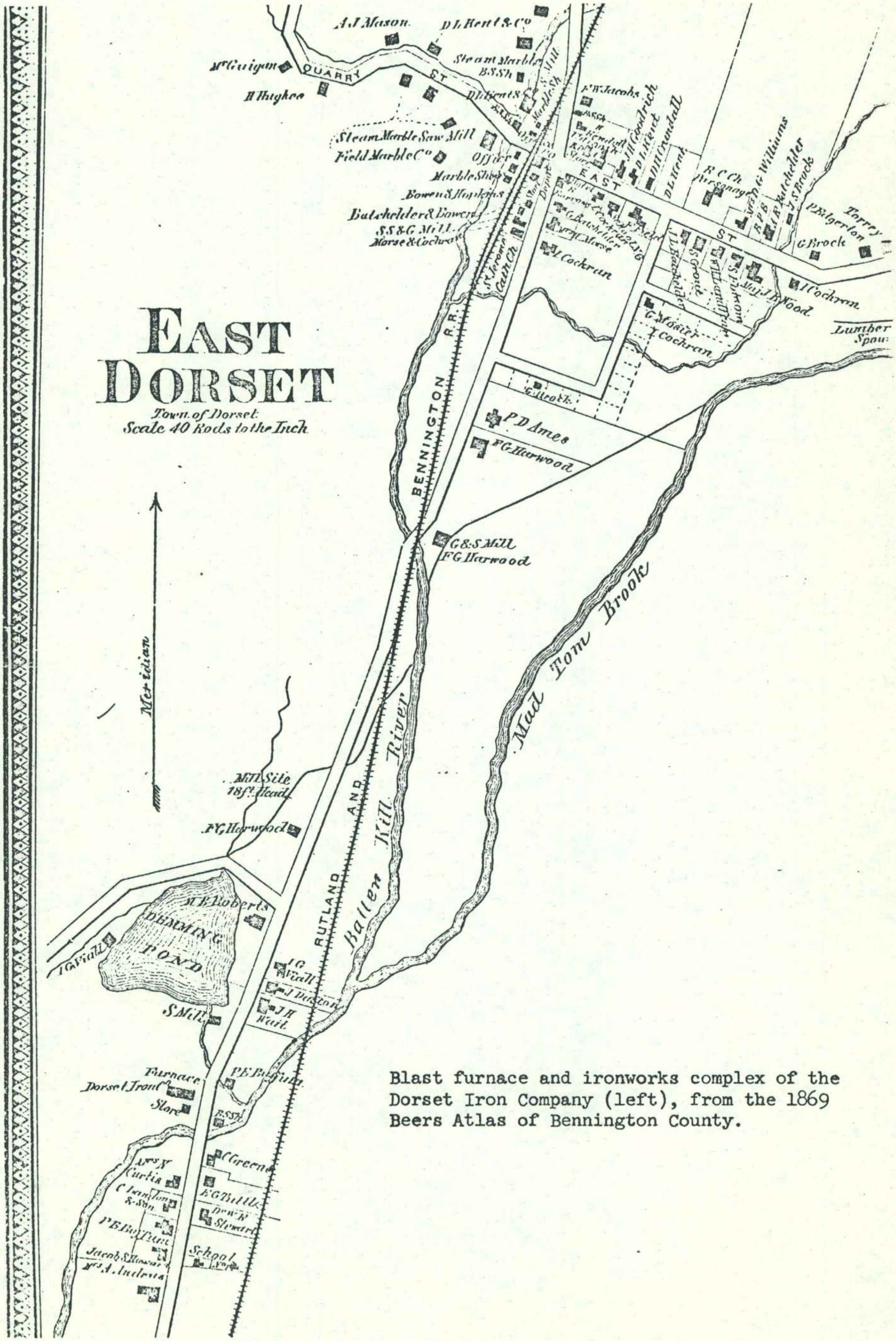
to Rutland
GREEN
MOUNTAIN
NATIONAL
FOREST
Forest Route 10
Black Branch Job
DANBY
MT TABOR
Ten Kilns (2 sites)
Griffith
Curtis/Allen Furnace
Parking Lot
NORTH DORSET
Emerald Lake State Park
EAST DORSET
Dorset Iron Co
South Village
Route 7
Route 11 & 30
U.S. Forest Service District Office
MANCHESTER CENTER
0
1
2
3
4
5
Approx Scale-Miles
"New" Route 7
Mark Skinner Library
MANCHESTER
Route 7A
to Bennington
VR

Heavy ironmaking activity such as that requiring blast furnace reduction methods commenced in Vermont soon after the close of the Revolutionary War. By the 1780's, blast furnaces were operating in Fair Haven and Orwell; in 1791 in Pittsford; 1793 in Bennington; and 1799 in Sheldon. The early to mid-1800's saw blast furnaces put into operation at Tinmouth, Vergennes, Highgate, Woodford, Brandon, Troy, and St Johnsbury. Additionally during this period, two blast furnaces operated in Dorset; one at North Dorset for a time in the 1840's, and the other farther south at East Dorset from about the same period to a bit later.

## East Dorset

The blast furnace at East Dorset was erected in the late 1840's. It was built by Francis Draper who made iron there for eight years. The furnace then lay idle a number of years. It was purchased in 1864 by the Dorset Iron Company, but two years later was not yet in blast although reported to be in fair working condition. In an 1874 report, the furnace was still out of blast. The following year it was repurchased by Draper who expected to repair it and resume ironmaking, probably to support a cupola furnace he owned at Windsor (which by now had become a center for heavy manufacture). Draper also owned extensive ore beds a mile north of the furnace. Research fails to show any iron production at East Dorset after 1854, however.

The blast furnace stack stands in 1983 in relatively good condition on the property of Mr and Mrs Dennis Conroy (of Niceville, Florida). Tenants on the property are the John Harris family. The furnace property is located in the South Village of East Dorset, a community along the short parallel stretch of the old Route 7, now bypassed to the east by the present highway. Of the ironworks complex that operated here, only the furnace stack remains visible. Much of the bosh and hearth lining has collapsed into a pile of rubble inside the base, but enough lining remains to see that it was of stone, rather than commercial-type refractory brick of more 'modern' furnaces. Many early-1800 blast furnaces in Vermont have been found to be lined with stone. The front (eastern) archway is stone block construction; the side archways have become filled in due to collapse of the earth adjacent to the stack. Remains of a road can be detected behind



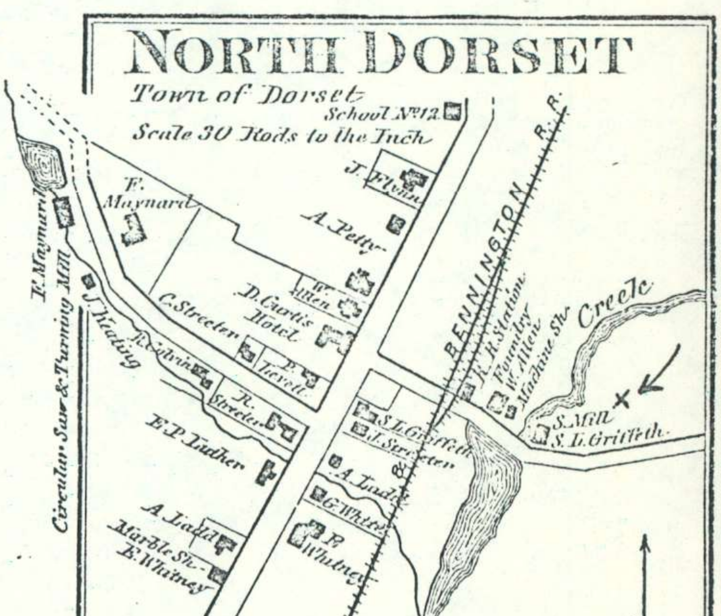

Blast furnace and ironworks complex of the Dorset Iron Company (left), from the 1869 Beers Atlas of Bennington County.

the stack leading to the top, probably the charging platform. One could walk right to the edge and look downward into the furnace interior, although this is not advised, given the unpredictable habit of unmortared stone walls and structures to collapse.

## <u>North Dorset</u>

Earliest reference to a blast furnace in North Dorset is by James Hodges, in 1849, describing an ochreous vein opened in Dorset by Curtis "a few rods east of his furnace on the Otter Creek". The Hodges report listed ten blast furnaces in Vermont, not all operating, among them one in North Dorset with an annual ironmaking capacity of 1000 tons. Little documented data is available on this furnace.

The furnace in 1983 is a collapsed ruin, little more than a pile of stones to the disinterested passerby. It is located on Emerald Lake State Forest property along the east side of the Otter Creek, about 500 feet east of the Emerald Motel (which is on Route 7). The ruins are approximately 12 feet high. Some of the stones may have been used in the construction of the later foundry and saw mill, nearby. The bosh of the furnace stands slightly above the collapsed walls. Standing within the partially filled-in bosh, its glazed walls are waist-high, giving the feeling of standing within a castle battlement.




Site of W. Allen Foundry and Machine Shop at North Dorset; approximate location of blast furnace ruin at the "X". From 1869 Beers Atlas of Bennington County.

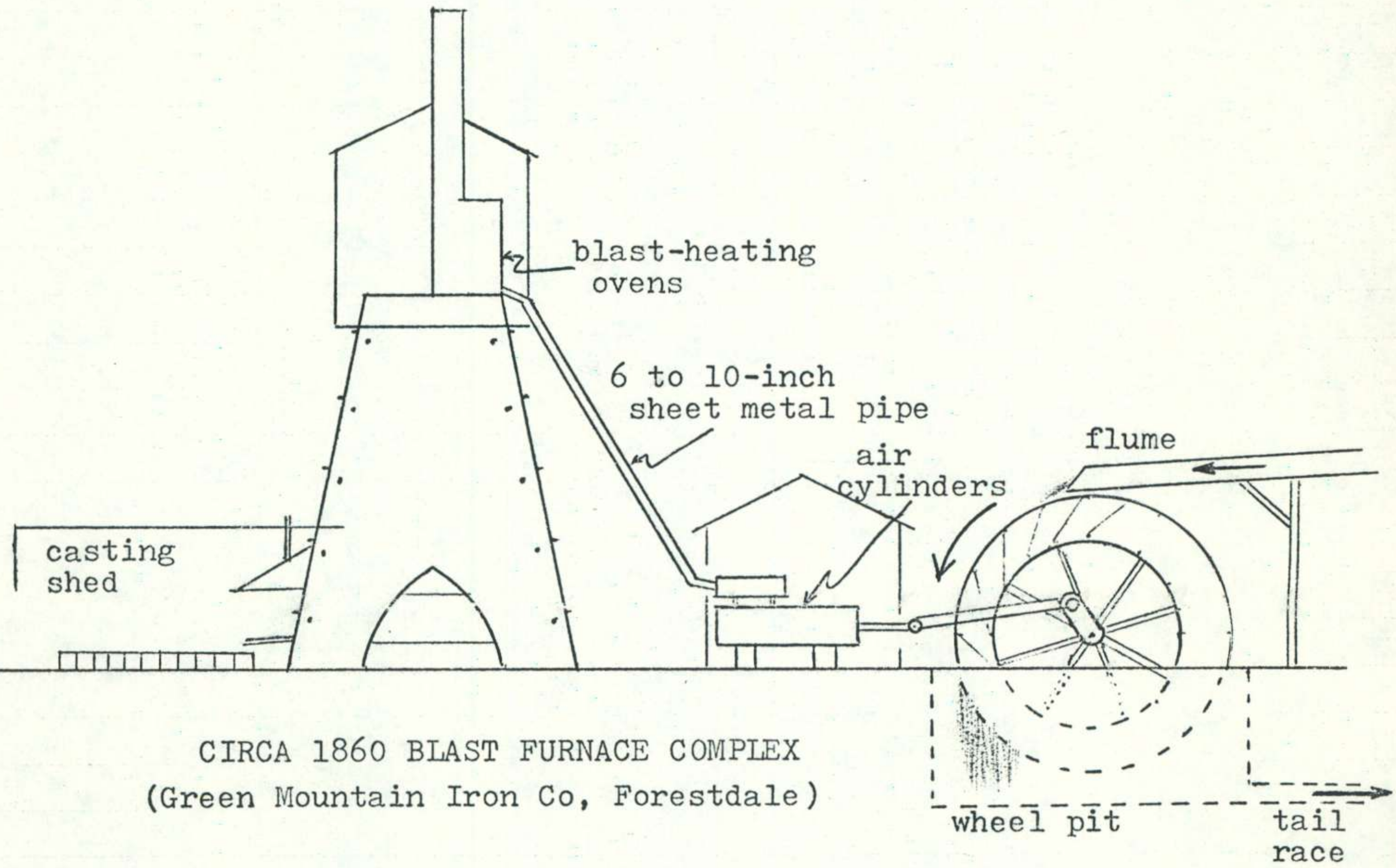
Bosh lining of the North Dorset furnace is rough lain stone, of a redish color, similar to that found at another collapsed furnace ruin in Tinmouth (approx 12 miles northwest). No archways are visible; the collapse is too complete. To the north and west of the ruin is a field of slag; at the northern edge of the slag field is a heavy iron artifact, possibly an anvil base.

Nearby, on the west side of the creek is the remains of a foundry. Earliest reference to it is its purchase in 1847 by W. (Welcome) Allen. It was then known as the "old iron foundry property", although whether in reference to the foundry or blast furnace or both is unsure (many early histories and maps interchange 'foundry' with 'forge' with 'furnace'). Since cast iron stoves were made at Allen's Foundry, it is possible the blast furnace and foundry operated for a while at the same time. On the 1856 Rice & Harwood map of Bennington County, it is identified as the Allen Machine Shop & Furnace, but the blast furnace is not shown. It was still the W. Allen foundry in 1874, but in 1889 and 1893 trade journals it was the F. (Florez) R. Allen Foundry.

In the midst of the foundry and blast furnace ruins is the barest trace of a saw mill site - introducing the next ironworks-related element of this tour. The Beers map of North Dorset identifies the saw mill as owned by S. (Silas) L. Griffith. A native of nearby Danby, Griffith acquired a significant interest in logging and lumbering enterprises in this area. Quick to notice the amount of waste wood at his mills and at the woodchopping areas, he turned waste into profit by converting it into charcoal.

## Mount Tabor

One of the most concentrated areas of charcoal making in Vermont was at Mount Tabor in the late 1800's, where it approached the scale of an industrial operation. High up in today's Green Mountain National Forest, Griffith operated as many as 30 charcoal kilns. These were at places called Ten Kilns Meadow, Four Kilns, Black Branch Job, and Griffith (identified as Old Job on current topo maps). There were an additional four kilns down below at Danby Depot, a few hundred feet east of Route 7. At Danby Depot, specially-constructed railroad cars transported the charcoal from Griffith's kiln operations to furnace and foundry customers throughout New York and New England.




CIRCA 1860 BLAST FURNACE COMPLEX
(Green Mountain Iron Co, Forestdale)

Each of these operations supported settlements of varying size consisting of woodchoppers, colliers, teamsters, and their families. Altogether, Griffith and his partner McIntyre employed some 500 men and used 100 horses and 18 yoke of oxen. The industry converted 20,000 cords of wood into a million bushels of charcoal annually.

Initially known as Mill Glen (and also as the Summit Job), it was at what was to become the village of Griffith where the charcoal business started in Mount Tabor. Here Silas Griffith rebuilt a burned saw mill to operate by steam and made 2 to 3 million feet of lumber annually. It was the lesser grades of wood and the immense amount of scrap that Griffith recognized as additional profit and in 1872 it prompted him to build his first six kilns here. In time, two more kilns were added to these operations which, by the 1880's was described as comprising 40 to 50 structures. These included the steam saw mill, a large boarding house for single men, tenant houses and cottages for families, a school house, general store and office, harness shop, wagon shop, blacksmith, stables for the animals, etc. When the post office opened, the community was known as Griffith, so identified on the 1893 USGS topo map.

The lumbering and charcoal industry at Mount Tabor made a fortune for Griffith. In 1893, he charred a whole maple log several feet in diameter in one of his kilns and transported it whole for exhibition at the World's Columbian Exposition in Chicago. Within a few years, however, the efficiency of the woodchoppers resulted in the depletion of the forest. The saw mill closed about 1905, the kilns cooled for the final time, and by 1912 the village was nearly deserted. Griffith sold his property to a New York lumber company, and by the 1930's, when the population of the entire town of Mount Tabor had dropped to close to a hundred, most of Griffith's original property holdings became part of the newly-created Green Mountain National Forest.

Except for the Lake Brook Trail, which traverses through the area, the site of Griffith has rapidly been reclaimed by nature. Cellar holes lie hidden in high summer grass while the collapsed ruins of seven charcoal kilns are nearly invisible in heavy brush. Horse shoes and axe heads are found everywhere, but most kiln hardware is gone. Yet, much remains for reasonable archeological interpretation of this forgotten industry.

Acknowledgements

Special thanks to the Executive Officers of NNEC/SIA, and also to the following who assisted and/or cooperated with me in the planing and organizing of this meeting-tour:

Mary Bort, Manchester

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Mr & Mrs John Harris, East Dorset

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John Griffith, Forest Ranger
Billee Hoornbeek, Forest Archeologist
Green Mountain National Forest

and also: Gary Baker of the Mark Skinner Memorial Library, Manchester

The Gourmet Shoppe, Manchester

Vic Rolando
33 Howard Street
Pittsfield, MA 01201

May 7, 1983

OK 3/23/83 In state Arch's Libe.

Lacelle, Claudette
1982 - MILITARY PROPERTY IN QUEBEC CITY, 1760-1871. History and Archaeology No. 57. Parks Canada, Ottawa. 248 pp., 35 illustrations. $12.25 in Canada ($14.70, Canadian funds, outside Canada). Cat. No. R64-81/1982-57E.

The Royal Regiment of Artillery was represented in Quebec City from 1759 to 1871 by ca. 60 companies in turn. The place of these companies in the general organization of the British Army is described, as is their position within the Royal Regiment of Artillery. Fluctuations in their strength in Quebec City are related to circumstances, including the total strength of the regiment in Canada. Disparities between officers, non-commissioned officers and soldiers in respect to conditions of entry into the service, career possibilities and pay are considered and the various duties of artillery companies in garrison towns such as Quebec City are described, bringing out the differences between artillerymen and other troops in the garrison.

When the British Army entered Quebec City after its victory over Montcalm in 1759, it established a presence that lasted more than a century and had a considerable influence on the city and its inhabitants. This paper assesses the effect of military property from 1760 to 1871. Military property appears to have had an enormous impact on the city's urbanization process, and provides insights into Quebec City society of the period.

Vermette, Luce
1982 - DOMESTIC LIFE AT LES FORGES DU SAINT-MAURICE. History and Archaeology No. 58. Parks Canada, Ottawa. 316 pp., 59 illustrations. $15.50 in Canada ($18.60, Canadian funds, outside Canada). Cat. No. R64-81/1982-58E.

This study examines items in everyday domestic use at Les Forges du Saint-Maurice, Quebec, in relation to the life of the people whose habits, dwellings, lifestyles and social positions they reflect. The survey is mainly concerned with two periods: the French regime (1729-60) and the Matthew Bell administration (1793-1845).

NOTE: Order the above Canadian publications from: Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec, Canada K1A OS9.

Council, R. Bruce, M. Elizabeth Will, and Nicholas Honerkamp
1982 - BLUFF FURNACE: ARCHAEOLOGY OF A NINETEENTH CENTURY BLAST FURNACE. Order from The Jeffrey L. Brown Institute of Archaeology, University of Tennessee - Chattanooga, TN. 37402. 156 pages, 41 photos and line drawings, 1 map, 9 tables. US$5.50.

Results of extensive archaeological and documentary research relating to the Bluff Furnace Site (1854-1860), a hot-blast iron furnace in Chattanooga, Tennessee, are reported. Research focussed on the definition of discreet activity areas at the site, identifying the industrial processes that occurred there and determining their relative efficiencies, and establishing the local and regional significance of the operation in an economic and in an industrial sense. Major structural components of the early charcoal fueled and later coke-fueled periods of the site are discussed and illustrated, including the base of a coke-fired cupola containing an *in situ* iron salamander. Based on analysis of fuels, by-products, and pig iron samples, the site is compared to contemporaneous blast furnaces in the United States.

Miller, Henry M, with contributions by Alexander H. Morrison, III and Garry Wheeler Stone
1982 - A Search for the Citty of St. Maries: A Report on the 1981 Excavations in St. Mary's City, Maryland.

This illustrated report includes a discussion of the Prehistoric, 17th and 19th century artifacts, and emphasizes the spatial distributions of these materials with numerous maps. The report discusses the historical documentation pertaining to the site, significantly alters the previous interpretations of these documents with archaeological data and presents the first maps of the layout of the center of the 17th century capital. A limited number of copies will be available at cost. Write to Henry M. Miller, St. Mary's City Commission, St. Mary's City, Maryland 20686 for ordering information.

Nine issues of the Journal of the Virgin Islands Archaeological Society (JVIAS) have been published of which six contain articles pertinent to historical archaeology. For information on availability and price of back issues contact Alesa M. Penso, JVIAS,

From: Rolando 1980.

Table 2. Topographic Data: Blast Furnaces & assigned site survey numbers.



| Town | Blast Furnace | Location | UTM Coordinate | Quadrangle | Built | Alter | Aband | Blast | Bosh | Tuyere No | Tuyere Dia | Tubs | Wheel Dia | Wheel Wdt | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bennington | Fassett & Hathaway | Furnace Bk | 18/6483XX/4752XXX | Bennington | 1793 | | | | | | | | | | |
| | Sage (1799) | | | | | 1803<br>1803 | 1803 | | | | | | | | |
| | Sage & Olin | E Bennington | 18/6506XX/474935X | Bennington | 1804 | | | | | | | | | | |
| | Trenor (1811) | | | | | | | | | | | | | | |
| | Hunt (1820) | | | | | | 1821 | | | | | | | | |
| | Hunt | E Bennington | 18/650650/4749300 (east stack) | Bennington | 1822 | | | | | | | | | | |
| | Benn Iron Co (1822) | UT-BE-10 | | | | | | | | | | | | | |
| | *Brock & Hinsdill (c1846) | | | | | | c1840 | | 9X40 | | | 4X22 | 22' | 121 | 243 |
| | Benn Iron Co | E Bennington | 18/650649/4749300 (west stack) | Bennington | 1822 | | | | | | | | | | |
| | *Brock & Hinsdill (c1846) | UT-BE-11 | | | | | 1853 | Hot | 9½X40 | | | 4X22 | | | |
| | Benn Iron Co | E Bennington | 18/650650/4749300 (the pup) | Bennington | c1831 | | | | | | | | | | |
| | Brock & Hinsdill (c1846) | | | | | | c1840 | | | | | | | | |
| Brandon | Conant | Brandon Vil F.S. 16 (RU) | 18/653700/4851100 | Brandon | 1820 | 1839 | c1860 | Cold | 8X35 | 2 | 2½" | 6½X30 | 25' | 8' | 244 |
| | *Grn Mtn I Co | Forestdale Ut-RU-41 | 18/656900/4854800 | Brandon | 1823 | 1854 | | | 9X42 | 3 | 2½" | 5X30 | | | 245 |
| | | | | | | | 1855 | 600° | 10X40 | 3 | 4" | | | | 246 |
| Dorset | Curtis UT-BE-35 | NoDorset | unk | Dorset | c1840 | | | | | | | | | | |
| | * Draper | S Dorset Pd | 18/661350/4787600 | Manchester | c1846 | | | | | | | | | | |
| | Dorset Iron Co (1864) | UT-BE-9 | | | | | | | | | | | | | |
| | Draper (1870) | | | | | | 1875 | Cold | 7X32 | 2 | 3" | | | | 247 |
| Fair Haven | Lyon's Works F.S. 17 (RU) | upper falls | 18/64025X/482769X | Thorn Hill | 1788 | | | | | | | | | | 248 |
| Pittsford Ut-RU-57 | Keith | Furnace Bk | unk | Proctor | 1791 | | | | | | | | | | |
| | Gibbs & Co (1795) | | | | | | | | | | | | | | |
| | Leach (1824) | | | | | | | | 8X27 | | | | | | 249 |
| | Granger (1826) | | 18/661030/4842550 | Proctor | | 1824<br>1827<br>1853 | | 600° | 9X42 | 3 | 2½" | 5½X51 | 24' | | 250 |
| | Vermont Iron Co (1865) | | | | | | | Warm | 9X40 | 3 | 3" | | | | 251 |
| | * | | | | | | c1880 | Hot | 10X40 | | | | | | 252 |
| Plymouth | Tyson UT-WN-51 | Tyson Vil | 18/685450/4814900 | Ludlow | 1837 | | 1872 | Warm | 9X35 | 2 | 3" | | 32' | 5¼ | 253<br>254 |
| St Johnsbury UT CA 20 | Paddock Iron Works | NE St Jbry | 18/737800/4923200 | St Johnsbury 15' | 1828 | | c.1845 | | | | | | | | |

Table 2. Topographic Data: Blast Furnaces (con't)



| Town | Blast Furnace | Location | UTM Coordinate | Quadrangle | Built | Alter | Aband | Blast | Bosh | Tuyere No | Tuyere Dia | Tubs | Wheel Dia | Wheel Wdt | SEE NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shaftsbury | Douglass & Bangs | unk | unk | unk | c1829 | | | | | | | | | | |
| UT-BE-36 | @H. Burden & Sons | S Shaftsbury | 18/645260/4755660 | Bennington | 1863 | | | Hot | 10X28<br>8X23 | 2 | 4" | 2½X? | | | 255<br>256 |
| Sheldon UT FR-68 | Keith #1 | Sheldon Ctr | 18/662460/4974700 | Enosburg F. 15' | 1799 | | 1823 | | | | | | | | |
| UT-FR-67 | Keith #2 | Sheldon Ctr | 18/662459/4974700 | Enosburg F. 15' | 1824 | | c1850 | | | | | | | | |
| Tinmouth | @Willard & Perry | at the dam | 18/659550/4817050 | Middletn Spgs | c1810 | | | | | | | | | | |
| UT RV-76 | *(unidentified) | N of dam | 18/659480/4816860 | Middletn Spgs | c1815 | | | | | | | | | | 258 |
| UT-RV-77 | *Rathbone & Vaughan | N of Rte 140 | 18/658530/4812570 | Middletn Spgs | 1815 | | 1837 | | | | | | | | |
| Troy UT-OL-3 | *Boston & Troy Iron Co.<br>Orleans Iron Co. (1847) | River Rd | 18/704870/4979450 | Irasburg 15' | 1837 | | 1846 | | ?X30 | | | | | | 259 |
| Vergennes UT AD 146 | Monkton I Co | below falls | 18/63925X/489160X | Pt Henry 15' | 1809 | | 1816 | | | | | | | | |
| | @Rathbone | below falls | 18/63925X/489160X | Pt Henry 15' | 1824 | | c1830 | | | | | | | | |
| Woodford | Robinson & Lyman<br>Hunt & Quimby (1822) | E part | 18/651XXX/4749XXX | Bennington | c1802 | | | | | | | | | | |

Explainations of above:
Bosh: Dia X Height (in feet)
Tubs: Dia (ft) X Stroke (in)
UTM: X is an undetermined value
* visible ruins
@ slag in evidence
In 'Blast Furnace' column: the year in parenthesis reflects new ownership.

See VT-RU-41 in town of Forest Dale in town/county file. for additional info.

from: Vic Rolando
8/79 p.c.

| TOWN | FORGE | DATES | QUAD | LOCATION | UTM |
|---|---|---|---|---|---|
| Bristol | Scott #1 | 1791- ? | Bristol | Lower Bridge | 18/65330X/48877XX |
| | Scott #2 | ? | " | Below Scott #1 | 18/65335X/48874XX |
| | Franklin | 1802-1830 | " | Bristol Village | 18/6536XX/4888XXX |
| | Chase | 1832-(1840's?) | " | Baldwin Creek | ? |
| | Holley | c1850's | " | East of Village | 18/655290/4887600 |
| | Burnham | c1850's? | " | No. of Baldwin Ck | ? |
| Ferrisburg | Barnum | c1800's | Monkton | Monkton Road Bridge | 18/6450XX/48939XX |
| | Monkton Iron Co. | 1807-1810's | " | " " " | " " |
| | Barnum | c1820's | " | Walkers Falls | 18/64417X/48952XX |
| | Fuller | early 1800's | " | Ferrisburg Hollow | 18/640690/4895000 |
| Goshen | Kendall | ? | ? | E. Side of Mountain | ? |
| Lincoln | Soper & Pier | c1828-1830 | South Mountain | West Lincoln | 18/65823X/4886740 |
| | Burnham | 1830-1860 | " | " | 18/65813X/4886740 |
| | Ackworth #1 | 1828-1830 | " | " | 18/658600/4886600 |
| | Ackworth #2 | 1830-1860 | " | " | " " |
| Middlebury | Middlebury Forge | early 1800's-1890 | East Middlebury | East Middlebury | 18/653370/4870130 |
| New Haven | Aiken: | | | | |
| | Pocket Furnace #1 | 1815-1830 | Middlebury | Brooksville | 18/646XXX/4880XXX |
| | Pocket Furnace #2 | ? -1830 | " | " | " " |
| Orwell | Lyon | 1788- ? | Orwell | East Creek | 18/634XXX/4851XXX |
| Salisbury | Sawyer | 1791- ? | East Middlebury | Leicester River | 18/653XXX/4862XXX |
| | Salisbury Bloomery | 1840's-1857+ | " " | " " | 18/653250/4862050 |
| Shoreham | Shoreham #1 | c1790- ? | Orwell | Richville | 18/6387XX/48590XX |
| | Shoreham #2 | (1800+)- ? | " | " | 18/658510/4859160 |
| Starksboro | Fergusson & Sayles | 1819-1871+ | Bristol | Starksboro Village | 18/655100/4898760 |
| | Ferguson & Bushnell | c1820's | " | East of Village | 18/6556XX/4898800 |
| | East Mountain | c1840's | " | Upper Lewis Creek | 18/656XXX/4895XXX |

From: VT Arch. Society Newsletter No. 38 Jan. 1982.

# Searchers Find More Vermont Furnace Sites and a Standing Ruin in 1981

**by Vic Rolando**

The search for Vermont blast furnaces continued in 1981 both in the libraries and in the field. Four suspected blast furnace sites were located and documented with results that contribute to further understanding of the extent of this industry in Vermont. In Highgate, a previously unrecorded blast furnace was found. Along Furnace Brook in Bennington, a known but unlocated furnace site was finally found. At Orwell, a suspected furnace site was found in the field, and belatedly in the files at the Division for Historic Preservation. At North Dorset, another suspected blast furnace site yielded a previously undocumented standing furnace ruin. These have all been written up, mapped and reported to the Division for Historic Preservation.

I learned about the Highgate site from R. John Corby of Ottawa. There are some historical references to Abel Drury, Israel Keith, and a furnace (but not a blast furnace) in Highgate (Hemenway 1871:254, 285; Thompson 1842:89). Keith also built furnaces in Pittsford (1791) and Sheldon (1799). Corby said that the lessee of the furnace property estimated the site to date to the "Hessian-British period", circa 1720, but that he did not offer any evidence for this claim. It was also Corby's understanding that the furnace was thought to have been built in Quebec, but was in Vermont after later border definition. Based on the Drury/Keith connection, I estimate that the furnace was in operation from about 1790 -1820, if this is the same furnace site at all.

The site is on the Rock River, four miles northeast of Highgate Springs. The whole area around the site is involved in speculative drilling for gas and oil, and colored tapes and survey stakes are in and around the furnace site. A low mound near the river might be the actual furnace remains. Some blast furnace slag and charcoal were recovered at its edges. Photos of ironworks-related artifacts found here in 1973 and now in his possession have been loaned to me by Corby.

In 1793, Fassett and Hathaway built a blast furnace in Bennington at Furnace Brook, so named for the furnace built there (Spargo 1938:9). John Spargo wrote that this was not the first blast furnace in Bennington, but that Blodgett's was, which in 1786 advertised the sale of "best refined bar iron...the above articles will be given for good coal, ore or pot metal [scrap iron] delivered at the forge" (Spargo 1938:27). Whereas Blodgett's made bar iron, a bloomery forge process, Fassett and Hathaway advertised in 1794 that their furnace "is now in blast..they will begin to cast this day" (Spargo 1938:9). Spargo misunderstood this crucial difference between forge and blast furnace. The 1793 Furnace Brook operation, therefore, was Bennington's first blast furnace.

It has never been known for certain where this important blast furnace is located. Whitelaw's 1796 map of Vermont places an ironworks symbol about 1½ miles south of the Shaftsbury town line. As it turns out, this is only a half mile too far north. Spurred on by the knowledge that fellow blast furnace researcher Richard Allen of New York was also looking for this site, I picked up bits of slag in lower Furnace Brook, and as weekends and weather permitted, sloshed upstream following the "trail" as finds of slag slowly increased in size and quantity, then suddenly stopped appearing. At this spot are the washed-out and collapsed remains of a dam and mill. Although it is not certain that the remains here are directly connected with the blast furnace, no more slag can be found for hundreds of feet upstream. Limited test pitting in and around the remains unearthed much slag and charcoal. Shallow trenching through an island in mid-brook immediately downstream from the dam also revealed a high density of typical multicolored glassy blast furnace slag.

Although it was learned soon thereafter that information already existed in the Division's files about an ironworks on East Creek in Orwell, the site was visited on Labor Day through independent research that has added to and clarified the Division's folder. In addition to his forges and blast furnace at Fair Haven, Matthew Lyon built a blast furnace in Orwell in 1788, working bog ore from nearby lake-level swamps and from Shoreham (Goodhue 1861:94). Whitelaw's 1796 map of Vermont identifies a "Furnace" at the site, and indicated a road north and south from it. Field inspection located the south road winding downhill to the site, where the ironworks remains consist of a few low mounds of partially exposed slag, a possible stone-lined wheel pit and shallow tail race, the head race leading from the falls above, and a shallow 2-foot diameter depression, possibly the furnace site, that yielded more slag, some brick, and a burned-end hearth stone. Judging from the disposition of the features and artifacts, the blast furnace was small--a pocket furnace--such as the "pup" at Bennington. The site is on the south side of East Creek near the base of a 30 to 40-foot falls.

A suspected blast furnace site in North Dorset was inspected in late September. Much foundry slag and some foundations of a foundry and a sawmill were located and documented. On the east side of Otter Creek, one of the largest fields (50 by 70 feet) of blast furnace slag that I have encountered was found, estimated to be six feet deep in some places. Some

▶ 5

# More Furnace Sites

very heavy and unmoveable ironwork artifacts lie at the northern edge of this slag field. About 20 feet southeast of the field is the ruin of the blast furnace, with its outer walls collapsed. The circular bosh with its glazed internal walls rises above the rubble, looking like a medieval battlement. The construction date of the furnace is not known, but it was in operation in the early 1840s (Hodges 1849: 290-291), and out of blast by 1856 (Lesley 1859:76).

This North Dorset stack brings to nine the total number of identifiable blast furnace remains in Vermont. All except the Troy stack stand a few miles either side of Route 7, from Forestdale south to Bennington.

REFERENCES CITED


Goodhue, J.F.
1861 History of the town of Shoreham, Vermont. A.H. Copleand, Middlebury, Vermont.

Hemenway, A.M.
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Lesley, J.P.
1859 Bulletin of the American Iron Association: 1856-1858.

Spargo, J.
1938 Iron mining and smelting in Bennington, Vermont: 1786-1842. Bennington Museum Historical Publication no.2.

Thompson, Z.
1842 History of Vermont. Chauncey Goodrich, Burlington, Vermont.

Whitelaw, J.
1796 A correct map of the state of Vermont.


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HISTORY OF IRONMAKING--WALL CHART published by the National Park Service, provides a concise introduction to the history and techniques of iron production. The chart is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Single copies cost $1.50.

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# EWING LAB SCHEDULE

| | | |
|---|---|---|
| Jan.7 | Thursday | 7-9 |
| Jan.13 | Wednesday | 5:30-7:30 |
| Jan.21 | Thursday | 7-9 |
| Jan.27 | Wednesday | 5:30-7:30 |
| Feb.4 | Thursday | 7-9 |
| Feb.10 | Wednesday | 5:30-7:30 |
| Feb.18 | Thursday | 7-9 |
| Feb.24 | Wednesday | 5:30-7:30 |
| Mar.4 | Thursday | 7-9 |
| Mar.10 | Wednesday | 5:30-7:30 |
| Mar.18 | Thursday | 7-9 |
| Mar.24 | Wednesday | 5:30-7:30 |
| Apr.1 | Thursday | 7-9 |
| Apr.7 | Wednesday | 5:30-7:30 |
| Apr.15 | Thursday | 7-9 |

# MEMBERSHIP

as of January 26, 1982. First column shows year for which membership has been paid. Second column shows type of membership. If "81" appears opposite your name, you owe dues for 1982.

| | | |
|---|---|---|
| 81 | Cont | Jim Adams |
| 81 | Sen | Irene E. Allen |
| 81 | Ind | Robert Atchinson |
| 81 | Ind | Louise Basa |
| 81 | Ind | William Bayreuther III |
| 81 | Ind | Marjorie Breton |
| 81 | Ind | Deanna Brightstar |
| 81 | Ind | George F. Butts |
| 82 | Sen | Lois Callan |
| 82 | Ind | Gina Campoli |
| 81 | Ind | Arthur B. Cohn |
| 81 | Sen | Grace H. Cook |
| 81 | Ind | Warren L. Cook |
| 82 | Fam | Fred & Joan Cowan |
| 81 | Sus | John & Joyce Daniels |
| 81 | Ind | Kevin Dann |
| 81 | Ind | Gordon Day |
| 82 | Sen | Leon Dean |
| 82 | Sen | Warren Dexter |
| 82 | Ind | Prudence Doherty |
| 82 | Stud | Sarah Doherty |
| 81 | Stud | David DuBrul |
| 82 | Exch | ESAF |
| 81 | Sust | John & Judith Farmer |
| 81 | Ind | Muriel Farrington |
| 81 | Ind | Carol Fitzpatrick |
| 81 | Ind | Bruce K. Flewelling |
| 81 | Ind | Suzanne Gallagher |
| 81 | Ind | Mary Gelinas |
| 81 | Cont | Frank Gonzales |
| 81 | Cont | James E. Griffin |
| 81 | Ind | Karla S. Hamilton |
| ** | Life | Lucien & Jane Hanks |
| 81 | Ind | William A. Haviland |
| 81 | Ind | Billee M. Hornbeek |
| 81 | Sen | Carleton Howe |
| 81 | Sen | R. Arthur Johnson |
| 81 | Ind | Lauren Kelley |
| 81 | Ind | James N. Kennedy, MD |
| 82 | Ind | Edward A. Krause |
| 81 | Stud | Laureen A. LaBar |
| 81 | Ind | Gale Lawrence |
| 81 | Ind | James Lawrence |
| 81 | Fam | Thomas & Joan Lawrence |
| 82 | Ind | Charles G. Leeuw |
| 81 | Ind | Edward Lenik |
| 82 | Stud | Anna Louka |
| 81 | Ind | Lee Marion |
| 81 | Ind | Barbara McMillan |
| 81 | Ind | Raymond J. Maggio |
| 81 | Inst | Middlebury College Lib. |
| 81 | Ind | Jay Edward McMahon |

Submitted to VAS for Publication in Newsletter

More Vermont Furnace Sites and Another
Standing Ruin Found in 1981

Vic Rolando VR
October 1, 1981

The search for Vermont blast furnaces continued in 1981 both in the libraries and in the field. Four suspected blast furnace sites were located and documented with results that contribute further understanding of the extent of this industry in Vermont. In Highgate, a previously unrecorded blast furnace site was found; along Furnace Brook in Bennington, a known but unlocated furnace site was finally found; at Orwell, a suspected furnace site was found both in the field and, belatedly, in DHP files; and at North Dorset, another suspected blast furnace site yielded a previously undocumented standing furnace ruin. These have all been written up, mapped, and reported to DHP and the following are abridged from these field reports.

The Highgate site was learned through R. John Corby of Ottawa, who advised me of it following my presentation of "Vermont Ironworks" to the Annual Meeting of the SIA in Hartford, Ct., in May 1981. Further correspondence with Corby found me on-site in July. There are some references to Abel Drury, Israel Keith, and a furnace (but not a blast furnace) in Highgate (Hemenway 1871:254, 258; and Thompson 1842:89). Keith also built blast furnaces in Pittsford (1791) and Sheldon (1799). Corby said that the lessee of the furnace property estimated the site to date to the 'Hessian-British period' ca 1720, but that he didn't offer any evidence for this. It was also Corby's understanding that the furnace was thought to have been built in Quebec, finding itself in Vermont after later border definition. Based on the Drury/Keith connection, I estimate the furnace in operation about 1790-1820, if this is the same furnace site at all. The site is on the Rock River, four miles NE of Highgate Springs. The whole area around the site is involved in speculative drilling for gas and oil according to the lessee, and colored tapes and survey stakes are in and around the furnace site. A low mound near the river might be the actual furnace remains but hasn't been confirmed, although some blast furnace slag and charcoal were uncovered in three shallow (6" deep) test pits at its edges. Photos of ironworks-related artifacts found here in 1973 and now in his possession have been loaned to me by Corby.

In 1793, Fassett and Hathaway built a blast furnace in Bennington at Furnace Brook, so named for the furnace built there (Spargo 1938:9). John Spargo wrote that this was not the first blast furnace in Bennington, but that Blodgett's was, which in 1786 advertised the sale of "best refined bar iron...the above articles will be given for good coal, ore or pot metal (scrap iron) delivered at the forge" (Spargo 1938:27). Whereas Blodgett's made bar iron, a bloomery forge process, Fassett and Hathaway however advertised in 1794 that their furnace "is now in blast... they will begin to cast this day" (Spargo 1938:9). Spargo misunderstood this crucial difference between forge and blast furnace. The 1793 Furnace Brook operation, therefore, was Bennington's first blast furnace.

It has never been known with a relative degree of certainty where this important blast furnace site is located. Whitelaw's 1796 map of Vermont places an ironworks symbol on Furnace Brook about 1½ miles south of the Shaftsbury town line. As it turns out, he was only a half-mile too far north. Spurred on by the knowledge that fellow New York State blast furnace reseracher Richard Allen was also looking for this site, I picked up bits of slag in lower Furnace Brook, and as weekends and weather permitted, sloshed upstream following the 'trail' as finds of slag slowly increased in size and quantity, then suddenly stopped appearing. At this spot are the washed-out and collapsed remains of a dam and mill. Although it is not sure that the remains here are directly connected with the blast furnace, or a saw mill which may also have occupied this or a nearby site, no slag can be found for hundreds of feet upstream; test pits in and around the remains unearthed much slag and charcoal; and shallow trenching through an 'island' in mid-brook immediately downstream of the dam also revealed a high density of typical multicolored glassy blast furnace slag. The site is located 1000 feet west of Chapel Road and equidistant north of an abandoned dump.

Although it was learned soon thereafter that information already existed in DHP files about an ironworks on East Creek in Orwell, the site was visited on Labor Day through independent research that has added to and clarified the DHP folder. In addition to his forges and blast furnace at Fair Haven, Matthew Lyon built a blast furnace in Orwell in 1788, working bog ore from nearby lake-level swamps and from Shoreham (Goodhue 1861:94). Whitelaw's 1796 map of Vermont identifies a "Furnace" at the site, and indicated a road north and south from it. Field inspection located the south road winding downhill to the site where the ironworks remains consist of a few low mounds of partially exposed slag (someone else had been digging here), a possible stone-lined wheel pit and shallow tail race, the head race leading from the falls above, and a shallow 2-foot diameter depression, possibly the furnace site, that yielded more slag, some brick, and a burned-end hearth stone. Judging from the disposition of the features and artifacts, the blast furnace was small- a pocket furnace - such as 'the pup' at Bennington. The site is in a cattle pasture on the south side of East Creek near the base of a 30 to 40-foot falls. It is about 3/4 mile downstream from the Route 73A bridge,

A suspected blast furnace site in North Dorset was inspected in late September. Much foundry slag and some foundations of a foundry and a saw mill were located and documented (Beers 1869:10). The site is located near the headwaters of Otter Creek, 450 feet east of Route 7 opposite the Emerald Motel along a dirt road. On the east side of Otter Creek, one of the largest fields (50 by 70 feet) of blast furnace slag I have encountered was found, estimated in some places to be six feet deep. Some very heavy and unmoveable ironworks artifacts lie at the northern edge of this slag.

About 20 feet SE of the slag field is the ruin of the blast furnace, with its outer walls collapsed. The circular bosh with its glazed internal walls rises above the rubble, looking like a medieval battlement. Construction date of the furnace is unknown, but it was in operation in the early 1840's (Hodges 1849:290-291), and out of blast by 1856 (Lesley 1859:76).

This North Dorset stack brings to nine the total number of identifiable blast furnace ruins in Vermont. All except the Troy stack stand a few miles either side of Route 7, from Forestdale south to Bennington. The North Dorset blast furnace lies on the same side of Route 7 as the Route 7 bypass construction, currently at Manchester, seven miles south.

References cited:

Beers, F.W. Atlas of Bennington County, Vermont New York:F.W. Beers, 1869

Goodhue, J.F. History of the Town of Shoreham, Vermont Middlebury: A.H. Copeland, 1861

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Hodges, J.T. "Iron Ore and the Iron Manufacture of the United States: Vermont" American Railroad Journal Henry V. Poor, ed., New York: 54 Wall Street, May 12, 1849, pp 290-291.

Lesley, J.P. Bulletin of the American Iron Association:1856-1858 (n.p.-n.d.)

Spargo, J. Iron Mining and Smelting in Bennington, Vermont:1786-1842 Bennington Historical Museum Publication No. 2, 1938

Thompson, Z. History of Vermont Burlington:Chauncey Goodrich (Part III) 1842

Whitelaw, J. A Correct Map of the State of Vermont 1796

Author's note: For those interested in additional ironmaking information, a Xerox copy of my following efforts are now on file at the UVM and the VHS libraries:

A Survey of the Stone Blast Furnaces of New England and Eastern New York State 1977 (133 pp, illus, maps, footnotes, biblio, index)

Ironmaking in Vermont: 1775-1890 MA thesis: College of St Rose, Albany, NY 1980 (132 pp, illus, maps, footnotes, biblio)

VAS Newsletter No. 33
Oct. 1980

# Stone Blast Furnaces in Vermont

*This list of furnaces was accidentally omitted from last issue's article by Victor Rolando, entitled, "Search for Vermont Furnaces Yields Dramatic Discoveries."*

| | | |
|---|---|---|
| BENNINGTON | | |
| | Furnace Brook | 1793-1803 |
| | Sage & Olin | 1804-1823 |
| | * Hunt | 1822-ca. 1840 |
| | * Benn. Iron Co. | 1822-1853 |
| | Benn. Iron Co. | ca. 1831-ca. 1840 |
| BRANDON | | |
| | Conant | 1820-ca. 1860 |
| | * Forestdale | 1823-1855 |
| DORSET | | |
| | Curtis | ca. 1840- ? |
| | * Dorset Iron Co. | ca. 1846-1875 |
| FAIR HAVEN | | |
| | Lyon | 1788- ? |
| PITTSFORD | | |
| | Keith | 1791- ? |
| | Gibbs & Co. | 1795-1824 |
| | Leach | 1824- ? |
| | Granger | 1853-1865 |
| | * Vermont Iron Co. | 1865-ca. 1880 |
| PLYMOUTH | | |
| | Tyson | 1837-1872 |
| ST. JOHNSBURY | | |
| | Paddock Iron Co. | 1828- ? |
| SHAFTSBURY | | |
| | Douglass & Bangs | ca. 1829- ? |
| | H. Burden & Sons | 1863- ? |
| SHELDON | | |
| | Keith #1 | 1799-1823 |
| | Keith #2 | 1824-ca. 1850 |
| TINMOUTH | | |
| | William & Perry | ca. 1810- ? |
| | * (unknown) | ca. 1815- ? |
| | * Rathbone & Vaughan | 1815-1837 |
| TROY | | |
| | * Boston & Troy I. Co. | 1837-1846 |
| VERGENNES | | |
| | Monkton Iron Co. | 1809-1816 |
| | Rathbone | 1824-1830 |
| WOODFORD | | |
| | Robinson & Quimby | ca. 1820- ? |

* Standing or identifiable furnace ruin

## ACADEMIC PRESS PUBLISHES SNOW'S NEW BOOK ON NEW ENGLAND ARCHEOLOGY

Dean Snow has just completed a book entitled, *Archaeology of New England* (Academic Press). Members will remember Snow well because he has been a featured speaker at Society meetings on at least two occasions.

His book is written to appeal to both the professional and the avocational archeologist. He expresses a deep concern about the widening gap between these two groups and about the declining membership of many archeological societies. Snow feels that archeology will lose much of its character if it loses its non-professional component and one of the implicit aims of his book is to negotiate a new "contract" between the two. We'll have a review of the new book in an upcoming issue.

VERMONT ARCHAEOLOGICAL SOCIETY, INC.
BOX 663, BURLINGTON, VT 05402


FIRST CLASS

TO

Giovanna Neudorfer
Box 601
Waterbury, VT 05676

# STONE BLAST FURNACES OF VERMONT

By Victor R. Rolando

Wrought and cast iron were made in at least 62 bloomery forge and 18 blast furnace sites in Vermont between 1775 and 1890. During this period, 75 bloomery forges and 28 blast furnaces were fired at these sites (Rolando 1980:107-113). Field investigations made in 1978 and 1979 to locate the surface remains of nine of these forges resulted in a few bits of slag, one flume, and one possible dam site. The search for blast furnace sites, however, has netted more dramatic discoveries. Standing ruins of blast furnace stacks exist in Bennington, Dorset, Forestdale, Pittsford, and Troy. Trace ruins are also identifiable in Tinmouth and Plymouth. The remaining sites, which display either questionable or no surface evidence are Brandon, Fair Haven, Shaftsbury, Sheldon, St. Johnsbury, Vergennes, and Woodford.

These blast furnaces measure 20 feet to 30 feet square at the base and 23 to 40 feet high, tapering inward from the base. The outside walls of the earlier furnaces, such as those in Bennington, Dorset, and Troy, are of coarsely laid, rough cut (or uncut) stone. Walls of the later blast furnaces at Forestdale and Pittsford are of uniformly laid and large finished stone. All walls were laid without mortar or cement.

Each blast furnace was built close enough to a low hill to allow a short, high bridge to connect the hilltop to the top of the furnace, affording the means of charging the furnace with iron ore, fuel, and flux. Iron ore was mined locally and sometimes mixed with ore from New York state. The fuel was charcoal, made in kilns located in the surrounding forests or at the furnace site. Anthracite coal was considered at Dorset (Neilson 1866:220), and actually used without success in 1854 at the Forestdale stack (Lesley's Guide 1859:25). At the Conant furnace in Brandon, a dense peat called lignite ("brown coal") was used to supplement expensive charcoal. To facilitate removal of impurities from the iron, a limestone flux was added to the charge of iron and coal. The limestone combined with the impurities to form slag, visible at most furnace sites as multicolored "stone".

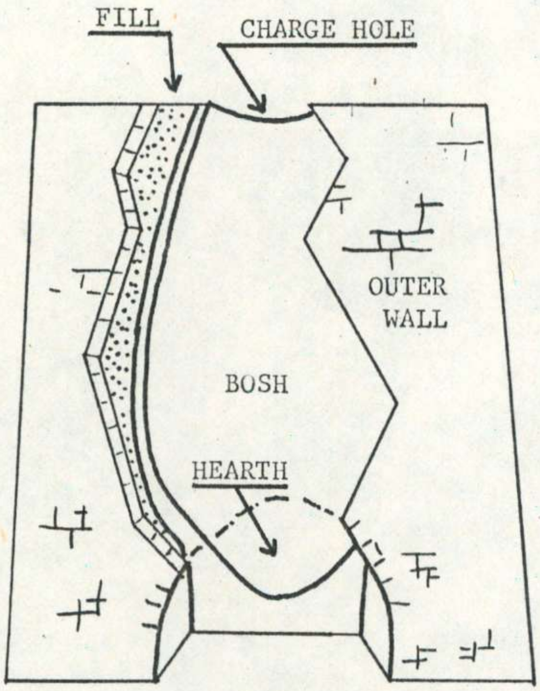
The forced draft for which the blast furnace was named was generated for earlier furnaces by large bellows, driven by waterwheels. Usually operated alternately and in pairs, 4-foot wide by 20-foot long bellows were not uncommon at the turn of the 19th century. Soon after, these bulky and cumbersome devices were replaced by wooden cylinders and pistons, the forerunners of today's air compressors. The 1839 alteration of Conant's furnace to accommodate two 6½-foot diameter cylinders is the earliest recorded use of these blast machines in Vermont (Lesley's Bulletin 1859:77). The cylinder heads were double-acting, with inlets and outlets closed by wood flap valves on leather hinges. (At a contemporary site at Tahawus, New York in 1977, I found the remains of wooden cylinders and pistons and their cast iron piston rods.) The pistons were operated by piston rods made either of cast iron or wood (wood was used at Hopewell Furnace, Pa), connected and driven from each side of the water wheel. The cylinders were mounted either next to the waterwheel (Tahawus) or on scaffolding above it (Hopewell).

The blast was connected to the furnace hearth through one of the arches at the base of the stack by cast iron nozzles called tuyeres. The tuyeres were usually double-walled and cooled by circulating water to keep them from melting.

Early blast furnaces had one or two arches; later furnaces had four. Early furnaces such as the c1820 stack in Bennington, employed corbelled arches with no decorative molded bands. The Dorset and Forestdale furnaces, of slightly later construction, contain splendid wedge-stone arches, while the Pittsford furnace, which operated until the 1880s, has a three-tiered molding of mortared brick. The red underlain with yellow brick soffit extends the entire depth of the arch ceiling.

These archways also gave ironworkers access to the hearth, from which the molten iron and slag were periodically drawn off. The hearth sat at the center of the furnace base. It was massively walled and supported with stone and/or brick to support not only the heavy molten iron and slag in it but also the entire bosh, which entended to the top of the furnace. The bosh was the inner stone or brick-lined vertical cavity in which the actual melting took place. Its configuration was like an egg, standing on its wider end. It was at this wide point where the tuyeres were connected and melting temperatures were the highest.

Early furnace boshes, such as one of those at Tinmouth, were lined with a hard stone, possibly schist or gneiss. As the technology advanced, iron characteristics were found to be affected by the nature of the bosh lining, prompting the use of various refractory bricks. Bosh bricks from the c1840 Troy furnace appear to be ordinary red bricks; from the c1850 Forestdale furnace they are yellow firebrick made in Troy, New York. Bosh




Cutaway view into a
typical blast furnace.

brick is distinctive from decorative brick for its burned and/or glazed end, caused by the extreme heat in the hearth. (Glass foundaries, bloomery forges, iron foundary cupola furnaces (air furnaces), lime kilns, and other metal processing furnaces also employ firebrick lined hearths as do present-day home heating gas and oil furnaces.) Some firebricks were tapered to better fit the circular bosh configuration; all firebricks were mortared.

The space between the inner circular bosh wall and the outer square furnace wall was filled with rough stone of all shapes and sizes. This fill provided an insulating jacket around the bosh and support to hold the bosh vertical. This fill is visible at the two Bennington furnaces, each of which is partially collapsed. Parts of the Forestdale and Pittsford furnaces are also exposed.

The two Bennington furnaces are located on private property off Route 9 at Furnace Grove. They are next to a residence which once served as the ironworks company store; later a chair factory. A good waterwheel pit remains next to the eastern stack, and a depression traces the route of the flume from the site of the forge pond to the wheel pit. Otherwise, all surface traces of bloomery forges, charcoal kilns, charging and casting sheds, coal and ore houses, and a third smaller 'pocket' furnace (which stood between the two stacks) are gone beneath gardens, lawn, roads, and underbrush. Public access is practically unrestricted.

The stack at Dorset stands on private property just west of a bypassed stretch of Route 7 one mile north of the town line. No other surface remains are visible.

The Forestdale stack stands in a heavily wooded, state-owned area a few minutes' hike up an old road northeast of the village. The Pittsford furnace is relatively hidden along Furnace Brook a mile northeast of Pittsford village. No surface remains except fallen arch and bosh bricks and much slag are visible at either site.

The most significant blast furnace site for the quantity and quality of interpretive surface remains is at Troy. This site is located about $2\frac{1}{2}$ miles north of Route 100 on the east shore of the Missisquoi River. It can be reached by a 10-minute hike through a pasture off River Road.

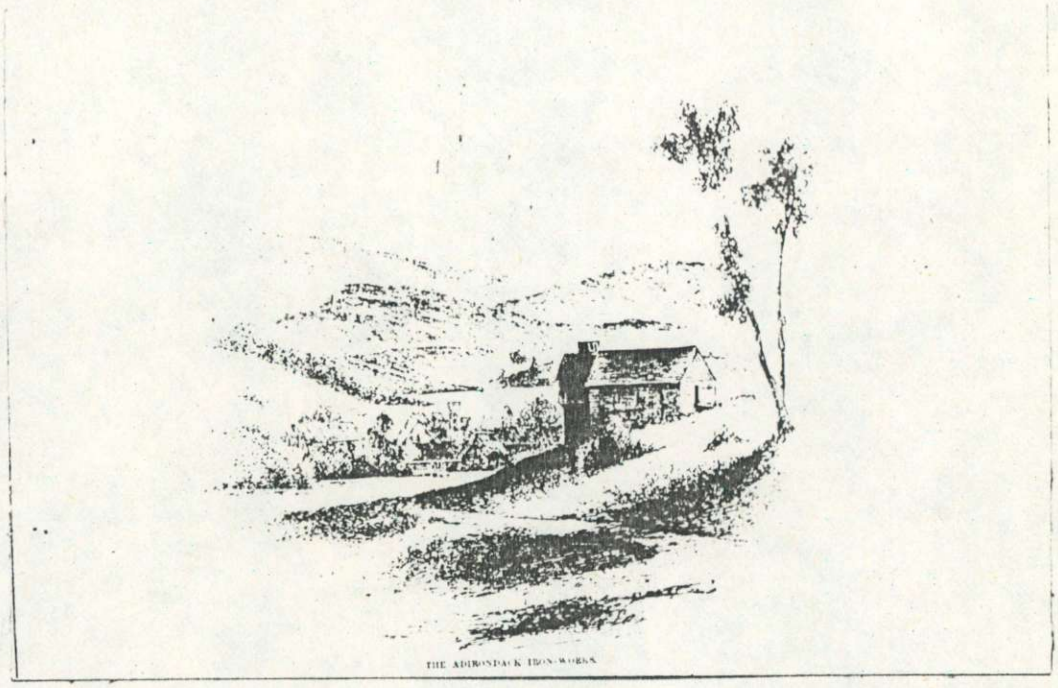
The blast furnace was built in 1837 and abandoned in 1846 (Hemenway 1877:325). It stands immediately downstream from a falls where a narrow gorge forms a right-angle bend in the river. An approximately 300-foot flume cuts diagonally across the inside of this bend, affording a good head at the waterwheel pit, near the stack. The flume is 15 to 20 feet wide and 6 to 10 feet deep, cut through the rock. The dam, which backed the water into the flume, was probably located in the narrow gorge although inspection during a low water period in 1979 failed to reveal any evidence here. Another possible dam location exists upstream, where the flume leaves the river.

The wheel pit is about 20 feet west of the furnace stack. A narrow rock cut through a low hill between the stack and the pit leads to speculation that (1) the blast machines were either located here, feeding air to a tuyere in a possible arch at the east wall, or (2) the waterwheel shaft came through this cut to power the machines closer to the stack. Locating the archways in the stack would help to interpret various features of the furnace site, but all walls except the south are partially collapsed, burying probable arch locations.

Directly east of the stack are stone walls, foundations, and an iron hollow-ware 43 inches in diameter and 23 inches deep, possibly a potash kettle cast at the site. A tail race from one of the foundation holes may indicate a wheel pit that powered a bloomery forge or a cupola furnace for remelting and casting stoves, hollow-ware, and boundary markers. (Many of the latter, cast at this furnace, were used along the nearby international boundary.) Glazed firebrick are found in and around this hole. Heavy iron mountings, possibly to support a waterwheel, lie at one corner of the foundation. A small dry inlet in one side of the foundation could have fed water to run the wheel, but its connection to the flume or river cannot be found. Slag and waste iron are scattered throughout the immediate furnace area.

During its active ironmaking days, the furnace stack was surrounded by buildings, in contrast to today's open appearance. These buildings protected the blast machines and casting activities around the base of the furnace and the charging operations at the top. The charging house sat directly on the furnace with a tall chimney that vented smoke and stack gases away from the work areas. Foundations on the charging hill behind the furnace indicate that the charging bridge might also have been enclosed. A sketch of a c1844 blast furnace at Tahawus, New York which is contemporary with the Troy furnace in time and wilderness environment, indicates a likely configuration of the immediate furnace structures (Masten 1923:132).

Threading through the rubble of the collapsed furnace walls are the twisted iron straps that held the stack walls together. Their ends are slotted for pins to hold iron end plates snugly against the wall. All pins have been removed, even from the undisturbed wall, but the only end



THE ADIRONDACK IRON-WORKS

c1844 A ~~c1840~~ blast furnace complex at Tahawus, New York, a contemproary to the Troy furnace. (Masten 1923:132) plate was found a few dozen feet downstream, in knee-deep water. The vicinity of the river near the furnace should not be overlooked in the search for artifacts.

The ironworks supported a village that had a boarding house and post office (Thompson 1842:174). No trace of village cellar holes could be found. They may have been in the present relatively smooth pasture that borders the wooded furnace site. The old road that ran parallel to River Road leads down through the woods to the southeast and uphill out of the woods east of the tail race. The road is indicated on Beers' Atlas, and shows structures in the ironworks vicinity (Beers 1878:50).

Vigilance is one response to threats to archeological and historic resources. But vigilance must be coupled with accurate identification and ongoing inventory of sites. Unlike blast furnace sites that were destroyed years ago by later mills in Sheldon, a hydroelectric power station and recently a sewage treatment facility in Vergennes, and industrial development in St. Johnsbury, the Troy furnace site has managed to escape relatively undisturbed. This is due largely to its remote location. The Troy furnace site does, however, fall well within an area of the upper Missisquoi River that is threatened with inundation from the projected construction of a high dam about two miles downstream. This would place most of the Troy ironmaking site under 25 feet of water.

Assisted by an inventory already accomplished for DHP on a majority of the bloomery forge and blast furnace sites in Vermont, the UVM contract archeology team has already started initial identification of this potentially sensitive archeological site plus an earlier bloomery forge site two miles upstream. This effort also includes the identification of other historic and prehistoric sites at this and five threatened downstream dam sites. The result of this identification effort will allow DHP to proceed effectively with the implementation of federal and state historic preservation laws.

April 2, 1980
Pittsfield, Mass.

Vic Rolando

Stone Blast Furnaces of Vermont

| Location / Furnace | Dates | Location / Furnace | Dates |
|---|---|---|---|
| Bennington | | St. Johnsbury | |
| Furnace Brook | 1793- 1803 | Paddock Iron Co. | 1828- ? |
| Sage & Olin | 1804- 1821 | | |
| *Hunt | 1822-c1840 | Shaftsbury | |
| *Benn. Iron Co. | 1822- 1853 | Douglass & Bangs | c1829- ? |
| Benn. Iron Co. | c1831-c1840 | H. Burden & Sons | 1863- ? |
| | | | |
| Brandon | | Sheldon | |
| Conant | 1820-c1860 | Keith #1 | 1799- 1823 |
| *Forestdale | 1823- 1855 | Keith #2 | 1824-c1850 |
| | | | |
| Dorset | | Tinmouth | |
| Curtis | c1840- ? | Willard & Perry | c1810- ? |
| *Dorset Iron Co. | c1846- 1875 | * (unknown) | c1815- ? |
| | | *Rathbone & Vaughan | 1815- 1837 |
| Fair Haven | | | |
| Lyon | 1788- ? | Troy | |
| | | *Boston & Troy I. Co. | 1837- 1846 |
| Pittsford | | | |
| Keith | 1791- ? | Vergennes | |
| Gibbs & Co. | 1795- 1824 | Monkton Iron Co. | 1809- 1816 |
| Leach | 1824- ? | Rathbone | 1824- 1830 |
| Granger | 1853- 1865 | | |
| *Vermont Iron Co. | 1865-c1880 | Woodford | |
| | | Robinson & Quimby | c1820- ? |
| Plymouth | | | |
| Tyson | 1837- 1872 | | |

* Standing or identifiable furnace ruin.

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30 August 1981



Dear Giovanna,

If you haven't sent out the Route 7 bypass info yet, forget it. I've found out that the 'bits and pieces' I thought, aren't. The whole stretch from Arlington to Manchester Depot is well under construction. No wondering where it goes; it's very obvious. But it doesn't seem to be near any iron mine or charcoal kiln sites that I know of. I hiked about two miles up the Lye Brook Wilderness Trail this past Saturday, looking for the iron mine there with no real luck. Where ever it is, it's well east of the new Route 7 workings. Up that same Lye Brook ravine are remains of railroad beds and trestles from the lumbering days, around the 1900's I think. The Lye Brook ravine itself is very impressive; a jumble of giant boulders. I'll have to get back up there some day I have more time to really enjoy.

My elusive blast furnace at Manchester Center isn't. (I think.) I'm pretty sure the blast furnace slag I found in the stream bed in the Center last week comes from East Dorset. Not that it washed down, even though it's only three miles upstream; it's a different stream. In 1884 the wood bridge at Manchester Center (or Factory Point, as it was then called) was replaced by an iron truss bridge. I found a photo of it, and it sits on a relatively high abutment, much the same where today's bridge is. The iron bridge was in turn replaced by an arch marble bridge in 1912, and widened to today's width in 1942. I speculated that slag might have been used, at least in part, to fill the iron bridge abutment. To check it out, I returned to the bridge this Saturday, and after careful inspection, managed to find a handfull of small chips of the same type and color blast furnace slag in and adjacent to a parking lot where the old abutment used to be. I never did believe that a blast furnace existed in Manchester Center (or Factory Point). A reference to the bare remains of an old stack in the 1930's, right next to Route 7 in Manchester Center must be with regard to the remains of a blacksmith forge and chimney, that existed in the parking lot where I found yesterday's blast furnace slag. The two have absolutely no connection.

I have finallly located someone related to a former worker at the Burden Works in Shaftsbury. A woman's great-great grandfather worked as furnaceman for Burden in the 1860's-70's. This woman also has some tools and other things from his days. She also thinks there's a piece of pig iron in the attic! She was suprised anyone else would be interested in these things. Her son gave me a guided tour of the 'furnace grounds', and I have finally physically located some foundations. It's very heavily overgrown, however, so I'll return in a few months when the foliage situation should improve.

And on to Furnace Brook, Bennington. After countless hours inspecting maps and practically crawling on my hands and knees in that brook, tracing slag finds upstream, I ran out of slag this afternoon. Well, not exactly. I had been doing this for some days now, but the going is slow. So I gave my best guess as to exactly where Whitelaw's ironworks symbol on his 1796 map was on my topo, and visited the spot. It's almost on top of an abandoned dump! This afternoon, I managed to hike down from the road, around the dump, and follow the stream up for about a quarter mile. The slag stopped after findsome good 10-inch to 1-foot diameter pieces immediately downstream of the remains of a dam and some foundations. I don't think the foundations are actually the blast furnace foundations, but from something that came later. If it was a good blast furnace site in one year, it could very well be a good site for something else later, n'est pas? There are what I believe to be a wheel pit. with sufficient foundation for a structure next to it. It might have housed blast machinery earlier, maybe a saw mill later. But in addition to the slag here, the stream ran very red. In fact, on the bank adjacant to the foundation walls, the red was thick enough to be scooped with a spoon. Maybe leaching out from some iron ore that hadn't been worked? And also, the structure was built against the embankment of a small, artificial hill, much like early furnaces were; to afford bridge access to the stack. There were no hearth brick to be found, but that isn't unusual. At Tinmouth, ordinary rock was used for hearth lining. Could be why the furnace didn't work out well. And about the sides of the embankment, there were all manner of charcoal.

It took an hour to get down from the dump and up the stream to this spot, but I found a short-cut out. It'll make for easy enough access to return again next week, and do more investigating here. If it does turn out to be the blast furnace, it's a very important find. No one has ever really known where it was. And what's more, I've found the slag to be of a very good quality; highly colorful, bright, and multi-colored (green, black, and light blue). I hadn't expected to find such colorful slag for such an older furnace site.

That's not all... folks. While studying a history of the Town of Shoreham, for iron ore there, I ran across the statement in the 1861 book that the ore in Shoreham wasn't good for wrought iron, so it was used at Mathew Lyon's furnace in Orwell where some good cast iron pieces were made. In my thesis I had concluded that this was a bloomery forge operation, but now it looks like an honest blast furnace. Funny the clue should come out of another town's history. I guess my next major search is in Orwell, maybe this Labor Day weekend. Incidently, I've been baging slag samples the past two years. I have bags of slag, identified as to site, and the date I baged it. Just so you know, in case anyone wants to do some kind of slag analysis with Vermont slag.

Sorry I don't have anything more to report, but I have to end this weekend and go to work tomorrow (work? tomorrow?). I'm planning a Friday-Saturday weekend in the VHS/UVM libraries about the middle of September, workload at GE permitting, so maybe I'll see you then.

Data for the ironworks article is obviously piling up, much to my satisfaction. I'm very glad that I didn't let Bob West publish what I had last year. When I finish, I should also have scads of new and corrected information for your files also. I don't plan to publish UMT coordinates and such in the new article, but I am keeping track for you.

Love to all. If you run into a single woman with a bent for a fanatic dirt historian, point her my way.

Vic

not a blast furnace

24 August 1981

Dear Giovanna,

see letter 30 Aug.

No, no problem. Just a good weekend! I've been checking some loose ends from my thesis research, and this weekend's was a supposed blast furnace in Manchester Center. I should have left well enough alone. I went up yesterday (Sunday), not expecting to find anything but found blast furnace slag in the stream that runs right throughthe village. Honest-to-God blast furnace slag; bright blue, black, and white/grey. It's in the stream bed from the Route 7 bridge to well below the dam just a few hundred feet downstream (east). Also, there's an old iron turbine along the shore, just waiting for someone to haul away as part of his/hie collection. It has an 18X9 (1869 or 1888) date on it. I'm going back up next weekend for another look, and better date it. I'm also planning some library work there. There's an iron mine a few miles away along Lye Brook that is supposed to hve been mined by the Clove Springs Iron Company in Dutchess County. I know about that company from previous work. To have hauled iron ore a hundred-plus miles by the company meant that it must have been pretty good ore. So why not a local blast furnace at one time? Dunno. I'll have a better story later. My blast furnace count for Vermont is closing in on 30! Especially if I eventually figure out the ellusive North Dorset 'blast' furnace.

I should have some sort of a draft outline of the ironworks article in a week or so. I'm still trying to sort out where to place some sites (in the outline), but I'm also considering including some non-ironmaking, but significant ironworking sites. ~~wherexth~~ These include the Gray Foundry in Poultney (don't look it up, it don't exist anymore), the works at Randolph, things at Windsor and Rutland, etc. I'm also going to write to the VHS tonight right after this letter to find out what their requirements are with respect to articles. It's starting to feel good making weekly weekend trips to Vermont again. I can do quite a bit on one-day drives from Pittsfield as long as I plan the trip carefully, and lug along everything I <u>may</u> need, which if I don't bring, I <u>will</u> need.

The way the article is being put together, is not a strict archaeological survey, but one of combining that, along with historical information. I really don't know what that makes it, although I'm sure the VHS should be interested. At least, I don't know of anything of the sort ever being done in Vermont (now <u>that's</u> ironic!).

Forging along... I'm also writing to Sandy to at long last take him up on his offer to put me up some evening. I plan to do an extensive amount of work at the Rutland Free Library sometime in September. The Proctor/Rutland area is within 25 miles of about 90% of my ironworks sites. I figured the other day that Addison and Rutland Counties alone account for 55% of the ironworks and ironmaking sites in all of Vermont.

Gotta go... Hi to all.

Vic

November 5, 1979

RECEIVED NOV 7 1979

Philip F. Elwert, Curator
Vermont Historical Society
109 State Street, Pavilion Building
Montpelier, Vermont 05602

Dear Phil,

Many thanks for the prompt action on supplying the photos. They are sharp beyond my expectations, and are usable within the next few weeks. I most definitely will give VHS the proper credit line. The photos are being used as part of my MA thesis, which is a survey of ironmaking sites in Vermont. As of this writing, I have located exactly 100 bloomery and blast furnace sites in the state. It's time to quit! I have no plan to publish the thesis, but I do plan to use it as a basis for writing a comprehensive study of ironmaking in Vermont at some later time. I will still have to research the iron mines and bog ore beds, charcoal-making industries and kilns, etc. There's a long way to go yet. But I will, none-the-less, make a copy of the thesis for the VHS. The main purpose for the survey is for your SHPO office, right upstairs.

I have found a couple of related items for your interest:

1). The 'Tyson Furnace' painting, according to your files, was painted by an unknown artist. In Guy Hubbard's Industrial History of Windsor, Vt (1922) p 53, he talks of "an oil painting of the furnace made years ago by Mr. Myron Dimmick (a workman at the furnace who became a landscape painter)".

2). There is a Tyson Stove on display in the VHS museum, dated on the card "ca 1883". Nothing I have turned up on operations at the works indicate its blast furnace in operation beyond 1872 and at that time it was not known as the Tyson Iron Works, but the Spathic Iron Company (of Hartford, Conn.). The Tyson Iron Company ceased to exist right after the Civil War. I can only think that the "ca 1883" date may indicate continued casting of the popular Tyson Stove by a later foundry while retaining the Tyson Stove name for advantageous sales purposes. If you can shed any light on that in the way of confirming the "ca 1883" date (realizing the ± nature of ca), or who might have been casting Tyson Stoves at that time, I would appreciate it.

Sincerely,

Vic

Victor R. Rolando
34 Howard Street
Pittsfield, Massachusetts 01201

Hi - My car broke down - getting fixed, but may be back up in a few weeks. I'll let you know when.

Be good.

Vic

(over)

I keep running into references in various Vt histories of a steamboat that predates Fulton that sank in Lake Morey. Do you know of it? With your interest in Underwater Archeology, I thought this might interest you. I'll look more into it if you are interested.

JR

April 7, 1980

Dear Giovanna,

Here's that pest again...

Enclosed are ~~two~~ 3 things. First, a Xerox of an article I found in the Nov '77 issue of the SIA Newsletter, while looking for something else. It appears to describe one of the bridges I reported to you last fall, made of railroad track, in Wallingford. Maybe you should attach it to the same report on that bridge. Second item, a Xerox of what appears to be a review of your Stone Chambers article. This item comes from the ESAF News (Aug '79) which I only just this week received. I suspect you also get this, but just in case... Incidently, in case you would like, I subscribe to the NYSAA Bulletins, and would mail them to you, if you don't get them. (COPY OF CONTENTS ALSO ENCLOSED)

I checked into why UTMs in the forms I sent to you last year differ from the thesis. I've figured it out. When I was making out the forms, I hadn't ever used UTMs before and assumed that the grids ran parallel to the sides of the map. Of course, I've since found out they don't. For UTMs near the edge, they probably are accurate, but toward the middle they are way out. When I discovered this (I can't remember how I discovered it), I bought myself a 24" steel rule to reach the entire length and width of the topo, and determine the accurate UTM. Sorry about that. Use the thesis UTMs. They're the correct ones.

Your assistant, Donna, is keeping my office phone jingling. No problem, but I have to keep a copy of the thesis at work now. Again, no problem. Glad to help. I hope you understood that I didn't confirm all the sites in the report. This I hope to do this year, for as much time as I have available to do (and gas $$$ holds out). By year's end there should be an addendum to the thesis with more accurate UTMs (here we go again!). I also hope to be able to give a better report on what visible remains there are, photos, etc. Remember, Giovanna; I'm an amateur. With an MA yet, but still an amateur. I value that. (It's also my way out!)

I received the UVM Summer Session bulleting last week and am planning to spend the week following July 4th at Chester's IA course. I took this back in the summer of '78, at which time we recorded the old Vermont Bobbin Factory in Burlington. I don't know what we'll be doing this year, but Chester usually comes through. I won't be needing credit this time, so it should be more relaxed and fun. Also, I'll have time to do some evening work at the Wilbur Collections Library, maybe get in some socializing along the way. Hmmm-m-m...

Thursday's my last day of school. No more teachers, no more books....

Keep well; lots of love...

Vic

TEK BEARING COMPANY, Inc.
776-A Watervliet Shaker Road Latham, N. Y. 12110 (518) 785-4131

Richard S. Allen
13 Aspinwall Road
Albany, NY 12211

FEB 10, 1980

DEAR VIC:

THE THESIS ON VERMONT REC'D.

MANY THANKS AND WELL DONE!

I SPENT ALL EVENING GOING OVER IT - CHECKING MAPS AND ALL - YOU HAVE DONE AN ADMIRABLE JOB. SO MANY "NEW" THINGS, AND YOUR FINDINGS COINCIDE WITH MUCH I'D THOUGHT ABOUT, BUT NEVER REALLY KNEW.

BEST, —

Rich



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- WOODFORD HOLLOW IS TOO MUCH CHANGED TO FIND ANYTHING NOW, IN MY OPINION, WHAT WITH ROAD CHANGES, RAILROAD BUILDING, STREAM CHANGES, FLOODS AND EXPLOSIONS OF THE LATER POWDER WORKS.

- ON THAT "MIDDLEBURY FURNACE" QUESTION - J.T. HODGE IS COMPARING CROWN POINT WITH THE MIDDLEBURY (SUMMIT CO.) AND ELYRIA (LORAIN CO) OHIO FURNACES. (THEY ARE LISTED AS "ABANDONED" IN LESLEY'S 1859 BOOK.

HAVE VERGENNES SITE TO

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— SURPRISED AT YOUR DISCOVERY OF AN ACTUAL STOVE MADE AT TYSON FURNACE. AND THE CUT OF THE BRANDON WORKS "BLAST FURNACE"

— I'M WITH YOU ON SUTHERLAND FALLS BEING A FORGE ONLY.

— YOUR TINMOUTH RESEARCH IS MOST REVEALING — IN FACT YOU HAVE LAID TO REST SO MANY OF THE "RUMORS OF IRON WORKS" — CHITTENDEN, MANCHESTER, ETC.

WE MAY YET TURN UP SOME SLAG IN THE NOTCH AT NO. DORSET,

— AND ON FURNACE BROOK IN BENNINGTON



TEK BEARING COMPANY, Inc.
776-A Watervliet Shaker Road Latham, N. Y. 12110 (518) 785-4131

CHECK OUT FURTHER DOWNSTREAM WHICH THE KELLER COLLECTION IN AISI STUFF IN WASHINGTON SHOWS.

HAVE NOT FOUND THE BOOK YET — WITH A TITLE "MERCHANT PRINCES OF BOSTON" (OR SOME SUCH TITLE — RECENT), WHICH IS SUPPOSED TO HAVE MATERIAL ON BOSTON FINANCING OF MONKTON I.W.

ETC, ETC. — RSA

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STATE OF VERMONT
Division for Historic Preservation
Montpelier, Vt. 05602

HISTORIC SITES & STRUCTURE SURVEY
Blast Furnace (ironmaking) Survey Form

SURVEY NUMBER:
NEGATIVE FILE NUMBER:
UTM REFERENCES:
Zone/Easting/Northing
USGS QUAD MAP:
Accessibility to public:
☐ Yes ☐ No ☐ Restricted

COUNTY:
TOWN:
LOCATION:

Visible from public road:
☐ Yes ☐ No ☐ Seasonal
Builder/Contractor:

COMMON NAME:
OTHER NAME(S):

Date built:
Date(s) rebuilt:
Date abandoned:

OWNER:
ADDRESS:

Level of significance:
☐ Local ☐ State ☐ National

DESCRIPTION, CONDITION, EVIDENCE OF SITE:
☐ Standing furnace ☐ No visible evidence
☐ Partially standing ruin ☐ Historical marker
☐ Collapsed ruins ☐ Other ____________
☐ Trace ruins

STRUCTURE:
External: ☐ Fine ashlar ☐ Uncut stone
☐ Rough ashlar ☐ Brick

Bosh: ☐ Refractory brick ☐ Contoured brick
☐ Nonrefractory brick ☐ None visible

Hearth: ☐ Stone ☐ Brick ☐ None visible

Archway: ☐ Stone ☐ Brick No. of tiers ______

Bracing: ☐ Iron rod ☐ End plates ☐ Slotted ☐ Keys
☐ Wood beam ☐ Face straps ☐ Threaded ☐ Nuts

Other: ☐ Tuyeres ☐ Bustle pipes ☐ sight holes ☐ Other ______

APPENDAGES: Ovens: ☐ Top ☐ Separate ☐ None
Bridge: ☐ Iron ☐ Wood ☐ None

RELATED EVIDENCE(S): ☐ Wheel pit ☐ Flume ☐ Dam
☐ Roads ☐ Slag ☐ Coal ☐ Dam site
☐ Iron ore ☐ Cellar holes ☐ Walls ☐ Sprue
☐ Surface artifacts ____________

DIMENSIONS: (Meters)
Furnace: Ht. ______ Base ______ X ______
Bosh: Ht. ______ Diameter ______
Main Arch: Ht. ______ Base width ______

THREAT TO SITE: ☐ Zoning ☐ Vandalism ☐ Development ☐ Deterioration
☐ Roads ☐ Flooding ☐ Private ☐ None

LOCAL ATTITUDE: ☐ Positive ☐ Negative ☐ Mixed ☐ Other ______

SURROUNDING ENVIRONMENT: ☐ Open land ☐ Woodland ☐ Stream
☐ Scattered bldgs ☐ Industrial ☐ Commercial ☐ Moderate build-up
☐ Agricultural ☐ Residential ☐ Other ______

ADDITIONAL DATA:

| | | |
|---|---|---|
| Power: | ☐ Water | ☐ Steam |
| Fuel: | ☐ Charcoal | ☐ Anthracite |
| Draft: | ☐ Bellows | ☐ Tubs |
| Ore: | ☐ Bog | ☐ Local ________ |
| | ☐ Pit/Mine | ☐ Imported ________ |

Other:

RELATED STRUCTURES:

STATEMENT OF SIGNIFICANCE:

REPOSITORY OF MATERIAL FROM SITE:

REFERENCES:

PHOTO:

MAP: (North indicated in circle)

RECORDED BY:

PHOTO DATE:

DATE RECORDED:

VIEW:

November 24, 1986

Vermont Inventory of Industrial Sites

| AD- | Stat | Addison County | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 16 | * | Huntley Island CKM? - Leicester | Yes | 78 | |
| 146 | | Monkton Iron Co BF/BL/FDY - Vergennes | No | 76 | 81 |
| 299 | * | Middlebury Forge BL - East Middlebury | Yes | 80 | |
| 300 | | Orwell BF - Orwell | No | 77 | 81 |
| 314 | | Dragon Brk CKB - Ripton | Yes | 83 | 85 |
| 315 | | Widow's Trail CKB - Ripton | Yes | 83 | |
| 318 | | Huntley LK - Leicester | Yes | 84 | |
| 338 | | Billings CKB - Ripton | Yes | 85 | |
| 339 | | Eagle Forge BL - East Middlebury | Yes | 85 | |
| 340 | * | Little Otter BF - New Haven | No | 85 | |
| 341 | | Kewaydin CKM - Salisbury | Yes | 85 | |
| 348 | | Alder Brk CKM (east) - Ripton | Yes | 85 | |
| 351 | | Alder Brk CKM (west) - Ripton | Yes | 85 | |
| 355 | * | Green Mtn Lime Co LK - New Haven | No | 85 | |
| 356 | * | Sandusky CKB? - Granville | No | 85 | |
| 404 | | Richville Mills & BL - Shoreham | No | 86 | |
| 405 | | Widow Glynn CKM - Leicester | Yes | 86 | |
| 406 | | Sawyer's Forge BL - Salisbury | No | 86 | |
| 407 | | Salisbury Forge BL - Salisbury | No | 86 | |
| 409 | | Bedell LK - Bristol | No | 86 | |
| 414 | | Brooksville Edge Tool Co FDY - New Haven | No | 86 | |
| 415 | | Wainwright/Davenport FDY - Middlebury | No | 86 | |
| 416 | | Holley Forge BL - Bristol | No | 86 | |
| 417 | | Lewis Creek Farm BL - Starksboro | No | 86 | |
| F.S.- | | | | | |
| 49 | * | Lk Dunmore Glass Fac - Salisbury | No | 78 | 81 |
| 50 | * | Soper & Pier; Burnham BL - Lincoln | Yes | 81 | |
| 85 | | Mt Fuller CKM - Monkton | No | 86 | |
| 86 | | Bristol Village Forge BL - Bristol | No | 86 | |

| BE- | Stat | Bennington County | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 9 | * | East Dorset BF - Dorset | No | 83 | |
| 10 | * | Benn Iron Co (east stack) BF - Bennington | No | 80 | |
| 11 | * | Benn Iron Co (west stack) BF - Bennington | No | 80 | |
| 35 | * | North Dorset BF - Dorset | Yes | 81 | 83 |
| 36 | * | Burden BF - Shaftsbury | No | 81 | |
| 37 | | Red Cabin CKB - Glastenbury | Yes | 82 | |
| 39 | | Mad Tom 3 CKB - Peru | Yes | 83 | |
| 40 | | Mad Tom 1 CKB - Peru | Yes | 83 | |
| 41 | | Mad Tom 5 CKB - Peru | Yes | 83 | |
| 42 | | Winhall River CKB - Winhall | Yes | 83 | |
| 43 | | Bromley Brk CKB - Winhall | Yes | 83 | |
| 44 | | Bourn Brk CKB - Winhall | Yes | 83 | |
| 45 | * | Bickford Hollow CKB - Glastenbury | Yes | 83 | |
| 46 | | East Fork CKB - Glastenbury | Yes | 83 | |
| 47 | | West Fork CKB - Glastenbury | Yes | 83 | |
| 50 | | Heartwellville CKS - Readsboro | Yes | 83 | |
| 51 | | Heartwellville CKB - Readsboro | Yes | 83 | |
| 52 | | Heartwellville Conical CKB - Readsboro | Yes | 83 | |
| 53 | | Cotykilns CKS - Stamford | Yes | 85 | |
| 54 | | Dutch Hill site CKS - Readsboro | Yes | 85 | |
| 55 | | Cowen (Gulley; Kimbal) Brook CKS - Stamford | Yes | 85 | |
| 56 | | Sterba CKB & CKM - Glastenbury | Yes | 85 | |
| 57 | | Hager Hill site CKB? - Woodford | Yes | 85 | |
| 58 | | Bacon Hollow CKM - Sunderland | Yes | 85 | |

| | | | GMNF Proc Bdy? | Recorded Init | Update |
|---|---|---|---|---|---|
| Bennington Cty (Cont): | | | | | |
| BE- | | | | | |
| 61 | | East Mtn CKM - Shaftsbury ........................ | Yes | 85 | |
| 62 | | East Mtn CKS (north) - Shaftsbury ............ | Yes | 85 | |
| 63 | | East Mtn CKS (south) - Glastenbury ........... | Yes | 85 | |
| 64 | | Furnace Brk BF - Bennington .................. | No | 85 | |
| 105 | | Kennedy CKS - Stamford ...................... | Yes | 86 | |
| 106 | * | Cardinal (Nunge) Brook CKB - Stamford ....... | Yes | 86 | |
| 107 | | Crazy John Stream CKS - Stamford ............ | Yes | 86 | |
| 108 | | Thompson Farm CKM - Stamford ................ | Yes | 86 | |
| 109 | | Barnumville LK - Manchester ................. | No | 86 | |
| 110 | | MD&G RR - Manchester/Dorset ................... | No | 86 | |
| F.S.- | | | | | |
| 4 | | Burden I. Co iron mines - Bennington ......... | No | 79 | |
| | | Unidentified Concrete Structures - Pownal..... | No | 85 | |
| CA- | Stat | **Caledonia County** | | | |
| 20 | | Paddock Ironworks BF - St Johnsbury .......... | No | 81 | |
| CH- | Stat | **Chittenden County** | | | |
| 17 | | So Burlgtn LK (prehistoric) - So Burlgtn ..... | No | 68 | |
| 282 | | Weston LK - So Burlington ..................... | No | 86 | |
| 283 | | Stevens FDY - Colchester ...................... | No | 86 | |
| 284 | | Winooski Park LK - Colchester ................. | No | 86 | |
| F.S.- | | | | | |
| 4 | * | Colchstr Bog Iron Mine - Colchester .......... | No | 77 | |
| 6 | * | Clay Point Brickyard - Colchester ............ | No | 77 | |
| 7 | * | Red Rock Point Brickyard - Colchester ........ | No | 77 | |
| 70 | | Spafford Forge BL - Williston ................. | No | 80 | |
| ES- | Stat | **Essex County** | | | |
| FR- | Stat | **Franklin County** | | | |
| 67 | * | Keith (west) BF - Sheldon ..................... | No | 80 | |
| 68 | * | Keith (east) BF - Sheldon ..................... | No | 80 | |
| 149 | | Rock River BF - Highgate ...................... | No | 81 | |
| 163 | | Barney Forge BL - Swanton ..................... | No | 85 | |
| 169 | | Kenfield FDY - Fairfax ........................ | No | 86 | |
| F.S.- | | | | | |
| 12 | | (VT-FR-163) ..................................... | No | 80 | |
| GI- | Stat | **Grand Isle County** | | | |
| LA- | Stat | **Lamoille County** | | | |
| OR- | Stat | **Orange County** | | | |
| 14 | | Ely Copper Mine - Vershire .................... | No | 80 | |
| OL- | Stat | **Orleans County** | | | |
| 3 | | Troy BF - Troy .................................. | No | 80 | |
| RU- | Stat | **Rutland County** | | | |
| 41 | * | Forestdale BF - Brandon ....................... | Yes | 80 | |
| 57 | * | Granger BF - Pittsford ........................ | No | 80 | 85 |

| | | | GMNF Proc Bdy? | Recorded Init | Update |
|---|---|---|---|---|---|
| Rutland Cty (Cont): | | | | | |
| RU- | | | | | |
| 76 | * | Terminini BF - Tinmouth | No | 80 | |
| 77 | * | Jaquay BF - Tinmouth | No | 80 | |
| 78 | | Old Job CKB - Mt Tabor | Yes | 82 | 83 |
| 79 | | Ten Kilns CKB - Mt Tabor | Yes | 82 | |
| 84 | | Black Branch CKB - Mt Tabor | Yes | 83 | 85 |
| 85 | | Four Kilns CKB - Mt Tabor | Yes | 82 | 83 |
| 86 | | Greeley Mills SM & CKM? - Mt Tabor | Yes | 83 | |
| 87 | | Chipman Forge BF/BL? - Tinmouth | No | 83 | |
| 97 | | Chippenhook BF - Clarendon | No | 85 | |
| 98 | | Scotch Hill stone pit - Fairhaven | No | 85 | |
| 99 | | Coburn BF - West Haven | No | 85 | |
| 103 | | Iron Mine - Chittenden | No | 85 | |
| 108 | | Kiln #36 CKB - Mt Tabor | Yes | 85 | |
| 109 | | Forestdale Iron Mines - Brandon | No | 85 | |
| 153 | | Gibbs & Cooley FDY/BF - Pittsford | No | 86 | |
| 154 | | Maplebrook Farm LK - Tinmouth | No | 86 | |
| 155 | | Kiln Brook CKB - Chittenden | Yes | 86 | |
| 156 | | Lampman CKS (Rect) - Chittenden | Yes | 86 | |
| 157 | | Vt Lime Prod Co LK - Mt Tabor | No | 86 | |
| 160 | | Danby Mtn Road CKB - Danby | No | 86 | |
| 161 | | Crow Hill Farm LK - Tinmouth | No | 86 | |
| 162 | | Tinmouth Pond Dam BF - Tinmouth | No | 86 | |
| 163 | | Palumbo Farm Iron Mines - Tinmouth | No | 86 | |
| 164 | | Circular Stone-Lined Feature - Mt Holly | No | 86 | |
| 165 | | S. Bromley Farm LK - Wallingford | No | 86 | |
| 166 | | 'The Cobble' LKs - Clarendon | No | 86 | |
| 167 | | Crow Hill Farm Iron Mine - Tinmouth | No | 86 | |
| 171 | * | Packard Mill/Forge Site BL - Tinmouth | No | 86 | |
| F.S.- | | | | | |
| 13 | * | Worth Mtn CKM - Goshen | Yes | 80 | |
| 17 | | Davey's Forges BL - Fair Haven | No | 81 | |
| 19 | | Danby Sta CKB (Carvage) - Mt Tabor | Yes | 82 | |
| WA- | Stat | **Washington County** | | | |
| 21 | | Waterbury Last Block Co SM - Waterbury | No | 86 | |
| 25 | * | Rice's Forge BF/FDY - Waitsfield | No | 86 | |
| WD- | Stat | **Windham County** | | | |
| 37 | | Mt Snow Iron Mines - Dover | Yes | 85 | |
| 38 | | Somerset Forge BL - Dover | No | 84 | |
| 66 | | Harold Field's Charcoal Kiln - Stratton | Yes | 86 | |
| 67 | | Janet Greene Farm LK - Dover | Yes | 86 | |
| 68 | | W Thayer LK - Jamaica | No | 86 | |
| 69 | | PA Haven LK - Jamaica | No | 86 | |
| 70 | | A Howard LK - Jamaica | No | 86 | |
| WN- | Stat | **Windsor County** | | | |
| 51 | | Tyson BF - Plymouth | No | 81 | |
| 58 | | Upper Falls LK - Weathersfield | No | 85 | |
| 59 | | Upper Falls Mills - Weathersfield | No | 85 | |
| 104 | | Amsden LKs - Weathersfield | No | 86 | |

| | | GMNF Proc Bdy? | Recorded Init | Update |
|---|---|---|---|---|
| Windsor Cty (Cont): | | | | |
| F.S.- | | | | |
| 14 | Upper Falls Forge BL? - Weathersfield ........ | No | 85 | |

* = Needs further archival/field work or Site Survey Form update

Legend

BF = Blast furnace
BK = Brick kiln
BL = Bloomery
CKB = Charcoal kiln, brick
CKS = Charcoal kiln, stone
CKM = Charcoal kiln, mound
FDY = Foundry
LK = Lime kiln
SM = Saw mill

Inventory in Progress

Addison County:
Addison ...... Potash Bay
Bristol ...... Barker Charcoal kiln
Bristol ...... Dam upstream of Rockydale
Bristol ...... Iron mine (1857 map)
Ferrisburg ... Lime kiln at Plank Road (Beers)
Ferrisburg ... Bloomery at the Hollow (R. Robinson)
Hancock ...... Charcoal kilns (Dick DeBonis)
Leicester .... Charcoal mounds and blast furnace per Peleszak
Monkton ...... Iron mine (John Peters)
New Haven .... Mill foundations/forge at New Haven Mills
New Haven .... Lime kiln (Beers)
Shoreham ..... Charcoal mounds (?) per UVM Remote Sensing Lab
Vergennes .... Tunnel complex (update)
Weybridge .... Blast furnace site (Beldens)

Bennington County:
Bennington ... Lime kilns (silos?) at Bennington Potters
Manchester ... "Mystery" foundation along upper Lye Brook
Manchester ... Remains at holding pond
@ Manchester ... Lime kiln at Dr Treat's
Readsboro .... Saw Mill west of Heartwellville (new logging road)
Readsboro .... Saw mill north of Heartwellville
Readsboro .... "Furnace" (Hugh Jackes)
Readsboro .... Ruins west end of Heartwellville
Sunderland ... Saw mill at Bacon Hollow
Winhall ...... Rootville sawmill/house remains
@ Winhall ...... Charcoal kilns at Snow Valley (Bob West's uncle)

Caledonia County:
Lyndon ....... Murkland foundry

Chittenden County:
Burlington ... Water power systems at Winooski Falls
Essex ........ Brick kilns at Condo (FS assigned?)
Hinesburg .... Patrick foundry at Mechanicsville

November 24, 1986
Vermont Inventory of Industrial Sites
Inventory in Progress (Cont)

Chittenden Cty (cont):
- Shelburne .... Mills/ bloomery sites at Falls
- Westford ..... Bloomeries
- Winooski ..... Water power systems at the falls

Franklin County:
- Highgate ..... Lime kilns at Limekiln Point

Lamoille County:
- Morristown ... Forge at Cady's Falls

Orange County:
- Thetford ..... Blast Furnace per Peter Thomas letter (Paige 1978)

Rutland County:
- Brandon ...... Charcoal kilns in "The Basin"
- Brandon ...... Conant furnace
- Chittenden ... Charcoal kiln(s) per Walling
- Danby ........ Quarry RR east slope of Dorset Mtn
- Pittsford .... Add'l sites in Grangerville (Allan Hitchcock)
- Sudbury ...... Charcoal kilns on Miller Hill (Mary Kennedy)
- Wallingford .. Works at Homer Stone Brook

Washington County:
- Calais ....... Forge at Joe's Brook
- @ Waitsfield .... Rice's Forge (VT-WA-25)
- Waterbury .... Charcoal kilns at State Park (Bill Gove)

Windham County:

Windsor County:
- Bethel ....... White River Iron Co
- Rochester .... Coal kilns per Beers
- Weathersfield . Lime kiln south of Amsden
- @ Woodstock ..... Cobb furnace at English Mills

@ = research in hot pirsuit
# = ground survey accomplished; report and forms in process.

Vic Rolando
33 Howard Street
Pittsfield, Mass 01201

B:Vermont.Inv

| | | | Proc Bdy GMNF | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| Rutland Cty (Cont): | | | | | |
| RU- | | | | | |
| 156 | | Lampman CKS (Rect) - Chittenden .............. | Yes | 86 | |
| 157 | | Vt Lime Prod Co LK - Mt Tabor ................ | No | 86 | |
| new | | Danby Mtn Road CKB - Danby ................... | No | 86 | |
| F.S.- | | | | | |
| 3 | * | Worth Mtn CKM - Goshen ....................... | Yes | 80 | |
| 17 | | Davey's Forges BL - Fair Haven ............... | No | 81 | |
| 19 | | Danby Sta CKB (Carvage) - Mt Tabor ........... | Yes | 82 | |
| WA- | Stat | **Washington County** | | | |
| WD- | Stat | **Windham County** | | | |
| 37 | | Mt Snow Iron Mines - Dover ................... | Yes | 85 | |
| 38 | | Somerset Forge BL - Dover .................... | No | 84 | |
| WN- | Stat | **Windsor County** | | | |
| 51 | | Tyson BF - Plymouth .......................... | No | 81 | |
| 58 | | Upper Falls LK - Weathersfield ............... | No | 85 | |
| 59 | | Upper Falls Mills - Weathersfield ............ | No | 85 | |
| F.S.- | | | | | |
| 14 | | Upper Falls Forge BL? - Weathersfield ........ | No | 85 | |

* = Needs further archival/field work or Site Survey Form update

Legend

| | |
|---|---|
| BF = Blast furnace | CKM = Charcoal kiln, mound |
| BK = Brick kiln | FDY = Foundry |
| BL = Bloomery | LK = Lime kiln |
| CKB = Charcoal kiln, brick | SM = Saw mill |
| CKS = Charcoal kiln, stone | |

February 2, 1987
Vermont Inventory of Industrial Sites

| AD- | Ref Ch Pg | Addison County | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 16 | 6- 9 | Huntley Island CKM? - Leicester .............. | Yes | 78 | |
| 146 | 5-31 | Monkton Iron Co BF/BL/FDY - Vergennes ........ | No | 76 | 81 |
| 299 | 5-24 | Middlebury Forge BL - East Middlebury ........ | Yes | 80 | |
| 300 | 5-17 | Orwell BF - Orwell ........................... | No | 77 | 81 |
| 314 | 6- 9 | Dragon Brk CKB - Ripton ...................... | Yes | 83 | 85 |
| 315 | 6- 9 | Widow's Trail CKB - Ripton ................... | Yes | 83 | |
| 318 | | Huntley LK - Leicester ....................... | Yes | 84 | |
| 338 | 6- 9 | Billings CKB - Ripton ........................ | Yes | 85 | |
| 339 | 5-24 | Eagle Forge BL - East Middlebury ............. | Yes | 85 | |
| 340 | 5-39 | Little Otter BF - Hew Haven .................. | No | 85 | |
| 341 | 6- 9 | Kewaydin CKM - Salisbury ..................... | Yes | 85 | |
| 348 | 6- 9 | Alder Brk CKM (east) - Ripton ................ | Yes | 85 | |
| 351 | 6- 9 | Alder Brk CKM (west) - Ripton ................ | Yes | 85 | |
| 355 | | Green Mtn Lime Co LK - New Haven ............. | No | 85 | |
| 356 | 6- 9 | Sandusky CKB? - Granville .................... | No | 85 | |
| 404 | 5-46 | Richville Mills & BL - Shoreham .............. | No | 86 | |
| 405 | 6- 9 | Widow Glynn CKM - Leicester .................. | Yes | 86 | |
| 406 | 5-23 | Sawyer's Forge BL - Salisbury ................ | No | 86 | |
| 407 | 5-23 | Salisbury Forge BL - Salisbury ............... | No | 86 | |
| 409 | | Bedell LK - Bristol .......................... | No | 86 | |
| 414 | 7-12 | Brooksville Edge Tool Co FDY - New Haven ..... | No | 86 | |
| 415 | 5-27 | Wainwright/Davenport FDY - Middlebury ........ | No | 86 | |
| 416 | 5-44 | Holley Forge BL - Bristol .................... | No | 86 | |
| 417 | 5-73 | Lewis Creek Farm BL - Starksboro ............. | No | 86 | |
| F.S.- | | | | | |
| 49 | | Lk Dunmore Glass Fac - Salisbury ............. | No | 78 | 81 |
| 50 | 5-43 | Soper & Pier; Burnham BL - Lincoln ........... | Yes | 81 | |
| 85 | 6- 8 | Mt Fuller CKM - Monkton ...................... | No | 86 | |
| 86 | 5-44 | Bristol Village Forge BL - Bristol ........... | No | 86 | |
| BE- | | Bennington County | | | |
| 9 | 5-10 | East Dorset BF - Dorset ...................... | No | 83 | |
| 10 | 5- 3 | Benn Iron Co (east stack) BF - Bennington .... | No | 80 | |
| 11 | 5- 3 | Benn Iron Co (west stack) BF - Bennington .... | No | 80 | |
| 35 | 5- 8 | North Dorset BF - Dorset ..................... | Yes | 81 | 83 |
| 36 | 5-73 | Burden BF - Shaftsbury ....................... | No | 81 | |
| 37 | 6-17 | Red Cabin CKB - Glastenbury .................. | Yes | 82 | |
| 39 | 6-15 | Mad Tom 3 CKB - Peru ......................... | Yes | 83 | |
| 40 | 6-15 | Mad Tom 1 CKB - Peru ......................... | Yes | 83 | |
| 41 | 6-15 | Mad Tom 5 CKB - Peru ......................... | Yes | 83 | |
| 42 | 6-15 | Winhall River CKB - Winhall .................. | Yes | 83 | |
| 43 | 6-15 | Bromley Brk CKB - Winhall .................... | Yes | 83 | |
| 44 | 6-15 | Bourn Brk CKB - Winhall ...................... | Yes | 83 | |
| 45 | 6-17 | Bickford Hollow CKB - Glastenbury ............ | Yes | 83 | |
| 46 | 6-17 | East Fork CKB - Glastenbury .................. | Yes | 83 | |
| 47 | 6-17 | West Fork CKB - Glastenbury .................. | Yes | 83 | |
| 50 | 6-19 | Heartwellville CKS - Readsboro ............... | Yes | 83 | |
| 51 | 6-19 | Heartwellville CKB - Readsboro ............... | Yes | 83 | |
| 52 | 6-19 | Heartwellville Conical CKB - Readsboro ....... | Yes | 83 | |
| 53 | 6-18 | Cotykilns CKS - Stamford ..................... | Yes | 85 | |
| 54 | 6-19 | Dutch Hill site CKS - Readsboro .............. | Yes | 85 | |
| 55 | 6-18 | Cowen (Gulley; Kimbal) Brook CKS - Stamford .. | Yes | 85 | |
| 56 | 6-16 | Sterba CKB & CKM - Glastenbury ............... | Yes | 85 | |
| 57 | 6-17 | Hager Hill site CKB? - Woodford .............. | Yes | 85 | |
| 58 | 6-17 | Bacon Hollow CKM - Sunderland ................ | Yes | 85 | |

| BE- | Ref Ch Pg | | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 61 | 6-16 | East Mtn CKM - Shaftsbury | Yes | 85 | |
| 62 | 6-16 | East Mtn CKS (north) - Shaftsbury | Yes | 85 | |
| 63 | 6-16 | East Mtn CKS (south) - Glastenbury | Yes | 85 | |
| 64 | 5- 3 | Furnace Brk BF - Bennington | No | 85 | |
| 105 | 6-19 | Kennedy CKS - Stamford | Yes | 86 | |
| 106 | 6-18 | Cardinal (Nunge) Brook CKB - Stamford | Yes | 86 | |
| 107 | 6-19 | Crazy John Stream CKS - Stamford | Yes | 86 | |
| 108 | 6-18 | Thompson Farm CKM - Stamford | Yes | 86 | |
| 109 | | Barnumville LK - Manchester | No | 86 | |
| 110 | | MD&G RR - Manchester/Dorset | No | 86 | |
| F.S.- | | | | | |
| 4 | 2-11 | Burden I. Co iron mines - Bennington | No | 79 | |
| | | Unidentified Concrete Structures - Pownal | No | 85 | |
| CA- | | **Caledonia County** | | | |
| 20 | 5-59 | Paddock Ironworks BF - St Johnsbury | No | 81 | |
| CH- | | **Chittenden County** | | | |
| 17 | | So Burlgtn LK (prehistoric) - So Burlgtn | No | 68 | |
| 282 | | Weston LK - So Burlington | No | 86 | |
| 283 | | Stevens FDY - Colchester | No | 86 | |
| 284 | | Winooski Park LK - Colchester | No | 86 | |
| F.S.- | | | | | |
| 4 | | Colchstr Bog Iron Mine - Colchester | No | 77 | |
| 6 | | Clay Point Brickyard - Colchester | No | 77 | |
| 7 | | Red Rock Point Brickyard - Colchester | No | 77 | |
| 70 | 5-17 | Spafford Forge BL - Williston | No | 80 | |
| ES- | | **Essex County** | | | |
| FR- | | **Franklin County** | | | |
| 67 | 5-47 | Keith (west) BF - Sheldon | No | 80 | |
| 68 | 5-47 | Keith (east) BF - Sheldon | No | 80 | |
| 149 | 5-47 | Rock River BF - Highgate | No | 81 | |
| 163 | 5- 2 | Barney Forge BL - Swanton | No | 85 | |
| 169 | 5-10 | Kenfield FDY - Fairfax | No | 86 | |
| F.S.- | | | | | |
| 12 | 5- 2 | (VT-FR-163) | No | 80 | |
| GI- | | **Grand Isle County** | | | |
| LA- | | **Lamoille County** | | | |
| OR- | | **Orange County** | | | |
| 14 | | Ely Copper Mine - Vershire | No | 80 | |
| OL- | | **Orleans County** | | | |
| 3 | 5-71 | Troy BF - Troy | No | 80 | |
| RU- | | **Rutland County** | | | |
| 41 | 5-57 | Forestdale BF - Brandon | Yes | 80 | |
| 57 | 5-50 | Granger BF - Pittsford | No | 80 | 85 |

| RU- | Ref Ch Pg | | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 76 | 5-13 | Terminini BF - Tinmouth | No | 80 | |
| 77 | 5-13 | Jaquay BF - Tinmouth | No | 80 | |
| 78 | 6-13 | Old Job CKB - Mt Tabor | Yes | 82 | 83 |
| 79 | 6-13 | Ten Kilns CKB - Mt Tabor | Yes | 82 | |
| 84 | 6-13 | Black Branch CKB - Mt Tabor | Yes | 83 | 85 |
| 85 | 6-13 | Four Kilns CKB - Mt Tabor | Yes | 82 | 83 |
| 86 | 6-13 | Greeley Mills SM & CKM? - Mt Tabor | Yes | 83 | |
| 87 | 5-13 | Chipman Forge BF/BL? - Tinmouth | No | 83 | |
| 97 | 5-16 | Chippenhook BF - Clarendon | No | 85 | |
| 98 | | Scotch Hill stone pit - Fairhaven | No | 85 | |
| 99 | 5-21 | Coburn BF - West Haven | No | 85 | |
| 103 | | Iron Mine - Chittenden | No | 85 | |
| 108 | 6-14 | Kiln #36 CKB - Mt Tabor | Yes | 85 | |
| 109 | | Forestdale Iron Mines - Brandon | No | 85 | |
| 153 | 5-47 | Gibbs & Cooley FDY/BF - Pittsford | No | 86 | |
| 154 | | Maplebrook Farm LK - Tinmouth | No | 86 | |
| 155 | 6-10 | Kiln Brook CKB - Chittenden | Yes | 86 | |
| 156 | 6-10 | Lampman CKS (Rect) - Chittenden | Yes | 86 | |
| 157 | | Vt Lime Prod Co LK - Mt Tabor | No | 86 | |
| 160 | 6-10 | Danby Mtn Road CKB - Danby | No | 86 | |
| 161 | | Crow Hill Farm LK - Tinmouth | No | 86 | |
| 162 | 5-13 | Tinmouth Pond Dam BF - Tinmouth | No | 86 | |
| 163 | 2- 4 | Palumbo Farm Iron Mines - Tinmouth | No | 86 | |
| 164 | | Circular Stone-Lined Feature - Mt Holly | No | 86 | |
| 165 | | S. Bromley Farm LK - Wallingford | No | 86 | |
| 166 | | 'The Cobble' LKs - Clarendon | No | 86 | |
| 167 | 2- 4 | Crow Hill Farm Iron Mine - Tinmouth | No | 86 | |
| 171 | 5-13 | Packard Mill/Forge Site BL - Tinmouth | No | 86 | |
| F.S.- | | | | | |
| 13 | | Worth Mtn CKM - Goshen | Yes | 80 | |
| 17 | 5-17 | Davey's Forges BL - Fair Haven | No | 81 | |
| 19 | 6-13 | Danby Sta CKB (Carvage) - Mt Tabor | Yes | 82 | |
| WA- | | **Washington County** | | | |
| 21 | | Waterbury Last Block Co SM - Waterbury | No | 86 | |
| 25 | 5-64 | Rice's Forge BF/FDY - Waitsfield | No | 86 | |
| WD- | | **Windham County** | | | |
| 37 | 2-11 | Mt Snow Iron Mines - Dover | Yes | 85 | |
| 38 | 5- 7 | Somerset Forge BL - Dover | No | 84 | |
| 66 | 6-16 | Harold Field's Charcoal Kiln - Stratton | Yes | 86 | |
| 67 | | Janet Greene Farm LK - Dover | Yes | 86 | |
| 68 | | W Thayer LK - Jamaica | No | 86 | |
| 69 | | PA Haven LK - Jamaica | No | 86 | |
| 70 | | A Howard LK - Jamaica | No | 86 | |
| WN- | | **Windsor County** | | | |
| 51 | 5-65 | Tyson BF - Plymouth | No | 81 | |
| 58 | | Upper Falls LK - Weathersfield | No | 85 | |
| 59 | | Upper Falls Mills - Weathersfield | No | 85 | |
| 104 | | Amsden LKs - Weathersfield | No | 86 | |
| F.S.- | | | | | |
| 14 | 5-63 | Upper Falls Forge BL? - Weathersfield | No | 85 | |

Legend

| | |
|---|---|
| BF = Blast furnace | CKM = Charcoal kiln, mound |
| BK = Brick kiln | FDY = Foundry |
| BL = Bloomery | LK = Lime kiln |
| CKB = Charcoal kiln, brick | SM = Saw mill |
| CKS = Charcoal kiln, stone | |

Ref = Chapter/Page in Rolando manuscript.

February 2, 1987
Vermont Inventory of Industrial Sites

Addison County:
- Addison ...... Potash Bay
- Bristol ...... Barker Charcoal kiln
- Bristol ...... Dam upstream of Rockydale
- Bristol ...... Iron mine (1857 map)
- Ferrisburg ... Lime kiln at Plank Road (Beers)
- Ferrisburg ... BL/BF at Monkton Road (Keller Photo)
- Ferrisburg ... Bloomery at the Hollow (R. Robinson)
- Hancock ...... Charcoal kilns (Dick DeBonis)
- Leicester .... Charcoal mounds and blast furnace per Peleszak
- Monkton ...... Iron mine (John Peters)
- New Haven .... Mill foundations/forge at New Haven Mills
- New Haven .... Lime kiln (Beers)
- Shoreham ..... Charcoal mounds (?) per UVM Remote Sensing Lab
- Vergennes .... Tunnel complex (update)
- Weybridge .... Blast furnace site (Beldens)

Bennington County:
- Bennington ... Lime kilns (silos?) at Bennington Potters
- Manchester ... "Mystery" foundation along upper Lye Brook
- Manchester ... Remains at holding pond
- @ Manchester ... Lime kiln at Dr Treat's
- Readsboro .... Saw Mill west of Heartwellville (new logging road)
- Readsboro .... Saw mill north of Heartwellville
- Readsboro .... "Furnace" (Hugh Jackes)
- Readsboro .... Ruins west end of Heartwellville
- Sunderland ... Saw mill at Bacon Hollow
- Winhall ...... Rootville sawmill/house remains
- @ Winhall ...... Charcoal kilns at Snow Valley (Bob West's uncle)

Caledonia County:
- Lyndon ....... Murkland foundry

Chittenden County:
- Burlington ... Water power systems at Winooski Falls
- Essex ........ Brick kilns at Condo (FS assigned?)
- Hinesburg .... Patrick foundry at Mechanicsville
- Shelburne .... Mills/ bloomery sites at Falls
- Westford ..... Bloomeries
- Winooski ..... Water power systems at the falls

Franklin County:
- Highgate ..... Lime kilns at Limekiln Point

Lamoille County:
- Morristown ... Forge at Cady's Falls

Orange County:
- Thetford ..... Blast Furnace per Peter Thomas letter (Paige 1978)

Rutland County:
- Brandon ...... Charcoal kilns in "The Basin"
- Brandon ...... Conant furnace
- Chittenden ... Charcoal kiln(s) per Walling
- Danby ........ Quarry RR east slope of Dorset Mtn
- Pittsford .... Add'l sites in Grangerville (Allan Hitchcock)
- Sudbury ...... Charcoal kilns on Miller Hill (Mary Kennedy)
- Wallingford .. Works at Homer Stone Brook

February 2, 1987
Vermont Inventory of Industrial Sites

Washington County:

|   |   |   |
|---|---|---|
|   | Calais ....... | Forge at Joe's Brook |
| @ | Waitsfield .... | Rice's Forge (VT-WA-25) |
|   | Waterbury .... | Charcoal kilns at State Park (Bill Gove) |

Windham County:

Windsor County:

|   |   |   |
|---|---|---|
|   | Bethel ....... | White River Iron Co |
|   | Rochester .... | Coal kilns per Beers |
|   | Weathersfield . | Lime kiln south of Amsden |
| @ | Woodstock ..... | Cobb furnace at English Mills |
|   | Woodstock ..... | Granger foundry (Dana; L. Granger) |

@ = research in hot pirsuit
# = ground survey accomplished; report and forms in process.

Vic Rolando
33 Howard Street
Pittsfield, Mass 01201 B:Vermont.Inv

| AD- | Ref Ch Pg | Addison County | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 16 | 6- 9 | Huntley Island CKM? - Leicester | Yes | 78 | |
| 146 | 5-31 | Monkton Iron Co BF/BL/FDY - Vergennes | No | 76 | 81 |
| 299 | 5-24 | Middlebury Forge BL - East Middlebury | Yes | 80 | |
| 300 | 5-17 | Orwell BF - Orwell | No | 77 | 81 |
| 314 | 6- 9 | Dragon Brk CKB - Ripton | Yes | 83 | 85 |
| 315 | 6- 9 | Widow's Trail CKB - Ripton | Yes | 83 | |
| 318 | | Huntley LK - Leicester | Yes | 84 | |
| 338 | 6- 9 | Billings CKB - Ripton | Yes | 85 | |
| 339 | 5-24 | Eagle Forge BL - East Middlebury | Yes | 85 | |
| 340 | 5-39 | Little Otter BF - New Haven | No | 85 | |
| 341 | 6- 9 | Kewaydin CKM - Salisbury | Yes | 85 | |
| 348 | 6- 9 | Alder Brk CKM (east) - Ripton | Yes | 85 | |
| 351 | 6- 9 | Alder Brk CKM (west) - Ripton | Yes | 85 | |
| 355 | | Green Mtn Lime Co LK - New Haven | No | 85 | |
| 356 | 6- 9 | Sandusky CKB? - Granville | No | 85 | |
| 404 | 5-46 | Richville Mills & BL - Shoreham | No | 86 | |
| 405 | 6- 9 | Widow Glynn CKM - Leicester | Yes | 86 | |
| 406 | 5-23 | Sawyer's Forge BL - Salisbury | No | 86 | |
| 407 | 5-23 | Salisbury Forge BL - Salisbury | No | 86 | |
| 409 | | Bedell LK - Bristol | No | 86 | |
| 414 | 7-12 | Brooksville Edge Tool Co FDY - New Haven | No | 86 | |
| 415 | 5-27 | Wainwright/Davenport FDY - Middlebury | No | 86 | |
| 416 | 5-44 | Holley Forge BL - Bristol | No | 86 | |
| 417 | 5-73 | Lewis Creek Farm BL - Starksboro | No | 86 | |
| 430 | | Fuller Forge BL - Ferrisburg | No | 87 | |
| 431 | | Doreen's Forge BL - Ferrisburg | No | 87 | |
| 432 | | Monkton Iron Co Forge BL (BF?) - Ferrisburg | No | 87 | |
| F.S.- | | | | | |
| 49 | | Lk Dunmore Glass Fac - Salisbury | No | 78 | 81 |
| 50 | 5-43 | Soper & Pier; Burnham BL - Lincoln | Yes | 81 | |
| 85 | 6- 8 | Mt Fuller CKM - Monkton | No | 86 | |
| 86 | 5-44 | Bristol Village Forge BL - Bristol | No | 86 | |
| BE- | | **Bennington County** | | | |
| 9 | 5-10 | East Dorset BF - Dorset | No | 83 | |
| 10 | 5- 3 | Benn Iron Co (east stack) BF - Bennington | No | 80 | |
| 11 | 5- 3 | Benn Iron Co (west stack) BF - Bennington | No | 80 | |
| 35 | 5- 8 | North Dorset BF - Dorset | Yes | 81 | 83 |
| 36 | 5-73 | Burden BF - Shaftsbury | No | 81 | |
| 37 | 6-17 | Red Cabin CKB - Glastenbury | Yes | 82 | |
| 39 | 6-15 | Mad Tom 3 CKB - Peru | Yes | 83 | |
| 40 | 6-15 | Mad Tom 1 CKB - Peru | Yes | 83 | |
| 41 | 6-15 | Mad Tom 5 CKB - Peru | Yes | 83 | |
| 42 | 6-15 | Winhall River CKB - Winhall | Yes | 83 | |
| 43 | 6-15 | Bromley Brk CKB - Winhall | Yes | 83 | |
| 44 | 6-15 | Bourn Brk CKB - Winhall | Yes | 83 | |
| 45 | 6-17 | Bickford Hollow CKB - Glastenbury | Yes | 83 | |
| 46 | 6-17 | East Fork CKB - Glastenbury | Yes | 83 | |
| 47 | 6-17 | West Fork CKB - Glastenbury | Yes | 83 | |
| 50 | 6-19 | Heartwellville CKS - Readsboro | Yes | 83 | |
| 51 | 6-19 | Heartwellville CKB - Readsboro | Yes | 83 | |
| 52 | 6-19 | Heartwellville Conical CKB - Readsboro | Yes | 83 | |
| 53 | 6-18 | Cotykilns CKS - Stamford | Yes | 85 | |
| 54 | 6-19 | Dutch Hill site CKS - Readsboro | Yes | 85 | |
| 55 | 6-18 | Cowen (Gulley; Kimbal) Brook CKS - Stamford | Yes | 85 | |

| BE- | Ref Ch Pg | Bennington Cty (Cont) | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| 56 | 6-16 | Sterba CKB & CKM - Glastenbury | Yes | 85 | |
| 57 | 6-17 | Hager Hill site CKB? - Woodford | Yes | 85 | |
| 58 | 6-17 | Bacon Hollow CKM - Sunderland | Yes | 85 | |
| 61 | 6-16 | East Mtn CKM - Shaftsbury | Yes | 85 | |
| 62 | 6-16 | East Mtn CKS (north) - Shaftsbury | Yes | 85 | |
| 63 | 6-16 | East Mtn CKS (south) - Glastenbury | Yes | 85 | |
| 64 | 5- 3 | Furnace Brk BF - Bennington | No | 85 | |
| 105 | 6-19 | Kennedy CKS - Stamford | Yes | 86 | |
| 106 | 6-18 | Cardinal (Nunge) Brook CKB - Stamford | Yes | 86 | |
| 107 | 6-19 | Crazy John Stream CKS - Stamford | Yes | 86 | |
| 108 | 6-18 | Thompson Farm CKM - Stamford | Yes | 86 | |
| 109 | | Barnumville LK - Manchester | No | 86 | |
| 110 | | MD&G RR - Manchester/Dorset | No | 86 | |
| 117 | | Manchester Depot LK - Manchester | No | 87 | |
| 118 | | No Pownal LK - Pownal | No | 87 | |
| | | Schoolhouse CKB - Winhall | Yes | 88 | |
| | | Holbrook SM - Pownal | Yes | 88 | |
| F.S.- | | | | | |
| 4 | 2-11 | Burden I. Co IM - Bennington | No | 79 | |
| | | Unidentified Concrete Structures - Pownal | No | 85 | |
| CA- | | **Caledonia County** | | | |
| 20 | 5-59 | Paddock Ironworks BF - St Johnsbury | No | 81 | |
| CH- | | **Chittenden County** | | | |
| 17 | | So Burlgtn LK (prehistoric) - So Burlgtn | No | 68 | |
| 282 | | Weston LK - So Burlington | No | 86 | |
| 283 | | Stevens FDY - Colchester | No | 86 | |
| 284 | | Winooski Park LK - Colchester | No | 86 | |
| F.S.- | | | | | |
| 4 | | Colchester Bog IM - Colchester | No | 77 | |
| 6 | | Clay Point BY - Colchester | No | 77 | |
| 7 | | Red Rock Point BY - Colchester | No | 77 | |
| 70 | 5-17 | Spafford Forge BL - Williston | No | 80 | |
| ES- | | **Essex County** | | | |
| FR- | | **Franklin County** | | | |
| 67 | 5-47 | Keith (west) BF - Sheldon | No | 80 | |
| 68 | 5-47 | Keith (east) BF - Sheldon | No | 80 | |
| 149 | 5-47 | Rock River BF - Highgate | No | 81 | |
| 163 | 5- 2 | Barney Forge BL - Swanton | No | 85 | |
| 169 | 5-10 | Kenfield FDY - Fairfax | No | 86 | |
| 177 | | Sheridan FDY - Highgate | No | 87 | |
| 178 | | Fonda LK - Swanton | No | 87 | |
| 179 | | John's Bridge LK - Swanton | No | 87 | |
| F.S.- | | | | | |
| 12 | 5- 2 | (VT-FR-163) | No | 80 | |
| GI- | | **Grand Isle County** | | | |
| LA- | | **Lamoille County** | | | |

| | Ref Ch Pg | | GMNF Proc Bdy? | Recorded Init | Update |
|---|---|---|---|---|---|
| OR- | | **Orange County** | | | |
| 14 | | Ely Copper Mine - Vershire .................... | No | 80 | |
| OL- | | Orleans County | | | |
| 3 | 5-71 | Troy BF - Troy ................................ | No | 80 | |
| RU- | | **Rutland County** | | | |
| 41 | 5-57 | Forestdale BF - Brandon ....................... | Yes | 80 | |
| 57 | 5-50 | Granger BF - Pittsford ........................ | No | 80 | 85 |
| 76 | 5-13 | Terminini BF - Tinmouth ....................... | No | 80 | |
| 77 | 5-13 | Jaquay BF - Tinmouth .......................... | No | 80 | |
| 78 | 6-13 | Old Job CKB - Mt Tabor ........................ | Yes | 82 | 83 |
| 79 | 6-13 | Ten Kilns CKB - Mt Tabor ...................... | Yes | 82 | |
| 84 | 6-13 | Black Branch CKB - Mt Tabor ................... | Yes | 83 | 85 |
| 85 | 6-13 | Four Kilns CKB - Mt Tabor ..................... | Yes | 82 | 83 |
| 86 | 6-13 | Greeley Mills SM & CKM? - Mt Tabor ............ | Yes | 83 | |
| 87 | 5-13 | Chipman Forge BF/BL? - Tinmouth ............... | No | 83 | |
| 97 | 5-16 | Chippenhook BF - Clarendon .................... | No | 85 | |
| 98 | | Scotch Hill stone pit - Fairhaven ............. | No | 85 | |
| 99 | 5-21 | Coburn BF - West Haven ........................ | No | 85 | |
| 103 | | Iron Mine - Chittenden ........................ | No | 85 | |
| 108 | 6-14 | Kiln #36 CKB - Mt Tabor ....................... | Yes | 85 | |
| 109 | | Forestdale IM - Brandon ....................... | No | 85 | |
| 153 | 5-47 | Gibbs & Cooley FDY/BF - Pittsford ............. | No | 86 | |
| 154 | | Maplebrook Farm LK - Tinmouth ................. | No | 86 | |
| 155 | 6-10 | Kiln Brook CKB - Chittenden ................... | Yes | 86 | |
| 156 | 6-10 | Lampman CKS (Rect) - Chittenden ............... | Yes | 86 | |
| 157 | | Vt Lime Prod Co LK - Mt Tabor ................. | No | 86 | |
| 160 | 6-10 | Danby Mtn Road CKB - Danby .................... | No | 86 | |
| 161 | | Crow Hill Farm LK - Tinmouth .................. | No | 86 | |
| 162 | 5-13 | Tinmouth Pond Dam BF - Tinmouth ............... | No | 86 | |
| 163 | 2- 4 | Palumbo Farm IM - Tinmouth .................... | No | 86 | |
| 164 | | Circular Stone-Lined Feature - Mt Holly ....... | No | 86 | |
| 165 | | S. Bromley Farm LK - Wallingford .............. | No | 86 | |
| 166 | | 'The Cobble' LKs - Clarendon .................. | No | 86 | |
| 167 | 2- 4 | Crow Hill Farm IM - Tinmouth .................. | No | 86 | |
| 171 | 5-13 | Packard Mill/Forge Site BL - Tinmouth ......... | No | 86 | |
| 179 | | District 8 LK - Mendon ........................ | Yes | 87 | |
| 180 | | Rounds Pinnacle LK - Shelburne ................ | No | 87 | |
| | | Beaudry Brook CKM - Chittenden ................ | Yes | 88 | |
| F.S.- | | | | | |
| 13 | | Worth Mtn CKM - Goshen ........................ | Yes | 80 | |
| 17 | 5-17 | Davey's Forges BL - Fair Haven ................ | No | 81 | |
| 19 | 6-13 | Danby Sta CKB (Carvage) - Mt Tabor ............ | Yes | 82 | |
| WA- | | **Washington County** | | | |
| 21 | | Waterbury Last Block Co SM - Waterbury ........ | No | 86 | |
| 25 | 5-64 | Rice's Forge BF/FDY - Waitsfield .............. | No | 86 | |
| WD- | | **Windham County** | | | |
| 37 | 2-11 | Mt Snow IM - Dover ............................ | Yes | 85 | |
| 38 | 5- 7 | Somerset Forge BL - Dover ..................... | No | 84 | |
| 66 | 6-16 | Harold Field's CK - Stratton .................. | Yes | 86 | |
| 67 | | Janet Greene Farm LK - Dover .................. | Yes | 86 | |
| 68 | | W Thayer LK - Jamaica ......................... | No | 86 | |
| 69 | | PA Haven LK - Jamaica ......................... | No | 86 | |

| | Ref Ch Pg | | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| WD- | | Windham Cty (Cont) | | | |
| 70 | | Howard LK - Jamaica | No | 86 | |
| WN- | | Windsor Cty | | | |
| 51 | 5-65 | Tyson BF - Plymouth | No | 81 | |
| 58 | | Upper Falls LK - Weathersfield | No | 85 | |
| 59 | | Upper Falls Mills - Weathersfield | No | 85 | |
| 104 | | Amsden LKs - Weathersfield | No | 86 | |
| 108 | | Burnt Mtn LK - Plymouth | No | 87 | |
| 109 | | Campground LK - Plymouth | No | 87 | |
| 110 | | Anna Rice LK - Plymouth | No | 87 | |
| 111 | | Black Pond LK - Plymouth | No | 87 | |
| 112 | | Knapp LK - Plymouth | No | 87 | |
| 113 | | Brookwood LK - Plymouth | No | 87 | |
| 114 | | Money Brook LK - Plymouth | No | 87 | |
| F.S.- | | | | | |
| 14 | 5-63 | Upper Falls Forge BL? - Weathersfield | No | 85 | |

Legend

BF = Blast furnace
BL = Bloomery
BY = Brickyard (brick kiln)
CKB = Charcoal kiln (brick)
CKM = Charcoal kiln (mound)
CKS = Charcoal kiln (stone)
FDY = Foundry (iron)
IM = Iron Mine
LK = Lime kiln
SM = Saw mill

Ref = Chapter/Page in Rolando manuscript.
Ch = Chapter " " "
Pg = Page " " "

August 1, 1988
Vermont Inventory of Industrial Sites
Inventory in Progress

Addison County:

- Addison ...... Potash Bay
- Bristol ...... Barker Charcoal kiln
- Bristol ...... Dam upstream of Rockydale
- Bristol ...... Iron mine (1857 map)
- Ferrisburg ... Lime kiln at Plank Road (Beers)
- Ferrisburg ... Bloomery at the Hollow (R. Robinson)
- Hancock ...... Charcoal kilns (Dick DeBonis)
- Leicester .... Charcoal mounds and blast furnace per Peleszak
- Monkton ...... Iron mine (John Peters)
- New Haven .... Mill foundations/forge at New Haven Mills
- New Haven .... Lime kiln (Beers)
- Shoreham ..... Charcoal mounds (?) per UVM Remote Sensing Lab
- Vergennes .... Tunnel complex (update)
- Weybridge .... Blast furnace site (Beldens)

Bennington County:

- Bennington ... Lime kilns (silos?) at Bennington Potters
- Manchester ... "Mystery" foundation along upper Lye Brook
- Manchester ... Remains at holding pond
- Readsboro .... Saw Mill west of Heartwellville (new logging road)
- Readsboro .... Saw mill north of Heartwellville
- Readsboro .... "Furnace" (Hugh Jackes)
- Readsboro .... Ruins west end of Heartwellville
- Sunderland ... Saw mill at Bacon Hollow
- Winhall ...... Rootville sawmill/house remains
- Winhall ...... Charcoal kilns at Snow Valley (Bob West's uncle)

Caledonia County:

- Lyndon ....... Murkland foundry

Chittenden County:

- Burlington ... Water power systems at Winooski Falls
- Essex ........ Brick kilns at Condo (FS assigned?)
- Hinesburg .... Patrick foundry at Mechanicsville
- Shelburne .... Mills/ bloomery sites at Falls
- Westford ..... Bloomeries
- Winooski ..... Water power systems at the falls

Franklin County:

- Highgate ..... Lime kilns at Limekiln Point

Lamoille County:

- Morristown ... Forge at Cady's Falls

Orange County:

- Thetford ..... Blast Furnace per Peter Thomas letter (Paige 1978)

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- Brandon ...... Charcoal kilns in "The Basin"
- Brandon ...... Conant furnace
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- Danby ........ Quarry RR east slope of Dorset Mtn
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Washington County:

Calais ........ Forge at Joe's Brook
Waitsfield .... Rice's Forge (VT-WA-25)
Waterbury .... Charcoal kilns at State Park (Bill Gove)

Windham County:

Windsor County:

Bethel ........ White River Iron Co
Reading ........ Stone Tower (postcard)
Rochester .... Coal kilns per Beers
Weathersfield . Lime kiln south of Amsden
Woodstock ..... Cobb furnace at English Mills
Woodstock ..... Granger foundry (Dana; L. Granger)

Vic Rolando
41 Lebanon Avenue
Pittsfield, Mass 01201

(413) 442-5895 - home
(413) 494-3894 - work

B:Vermont.Inv

| Code | Ref Ch Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| **AD-** | | **Addison County** | | | |
| 6 | 6- 9 | Huntley Island CKM? - Leicester | Yes | 78 | |
| 146 | 5-31 | Monkton Iron Co BF/BL/FDY - Vergennes | No | 76 | 81 |
| 299 | 5-24 | Middlebury Forge BL - East Middlebury | Yes | 80 | |
| 300 | 5-17 | Orwell BF - Orwell | No | 77 | 81 |
| 314 | 6- 9 | Dragon Brk CKB - Ripton | Yes | 83 | 85 |
| 315 | 6- 9 | Widow's Trail CKB - Ripton | Yes | 83 | |
| 318 | | Huntley LK - Leicester | Yes | 84 | |
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| 348 | 6- 9 | Alder Brk CKM (east) - Ripton | Yes | 85 | |
| 351 | 6- 9 | Alder Brk CKM (west) - Ripton | Yes | 85 | |
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| 356 | 6- 9 | Sandusky CKB? - Granville | No | 85 | |
| 404 | | Richville Mills & BL - Shoreham | No | 86 | |
| 405 | 6- 9 | Widow Glynn CKM - Leicester | Yes | 86 | |
| 406 | 5-23 | Sawyer's Forge BL - Salisbury | No | 86 | |
| 407 | 5-23 | Salisbury Forge BL - Salisbury | No | 86 | |
| 409 | | Bedell LK - Bristol | No | 86 | |
| 414 | 7-12 | Brooksville Edge Tool Co FDY - New Haven | No | 86 | |
| 415 | 5-27 | Wainwright/Davenport FDY - Middlebury | No | 86 | |
| 416 | 5-44 | Holley Forge BL - Bristol | No | 86 | |
| 417 | 5-73 | Lewis Creek Farm BL - Starksboro | No | 86 | |
| 430 | | Fuller Forge BL - Ferrisburg | No | 87 | |
| 431 | | Doreen's Forge BL - Ferrisburg | No | 87 | |
| 432 | | Monkton Iron Co Forge BL (BF?) - Ferrisburg | No | 87 | |
| **F.S.-** | | | | | |
| 49 | | Lk Dunmore Glass Fac - Salisbury | No | 78 | 81 |
| 50 | 5-43 | Soper & Pier; Burnham BL - Lincoln | Yes | 81 | |
| 85 | 6- 8 | Mt Fuller CKM - Monkton | No | 86 | |
| 86 | 5-44 | Bristol Village Forge BL - Bristol | No | 86 | |
| **BE-** | | **Bennington County** | | | |
| 9 | 5-10 | East Dorset BF - Dorset | No | 83 | |
| 10 | 5- 3 | Benn Iron Co (east stack) BF - Bennington | No | 80 | |
| 11 | 5- 3 | Benn Iron Co (west stack) BF - Bennington | No | 80 | |
| 35 | 5- 8 | North Dorset BF - Dorset | Yes | 81 | 83 |
| 36 | 5-73 | Burden BF - Shaftsbury | No | 81 | |
| 37 | 6-17 | Red Cabin CKB - Glastenbury | Yes | 82 | |
| 39 | 6-15 | Mad Tom 3 CKB - Peru | Yes | 83 | |
| 40 | 6-15 | Mad Tom 1 CKB - Peru | Yes | 83 | |
| 41 | 6-15 | Mad Tom 5 CKB - Peru | Yes | 83 | |
| 42 | 6-15 | Winhall River CKB - Winhall | Yes | 83 | |
| 43 | 6-15 | Bromley Brk CKB - Winhall | Yes | 83 | |
| 44 | 6-15 | Bourn Brk CKB - Winhall | Yes | 83 | |
| 45 | 6-17 | Bickford Hollow CKB - Glastenbury | Yes | 83 | |
| 46 | 6-17 | East Fork CKB - Glastenbury | Yes | 83 | |
| 47 | 6-17 | West Fork CKB - Glastenbury | Yes | 83 | |
| 50 | 6-19 | Heartwellville CKS - Readsboro | Yes | 83 | |
| 51 | 6-19 | Heartwellville CKB - Readsboro | Yes | 83 | |
| 52 | 6-19 | Heartwellville Conical CKB - Readsboro | Yes | 83 | |
| 53 | 6-18 | Cotykilns CKS - Stamford | Yes | 85 | |

| Code | Ref Ch Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| **BE-** | | **Bennington County (Cont)** | | | |
| 54 | 6-19 | Dutch Hill site CKS - Readsboro | Yes | 85 | |
| 55 | 6-18 | Cowen (Gulley; Kimbal) Brook CKS - Stamford | Yes | 85 | |
| 56 | 6-16 | Sterba CKB & CKM - Glastenbury | Yes | 85 | |
| 57 | 6-17 | Hager Hill site CKB? - Woodford | Yes | 85 | |
| 58 | 6-17 | Bacon Hollow CKM - Sunderland | Yes | 85 | |
| 61 | 6-16 | East Mtn CKM - Shaftsbury | Yes | 85 | |
| 62 | 6-16 | East Mtn CKS (north) - Shaftsbury | Yes | 85 | |
| 63 | 6-16 | East Mtn CKS (south) - Glastenbury | Yes | 85 | |
| 64 | 5- 3 | Furnace Brk BF - Bennington | No | 85 | |
| 105 | 6-19 | Kennedy CKS - Stamford | Yes | 86 | |
| 106 | 6-18 | Cardinal (Nunge) Brook CKB - Stamford | Yes | 86 | |
| 107 | 6-19 | Crazy John Stream CKS - Stamford | Yes | 86 | |
| 108 | 6-18 | Thompson Farm CKM - Stamford | Yes | 86 | |
| 109 | | Barnumville LK - Manchester | No | 86 | |
| 110 | | MD&G RR - Manchester/Dorset | No | 86 | |
| 117 | | Manchester Depot LK - Manchester | No | 87 | |
| 118 | | No Pownal LK - Pownal | No | 87 | |
| 134 | | Schoolhouse CKB - Winhall | Yes | 88 | |
| 135 | | Holbrook SM - Pownal | Yes | 88 | |
| in process | | Amaden Lime Kilns - Readsboro | Yes | | |
| **F.S.-** | | | | | |
| 4 | 2-11 | Burden I. Co IM - Bennington | No | 79 | |
| | | Unidentified Concrete Structures - Pownal | No | 85 | |
| **CA-** | | **Caledonia County** | | | |
| 20 | 5-59 | Paddock Ironworks BF - St Johnsbury | No | 81 | |
| **CH-** | | **Chittenden County** | | | |
| 17 | | So Burlgtn LK (prehistoric) - So Burlgtn | No | 68 | |
| 282 | | Weston LK - So Burlington | No | 86 | |
| 283 | | Stevens FDY - Colchester | No | 86 | |
| 284 | | Winooski Park LK - Colchester | No | 86 | |
| 365 | | Lime Kiln Rd LK - Charlotte | No | 88 | |
| **F.S.-** | | | | | |
| 4 | | Colchester Bog IM - Colchester | No | 77 | |
| 6 | | Clay Point BY - Colchester | No | 77 | |
| 7 | | Red Rock Point BY - Colchester | No | 77 | |
| 70 | 5-17 | Spafford Forge BL - Williston | No | 80 | |
| **ES-** | | **Essex County** | | | |
| **FR-** | | **Franklin County** | | | |
| 67 | 5-47 | Keith (west) BF - Sheldon | No | 80 | |
| 68 | 5-47 | Keith (east) BF - Sheldon | No | 80 | |
| 149 | 5-47 | Rock River BF - Highgate | No | 81 | |
| 163 | 5- 2 | Barney Forge BL - Swanton | No | 85 | |
| 169 | 5-10 | Kenfield FDY - Fairfax | No | 86 | |
| 177 | | Sheridan FDY - Highgate | No | 87 | |
| 178 | | Fonda LK - Swanton | No | 87 | |
| 179 | | John's Bridge LK - Swanton | No | 87 | |
| 186 | | Rixford Foundry - East Highgate | No | 88 | |
| in process | | Missisquoi Lime Co LK - Hughgate | No | | |

| Code | Ref Ch Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| | | **Franklin County (Cont)** | | | |
| **F.S.-** | | | | | |
| 12 | 5- 2 | (VT-FR-163) | No | 80 | |
| **GI-** | | **Grand Isle County** | | | |
| **LA-** | | **LaMoille County** | | | |
| **OR-** | | **Orange County** | | | |
| 14 | | Ely Copper Mine - Vershire | No | 80 | |
| **OL-** | | **Orleans County** | | | |
| 3 | 5-71 | Troy BF - Troy | No | 80 | |
| **RU-** | | **Rutland County** | | | |
| 41 | 5-57 | Forestdale BF - Brandon | Yes | 80 | |
| 57 | 5-50 | Granger BF - Pittsford | No | 80 | 85 |
| 76 | 5-13 | Terminini BF - Tinmouth | No | 80 | |
| 77 | 5-13 | Jaquay BF - Tinmouth | No | 80 | |
| 78 | 6-13 | Old Job CKB - Mt Tabor | Yes | 82 | 83 |
| 79 | 6-13 | Ten Kilns CKB - Mt Tabor | Yes | 82 | |
| 84 | 6-13 | Black Branch CKB - Mt Tabor | Yes | 83 | 85 |
| 85 | 6-13 | Four Kilns CKB - Mt Tabor | Yes | 82 | 83 |
| 86 | 6-13 | Greeley Mills SM & CKM? - Mt Tabor | Yes | 83 | |
| 87 | 5-13 | Chipman Forge BF/BL? - Tinmouth | No | 83 | |
| 97 | 5-16 | Chippenhook BF - Clarendon | No | 85 | |
| 98 | | Scotch Hill stone pit - Fairhaven | No | 85 | |
| 99 | 5-21 | Coburn BF - West Haven | No | 85 | |
| 103 | | Iron Mine - Chittenden | No | 85 | |
| 108 | 6-14 | Kiln #36 CKB - Mt Tabor | Yes | 85 | |
| 109 | | Forestdale IM - Brandon | No | 85 | |
| 153 | 5-47 | Gibbs & Cooley FDY/BF - Pittsford | No | 86 | |
| 154 | | Maplebrook Farm LK - Tinmouth | No | 86 | |
| 155 | 6-10 | Kiln Brook CKB - Chittenden | Yes | 86 | |
| 156 | 6-10 | Lampman CKS (Rect) - Chittenden | Yes | 86 | |
| 157 | | Vt Lime Prod Co LK - Mt Tabor | No | 86 | |
| 160 | 6-10 | Danby Mtn Road CKB - Danby | No | 86 | |
| 161 | | Crow Hill Farm LK - Tinmouth | No | 86 | |
| 162 | 5-13 | Tinmouth Pond Dam BF - Tinmouth | No | 86 | |
| 163 | 2- 4 | Palumbo Farm IM - Tinmouth | No | 86 | |
| 164 | | Circular Stone-Lined Feature - Mt Holly | No | 86 | |
| 165 | | S. Bromley Farm LK - Wallingford | No | 86 | |
| 166 | | 'The Cobble' LKs - Clarendon | No | 86 | |
| 167 | 2- 4 | Crow Hill Farm IM - Tinmouth | No | 86 | |
| 171 | 5-13 | Packard Mill/Forge Site BL - Tinmouth | No | 86 | |
| 179 | | District 8 LK - Mendon | Yes | 87 | |
| 180 | | Rounds Pinnacle LK - Shelburne | No | 87 | |
| 188 | | Beaudry Brook CKM - Chittenden | Yes | 88 | |
| 189 | | Pittsfield Iron Co Mine - Chittenden | Yes | 88 | |
| 190 | | Furnace Brook CKB - Chittenden | Yes | 88 | |
| in process | | Seager Hill LK - Brandon | No | | |
| in process | | Howard Hill LK - Benson | No | | |
| in process | | Steam Mill Brook Mills - Chittenden | Yes | | |
| in process | | Devil's Den LK - Mt Tabor | Yes | | |
| in process | | Mitchell/Harrison Iron Mines - Chittenden | Yes | | |

December 31, 1988

# Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|
| | | **Rutland County (Cont)** | | | |
| **F.S.-** | | | | | |
| 13 | | Worth Mtn CKM - Goshen | Yes | 80 | |
| 17 | 5-17 | Davey's Forges BL - Fair Haven | No | 81 | |
| 19 | 6-13 | Danby Sta CKB (Carvage) - Mt Tabor | Yes | 82 | |
| **WA-** | | **Washington County** | | | |
| 21 | | Waterbury Last Block Co SM - Waterbury | No | 86 | |
| 25 | 5-64 | Rice's Forge BF/FDY - Waitsfield | No | 86 | |
| **WD-** | | **Windham County** | | | |
| 37 | 2-11 | Mt Snow IM - Dover | Yes | 85 | |
| 38 | 5- 7 | Somerset Forge BL - Dover | No | 84 | |
| 66 | 6-16 | Harold Field's CK - Stratton | Yes | 86 | |
| 67 | | Janet Greene Farm LK - Dover | Yes | 86 | |
| 68 | | W Thayer LK - Jamaica | No | 86 | |
| 69 | | PA Haven LK - Jamaica | No | 86 | |
| 70 | | Howard LK - Jamaica | No | 86 | |
| **WN-** | | **Windsor County** | | | |
| 51 | 5-65 | Tyson BF - Plymouth | No | 81 | |
| 58 | | Upper Falls LK - Weathersfield | No | 85 | |
| 59 | | Upper Falls Mills - Weathersfield | No | 85 | |
| 104 | | Amsden LKs - Weathersfield | No | 86 | |
| 108 | | Burnt Mtn LK - Plymouth | No | 87 | |
| 109 | | Campground LK - Plymouth | No | 87 | |
| 110 | | Anna Rice LK - Plymouth | No | 87 | |
| 111 | | Black Pond LK - Plymouth | No | 87 | |
| 112 | | Knapp LK - Plymouth | No | 87 | |
| 113 | | Brookwood LK - Plymouth | No | 87 | |
| 114 | | Money Brook LK - Plymouth | No | 87 | |
| 118 | | Taylor LK - Cavendish | No | 88 | |
| | 121 | Ward Lime Works LK - Plymouth | No | 88 | |
| | 120 | Frog City LK - Plymouth | No | 88 | |
| | 119 | Grass Pond LK - Plymouth | No | 88 | |
| | | Branch Brook Rd LK - Weathersfield | No | 88 | |
| **F.S.-** | | | | | |
| 14 | 5-63 | Upper Falls Forge BL? - Weathersfield | No | 85 | |

Legend

BF = Blast furnace
BL = Bloomery
BY = Brickyard (brick kiln)
CKB = Charcoal kiln (brick)
CKM = Charcoal kiln (mound)
CKS = Charcoal kiln (stone)
FDY = Foundry (iron)
IM = Iron Mine
LK = Lime kiln
SM = Saw mill

Ref = Chapter/Page in Rolando manuscript
Ch = Chapter " " "
Pg = Page " " "

December 31, 1988

Vermont Inventory of Industrial Archeology Sites

Inventory in Progress

Addison County:
- Addison ...... Potash Bay
- Bristol ...... Barker Charcoal kiln
- Bristol ...... Dam upstream of Rockydale
- Bristol ...... Iron mine (1857 map)
- Ferrisburg ... Lime kiln at Plank Road (Beers)
- Hancock ...... Charcoal kilns (Dick DeBonis)
- Leicester .... Charcoal mounds and blast furnace per Peleszak
- Monkton ...... Iron mine (John Peters)
- New Haven .... Mill foundations/forge at New Haven Mills
- New Haven .... Lime kiln (Beers)
- Shoreham ..... Charcoal mounds (?) per UVM Remote Sensing Lab
- Vergennes .... Tunnel complex (update)
- Weybridge .... Blast furnace site (Beldens)

Bennington County:
- Bennington ... Lime kilns (silos?) at Bennington Potters
- Manchester ... "Mystery" foundation along upper Lye Brook
- Manchester ... Remains at holding pond
- Readsboro .... Saw Mill west of Heartwellville (new logging road)
- Readsboro .... Saw mill north of Heartwellville
- Readsboro .... "Furnace" (Hugh Jackes)
- Readsboro .... Ruins west end of Heartwellville
- Sunderland ... Saw mill at Bacon Hollow
- Winhall ...... Rootville sawmill/house remains
- Winhall ......Charcoal kilns at Snow Valley (Bob West's uncle)

Caledonia County:
- Lyndon ....... Murkland foundry

Chittenden County:
- Burlington ... Water power systems at Winooski Falls
- Essex ........ Brick kilns at Condo (FS assigned?)
- Hinesburg .... Patrick foundry at Mechanicsville
- Shelburne .... Mills/ bloomery sites at Falls
- Westford ..... Bloomeries
- Winooski ..... Water power systems at the falls

Franklin County:

Lamoille County:
- Morristown ... Forge at Cady's Falls

Orange County:
- Thetford ..... Blast Furnace per Peter Thomas letter (Paige 1978)

Rutland County:
- Brandon ...... Charcoal kilns in "The Basin"
- Brandon ...... Conant furnace
- Chittenden ... Charcoal kiln(s) per Walling
- Danby ........ Quarry RR east slope of Dorset Mtn
- Pittsford ....Add'l sites in Grangerville (Allan Hitchcock)
- Sudbury ...... Charcoal kilns on Miller Hill (Mary Kennedy)
- Wallingford .. Works at Homer Stone Brook

Washington County:
- Calais ....... Forge at Joe's Brook
- Waterbury .... Charcoal kilns at State Park (Bill Gove)

Windham County:

Windsor County:

Bethel ....... White River Iron Co
Reading ....... Stone Tower (postcard)
Rochester .... Coal kilns per Beers
Woodstock ..... Cobb furnace at English Mills
Woodstock ..... Granger foundry (Dana; L. Granger)
Woodstock ..... LK near 'Kendron'
Woodstock ..... Taftsville

Vic Rolando
41 Lebanon Avenue
Pittsfield, Mass 01201

(413) 442-5895 - home
(413) 494-3894 - work

B:Vermont.Inv

August 11, 1989
Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| **AD-** | | | **Addison County** | | | |
| 16 | | | Huntley Is. CKM & prehistoric - Leicester | Yes | 78 | |
| 146 | | | Monkton Iron Co BF/BL/FDY - Vergennes | No | 76 | 81 |
| 299 | | | Middlebury Forge BL - East Middlebury | Yes | 80 | |
| 300 | | | Orwell BF - Orwell | No | 77 | 81 |
| 314 | | | Dragon Brk CKB - Ripton | Yes | 83 | 85 |
| 315 | | | Widow's Trail CKB - Ripton | Yes | 83 | |
| 318 | | | Huntley LK - Leicester | Yes | 84 | |
| 338 | | | Billings CKB - Ripton | Yes | 85 | |
| 339 | | | Eagle Forge BL - East Middlebury | Yes | 85 | |
| 340 | | | Little Otter BF - New Haven | No | 85 | |
| 341 | | | Kewaydin CKM - Salisbury | Yes | 85 | |
| 348 | | | Alder Brk CKM (east) - Ripton | Yes | 85 | |
| 351 | | | Alder Brk CKM (west) - Ripton | Yes | 85 | |
| 355 | | | Green Mtn Lime Co LK - New Haven | No | 85 | |
| 356 | | | Sandusky CKB? - Granville | No | 85 | |
| 404 | | | Richville Mills & BL - Shoreham | No | 86 | |
| 405 | | | Widow Glynn CKM - Leicester | Yes | 86 | |
| 406 | | | Sawyer's Forge BL - Salisbury | No | 86 | |
| 407 | | | Salisbury Forge BL - Salisbury | No | 86 | |
| 409 | | | Bedell LK - Bristol | No | 86 | |
| 414 | | | Brooksville Edge Tool Co FDY - New Haven | No | 86 | |
| 415 | | | Wainwright/Davenport FDY - Middlebury | No | 86 | |
| 416 | | | Holley Forge BL - Bristol | No | 86 | |
| 417 | | | Lewis Creek Farm BL - Starksboro | No | 86 | |
| 430 | | | Fuller Forge BL - Ferrisburg | No | 87 | |
| 431 | | | Doreen's Forge BL - Ferrisburg | No | 87 | |
| 432 | | | Monkton Iron Co Forge BL (BF?) - Ferrisburg | No | 87 | |
| 466 | | | Worth Mtn CKM - Goshen | Yes | 80 | |
| XXX | | | Barker CK - Bristol | Yes | 89 | |
| | | | Brickyard - Bristol | No | 89 | |
| **F.S.-** | | | | | | |
| 49 | | | Lk Dunmore Glass Fac - Salisbury | No | 78 | 81 |
| 50 | | | Soper & Pier; Burnham BL - Lincoln | Yes | 81 | |
| 85 | | | Mt Fuller CKM - Monkton | No | 86 | |
| 86 | | | Bristol Village Forge BL - Bristol | No | 86 | |
| **BE-** | | | **Bennington County** | | | |
| 9 | | | East Dorset BF - Dorset | No | 83 | |
| 10 | | | Benn Iron Co (east stack) BF - Bennington | No | 80 | |
| 11 | | | Benn Iron Co (west stack) BF - Bennington | No | 80 | |
| 35 | | | North Dorset BF - Dorset | Yes | 81 | 83 |
| 36 | | | Burden BF - Shaftsbury | No | 81 | |
| 37 | | | Red Cabin CKB - Glastenbury | Yes | 82 | |
| 39 | | | Mad Tom 3 CKB - Peru | Yes | 83 | |
| 40 | | | Mad Tom 1 CKB - Peru | Yes | 83 | |
| 41 | | | Mad Tom 5 CKB - Peru | Yes | 83 | |
| 42 | | | Winhall River CKB - Winhall | Yes | 83 | |
| 43 | | | Bromley Brk CKB - Winhall | Yes | 83 | |
| 44 | | | Bourn Brk CKB - Winhall | Yes | 83 | |
| 45 | | | Bickford Hollow CKB - Glastenbury | Yes | 83 | |
| 46 | | | East Fork CKB - Glastenbury | Yes | 83 | |
| 47 | | | West Fork CKB - Glastenbury | Yes | 83 | |
| 50 | | | Heartwellville CKS - Readsboro | Yes | 83 | |

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| BE- | | | **Bennington County (Cont)** | | | |
| 51 | | | Heartwellville CKB - Readsboro .............. | Yes | 83 | |
| 52 | | | Heartwellville Conical CKB - Readsboro ....... | Yes | 83 | |
| 53 | | | Cotykilns CKS - Stamford .................... | Yes | 85 | |
| 54 | | | Dutch Hill site CKS - Readsboro .............. | Yes | 85 | |
| 55 | | | Cowen (Gulley; Kimbal) Brook CKS - Stamford .. | Yes | 85 | |
| 56 | | | Sterba CKB & CKM - Glastenbury ............... | Yes | 85 | |
| 57 | | | Hager Hill site CKB? - Woodford .............. | Yes | 85 | |
| 58 | | | Bacon Hollow CKM - Sunderland ................ | Yes | 85 | |
| 61 | | | East Mtn CKM - Shaftsbury .................... | Yes | 85 | |
| 62 | | | East Mtn CKS (north) - Shaftsbury ............ | Yes | 85 | |
| 63 | | | East Mtn CKS (south) - Glastenbury ........... | Yes | 85 | |
| 64 | | | Furnace Brk BF - Bennington .................. | No | 85 | |
| 105 | | | Kennedy CKS - Stamford ...................... | Yes | 86 | |
| 106 | | | Cardinal (Nunge) Brook CKB - Stamford ....... | Yes | 86 | |
| 107 | | | Crazy John Stream CKS - Stamford ............ | Yes | 86 | |
| 108 | | | Thompson Farm CKM - Stamford ................ | Yes | 86 | |
| 109 | | | Barnumville LK - Manchester ................. | No | 86 | |
| 110 | | | MD&G RR - Manchester/Dorset ................. | No | 86 | |
| 117 | | | Manchester Depot LK - Manchester ............ | No | 87 | |
| 118 | | | No Pownal LK - Pownal ....................... | No | 87 | |
| 134 | | | Schoolhouse CKB - Winhall ................... | Yes | 88 | |
| 135 | | | Holbrook SM - Pownal ......................... | Yes | 88 | |
| XXX | | | Sylvan Ridge CKS ............................. | Yes | 89 | |
| XXX | | | Fisher Road LK - Arlington ................... | No | 89 | |
| XXX | | | Judson Quarry LK - Arlington ................. | No | 89 | |
| XXX | | | No. Dorset LK - Dorset ....................... | No | 89 | |
| | | | Amaden LK - Readsboro ........................ | Yes | | |
| F.S.- | | | | | | |
| ? | | | Burden I. Co IM - Bennington ................. | No | 79 | |
| 4 | | | Unidentified Concrete Structures - Pownal..... | No | 85 | |
| CA- | | | **Caledonia County** | | | |
| 20 | | | Paddock Ironworks BF - St Johnsbury .......... | No | 81 | |
| CH- | | | **Chittenden County** | | | |
| 1 | | | Pine Island (CK & prehistoric) ............... | No | 78 | |
| 17 | | | So Burlgtn LK (prehistoric) - So Burlgtn ..... | No | 68 | |
| 282 | | | Weston LK - So Burlington .................... | No | 86 | |
| 283 | | | Stevens FDY - Colchester ..................... | No | 86 | |
| 284 | | | Winooski Park LK - Colchester ................ | No | 86 | |
| 365 | | | Lime Kiln Rd LK - Charlotte .................. | No | 88 | |
| F.S.- | | | | | | |
| 4 | | | Colchester Bog IM - Colchester ............... | No | 77 | |
| 6 | | | Clay Point BY - Colchester ................... | No | 77 | |
| 7 | | | Red Rock Point BY - Colchester ............... | No | 77 | |
| 70 | | | Spafford Forge BL - Williston ................ | No | 80 | |
| ES- | | | **Essex County** | | | |
| FR- | | | **Franklin County** | | | |
| 67 | | | Keith (west) BF - Sheldon .................... | No | 80 | |
| 68 | | | Keith (east) BF - Sheldon .................... | No | 80 | |

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| FR- | | | **Franklin County (Cont)** | | | |
| 149 | | | Rock River BF - Highgate | No | 81 | |
| 163 | | | Barney Forge BL - Swanton | No | 85 | |
| 169 | | | Kenfield FDY - Fairfax | No | 86 | |
| 177 | | | Sheridan FDY - Highgate | No | 87 | |
| 178 | | | Fonda LK - Swanton | No | 87 | |
| 179 | | | John's Bridge LK - Swanton | No | 87 | |
| 186 | | | Rixford FDY - East Highgate | No | 88 | |
| | | | Missisquoi Lime Co LK - Highgate | No | | |
| F.S.- | | | | | | |
| 12 | | | (VT-FR-163) | No | 80 | |
| GI- | | | **Grand Isle County** | | | |
| LA- | | | **LaMoille County** | | | |
| OR- | | | **Orange County** | | | |
| 14 | | | Ely Copper Mine CW - Vershire | No | 80 | |
| OL- | | | **Orleans County** | | | |
| 3 | | | Troy BF - Troy | No | 80 | |
| RU- | | | **Rutland County** | | | |
| 41 | | | Forest Dale BF - Brandon | Yes | 80 | |
| 57 | | | Granger BF - Pittsford | No | 80 | 85 |
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| 77 | | | Jaquay BF - Tinmouth | No | 80 | |
| 78 | | | Old Job CKB - Mt Tabor | Yes | 82 | 83 |
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| 86 | | | Greeley Mills SM & CKM? - Mt Tabor | Yes | 83 | |
| 87 | | | Chipman Forge BL - Tinmouth | No | 83 | |
| 97 | | | Chippenhook BF - Clarendon | No | 85 | |
| 98 | | | Scotch Hill LK - Fair Haven | No | 85 | 89 |
| 99 | | | Coburn BF - West Haven | No | 85 | |
| 103 | | | Iron Mine IM - Chittenden | No | 85 | |
| 108 | | | Kiln #36 CKB - Mt Tabor | Yes | 85 | |
| 109 | | | Forest Dale IM - Brandon | No | 85 | |
| 153 | | | Gibbs & Cooley FDY/BF - Pittsford | No | 86 | |
| 154 | | | Maplebrook Farm LK - Tinmouth | No | 86 | |
| 155 | | | Kiln Brook CKB - Chittenden | Yes | 86 | |
| 156 | | | Lampman CKS (Rect) - Chittenden | Yes | 86 | |
| 157 | | | Vt Lime Prod Co LK - Mt Tabor | No | 86 | |
| 160 | | | Danby Mtn Road CKB - Danby | No | 86 | |
| 161 | | | Crow Hill Farm LK - Tinmouth | No | 86 | |
| 162 | | | Tinmouth Pond Dam BF - Tinmouth | No | 86 | |
| 163 | | | Palumbo Farm IM - Tinmouth | No | 86 | |
| 164 | | | Circular Stone-Lined Feature - Mt Holly | No | 86 | |
| 165 | | | S. Bromley Farm LK - Wallingford | No | 86 | |
| 166 | | | 'The Cobble' LKs - Clarendon | No | 86 | |
| 167 | | | Crow Hill Farm IM - Tinmouth | No | 86 | |
| 171 | | | Packard Mill/Forge Site BL - Tinmouth | No | 86 | |
| 179 | | | District 8 LK - Mendon | Yes | 87 | |

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| RU- | | | **Rutland County (Cont)** | | | |
| 180 | | | Rounds Pinnacle LK - Shelburne | No | 87 | |
| 188 | | | Beaudry Brook CKM & IM - Chittenden | Yes | 88 | |
| 189 | | | Pittsfield Iron Co IM - Chittenden | Yes | 88 | |
| 190 | | | Furnace Brook CKB - Chittenden | Yes | 88 | |
| XXX | | | Seager Hill LK - Brandon | No | 89 | |
| 195 | | | Gamaliel Leonard BL - Fair Haven | No | 89 | |
| XXX | | | Howard Hill LK - Benson | No | | |
| XXX | | | Devil's Den LK - Mt Tabor | Yes | | |
| XXX | | | Briggs LK - Fair Haven | No | 89 | |
| | | | Steam Mill Brook Mills - Chittenden | Yes | | |
| | | | Mitchell/Harrison IM - Chittenden | Yes | | |
| F.S.- | | | | | | |
| 17 | | | Davey's Forges BL - Fair Haven | No | 81 | |
| 19 | | | Danby Sta CKB (Carvage) - Mt Tabor | Yes | 82 | |
| WA- | | | **Washington County** | | | |
| 21 | | | Waterbury Last Block Co SM - Waterbury | No | 86 | |
| 25 | | | Rice's Forge BF/FDY - Waitsfield | No | 86 | |
| WD- | | | **Windham County** | | | |
| 37 | | | Mt Snow IM - Dover | Yes | 85 | |
| 38 | | | Somerset Forge BL - Dover | No | 84 | |
| 66 | | | Harold Field's CK - Stratton | Yes | 86 | |
| 67 | | | Janet Greene Farm LK - Dover | Yes | 86 | |
| 68 | | | W Thayer LK - Jamaica | No | 86 | |
| 69 | | | PA Haven LK - Jamaica | No | 86 | |
| 70 | | | Howard LK - Jamaica | No | 86 | |
| WN- | | | **Windsor County** | | | |
| 51 | | | Tyson BF - Plymouth | No | 81 | |
| 58 | | | Upper Falls LK - Weathersfield | No | 85 | |
| 59 | | | Upper Falls Mills - Weathersfield | No | 85 | |
| 104 | | | Amsden LKs - Weathersfield | No | 86 | |
| 108 | | | Burnt Mtn LK - Plymouth | No | 87 | |
| 109 | | | Campground LK - Plymouth | No | 87 | |
| 110 | | | Anna Rice LK - Plymouth | No | 87 | |
| 111 | | | Black Pond LK - Plymouth | No | 87 | |
| 112 | | | Knapp LK - Plymouth | No | 87 | |
| 113 | | | Brookwood LK - Plymouth | No | 87 | |
| 114 | | | Money Brook LK - Plymouth | No | 87 | |
| 118 | | | Taylor LK - Cavendish | No | 88 | |
| 119 | | | Grass Pond LK - Plymouth | No | 88 | |
| 120 | | | Frog City LK - Plymouth | No | 88 | |
| 121 | | | Ward Lime Works LK - Plymouth | No | 88 | |
| 123 | | | Branch Brook Rd LK - Weathersfield | No | 88 | |
| XXX | | | Emerson LK - Rochester | Yes | 89 | |
| F.S.- | | | | | | |
| 14 | | | Upper Falls Forge BL? - Weathersfield | No | 85 | |

August 11, 1989
Vermont Inventory of Industrial Archeology Sites

Legend

| | | | |
|---|---|---|---|
| BF | = Blast furnace | Ref | = Chapter/Page in Rolando manuscript |
| BL | = Bloomery | Ch | = Chapter " " " |
| BY | = Brickyard (brick kiln) | Pg | = Page " " " |
| CKB | = Charcoal kiln (brick) | | |
| CKM | = Charcoal kiln (mound) | LK | = Lime kiln |
| CKS | = Charcoal kiln (stone) | SM | = Saw mill |
| FDY | = Foundry (iron) | IM | = Iron Mine |

June 30, 1990
Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| AD- | | | **ADDISON COUNTY** | | | |
| 16 | | | Huntley Is. CKM & prehistoric - Leicester .. | Yes | 78 | |
| 146 | | | Monkton Iron Co BF/BL/FDY - Vergennes ...... | No | 76 | 81 |
| 299 | | | Middlebury Forge BL - East Middlebury ...... | Yes | 80 | |
| 300 | | | Orwell BF - Orwell ......................... | No | 77 | 81 |
| 314 | | | Dragon Brk CKB - Ripton .................... | Yes | 83 | 85 |
| 315 | | | Widow's Trail CKB - Ripton ................. | Yes | 83 | |
| 318 | | | Huntley LK - Leicester ..................... | Yes | 84 | |
| 338 | | | Billings CKB - Ripton ...................... | Yes | 85 | |
| 339 | | | Eagle Forge BL - East Middlebury ........... | Yes | 85 | |
| 340 | | | Little Otter BF - New Haven ................ | No | 85 | |
| 341 | | | Kewaydin CKM - Salisbury ................... | Yes | 85 | |
| 348 | | | Alder Brk CKM (east) - Ripton .............. | Yes | 85 | |
| 351 | | | Alder Brk CKM (west) - Ripton .............. | Yes | 85 | |
| 355 | | | Green Mtn Lime Co LK - New Haven ........... | No | 85 | |
| 356 | | | Sandusky CKB? - Granville .................. | No | 85 | |
| 395 | | | Worth Mtn CKM - Goshen ..................... | Yes | 80 | |
| 404 | | | Richville Mills & BL - Shoreham ............ | No | 86 | |
| 405 | | | Widow Glynn CKM - Leicester ................ | Yes | 86 | |
| 406 | | | Sawyer's Forge BL - Salisbury .............. | No | 86 | |
| 407 | | | Salisbury Forge BL - Salisbury ............. | No | 86 | |
| 409 | | | Bedell LK - Bristol ........................ | No | 86 | |
| 414 | | | Brooksville Edge Tool Co FDY - New Haven ... | No | 86 | |
| 415 | | | Wainwright/Davenport FDY - Middlebury ...... | No | 86 | |
| 416 | | | Holley Forge BL - Bristol .................. | No | 86 | |
| 417 | | | Lewis Creek Farm BL - Starksboro ........... | No | 86 | |
| 430 | | | Fuller Forge BL - Ferrisburg ............... | No | 87 | |
| 431 | | | Doreen's Forge BL - Ferrisburg ............. | No | 87 | |
| 432 | | | Monkton Iron Co Forge BL (BF?) - Ferrisburg. | No | 87 | |
| 467 | | | Barker CK - Bristol ........................ | Yes | 89 | |
| XXX | | | Martel LK - New Haven ...................... | No | 90 | |
| F.S.- | | | | | | |
| 49 | | | Lk Dunmore Glass Fac - Salisbury ........... | No | 78 | 81 |
| 50 | | | Soper & Pier; Burnham BL - Lincoln ......... | Yes | 81 | |
| 85 | | | Mt Fuller CKM - Monkton .................... | No | 86 | |
| 86 | | | Bristol Village Forge BL - Bristol ......... | No | 86 | |
| BE- | | | **BENNINGTON COUNTY** | | | |
| 9 | | | East Dorset BF - Dorset .................... | No | 83 | |
| 10 | | | Benn Iron Co (east stack) BF - Bennington .. | No | 80 | |
| 11 | | | Benn Iron Co (west stack) BF - Bennington .. | No | 80 | |
| 35 | | | North Dorset BF - Dorset ................... | Yes | 81 | 83 |
| 36 | | | Burden BF - Shaftsbury ..................... | No | 81 | |
| 37 | | | Red Cabin CKB - Glastenbury ................ | Yes | 82 | |
| 40 | | | Mad Tom 1 CKB - Peru ....................... | Yes | 83 | |

June 30, 1990
Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| **BE-** | | | **Bennington County (Cont)** | | | |
| 41 | | | Mad Tom 5 CKB - Peru | Yes | 83 | |
| 42 | | | Winhall River CKB - Winhall | Yes | 83 | |
| 43 | | | Bromley Brk CKB - Winhall | Yes | 83 | |
| 44 | | | Bourn Brk CKB - Winhall | Yes | 83 | |
| 45 | | | Bickford Hollow CKB - Glastenbury | Yes | 83 | |
| 46 | | | East Fork CKB - Glastenbury | Yes | 83 | |
| 47 | | | West Fork CKB - Glastenbury | Yes | 83 | |
| 50 | | | Heartwellville CKS - Readsboro | Yes | 83 | |
| 51 | | | Heartwellville CKB - Readsboro | Yes | 83 | |
| 52 | | | Heartwellville Conical CKB - Readsboro | Yes | 83 | |
| 53 | | | Cotykilns CKS - Stamford | Yes | 85 | |
| 54 | | | Dutch Hill site CKS - Readsboro | Yes | 85 | |
| 55 | | | Cowen (Gulley; Kimbal) Brook CKS - Stamford. | Yes | 85 | |
| 56 | | | Sterba CKB & CKM - Glastenbury | Yes | 85 | |
| 57 | | | Hager Hill site CKB? - Woodford | Yes | 85 | |
| 58 | | | acon Hollow CKM - Sunderland | Yes | 85 | |
| 60 | | | (Tannery - Searsburg) | ? | ? | |
| 61 | | | East Mtn CKM - Shaftsbury | Yes | 85 | |
| 62 | | | East Mtn CKS (north) - Shaftsbury | Yes | 85 | |
| 63 | | | East Mtn CKS (south) - Glastenbury | Yes | 85 | |
| 64 | | | Furnace Brk BF - Bennington | No | 85 | |
| 105 | | | Kennedy CKS - Stamford | Yes | 86 | |
| 106 | | | Cardinal (Nunge) Brook CKB - Stamford | Yes | 86 | |
| 107 | | | Crazy John Stream CKS - Stamford | Yes | 86 | |
| 108 | | | Thompson Farm CKM - Stamford | Yes | 86 | |
| 109 | | | Barnumville LK - Manchester | No | 86 | |
| 110 | | | MD&G RR - Manchester/Dorset | No | 86 | |
| 117 | | | Manchester Depot LK - Manchester | No | 87 | |
| 118 | | | No Pownal LK - Pownal | No | | |
| 134 | | | Schoolhouse CKB - Winhall | Yes | 88 | |
| 135 | | | Holbrook SM - Pownal | Yes | 88 | |
| 141 | | | No. Dorset LK - Dorset | No | 89 | |
| 142 | | | Sylvan Ridge CKS | Yes | 89 | |
| 143 | | | Fisher Road LK - Arlington | No | 89 | |
| 144 | | | Judson Quarry LK - Arlington | No | 89 | |
| XXX | | | Amaden LK - Readsboro | Yes | | |
| XXX | | | Manchester Ctr Reservoir LK - Manchester ... | | | |
| **F.S.-** | | | | | | |
| ? | | | Burden I. Co IM - Bennington | No | 79 | |
| 4 | | | Unidentified Concrete Structures - Pownal... | No | 85 | |
| **CA-** | | | **CALEDONIA COUNTY** | | | |
| 20 | | | Paddock Ironworks BF - St Johnsbury | No | 81 | |

June 30, 1990

Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| **CH-** | | | **CHITTENDEN COUNTY** | | | |
| 1 | | | Pine Island (CK & prehistoric) ............. | No | 78 | |
| 17 | | | So Burlgtn LK (prehistoric) - So Burlgtn ... | No | 68 | |
| 282 | | | Weston LK - So Burlington .................. | No | 86 | |
| 283 | | | Stevens FDY - Colchester ................... | No | 86 | |
| 284 | | | Winooski Park LK - Colchester .............. | No | 86 | |
| 365 | | | Lime Kiln Rd LK - Charlotte ................ | No | 88 | |
| **F.S.-** | | | | | | |
| 4 | | | Colchester Bog IM - Colchester ............. | No | 77 | |
| 6 | | | Clay Point BY - Colchester ................. | No | 77 | |
| 7 | | | Red Rock Point BY - Colchester ............. | No | 77 | |
| 70 | | | Spafford Forge BL - Williston .............. | No | 80 | |
| **ES-** | | | **ESSEX COUNTY** | | | |
| **FR-** | | | **FRANKLIN COUNTY** | | | |
| 67 | | | Keith (west) BF - Sheldon .................. | No | 80 | |
| 68 | | | Keith (east) BF - Sheldon .................. | No | 80 | |
| 149 | | | Rock River BF - Highgate ................... | No | 81 | |
| 163 | | | Barney Forge BL - Swanton .................. | No | 85 | |
| 169 | | | Kenfield FDY - Fairfax ..................... | No | 86 | |
| 177 | | | Sheridan FDY - Highgate .................... | No | 87 | |
| 178 | | | Fonda LK - Swanton ......................... | No | 87 | |
| 179 | | | John's Bridge LK - Swanton ................. | No | 87 | |
| 186 | | | Rixford FDY - East Highgate ................ | No | 88 | |
| XXX | | | Missisquoi Lime Co LK - Highgate ........... | No | | |
| **F.S.-** | | | | | | |
| 12 | | | (VT-FR-163) ................................ | No | 80 | |
| **GI-** | | | **GRAND ISLE COUNTY** | | | |
| **LA-** | | | **LAMOILLE COUNTY** | | | |
| **OR-** | | | **ORANGE COUNTY** | | | |
| 14 | | | Ely Copper Mine CW - Vershire .............. | No | 80 | |
| **OL-** | | | **ORLEANS COUNTY** | | | |
| 3 | | | Troy BF - Troy ............................. | No | 80 | |
| **RU-** | | | **RUTLAND COUNTY** | | | |
| 41 | | | Forest Dale BF - Brandon ................... | Yes | 80 | |
| 57 | | | Granger BF - Pittsford ..................... | No | 80 | 85 |
| 76 | | | Terminini BF - Tinmouth .................... | No | 80 | |
| 77 | | | Jaquay BF - Tinmouth ....................... | No | 80 | |

June 30, 1990
Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| **RU-** | | | **Rutland County (Cont)** | | | |
| 78 | | | Old Job CKB - Mt Tabor | Yes | 82 | 83 |
| 79 | | | Ten Kilns CKB - Mt Tabor | Yes | 82 | |
| 84 | | | Black Branch CKB - Mt Tabor | Yes | 83 | 85 |
| 85 | | | Four Kilns CKB - Mt Tabor | Yes | 82 | 83 |
| 86 | | | Greeley Mills SM & CKM? - Mt Tabor | Yes | 83 | |
| 87 | | | Chipman Forge BL - Tinmouth | No | 83 | |
| 97 | | | Chippenhook BF - Clarendon | No | 85 | |
| 98 | | | Scotch Hill LK - Fair Haven | No | 85 | 89 |
| 99 | | | Coburn BF - West Haven | No | 85 | |
| 103 | | | Iron Mine IM - Chittenden | No | 85 | |
| 108 | | | Kiln #36 CKB - Mt Tabor | Yes | 85 | |
| 109 | | | Forest Dale IM - Brandon | No | 85 | |
| 153 | | | Gibbs & Cooley FDY/BF - Pittsford | No | 86 | |
| 154 | | | Maplebrook Farm LK - Tinmouth | No | 86 | |
| 155 | | | Kiln Brook CKB - Chittenden | Yes | 86 | |
| 156 | | | Lampman CKS (Rect) - Chittenden | Yes | 86 | |
| 157 | | | Vt Lime Prod Co LK - Mt Tabor | No | 86 | |
| 160 | | | Danby Mtn Road CKB - Danby | No | 86 | |
| 161 | | | Crow Hill Farm LK - Tinmouth | No | 86 | |
| 162 | | | Tinmouth Pond Dam BF - Tinmouth | No | 86 | |
| 163 | | | Palumbo Farm IM - Tinmouth | No | 86 | |
| 164 | | | Circular Stone-Lined Feature - Mt Holly | No | 86 | |
| 165 | | | S. Bromley Farm LK - Wallingford | No | 86 | |
| 166 | | | 'The Cobble' LKs - Clarendon | No | 86 | |
| 167 | | | Crow Hill Farm IM - Tinmouth | No | 86 | |
| 171 | | | Packard Mill/Forge Site BL - Tinmouth | No | 86 | |
| 179 | | | District 8 LK - Mendon | Yes | 87 | |
| 180 | | | Rounds Pinnacle LK - Shelburne | No | 87 | |
| 188 | | | Beaudry Brook CKM & IM - Chittenden | Yes | 88 | |
| 189 | | | Pittsfield Iron Co IM - Chittenden | Yes | 88 | |
| 190 | | | Furnace Brook CKB - Chittenden | Yes | 88 | |
| 194 | | | Seager Hill LK - Brandon | No | 89 | |
| 195 | | | Gamaliel Leonard BL - Fair Haven | No | 89 | |
| 196 | | | Briggs LK - Fair Haven | No | 89 | |
| 197 | | | Devil's Den LK - Mt Tabor | Yes | 89 | |
| 198 | | | Howard Hill LK - Benson | No | 89 | |
| XXX | | | Steam Mill Brook Mills - Chittenden | Yes | | |
| XXX | | | Mitchell/Harrison IM - Chittenden | Yes | | |
| XXX | | | Conant Furnace BF - Brandon | No | 90 | |
| **F.S.-** | | | | | | |
| 17 | | | Davey's Forges BL - Fair Haven | No | 81 | |
| 19 | | | Danby Sta CKB (Carvage) - Mt Tabor | Yes | 82 | |

June 30, 1990
Vermont Inventory of Industrial Archeology Sites

| Code | Ref Ch | Ref Pg | County/Site Name/Town | GMNF Proc Bdy? | Recorded Init | Recorded Update |
|---|---|---|---|---|---|---|
| **WA-** | | | **WASHINGTON COUNTY** | | | |
| 21 | | | Waterbury Last Block Co SM - Waterbury ..... | No | 86 | |
| 25 | | | Rice's Forge BF/FDY - Waitsfield ........... | No | 86 | |
| **WD-** | | | **WINDHAM COUNTY** | | | |
| 37 | | | Mt Snow IM - Dover ......................... | Yes | 85 | |
| 38 | | | Somerset Forge BL - Dover .................. | No | 84 | |
| 66 | | | Harold Field's CK - Stratton ............... | Yes | 86 | |
| 67 | | | Janet Greene Farm LK - Dover ............... | Yes | 86 | |
| 68 | | | W Thayer LK - Jamaica ...................... | No | 86 | |
| 69 | | | PA Haven LK - Jamaica ...................... | No | 86 | |
| 70 | | | Howard LK - Jamaica ........................ | No | 86 | |
| **WN-** | | | **WINDSOR COUNTY** | | | |
| 51 | | | Tyson BF - Plymouth ........................ | No | 81 | |
| 58 | | | Upper Falls LK - Weathersfield ............. | No | 85 | |
| 59 | | | Upper Falls Mills - Weathersfield .......... | No | 85 | |
| 104 | | | Amsden LKs - Weathersfield ................. | No | 86 | |
| 108 | | | Burnt Mtn LK - Plymouth .................... | No | 87 | |
| 109 | | | Campground LK - Plymouth ................... | No | 87 | |
| 110 | | | Anna Rice LK - Plymouth .................... | No | 87 | |
| 111 | | | Black Pond LK - Plymouth ................... | No | 87 | |
| 112 | | | Knapp LK - Plymouth ........................ | No | 87 | |
| 113 | | | Brookwood LK - Plymouth .................... | No | 87 | |
| 114 | | | Money Brook LK - Plymouth .................. | No | 87 | |
| 118 | | | Taylor LK - Cavendish ...................... | No | 88 | |
| 119 | | | Grass Pond LK - Plymouth ................... | No | 88 | |
| 120 | | | Frog City LK - Plymouth .................... | No | 88 | |
| 121 | | | Ward Lime Works LK - Plymouth .............. | No | 88 | |
| 123 | | | Branch Brook Rd LK - Weathersfield ......... | No | 88 | |
| 124 | | | Emerson LK - Rochester ..................... | Yes | 89 | |
| XXX | | | Messer Hill Road LK - Plymouth ............. | No | 90 | |
| XXX | | | Grand View Lodge Road Lower LK - Plymouth .. | No | 90 | |
| XXX | | | Grand View Lodge Road Upper LKs - Plymouth . | No | 90 | |
| XXX | | | Branch Brook Upper LK - Weathersfield ...... | No | 90 | |
| XXX | | | Cavendish Station LK - Cavendish ........... | No | 90 | |
| XXX | | | Stearns Farm LK - Cavendish ................ | No | 90 | |
| **F.S.-** | | | | | | |
| 14 | | | Upper Falls Forge BL? - Weathersfield ...... | No | 85 | |

Legend

BF = Blast furnace
BL = Bloomery
BY = Brickyard (brick kiln)
CKB = Charcoal kiln (brick)
CKM = Charcoal Kiln (mound)
CKS = Charcoal Kiln (stone)
FDY = Foundry
IM = Iron Mine
LK = Lime Kiln
SM = Saw Mill

| Site Name | | | Site No. |
|---|---|---|---|
| Fuller Forge | | | UT-AD - 430 |
| Doreen's | " | | " " - 431 |
| Monkton Iron Co Forge | | | " " - 432 |
| Manchester Depot Lime Kilns | | | " - BE - 117 |
| No. Pownal Lime Kilns | | | " " - 118 |
| Sheridan Foundry | | | " - FR - 177 |
| Fonda Lime Kilns | | | " " - 178 |
| John's Bridge Lime Kiln | | | " " - 179 |
| District 8 | " | " | " - RU - 179 |
| Rounds Pinnacle | " | " | " " - 180 |
| Burnt Mtn | " | " | " - WN - 108 |
| Campground | " | " | " " - 109 |
| Anna Rice | " | " | " " - 110 |
| Black Pond | " | " | " " - 111 |
| Knapp | " | " | " " - 112 |
| Brookwood | " | " | " " - 113 |
| Money Brook | " | " | " " - 114 |

Thanks.

# REPORT ON THE SURFACE REMAINS OF THE NEW HAMPSHIRE IRON FACTORY COMPANY

AT

FRANCONIA, NEW HAMPSHIRE

Recorded by

Northern New England Chapter
Society for Industrial Archeology

on

September 9–11, 1994
May 27–28, 1995
and
August 24, 1996

Prepared by
Victor R. Rolando
Project Leader

November 1, 1996

**Victor R. Rolando**
**Research Consultant - Industrial Archeology**
**214 Jefferson Heights Bennington, VT 05201**
**(802) 442-0105 vic.rolando@juno.com**

November 1, 1996

Original copies of this report were distributed on or about this date as follows:

| | Copies |
|---|---|
| Franconia Area Heritage Council (Jewell Friedman) | 3 |
| New Hampshire Division of Historical Resources (James L. Garvin) | 2 |
| Vermont Division for Historic Preservation (Giovanna Peebles) | 2 |
| New Hampshire Historical Society library (William Copeley) | 1 |
| Spares | 3 |

## Contents

Contents (continued)



**Figures**

Figures (continued)



**Tables**

## Foreword

On July 27, 1993, Jewell A. Friedman of the Franconia Area Heritage Council wrote to the late Dr. William Taylor of the Department of Social Studies, Plymouth State College, about the possibility of help from the Northern New England Chapter of the Society for Industrial Archeology (NNEC-SIA) in saving the blast furnace ruin presently standing at the village (see letter in Appendix G). Dr. Taylor read the letter at the fall annual meeting of the chapter on October 16, 1993 at Middlebury, Vermont, at which time attendees agreed that the chapter should actively respond in some supportive manner.

Since I knew something about the blast furnace and had last visited the site in 1984, I volunteered to contact Jewell Friedman and organize the recording session at Franconia for sometime in 1994. These plans eventually culminated in a 3-day archeology and recording session the weekend of September 9-11, 1994, and a follow-up 2-day weekend of May 27-28, 1995. A final 1-day visit to double-check some measurements and further investigate some questionable features was planned and cancelled in April (snow) and May (heavy rain), and finally made on August 24, 1996.

Over 500 volunteer-hours of effort were expended in surveying, photographing, measuring, surface exploring, shallow excavating, interpreting, and recording the blast furnace ruin and associated surface features on both sides of the Gale River, followed by archival research, writing, and drafting, all at everyone's personal expenses.

This report would not have been possible without the assistance of all the participants. Many of our better field sketches are presented in the report "as is" except for slight photo-reduction for fit. All photos, sketches, and drawings not otherwise credited are by the author.

Victor R. Rolando

Victor R. Rolando
Bennington, Vermont

**Acknowledgements**

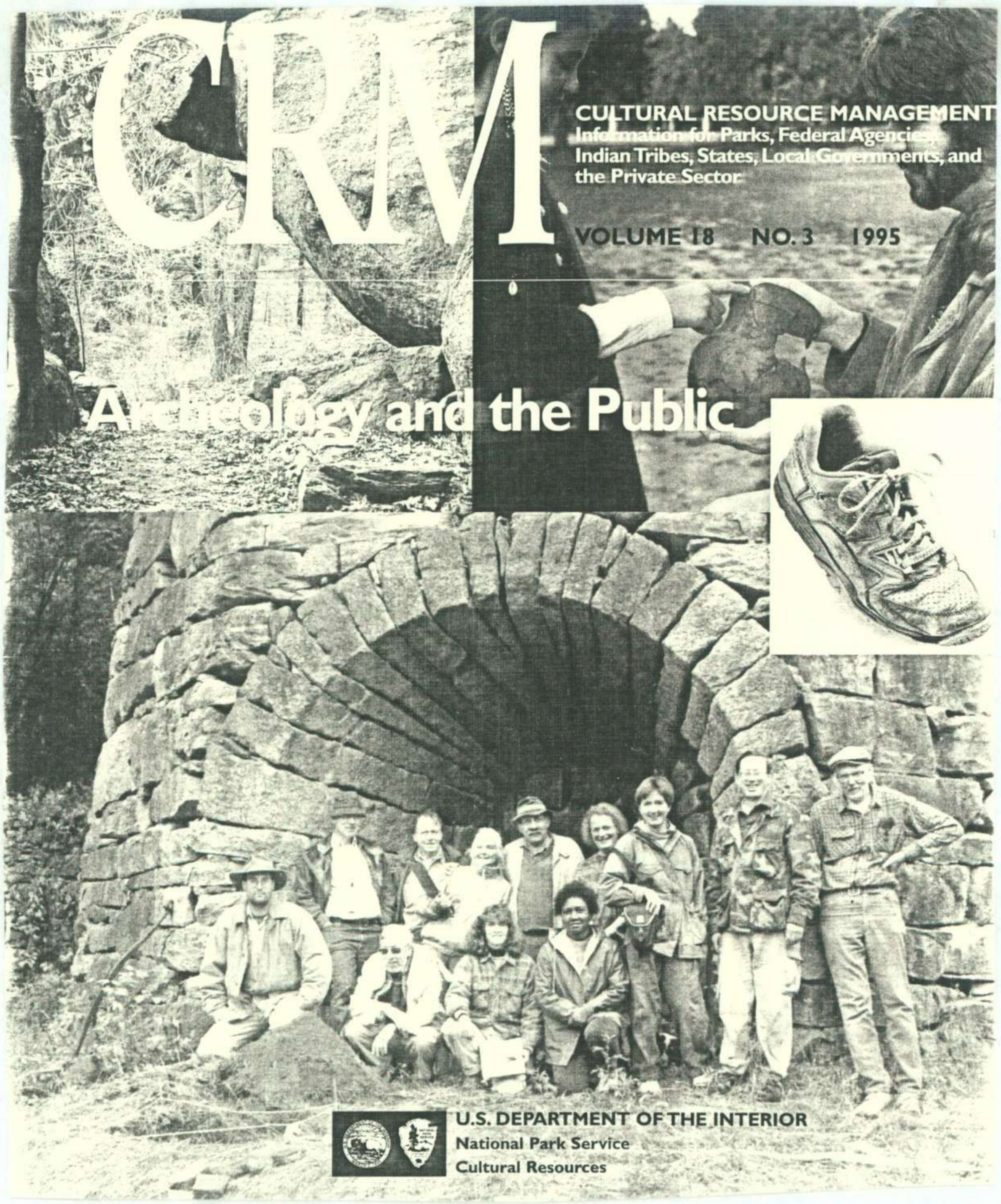
The author thanks everyone who came from throughout the northeast at their own expense to volunteer their effort and expertise for the two recording sessions. Some worked the whole five sometimes sunny, but mostly chilly, drizzly days; some could spare only one day. Friends and help-mates carried our tools and gear in and out of the site or provided morning donuts and coffee at strategic times.

The volunteers for the September 9-11, 1994 session, in addition to myself and wife Donna, were: Megan Battey (and husband George Todd) of New Haven, Vt., Krista Butterfield of Brownfield, Me., Karl and Eleanor Danneil of Nassau, N.Y., Bill, Allison, and Jonathan Edwards of Richmond, Mass., David Engman of Boston, Mass., Dennis Howe of Concord, N.H., Matt Kierstead of Wellesley, Mass., Gloria Miller of Saratoga Springs, N.Y., Woody Openo of Somersworth, N.H., Marjorie Robbins of Middlebury, Vt., Walt Ryan of Claremont, N.H., Carol Weatherwax of Gansevoort, N.Y., and Duncan Wilkie of Montpelier, Vt.

For the May 27-28, 1995 session, volunteers were Megan Battey, Karl and Eleanor Danneil, Matt Kierstead, and Duncan Wilkie.

A 1-day return inspection was made August 24, 1996, assisted by Matt Kierstead.

Special thanks go to Jewell Friedman of the Franconia Area Heritage Council, for mobilizing local support, having the site cleared of brush, providing ladders, introducing us to the locals as they came to observe us, and organizing a Saturday evening supper and program, and later for continuing to feed data and illustrative materials to me; to James L. Garvin, Architectural Historian, New Hampshire Division of Historical Resources (NH DHR), for researching and writing his valuable manuscript on the origins of the New Hampshire Iron Factory Company, for his timely assistance to me in my accumulation of data and materials for this report, and for reading and editing my draft report; to Gary Hume, New Hampshire State Archeologist, for the generous loan of the Division's transit and associated equipment for the September 9-11, 1994 recording session; to William Copeley of the New Hampshire Historical Society (NHHS) library for his patience with me one morning in February; to Frank Meyers, Director of the N.H. State Archives for his assistance; to Olive Stannard and Sylvia Casey for assistance given in 1973 and 1985; and especially to property owners Mr. and Mrs. Kevin O'Brien for allowing the Franconia Area Heritage Council to organize the sessions and provide support to all of us by allowing us the use of their household facilities during all the recording sessions (the property has been on the market and as of August 24, 1966, a prospective buyer is negotiating).




Most of us made the front cover of *CRM* in 1995. Standing left to right in the east arch of the Franconia blast furnace are Walt Ryan, Dennis Howe, Marjorie Robbins, Victor Rolando, Carol Weatherwax, Megan Battey (who took the time–delay photo), Karl Danneil, and David Engman. In front are Matt Kierstead, Woody Openo, Krista Butterfield, and Gloria Miller. Conspicuously absent is the late Dr. William Taylor, who was our most loyal supporter from the very beginning and would have been one of our most active recording session participants (*CRM*, Vol. 18, No. 3, 1995, by permission).

## Goals of the Recording Sessions

Although written history appears to provide everything we should know about early industries, many times when one studies these histories closely, questions arise that are neither addressed nor answered. Research into primary documentation answers some questions but even primary documentation is often fraught with missing, or worse, misleading information. Sometimes the only way around documentation dead-ends is to inspect the site, document what remains, and compare what is found to what is documented. Yet, as happens many times, for every question answered whether through archival research or field inspection, two more questions immediately pop into mind. And the Franconia recording project proved to be no exception.

We knew there was a standing furnace ruin at Franconia, but we didn't know what lay hidden in the brush or just under the surface of the ground. From previous visits and inspection of photographs, it was obvious that we were going to encounter many stone walls, a possible dam site somewhere upstream of the furnace, and hopefully some surface evidence that might connect the dam and furnace sites.

We don't know exactly when the stack was built. Many historical accounts date the stack to 1805, but was what today stands on the west side of the Gale River actually built in 1805? What could we learn by studying the remains that might support or disprove this? Why was the stack built with eight sides instead of the usual four sides? Would we find a substantial quantity of potential archeological remains that would provide us with more detail about the day-to-day technology of operations?

The primary goal of the project was to gather the data that resulted in this report, written for the Franconia Area Heritage Council. Included in this primary goal is a list of recommendations to the Council plus a formal request to the New Hampshire Division of Historical Resources to aid the Council in their preservation endeavors regarding the furnace stack and associated properties with whatever support the Division may be able to muster.

The initial task, therefore, was to record the site in terms of: (a) the furnace ruin and its immediate features, (b) stone walls and foundation remains in the direct vicinity of the stack, (c) the grounds uphill to the northwest, west, and southwest of the stack, (d) the dam site, (e) the waterpower system, and (f) anything else that showed up either in the stream or on the east side of the river. An ancillary goal, beyond physically documenting what was there, was to draw public attention to the site in hopes of prompting some historic preservation response by present or future property owners. It is also hoped that this report, and the efforts of the volunteers, will underscore the value of this true New Hampshire treasure.

Our strategy was to measure the furnace stack and nearby related features and also to map them through data provided by compass and/or theodolite survey and field sketching. Black-and-white and color photos and slides would be taken to support field notes and sketches. These plus all the measurements would be plotted at a later time into comprehensive drawings. This approach would presumably result in a hoard of data to work with and analyze. And the resulting sheets of data, field sketches, and photos did produce much good data to study. But as expected from personal experience, the data also left many original questions unanswered and, most important, raised many new unanticipated questions. Thus, some of us returned the following spring to try to answer some of these questions and also to fill in some gaps in the accumulating data. In the end, I returned again the spring of 1996 for more measurements and answers to more questions.

We also performed limited archeological work, where deemed necessary, but only dug through collapsed overburden to locate ends or bottoms of walls or reveal otherwise hidden features. No primary features were disturbed.

Finally, we want to acknowledge existing buildings in the area that were owned by or were related to the ironworks, plus the identity and/or location of iron mines and charcoal kilns that were also either owned by or were related to the operation of the ironworks. These do not directly impact on the furnace grounds, but they do have an important connection, and so need mentioning for the record.

It was never the intent of the recording sessions to produce a comprehensive history of the iron industry in Franconia or to provide high-quality measured drawings such as those made at archeology field schools or by professional architects. We feel that Jim Garvin's "Chronology" more than satisfies the present need for historical information and that our field-sketch quality drawings are sufficient for the purposes of the sessions. And in 1996, while this report was being written, Roger Aldrich of nearby Sugar Hill published his history of the ironworks (see Bibliography). We had neither time nor funds to provide anything more than what appears in this report.

The included field sketches may by redrawn or used as guides for specialized follow-up field sessions at the site, possibly sponsored by a field school by a state college or the New Hampshire Division of Historic Resources. Additional sketches not in this report are held by the project leader and are available for inspection and/or copying (see page ii).

## Recommendations

The results of research carried out at Franconia might well have long-term national significance. As we returned to re-check various measurements we also discovered certain details of the stack and site we hadn't noticed during the earlier visits. The first visit awed everyone by the immensity of the undertaking. During the second visit, no longer intimidated by the stack, we started taking stock of details not noticed earlier. During the third visit in 1996, Matt Kierstead and I were crawling about the inside of the stack, speculating on the reasons for a number of the stack's features. We were also getting more and more intrigued with the quantity and character of slag that is eroding out of the bank on the east shore of the river. The fact is that as time passes and study continues at the site, more and more significant information will accumulate that will affect perceptions on the "how's and why's" of blast furnace technology elsewhere in the country.

The furnace ruin at Franconia is this state's only such industrial monument (figure 1). Of the well over 100 furnaces known to have operated in New England, it is one of only 11 surviving original stacks that stand in the same relatively good condition. Connecticut has at least five: East Canaan (a state park), Lime Rock (being restored as of this writing), Kent, Mt. Riga, and Roxbury. Vermont has four: Forestdale (a state historic site which was restored in 1995), Pittsford, and Bennington (two). Maine has one: Katahdin furnace in Brownville (a state park). Massachusetts has one: Richmond (another, at Lynn - the Saugus Iron Works National Historic Site - is a reconstruction).

One thing that sets the Franconia furnace apart from the other ten is its eight-sided configuration. Since a totally exhaustive study has not been made, it cannot be stated that the 8-sided Franconia stack is unique, but there is no other in New England and none is known anywhere else. Roger Aldrich of Sugar Hill believes an octagonal furnace exists at Hopewell, Pa. (Aldrich to Rolando, August 24, 1996). A phone conversation to the curator at Hopewell on August 26, 1996, failed to confirm this.

Left unattended and abandoned to the elements, the stack will lose a stone here and there until one spring, it will suddenly collapse. Maybe not the entire stack all at once but a large section of wall, most likely the largest arch. Just like that!

Water is the greatest enemy of furnace ruins. Rain water and snow melt seep into small spaces and is held like a sponge. During winter the water freezes and the expansion moves the stones a tiny bit. One spring, after the ice melts, the stones lose grip on each other and give way. It is much cheaper and simpler to protect what there is now against

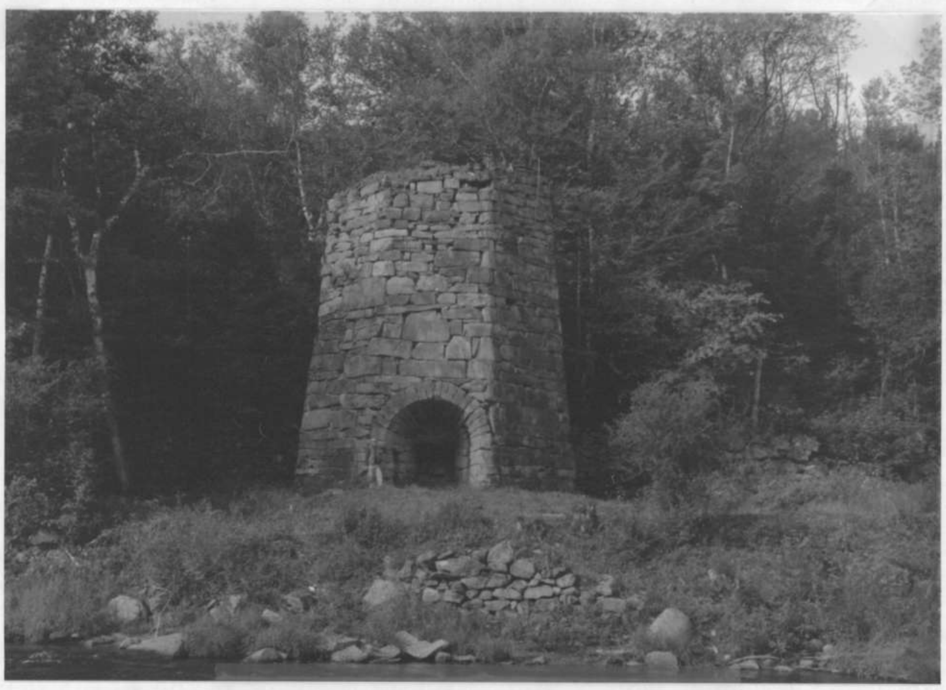


Figure 1. *View of the furnace and grounds from the east side of the Gale River in 1994 (Megan Battey photo).*

water absorption and freezing than to repair the damage later. In practice, collapsed furnace ruins are rarely, if ever, restored. The following are therefore recommended:

1. The immediate short-term goal is the primary recommendation of this report, which is for the Franconia Area Heritage Council to continue in its efforts to acquire the furnace property through combination of private and public fund-raising. Preservation and interpretation of the property follow naturally, but cannot be carried out without accomplishing the primary goal. This cannot be overstated.

2. A professional engineer/architect should be contracted to inspect and evaluate the stack with a goal toward recommending immediate stabilizing actions and a long-term preservation program. An immediate action must be to build a roof atop the stack to protect it from further water damage (this has been done in Vermont at Forestdale and Pittsford with good success). A long-term preservation program could include fabrication of missing binder plates, keys, and straps (if found to have been used in the first place), reinforcement of the lower courses of furnace lining to prevent further loosening and loss of firebrick in this area, and pointing up of all loose stones following the removal of vegetation from the walls and top of the stack. Stones lying in and around the stack should not be moved until it is determined where they came from.

3. Give serious consideration toward the creation of an interpretive park associated with the ruins and grounds, as presently envisioned by the current overseers of the acquisition project. Access to the furnace property might even be enhanced by a small, seasonal footbridge over the river, connecting the interpretive park alongside Main Street to the furnace grounds, thus alleviating the trip over the Route 117 bridge. An interpretive park would provide a tourist dividend to the local economy since the park is only minutes drive from I-93 Exit 38, and most of downtown Franconia is driven through between the Exit and the park. The existing Casey/O'Brien house would make an excellent visitor's center/museum/research center. Additional use of the building for community functions could provide income to offset costs for upkeep of the building. Selective clearing of trees between the building and furnace would enhance the site.

4. The "collecting" of slag for souvenirs by tourists on the furnace grounds, in the river, or along the shores should be discouraged. Appearing limitless, the range of slag at the site has not yet been fully analyzed and documented, and therefore not yet thoroughly understood. Slag analysis might tell us much about the types of Franconia iron making operations and is an important artifact not to be overlooked in the overall study of the site. Mixed in with slag are also various iron artifacts that might appear to be just so much "rusted junk" but could provide important technical information about the site.

5. Continue to investigate and research the immediate grounds, do appropriate archeology work, do an architectural survey of the town, locate the sources of iron ore and charcoal, research deeds for former land owners, locate the company's tenements, stores, sales offices, etc. Create an environmentally safe and secure storage area and research center for papers, photographs, books, ledgers, etc., pertaining to the site.

See also Jim Garvin's recommendations in Appendix A, pages 77-78.

## Site Location and Description

Franconia is a New Hampshire town in Grafton County, about 80 miles north of Concord. The main community, Franconia village, lies mostly between I-93 on the east and the Gale River on the west, although a significant part of the southwest corner of the village lies on the west side of the river.

The ironworks site is an approximately ½-acre piece of ground on the west shore of the Gale River, opposite the village of Franconia. The most visible attribute of the furnace grounds is the tall stone stack, very visible from the visitor's center at the State Historic Marker on the east side of the river. Less obvious are high stone walls that surround the stack on three sides (north, west, and south), and nearly hidden in underbrush are barely noticeable remnants of stone walls that were foundations of other buildings and remains of the head race.

The UTM coordinates of the furnace stack are 19/4901083/279894 per USGS Sugar Hill, N.H. 7.5' Quadrangle dated 1967, photorevised 1988 from aerial photographs taken in 1983 (figure 2). The UTM coordinates were determined after plotting the position of the stack based on data provided by the theodolite survey. The topo does not show the furnace stack but does show the O'Brien/Casey house between the 940- and 960-foot contour lines; the lower furnace grounds lie between the river and the 920-foot contour lines (see "The Theodolite Survey" on page 12 and Appendix C for complete information).

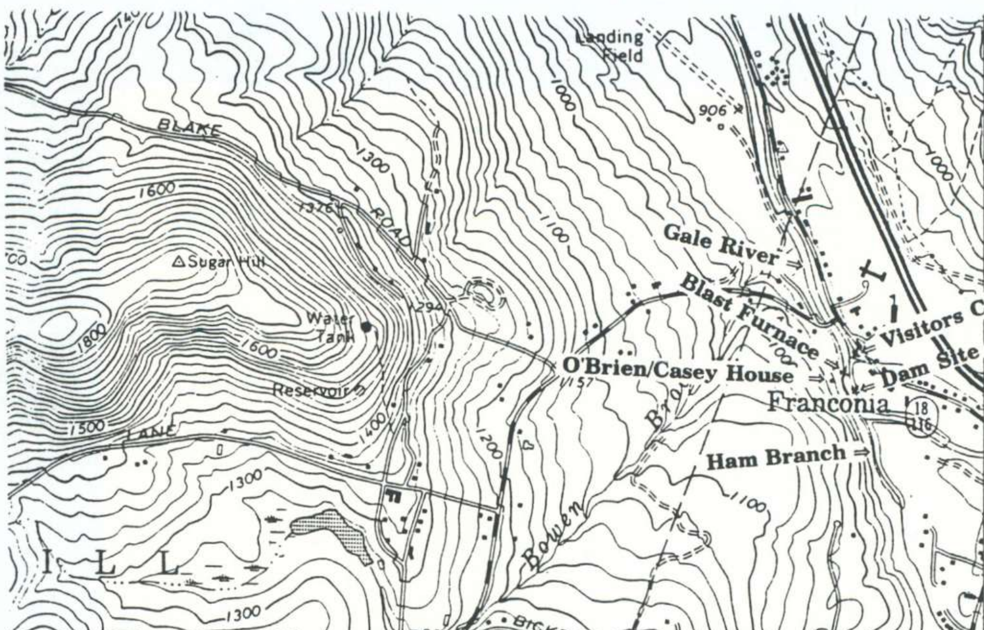



Figure 2. *Franconia village vicinity with locations of the furnace stack, dam site, and other features* (USGS Sugar Hill *topo*).

The furnace grounds are 550 feet south of the Route 117 bridge over the Gale River although the archeologically sensitive area of the site includes the entire west side of the river south of the bridge to the dam site, which is about 800 feet upstream, and extends at least 500 feet inland on both sides of the river, covering an area of about 20 acres.

The Gale River rises on the northern slopes of 5,249-foot high Mount Lafayette where a number of branches join to form the Gale River in the town of Bethlehem, a short distance east of the Franconia town line. From here the river flows a generally south-western direction and turns sharply northwest just south of Franconia village. About $\frac{1}{4}$ mile short of the Route 117 bridge the river picks up another main tributary, the Ham Branch, and turns due north, passes by the furnace site, and continues on to its juncture with the Ammonoosuc River, about 5 miles southwest of Littleton village. Early histories refer to the river as the "south branch of the Amonoosack River." (Garvin 1994:3 [1810]), and "south branch of the Ammonoosuc" (Garvin 1994:10 [1855]). Remains of the dam that provided waterpower to the ironworks are about 248 feet upstream of the furnace ruin.

The village of Franconia is on relatively flat ground, whereas the ground on the west side of the river rises abruptly within a few dozen feet of the river. Since blast furnaces are "top-loading" devices, the proximity of (a) the hill, for access to the top of the furnace, (b) the river, for a source of waterpower, (c) iron mines on the slopes of Ore Hill, about $3\frac{1}{2}$ miles to the southwest, and (d) the village, for labor force and roads to the outside world, all provided an ideal location to construct the ironworks complex.

*Figure 3. The Casey / O'Briens house, uphill behind the furnace stack in 1996. The furnace stack is just downhill to the left (east).*

The visible remains, in addition to the furnace stack, are stone walls north, west, and east of the stack, possible foundation remains uphill and across a private driveway north of the O'Brien residence, and a power race along the west bank of the river from about the dam site north to a possible waterwheel pit adjacent the south side of the stack.

Soon after World War II the furnace stack was threatened with demolition. Local businessman Frank E. Casey, Sr. and wife Sylvia purchased the furnace grounds in 1950 and saved the stack from damage. To draw public attention to its historical significance he named his restaurant "The Stone Stack Restaurant" (this was the second of his two restaurants; see "Associated Village Structures and Landmarks" on page 70). He cleared away the high brush and trees that had hidden the stack from the view across the river since the turn of the century and focused more public attention toward the plight of the stack by publishing a brochure, *Old Stone Stack*, which contained a thumbnail history of the ironworks (see Bibliography). He invited the public to visit the grounds and inspect the stack, which he called "the landmark of a forgotten industry." Mr. Casey died in 1967; wife Sylvia lives in the house where the Stone Stack Restaurant was (southwest side of Route 117 bridge).

In 1978, Mr. Casey's son, Charles, built a house on a small, level, cleared area about 200 feet west and uphill from the furnace stack (figure 3). The forest makes the house invisible from Main Street in summer. The house and furnace property is presently owned by Mr. and Mrs. Kevin O'Brien. As of this writing (August 1996) the property is on the market and a prospective buyer is negotiating.

I first learned of the site in 1973. My parents were driving through New Hampshire when they noticed the stack and state marker. Aware of my interest in such things they took a few photos, made some local inquiries, and got me in contact with Olive Stannard. She in turn provided me with the first information I was to have about the site. On April 15, 1984, the day after a combined New Hampshire and Vermont archaeological society meeting at Dartmouth College, I drove to Franconia to see the furnace. The stack and site had been blanketed by overnight snow, but I managed to take photos of the intriguing 8-sided stack, walk the passageways between the arches, but found no one at home above the stack. I learned from a June 8, 1985 phone call to Sylvia Casey that the furnace and grounds were then owned by Adelaide and Frank E. Casey, Jr.

The site was inspected on July 6, 1989 by James L. Garvin, NH DHR Architectural Historian, to check the furnace structure for amount and cause of deterioration and to make recommendations for stabilization and protection of the structure in future years. Jim recognized that water penetration and frost action posed the greatest threat to the furnace and recommended the stack be topped with a cap and roof. His full site report is presented in Appendix A.

The first serious attempt at documenting the site was done in 1991 by Duncan Wilkie, then with Plymouth State College, for a National Register Nomination, which was neither completed nor submitted. Wilkie's walk-over survey identified the power canal, a possible bellows area, casting bed, and other features in the vicinity of the stack (figure 4). His paperwork is on file at the NH DHR office.

## Historical Overview

A history of the ironworks by James L. Garvin is presented in Appendix B. It provides an excellent, detailed history of the ironworks operations and sources of primary information about the site. Only a synopsis of that report is therefore included in the following overview.

The New Hampshire Iron Factory Company was incorporated in 1805 by the state legislature and is referred to in some historical literature as the "Lower Works," to differentiate it from another ironworks about a mile upstream called the "Upper Works." In 1808, the "Upper Works" was incorporated as the Haverhill and Franconia Iron Works.

The 1805 map of Franconia (figure 5) identifies "N.H. Iron Factory" on the east side of a river just north of the juncture of the Gale River and Ammonoosuck [sic] South Branch, although buildings are shown on both sides of the river. A canal, also on the east side of the river just upstream of the fork, lead Duncan Wilkie and me to agree that the main works were on the east side of the river at the time. Among buildings on the west side of the river is the word "Iron." Upstream on the South Branch are "Haverhill & Franconia Iron Factory" buildings showing a canal on the west side "for Mills."

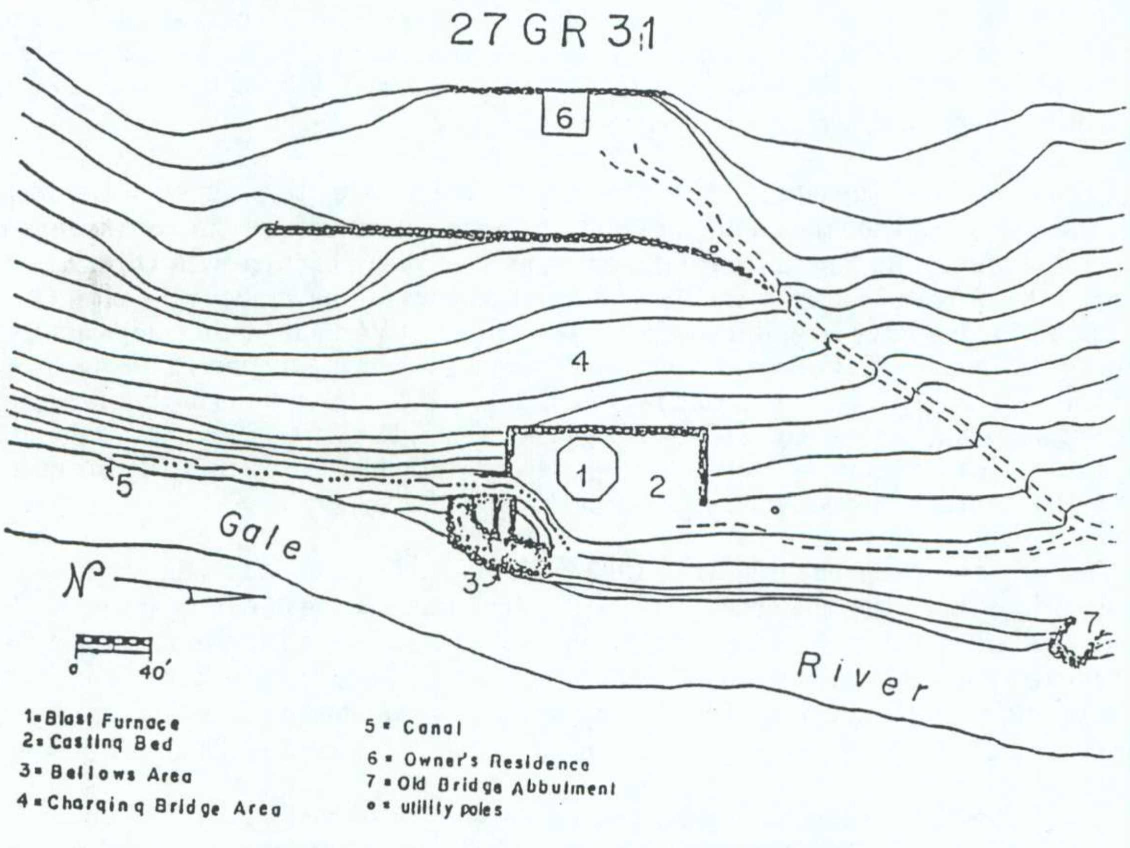



Figure 4. *Map of the site drawn in 1991 by Duncan Wilkie. The "27GR31" at the top is the site number; that is, 27 = New Hampshire, GR = Grafton County, and 31 = the 31st site registered in Grafton County (courtesy Duncan Wilkie).*

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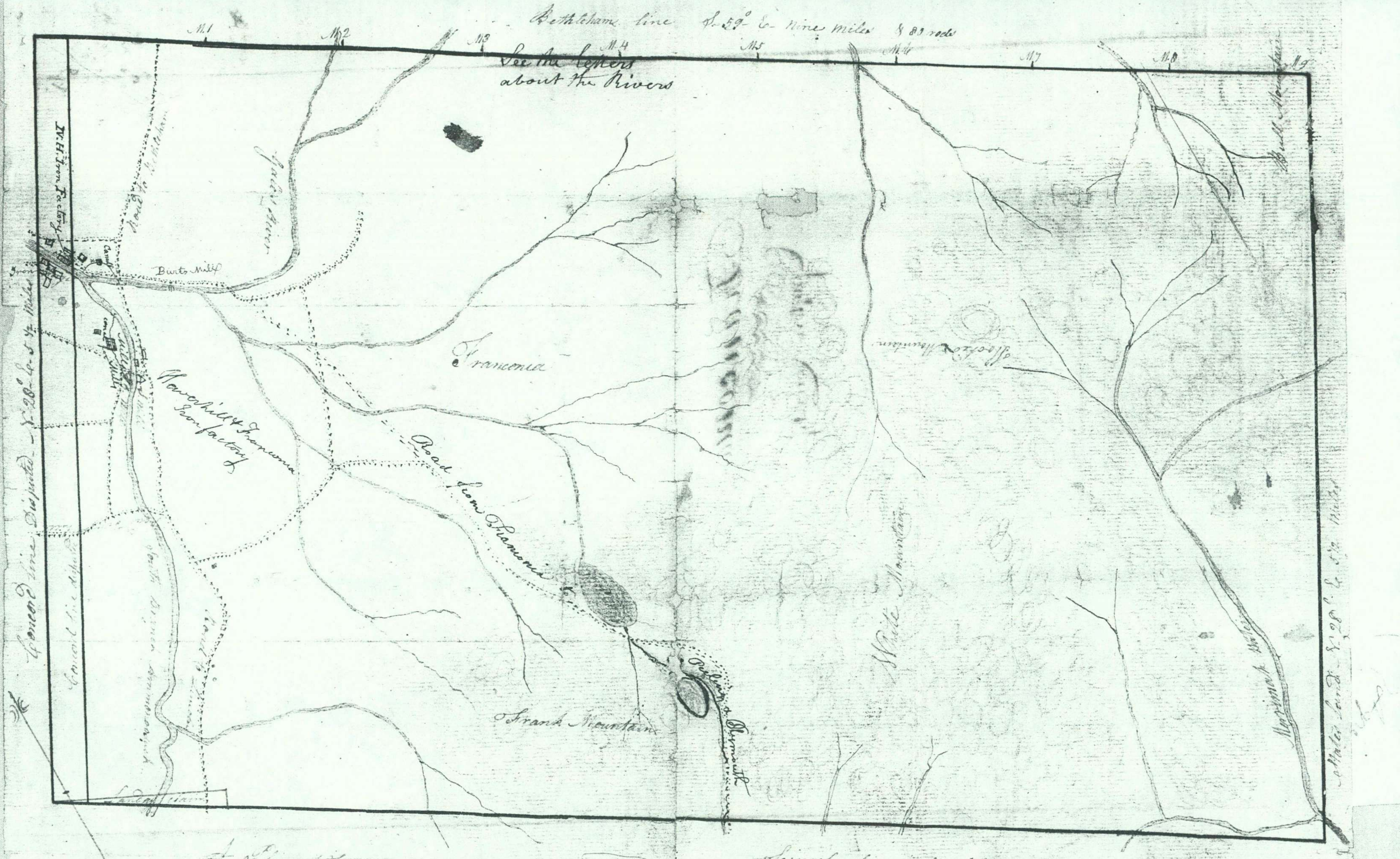



A Plan of Franconia laid down by a scale of 200 rods to the inch as Surveyed in Oct.r 1805 by me Jeremiah Eames Jun.r Surveyor

Figure 5. *The 1805 map of Franconia, showing the "N.H. Iron Factory" at the upper left and the "Haverhill & Franconia Iron Factory" just upstream (courtesy Frank Meyers, Director, State Archives).*

Two stock certificates were studied at the NHHS Library on February 9, 1996. The stocks are for ". . . one share . . . of the property of the New Hampshire Iron Factory Company . . . ." At the top of the certificates is an engraving identified "New Hampshire Iron Factory." One certificate is dated August 1, 1806; the other is dated May 29, 1810 (figure 6).

The engraving shows factory buildings standing on the sides of two small streams that are about to join outside the immediate foreground (figure 6). The building to the right of the stream might house a blast furnace, as indicated by the top of a stack extending out through the roof and also by many other tall chimneys that were usually associated with furnace operations. The stream, rising from background hills, might be today's Gale River, and passes directly next to the furnace building. To the left of the other stream, which also rises in the background hills, are three buildings. The building nearest the stream has maybe three chimneys in a row, very close to each other, and might be indicating three bloomery or refining forges inside. An adjacent building, somewhat smaller, has no chimney and might have served as a storage shed. What appears to be a residence stands up a road to the far left in the illustration.

The two streams shown in the illustration raise some questions. Is one of them today's Gale River and the other the Ham Branch? They join about 500 feet upstream of today's furnace site. Or might the left stream shown in the illustration be the small unnamed intermittent brook shown on the current USGS topographical map about opposite the furnace site that rises on Scrag Hill to the east of I–93?

The engraving might not be a view of this site at all, but maybe conjectural, done by an engraver who had never seen this site, but drew on information from another ironworks to create this symbolic representation as an ornament for the stock certificate. But if this is a true illustration of the site, then the 1806 date of one of the certificates might be a new early date for the furnace to have been in operation.

The furnace was rebuilt in 1816 resulting in the top of the 24–foot high furnace being raised to 28 feet. That same year, a modern system of blowing cylinders replaced the bellows. The works were described in 1817 as containing a blast furnace, an air furnace and steel furnace, a pounding ore–separating machine, and a forge and trip–hammer shop, each of which contained four fires and two hammers. In 1832 the works were valued at $50,000 and the manufacture of 300 tons of castings and 130 tons of bar iron cost $27,200 against sales of $34,000. The works were, however, described as not being successful and the articles manufactured of an inferior quality.

The company was reported in 1841 to have been in blast 16 to 26 weeks at a time, consuming 200,000 to 300,000 bushels of charcoal each year. Each furnace charge consisted of 15 bushels of charcoal, 280 pounds of iron, and a box of limestone; 160 bushels of charcoal was required to smelt a ton of ore that yielded 55.12% iron. In 1844 the furnace was described as being 34 feet high. Six feet above the hearth, the boshes were 8 feet 3 inches in diameter, or 12 feet in diameter before the lining was put in. The work (casting) arch was described as being 11 feet wide while the tuyere (air blast) arches were 8 feet 8 inches wide. This compares with an 1858 report that the ca. 1823 furnace at

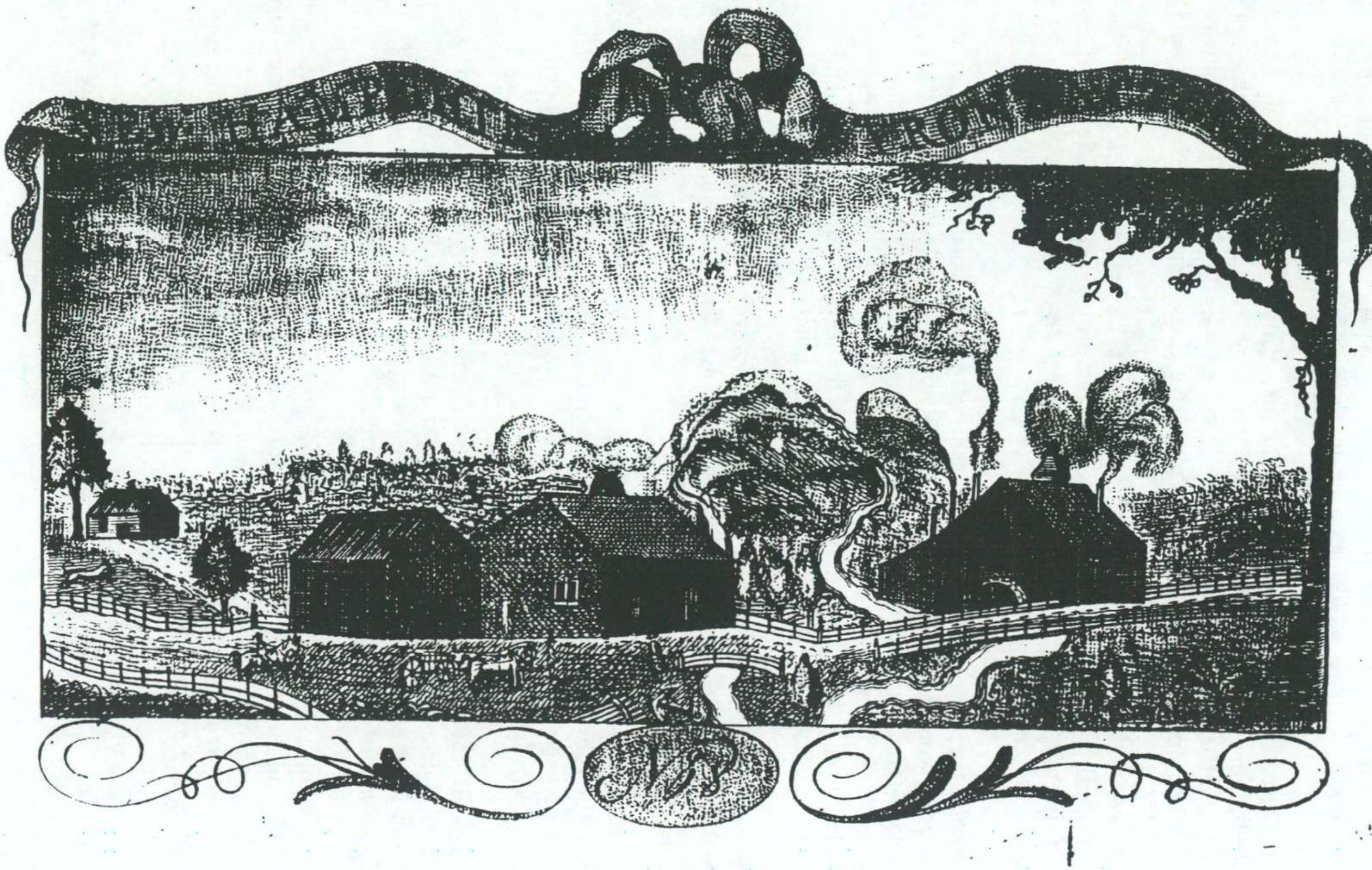


Figure 6. *An engraving on a New Hampshire Factory Company share dated 1806 that supposedly shows the ironworks at Franconia (NHHS Collections).*

Forestdale, Vt., and the ca. 1791 furnace at Pittsford, Vt., rebuilt in 1827 and enlarged in 1853, both had a 9-foot diameter bosh (Lesley 1858:75). The casting arch at Forestdale, rebuilt in 1995, is 8 feet wide, whereas the casting arch at Pittsford is 13 feet wide.

The 1850 US Census described the property as including a shingle mill, a blast furnace, a cupola furnace, a forge shop of five fires and two hammers, a machine shop of nine fires and three lathes, a wheelwright's shop, and saw and grist mills, all powered by water. The mine was horse-powered. Seven years later the entire property was sold.

The 1860 map of Grafton County identifies the village as "Franconia Iron Works," with iron works buildings shown on the west side of the river along with a bedstead factory. Among the few buildings on the east side of the river are seven buildings identified as "N.H. I. Co's Tenant Houses."

Exactly when the furnace breathed its last is uncertain. According to Garvin, an 1881 periodical stated that work at the furnace and mine was suspended about 1865. A national ironworks report published in 1858 barely acknowledged the existence of the works, saying only "not doing much for several years" (Lesley 1858:76). The next year it reported the works "had not been in active operation for some years" (Lesley 1859:25). Yet another report said that the furnace continued in blast until 1870 (Garvin 1994:11 [1878]).

Two dates were found that identified when the works were destroyed. One, which appeared in the April 13, 1883 *Littleton Journal*, indicates that the works had long been out of operation. The other has the fire on July 4, 1884.

> The old iron ore furnace, built many years ago, burned last Thursday night about 11 o'clock. It was thought to be the work of an incendiary. Such a dilapidated building did not add to the attractiveness of our pleasant town and we could not but rejoice at the destruction of it (Welch 1972:131).

> ...the buildings fell into decay and in 1884 were demolished by fire. All but the stone stack. Men now living attest that the fire was a deliberate prank. It was ignited with kerosene stolen from the rear of Eleazer Parker's general store close by. The fire occurred on the eve of the 4th of July (Serafini 1952:17).

A photo "made about 1875" shows the New Hampshire Iron Works complex, river, and dam (see figure 45), taken downstream of the works. It clearly shows the furnace building with its heating oven chimneys rising out the roof, the casting building on the north side of the stack with its characteristic roof-top monitors, and other buildings associated with the charging bridge and storage sheds on the hill west of the stack.

A 10- to 15-foot-high dam can be seen upstream in the photo, with another large building at the left (east) end of the dam. Water appears to be flowing over the dam. Between the dam and the furnace complex on the west side of the river is an unidentified structure that might be associated with waterpower systems since remains of the head race were found in that area. Unfortunately, no one queried at Franconia knew the whereabouts of the original of this very informative photograph.

A turn-of-the century postcard with a post office cancellation date of 1908 shows the stack standing in relatively good condition (figure 7). There are no bindings around the upper section of the stack but close inspection with a magnifier appears to show small face plates on the binder rod of the northeast pillar wall. Trees to the left hide the dam site from view, but the river in the far background appears low, as if the dam was either open or breached. Another post card of the same approximate period shows the stack taken from above and to the west, with the village in the far background (figure 7). The two post cards show the stack in remarkable good condition. The top of the stack in the second card is perfectly flat and no stones out of place.

## State Historical Markers

Two state historical markers were found that relate to the iron works; one directly and the other indirectly. The first was erected at Franconia in 1962 on the east side of Main Street (now stands on the west side), calling the public's attention to the historic site across the river. The marker was the ninth of what by 1995 had totalled 169 markers state-wide. It reads:

STONE IRON FURNACE

> Due west stands New Hampshire's sole-surviving example of a post-Revolutionary furnace for smelting local iron ore. The industry flourished during the first half of 19th century. It produced pig and bar iron for farm tools and cast iron ware, including famous "Franconia Stoves".

The other marker was erected in 1970 on the east side of Route 302 in the town of Lisbon, about five miles west of Littleton village. The marker identifies a stone-made charcoal kiln ruin atop a small rise, just across the highway (see figure 50, page 73):

OLD COAL KILN

> A reminder of bygone days, this stone structure was used to make wood into charcoal for the nearby iron smelters. Pine knots, a waste material from the adjacent lumber mill, were a prime source for charcoal. Charcoal production through this kiln, built in the 1860's, was necessary to the iron mining industry.

## The Theodolite Survey

The survey team consisted of Bill Edwards and Karl Danneil, assisted by Jonathan Edwards and Eleanor Danneil. They used a Pentax model Geotec T-24B theodolite and a stadia identified as UNH #13A. The instruments were generously loaned to us by the New Hampshire Division of Historic Resources. The team's main assignment was to establish a datum point at the furnace grounds that we could use for accurately locating the stack on the USGS topo map. In the process, we also surveyed the dam site, a point alongside the interpretive park, and other significant features in and around the overall ironworks area. See Appendix C for the full survey report and printouts of input and calculated data.

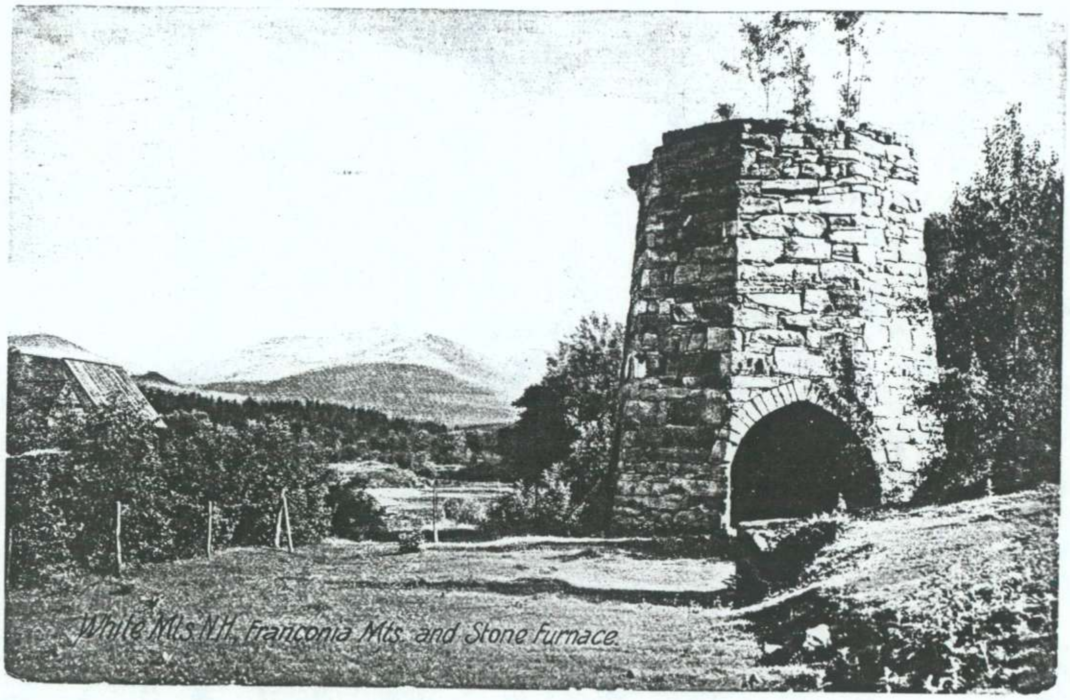



Figure 7. *A postcard cancelled August 31, 1908 on reverse, showing the furnace stack in relatively good condition.*

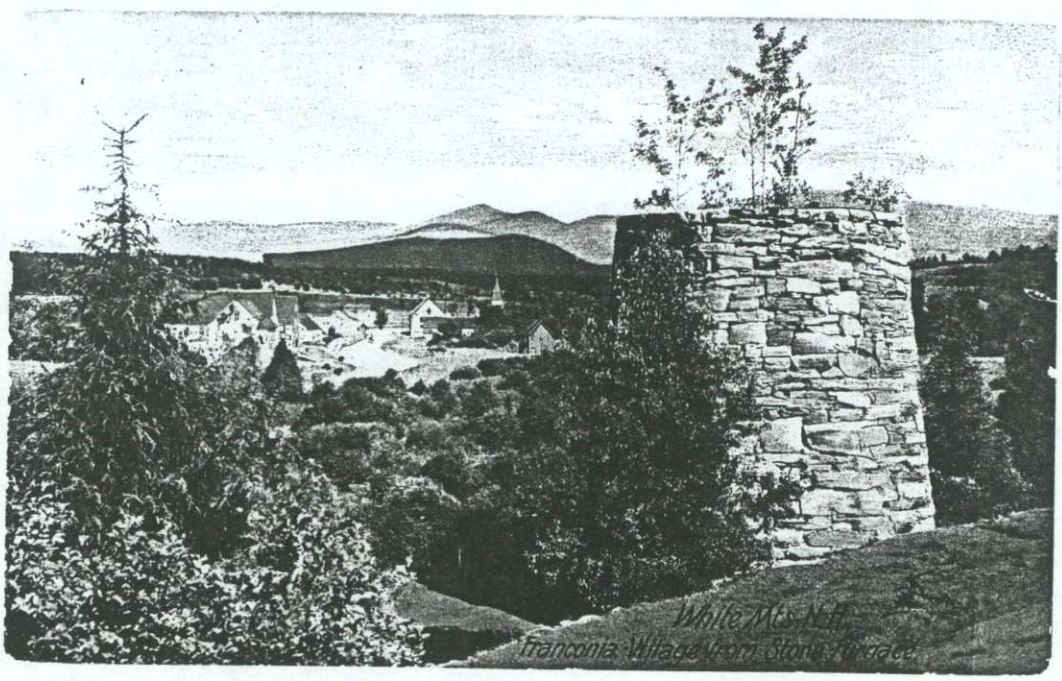



Figure 8. *Another early 1900s postcard, taken from uphill of the stack, with the village in the background.*

The initial starting point for the survey on September 9 was the Route 117 bridge, but it was found to cause too much magnetic deviation. The next day the starting point was moved to the east side of Route 18, across from the bridge. (All survey data for September 9 on page 1 of Table C3 should therefore be ignored.) From that starting point, datums were established at the Visitor's Center, the furnace grounds, and the dam site. These are the three primary furnace grounds datum points (figure 9). The furnace datum was made the main site datum point (i.e., X=0.0, Y=0.0, Z=0.0). Location of this datum point was chosen to allow as unobstructed visibility as possible in all directions. The elevation of the furnace datum is 920.436 feet (920 feet, 5¼ inches).

The survey data allowed us to accurately locate the stack on the USGS topo map, and measurement its UTM coordinates at 19/4901083/279894. The height of the stack (from the bottom to the top of the downer pipe) was sighted and calculated to be 33.953 feet (33 feet, 11-7/16 inches). The slope of the bottom 13 vertical feet of the stack at the south corner of the southeast pillar (Sta 110) was found to be 5.085 degrees. The ends of the binder rods in the northeast and southeast pillars were also found to be level with the cross beam assemblies in each arch, an important piece of information that was to add to our knowledge of what the internal hardware was all about.

During the survey we found a highway survey marker in the northeast wingwall of the Route 117 bridge, which the survey team initially used as its primary reference point. The marker is identified "State of New Hampshire DPW&H 161 0090". A query to William Hauser of the New Hampshire Department of Transportation about the benchmark resulted in the following from Charles H. Hood, Chief, Project Development Section:

> Approximate latitude 44000N. Approximate longitude 0713000W. Approximate elevation 920.13 feet. The benchmark is 2.5 feet above Route 18, 50.0 feet west from the center of Route 18, and 24.0 feet north from the center of Route 117 (Hood to Rolando, Jan 10, 1996).

Unfortunately, the latitude and longitude provided above serve only to identify the lower right-hand corner of the USGS 15' quadrangle in which the benchmark is located; only elevation was provided. None-the-less, we located the position of the benchmark by sighting back from the new starting point.

## Origins of the Furnace Stack

When was the present stack built? Although the New Hampshire Iron Factory Company was incorporated in 1805, there is no mention of a furnace. The earliest mention of a "furnace" was in Joseph Bray's report on the condition of the company in 1810. In that report he stated that "the first fire-stone used in the [first] furnace was imported from Connecticut" (Garvin 1994:2 [1810]). Writing in 1841 and again in 1844, geologist Charles T. Jackson said that the furnace then in operation was "erected in 1811" (Garvin 1994:3 [1811]).

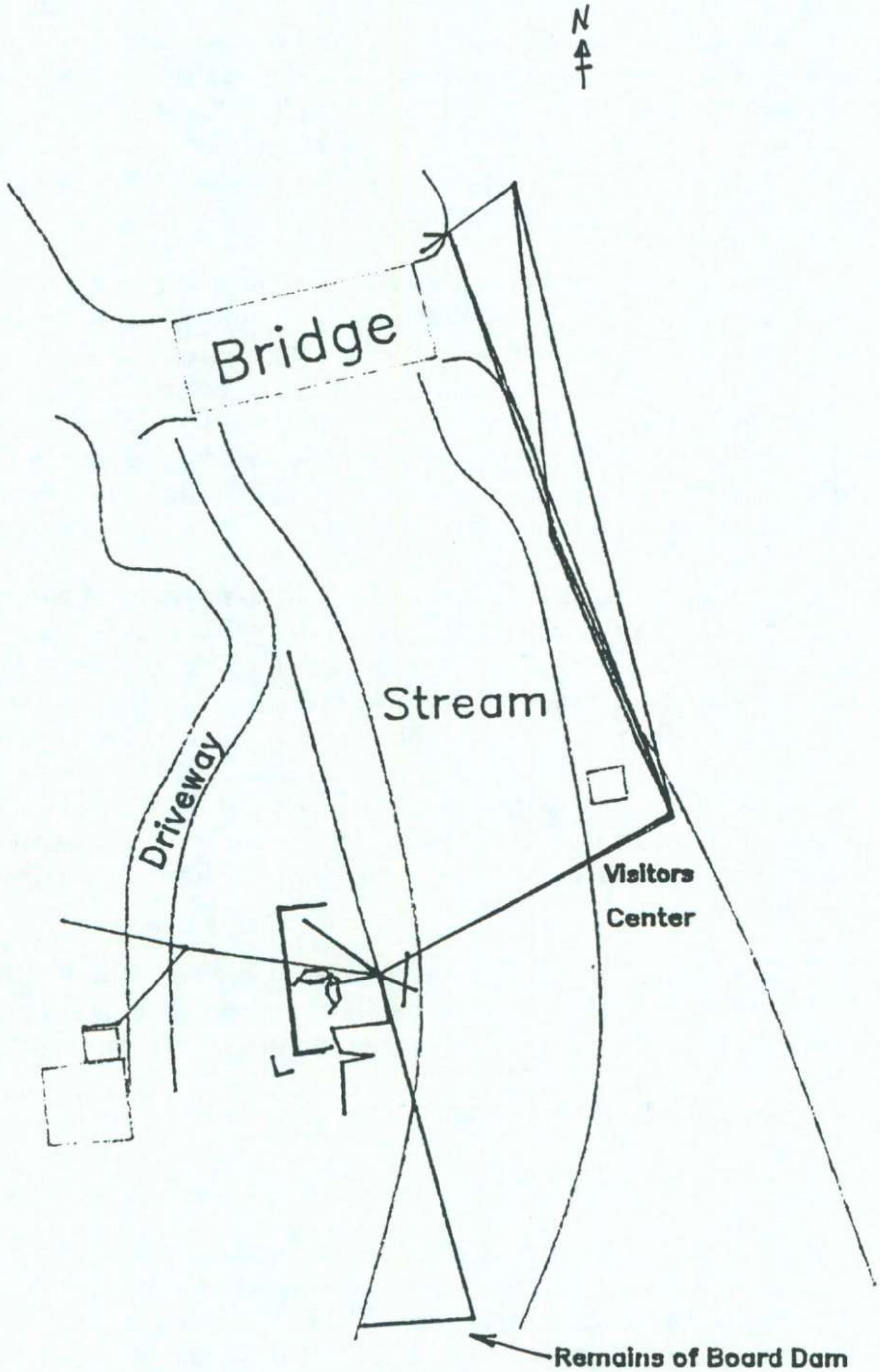



Figure 9. *Primary points of the theodolite survey (Danneil CAD / CAM drawing).*

In 1816, William P. Page wrote that Isaac Williams recommended "rebuilding of the furnace lining and lower parts, but evidently proposed to *keep the major walls of the existing furnace intact*" and "we...went to work, removed the old lining and hearth, had stones for the new Furnace got out and repaired." Page also wrote that the furnace was raised from 24 to 28 feet in height, which means that at least the top of the outside walls was new (Garvin 1994:3 [1816]). In 1844 the furnace was described by geologist Charles T. Jackson as being "by my measurements" 34 feet high (Garvin 1994:9 [1844]). Was the extra 6 feet in height of the stack the result of a recently installed hot-blast system that was also mentioned by Jackson?

Garvin wrote that the present furnace was constructed in 1859, under supervision of S. Pettee, Jr. (Garvin 1994:11 [1859]). Unfortunately, there are no mention of heights, bosh diameters, lining or hearth types, etc., that could be used to accurately field-verify this data. The stack was described in 1866 as being erected in 1845, 38 feet high, with boshes 9½ feet in diameter (Neilson 1866:217). This furnace height and bosh diameter does not match Jackson's 1844 measurements, so maybe the stack was in fact rebuilt between then and 1866. But was the stack totally rebuilt or was some additional height added for modified ovens and bosh? (See more discussion on page 51.)

Since Jackson wrote in 1844 that the inside diameter was 12 feet before the lining was installed, there was easily enough room for a new 9½-foot diameter bosh. Does the present stack, except for its internal modifications and added height, date to 1805/1810, 1811, 1816, 1845, or 1859? When measured on August 24, 1996, the inside diameter without at its widest measured exactly 9½ feet (see Bosh Lining on page 50).

Based on my observations of other furnace ruins, my original 'best guess' of when the Franconia stack was built was ca. 1810-1820. Jim Garvin pointed out that the tool marks on furnace stones (half-round drilled holes) indicate post-1830 stone working. According to Jim, "Pre-1830 splitting was done with flat wedges in flat slots. Post-1830 splitting was done with plugs and feathers in round holes" (Garvin to Rolando, Feb. 19, 1996).

## Seneca Pettee, Jr.

Chiseled into the bottom voussoir stone in the west wall of the north arch is S. PETTEE JR. 1859 in 4½-inch-high letters on a recessed flat section of the stone. The recessed section measures 6½ inches high by 5 feet 4½ inches wide. The stone is 7 feet 5½ inches long by 9 inches high at the inside end and 1 foot 10 inches high at the outside end (figure 10). It is the largest stone in the arch and is just inside the arch opening.

Who is this person and why did his name come to be on the side wall of the casting arch? We assume "S. Pettee, Jr." to be Seneca Pettee, who was connected with many ironworks operations in New England in the mid-1800s. Whether Pettee chiseled his name in the arch wall or he contracted someone to do it for him is unknown.

Seneca Pettee was born in 1785 at Foxborough, Mass. Of his four brothers, Joseph ran the Mount Riga blast furnace at Salisbury, Conn., Hiram ran blast furnaces at Lenox and Lanesboro, Mass., and Simon was an inventor. The following is part of a manuscript on Seneca Pettee received from Richard S. Allen in 1995 (Allen ms., Jan 1992):

> Seneca Pettee, whose capabilities seem to have run to the building of blast furnaces and the setting up of iron works, reportedly came to Mount Riga with Joseph in 1804-06, where they finished erecting the King/Kelsey furnace in 1810 along with Willaby Dexter. Joseph was associated with the iron works at Mt. Riga for the remainder of his life.
>
> Seneca and his wife Lucy lived on the mountain during the next two decades. At least four of their children, who died in infancy, are buried at the Mt Riga cemetery, which was established in 1816 "near the mountain furnace." His first wife, Polly, is also buried there.
>
> It is probable that Seneca Pettee left the mountain furnace shortly after the Holley, Coffing & Pettee partnership was set up in 1829. Holley & Coffing were expanding beyond the limits of the town of Salisbury. They built the blast furnace at Richmond, Mass. in 1830. This almost certainly involved Seneca Pettee, since soon after its completion the furnaces was reported to have been run "for some years," by "Gates, Pettee & Co."
>
> Next, in 1846, Nelson H. Stevens of Richmond, Mass., and Seneca Pettee built a cold-blast furnace, 37 feet high, beside the Hoosic River north of the Main Street Bridge in North Adams, Mass. Incorporated in 1847, the North Adams Iron Company included Nelson H. Stevens, Seneca Pettee, Rodman H. Wells, J. H. Chapin, and Charles K. Bingham. This company, after difficulties with the use of various ores from the North Adams area, went bankrupt and was sold in 1858.
>
> Thomas N. Richmond, a lawyer and later proprietor of the Berkshire Glass and Sand Company (1850 to 1857, and 1862 to 1865), together with Seneca Pettee, bought land for an iron works at Cheshire, Mass. in 1848. This furnace was not finished and in blast until February 11, 1851. The Cheshire Furnace was "managed for a time by Messrs. Pettee & Richmond."
>
> In Lenox, another Berkshire County town, the Lenox Iron Works was incorporated in 1848. Hiram, a third Pettee brother, lived at Lenox Furnace (today's Lenoxdale) in 1858. The iron company also had a glass works, of which Hiram Pettee was the first manager. According to local history, Seneca Pettee took over management of the glass manufactory when his brother Hiram went to manage the Briggs Iron Company's blast furnace in Lanesboro, Mass. (originally built in 1847). Hiram Pettee's house in Lenox Furnace appears on an 1858 wall map of Berkshire County.
>
> Seneca Pettee had a hand in building or operating four different blast furnaces in Berkshire County, Mass., and his brother Hiram ran at least one. Seneca disappeared from western New England in the 1850s. He may have gone "west" to Michigan or Ohio where there were new iron deposits discovered and/or being developed, with need of men of his expertise. Or he may have died...

In addition to Rick Allen's findings, Duncan Wilkie (via Jonathan R. Sanborn) identified Pettee as having been an agent of the Katahdin Iron Works in Maine in 1856 (Garvin 1994:11 [1859]; Sanborn to Rolando, Jan. 16, 1966). Sanborn found that an "S. Pettee" (no first name given) wrote to the owner of the Katahdin Iron Works on January

4, 1856 (Eastman 1965:92). Wilkie also believes that the two ironworks might have been owned by the same company at the time. That's an interesting possibility.

How long did Pettee remain at Franconia? He was postmaster in Franconia in 1861 (Welch 1972:71), and his name appears on the 1860 Grafton County map as "S. Pettee Jr" with "Store & PO" immediately next door to the south, directly across the river from the iron works in the village at the time identified "Franconia Iron Works," but his name does not appear in the Child's 1885 *Gazetteer of Grafton County*. Jewell Friedman checked into local records but found no indication of Pettee buried in any Franconia cemeteries, stating that death records for that period are incomplete. The spring of 1996, however, Bill Edwards said that he believed he found Pettee's grave at a cemetery behind the old Methodist Church on Route 7A in Ashley Falls, Mass. This is being checked into further.

Seneca Pettee would have been about 25 years old when he and his brother finished building the Mt Riga furnace in 1810. One has to wonder whether he learned the trade at a school of engineering or did he apprentice at a furnace somewhere at an early age. We know next to nothing about his formative years. It is also interesting that although the roof of the archway is engraved "Jr.," no mention of a "Jr" can be found in any of the provided data or other sources except the Welch references. "Junior" is usually someone with the same given name as his father, but Seneca's father is Simon (1749–1823) in a genealogy chart provided by Karl Danneil, and no other Seneca can be found in the chart. Unfortunately, only names with descendants are listed by name. But it does beg the question: Was there a Seneca Pettee, Jr. in addition to a Seneca Pettee?

*Figure 10. Inside the west wall of the north arch showing the "Pettee" engraving.*

## The Outside Walls

The outside walls of the furnace are build of rough-lain granite with no sign of mortar (see figure 1). Source of the granite is unknown. The rough nature of the stone hints at early 19th-century construction when compared to similar constructions built elsewhere in New England (e.g., Forestdale, Vt., ca 1823; East Dorset, Vt., ca. 1846; and Bennington, Vt., ca. 1822).

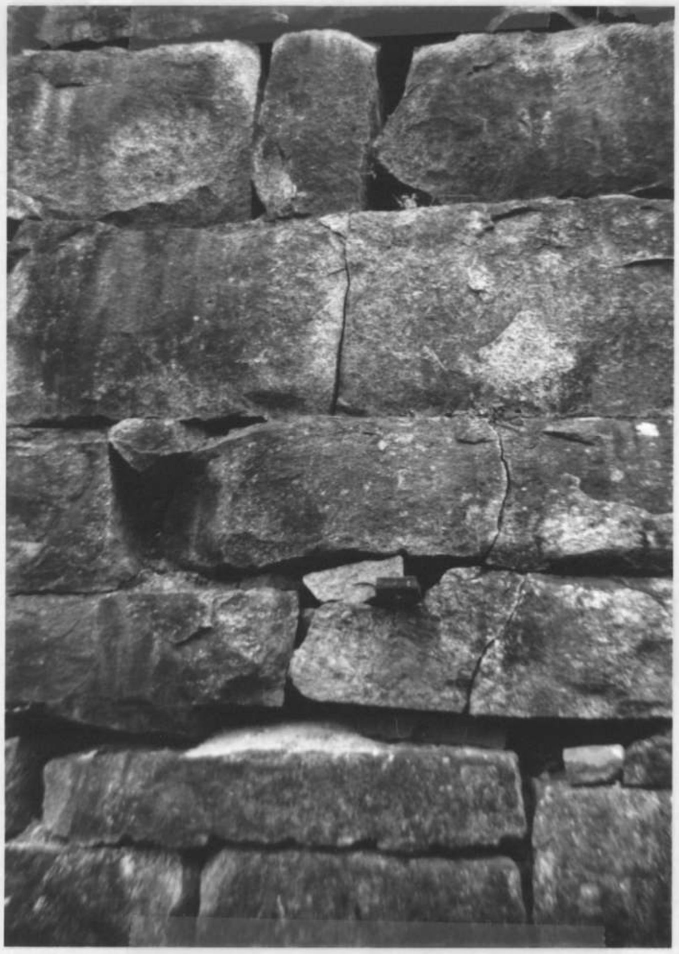
At first thought, the furnace appeared to have been built 8-sided to conserve construction stone that would have gone into extending the walls out to 90-degree corners. Each truncated wall not built out to a corner saved about 1,500 cubic feet of material and associated labor. The corners are among the most fragile parts of the structure because the walls there are the thinnest. Damage from weathering and falling trees takes a significant toll on loosening corner stones. Eliminating the sharp corner therefore reduced corner damage. Except, of course, there would be no corner damage to a wall that was inside a furnace building in the first place. So, why the flattened corners?

A possible answer to why the flattened corners was arrived when the binding and binding support system was discovered inside the stack. This binders and cross beam ring arrangement connects internal hardware that supports part of the bosh lining above it, yet also provides an anchor for wall binders that extended outward at the corners, thus requiring flattened corners (see "Binders," page 35 for details).

Another distinctive feature of the stack is the change in character of the stone wall that can be seen near the top. At a point starting about 36 feet above the ground, the stonework changes from a pattern of large stones below to one of slightly smaller stones above (see figure 1). If this approximately 36-foot interface level of the stack relates to one of the original pre-1844 heights of the stack, then everything above this level might relate to changes in the stack's main wall affected by installation and modification(s) of the heating ovens. It would have been very informative to see what exactly was inside the top of the stack, but due to the fragile nature of stones leaning out the top of the stack, we didn't dare run a ladder up the side and inspect the top. Close inspection and photos in and around the top should be done before it is roofed.

Although the walls appear relatively smooth and stable from across the river, close inspection reveals many pieces of stones missing and others cracked. Hairline cracks seen throughout the surface of the outside walls (figure 11) betray destructive weathering forces at work. Two large holes in the upper third section of the southwest wall show where stones have fallen out (figure 12). In the bottom course of the wall, in the southeast corner of the south arch, a piece of stone is broken off. A piece laying on the ground alongside appeared to fit but wouldn't stay in place unassisted. Other stones lying about at the base of the stack might be those missing from above. They should not be tossed away or even moved from where they lie, but be left as is to provide clues as to where they came from.

Since the surface of the ground varies in height around the base of the stack, a string was wrapped around the stack, level with the highest point on the ground at the base.



⇐
Figure 11. *Hairline cracks in the otherwise solid masonry of the northeast pillar wall,*

⇒
Figure 12. *Two large holes left by fallen stones in the southwest pillar.*

This was a spot between the west and south arches (the southwest pillar). Thin pieces of wood were placed vertically at corners of the stack to prevent the taunt string from creeping up or down into spaces between the stones and skewing the level of the string. The string was drawn tight and adjusted several times before it was measured level all around the stack. Vertical measurements between the string and the ground were taken to coincide with various feature points of the stack.

Table 1 presents the distance to ground below the level string, starting at the middle of the north arch and proceeding counterclockwise (as viewed looking down) around the stack. Note that "ground level" varied around the stack by as much as 23 inches although the average of all measurements was about 15½ inches. Heights of the binder ends in each of the four walls measured from 45½ to 51½ inches above the string as shown in table 2. Left, middle, and right in the table pertain to the left corner, middle, and right corner of the arch as viewed facing the arch from the outside. Figure 13 identifies arch and wall orientations used throughout this report.

The circumference of the stack was measured at 1-foot above the string and found to be 98 feet 7½ inches. This compares favorably with the sum of the dimensions (figure 14), which add up to 99 feet 7 inches, or less than 1% difference. Although from a distance, the sides of the stack appear symmetrical, measurements disclosed small differences in width among the individual wall sections. At near ground level, the widths of the wall measurements ranged from 12 feet 9½ inches to 11 feet 11 inches wide. Running another string from the southeast pillar, level with the circular sting at that point, and out to the surveyed furnace datum point, 31 feet away, measured 52 inches above the datum point.

Table 1. Distance to Ground Below Level String Around the Base of the Stack.

| | | Vertical Measuring Points | | | |
|---|---|---|---|---|---|
| Pillar | Arch | Left | Middle | Right | Wall |
| | No. | - | 17" | 21" | |
| NW | | | | | 13" |
| | W. | 15" | 17" | 10½" | |
| SW | | | | | 0" |
| | So. | 17" | 20" | 23" | |
| SE | | | | | 20" |
| | E. | 17" | 19" | 17" | |
| NE | | | | | 17" |

Table 2. Heights of Ends of the Binder Rods Above String Level.

| Wall | Binder Height |
|---|---|
| NW | 43¾" |
| SW | 51½" |
| SE | 45½" |
| NE | 49¾" |

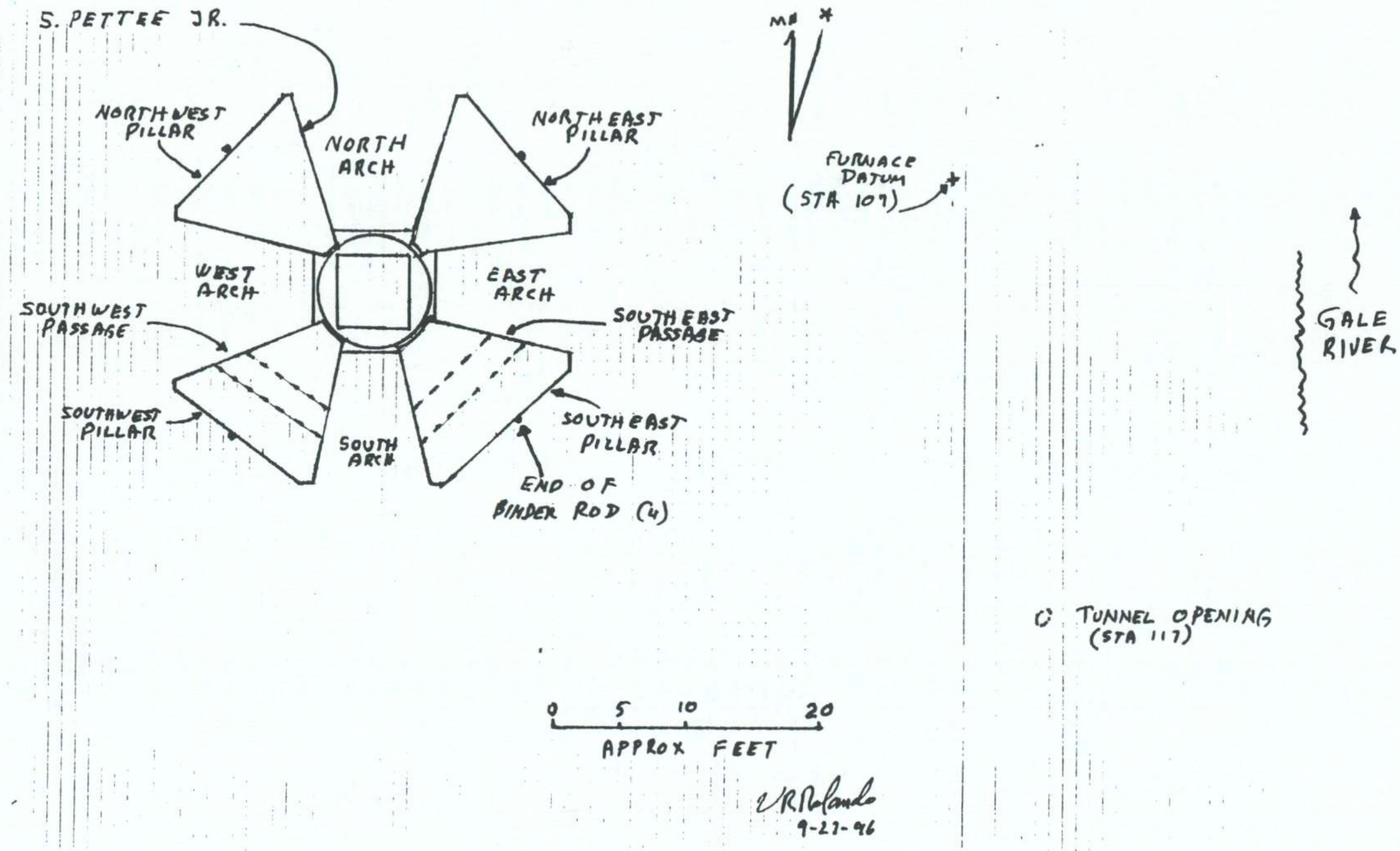



Figure 13. *Furnace stack orientation and nomenclature (Rolando drawing).*

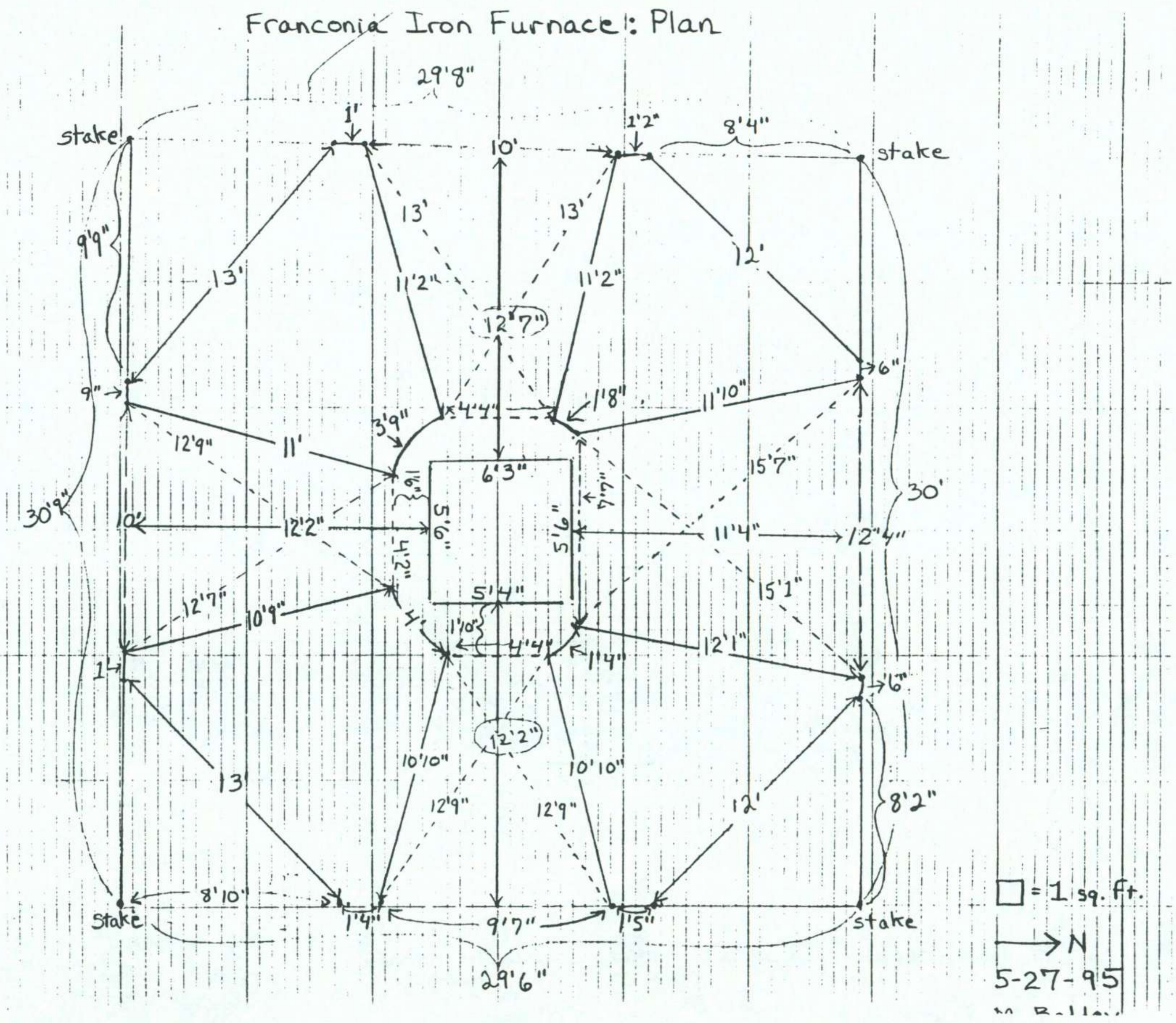



Figure 14. *Ground–level measurements of arch openings, hearth, and corner pillars (Megan Battey field sketch).*

If built with the usual four corners, the stack would have measured about 30 feet square near present ground level. Considering that there is a level of overburden on the ground around the furnace walls from brick and stones that have fallen out and off the furnace plus decayed material from structures that once stood around the stack, we figured that measurement at the original ground level a few inches farther down might have resulted in an exactly 30- by 30-foot square dimension, or a 900-square-foot footprint. Cutting across the four corners at the edge of each of the four archways reduced the footprint by about 150 square feet to 750 square feet.

To determine what the dimensions of the "square" footprint might be, a recording crew established where the four corner points of the stack walls would have been by laying out straight level strings parallel to the four arch entrances. Measurements between these fictitious corners where the strings crossed show that the furnace footprint is not "square" after all. The south, west, and east walls respectively measured 30 feet 9 inches east-west, 29 feet 8 inches north-south, and 29 feet 6 inches north-south, between their imaginary corners. Only the north wall measured exactly 30 feet wide out to its imaginary east-west corners. It would have been interesting to have dropped a plumb line down the inside of the stack to see if the stack is standing straight or is leaning to one side.

The Serafini article states that the stack has the figure 1853 chiseled on its north face (Serafini 1952:17). We found 1859 chiseled into one of the north arch ceiling stones but no 1853 anywhere. The large flat stone immediately above the top of the north arch would have been a likely spot for this, but it appears dateless from all appearances. I suspect Serafini's information crossed wires.

## The Arches and Corner Pillars

Whether one considers the arches to be "built into" the furnace walls, or are merely designed spaces remaining after construction of the four corner pillars (as called by Overman 1850:154), depends on one's point of view. When a blast furnace is constructed, the corner pillars are first built up, leaving room between the corners for arches. As the pillars rise, the arches are formed by curving over their ceilings until the tops of the arches meet. At that point the four distinct corner pillars converge as the stack continues to rise as a single structure.

The arches afford access to the interior workings of the furnace. The north arch was the casting arch and the other three, the east, south, and west arches, were the tuyere arches. The casting arch, also known as the work arch or the fire arch, was where the furnace was tapped to draw out the slag and molten iron. The tuyere arches afforded access to the tuyeres (air blast nozzles) and also to the side and rear walls of the hearth. Not all furnaces had four arches, however. In Vermont, the ca. 1822 (east) stack at Bennington has two arches while its neighboring 1823 (west) furnace has three arches, as did both the ca. 1846 East Dorset and 1837 Troy stacks. In most cases, the largest arch was the casting arch while the remaining smaller ones were tuyere arches. Only antebellum furnaces were found with less than four arches, which might give a clue as to when the present Franconia stack was built.

Deep inside all four arches are massive iron cross beams, and behind and below these is the hearth. These cross beams and the hearth are discussed later in this report.

The casting arch of the furnace is the main workplace, where the iron is tapped from the hearth and run out into molds. Everything that is fed into the top of the stack eventually comes out through the casting arch. Even slag, as it accumulates in the hearth, is periodically bled from the hearth to make room for more molten iron, and this slag is also run out through the casting arch. And it is in the casting arch that the ironmaster frequently tests the iron by drawing out small samples of iron from the hearth. Once the furnace is fired and until it is cooled, sometimes for as long as a year, there is always activity in the casting arch. When the hearth is tapped and the molten iron runs out, many people are needed in the casting arch, and it is for that reason that the casting arch is the largest arch of the furnace – so as to give the workers room to work without crowding and causing accidents that could cause both loss of product and loss of life.

The side of a furnace containing the casting arch can usually be identified in photos by looking for the building that extends outward from the side of the stack and also contains roof–top ventilators, called monitors. Other buildings sometimes crowd about the other side of the furnace. In late–19th–century furnaces, one of these might be the engine house, where electric– or diesel–driven pumps created the furnace blast. Other buildings might merely be storage sheds or provide protection to the bottom of the stack from weather. But only the casting shed usually contained the roof–top monitors, so that the heat given off by tapped molten iron below could rise and escape.

Figure 15. *The north arch, largest of the four.*

Some furnace operations are built such that the casting shed is in a straight-line with the charging bridge above, on the opposite side of the stack. At others, especially where there is insufficient ground room, as at Franconia, the casting shed, and thereby the casting arch, were built at right-angle to the charging bridge. This is a very common design that makes maximum use of limited ground area. The casting shed at Franconia, therefore, paralleled the Gale River, and since it extended from the north wall of the stack, the casting arch can also be correctly identified as the north arch.

<u>The North Arch:</u> Floor-level measurements found that the casting arch is 12 feet 4 inches wide at the mouth and 11 feet 4 inches deep (outside edge to face of hearth). The side walls of the arch closed inward with depth into the furnace and is 7 feet 7 inches wide at the hearth (figure 15). The west wall of the arch measured 11 feet 10 inches deep while the east wall is 12 feet 1 inch deep. Diagonal measurements also show the floor dimensions slightly askew. From the northwest to southeast arch corners is 15 feet 7 inches; from the northeast to southwest arch corners is 15 feet 1 inch. Floor area (between hearth and outside end of arch, and side walls) works out to 116.71 square feet.

The side walls of the arch rise vertically to about head-height, then curve to form a lancet-type roof at the opening. The measured heights of the vertical sections of the arch's side walls varied due to differences in ground levels within the arch. At the arch entrance the vertical section of the west wall measured 5 feet 7 inches; the east wall at 6 feet. From a level line across the arch opening at the top of the vertical sections of wall, the top of the arch measured 6 feet 4½ inches, for total arch height at this middle point of 11 feet 2½ inches. This height reduces to 7 feet 10½ inches at the inside end of the arch, where the roof appears more like a horseshoe type arch than a lancet-type.

The vertical side walls are made of stone similar to, and laid up in the same pattern as, the outside walls of the stack. Above the vertical sections of side walls, however, as the roof pitches over to form an arch, long wedges of granite are employed. These wedges were set in place with their larger dimensions facing upward and outward, effecting the lowered height and narrowed width with depth into the furnace interior that created a cone-shaped recess. A prominent keystone locks the arched ceiling in place. We do not know where (or when) the pieces of granite for the ceiling were quarried. Chiseled on the bottom stone (voussoir) of the arch's west wall, just inside the arch is "S. PETTEE JR. 1859" (discussed earlier in this report).

At the inside end of the north arch are the hearth and a large iron lintel (see figure 25). The sides of the hearth do not connect with the inside ends of the arch walls, but approximately 1-foot wide openings exist on both sides through which the east and west arches are visible. At the floor level, at least, the hearth is a stand-alone fixture of the stack. When in operation, the top of the hearth met with the arch roof behind a wall of large stones that lay atop the horizontal iron beam. All the cross beams extend the width of the arches, atop the inside ends of the vertical sections of the side walls. They also act as a headers to support stonework (and in some place, brickwork) at the inside ends of the arches. Since the lower layer of the bosh lining has collapsed, one can today look up behind all the cross beams and see into the stack.

Toward the end of the first weekend session, Krista Butterfield and Woody Openo were asked to dig into some of the breakdown on the floor of the north arch, immediately in front of the hearth. We hoped that maybe we could locate the bottom of the hearth and record the details of the openings. They dug slowly so as not to miss anything significant found in the breakdown, but going was slow through brick and slag. About a foot down, what might be the top of the notch started to appear between two side stones (figure 16), at which time digging ceased for the end of the day. The bottom of the hearth appears to be at least another 1 to 1½ feet down, buried under more breakdown.

Several pieces of thin metal plates and cut nails were uncovered while excavating the front of the hearth, which do not appear to have any connection with the hearth's operation (figure 17). They were photographed and turned over to the Visitor's Center.

The East Arch: The east arch opens toward the Gale River, and is one of the three tuyere arches (figure 18). The main purpose of this arch, therefore, is to provide access for the installation and maintenance of the tuyere nozzle near the floor of the inside end of the arch. The arch also provided access to the east side of the hearth in the event repair was needed here. The tuyere is not obvious.

The arch measures 9 feet 7 inches across the front at ground level and narrows to 4 feet 4 inches at the hearth. The north and south side walls of the arch are 10 feet 10 inches deep. Diagonals at floor level are 12 feet 9 inches, a symmetrical arch. Distance from the opening of the arch to the hearth is 12 feet 2 inches. These measurements agree

Figure 16. *The extent of digging through breakdown in front of the hearth.*

closely with some of those for the south arch, but not as close with the west arch. Floor area calculates to 72.19 square feet, about two-thirds (62%) the casting arch area (see figure 14).

The side walls rise vertically to just below head height before curving to form a lancet-type roof, similar as the casting arch. The measured heights of the vertical sections of the side walls varied due to differences in ground levels within the arch. At the arch entrance the vertical section of the north wall measured 4 feet 8½ inches; the south wall at 4 feet 11½ inches. From a level line across the arch opening at the top of the vertical sections of wall, the top of the arch measured 4 feet 7 inches, for a total height at this point of 9 feet 7 inches. This height reduces to about 6½ feet at the inside end of the arch, where the roof is more rounded than at the outside end. The vertical walls and roof appear to be made of the same type stones as in the casting arch.

An 11-inch outside diameter vertical iron pipe is in the north wall of the arch. The pipe is most likely the main blast pipe, called the downer, which came down from heating ovens that once sat atop the stack (see figure 18). From across the river and with the aid of binoculars, one can see the top end of the pipe barely sticking above stones directly above its position in the arch wall below. The underground end of the pipe probably circles the stack under the floor of the three tuyere arches (a bustle pipe). In the middle of each of the three arches a smaller-diameter vertical pipe (riser) provided blast to each of the three tuyere nozzles. Nothing is visible of the bustle pipe or riser connections; however, they might still be under the floor of the three tuyere arches unless they were dug up for scrap value (as was also the custom).

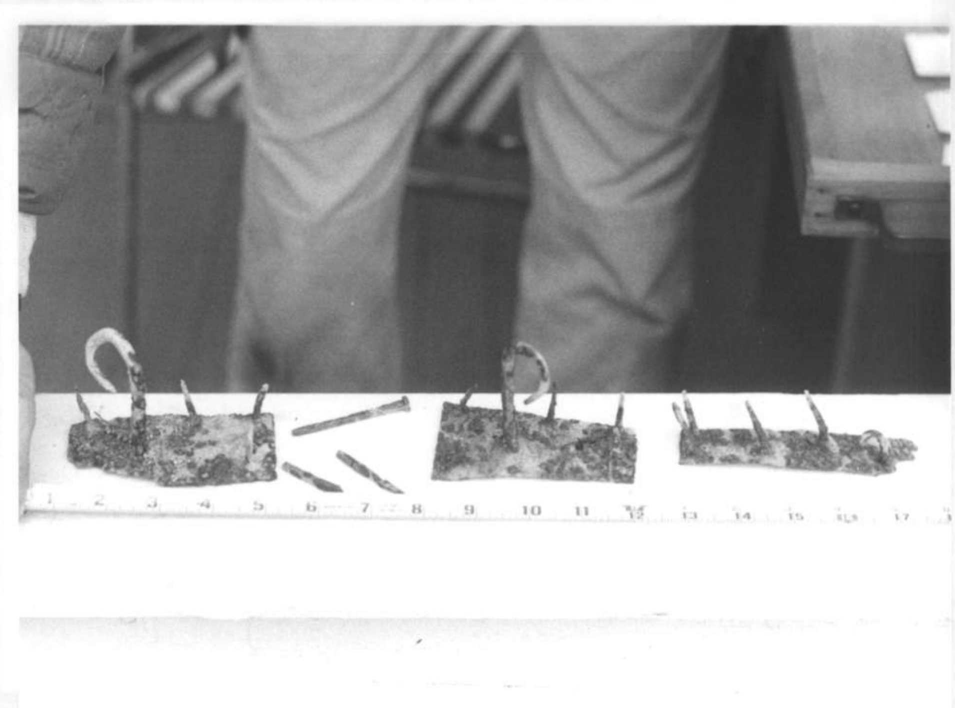


Figure 17. *Artifacts recovered by Butterfield and Openo in front of the hearth.*

The center of the downer pipe is 5 feet 3 inches from the outside wall of the stack which places it almost midway between the outer and inner ends of the arch wall. The pipe is recessed into the north wall of the arch in such a way that the pipe is flush with the vertical section of the arch wall. The cavity into which the pipe is set is 2 feet 2 inches wide by 1 foot 6 inches deep. The recess appears to have been chiseled into the wall to make the pipe fit, rather than the wall having been built around the pipe, so that the preheated air blast system might be a later adaption to the stack.

On the opposite side wall, 1 foot 5½ inches from the cross beam and 5 feet 4 inches above the floor is an iron hook. The hook extends 5 inches out from the wall and curves up and toward the wall, forming about a 3-inch diameter bend. The function of the hook is unknown. A guess is that it might have held a reamer, to clear out tuyere blockages.

The three tuyere arches are connected by internal passageways, so that one can walk (stooped over) from the east arch to the south arch, and then to the west arch without going outside the stack. Only at the Greenwood No. 2 furnace (the steam furnace) have I seen this. Greenwood No. 2 is the restored stack that can see when driving south on the NYS Thruway a few miles south of the Harriman Exit. The furnace, however, is much larger stack than the Franconia stack, so this is a distinctive feature. The passageways would appear at first to most likely be a convenience for workers to maintain the tuyeres, but the passageways might have been a later modification to the stack for laying the air blast and water cooling pipes around and under the furnace walls.

Figure 18. *The east arch, showing the downer pipe (right), the cross beam with one knob (center), and the passageway to the south arch (left).*

The passageway to the south arch is about 3 feet 3 inches from the outside wall. It is generally 24 inches wide by 5 feet high (see figure 18. The longer, outside (southeast) wall of the passageway is 11 feet 3 inches long and the shorter, inside (northwest) wall is 8 feet 8 inches long, for a floor area of 19.9 square feet. The opening diagonals are 5 feet 3 inches (lower east to upper west corners) and 5 feet 9 inches (lower west to upper east corners). The roof of the passageway is capped with a heavy lintel stone through its length and set immediately under the first level of granite voussoirs on that side.

At the inside end of the arch is a section of cross beam ring and the hearth (both discussed later). There is up to 16 inches of space between the inside edge of the cross beam ring and the breakdown material above the hearth, enough to see up into the upper stack area. Some structural material is obviously missing here (see explanation, page 50).

<u>The South Arch:</u> The south arch looks much like the east arch, except it doesn't have the downer pipe, but it has passageways on both sides (figure 19). Like the east arch, its main purpose was access to the tuyere and for hearth maintenance. It measures 10 feet across the front at ground level and narrows to 4 feet 2 inches at the hearth. The east and west side walls of the arch are 10 feet 9 inches and 11 feet deep, respectively. Diagonals at floor level are 12 feet 7 inches (southeast to northwest) and 12 feet 9 inches (southwest to northeast). The floor area calculates to 75.55 square feet, about two-thirds (64.7%) the casting arch area (see figure 14).

Figure 19. *The south arch, showing passageways to the east (right) and west (left) arches.*

The side walls rise vertically to just below head-height before curving to form a lancet-type roof, similar in style and material as the casting arch. The vertical section of the east wall at the arch entrance measured 4 feet 8 inches; the west wall 4 feet 2 inches (differences due to varying ground levels). Vertical height of the outside end of the arch from ground level to the ceiling measured 9 feet 8 inches, 1 inch less than the east arch height. This height reduces to 8 feet at the inside end of the arch, where, like the east arch, the ceiling is more rounded than at the outside end. Diagonals taken across the outside face of the arch from the level line at the base to the top edge of the vertical side walls are 10 feet 3 inches (lower west side wall to top east side wall) and 10 feet 2 inches (lower east side wall to top west side wall), or an almost exactly square opening.

Sticking up from the ground under the east side wall is the end of a 4½-inch (inside) diameter iron pipe, about halfway between the inside end of the east wall of the arch and the east passageway, possibly part of the tuyere's air-blast or water-cooling systems.

Passageways connect through both side walls of the arch to the east and west arches. Both passageways are capped with flat lintel stones throughout their lengths with the outside lintels set immediately under the first granite voussoirs. The lintel atop the entrance to the west passageway is cracked over the center of the passageway. Both passageways are 3 feet 3 inches in from the outside ends of the arch.

The passageway from the east arch is about 3 feet 10 inches from the outside end of the arch and is generally 22 inches wide by 5 feet 8 inches high at the center (compared to 24 inches wide by 5 feet high at the other end - uneven wall and ground levels).

The passageway to the west arch is 3 feet 6 inches from the outside end of the arch and is generally 24 inches wide by 5 feet 6 inches high at the center. The longer, outside (southwest) wall is 10 feet 11 inches long and the shorter, inside (northeast) wall is 8 feet 8 inches long, for a floor area of 19.6 square feet. The opening diagonals are both 5 feet 11 inches (lower south to upper north corners and upper south to lower north corners).

At the inside end of the arch is a section of cross beam ring assembly and the hearth. There is up to about 18 inches of space between the inside edge of the binder and the mass of breakdown above the hearth (discussed on page 50).

<u>The West Arch:</u> The west arch looks much like the east arch and it has only the one connecting passageway, to the south arch (figure 20). Like the south and east arches, its main purpose was access to tuyere and for hearth maintenance. This arch is difficult to photograph since it faces on a high stone foundation wall, 5 feet away. The close proximity to the wall further reduces air circulation in the arch resulting in perpetual dampness in the dark/dank arch.

The arch measures 10 feet across the front at ground level and narrows to 4 feet 4 inches across at the hearth. Distance between the outside end of the arch to the hearth is 12 feet 7 inches. The north and south side walls of the arch are both and 11 feet 2 inches deep; floor-level diagonals are both 13 feet. The floor area calculates to 75.08 square feet, about two-thirds (64.3%) the casting arch area (see figure 14).

The side arch walls rise vertically to just below head-height before curving to form a lancet-type roof, similar in style and material as the casting arch. The vertical section of the south wall at the arch entrance measured 4 feet 4 inches; the north wall 4 feet 9 inches (differences due to varying ground levels). Vertical height of the outside end of the arch from ground level to the top of the arch measured 9 feet 2½ inches, within an inch of the same measurements for the east and south arches. This height reduces to 6 feet 7½ inches at the inside end of the arch, where, like the east arch, the ceiling is more rounded than at the outside end. Diagonals taken across the outside face of the arch from ground level to the top edge of the vertical side walls are 11 by 11 feet.

The passageway from the south arch is about 3 feet 3 inches from the outside wall, is generally 24 inches wide by 5 feet 4 inches high at the middle (compared to 5 feet 6 inches high at the other end), and is capped with a flat lintel stone.

At the inside end of the arch is a section of the cross beam ring assembly and hearth, and a visible end of the tuyere nozzle at the bottom of the hearth (figure 21). The tuyere measured 6¼ inches inside diameter and 9 inches outside diameter. Two 1-inch inside diameter pipe holes bracket opposite sides of the tuyere nearly horizontally. These small pipes provided cooling water to keep the inside end of the tuyere from melting due to the high smelting temperature. Depth of the tuyere is 10½ inches (compared to tuyere measurements taken Forestdale, Vt: 7-inch inside diameter narrowing to 4 inches, 12 inches deep; water-cooling pipes 1-inch inside diameter).

Figure 20. *The west arch, photo taken from atop the foundation wall.*

Between the cross beam ring and the mass of breakdown, there is a large enough opening to stand up in it and see inside the stack. Through this opening it was noticed that the furnace lining ends at the start of the bosh, most of which has fallen out and created the space all around the bottom of the stack between the inside edge of the binder and support beam and a mass of breakdown (discussed on page 50). With little effort, one could crawl upward into the stack through this opening and make internal measurements.

The Corner Pillars: As mentioned earlier, pillars are either the corner areas that surround the arches or vice-versa. The fact is, the sole means of support for most of the furnace stack are the corner pillars. As the furnace is constructed, the pillars are first laid and are built up very carefully. Special attention is paid to the design and construction of the arch walls since the arches are always the furnace's weakest parts. Almost all collapsed furnace ruins have caved into their arches.

But the four corner pillars of the Franconia stack are not fully built out to 90-degree corners. Rather, because of other design considerations, the corner pillars had an additional requirement placed on them: they had to do the same job as regular pillars, but had to do it with less mass.

Except for the passageways that connect the east, south, and west arches, the pillars are built solid. They were built with stone that did not crush easily; therefore, granite and slate answered well but limestone did not. Overman mentions "good mortar" being used in building the pillars but it is not known how many furnace stacks employed mortar in their construction (Overman 1850:154).

Figure 21. *A tuyere peeking out of the floor in the west arch.*

In constructing the pillars, account must be taken for placement of binder rods and the base for the in-wall. In the case of the Franconia stack, this meant that space had to be designed into the pillar for the cross beam ring, its associated connecting and binding hardware, and interface with the bosh lining. When the pillars met at the tops of the arches, the wall thickness above the arches thinned to account for the fattest inside cross-section all the while the structure itself continued its inward-sloping shape. All this was held in place by the corner pillars.

Just as the physical condition of the pillars was an important design consideration when the stack was built, the physical condition of the pillars remains today a measure of how well preserved the stack is and how the structure may survive the future. The pillars therefore play an important part of any preservation strategy.

### Binders, The Cross Beam Ring Assembly, and Connecting Hardware

Binders seen at other furnace remains run from front to back, side to side, and diagonally through the stack. They are placed so they do not interfere with bosh linings and hearth stones (see Rolando 1992:26-27). "Iron hoops" or "reinforcing bands" were also supposed to have been employed at the furnace (Serafini, 1952:17; Aldrich 1996:9). The purpose of the binders and hoops was to support the outside walls and keep them from shifting and falling apart. Heating and cooling the stack had to take its toll on the stability of the loose masonry walls and various types of binding systems have been seen that attempted to solve this problem. Furnaces that were built in the earlier 1800s had few binders since the stacks were neither very tall nor very wide. Looking at some Vermont furnaces, for example, the ca. 1822 furnace at Bennington is 40 feet high and 31 feet square, the 1837 furnace at Troy is 30 feet high by 26 feet square, and the ca. 1823 furnace at Forestdale was 42 feet high (before enlarged in 1854) by 31½ feet square. But as stacks grew in height in order to draw better and produce a greater heat, the implementation of binding schemes became an important design consideration.

<u>Binder Rods:</u> As is normal for early- to mid-19th century blast furnaces, little binding hardware is visible at the Franconia furnace stack. The only binders visible from the outside are the ends of four flat iron bars, 1 inch thick by 3⅛ inches wide, extending 5 to 6 inches out the center of opposite sides of the four pillars (figure 22). Near the outside end of each binder is a ⅝-inch wide by 2¾-inch long hole that allowed for insertion of a beveled key, which in turn held an iron plate, probably 4 to 6 inches wide by 6 to 8 inches high by ½ inch thick, against the furnace wall. The bar bulges to 3⅝ inches wide at the key-hole. Each binder protrudes through the wall about mid-way between pillar corners, from 4 to 5 feet above the local ground level (see table 2, page 22).

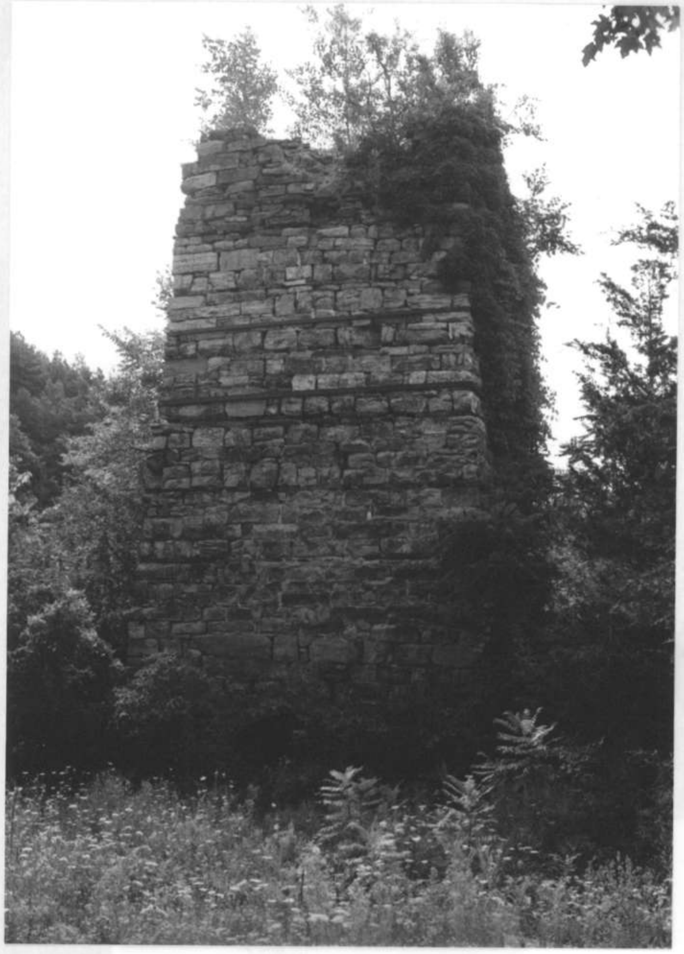
All four flat iron end plates and their beveled keys are missing, as is also usual for furnace ruins. The end plates are probably long gone but the smaller beveled iron keys might yet be buried somewhere below the binder ends. Inspection of a ca. 1908 postcard with a magnifying glass appears to show small face plates, maybe 4 inches high by 6 inches wide, on the northeast pillar wall (see figure 7). It is highly recommended that new iron plates and keys be fabricated and reinstalled to tighten the walls.

Stack Straps: Three "iron hoops" were reported to have girdled the outside walls of the stack's upper sections at one time and long since removed and sold for scrap (Serafini 1952:17). No instances of iron hoops, or straps, have ever been seen or known associated with blast furnaces, but that doesn't rule out their use. They have been used to bind the walls of some of the larger 19th-century lime kilns ruins (figure 23). Whether they were ever used at Franconia, they would have provided additional support to the upper sections of the stack. Aldrich wrote that he was told the bands were removed during World War I (Aldrich 1996:9), although a postcard cancelled in 1908 show no straps (see figure 7).

Cross Beam Ring Assemblies: Circling inside the stack, about level with the binders and the top of the hearth, is a massive piece of hardware. The sections that are visible inside the arches are flat and perpendicular to the long axis of the arches, while the inside edges of this hardware curves around the bosh. For the sake of discussion, names have been adopted for these various pieces of this hardware that are obviously not the original nomenclature, but they do serve the purpose of this report.

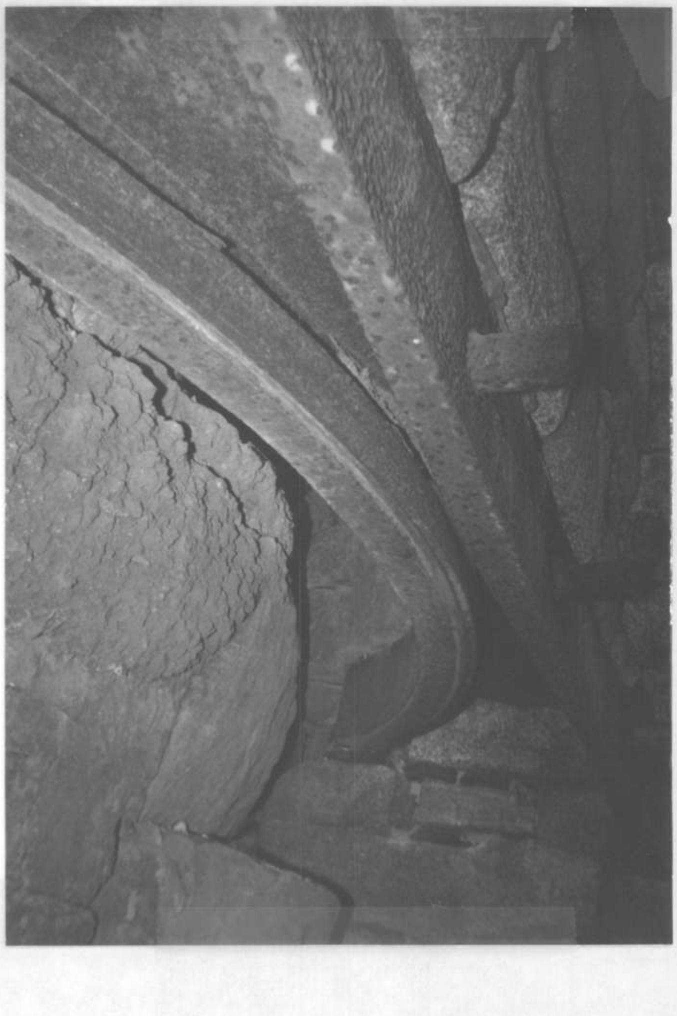
The horizontal pieces that span the width of the insides of the arches are called cross beams. Because the inside faces of the cross beam (sides that face the bosh) circle around the hearth, they are called the cross beam rings. Together they are referred to as cross beam ring assemblies. The hardware where the ends of the rings connect inside the corner pillars is called corner connecting hardware. The connecting hardware is visible only by bending up into the small spaces between the inside corners of the arches (figure 24). Here we also discovered the inside ends of the binder rods, which extend diagonally outward through the four corner pillar walls of the stack.

Figure 22. *The end of a binder rod sticking out through the southwest pillar wall.*



⇐
Figure 23. *A mid–19th–century lime kiln ruin at Greenwich, N.Y. that employed horizontal binder straps around the upper walls of the stack.*

⇒
Figure 24. *View looking upward at the cross beam and ring in the north arch. The front of the hearth is at the lower left. The far end of the ring connects with the west arch ring in the northwest pillar.*



The cross beam ring assemblies in the three tuyere arches are different than that in the casting arch. They were obviously made for a very specific purpose and we feel that we know very little about the reason behind another of the stack's interesting features. It proved to be one of the most difficult to record, and as of this writing, much still remains to be measured and recorded regarding it. A fuller study of it could provide us with a better understanding of how it was manufactured and built into the stack and what function(s) it serves.

We spent many hours inspecting, measuring, sketching, photographing, and guessing the function(s) the cross beams and rings. Matt Kierstead did the best job of sketching their details and most of his sketches are included in this report just as they were drawn. Each of these cross beam sections is then broken down into their sub-assembly parts. First we will look at each of the ring assemblies as they are observed in each arch (north, east, south, and west) and then how they connect inside the corner pillars, and maybe this will put it all together into a comprehensive and understandable presentation.

<u>The North Arch Cross Beam and Ring:</u> In addition to the large size of the north arch and the "S. Pettee, Jr." engraving on the wall, another obvious feature is the massive iron cross beam that spans the width of the inside of the arch along with the pair of round knobs that protrude from the front of the beam (figure 25). The cross beams in the other three arches are smaller and have only one knob each.

Figure 25. *The cross beam in the north arch, distinctive by its larger size than those in the other three arches.*

The cross beam is made up of separate sections that appear to have been welded to form a single piece. Facing the arch area is a flat, vertical surface. The inside edge is a flat plate that curves around the bosh, leaving the center the narrowest section of the assembly (figure 26). It is more than 9 feet 4 inches long (only one end is obvious; the other end is hidden inside the west wall of the arch). It is 9⅛ inches high and 3 inches deep at the center, tapering to 8¾ inches high by 1¼ inches deep at the right (west) end and 1⅝ inches at the left (east) end. At the center, it is 1⅝ inches from the back of the beam to the front of the iron ring behind it, and 9⅜ inches overall from the front of the beam to the inside (back) of the iron ring.

The two round iron knobs that stick out of the front face of the cross beam are 2¾ inches in diameter and 4½ inches long, and are 24 inches apart on center. Everything from sprues to tool hooks to tap supports have been conjectured for the knobs, but no viable explanation for the purpose(s) of these two knobs (or the knobs in the other three arches) has been accepted.

In cross-section, that is, viewing the assembly from the left (east) end, the cross beam looks like a letter "n" with the knobs sticking out the right leg of the letter (figure 27). The distance between the legs increases from about 4⅝ inches at the center to about 1 foot 10 inches wide at the east end, and to 1 foot 8 inches wide at the west end. The curved inside face of the assembly appears to be made up of two curved pieces, one L-shaped (the flat bottom facing toward the arch) and another smaller n-shaped, which is attached to the inside face of the L-shaped piece.

The horizontal thickness of the main beam section that straddles the width of the arch varies from 3 inches thick at the middle (between the two 2¾-diameter knobs) to 1¼ inches thick at the right (west) end and 1⅜ inches thick at the left (east) end. Holding up the wall of heavy stones that isolate the bosh from the arch area obviously requires more strength thus the increased thickness in the middle. Lying atop the cross beam is a flat iron plate 1⅝ inches wide at the center, just atop the thickest part of the cross beam, about 1 foot 10 inches wide at the east end and 1 foot 8 inches wide at the west end, as described previously as the distance between the legs of the n-shaped assembly.

Behind (inside) the curved section of the ring are the bosh walls. Between the inside curve of the ring and the top of the hearth are the remnants of the bosh lining (see page 50). The distance between the inside, center edge of the ring and the lining (the widest space) is 16 inches. This space would not exist during operation otherwise semi-molten iron and burning charge would have spewed into the casting arch workplace. With the decay of the lower areas inside the stack, accelerated by the accumulation of moisture from rain and snow falling down through the open top of the stack, the mortar rotted and bosh and inwall bricks fell out. This opening behind and above the cross beam may therefore account for most of the firebricks found in the floor of the arch adjacent to the bottom of the hearth.

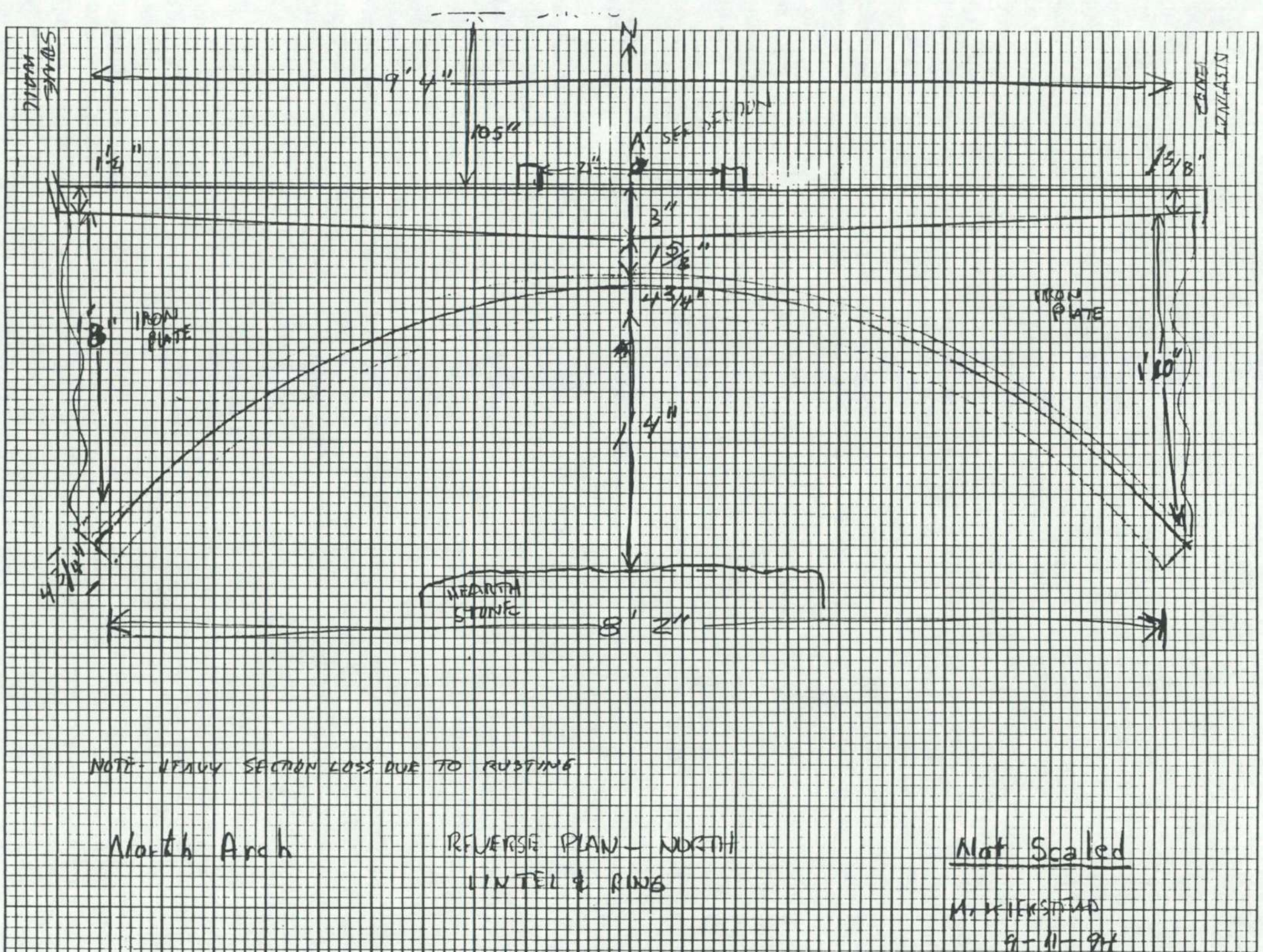



Figure 26. *The cross beam assembly in the north arch as viewed from the bottom. The two knobs face north, the right end of the beam points west, and left end points east (Matt Kierstead field sketch).*

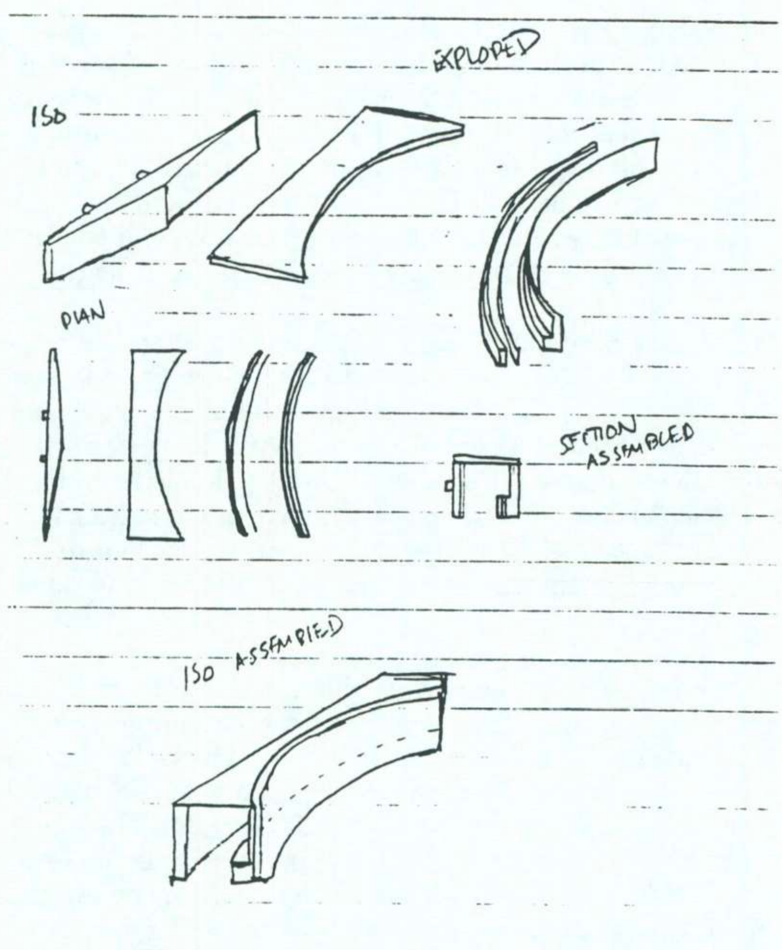



Figure 27. *The individual pieces of the cross beam and ring (Matt Kierstead field sketch).*

<u>The East Arch Cross Beam and Ring:</u> The single iron knob is the most visible difference between the beam in the three tuyere arches and that in the casting arch, which has two iron knobs. The knob is 3 inches in diameter and is about centered (left-right, up-down) in the beam (figure 28). It extends 4½ inches out from the face of the beam, which is 6½ inches high.

The cross beam, which rests on the arch side walls, is 4 feet 7½ inches long, 6½ inches high, and 9 inches deep (horizontal) behind the knob. Atop the beam rests a wall of stone, which on the inside, served as the backing for the bosh lining (now missing). As in the north arch, space behind the cross beam provides visibility into the interior of the stack. The inside edge of the beam ring continues the same relative curve around the bosh as the ring in the north and south arches.

<u>The South Arch Cross Beam and Ring:</u> The single knob in the center of the cross beam is 3 inches in diameter, is horizontally and vertically centered in the beam (figure 29), and extends 4½ inches out from the face of the beam. The cross beam, which rests on the arch side walls, is 4 feet 9 inches long, 6 inches high, and 9 inches deep (horizontal) behind the knob. Atop the beam rests a wall of stone, which on the inside, served as the backing for the now-missing bosh lining. As in the north and east arch, space behind the cross beam provides visibility into the interior of the stack and the inside edge of the beam ring continues the same relative curve around the bosh as the rings on each side.

<u>The West Arch Cross Beam and Ring:</u> The single knob in the center of the west arch cross beam is also 3 inches in diameter and also horizontally and vertically centered in the cross beam (figure 30). The know also extends 4½ inches out from the face of the beam. The cross beam, which rests on the arch side walls, is 4 feet 9 inches long, 6½ inches high, and 9 inches deep (horizontal) behind the knob. Atop the beam rests a wall of stone, the inside of which formerly served as the backing for the bosh lining. As in the other arches, one can look straight up behind the ring and see into the interior of the stack and the inside edge of the ring continues the same relative curve around the bosh as in the other three arches.

Inspection of the inside of the stack through a hole in the inside end of the arch, which is wide enough to stand up in, reveals that the firebrick lining inside the stack seems to be in place as far down as the start of the boshes, which is where the lining walls start to curve inward. Few firebricks can be seen covering the walls downward from that point. The walls here are stone-faced only (see figures 33 and 34). The curved inside edge of the cross-beam cannot be seen from this vantage point since it is too low, hidden behind the mass of breakdown and remnants of the bosh lining. Given the seemingly precarious nature of the stone walls and the number of firebricks and debris seen atop the breakdown, it seemed inadvisable to crawl up onto it and explore around its extremities. Instead, many photos were taken, some blindly, that is, held arm's length inside small holes and spaces, and pointed without sighting.

<u>Corner Connecting Hardware:</u> One of the most intricate pieces of hardware found inside the stack was also one of the least accessible. This is where the ends of the support

Figure 28. *Cross beam inside the east arch.*

Figure 29. *Cross beam inside the south arch.*

rings connected inside the corner pillars of the stack. All were visible to some degree but none in a position that made it easy to inspect, measure, photograph, and sketch.

Each connecting assembly essentially consists of either one or two pairs of bolts that straddle a center device that looks like a flat plate (referred to hereafter as a "binder plate"). These binder plates appear to be related to attaching the inside ends of the four binder rods that extend outward through the corner pillars to the outside faces of the corner walls. A physical connection was confirmed by measuring electrical continuity between the outside end of one of the binders and the cross beam ring with a battery-powered ohmmeter and long test wires. The theodolite survey also confirmed that the binder end rods in the northeast and southeast pillars are level with their inside cross beam ring hardware.

What we don't know is specifically how the attachment is mechanically accomplished. For example, there might be some kind of overlapping pieces of flat iron that extend beyond the ends of the rings, and these overlapping pieces have holes in them to allow bolts to be pushed through. Are the bolts threaded so nuts were screwed on them, or were these more of rivet-type connectors, attached when hot and allowed to contract tight when cool? The binder plate might be the internal end of the binder rod that was heated, pushed through a hole in the overlapping pieces, and hammered flat against the overlapping pieces while still hot, thus both securing the binder to the cross beam ring and providing another connection between the pieces.

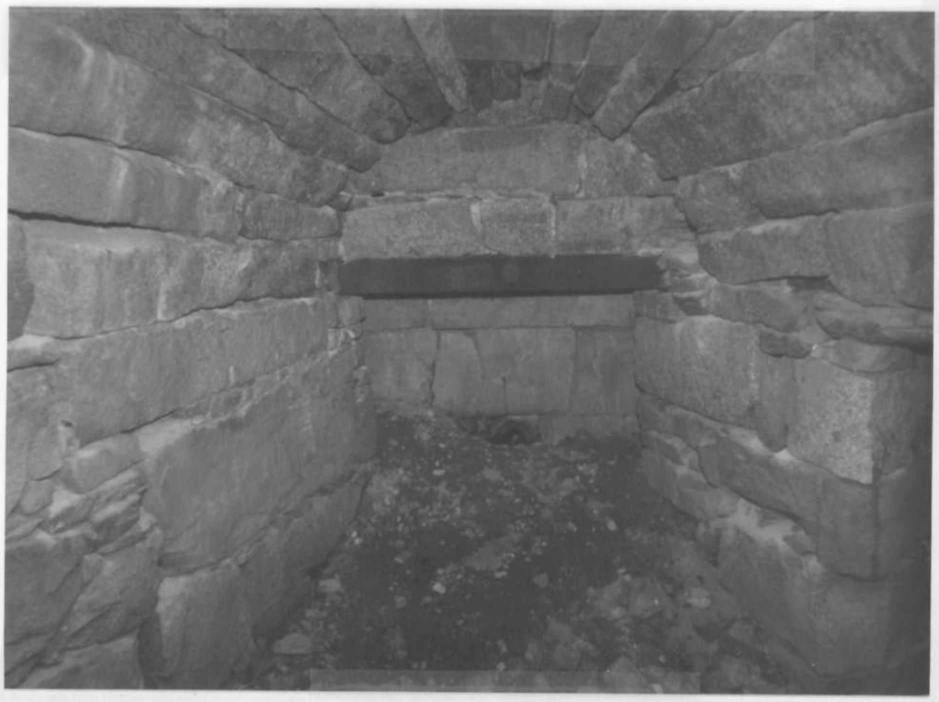


Figure 30. *Cross beam inside the west arch.*

The connecting hardware inside the southeast corner pillar measured 25 inches long between the ends of the cross beam rings (figure 31). The 3-inch wide by 4-inch high binder plate appeared centered between the ends of the rings, 11 inches on each side. Two 1-inch-diameter holes touching each side of the binder plate might contain the rusted remains of iron bolts. Another pair of 1-inch diameter rust-filled holes are about 4 inches farther to the left and right of the binder plate. Looking at the connection hardware from the inside of the stack, the face of this overlap section is 3¼ inches high at the left-most bolt hole, and 3½ high at the inner-left and inner-right bolt holes. Reason for the variance is unknown.

In the southwest corner pillar, the distance between the sides of the binder plate and the ends of the rings is 12 inches while between the other side of the binder plate and the ring end is 10½ inches. This binder plate is also 3 inches wide by 4 inches high. Two 1⅜ -inch square bolt heads are on each side of and touching the clip. The next pair of bolt heads, also 1⅜ inches square, are 7½ inches to the left and 6 inches to the right of the clip (as faced from the inside). This piece of hardware was difficult to measure but the face of the overlap sections appeared the same dimensions as those in the southeast corner pillar.

The binder plate inside the northwest corner pillar measured 3 inches wide by 4½ inches high and is straddled by only one pair of bolt holes. Horizontal distance between the north and west arch cross beam rings here is only 7 inches. The connecting hardware abuts the lower 4 inches of the north arch cross beam ring and the top 4 inches of the west arch ring (the two rings are offset). This connector assembly is so rusty and corroded that some hardware might be hidden by scale. Where the ends of the ring in the north arch curve into their corner pillars to connect with the rings on either side, the difference in their heights and their resulting connection offsets can be seen. In the northwest pillar, where the 9½-inch-high north ring and 6-inch-high west ring join, the west ring is 2 inches lower at the bottom and 1½ inches lower at the top than the north ring. The top flat portion of the ring behind the cross beam was found to be 4 inches lower than that of the north arch cross beam. The bottom edges are only an inch apart, accounting for the 3-inch difference in inside height between the two cross beams.

The offset is more dramatic in the northeast pillar, where the north end of the east arch ring is 4 inches lower than its north arch counterpart (figure 32), so that the overlap is only 1½ inches. The bottom edges are only an inch apart, in accordance with the 3-inch difference in height between the two cross beams.

All ring sections in the three tuyere arches are lower than the counterpart ring section in the north arch. These offsets are not seen as anything ominous; rather, due to design differences between the north arch cross beam assembly and those in the tuyere arches, there are bound to be differences where they interface. Nothing abnormal is read into this.

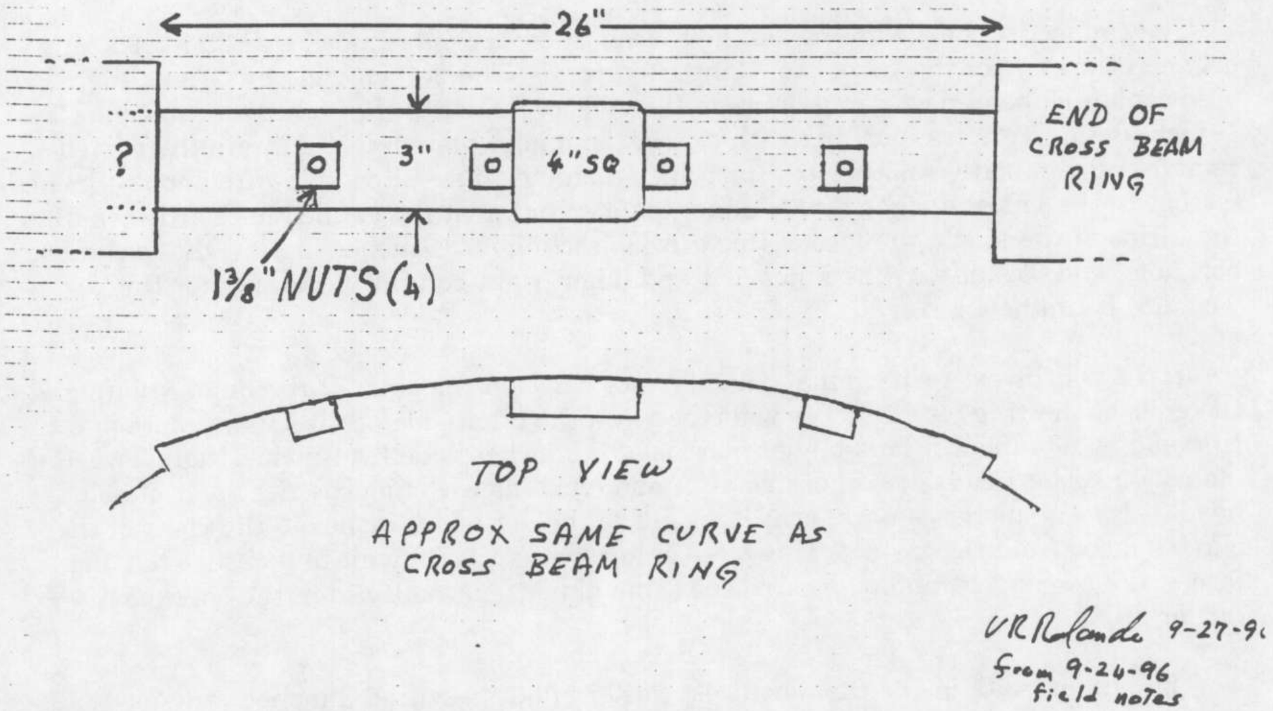



Figure 31. *Corner clip and connection hardware in the southwest pillar (Rolando drawing).*

Figure 32. *Area between the northeast pillar and bosh, showing how the east arch cross beam ring (right) misaligns with its counterpart in the north arch.*

## The Furnace and Bosh Linings, Hearth, and Firebricks

The inside of the furnace is what most directly affected the production of the iron: the firebrick lining, the character of the bosh, the type of firebrick employed, and the furnace charge.

The furnace lining is the layer of refractory material that lines the inside surface of the furnace. The lining is the primary interface between the furnace and the ingredients that make up the smelting process. The lining also insulates the inside area of the furnace from the outside walls. In days when blast furnaces used ordinary sandstone or slate for lining, the insulating value was poor and much of the heat of smelting was lost through conduction. In effect, the whole stack acted like one giant heat sink, and to compensate for that, more charcoal than necessary was burned to maintain the high smelting temperature inside the stack. Another problem with sandstone and slate was that their chemical properties were little understood at best, most likely not known at all. With the development and use of firebrick, with its known refractory properties, the smelting actions and certain characteristics of cast iron could be predicted. But with firebrick, the insides of furnaces also had to be built differently.

To keep the working surface of the firebrick lining smooth, the interface between the back side of the firebrick and the furnace proper had to somewhat smooth also. In most cases, that meant that an "in-wall" had to be built around the inside of the stack before the firebricks could be mortared into place. The in-wall was made of a strong, heat-resistant type common brick, although some in-walls have been seen that were made of firebrick. A correctly built in-wall also made it easier to replace the firebricks as needed, without having to affect the furnace proper. Inspection of the few existing 19th-century blast furnaces and lime kilns that still have their firebrick linings intact bear witness to the skill of masons that were able to build such intricately accurate structures. The linings not only had to rise perfectly round but also be symmetrically balanced.

The 1995 restoration work at Forestdale, Vt., revealed that in some places the in-wall was up to 2 feet thick. Common red bricks were mortared into crevices between layers of stone that comprised the internal "filler" between the outside walls and the in-wall. As the in-wall took shape, its interior took on a more smooth appearance, setting the surface for applying the firebrick layer. The firebricks were, of course, laid up starting from the bottom and working to the top. Starting at the bottom meant lining the bosh first.

The best way to visualize the bosh is to consider the inside of the furnace as resembling an egg standing on its fatter end. At the lower part of the egg where the sides curve inward is where, in the furnace, the bosh is. The bosh is considered to be that part of the stack that starts to narrow. Whether the bosh sloped inward sharply or slowly was a technicality of much debate among ironmasters during the 19th century. Generally, a gently sloping bosh was used in a furnace that burned charcoal, whereas a steeply sloping bosh was used when anthracite coal was the fuel.

The firebrick lining continues down to the bosh area, but because here the walls slope inward, more pressure in the form of weight and friction is put upon this lining. The refractory lining of the bosh is therefore sometimes of a different grade and/or quality than that of the upper lining, being thicker and heavier than ordinary firebrick.

Unlike the egg, which closes and meets at the bottom, in the furnace the lower end of the bosh ends in a 4-sided hole with vertical walls, through which everything drops. This hole is the hearth, and by the time the contents of the stack have gotten this far, they are in a near-molten state. The tuyeres (air blast nozzles) are about two-thirds the way down the hearth, making for this area the hottest part of the operation.

The firebrick lining might or might not continue down into the hearth to the bottom. Even after the advent of firebrick, some early 19th-century furnaces continued the practice of depending on high-quality refractory stones to line the hearth such that the stones served both construction and refractory purposes.

<u>The Furnace Charge:</u> The amount of iron ore, charcoal, and limestone flux fed into the furnace at a time was known as the furnace charge. Each charge had a strict ratio of these three ingredients, which were carefully weighed before feeding them into the furnace. The ratio of ingredients in the furnace charge depended on such things as the amount of impurities in the iron ore, the quality of the flux, whether the charcoal was made from hard or soft wood, etc.

A typical charge at the 19th-century Tyson, Vermont, furnace consisted of 12 bushels of charcoal (about 18 pounds each), 8 to 14 boxes of iron ore (about 100 pounds each), and two boxes of limestone flux (about 100 pounds each) for an average ratio of 14% charcoal, 73% ore, and 13% flux. The charge at Franconia in 1841 was "15 bushels of charcoal, 280 pounds of iron ore, and one box of limestone for flux. ...and the average yield of the ore that year was 55.12% of iron." (Garvin 1994:8 [1841]). That worked out to about 42% charcoal, 43% ore, and 15% flux. Franconia was burning more charcoal per ton of iron than Tyson for the nearly the same period of the technology.

By the mid-19th century, iron smelting was recognized as a chemical reaction rather than a burning and melting process, and chemical analyses of the iron ore, charcoal, and limestone came into play in determining their proper ratios per charge. The recommended charge by then was 15 bushels of charcoal to 700 pounds of iron ore (Overman 1850:167). To this was added about 50 to 60 pounds of limestone flux. This ratio worked out to 26% charcoal, 68% ore, and 5% flux, a much more efficient consumption of charcoal.

<u>The Furnace Lining</u>: Fortunately, most of the furnace lining still exists inside the Franconia stack. Considering that the furnace hasn't been fired or maintained for over 130 years, this is nothing short of a miracle. Someone designed well (Mr. Pettee?). Inspection of the lining from the hole inside the west arch roof shows no appreciable bricks missing from about head-height upwards. We had no bright lights to completely illuminate the inside so the photos we took of the inside were used for inspection (figures 33 and 34).

The lining appears to generally stop at the beginning of the bosh. This might not be true all around the interior because no one has yet to venture into the furnace proper for

Figure 33. *The interior of the stack from the access hole inside the west arch, looking eastward across the top of the mass of breakdown atop the hearth.*

Figure 34. *The inwall, below the bottom edge of the furnace lining, just above the north arch. Large inwall stones have fallen from the holes at left, encouraging lining bricks above to drop down.*

a close look, being satisfied with inspection from the access hole in the west arch. Whole sections of the bottom courses of lining are open to the bottom of the stack, with nothing below providing support for that bottom course. This is not a good situation. Firebrick will fall out either brick by brick, or whole sections of the lining could fall out at once. The reinforcement of this bottom course of lining is a primary preservation recommendation.

Because we didn't crawl into the furnace we don't know what type firebrick lines the furnace. That could be a project for the future, when the lining is reinforced and appears more stable.

<u>The Bosh and Bosh Lining:</u> Sitting atop the hearth and looking much like a giant mushroom is a mass of coarse, reddish material. The mass is separated from the interior edges of the stack by up to about 16 inches in some places. Viewing the mass from the archways one can see bits of stone and brick embedded in it. About a 1-inch wide vertical crack that runs through the mass can be seen from the east arch. The crack runs from the top down through the hearth stones below.

The top of this mass can best be seen inside the furnace by carefully standing in the opening inside the west arch. At this point the mass is about chest high, or about 2 feet above the visible top of the hearth. The mass is not flat; rather, it rises across the diameter, west to east. There is a slight dimple near the middle and higher rise at the eastern side.

When this mass was first inspected in 1994 it was thought to be the remains of a frozen charge , or salamander, which had resulted from the premature cooling of a charge in the stack, a classical case of a "catastrophe failure." Re-inspection of this feature with Matt Kierstead in 1996 changed that thinking.

It is Matt's opinion that the mass is the remains of material, possibly clay, that existed between the bosh lining and the in-wall. In fact, close inspection of the mass revealed no evidence of iron in any form present. To further this thought, Matt brushed away some surface debris at the top of the mass near the access hole in the west arch and uncovered a course of firebrick about a foot in from the outside edge of the mass. The course of brick appeared to circle all around inside of the furnace, just below the surface. He speculated that between the firebrick and the outside edge was originally a clayish composition that formed the configuration of the bosh. It is the inside edge of that clayish composition that we can see through the arches. Roger Aldrich noted in his book that "the company found a good bed of clay for lining the bosh about a mile below the works and near that they found sandstone for the hearth" (Aldrich 1996:29).

Between the clayish composition and the stoneworks of the furnace might have been a layer of sand, which functioned both to form the clay and provide more high-temperature insulation. The wall of brick and/or stone that held the layer of sand collapsed some time ago allowing the sand to drop out. (See Robert B. Gordon's "Industrial Archeology of American Iron and Steel," *IA,* 1992, figure 14, page 17, for an example of this.)

The material inside the circle of brick was therefore thought to be an accumulation of breakdown - broken and rotten brick lining, stones, and vegetation that has fallen down and piled up through the years. If this could be excavated we might expose the inside of the bosh down to the hearth. We might then be able to measure the angle of the bosh and learn more about the technology of iron making in Franconia.

Charles Jackson reported in his 1844 report that the bosh was "8 feet 3 inches in diameter at the boshes, *or 12 feet before the lining was put in*" (Garvin 1994:79 [1844]). While inspecting the interior of the stack from the access hole in the west arch in 1996, a steel tape was worked across the top of the very uneven surface of the breakdown to the opposite side. The diameter, between internal stone wall areas, below the bottom edge of firebrick lining, and at a point generally 2 feet above the bottom of the cross beam ring measured 8 feet 10 inches. This indicates a major configuration difference between 1844 and existing dimensions, further supporting a post-1844, or a possible 1859 date of construction for the present, standing stack as Garvin apparently correctly claims (Garvin 1989:3) (see Appendix A, page 76).

The Hearth: For the large size of these early furnaces, their hearths always appear too small; out of proportion to the overall dimensions of the stack. The base of the hearth measures 31¾ square feet and the base of the stack measures about 755 square feet, resulting in a hearth that is less than 5% of the furnace's footprint (see figure 14). At Forestdale, Vt., the hearth measures 19¾ square feet, which is only 2% of the stack's 992¼ square-foot footprint, half that as Franconia. The floor inside the Forestdale hearth is a scant 6 square feet.

Viewing the Franconia hearth from all of the arches, one can see around the sides of the hearth into all of the adjoining arches due to the collapse of the bosh lining. Inside the north arch the corners of the hearth are 14 and 16 inches from the inside center of the northwest and northeast corner pillars, respectively; inside the south arch the corners of the hearth are 15 and 14 inches from the inside center of the southwest and southeast corner pillars, respectively.

Appearing square in shape, the hearth is actually 5 feet 6 inches wide in the north and south arches, 5 feet 4 inches wide in the east arch, and 6 feet 3 inches wide in the west arch. It was made of large rough-cut quartzite. Due to the amount of surface accumulation of breakdown, the exact bottom dimensions of the hearth are unknown. Likewise, internal collapse of brick lining confuses the determination of where the top of the hearth joins the bottom of the bosh, which also frustrated any internal measurements.

The north face of the hearth is a solid stone wall with two vertical wall sections extending outward about 16 inches on each side (see figure 14). Stones in the east wall of the hearth are cracked, and one of the lower, center stones missing. A vertical crack in the center stone of the hearth continues upward to the top and into the breakdown mass above (see figure 28). The south wall of the hearth shows brickwork (hearth lining?) where maybe a stone should be. Maybe the large stone lying on the floor of the arch a few feet in front of the hearth is the missing stone? Although the west wall is also cracked, it seems only slightly so. At the bottom of the hearth's west wall is a tuyere (see figure 21).

Matt Kierstead spent some time during our 1996 visit and explained the differences between so-called "catastrophic accidents," which resulted in the abandonment of furnaces, and "routine events," which occurred as part of normal operation. Simply put, a catastrophic accident was a cases in which a full charge cooled and "froze" in the stack before it could be removed. This might have been caused by a malfunctioning waterpower system that halted the blast or a blockage within the stack that prevented fuel from descending into the bosh. Evidence of these are huge, crusty globs of iron and slag seen near furnace ruins, referred to in the general literature as "bears" (due to their large dark appearance). But all "bears" or "salamanders" are not caused by accidents. In fact, most were probably caused by such routine events as the iron slowly working its way into the bosh and/or hearth lining, or cooling and creeping up the bottom walls of the hearth until it started to envelope a tuyere. As Matt explained it, the ironmasters knew that the bosh and hearth were good for only a limited time before the creeping fingers of iron were about to block a tuyere or break through a wall. This was all normal operation and the shutdown and removal of these large sections of iron-bearing salamanders along with solidly attached pieces of tuyere, hearthstone, or whatever the iron it had attacked was a normal, however troublesome and costly, expense.

Re-inspection in 1996 of the section of hearth in the north arch that was excavated and exposed in 1994 show what appear to be lines of iron that had just starting working through fissures in the stone face of the hearth. When the ironmaster saw iron start to appear in these fissures he recognized it as the end of the hearth's useful life. It was time for him to shut down the furnace and look at the books. Not a "catastrophic accident" as we might believe, but a normal event in the life of the operation. And when the books told the ironmaster that it was no longer worth the investment to re-line the bosh and rebuild the hearth, then it was time to close the works for good, which is probably closer to the real reason why the Franconia stack closed when it did.

<u>Firebricks</u>: Early 19th-century blast furnaces were lined with whatever heat resistant stone was locally and/or economically available. Such stone as sandstone and schist satisfied this requirement for most applications. Jackson's 1841 report described the furnace interior lined with mica slate and its hearth stones made of quartz rock (Garvin 1994:8 [1841]). And although his 1844 report made no mention of lining material, an illustration of a lime kiln at Lisbon elsewhere in Jackson's report shows a brick lining, thus providing an possible early date for availability of firebrick for use at the Franconia furnace. Conversion to brick lining might have accompanied the installation of hot blast apparatus and associated increase of stack height in, or shortly before, 1844.

Bricks are sometimes ignored as an archeological resource, probably because at some industrial sites bricks and are everywhere in overwhelming abundance and usually in broken pieces. Yet, many bricks have markings on them, identifying their manufacturer. Since many companies changed names down through time, interpreting brick marks can provide valuable dating information, and therefore, a window of time for which the use of the brick at an archeological site could be determined. Brick marks can also provide information as to where construction materials came from. The discovery of firebrick at the Franconia furnace site made at Perth Amboy, N.J., therefore tells us something about the economics of heavy industry in this otherwise remote corner of the state.

Firebricks from as far away as New Jersey would have probably not have been purchased until there was a railroad connection close to Franconia. The tracks of the Boston, Concord & Montreal Railroad reached Woodsville in 1853, then extended through Lisbon to Littleton later in the same year (Garvin to Rolando, Feb. 19, 1996).

All bricks found at the site, whether of the common or firebrick variety, were inspected, measured, and their markings recorded. Photos were taken of some. Only commercial markings are considered important dating mechanisms. Dimensions also indicated a variety in shapes, however, which might provide information on their possible uses. Dimensions might also be used for comparison with bricks of identical or similar dimensions that are mortared in place but whose markings either cannot be totally deciphered or whose uses are undetermined.

The only bricks found at the furnace site were inside or at the mouth of the arches. Shallow excavating at the base of the hearth in the north arch uncovered some of the best-preserved bricks. As no brick was seen as part of any outer construction of the stack, these were probably those that had fallen from the lower courses of the internal furnace lining. Inspection of the inside through a hole in the upper-left corner of the west archway verified internal brick lining and possibly an additional brick inwall. Lining bricks were laid in rowlock fashion (side-by-side). Since the hearth is choked with the frozen remains of the final charge, internal inspection of lining material is impossible. Table 3 presents data on bricks found in the north and west archways.

Table 3. Firebrick Data.

| Type | Dimensions* | Marking** |
|---|---|---|
| firebrick | $9$ by $4\frac{3}{8}$ by $2\frac{1}{2}$ | A HALL & SONS***<br>No 2<br>Amboy, NJ |
| firebrick | $9$ by $4\frac{1}{2}$ by $2\frac{3}{8}$ | A HALL & SONS<br>?YIRA<br>AMBOY, NJ |
| firebrick | $8\frac{5}{8}$ by $4\frac{1}{4}$ by $2\frac{3}{8}$ | LK<br>(reverse side textured) |
| red brick | $7\frac{1}{2}$ by $3\frac{3}{4}$ by $1\frac{5}{8}$ | none |

* in inches

** underscore = questionable character

*** Alfred Hall, brick maker, appears in *Kirkbride's Business Directory for 1850 and 1851* (Weiss 1966:42).

What the "No 2" refers to on one of the firebricks is not known. Nothing can be found that documents brick numbers. Of the over 100 bricks this author has recorded the past few years, five "No 1" and two "No 2" firebricks have been encountered. Two of the "No 1" firebricks are wedge shaped, two others are of unrecorded shape (not measured), and one is a nearly standard firebrick size. One of these "No 2" firebricks measured close to the standard firebrick size while the other is wedge shaped and measured 13½ by 4⅜/6 by 2½ inches (Rolando brick files). Since size and shape do not appear to be related to number, the number might indicate brick hardness or temperature resistance.

Although the three recorded firebricks were close in size, it is unknown what brick-making standards were in force in the 1850s. Brick size was regulated by the English government as early as 1571, while standardization of American bricks didn't occur until the late 19th century, with different brick manufacturing associations announcing different standards. The standard size for firebrick appears to have been 9 by 4½ by 2½ inches (Gurcke 1987:117). Since these standards were based mainly upon what were generally accepted sizes already being used by the brickmaking industry at the time, the similarity between that standard and the dimensions of the recorded Franconia bricks should, therefore, come as no surprise. It also makes the point that at least the firebrick used in lining the Franconia stack was a state-of-the-art material.

One brick recorded at Franconia displays an unintelligible mark where the other indicates "No 2". The mark appears to be a 4- or 5-letter word ending in "..IRA", or possibly "..YIRA". What this means is unknown. No other brick was found that approached this mysterious marking. Likewise unknown is the meaning of "LK" on another brick (Lehigh Kiln?).

Furnace linings didn't last forever. As the smelting progressed, the face of the firebrick lining burned. When a significant amount of brick burned away, the furnace was shut down, the lining torn out, and new lining installed. It was not unusual for furnaces to be relined about once a year, for a heavily used furnace in constant operation.

Finding where brick, slag, and damaged hardware were dumped can prove a valuable find. We found some material from the furnace north of the stack, forming the base of the road that used to lead south from Route 117 to the works. It would be expected, therefore, that much old firebrick would be found eroding out the sides of this low embankment. Close inspection of the length of the embankment, however, revealed no significant pieces of firebrick, either on the surface or after shallow excavating at various places along the embankment. Waste firebrick either was dumped elsewhere, it remains deeper under the old roadway, or maybe the original firebrick lining is still in the furnace.

Further work is suggested in investigating and recording what bricks remain inside the stack, documenting dimensions, markings, type, and functions, and pin-pointing exactly where in the stack the recorded bricks came from. No bricks that are mortared or otherwise set in place in or on the stack should be disturbed or removed from their place in the process of any recording activity. Controlled excavation into surface breakdown debris inside the archways should reveal more bricks that have fallen out from the lining and inwall. Former dump areas outside the immediate ironworks vicinity should also be located and investigated for the presence of waste furnace material.

## East Arch Excavation

One of the recorders, Jonathan Edwards, brought along his metal detector which we put to use finding what could be detected around the base of the stack. A 4-foot-long area in front of the east arch gave a strong signal, appearing to indicate a large metal artifact just below the surface. Since the surface area around the stack is mostly breakdown from the stack, we decided that excavating until we found undisturbed ground was not in violation of archeological ethics. Megan Battey, whose archeological experience includes working with David Starbuck at Rogers Island the past number of summers, volunteered to do the small excavation.

The area chosen for excavation was about 5½ feet out from the end of the east arch. Megan carefully dug an approximately 2- by 3-foot pit to the depth of about a foot, uncovering bits of wood, fragments of glass, a number of cut nails, and piece of flat, thin metal (figures 35 and 36). The large, hoped-for ingot of pig iron was not found. The artifacts were photographed, bagged, and turned over to the project leader for storage. A piece of plastic sheet was laid out at the bottom of the pit before it was backfilled. See Appendix D for Megan's full excavation report, site sketch, and identification of artifacts.

## Furnace and Other Slag

Slag is that ubiquitous waste material that is usually the first surface clue one looks for when searching for blast furnace remains in the field as a by-product of iron smelting. Early 19th-century blast furnaces produced varying amounts of slag, and deposits have been found both upstream and downstream at some of the sites. And the Franconia furnace site was no exception, where slag was found almost everywhere at the site, including on the opposite side of the river (see Robert B. Gordon "Material Evidence of Ironmaking Techniques" *IA*, Vol. 21, No. 2, 1995, pp. 69-80 for recent slag analysis).

Although the Franconia blast furnace operated from about 1811 to maybe the 1860s, there is no large mass of slag in evidence to reflect this. As was the practice, blast furnaces operated only when certain factors were favorable. One such factor was the market price of iron, which was in turn affected by market demand (or lack of), foreign competition, wars, and general state of the economy. During periods of western settlement, the demand for iron made it profitable for a remote furnace in the northern mountains of New Hampshire to fire up and produce cast iron. Otherwise, the furnace remained cold during periods of economic depression. As we learned in Garvin's report, the furnace operated on and off, and one wonders if maybe it was off more than it was on, which could account for so little slag compared to the purported years of operation.

Pieces of slag were found eroding out of an embankment about 50 feet northeast of the stack, out of the shore line due east of the stack, and out of the hillside and shoreline at various places downstream and upstream of the stack. Furnace slag was also found on the east bank of the river, directly opposite and upstream from the stack. These deposits were not, however, in great quantities. The most significant deposit of furnace slag was found just southeast of the stack among low stone foundation walls. It is suspected that the

Figure 35. *The extent of digging into overburden in front of the east arch.*

Figure 36. *Artifacts recovered from the east arch excavation (Megan Battey photo).*

immediate furnace area experienced mechanized earthmoving, so that former piles of slag might have been spread about. Slag could also have been used for fill or mixed with bitumen for road surfacing miles from the site.

Furnace slag was also found in the backyards of apartments east of the dam site, some 250 feet upstream of the stack. After seeing some tiny pieces on the surface, scraping with the heel of a shoe uncovered slag in many places in the yard. One wonders in how much slag might be found in many village front and back yards, and what that might tell us of potential bloomery and air furnace sites.

Colors of slag were light to dark blue and black. Crusty, dull black slag was also encountered, usually indicative of a poor heat (figure 37). Few pieces of slag larger than a baseball were found. Nothing significant could be learned from inspection of the slag found in the immediate vicinity of the stack.

Slag found across the river raised some interesting questions. Much of the slag here was black and heavy, appearing more like bloomery-type slag (figure 38). Since there is some hint of a bloomery and/or steel works having operated on this side of the river at an early time, this slag might be the only currently visible surface remains of these operations. Some dark slag was found eroding out of the shore only inches below the surface, but shallow testing a few feet inland surprisingly uncovered no slag of any sort. Samples of this slag were analyzed by Matt Kierstead and his report is reproduced in full in Appendix E.

It is recommended that "collecting" of slag by tourists as souvenirs be discouraged. Appearing limitless, the range of slag at the site has not yet been fully analyzed and documented, and therefore not yet thoroughly understood. Future slag analysis might tell us much about the types and efficiency of Franconia iron making operations, and is an important artifact not to be overlooked in the overall study of the site.

## The Waterpower System

Some surface indications exist to provide information regarding the waterpower system. We know of the dam, and from surface findings there and some old illustrations, have a handle on what existed there. And we also know that a flume conveyed water down the west side of the river into the furnace grounds. The water probably powered a waterwheel at an earlier time and the works might have converted to turbine drive by the 1860s (although at Forestdale, Vt., the waterwheel was employed to its final blast in 1864). Nothing can be found that indicated the Franconia operations ever used turbines to drive anything connected with the furnace operations.

The Dam Site: The photo of the works shown in the *White Mountain Echoes* and identified as being taken "about 1875," shows the dam upstream of the stack but exhibits few details about the dam's physical characteristics. It appears about one story high compared to the building standing at its east end, and water seems to be flowing over it (see figure 45). The building that stood at the left end of the dam is identified as Steven

Figure 37. *Typical pieces of blast furnace slag found at the site.*

Figure 38. *Slag found on the east side of the river, probably not of blast furnace origin.*

Eaton's sawmill, run by waterpower (Welch 1972:55). Another structure, at the right end was the head gate, which controlled the flow of water into the head race. A post-1884 photo no longer shows the gate house (Aldrich ltr., Jan. 17. 1996). Physical location of the remains of the dam and recording what remains existed was one of the project's priorities.

We were led to the remains of the dam by Duncan Wilkie, who had done previous recording work here in the early 1990s (see figure 4). The east end of the dam was found along the shore of the river 280 feet west of the stone foundation of the apartment building on the west side of Main Street. The east end of beam A (figure 39) was surveyed at 248.232 feet 165.245 degrees from the furnace datum point. Visible surface remains of the dam consisted mainly of two sections of log cribbing and four stub ends of sheathing sticking out of the ground just upstream from the cribbing. Duncan Wilkie and Megan Battey recorded the dam site (figures 40 and 41).

The two pieces of cribbing lay parallel to each other at right angles to the river. The upstream of the two beams, beam A, measured 14½ inches wide by 5 feet long. This beam contained four holes, a few inches deep, about a foot apart along the center of its length, as if vertical iron rods might have rested in them. The other beam, beam B, measured about 10 inches wide by 5½ feet long. Beam B also had a series of holes roughly along its center line. No attempt was made to excavate to determine the depth of the beams into the ground or if more beams lay below. Both top surface of beams were at the time of measurement above the waterline; beam A, a foot from the water's edge and beam B at the water's edge. Both were probably 50% below the water table.

The ends of four sheathing boards stuck up through the ground, in pairs of two each. They were in line with each other, parallel to and just upstream of the cribbing beams. They measured about 1 inch thick by about 15 inches wide and protruded upward toward the cribbing beams at about a 45-degree angle. The first pair, pair C, were 3½ feet upstream of beam A. Pair D were about 4½ feet southwest of the west end of beam A. Pair C were 3 to 4 feet from the water's edge while pair D were in the water, less than an inch deep at that point. No further surface evidence of dam features could be found on this side of the river or in the river bottom as best it could be inspected by wading out into the river. The center of the river was about 2 feet deep in this vicinity (although in August 1996, evidence was found to show that the river had risen up to an additional 6 feet during the spring thaw).

Inspection of the opposite (west) side of the river in 1996 revealed two iron rods well-driven into river-bottom ledge. One rod was 1½ inches square a was holding horizontal beams running parallel to the river in the embankment; another rod, 15 inches due east in the river, measured 1⅝ inches in diameter. Immediately adjacent in the upstream direction were the ends of more beams, appearing to be perpendicular to the river (jutting out from under the embankment). This area is exactly opposite the dam site on the east shore and appears to be at the start of the head race feature.

Insufficient physical remains are evident to allow an accurate description of the type of dam that stood here. From what there is, it could have been a plank crib type dam, that is, one made of heavy wood beams laid at right angles and built up in "boxes" that

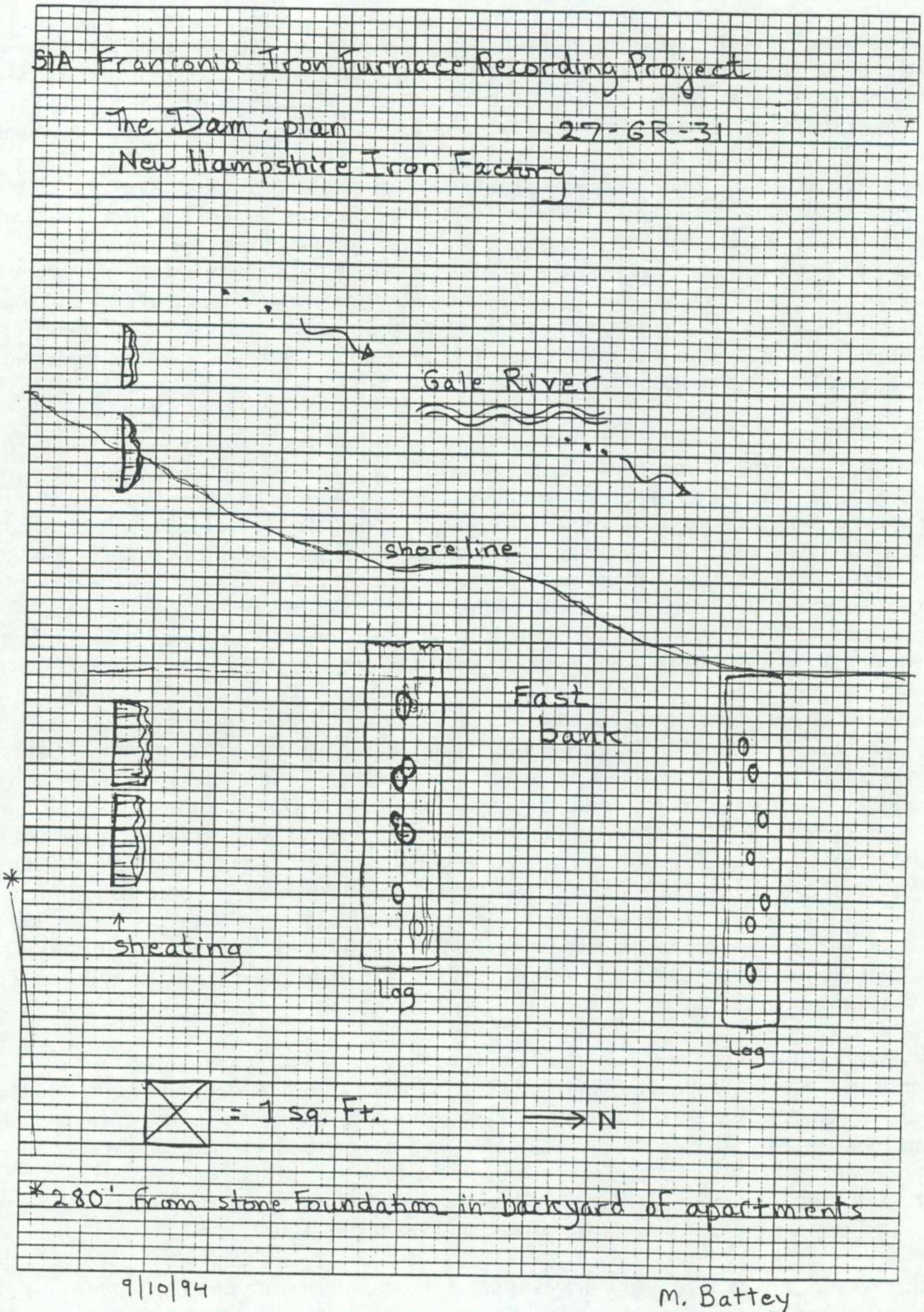



Figure 39. *Surface remains of cribbing at the dam site (Megan Battey field sketch).*

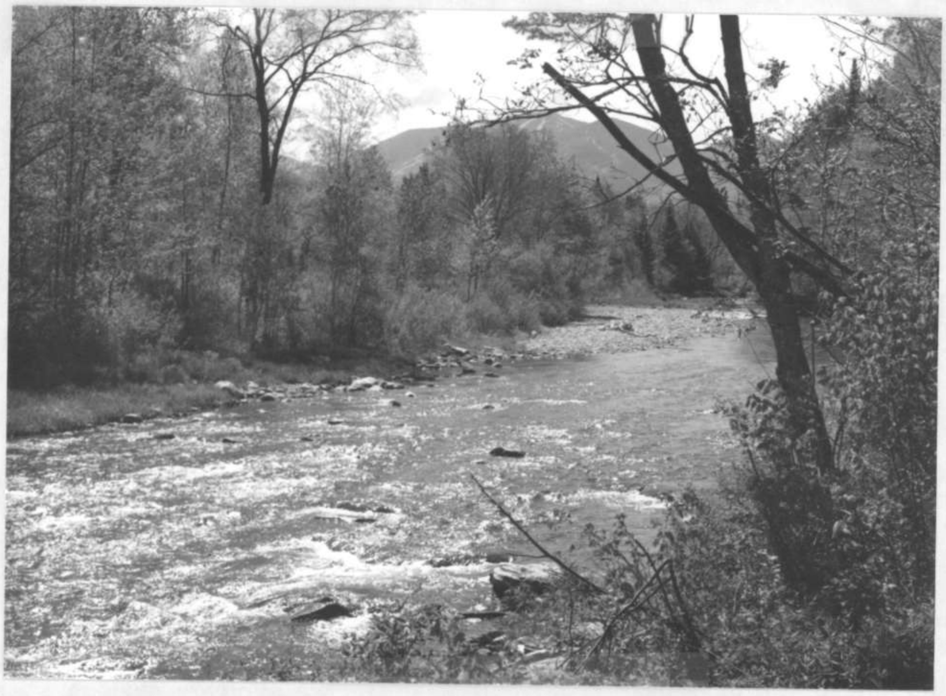


Figure 40. *The dam site from in front of the furnace stack. The dam site is in the center of the photo, diagonally across the river.*

Figure 41. *Wood remains of dam cribbing at the dam site (Megan Battey photo).*

were filled with rock for heavy anchoring. Plank boards were then laid up at a slowly rising slope on the upstream side to the top of the boxed cribs, nailed flat across the top of the rock-filled cribs, and vertically against the downstream face of the cribs. The sloping upstream boards broke the force of rushing water, allowing it to flow up and over the tops of the closely-boarded cribs. Many other mill dams have been observed of similar type construction. They were relatively simple in design, easy and inexpensive to build, and withstood spring run-off. Variations of this dam, such as a "crib dam with plank covering" and "pile and frame dam" are other possibilities (see Leffel 1874:71-77).

It is unknown when the dam was destroyed although most likely one spring by a freshet. Two early 20th-century vintage postcards that show the furnace stack also show, in one, the dam standing with the mill building beside it; the other shows neither dam nor mill. If the dates of these postcards could be determined, then a bracket of time for the destruction of the dam could be determined.

The Head and Tail Races: A ditch-like feature that parallels the river south of the stack for about 50 feet is most likely part of the head race. The race is most visible at its northern end. Followed south (upstream) toward the dam, it becomes better defined for a few feet, then seems to get lost in embankment debris and brush (figure 42). It is not known whether the water flowed directly inside this feature or through pipes laid in it.

Nothing can be found that sheds any light on the waterpower system at the furnace, The US Census of 1850 describes the works as containing, among other things, "a water-powered blast furnace" without indicating whether powered by waterwheel or turbine

Figure 42. *View north down the head race looking toward the stack.*

(Garvin 1994:9 [1850]). A deep depression immediately southeast of the stack might have been a wheel or turbine pit; excavation here might reveal which. Clearing some overburden in the depression uncovered sections of an old pipe, a casting that appears to be a part of a horse buggy, and maybe a base for a cast iron stove. Jewell Friedman said that some earth had been moved about around the stack many years ago so material found here might have come from anywhere.

About 30 feet southeast of the stack is a small hole that didn't seem important until a 6-foot-long stick was poked horizontally into it without hitting an end (figure 43). The hole seemed to head back toward the stack. Having no flashlights, we were unable to inspect the tunnel further. A flash photo taken by holding a camera in the hole resulting in discovering a stone-lined wall, two courses high, in relatively good condition (figure 44). Since the tunnel is part way between the above described depression and the river, might it have been used to drain hot water after having circulated through the tuyeres?

## Lower Level Buildings and Foundation Walls

Inspection of the ca. 1875 photograph of the works in the Serafini article provides a wealth of information about the disposition of buildings at the site. It shows the ironworks complex, river, and dam (figure 45). The view is from the downstream side and clearly shows the furnace building, the tall building facing the river, and the long casting building that parallels the river. The design and layout of the buildings is conventional for the period and is similar to layouts of contemporary blast furnace operations inspected in other states.

Except for the top chimneys, no parts of the furnace stack were visible since the building insulated the stack from the cooler outside environment. All the buildings standing on and around the stack were made of wood, and what was not destroyed by the fire was probably dismantled and sold for salvage value, as also was the custom.

<u>The Top House:</u> The tall building that faces the river houses the furnace stack. If counting the rows of windows is an accurate measure, then the furnace building is three stories tall. The top floor is level with the charging bridge, and therefore nearly at ground level with the sheds seen at the upper level.

The appropriately named top house sits atop the furnace. This structure was an integral part of the building that completely surrounded the stack. It protected the stack from the elements and acted to insulate it and keep the heat of smelting from being "drained" off. The top house gave workers a protected area in which to attend to the needs of the process, which was to open the charging door to feed into the furnace its charge of ore, fuel, and flux, and then close the door. It also housed the heating ovens, in which otherwise wasted exhaust gases were recycled through radiator tubes to preheat cold incoming draft before it was applied to the tuyeres near the bottom of the stack. The top end of the air blast pipe (the downer) which descends down into the east arch can be seen at the top of the stack from across the river with the aid of binoculars.

Figure 43. *The open end of the tunnel (right). The stack's east arch in background.*

Figure 44. *Inside the tunnel, taken by holding a flash camera just inside the small opening. Note the stone wall in good condition.*

A pair of chimneys and a roof-top monitor can be seen at the very top of the building. Why one chimney is shorter than the other is unknown. Both were probably related to exhausted spent hot gases that heated the radiators. When the furnace received a charge, the top had to be opened and much smoke and gas rose up out of the stack. These rose to the top of the building and escaped through the small roof-top monitor also seen in the photo (see figure 49 for another view of the chimneys and monitor).

The Casting Shed Area: The long, 1½-story building that parallels the river is the casting shed. The casting area of the shed is betrayed by its characteristic roof-top monitors, which run the length of the building. The monitors allowed the heat given off from casting to rise upward from the casting floor and out the roof. The chimney rising from the top of the casting building along the north wall of the furnace building vented heat from the casting arch directly below, another characteristic design seen in many drawings and photos of 19th-century blast furnace operations.

The physical outline of where the casting shed stood is seen by the foundation walls that partially surround the stack on three sides. Consisting in most part of massive stones, this wall is all that remains to provide a visible sense of the casting building's dimensions and proportion (figure 46). Assuming the casting building set upon these foundation walls, the building was 50 feet long by up to 40 feet wide.

Blast Machinery Area: Level with the top of the casting shed foundation wall south-west of the stack is a relatively level 35-foot wide area. A 6-foot 7-inch long section of

Figure 45. *Photo of the works taken "about 1875" (Serafini 1952:15).*

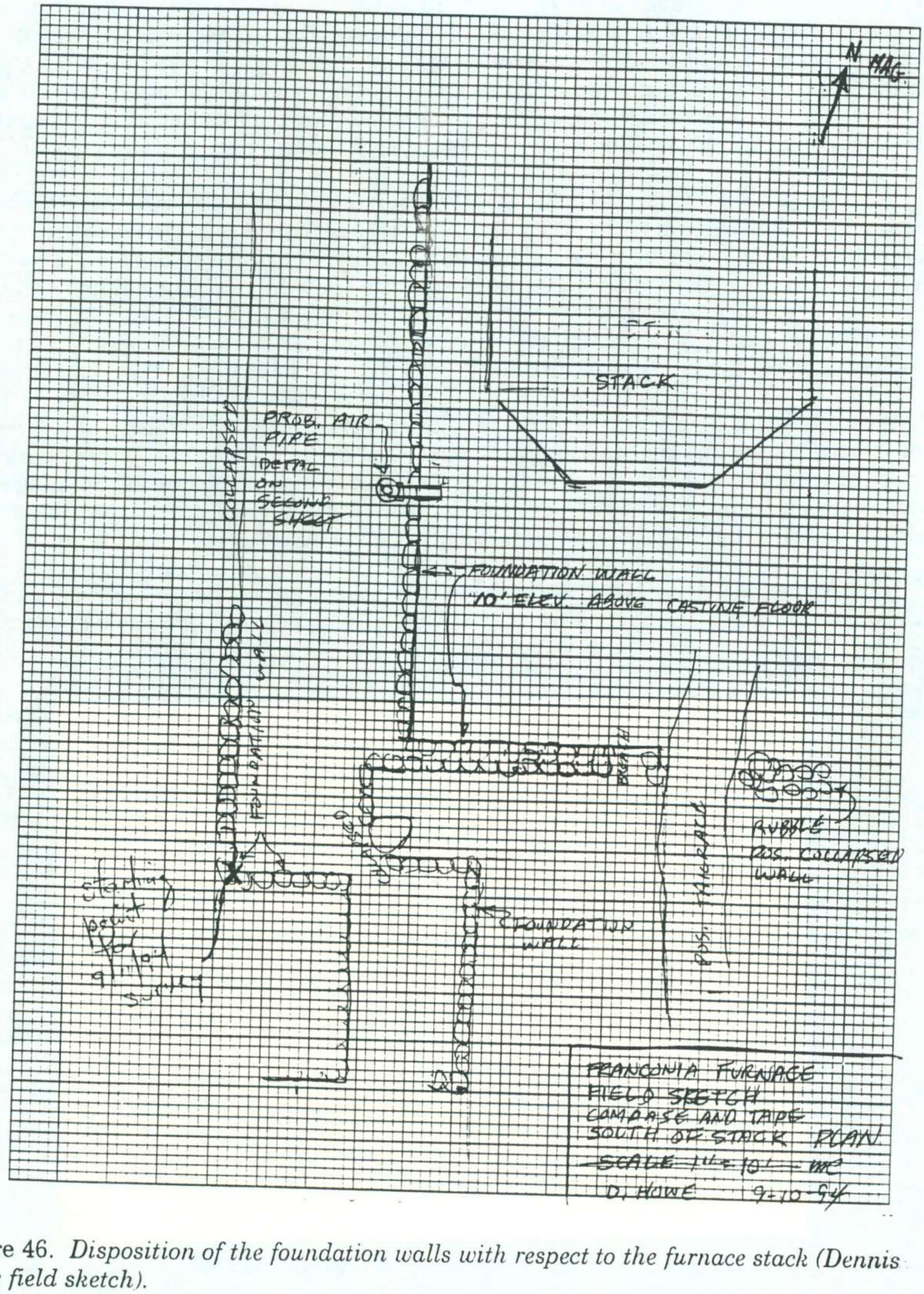



Figure 46. *Disposition of the foundation walls with respect to the furnace stack (Dennis Howe field sketch).*

cast iron pipe lays atop the wall here, its 11-inch diameter open end facing the river (figure 47). The 11-inch pipe diameter closely matches the dimension of the downer pipe in the east arch. The wall is 10 feet high above the local ground level at this point. The pipe might indicate this as being where the air-blast machinery operated. Detail inspection of the surface in this area for such things as machine mounts or heavy iron rods might reveal clues to the arrangement of blast machinery.

The main north-south wall makes a right-angle turn about 55 feet south of the stack and gets involved in two levels of stone walls. This uphill area immediately west of the flume might have been connected with the waterpower system, but this is just conjecture. These walls might be related to sheds that stood about here.

### Upper Level Buildings and Foundation Walls

The ca. 1875 photo shows the charging bridge, some upper level sheds, and another high stone wall (see figure 45). In these upper sheds the ingredients that were to be fed into the stack were stored. Although large amounts of iron ore and limestone could be accumulated, charcoal was kept only in small amounts so it wouldn't absorb moisture and burn poorly. For that reason, charcoal was usually made close to the time it was needed. Close inspection of the 1875 photo shows two buildings standing at the upper level. A third building might be partially hidden by the charging bridge although what appears to be the peak of its roof shows just above the roof of the bridge.

The Charging Bridge: Only two illustrations show the charging bridge with any clarity (see figures 45 and 48). The charging bridge connected the top of the furnace stack to the hill behind (west of) the stack, perpendicular to the flow of the river. The purpose of the bridge was to provide a convenient access to the top of the stack so the iron ore, charcoal, and limestone flux could be fed into the top of the furnace. The floor of the bridge was usually on the same level with the top of the stack so that no steps or inclines were involved. It was also level with a platform of area on hill-side end of the bridge.

The charging bridge at Franconia was supported by a pair of side-by-side vertical beams, mid-way between the top-house and the hillside. As was the usual practice, the bridge also appears from the photos to have been made completely of wood. It had a peak roof that ran its length which gave the appearance of a typical New England wooden covered bridge (and may have incorporated typical covered bridge truss designs).

We don't know the dimensions of the top house or the structure that surrounded the stack, so we don't know exactly how long the charging bridge was. A good estimate based on ground measurements, however, indicate a length of 50 feet. Close inspection of figures 44 and 48 with particular attention to comparing heights of known stone walls in comparison to structural features closely confirms the 50-foot estimated length of the bridge, which also appears to have been about 8 feet high from floor to peak. The floor of the bridge appears flat and without tracks for rail-type vehicles. Carts containing furnace ingredients were therefore manually pushed across the bridge to the top of the furnace.

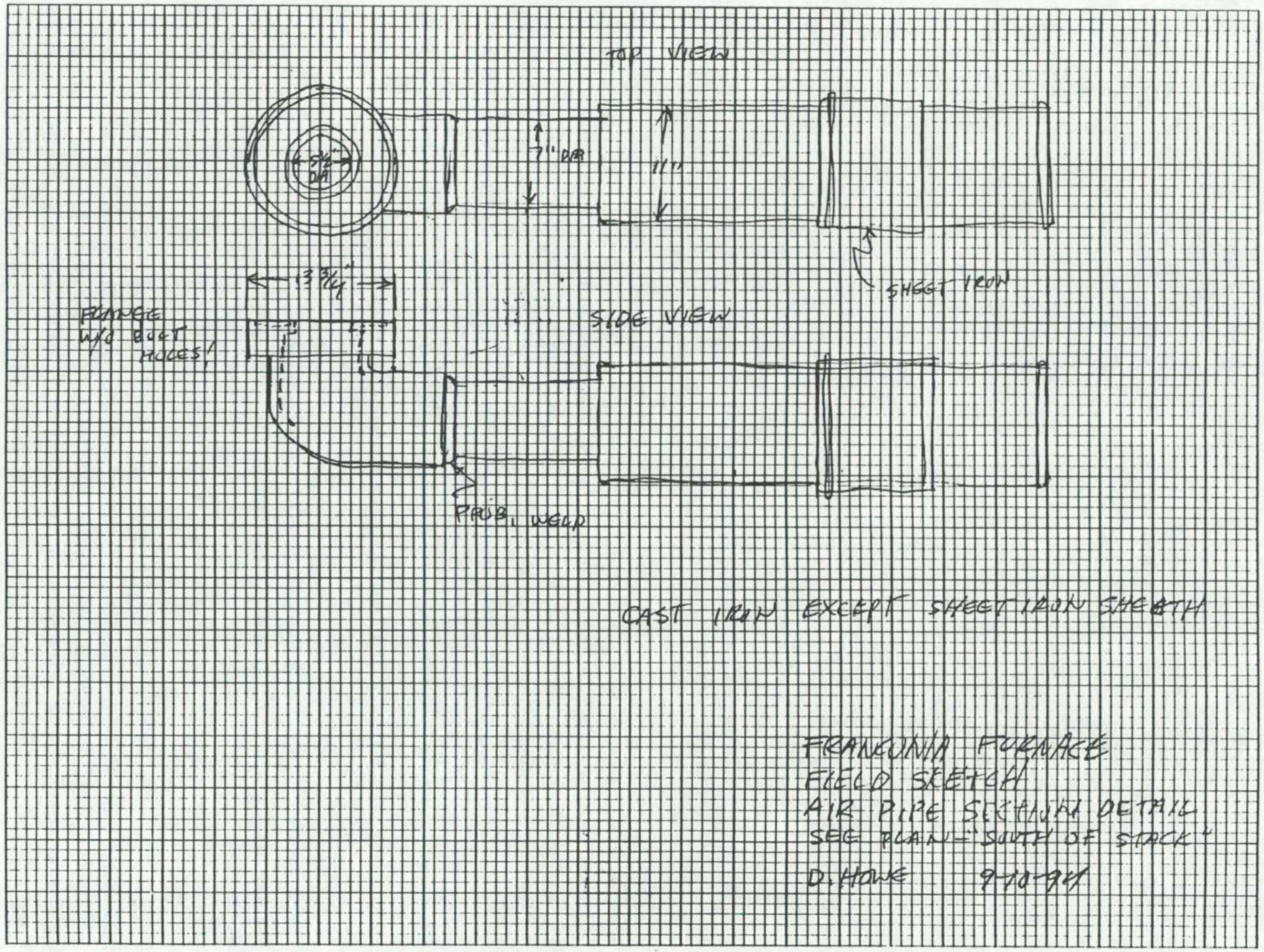



**Figure 47.** *Details of the cast iron pipe, probably part of the air blast system, found atop the foundation wall just southwest of the stack (Dennis Howe field sketch).*

<u>Upper Sheds and Stone Walls:</u> At least three sheds stood on the hillside immediately west of the stack. Photos loaned to me by Roger Aldrich (via Jewell Friedman) show one shed (25 feet wide by 50 feet long?) at the uphill end of the charging bridge, and two more of about the same size standing side-by side about 100 feet south of the first shed. Where the charging bridge shed stood is now mostly the driveway/parking area for the Casey/O'Brien house. The site of the other two sheds to the south is an area of disturbed ground, although there might be some surface material there. The area was overgrown and the surface of the ground was difficult to see the day we inspected it.

The shed closest to the bridge was where the furnace ingredients were weighed prior to being fed into the stack. The other two sheds were probably the storage sheds. Which stored what we do not know, but we did find pieces of iron ore and charcoal throughout the upper level areas of the sheds. We also found curious depressions that might have been platforms for other buildings about 200 feet southeast of the house.

About 50 feet north of the O'Brien house is a pile of what appears to be pieces of iron ore. Whether this was always there or collected over time by the owners is not known. Farther uphill we were told is the foundation remains of "the dynamite shed." A search for it proved fruitless, although we don't doubt it is there, somewhere.

Walt Ryan and Krista Butterfield made an extensive survey of this upper area by means of a hand-held compass. Their survey followed various stone walls that parallel lower walls. The survey crew also shot some lines into the upper area and the results of

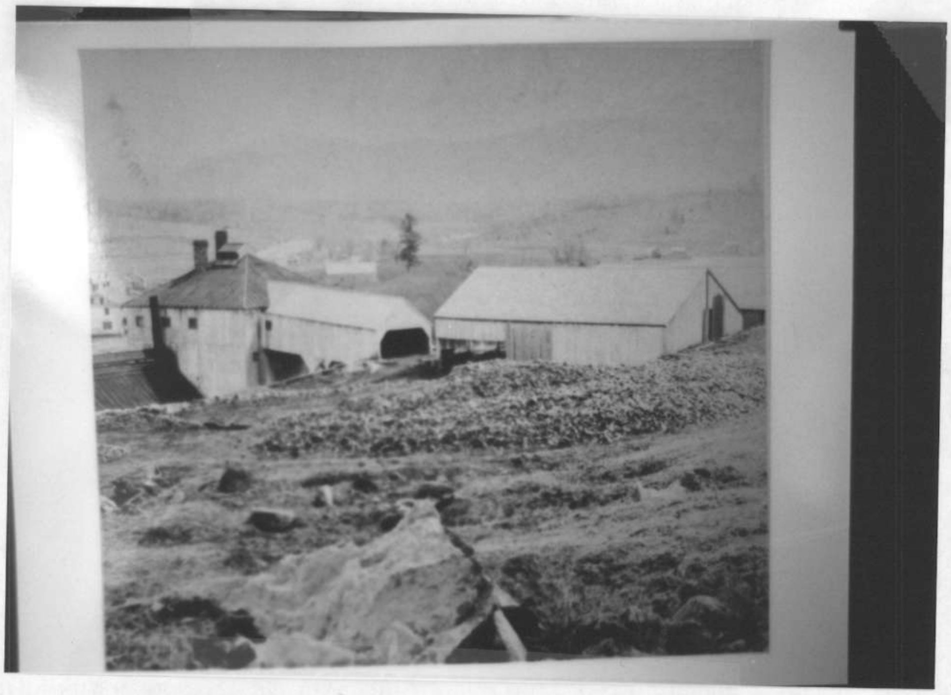


Figure 48. *An undated photo of the works taken uphill and northwest of the stack. Village buildings can barely be seen in the distance (courtesy Richard S. Allen and Robert M. Vogel).*

both these surveys, along with important identifying points, were sketched out. A tabulation of this survey is included in Appendix F. Possibly at some future time we could scan all the old photos of the site into a PC and create a floor plan of the buildings with some CAD/CAM software.

Although I can understand why, it is too bad that Charles Casey built the house where he did, in the midst of the sites of the upper sheds. Much valuable information is probably lost forever due to the earth moving to build the house and garage foundations.

### Associated Village Structures, Landmarks, and Artifacts

A number of buildings in and around the village once related directly or indirectly, to the ironworks. For example, the first store in the village was run by the "iron Foundry Company." It became Sanborn's Store, and later, owned by Frank E. Casey, Sr. (Welch 1972:45). Casey had the first of his two restaurants, Casey's Grill (1938–1948), on the first floor while upstairs was used for town and Grange meetings, movies, dances, Odd Fellows, and other functions. Casey sold the building in 1948 and it burned later that year. This building stood immediately south of the present gas station that is on the east side of Route 18 at the Route 117 bridge. In 1950, the Caseys opened their second restaurant, "The Stone Stack Restaurant," in their home across the bridge (the large white house where we parked our cars during the recording sessions), and operated it for a few years, probably to 1953 (Friedman to Rolando, Feb. 10, 1996).

There is also mention of the "Old Iron Mine Tavern" (1972:46 and photo 1972:44), a map showing the "Old Iron Store" (1972:10), and the "New Hampshire Foundry Company blacksmith shop" (1972:52). The town's first library was in a building also owned by the ironworks (1972:123). Not being familiar with village buildings, we do not know if any of these exist today. It would be beneficial to locate and document all buildings that had former connections to the ironworks.

In 1952, the foundation for the Upper Works boarding house were still visible "nearly opposite the entrance to the Sugar Hill swimming pool" (Serafini 1952:15). And the boarding house for miners, located on the slope of Ore Hill above the present Sunset Hill House garages, was taken down years later and reassembled at the lower end of Sugar Hill village, and was the home of Edward Jesseman (1952:16).

The present Route 117 bridge was built in 1972. It replaced an earlier bridge that crossed the river here and appears to have been a parker truss with steel girders. It was hit by a truck carrying steel reinforcing rod for I-93 construction, perhaps in 1972, and was eventually replaced by the present concrete bridge. From information provided by Jewell Friedman (from Roger Aldrich and Don Eastman of Franconia), at least two steel bridges crossed the river in this area. One early photo shows a wood bridge of possible pony truss design, which might explain the stone abutments we found about 100 feet upstream of the bridge while doing our initial walkover survey of the grounds.

No railroad station exists in the village; the only known station in town was built well after the iron company era for tourists at the notch. Railroad connection for the ironworks was probably at Littleton, 5 miles north, although a connection with the line at North Lisbon Station (identified "Barrett" on the USGS topo map) via Streeter Pond Road was a half-mile shorter. It would be interesting to find how the company shipped out its products; maybe there's a yet-undiscovered piece of pig iron or other significant artifact laying about the tracks?

Pictures in Welch show stoves and kettles attributed to Iron Factory Company, both being common products of 19th-century ironworks (1952:48-52). The kettles today are at Cannon Mountain House on Easton Road and are of various sizes. Jewell Friedman measured one for me: 39-inch inside diameter at the lip by 16 inches deep, ⅜-inch thick walls, two 3½- by ½-inch handles, and three ¼-inch holes in the lip, equidistant apart, as if for hanging (Friedman to Rolando, Feb. 10, 1996). The largest of the kettles was used for scalding hogs, after butchered, to loosen the bristles (Aldrich to Friedman). In 1996, two more kettles were inspected in front of Polly's Pancake Parlor up Route 117 in Sugar Hill, which Roger Aldrich attributed to the Franconia ironworks.

During the course of writing this report and doing background research, a number of 19th-century photographs of the furnace grounds, before and after the fire, were brought to my attention. Many also show glimpses of the village on the other side of the river. Some of these photographs were seen at the NHHS library; others were shown to me by Jewell Friedman (most came from Roger Aldrich of Sugar Hill, who wrote a book on the subject; another came from Don Eastman).

## Iron Mines and Charcoal Kilns

A number of iron mines and charcoal kilns are known to have operated in the vicinity of the ironworks and the purpose of this section is merely to document those that have been noted from various sources. During the 1994 recording session, Duncan Wilkie led a lunch hour expedition to one of the ore pits on Ore Hill.

<u>Iron Mines and Ore Pits:</u> The following are references to iron mining that are mentioned in Garvin's chronology (Appendix B):

The earliest mention of mining iron ore 1810, when "the company was taking all its ore from the Coleby lot on Ore Hill. This ore was described as superior to that from the Howland lot, which the company previously mined." Ore Hill is a 2,025-foot mountain about 2½ miles southwest of the works in the town of Sugar Hill (USGS Sugar Hill topo). Location of the Howland lot is not known.

In 1816, ore was taken from "the Ditch, which had for some years been abandoned." In 1823 it is noted that "ore is obtained from a mountain in the east part of (Lisbon), three miles from the furnace...yielding 56 to 63%." In 1849 "a rich vein of granular magnetic iron ore" is described in the southeastern corner of Lisbon. The vein is 3½ to 4 feet wide and was opened 40 rods long and 144 feet deep. The south-eastern corner of Lisbon is about 2½ miles west of Ore Hill. The last mention is in 1859, when it is reported that the iron mining in Lisbon employed 22 hands with a 25-horsepower steam engine.

Serafini wrote that iron ore was discovered in the 1790s on Iron Mountain, now Ore Hill (1952:15). After the Civil War, a Mr. Best of Montreal took several tons of ore from the mines in Sugar Hill. The mining rights were purchased by Brown and Wales Company, and the mining rights remains with descendants of the Wales family although the property was owned by Warren R. Swift (Serafini 1952:17).

The *History of Franconia* mentions that iron ore was found in town in the 1790s and the vein crossed Stinson Hill (which cannot be located on any USGS maps) toward Sugar Hill (Welch 1972:37). *Mining Lore from New Hampshire* by Lillian A. Burns (1980) describes various folklore connected with iron mining at and around Franconia.

*Over the River* contributes two pages describing iron mines at Ore Hill (and modern photo of entrance) and an old mine in Landaff, probably the Chandler Mine. It is "near where the old road from Mill Brook to Dearth Brook crosses a branch of Mill Brook, a little north of Moody's Ledge and Cobble Hill. There is said to be a large shaft of another iron mine southeast of Green Mountain, near an old trail going south from the Ireland School" (Blasidell 1982:44-45). The town of Landaff borders Sugar Hill on the southwest. Cobble Hill is in the southwest corner of the USGS Sugar Hill topo. The best job is done by Roger Aldrich in his recently published book, which devotes many pages to describing the mines (Aldrich 1996:28-33).

Duncan Wilkie led a lunch hour trip to a mine up Route 116 for 1.8 miles, right on Lafayette Road for 0.7 miles, left on Toad Hill Road (Forbes Road on USGS topo) for 1.2 miles, then right at a fork (Sugar Hill/Franconia town line) for 0.4 mile to large stones on left and woods road to the right. They parked and hiked up the road, taking the left fork at 100 feet (snowmobile trail). About 5 minutes walk uphill revealed deep pits on the left and right (Battey to Rolando, Sept. 11, 1994). Inspection of the USGS Sugar Hill topo shows this to be the southeast slope of Ore Hill, coinciding with the location of the "Franconia Iron Mine" per another source, which describes the mine as "Two large shafts and large cut (Dangerous). Several other shafts reported in woods...walk north uphill on old mine road...2nd mine go 100 feet north of 1st mine and take right fork of road to summit of next hill north and mine dump" (Morrill 1960:22).

<u>Charcoal Kilns:</u> A state historic marker identifies a charcoal kiln ruin beside Route 302 in the town of Lisbon, 1.65 miles east of the Route 117 (see page 13). The historic marker is on the south (river) side of the highway and the kiln ruin atop a low bluff on the opposite side. A steep but negotiable path leads up the side of the hill to the ruin, which, if you know exactly where to look, can be seen from the highway (figure 49).

The kiln was built of stone and much of its lower half is intact. It is overgrown with thick brush and it is difficult to see inside or measure accurately. From the outside, the ruin appears to have vertical walls but inside inspection revealed a definite beehive (conical) configuration. A section of inside wall was found to slope inward 27 inches at a point 54 inches high (60-degree inward slope). The inside diameter measured as near to the floor of the kiln as was possible, taking the breakdown into consideration, came out to about 17 feet, somewhat smaller than the usual 28- to 32-foot diameters found in Vermont. The uneven walls measured 2 to 3 feet thick with a southwest section of wall measuring about 7½ feet tall (outside measurement). Vent holes at various locations in the walls are coated with pitch. The kiln's main door, evidenced by a small amount of surface breakdown, faces the open field to the northeast. A search in the area failed to disclose anything further relating to the kiln or charcoal making. No hardware was found. Modern work on the highway immediately adjacent have obviously impacted on the site.

Charcoal was also made on Ridge Road and up Coal Hill Road (Welch 1972:53). Ridge Road is off Route 116, a mile south of Franconia village, and runs somewhat parallel to Route 116 about a half mile and 100 feet uphill to the northwest. The 1860 Grafton County map shows two "Coal Kiln" sites in Sugar Hill, one about a half-mile and another about a mile up Blake Road from Route 117.

Coal Hill Road is the east fork off Route 18 south of Franconia village just across the Gale River bridge. The road ducks under I-93, intersects with other roads, then steadily climbs the northwest slope of a hill, somewhat paralleling the Gale River on its left. Welch wrote that much charcoal is churned up when the road is plowed and that "the sites of the pits where charcoal was made are still visible on the farm, which is now a summer home known as Foxwood, owned by Mr. and Mrs. Willard S. Robbins" (Welch 1972:53). The inside back cover of the Welch book is a map identified "copy of plan of 1853" which shows tracts in the northeast part of the town identified "NHIFC" that might be the woodlots for making charcoal.

Figure 49. *Stone-built charcoal ruin alongside Route 202, about 5 miles west of Littleton village and identified by a state historical marker. The ruin is in typically good condition for this type building material.*

## Appendix A

*Memorandum of a Site Visit to the Franconia Iron Works Blast Furnace on July 6, 1989*

by James L. Garvin, Architectural Historian
New Hampshire Division of Historical Resources
July 17 and August 24, 1989
(Typeset for this report from copy provided by Garvin)

The purpose of this visit was to inspect the structure of the blast furnace, to gauge the amount and cause of deterioration, and to make recommendations for stabilization and protection of the structure in future years.

The blast furnace may be assumed to date from 1859, the date inscribed in a large voussoir in its northern arch in company with the name of "S. Pettee, J$^{r}$," evidently the stone mason who rebuilt the furnace for the last time. Nothing about the technology of stone splitting visible on the exterior surfaces of the octagonal furnace suggests a date earlier than about 1830; everything about the work would be typical of 1859.

The furnace is composed of an inner and an outer shell of dry–laid stone masonry, a large part of this being split granite rubble. The outer shell, well recorded in historic and recent photographs, is very skillfully laid, particularly in the area of the four splayed arches on the principal faces of the furnace.

The presence of the inner shell of the furnace can only be deduced from a study of the top, where the stones of the inside structure are visible around a furnace lining of firebrick manufactured in Perth Amboy, New Jersey. The function of the inner shell is evidently a structural one, providing support and rigidity for the renewable lining of refractory bricks. Without further investigation, it is difficult to judge whether this inner. shell is laid dry or in some kind of mortar, but for the moment it appears that its stones may be bedded in fire clay. There is a generalized fill between the inner and outer shells of the furnace; again, without further study it is impossible to judge whether this is composed of rubble, clay, or both. The inner and outer shells of the furnace are bound together on the four solid faces of the structure by horizontal iron bars which are bent over inner iron bands and then extend through the walls of the furnace to the outside, where they are pierced for large vertical iron keys or wedges (now lost). By this means, the bottom of the furnace, subject to the greatest pressure of molten iron and to the greatest degree of thermal expansion, was locked into a single unit.

As mentioned above, the furnace is lined with refractory bricks bearing the impression of a New Jersey manufacturer. This firebrick is quite intact and undamaged except in a zone extending down a few feet from the charging hole or tunnel head. Several apertures in the brickwork may be observed below the top of the furnace, seemingly placed rather regularly at intervals near the tunnel head. These may represent accidental losses of brick, or may be remnants of a system for forcing the draft or otherwise regulating the firing. The apertures appear to be topped with flat arches built from bricks; if so, they are certainly deliberate openings constructed for a purpose. The firebrick lining of the lower arts of the furnace is generally in good though slightly spalled condition. Below a certain line, perhaps 8 feet or so above the top of the crucible, the walls are coated with hardened slag and appear in a condition generally better than the walls above.

The bottom of the furnace is composed of a saucer-shaped crucible built of a ganister or mastic evidently composed of brickbats and clay or mortar. This crucible curves upward and outward to meet curtain walls of granite, which rest on cast iron beams at the rear of each arch. It may be assumed that these curtain walls are the bottoms of the inner shell of granite which extends to the top of the furnace. There is a slight gap between the iron beams at each curtain wall and the top of the crucible, probably representing the point where a tuyere entered the hearth. The crucible is supported on a square foundation which appears to be constructed of granite which has been discolored and partly decomposed by heat. This foundation is set well within the inner walls of the furnace, so that there is an aperture between its corners and the inner walls of the furnace.

The crucible and the boshes of the furnace are largely filled with debris; this is considerably deeper at the south wall than at the north, where the dam and casting floor were located. This debris may be part of a charge of ore, flux and charcoal which was never fired, or may even be the remains of a partly-fired charge which was simply left to cool in the furnace at the time of abandonment. It was coon in mid-nineteenth century iron manufacture to bank a furnace which was to be stopped for any length of time, as might have happened during the uncertain final days of operation. Thus, the debris left in the furnace may be the remains of a banking charge, in which it might be assumed that most or all of the fuel would eventually have been consumed while the mineral parts would have become reduced to a friable state as they slumped to the bottom over a period of a few days.

The abutments beneath the southeast and southwest faces of the furnace are pierced by low tunnels for a belly-pipe which supplied air to the tuyeres on the east and west faces of the structure.

Deterioration of the furnace may be ascribed to two causes: water and frost action and displacement of stones by tree roots. Of these, the more destructive agent is undoubtedly water and frost action. If water could be excluded from the furnace altogether, tree growth in and on the structure would cease.

The furnace was undoubtedly built in 1859 with the intention that its flanks, at least, would be sheltered beneath the roof of a large building which surrounded the structure. The single photograph of the iron works buildings that has been reproduced is not very clear, but seems to show that most of the furnace top was also roofed. Thus, it may be assumed that the furnace was designed more for its ability to contain heat and molten iron and to undergo expansion and contraction than for its ability to withstand water and weather.

It is, therefore, remarkable that the furnace has survived more than a century of exposure to the weather since its buildings burned in 1884. The fact that the stack has remained essentially intact suggests that no extreme measures will be required for its future protection. It will probably be advisable to undertake a minimal treatment at present and then simply to observe the results for some years before considering anything more drastic.

The main visible results of exposure over the years may be summed up as: 1) deterioration of the firebrick lining to a point a few feet below the tunnel head; 2) loss of some stones from the outer edges of the furnace top, probably from frost jacking; 3) loss of a few stones from the battered outer walls of the furnace, most notably one large stone halfway up the angle between the south and southwest faces of the stack; and 4) deterioration of some parts of the crucible from water and frost action.

In addition, the furnace is partly covered with a growth of small trees. These are mostly poplars, but also include balsam firs, tamaracks, and a few other species. Some of these trees have established themselves in fissures in the walls of the furnace; most of them are growing on the flat, earth-filled top. Photographs from the turn of the century show trees growing on the furnace at that time, as well. Since none of the present trees is large, it appears that trees have either been removed periodically, or (more likely) that they eventually die or are broken off by wind. The fact that the top of the furnace is covered by an incrustation of hard, brittle lichen suggests that the soil or clay infilling has low nutritive value; this, in turn, may prevent most trees from attaining much age or size.

It appears, therefore, that the greatest danger to the furnace is water penetration and frost action rather than plant growth, although the latter should certainly by kept to a minimum. It seems that it would be highly beneficial to exclude as much water as possible from the top of the furnace, where it can easily penetrate the clay infill. This should stop frost jacking of the perimeter stones of the outer wall, and should also reduce frost damage to the upper zone of the brick lining.

At the same time, it appears that the flue of the furnace should be kept open to provide ventilation of the interior. There is a strong tendency toward condensation within a massive masonry structure such as this, as well as the likelihood of rising damp from the ground below. It is important that air be permitted to circulate through the furnace base openings and up the flue in order to carry off this moisture and prevent frost damage in the winter. The amount of rainwater that would enter the furnace through the open tunnel head is probably of little consequence in comparison with the danger of stagnant moisture trapped within the body of the structure. If rainwater could be kept out of the tunnel head by means of an open cupola of some kind, that would be still better.

In order to reduce further damage to the furnace, both through the action of tree roots and (more important) through frost action, I would recommend the following procedure:

1. Cut off all trees growing on the walls and top of the furnace.

2. Treat all tree stubs with full-strength herbicide (ammate or equivalent) to prevent regrowth.

3. Cover the top of the furnace with a cap of fiberglass cloth and resin, using

pressure-treated 2- by 6-inch lumber, if needed, to produce an even slope to the outside and to add weight for stability in the wind. There appears to have been a brick-lined gutter constructed from the mouth of the furnace to the southeast face; this retains a crude spout of cantilevered stone slabs, apparently intended to carry water or other material away from the lower walls of the stack. This cantilevered low point would be the natural point of discharge for the water which would accumulate on a fiberglass cover.

4. Build a simple cupola of wood framing, with a fiberglass cover, to protect the tunnel head from rain, keeping the cover low enough to be inconspicuous or invisible from the public observation point east of the Gale River, yet high enough to encourage a good updraft through the flue.

This procedure has the advantage of being fairly simple, of being completely reversible, and of making no structural change to the furnace as it survives. It should be considered an experiment, to be monitored periodically. The fiberglass blanket would weather slowly and probably be somewhat affected by sunlight, and would probably have to be retreated with resin at fairly extended intervals. Construction of such a cap would entail some expense and cooperation from the owners and from local authorities. Given the amount of local interest in the furnace, however, the cost of such treatment should be reasonable and the procedure relatively easy to carry out.

## Appendix B

# CHRONOLOGY OF THE DEVELOPMENT OF THE NEW HAMPSHIRE IRON FACTORY COMPANY FROM 1805 TO 1884

**James L. Garvin**
**New Hampshire Division of Historical Resources**
**May 1994; revised August 1994**
(Typeset for this report from copy provided by Garvin)

**1764** Town of Franconia incorporated.

**1794** Jeremy Belknap, writing volume III of his *The History of New-Hampshire,* mentions bog iron ore and refers to a report of a portion of Mount Washington "where the magnetic needle refuses to traverse; this is probably caused by a body of iron ore," but makes no mention of a discovery of such ore near Franconia.

**1801** According to research by Duncan C. Wilkie, based on Grafton County court records (63-323, 63-324, 63-325) of 1814, the first forge and dam built on the two-acre blast furnace lot were erected in the summer of 1801 or 1802 by Simon Oakes, Thomas Spooner, and David Applebee. Their dam was located forty feet from their forge. On April 16, 1805, the three sold their property to Daniel Bartlett, a Massachusetts blacksmith. In two sales the same year, Bartlett sold three-quarters and then the remaining one-quarter of the forge, land, water privileges, and a coal house to Asa Towne. Towne was an incorporator of the New-Hampshire Iron Factory Company (see below).

**1805** The New-Hampshire Iron Factory Company was incorporated by the New Hampshire legislature. Named incorporators were: Asa Towne, Amos Towne, Solomon Towne, Moses Lewis, Stephen P. Webster, Samuel Hutchings, William Simpson, Joshua Goodale, and Stephen Couch. The operation of the New-Hampshire Iron Factory Company began to be referred to as the "Lower Works" after the incorporation of the following.

**1808** The Haverhill and Franconia Iron Works was incorporated by the New Hampshire legislature. According to Eliphalet Merrill, writing in 1817, these "Upper Works" were "built on the same plan as the former, but their operations are not yet so extensive." Duncan Wilkie states that the "Upper Works" were located on the Ham Branch of the Gale River, about a mile from the "Lower Works." We know much less about the "Upper Works" than the "Lower Works."

**1809** Elias Hasket Derby of Salem, Massachusetts, compiled a lengthy study entitled "Interesting Facts Relating to Iron Works compiled by Elias Hasket Derby for the use of the Franconia Iron Company." This hand-written compilation, accompanied by meticulously-drawn diagrams and figures, included copies of forty articles and patents, largely transcribed from encyclopedias and philosophical magazines. Derby's compilation suggests the low level of practical experience possessed by the founders of the company.

**1810** A report on the condition of the New-Hampshire Iron Factory Company was written by Joseph Bray of Boston, and published in Salem, Massachusetts. Bray noted that "when the Company commenced its establishment upon the banks of the south branch of the Amonoosack, it there owned but two acres of land, on which stood a small forge." This forge, built at a cost of $2,200 by a Mr. Sarjent under the direction of incorporator Amos Towne, had proven insufficient and had been replaced by a new forge shop with four fires and two large trip hammers. The company initially had great difficulty in obtaining lumber, common bricks, and limestone for flux; and "the first fire-stone used in the [first] furnace was imported from Connecticut, and the transport along cost upwards of 20 dollars per ton."

By 1810, according to Bray's detailed inventories, the company owned 5,456 acres (a tract sufficient to supply its entire need for charcoal), a farm, a tavern, a saw- and gristmill, a blacksmith shop, a store at Franconia, and a store at Bath for the sale of its iron products. By this time, the company was taking all its ore from the Coleby lot on Ore Hill. This ore was described as superior to that from the Howland lot, which the company had previously mined. The Howland lot was made still less advantageous by the fact that the competing Franconia and Haverhill Iron Works owned 15% ("the right of one and a half tenth") of the ore from the Howland lot and used the same road for their ore wagons, to the detriment of the condition of the road.

The company then employed David Smith as its agent. Smith recommended both technological and administrative changes in the running of the company, including the building of a second furnace, so that one could be used strictly for the production of pig iron and the other, presumably, for the casting of hollow ware. If the corporate directors chose not to build a second furnace, Smith requested permission to redesign the lining of the present furnace, enlarging the inner diameter by 18 inches and thereby increasing the daily capacity of the furnace by 50%. Smith also urged the employment of a trained bookkeeper, accustomed to double-entry bookkeeping, so as to improve the directors' capacity to analyze their true financial condition.

Smith was also critical of the staffing of the furnace. He urged the employment of a good founder who understood the casting of pig iron; the employment of good forgers or refiners who could turn cast iron into wrought iron without the waste of time and fuel caused by current workmen, who were slow and inefficient; the employment of a practiced steel baker to use the new but idle experimental steel furnace or a larger one to be built; and the building of a new trip hammer shop attached to the company's blacksmith shop. By introducing the manufacture of steel, Smith assured the company's directors that they would have a product that would enjoy an almost unlimited demand and would repay the expense of freighting it all the way to coastal ports, whereas the current products of cast and wrought bar iron and hardware would never command a market outside the surrounding countryside.

**1811** According to Charles T. Jackson, writing in 1841 and again in 1844, the furnace then in operation was "erected in 1811, has been in operation since that time, and produces from 250 to 500 tons of excellent cast iron per annum." As reported below, however, extensive alterations to the furnace were carried out in 1816, so it is difficult to know whether the furnace standing in 1841 was really built in 1811, or whether this was misinformation.

**1816** A report written by William P. Page discusses the recommendations made by consultant Isaac Williams, who had been employed at Livingston's Furnace and was called "one of the most experienced Iron Masters in the country" by Page. Williams recommended the rebuilding of the furnace lining and lower parts, but evidently proposed to keep the major walls of the existing furnace intact. Page says that "we. . . went to work, removed the old lining and hearth, had stones for the new Furnace got out and repaired, and in short of three weeks from the time she blew out, had fire into her again." Page's report makes it clear that the furnace he rebuilt had an ovoid inner section, and this agrees with a diagram copied by Elias Hasket Derby about 1809. "Mr. Williams was not satisfied with any part of the old Furnace. It was too low, the shape of the cavity was bad, the boshes were too steep" and "together with the hearth, were badly worn by the fire." The steep boshes precipitated the charge too quickly into the lower portion of the furnace, while the enlarged upper section encouraged combustion too high up in the stack. The result, according to Page, was that the old furnace burned "in [an] irregular state, and from what I could learn, it had been more or less the difficulty of all former blasts." In addition to giving the rebuilt furnace a conical interior above the boshes (the shape illustrated in a cross-section published in 1844 by Jackson), Page and Williams raised the top of the furnace from twenty-four to twenty-eight feet in height, narrowing its dimensions from the old. They made a number of changes in the hearth area, and increased the diameter of the blowing piston.

The fact that the furnace had a blowing engine with a piston in 1816 is significant. In his diagram of a blast furnace, copied from Volume 5 of *Tilloch's Philosophical Magazine*, Elias Hasket Derby illustrated such a machine and described its pumping cylinder as six feet in diameter. According to Victor Rolando's history of iron, lime, and charcoal manufacture in Vermont, *200 Years of Soot and Sweat* (1992), the builders of the Monkton Iron Company blast furnace at Vergennes, Vermont, considered such an engine in 1808, but "wooden cylinders were so new that no one was found who knew how to make them," and so this furnace was blown by bellows. Rolando further states that "the accepted year for the appearance of blowing tubs in the Northeast is 1835." Yet we seem to see that the furnace at Franconia had such an engine before 1816, one that possibly survived from the time of construction of the first furnace before 1810 or from the rebuilding that may have taken place in 1811 following David Smith's recommendations.

In addition to the changes he describes carrying out to the furnace and blowing engine in 1816, Page repeated the recommendation made by David Smith in 1810 that the company erect a second furnace for castings. The older furnace would thereby be managed in a way that would increase the production of pig iron, while the second furnace, an Air Furnace, would further refine the cast iron during remelting, permitting thinner and finer patterns to be used and producing a more refined cast product. An air furnace is defined by Victor Rolando as a horizontal reverberatory furnace, not a vertical blast furnace.

At Page's suggestion, ore was then taken from "the Ditch, which had for some years been abandoned, [rather) than at the opening last made near the head of the hill." The miners were instructed to use a smaller diameter stone drill with a less delicate point, this avoiding breakage of drill points while nevertheless making smaller holes that required less powder in blasting. They also returned to a type of "lean" ore that had previously been thrown aside as worthless, finding that it made good iron when mixed with the purer ore in the rebuilt furnace.

**1817** When Eliphalet Merrill published his *Gazetteer of the State of New-Hampshire in* this year, he could state that

> The works consist of a blast furnace with a reservoir of water near the top as a precaution against fire, and air furnace, a steel furnace a pounding machine to separate the iron from the cinders, a forge with four fires and two hammers, a turning lathe, and a trip-hammer shop with four fires and two hammers.

If this is an accurate description, it appears that the recommendations of iron masters David Smith and Isaac Williams had been followed scrupulously by the company's board of directors, providing the company not only with a rebuilt blast furnace but also with a reverberatory furnace for remelting iron for casting and a third furnace for making steel.

**1823** The *Digest of Accounts of Manufacturing Establishments in the United States and Of Their Manufactures* (1823) describes the productions of the Upper and Lower Works under one entry, not differentiating their individual products. According to this document, the iron factories of Grafton County produced "stoves, cooking and parlor; hollow ware, potash kettles, machinery, bar iron, &c." with a market value of "$24,500 and part uncertain." The establishments annually consumed 1,000 tons of ore and 300,00 bushels of charcoal with a value of $17,000, They employed 90 men and paid $8,000 in annual wages. Their facilities included "2 blast furnaces; 8 forges; 2 trip hammers, &c " and were "partly in operation." The amount of capital invested was given as $200,000, The report goes on to note that

> this statement includes two establishments: with respect to one of which it is represented that there is abundance of the raw material in the neighborhood; yet from the low price of imported iron, the high price of labor, and [the] dull market, the establishment is but partly

> in operation. And with respect to the other, [establishment], it is said that, previously to, and during the late war, sales were readily effected: but that owing to the general gradual depression of business since that time, the sales have rather diminished, and that the company have a large amount of manufactures on hand unsold.

John Farmer's and Jacob B. Moore's *A Gazetteer of the State of New-Hampshire* (1823) notes that

> The ore is obtained from a mountain in the east part of Concord [changed to Lisbon in 1824), three miles from the furnace, and is considered the richest in the United States, yielding from 56 to 63 per cent, and the mine is said to be inexhaustible. About twelve or fifteen tons of iron are made in a week, and sixty men on average are employed annually.

**1824** The *Report of the Secretary of State, Of Such Articles Manufactured in the United States as Would Be Liable to Duties If Imported From Foreign Countries* (1824) tells us that in that year, both the Haverhill and Franconia Iron Factory and the New Hampshire Iron Factory Company were authorized to issue stock to the amount of $200,000. While the New Hampshire Iron Factory Company was listed as producing bar, iron, ironmongery, hardware, etc.," the Haverhill and Franconia Iron Factory was described as producing "iron & other things which may be wrought from ore." This implies that the "(Upper Works" may have produced only wrought iron, possibly by the direct process, rather than both cast and wrought products, yet a newspaper advertisement of the following year (see below under **1825**) lists a furnace among the assets of this company.

**1825** The *New-Hampshire Patriot* of July 18, 1825 advertised the sale of the Haverhill and Franconia Iron Manufactory (the "Upper Works"), giving the most detailed description of that operation that has yet come to light:

**NOTICE.**

> The Proprietors of the HAVERHILL and FRANCONIA IRON MANUFACTORY, having concluded to dispose of their establishment, offer the whole for sale, consisting of the Mill privilege with 240 acres of land adjoining, with the Furnace, Forge, Blacksmith shop,, Grist and Saw Mills, 2 Warehouses, 1 Store, 3 large barns, 6 dwelling houses, one which is calculated for a Tavern, and another for the Agent there, and the ore hill, with an inexhaustible vein of Iron Ore.
>
> The Mill Seat at Bath and every other portion of their land will he sold on the most reasonable terms, and at very reduced prices, for cash or approved notes with interest.
>
> The manufactured stock consists of Bar Iron, Plough moulds,

Sleigh Shoes, Tire Iron, Crow bars, Ox Chains, Shovels, Scythes, and a great variety of tools and wrought iron. Iron Castings, viz, Pot Ash and Cauldron Kettles, Pots and Kettles or various kinds, articles for family use, a variety of Plate, Cooking, and Close Stoves, Grudgeons, wheels, Forge hammers and a variety of machinery. Grain, Salt Pork, Cloths, Hats, and a great variety of articles too numerous to mention.

Persons disposed to make great bargains will be pleased to call on the Agent without delay, as the whole will be closed by the 1st of Oct. next. G. REYNOLDS, Agent.

Franconia, N.H. July 18. 1825

It should he noted that a George Reynolds was active in Manchester, N.H., from 1856 to 1860 as superintendent of Blodgett Edge Tool Manufacturing Company, and patented a machine for making axe polls in 1858; perhaps he was the former agent of the Haverhill and Franconia Iron Manufactory.

This description suggests strong parallels between the physical plants and the holdings of the New-Hampshire Iron Factory Company and the Haverhill and Franconia Iron Manufactory, with the major difference apparently being that the latter owned much less acreage (240 acres) than the former (which had 5,456 acres by 1810, 4,500 acres in 1857). To judge by the Joseph Bray report of 1810 on the New-Hampshire Iron Factory Company and by this newspaper advertisement for the Haverhill and Franconia Iron Manufactory, both companies had a blast furnace, a forge or forge shop, a blacksmith shop, dwelling houses, a tavern, saw and grist mills, and property at Bath, N.H.

**1827** According to various modern secondary accounts, perhaps beginning with the WPA book *Hands That Built New Hampshire (*1940) and repeated in Enzio Serafini's "Franconia's Forgotten Iron Industry," *White Mountain Echoes* (Winter 1952), "in 1827 the Upper Works was destroyed by fire and never rebuilt." The following source, however, suggests that the Upper Works was re-established; this re-establishment is not listed in the *Index to the Laws of New Hampshire* (1886).

**1827** A government publication, *Documents Relative to the Manufactures in the United States* (1832), tells us that "The Upper Works of Franconia, in Grafton County, was established in 1829" (see below under **1832**). This apparently refers to a second company that was constituted after a fire in 1827 (see above under **1827**). The report further lists this company's products as bar iron only, implying that the blast furnace mentioned in the newspaper advertisement of 1825 may have been inoperative or that the company converted the total product of the blast furnace to wrought iron.

**1832** *Documents Relative to the Manufactures in the United States* (1832) gives *the fo*llowing information about the Upper Works:

> The New Hampshire Iron Factory. This factory is located in Franconia, in the county of Grafton. It was established in 1805. The value of real estate, water power, buildings, and machinery, is $50,000, the original cost of which was $200,000. The expense of manufacturing 300 tons of castings and 130 tons of bar iron, is $27,200, the sales of which amount to $34,000.
>
> The Upper Works of Franconia, in Grafton County, was established in 1829. The value of real estate, water power, buildings and machinery, is $10,000. The expense of manufacturing 50 tons (gross) of bar iron, is $3,250, the sales of which amount to $5,500.
>
> The New Hampshire Iron Factory Company have not, until lately, been successful. The articles formerly manufactured were of an inferior quality, but at presently they are preferred, and the blacksmiths in the neighborhood of the works, set a high value upon the bar iron for many purpose.
>
> It is impossible to ascertain the number of persons employed in these establishments, as the ore is dug and transported to the works by contract, and the labor is mostly done by the job. When by the month, the lowest rate is $10, and boarded; and the highest rate by the month, is $14, and boarded. When employed by the day, the rate is $1 per day, and boarded. The article of bar iron is sold in Boston at 90 to 100 dollars per ton. The present rate of profit on the New Hampshire Iron Factory Company is 15-1/2 per cent, per annum, and that of the Upper Works is 22-1/2 per cent. The hollow ware is sold in New Hampshire at 6 cents per pound.
>
> The manufactures of these establishments at Franconia are so remote from the points of importation, that they are entirely out of foreign competition, within a circle of 50 miles.

**1833** E. T. Coke, in his *A Subaltern's Furlough, Vol. II (N*ew York, 1833), seems to confirm the continued existence of the Upper Works when he states

> I rode out early the following morning to the iron-works at Franconia, about six miles distant. They are the property of a company, and produce a metal of soft, tough quality, considered superior to any in the States. The ore is found in considerable quantities in the hills, three miles distant, and supplies another foundry in the immediate vicinity; both establishments, however, are upon a small scale..

**1841** Charles T. Jackson, M.D., issued his *First Annual Report on the Geology of the State of New Hampshire* in this year, repeating many of his comments concerning the New Hampshire Iron Manufacturing Company three years earlier in his *Final*

*Report on the Geology and Mineralogy of the State of New Hampshire* (Concord, N.H., 1844). Jackson notes that the "granular magnetic iron ore" the used exclusively by the company contains 69.04% iron, of which 60% was recovered during refining and 9% wasted. The company's agent was then Captain Putnam, who stated that the blast furnace was erected in 1811 and then produced from 250 to 500 tons of "excellent cast iron" per annum, which was partly sold in the form of castings and partly converted to bar iron--100 to 140 tons per year--at the forges.

Capt. Putnam reported that in 1841 "the stack of the furnace was built of granite and is lined with mice slate, which is found in the vicinity" with the hearth stones being made of Landaff quartz rock. The furnace was kept in blast from 16 to 26 weeks at a time, consuming from 200,000 to 300,000 bushels of charcoal each year. Each single charge of the furnace consisted of 15 bushels of charcoal, 280 pounds of iron ore, and one box of limestone for flux. Jackson reproduced the yearly production summary for the year 1838, which revealed that the blast continued 24 weeks that year, 160 bushels of charcoal were required to smelt a ton of ore, and the average yield of the ore that year was 55.12% iron.

In the same report, Jackson describes the source of limestone used as flux at the New Hampshire Iron Manufacturing Company. He states,

> Limestone likewise abounds in the town of Lisbon, near the S.W. extremity of Mink Pond, and is quarried and burnt for lime in several places. The principal quarries which are wrought belong to Messrs. Orren Bronson, Thomas Priest, David Priest, and Uriah Oakes. . . . Mr. Oakes' quarry is situated 2 miles west from Franconia furnace, and is wrought to some extent for lime. This kiln is built like the one before described, but is of larger dimensions, containing 100 tierces of lime. It is built of the common rocks found in the vicinity, and is lined with mica slate. The walls are from two to three feet in thickness, and the lining is 1 foot thick. The cost of the kiln was $100. He sells his lime for $1.50 per tierce, without the cask, and for $2 when packed in casks. . . . This limestone is situated favorably for supplying the Franconia furnace with a flux, to be used in smelting their iron ore, and I believe they obtain it for that purpose.

**1844** In his final report of 1844, Jackson reproduced a cross-section of a blast furnace from M. Dumas' *Chime applique aux Arts*, stating that this diagram "represents so nearly the structure and proportions of the Franconia furnace, that I have not thought it necessary to print my sketch, which was made from measurements taken then cold blast was used at the furnace." Jackson goes on to say that "the stack of Franconia furnace, by my measurements, is 34 feet high, 8 feet 3 inches in diameter at the boshes, or 12 feet before the lining was put in." and that the casting arch is 11 feet wide.

This description (and the Dumas cross-section diagram) indicates that the furnace was then a cold blast furnace with only one blast arch rather than the three now present.

Jackson also describes Tyson's Furnace in Plymouth, Vermont, a hot-blast furnace, stating that "since a much larger daily product of iron is obtained by less consumption of fuel, the hot blast is applicable to many of our New England furnaces. I understand that the hot blast has recently been introduced at my suggestion, in the Franconia furnace, but I have not yet witnessed the result, the change having [only] recently been made."

**1849** In *A Gazetteer of New Hampshire* (1849), John Hayward states:

> The town [of Franconia] owes its rise and prosperity to the discovery and working of a rich vein of granular magnetic iron ore, which exists within the present limits of the town of Lisbon, at its south-eastern corner. The iron ore is a vein from three and a half to four feet wide, included in granite rocks. The course of this vein is north thirty degrees east, south thirty degrees west, and its dip is to the south-east seventy or eighty degrees. It has been opened and wrought forty rods in length, and one hundred and forty-four feet in depth. The ore is blasted out by workmen employed by a contractor who supplies the Franconia furnaces. The mine is wrought open to day-light, and is but partially covered to keep out the rain. On measuring the direction of this vein, it was evident that it extended into the valley below, and on searching the hill-side, it was readily discovered in that direction.

**1850** The United States Census of 1850 describes the property as including a water-powered shingle mill, a water-powered blast furnace, a water-powered cupola furnace, a water-powered forge shop with five fires and two hammers, a water-powered machine shop with nine fires and three lathes, a water-powered wheelwright's shop, a water-powered saw- and grist mill, and a horse-powered mine.

A cupula furnace is a vertical furnace, akin to a blast furnace in design, for re-melting pig iron. Assuming that the term "air furnace" was accurately used in 1817, this earlier reverberatory re-melting furnace seems to have been supplemented by a vertically oriented re-melting furnace, probably with greater capacity, over the following decades of operation.

**1855** Edwin A. Charlton, in *New Hampshire As It Is* (12855), states that

> In December, 1805, a company was incorporated under the name of the New Hampshire Iron Manufactory. The buildings necessary for the prosecution of the enterprise were erected on the south branch of the Lower Ammonoosuc, and consist of a large blast furnace, a cupola furnace, a forge. trip hammer shop, blacksmith shop, and

> pattern shop. From 20 to 30 men are constantly employed. 250 tons of pig iron and from 200 to 300 tons of bar iron are produced annually. The ore is said to he the richest yet discovered. It yields from 56 to 90 per cent.

**1857** According to an advertisement of April 20, 1857, in the *New-Hampshire Patriot*, the entire property was to he sold at auction on May 6, 1857 at the tavern in Franconia, without reserve. The property was described as

> The entire property of the New Hampshire Iron Factory Company, (a large portion of which is only 5 miles distant from the White Mountains Railroad), consisting of about 4500 acres of unimproved land, situated in Franconia and the neighboring towns, mostly covered with a heavy growth of pine, spruce, hemlock, tamarack, and hard wood timber.
>
> Also, the Blast Furnace, (Pocket Furnace,) Forge, Machine Shop, stone Blacksmith Shop, Wood and Paint Shop, all situated in and near the Mill Pond, which affords ample water power for an extensive manufacturing business.
>
> Also, nine Dwelling Houses, Store and other buildings.
>
> The supply of iron ore belonging to the company is inexhaustible, and it is universally conceded to be in no respect inferior in quality and richness of yield to any in this country or Europe, and the manufacture can be profitably conducted, as in the immediate vicinity of the works there is a constant demand for vast quantities of pig and wrought iron.

It is hard to guess why the term "(Pocket Furnace)" is enclosed in parentheses in this advertisement. Does this term modify the words "Blast Furnace," indicating that the then-existing blast furnace was a pocket furnace, or does it merely refer to a secondary furnace? According to Victor Rolando, a pocket furnace was a diminutive blast furnace, often only five feet high, used either for preliminary testing of ore or for small-scale cast iron production for local markets. Possibly the cupola mentioned in 1855 took the form of such a furnace and the two terms, used two years apart, refer to the same device.

**1859** The present furnace was constructed under the supervision of "S. Pettee, Jr.," whose name, accompanied by the date "1859," appears on one of the voussoirs of the northern or casting arch of the four-arch furnace. Duncan Wilkie has identified S. Pettee as having been an agent of the Katahdin Iron Works in Maine in 1856. According to the United States Census of 1860, the new owners, who incorporated themselves under the name of the New Hampshire Iron Company, "...Commenced operations July 1, 1859," The same census indicated that the mining operation in Lisbon employed 22 hands, with a 25-horsepower steam engine, to produce 1,110 tons of iron ore valued at $5,000 each year. This is a marked advance over the census returns of 1850, which described the mining operation as horse–powered, as employing 8 hands, and as producing 500 tons of ore valued at $2,500 in that year.

**1865** An article in the "Franconia Iron Mine" in *The Granite Monthly* 4 (1881), p. 466, state that "for various causes the work at the furnace and mine was suspended about 1865 and had not been resumed."

**1870** The United States Census indicates no activity at the site: it was "Inoperative at Present." The same census states that $200,000 had been invested in the business and that it was powered by six water wheels generating 60 horsepower.

**1878** C. H. Hitchcock in Part V of his *The Geology of New Hampshire* *1886), notes that furnaces here "continued in blast till 1870," quoting from Jackson for other statistics of the former operation.

**1881** According to the *Index to the Laws of New Hampshire (1886*) the "New Hampshire Iron Factory Company" was reincorporated as the "New Hampshire Iron Company" in 1860 and again reincorporated as the "Franconia Iron Company" in 1881.

**1883** The Franconia Iron Company was listed in the *Concord Directory* of 1883 as "Incorporated 1812" [sic], with offices at 72 North Main Street. The officers of the corporation were Sylvester Marsh, president; Lyman D. Stevens, treasurer; Henry W. Stevens, secretary; S. Marsh, C. M. Ransom, T. H. Ford, Dr. Spaulding (Nashua), B. J. Cole (Lake Village), E. B. Parker (Lisbon), and Charles H. Greenleaf, directors.

**1884** Fire destroyed all portions of the iron works except for the main blast furnace.

## Appendix C

*The Theodolite Survey Report*
and
*Printout of Survey Data*

by Karl Danneil

A couple of data problems occurred: too much magnetic deviation when set up near the highway bridge, and improper setup of magnetic north for the straight line and Ryan's datum measurements. The first problem was solved by re-surveying and using another setup location. The second problem wasn't noticed until the data was plotted after returning home. The line to Ryan's datum goes through the furnace instead of a little north of it. Since I neglected to measure any previous reference point, I can only guess at the compass error magnitude. The data listing in table C1 (page 93) present both the unaltered results and the result using a 10-degree guess correction.

Explanation of the Data Printout Organization: Explanation of information included in the printouts of survey data collected at the furnace site. The survey was conducted to document the remains of the stone stack of the furnace, the several stone walls, and other structures that remain.

The locations of the structures were measured using a theodolite supplied by the New Hampshire Division of Historic Resources. All of the data collected uses magnetic north as the common reference.

The printouts present both the calculated data on the left side, and the original data with location comment on the right side. A few data points were corrected for obvious errors in which case a note has been attached to the comment about the correction. Measurement station numbers have been altered to keep the numbers from repeating within the set of data.

The primary calculated result is the X Y Z coordinate of the measurement end point (the "to" end). It was expected that these values would be helpful in drawing details and as a guide to insure that all the needed data has been collected. The computer programs that do the location calculations produce the included printouts and also output data files that can be loaded into CAD/CAM drafting programs so that an overall site depiction can be generated and printed out. The data can be supplied on floppy disk along with the generic Basic language programs.

The zero point for all the X Y Z locations was the furnace site datum selected by Vic Rolando east of the furnace. The positive directions are: X = northward, Y = eastward, Z = up. Datum points are manually entered into the computer data file based on point calculations and the program prints a message indicating the location of the new datum point. Forward and reverse readings are taken whenever the theodolite is moved so that magnetic deviation can be detected and corrected.

Details of the Theodolite Printout: The theodolite was setup to magnetic north, and all calculation were kept in magnetic north reference as noted above.

| Data Item | Description |
|---|---|
| X,Y,Z | Calculated location of end point of measurement in feet. |
| Sta# | Station number assigned to measured point. |
| Az | Azimuth angle to measured point, always eastward 0 to 360 degrees. |
| El | Elevation angle: Up = positive degrees (above horizontal). |
| Distance | Calculated horizontal distance to measured point in feet. |
| A1,A2,A3 | Theodolite azimuth angle readings in degrees, minutes, seconds of arc. |
| E1,E2,E3 | Theodolite elevation angle reading in degrees, minutes, seconds with horizontal = 0, and straight up = +90. |
| S1,S2,S3 | Survey stick readings at theodolite markings: high, middle, low marker. These readings are in meters. |

Details of the Pentax Theodolite: The Pentax theodolite was borrowed from the New Hampshire Division of Historic Resources, Concord, NH, through the kind efforts of James L. Garvin, Architectural Historian (and NNEC-SIA member) and Gary Hume, State Archeologist. The theodolite was a Pentax model Geotec T-24B. This theodolite is calibrated such that a difference of 1 meter from the high reading to the low reading calculates the distance to the stick to be 100 meters. A calibration check was performed by taping 50 meters, then taking readings with the telescope in its normal and 180-degree flipped positions. This check isn't rigorous, but indicates the theodolite was in proper calibration.

| Data Item | Description |
|---|---|
| Sta# | Station number assigned to the theodolite position. |
| H | Calculated height of the theodolite in feet. |
| X,Y,Z | Calculated location of the theodolite position in feet. |
| C | Theodolite compass correction angle in degrees. |

Object Measurements: To measure the location of objects, the survey stick was generally placed against the object and the stick middle reading corresponds to the object location. The computer program was altered so that the stick middle reading is the calculated position, instead of the base of the stick as in the normal theodolite measurement.

Other special measurements were also made such as to the top of the large pipe in the furnace. The measurement has to be carefully inspected to verify which calculations are valid versus forced for computational convince purposes.

## Table C1. Survey Data Without and With 10-Degree Azimuth Correction

Data with the azimuth error as measured - September 1994

Date: 10-04-1994 Computed Results Input Measured Data



9007 Theo position-- H,X,Y,Z,C= 4.583, 0.000, 0.000, 0.000, 2.039 Theo on Furnace Site Main Datum, straight line, 11Sept94

| X | Y | Z | Sta# | Az | El | Distance | A1 | A2 | A3 | E1 | E2 | E3 | Shi | Smid | Slow | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 206.700 | -109.033 | 5.298 | 401 | 332.189 | 1.783 | 233.808 | 330 | 9 | 0 | 1 | 47 | 0 | 7.736 | 6.562 | 5.397 | Straight line to near owners driveway, south of small pine tree |
| 175.681 | -92.670 | 3.943 | 402 | 332.189 | 1.783 | 198.720 | 330 | 9 | 0 | 1 | 47 | 0 | 7.825 | 6.824 | 5.837 | Straight line, about 30 feet south |
| 146.690 | -77.378 | 2.825 | 403 | 332.189 | 1.783 | 165.928 | 330 | 9 | 0 | 1 | 47 | 0 | 7.743 | 6.922 | 6.083 | Straight line, about 30 feet south |
| 117.990 | -62.239 | 2.221 | 404 | 332.189 | 1.783 | 133.464 | 330 | 9 | 0 | 1 | 47 | 0 | 7.185 | 6.516 | 5.850 | Straight line, about 30 feet south |
| 88.420 | -46.641 | 1.928 | 405 | 332.189 | 1.783 | 100.016 | 330 | 9 | 0 | 1 | 47 | 0 | 6.266 | 5.768 | 5.266 | Straight line, about 30 feet south |
| 60.590 | -31.960 | 1.067 | 406 | 332.189 | 1.783 | 68.535 | 330 | 9 | 0 | 1 | 47 | 0 | 5.994 | 5.650 | 5.308 | Straight line, in line with north wall, edge of furnace area |
| -9.083 | -116.560 | 24.738 | 407 | 265.545 | 11.833 | 119.452 | 263 | 30 | 20 | 11 | 50 | 0 | 4.957 | 4.340 | 3.737 | To bush on top of stone wall, near driveway to owner's house, bottom of wall, a Walt Ryan datum. |

Data with an additional 10-degree azimuth angle guess - September 1994

Date: 09-30-1994 Computed Results Input Measured Data

9007 Theo position-- H,X,Y,Z,C= 4.583, 0.000, 0.000, 0.000, 12.039 Theo on Furnace Site Main Datum, sraight lne, 11Sept94, +10- degrees guess

| X | Y | Z | Sta# | Az | El | Distance | A1 | A2 | A3 | E1 | E2 | E3 | Shi | Smid | Slow | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 222.493 | -71.483 | 5.298 | 401 | 342.189 | 1.783 | 233.808 | 330 | 9 | 0 | 1 | 47 | 0 | 7.736 | 6.562 | 5.397 | Straight line to near owners driveway south of small pine tree |
| 189.104 | -60.756 | 3.943 | 402 | 342.189 | 1.783 | 198.720 | 330 | 9 | 0 | 1 | 47 | 0 | 7.825 | 6.824 | 5.837 | Straight line, about 30 feet south |
| 157.898 | -50.730 | 2.825 | 403 | 342.189 | 1.783 | 165.928 | 330 | 9 | 0 | 1 | 47 | 0 | 7.743 | 6.922 | 6.083 | Straight line, about 30 feet south |
| 127.005 | -40.804 | 2.221 | 404 | 342.189 | 1.783 | 133.464 | 330 | 9 | 0 | 1 | 47 | 0 | 7.185 | 6.516 | 5.850 | Straight line, about 30 feet south |
| 95.176 | -30.578 | 1.928 | 405 | 342.189 | 1.783 | 100.016 | 330 | 9 | 0 | 1 | 47 | 0 | 6.266 | 5.768 | 5.266 | Straight line, about 30 feet south |
| 65.219 | -20.954 | 1.067 | 406 | 342.189 | 1.783 | 68.535 | 330 | 9 | 0 | 1 | 47 | 0 | 5.994 | 5.650 | 5.308 | Straight line, in line with north wall, edge of furnace area |
| 11.296 | -116.367 | 24.738 | 407 | 275.545 | 11.833 | 119.452 | 263 | 30 | 20 | 11 | 50 | 0 | 4.957 | 4.340 | 3.737 | To bush on top of stone wall, near driveway to owner's house, a Walt Ryan datum |

## Table C2. Input/Measured Survey Data

| Sta# | A1 | A2 | A3 | E1 | E2 | E3 | Shi | Smid | Slow | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 9000 | Theo position – H,X,Y,Z,C = | | | | 4.917, | 511.328, | 56.763, | –5.185, | –6.639 | 9Sep94 |
| 1 | 278 | 36 | 0 | –1 | –33 | 0 | 3.369 | 3.281 | 3.195 | To benchmark of bridge abutment, north of furnace area |
| 2 | 3 | 2 | 0 | –1 | –45 | 0 | 4.931 | 4.108 | 3.284 | Calibration – taped 50 meters North |
| 2 | 183 | 2 | 40 | –1 | –49 | 0 | 4.924 | 4.104 | 3.281 | Cal. – telescope flipped |
| 3 | 167 | 56 | 0 | 0 | 36 | 0 | 5.016 | 3.937 | 2.867 | 1st telephone pole south of bridge, along highway |
| Hi–Med,Med–Low,Delta(>.02 ft) = | | | | | 1.820844, | 1.870056, | 4.921198E–02 | | | |
| 4 | 166 | 18 | 0 | 0 | –5 | 0 | 6.414 | 4.593 | 2.723 | 2nd telephone pole south |
| Hi–Med,Med–Low,Delta(>.02 ft) = | | | | | 2.185013, | 2.102993, | 8.202004E–02 | | | |
| 5 | 166 | 18 | 40 | 0 | –4 | 0 | 5.466 | 3.281 | 1.178 | To datum in furnace Visitors Center drive |
| 9001 | Theo position – H,X,Y,Z,C = | | | | 4.667, | 109.234, | 205.726, | –4.048, | 0.000 | Theo on datum in furnace Visitors Center drive |
| 6 | 339 | 40 | 20 | 0 | –17 | 0 | 5.387 | 3.281 | 1.181 | Back sight to the bridge sidewalk datum – TOO MUCH VARIATION |
| 7 | 242 | 2 | 0 | 0 | 22 | 0 | 3.281 | 2.110 | 0.951 | To datum at furnace site, about 15 feet from river & 30 feet east of stack |
| 9002 | Theo position – H,X,Y,Z,C = | | | | 5.063, | 546.388, | 101.769, | –4.624, | 0.000 | Theo on east side of highway, north of furnace, to solve a magnetic variation problem on 9Sept94 – 10Sept94 |
| 101 | 234 | 38 | 40 | 1 | 50 | 0 | 3.678 | 3.281 | 2.884 | To benchmark on bridge abutment. 10Sept94 |
| 102 | 229 | 13 | 0 | 1 | 13 | 0 | 3.599 | 3.281 | 2.963 | To bridge datum,nail in sidewalk |
| 103 | 174 | 42 | 40 | 0 | 2 | 0 | 4.501 | 3.281 | 2.060 | 1st telephone pole south |
| 104 | 168 | 8 | 40 | 0 | 12 | 0 | 5.912 | 3.937 | 1.972 | 2nd telephone pole south |
| 105 | 166 | 36 | 0 | 0 | 13 | 0 | 5.518 | 3.281 | 1.056 | To datum in furnace visitors center drive |
| 9003 | Theo position – H,X,Y,Z,C = | | | | 4.708, | 112.353, | 205.172, | –1.155, | –0.544 | Theo on Visitors Center lot datum |
| 106 | 347 | 8 | 40 | 0 | –36 | 0 | 5.515 | 3.281 | 1.050 | Back sight to #0 (db9002), east side of highway near bridge |
| 107 | 241 | 50 | 20 | 0 | –4 | 0 | 4.449 | 3.281 | 2.110 | Across river to furnace site datum, nail & ribbon. Force to ZERO |
| 9004 | Theo position – H,X,Y,Z,C = | | | | 4.875, | 0.000, | 0.000, | 0.000, | 2.039 | Theo on furnace site datum |
| 108 | 59 | 15 | 20 | 0 | –29 | 0 | 4.961 | 3.799 | 2.625 | Back sight to Visitor Center datum |
| 109 | 163 | 12 | 20 | –1 | –49 | 0 | 4.524 | 3.281 | 2.041 | To dam, south in river, east side of stream near water, to center wood beam |
| Hi–Med,Med–Low,Delta(>.02 ft) = | | | | | 5.577374E–02, | 0.3772922, | 0.3215184 | | | |
| 110 | 231 | 46 | 20 | 2 | 37 | 0 | 4.813 | 4.757 | 4.380 | Southeast corner of base of furnace stack. Slow = 1.335 error |
| 111 | 237 | 59 | 0 | 2 | 41 | 0 | 3.438 | 3.281 | 3.123 | South corner, east face, base of stack |
| 112 | 241 | 15 | 40 | 3 | 8 | 0 | 3.435 | 3.281 | 3.123 | South edge of east arch |
| 113 | 258 | 30 | 0 | 3 | 18 | 0 | 3.428 | 3.281 | 3.136 | North edge of east arch |
| 114 | 262 | 18 | 20 | 2 | 57 | 0 | 3.428 | 3.281 | 3.136 | North corner of east face, base of stack |

**Table C2. Input/Measured Survey Data (continued)**

| Sta# | A1 | A2 | A3 | E1 | E2 | E3 | Shi | Smid | Slow | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 9004 (continued) | | | | | | | | | | |
| 115 | 274 | 37 | 0 | 2 | 43 | 0 | 4.131 | 3.937 | 3.747 | Northeast corner of octagon base. Slow = 1.042 error |
| 116 | 111 | 28 | 20 | −12 | −6 | 0 | 7.677 | 7.539 | 7.388 | Water edge, west side of Gale River, near furnace |
| Hi−Med,Med−Low,Delta(>.02 ft) = 0.2526217, 8.530092E−02, 0.1673207 | | | | | | | | | | |
| 117 | 166 | 3 | 0 | −6 | −12 | 0 | 4.846 | 4.593 | 4.508 | Stone tunnel, 307 deg. (NW) at least 13 feet long, 28 inches wide opening, at north edge of a canal |
| 118 | 220 | 11 | 20 | 0 | −40 | 0 | 6.814 | 6.562 | 6.316 | Northwest corner of canal junction/bend, bottom, south of furnace |
| 119 | 205 | 9 | 40 | 0 | −32 | 0 | 6.863 | 6.562 | 6.266 | Bottom of canal (tail race) from south, in line with stone wall going west |
| 120 | 183 | 16 | 40 | −3 | −35 | 0 | 3.317 | 3.035 | 2.753 | Stone corner of wall along 'tail race', south of furnace, near river |
| 121 | 201 | 35 | 20 | −1 | −15 | 0 | 4.924 | 4.596 | 4.268 | Tail race, west end, in center bottom of southward canal |
| 122 | 192 | 40 | 20 | −1 | −2 | 0 | 4.108 | 3.609 | 3.117 | South along canal, in center bottom |
| 123 | 212 | 16 | 40 | −1 | −2 | 0 | 4.961 | 4.659 | 4.360 | East corner of wall south of stack, north face of wall |
| 124 | 225 | 11 | 0 | 3 | 41 | 0 | 6.309 | 5.915 | 5.518 | West corner of wall, corner of south & west stone walls |
| 125 | 302 | 27 | 20 | 4 | 3 | 0 | 7.641 | 7.218 | 6.801 | Northwest junction of stone walls, near cavein of west wall |
| 126 | 322 | 8 | 40 | 4 | 4 | 0 | 7.651 | 7.336 | 7.018 | East end of north stone wall, 4 feet wide |
| 127 | 322 | 3 | 0 | 4 | 4 | 0 | 3.907 | 3.586 | 3.274 | East end of north stone wall, top, south (outside) corner |
| 128 | 302 | 49 | 20 | 7 | 47 | 0 | 4.373 | 3.937 | 3.510 | West end of north wall, corner junction with west wall, top, inside |
| 129 | 224 | 52 | 20 | 7 | 17 | 0 | 2.385 | 1.968 | 1.565 | South end of west stone wall, junction with south wall, top, inside |
| 130 | 215 | 25 | 40 | 4 | 19 | 0 | 4.646 | 4.311 | 3.986 | East end of south stone wall, top, inside |
| 131 | 224 | 25 | 0 | 9 | 55 | 0 | 4.455 | 3.937 | 3.432 | Upper wall, south west corner, wall jogs east, runs north |
| 132 | 231 | 22 | 40 | 11 | 5 | 0 | 3.770 | 3.281 | 2.795 | Upper wall, north of last point |
| 133 | 221 | 13 | 40 | 9 | 41 | 0 | 5.056 | 4.593 | 4.127 | South on upper wall, south going part, 3 foot wide |
| 134 | 305 | 18 | 20 | 2 | 7 | 0 | 5.899 | 5.577 | 5.256 | Casting shed area, pig yard datum |
| 135 | 53 | 25 | 0 | −14 | −59 | 0 | 7.684 | 7.546 | 7.424 | Retaining wall, river edge, dressed face of bridge abutment, north end |
| 136 | 140 | 22 | 0 | −17 | −25 | 0 | 7.037 | 6.890 | 6.742 | Retaining wall, river edge, dressed face of bridge abutment, south end |
| 9005 Theo position − H,X,Y,Z,C = 4.875, 0.000, 0.000, 0.000, 2.039 | | | | | | | | | | Theo on furnace site datum. OBJECTS 10Sept94 |
| Hi−Med,Med−Low,Delta(>.02 ft) = 9.842396E−03, 0.3313608, 0.3215184 | | | | | | | | | | |
| 205 | 256 | 57 | 0 | 5 | 24 | 0 | 4.760 | 4.751 | 4.419 | Large pipe in east arch, south edge, standard measure to bottom of pipe |
| 9006 Theo position − H,X,Y,Z,C = 4.625, 38.954, −51.052, 1.671, 0.273 | | | | | | | | | | Theo north of furnace, near north wall, pig yard datum. 11Sept94 |
| Hi−Med,Med−Low,Delta(>.02 ft) = 0.3510461, 0.2821488, 6.889725E−02 | | | | | | | | | | |
| 301 | 127 | 4 | 20 | 0 | 0 | 0 | 6.634 | 6.283 | 6.001 | Back sight to primary furnace site datum. Slow = 0.829 error |
| 303 | 160 | 12 | 20 | 3 | 17 | 0 | 5.597 | 5.417 | 5.236 | North arch & east edge of north face, corner of stack |
| 304 | 180 | 13 | 0 | 3 | 18 | 0 | 5.673 | 5.495 | 5.318 | North arch & west edge of north face of stack |
| 306 | 190 | 5 | 0 | 2 | 39 | 0 | 5.223 | 4.990 | 4.760 | Corner of west face of stack, north corner, bottom |

**Table C2. Input/Measured Survey Data (continued)**

| Sta# | A1 | A2 | A3 | E1 | E2 | E3 | Shi | Smid | Slow | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| 9007 | Theo position – H,X,Y,Z,C = | | | | 4.583, | 0.000, | 0.000, | 0.000, | 14.922 | Theo on furnace site main datum. STRAIGHT LINE 11Sept94 |
| 401 | 330 | 9 | 0 | 1 | 47 | 0 | 7.736 | 6.562 | 5.397 | Straight line, to near owner's driveway, south of small pine tree |
| 402 | 330 | 9 | 0 | 1 | 47 | 0 | 7.825 | 6.824 | 5.837 | Straight line, about 30 feet south |
| 403 | 330 | 9 | 0 | 1 | 47 | 0 | 7.743 | 6.922 | 6.083 | Straight line, about 30 feet south |
| 404 | 330 | 9 | 0 | 1 | 47 | 0 | 7.185 | 6.516 | 5.850 | Straight line, about 30 feet south |
| 405 | 330 | 9 | 0 | 1 | 47 | 0 | 6.266 | 5.768 | 5.266 | Straight line, about 30 feet south |
| 406 | 330 | 9 | 0 | 1 | 47 | 0 | 5.994 | 5.650 | 5.308 | Straight line, in line with north wall, edge of furnace area |
| 407 | 263 | 30 | 20 | 11 | 50 | 0 | 4.957 | 4.340 | 3.737 | To bush on top of stone wall, near driveway to owner's house, bottom of wall, a Walt Ryan datum |
| 9008 | Theo position – H,X,Y,Z,C = | | | | 5.021, | –239.925, | 63.192, | –6.275, | 0.573 | Theo on dam datum, east side of Gale River, 66 inches from west end of timber |
| 408 | 344 | 40 | 20 | 0 | 59 | 0 | 4.199 | 2.953 | 1.716 | Back–sight to furnace site main datum |
| 409 | 265 | 55 | 0 | 0 | 35 | 0 | 4.649 | 4.265 | 3.881 | To iron pin in rock on west of river, 16 inches on centers to another pin under bank |
| 9905 | Theo position – H,X,Y,Z,C = | | | | 4.875, | 0.000, | 0.000, | 0.000, | 2.039 | Theo on furnace site datum. OBJECTS 10Sept94 |
| 201 | 249 | 2 | 0 | 4 | 25 | 0 | 4.833 | 4.639 | 4.445 | East arch, cast iron header, south, bottom, at stone wall – 10Sept94 |
| 202 | 255 | 37 | 40 | 4 | 36 | 0 | 5.013 | 4.823 | 4.632 | East arch, cast iron header, north, bottom, at stone wall |
| 203 | 268 | 16 | 0 | 6 | 40 | 0 | 5.919 | 5.755 | 5.587 | Binder rod end, NW face of stack, center, outer corner of rod, south corner |
| 204 | 234 | 25 | 0 | 5 | 23 | 0 | 5.617 | 5.433 | 5.243 | Binder rod end, southeast face of stack, center, outer corner of rod, bottom, north corner |
| Hi–Med,Med–Low,Delta(>.02 ft) = | | | | | 9.842396E–03, | | 0.3313608, | 0.3215184 | | |
| 206 | 257 | 14 | 0 | 5 | 24 | 0 | 4.760 | 4.751 | 4.419 | Traverse to pipe at #5 (#205) altitude |
| 207 | 249 | 54 | 20 | 13 | 58 | 0 | 9.790 | 9.632 | 9.468 | Top of east arch, bottom corner of stone to south of center point |
| 208 | 257 | 17 | 0 | 44 | 18 | 0 | 0.000 | 0.000 | 0.000 | Top of large pipe at top of stack, south edge, top point |
| 209 | 232 | 5 | 0 | 13 | 38 | 0 | 13.12 | 13.123 | 13.123 | Southeast corner of base of stack |
| 210 | 233 | 44 | 20 | 13 | 38 | 0 | 13.12 | 13.123 | 13.123 | Traverse to stack at altitude |
| 9906 | Theo position – H,X,Y,Z,C = | | | | 4.625, | 38.954, | –51.052, | 1.671, | 0.273 | Theo north of furnace, near north wall, pig yard datum. 11Sept94 |
| 302 | 155 | 10 | 20 | 3 | 18 | 0 | 5.932 | 5.718 | 5.508 | Smid = object, binder rod, northeast face, north corner, bottom |
| 305 | 186 | 58 | 40 | 2 | 39 | 0 | 4.915 | 4.705 | 4.498 | Smid = object, binder rod, northwest face of stack, north corner, bottom |
| 307 | 176 | 13 | 20 | 2 | 28 | 0 | 3.783 | 3.560 | 3.340 | Smid = object, north arch header west side, bottom, at stone face |
| 308 | 165 | 0 | 0 | 2 | 27 | 0 | 3.783 | 3.560 | 3.340 | Smid = object, north arch header, east side, bottom, at stone face – stick readings missing, use numbers from #207 |
| 309 | 170 | 11 | 0 | 12 | 10 | 0 | 11.151 | 10.958 | 10.771 | Smid = object, north arch, arch top, bottom of key stone |

## Table C3. Computed Survey Results



| X | Y | Z | Sta# | Az | E | Distance | Comments |
|---|---|---|---|---|---|---|---|
| 9000 Theo position: H,X,Y,Z,C. = 4.917, 511.328, 56.763, −5.185, −6.639 | | | | | | | Sept. 9, 1994 |
| 511.923 | 39.398 | −4.019 | 1 | 271.961 | −1.550 | 17.382 | To bench mark of bridge abutment north of furnace |
| 675.543 | 46.391 | −9.403 | 2 | −3.614 | −1.750 | 164.619 | Calibration, taped 50 meters north |
| 347.448 | 67.058 | −9.581 | 2 | 176.405 | −1.817 | 164.285 | Calibration, telescope flipped |
| 307.809 | 125.673 | −1.955 | 3 | 161.294 | 0.600 | 214.881 | 1st telephone pole south of bridge, along highway |
| Hi−Med,Med−Low,Delta(>.02 ft) = 1.820844, 1.870056, 4.921198E−02 | | | | | | | |
| 165.251 | 185.050 | −5.398 | 4 | 159.661 | −0.083 | 369.090 | 2nd telephone pole south |
| Hi−Med,Med−Low,Delta(>.02 ft) = 2.185013, 2.102993, 8.202004E−02 | | | | | | | |
| 109.234 | 205.726 | −4.048 | 5 | 159.672 | −0.067 | 428.800 | To datum in visitors center drive |
| 9001 Theo position: H,X,Y,Z,C = 4.667, 109.234, 205.726, −4.048, 0.000 | | | | | | | Theo on datum in visitors center drive |
| 503.628 | 59.616 | −4.742 | 6 | 339.672 | −0.283 | 420.593 | Back sight to the bridge sidewalk datum |
| TOO MUCH VARIATION | | | | | | | |
| 0.000 | 0.000 | −0.000 | 7 | 242.033 | 0.367 | 232.932 | To datum at furnace site, about 15 ft from river and 30 ft east of furnace |
| 9002 Theo position: H,X,Y,Z,C = 5.063, 546.388, 101.769, −4.624, 0.000 | | | | | | | Sept. 10, 1994. Theo on east side of highway, north of furnace, to solve a magnetic variation problem on Sept. 9, 1994 |
| 500.493 | 37.082 | −0.304 | 101 | 234.644 | 1.833 | 79.355 | To bench mark on bridge abutment |
| 504.832 | 53.598 | −1.491 | 102 | 229.217 | 1.217 | 63.633 | To bridge datum, nail in sidewalk |
| 303.336 | 124.269 | −2.700 | 103 | 174.711 | 0.033 | 244.091 | 1st telephone pole south |
| 160.774 | 182.719 | −2.123 | 104 | 168.144 | 0.200 | 394.022 | 2nd telephone pole south |
| 112.353 | 205.172 | −1.155 | 105 | 166.600 | 0.217 | 446.186 | To datum in visitors center drive |
| 9003 Theo position: H,X,Y,Z,C = 4.708, 112.353, 205.172, −1.155, −0.544 | | | | | | | Theo on visitors center lot dsatum |
| 546.667 | 101.705 | −4.403 | 106 | 346.600 | −0.600 | 446.492 | Backsight to #0 (db9002), east side of highway near bridge |
| −0.000 | −0.000 | 0.000 | 107 | 241.295 | −0.067 | 233.921 | Across river to furnace site datum, nail & ribbon, force to ZERO |
| 9004 Theo position: H,X,Y,Z,C = 4.875, 0.000, 0.000, 0.000, 2.039 | | | | | | | Theo on furnace site datum |
| 112.188 | 204.870 | −0.895 | 108 | 61.295 | −0.483 | 233.585 | Back sight to visitor center datum |
| −239.925 | 63.192 | −6.275 | 109 | 165.245 | −1.817 | 248.232 | To dam, south, east side of stream, near water, to center wood beam |
| Hi−Med,Med−Low,Delta(>.02 ft) = 5.577374E−02, 0.3772922, 0.3215184 | | | | | | | |
| −25.517 | −34.879 | 2.093 | 110 | 233.811 | 2.617 | 43.261 | SE corner of furnace base. Slow = 1.335 error |
| −15.703 | −27.222 | 3.067 | 111 | 240.022 | 2.683 | 31.461 | South corner, east face, of furnace base |
| −13.962 | −27.761 | 3.295 | 112 | 243.300 | 3.133 | 31.121 | South edge of east arch |
| −4.784 | −28.706 | 3.272 | 113 | 260.539 | 3.300 | 29.151 | North edge of east arch |
| −2.870 | −28.980 | 3.095 | 114 | 264.345 | 2.950 | 29.160 | North corner of east face, furnace base |

**Table C3. Computed Survey Results (continued)**

| X | Y | Z | Sta# | Az | E | Distance | Comments |
|---|---|---|---|---|---|---|---|
| 9004 (continued) | | | | | | | |
| 4.439 | -38.041 | 2.755 | 115 | 276.656 | 2.717 | 38.342 | NE corner of furnace base. Slow = 1.042 error |
| -11.011 | 25.311 | -8.582 | 116 | 113.511 | -12.100 | 28.230 | Water's edge, west side of river, near furnace |
| Hi-Med,Med-Low,Delta(>.02 ft) = | | | 0.2526217, | 8.530092E-02, | 0.1673207 | | |
| -32.679 | 6.893 | -3.346 | 117 | 168.089 | -6.200 | 33.595 | Stone tunnel, 307 deg. (NW) at least 13 ft long, 28 in. wide opening, at north edge of a canal |
| -36.921 | -33.511 | -2.267 | 118 | 222.228 | -0.667 | 49.865 | NW corner of canal jct/bend, bottom, south of furnace |
| -53.103 | -27.291 | -2.242 | 119 | 207.200 | -0.533 | 59.708 | Canal from south, in line with stone wall going west, bottom of canal |
| -55.968 | -5.208 | -1.680 | 120 | 185.317 | -3.583 | 56.319 | Stone corner of wall along tail race south of furnace, near river |
| -60.087 | -26.286 | -1.152 | 121 | 203.628 | -1.250 | 65.600 | Tail race, west end, in center bottom of southward canal |
| -95.801 | -25.153 | -0.520 | 122 | 194.711 | -1.033 | 99.064 | South along canal, in center bottom |
| -49.572 | -33.837 | -0.866 | 123 | 214.317 | -1.033 | 60.029 | East corner of wall south of furnace, north face of wall |
| -53.478 | -57.795 | 4.029 | 124 | 227.222 | 3.683 | 78.904 | West corner of wall, corner of ssuth & west stone walls |
| 47.328 | -68.877 | 3.574 | 125 | 304.495 | 4.050 | 83.779 | NW junction of stone walls, near cave-in of west wall |
| 51.087 | -36.868 | 2.018 | 126 | 324.183 | 4.067 | 63.160 | East end of north stone wall, 4 ft wide |
| 51.026 | -36.952 | 5.768 | 127 | 324.089 | 4.067 | 63.160 | East end of north stone wall, top, south (outside) corner |
| 48.415 | -69.502 | 12.516 | 128 | 304.861 | 7.783 | 85.490 | West end of north wall, corner junction with west wall, top, inside |
| -55.130 | -58.936 | 13.221 | 129 | 226.911 | 7.283 | 81.358 | South end of west stone wall, junction with south wall, top, inside |
| -52.044 | -39.886 | 5.513 | 130 | 217.467 | 4.317 | 65.757 | East end of south stone wall, top, inside |
| -68.427 | -71.995 | 18.303 | 131 | 226.456 | 9.917 | 100.832 | Upper wall, SW corner, wall jogs east, runs north |
| -55.927 | -75.352 | 19.976 | 132 | 233.417 | 11.083 | 95.622 | Upper wall, north of last point |
| -65.696 | -61.836 | 15.676 | 133 | 223.267 | 9.683 | 91.524 | South on upper wall, south-going part, 3 ft wide |
| 38.954 | -51.052 | 1.671 | 134 | 307.345 | 2.117 | 64.260 | Casting shed area, pig yard datum |
| 13.714 | 19.922 | -9.144 | 135 | 55.456 | -14.983 | 25.037 | Retaining wall, river edge, dressed face of bridge abutment, no. end |
| -21.300 | 16.400 | 10.448 | 136 | 142.406 | -17.417 | 28.173 | Retaining wall, river edge, dressed face of bridge abutment., so. end |
| 9005 Theo position: H,X,Y,Z,C = | | | 4.875, | 0.000, 0.000, | 0.000, | 2.039 | Theo on furnace site datum. OBJECTS |
| Hi-Med,Med-Low,Delta(>.02 ft) = | | | 9.842396E-03, | 0.3313608, | 0.3215184 | | |
| -6.459 | -33.196 | 3.321 | 205 | 258.989 | 5.400 | 33.969 | Large pipe, east arch, south edge, standard measure to pipe bottom |
| 9006 Theo position: H,X,Y,Z,C = | | | 4.625, | 38.954, -51.052, | 1.671, | 0.273 | Theo north of furnace, near no. wall, pig yard datum. Sept 11, 1994 |
| Hi-Med,Med-Low,Delta(>.02 ft) = | | | 0.3510461, | 0.2821488, | 6.889725E-02 | | |
| 0.543 | -0.713 | 0.013 | 301 | 127.345 | 0.000 | 63.319 | Back sight to primary furnace site datum. Slow = 0.829 error |
| 5.051 | -39.032 | 2.943 | 303 | 160.479 | 3.283 | 36.030 | North arch & east edge of north face furnace corner |
| 3.640 | -51.354 | 2.837 | 304 | 180.490 | 3.300 | 35.374 | North arch & west edge of north face of furnace |
| -6.454 | -59.350 | 3.442 | 306 | 190.356 | 2.650 | 46.210 | Corner of west face of furnace, north corner, bottom |

## Table C3. Computed Survey Results (continued)



| X | Y | Z | Sta# | Az | E | Distance | Comments |
|---|---|---|---|---|---|---|---|
| 9007 | Theo position: | H,X,Y,Z,C = | 4.583, | 0.000, 0.000, | 0.000, | 2.039 | Theo on furnace site main datum. STRAIGHT LINE |
| 206.700 | −109.033 | 5.298 | 401 | 332.189 | 1.783 | 233.808 | Straight line, to near owner's driveway, south of small pine tree |
| 175.681 | −92.670 | 3.943 | 402 | 332.189 | 1.783 | 198.720 | Straight line, about 30 ft south |
| 146.690 | −77.378 | 2.825 | 403 | 332.189 | 1.783 | 165.928 | Straight line, about 30 ft south |
| 117.990 | −62.239 | 2.221 | 404 | 332.189 | 1.783 | 133.464 | Straight line, about 30 ft south |
| 88.420 | −46.641 | 1.928 | 405 | 332.189 | 1.783 | 100.016 | Straight line, about 30 ft south |
| 60.590 | −31.960 | 1.067 | 406 | 332.189 | 1.783 | 68.535 | Straight line, in line with north wall, edge of furnace area |
| −9.083 | −116.560 | 24.738 | 407 | 265.545 | 11.833 | 119.452 | To bush on top of stone wall, near driveway to owner's house, bottom of wall, a Walt Ryan datum |
| 9008 | Theo position: | H,X,Y,Z,C = | 5.021, | −239.925, 63.192, | −6.275, | 0.573 | Theo on river dam datum, dam site east side of river, 66 inches from west end of timber |
| 0.171 | −0.043 | 0.055 | 408 | 345.245 | 0.983 | 248.320 | Back sight to furnace site main datum |
| −244.625 | 13.427 | −4.738 | 409 | 266.490 | 0.583 | 76.767 | To iron pin in rock on west of river, 16 inches on centers to another pin under bank |
| 9905 | Theo position: | H,X,Y,Z,C = | 4.875, | 0.000, 0.000, | 0.000, | 2.039 | Theo on furnace site datum. OBJECTS 10Sept94 |
| −12.483 | −36.403 | 7.847 | 201 | 251.072 | 4.417 | 38.598 | East arch, cast iron header, south, bottom, at stone wall |
| −8.077 | −36.940 | 7.917 | 202 | 257.667 | 4.600 | 37.935 | East arch, cast iron header, north, bottom, at stone wall |
| 0.174 | −32.689 | 8.696 | 203 | 270.306 | 6.667 | 32.912 | Outer corner of binder, NE face of furnace, center, south corner |
| −20.485 | −30.898 | 8.368 | 204 | 236.456 | 5.383 | 37.236 | Outer corner of binder, SE furnace face, center, bottom, north corner |
| Hi–Med,Med–Low,Delta(>.02 ft) = | | | 9.842396E-03, | 0.3313608, | 0.3215184 | | |
| −6.295 | −33.227 | 8.072 | 206 | 259.272 | 5.400 | 33.969 | Taverse to pipe at #5 (#205) altitude |
| −9.385 | −28.788 | 12.406 | 207 | 251.945 | 13.967 | 31.201 | Top of east arch, bottom corner of stone to south of center point |
| 0.000 | 0.000 | 4.875 | 208 | 259.322 | 44.300 | 0.000 | Top of large pipe at top of furnace, south edge, top point |
| 0.000 | 0.000 | 4.875 | 209 | 234.122 | 13.633 | 0.000 | SE corner of furnace base |
| 0.000 | 0.000 | −8.248 | 210 | 235.778 | 13.633 | 0.000 | Traverse to stack at altitude |
| 9906 | Theo position: | H,X,Y,Z,C = | 4.625, | 38.954, −51.052, | 1.671, | 0.273 | Theo north of furnace, near north wall, pig yard datum. 11Sept94 |
| 0.587 | −33.523 | 8.728 | 302 | 155.445 | 3.300 | 42.252 | Smid = object, iron tie rod, NE face, north corner, bottom |
| −2.291 | −56.299 | 8.220 | 305 | 187.251 | 2.650 | 41.622 | Smid = object, iron tie rod, NW face of furnace, north corner, bottom |
| −5.172 | −48.349 | 8.200 | 307 | 176.495 | 2.467 | 44.250 | Smid = object, north arch header west side, bottom, at stone face |
| −3.803 | −39.813 | 8.188 | 308 | 165.273 | 2.450 | 44.250 | Smid = object, north arch header, east side, bottom, at stone face, stick readings missing, use numbers from #207 |
| 3.090 | −45.022 | 14.137 | 309 | 170.456 | 12.167 | 37.203 | Smid = object, north arch, bottom of key stone |

## Appendix D

*Excavation Report*
by Megan Battey

September 12, 1994

On September 10, 1994, exploration with a metal detector showed a linear feature approximately 14 feet long, 5½ feet from the east face of the furnace and running parallel to it. The following day a shallow pit was excavated at the south end of the (alleged) feature. (Loose stones leaning out from the furnace above the north end of the feature made that end an undesirable location for an excavation.)

The pit measured approximately 2 by 3 feet and was excavated to a depth of 1 foot. The first 6-inch layer (removed with a shovel) was rich, dark topsoil containing pieces of wood, brick, and stone. The second 6-inch layer (excavated with a trowel) was sandy soil ranging from a light color to a reddish brick color and contained brick fragments and schist stones. At the bottom of layer 2 was a dark stain of rotted or burned wood (figure D1). Seven glass fragments, 29 cut nails, and a flat, thin metal fragment were found in the stain.

The pit was photographed and rough sketches drawn. The artifacts were identified, photographed, bagged, and given to Victor Rolando (see figures 34 and 35, page 56). A sheet of plastic was placed at the bottom of the pit and it was backfilled.

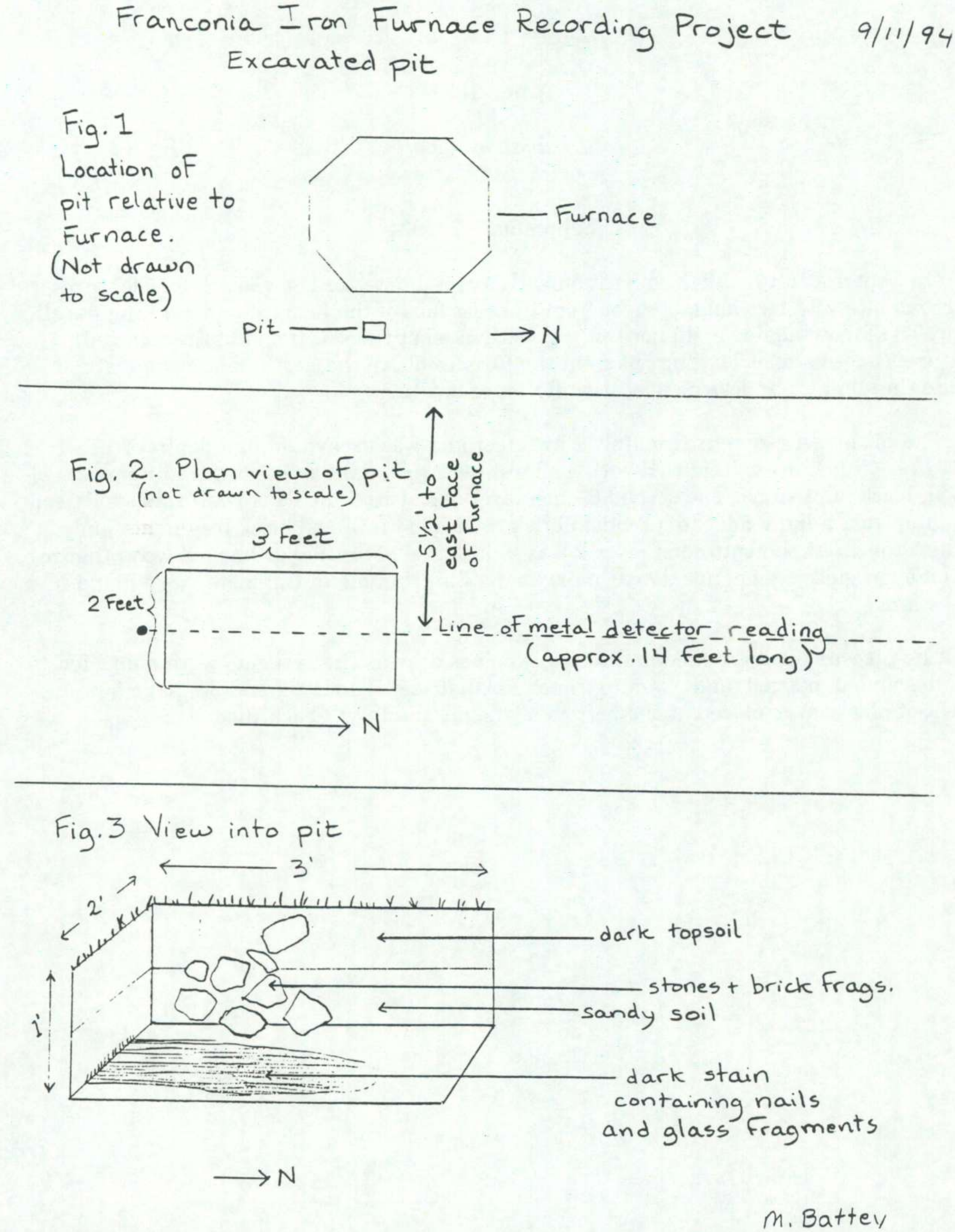



Figure D1. *Location, plan, and isometric view of excavated pit in front of the east arch (Megan Battey field sketch).*

## Appendix E

*Ironmaking Processes at Franconia Furnace:*
*Visual Slag Analysis and The Historical Record*
by Matthew A. Kierstead
September 1996



In September 1994, I joined the Northern New England Chapter of the Society for Industrial Archeology at a recording project at the former site of the New Hampshire Iron Factory Company "Lower Works" on the banks of the Gale River at Franconia, New Hampshire. I found several distinct types of ferrous metallurgical slag at this site. The characteristics of these slags appeared consistent with descriptions and samples of slags associated with the types of iron smelting and refining processes noted in the Lower Works historical record as outlined by James L. Garvin.[1] Between 1805 and 1870, the Lower Works included a blast furnace for smelting iron ore with charcoal fuel and limestone flux to produce molten pig iron; bloomery furnaces for the production of solid wrought iron directly from iron ore; and additional refining and converting processes, some of which did or did not generate slag. (As is the case with many early ironmaking sites, indiscriminate and unqualified use of the metallurgical terms "forge" and "furnace" in the historical literature make initial identification of some processes at the Franconia site difficult.)

The variety of slags I found at the Franconia Lower Works and the numerous processes suggested in the chronology prompted me to try to organize this information in order to make some connections which might confirm and/or eliminate some ironmaking processes and suggest directions for further research. In this essay I have briefly reviewed some relevant technological aspects of the ironmaking processes noted in or suggested by the Lower Works chronology, and I have attempted to establish some relationships between these processes and some of the raw materials and waste products consumed and discarded at the site. Future archaeology at the Franconia Lower Works may benefit from closer examination of the composition, extent, and location of these materials.

The SIA concentrated most of its Franconia recording activities on the standing octagonal stone blast furnace structure and the immediate area around it on the steep west river bank. Vitreous slag commonly associated with the primary blast furnace smelting of iron ore is abundant here; however, investigators found no evidence of a secondary iron refinery shop. The land on the east bank, across the river from the furnace, is flat and natural springs percolate from it in several places; for a short distance upstream, this bank and nearby brackish water are stained with bright orange rust. For some distance along and back from the east riverbank, I encountered widespread rusty and metallic slags, whose presence (as well as buried granite walls) suggest a location for the secondary metallurgical refining operations noted in the New Hampshire Iron Factory Company chronology.

The most common and easily identifiable type of slag found in the immediate area of the Franconia blast furnace stack is primary smelting slag, which was run from the blast furnace after the tapping of the molten pig iron, and disposed of nearby. This slag, typical of that from charcoal-fired blast furnaces, has a vitreous luster and conchoidal fracture, and sometimes exhibits flow and swirl patterns. Some of this slag is lighter in color, with a duller, more pumice-like, frothy texture. These two different types of blast furnace slags are thought to indicate the use of cold-blast and hot-blast furnaces respectively. The Franconia furnace operated with both cold and warm (heated, but not as hot as a true hot blast) air blasts; however, these slag characteristics should only be used as a rough indicator for blast type.[2] As at other blast furnace sites, much of the slag of the glassy variety at Franconia ranges from a dark, translucent bottle-green to an opaque turquoise blue. Slag coloration was sometimes used by iron masters to gauge blast furnace efficiency.[3] Through modern laboratory analysis, such as the archaeometallurgical work carried out by John H. White at the Eaton Furnace near Youngstown, Ohio, variations in slag coloration have been found to be the result of many factors, such as trace amounts of metal such as manganese and nickel in the iron ore, and therefore cannot be effectively used to judge historic blast furnace efficiency.[4]

The Franconia furnace was likely to have been a fairly efficient smelting operation because of the type of iron ore mined—a particularly rich deposit of magnetite. Of all the iron ores, magnetite possesses the highest possible stoichiometric ratio of iron to nonferrous constituents (72.4% iron to 27.6% oxygen, although this ideal molecular ratio is in reality never attained due to the presence of silica and other mineral impurities in the magnetite ore).[5] According to Charles T. Jackson's 1844 *Final Report on the Geology and Mineralogy of the State of New Hampshire*, samples of magnetite from the Franconia mines assayed as high as 69.04% iron, with only 9% wasted in the smelting process.[6] In the smelting of magnetite iron ore (which is now little-used in domestic iron- or steel-making) oxygen is released and iron is separated from the silica in the ore, forming a glassy slag. The efficiency of smelting furnaces of this type was also dependent on such factors other than ore quality as the composition of the flux (which, at Franconia, was a low-quality, siliceous limestone), and the bosh and stack (furnace interior) configuration, which influenced the shape of the oxidation-reduction zones within the furnace.[7]

The bulk of the glassy blast furnace slag was deposited on the furnace (west) side of the Gale River, but scattered slag of a similar nature appears on both banks, upstream and downstream of the furnace. Although the physical origin of any blast furnace slag found below the high-water level of the river is difficult to pinpoint, some slag possibly washed downriver from an upstream blast furnace associated with the iron-making operations of the Haverhill and Franconia Iron Company "Upper Works."[8]

The slag deposited on the east riverbank, opposite the furnace, can be divided into two varieties according to their distinctly different physical characteristics, although, in situ, these slags are mixed together, suggesting simultaneous deposition. One type of slag consists of heavy, rusty, metallic spongy masses with inclusions: silvery flakes of iron, glassy blobs, pebbles and small bits of charcoal are apparent on freshly broken surfaces. This slag could be interpreted as a type of blast furnace slag. According to John H. White, "Slags tapped from cold-blast charcoal furnaces may be texturally homogenous throughout, or they may be bisque-like, containing small fragments ...of charcoal... prills of iron, and under certain conditions (slow cooling) crystallized minerals."[9]; but the location, concentration, and extent of this slag and its dissimilarity to the other, vitreous blast furnace slag on site suggest an alternative origin.

Historical accounts of equipment and processes at the New Hampshire Iron Factory Company works indicate the presence of secondary iron refining operations which would have generated a ferrous slag waste product. Mention of an unspecified "forge" at this site appears as early as 1801.[10] In 1810, the New Hampshire Iron Factory Company's plant included "...a new forge shop with four fires and two large trip-hammers."[11] This arrangement resembles the layout of a bloomery forge. Early American iron-making equipment and procedures followed English precedent, and "Generally, the English forge had two hearths (called fires in the 1780s and 1790s) to each trip-hammer."[12] An 1817 description of the Franconia works includes "...a pounding machine to separate the iron from the cinders...," [indicative of the blooming process], and two shops with "...four fires and two hammers...."[13]

In the bloomery process, which is no longer practiced commercially in the United States, raw iron ore was converted into wrought iron. The iron ore was heated in a specialized charcoal hearth called a bloomery forge. Air was blown through the mass, reducing it to a pasty "bloom" of near-molten iron, silica slag and other solid impurities. A refined iron bloom remained a highly malleable solid, and never became a fluid, molten mass. Once a bloom reached a weight of roughly 200 pounds, it was removed with tongs and placed under a large trip hammer, which pounded out most of the slag and other impurities. The resulting product was wrought iron. (Wrought iron contains minute linear inclusions of silicious slag in physical association with the metal, rather than in solid solution as in cast iron, imparting to it a much higher degree of workability.)

The local presence of magnetite iron ore is another factor that suggests that the Franconia Works included a bloomery forge. By 1810, "...the company was taking all of its ore from the Coleby lot on [nearby] Ore Hill. This was described as superior to that from the Howland lot...."[14] The Ore Hill deposit is indeed magnetic iron ore. Wrought iron could be produced in a bloomery from other iron ores such as bog iron ore (limonite), but magnetite was a preferred charge.[15] This is evident in the historical concentration of the American bloomery industry in the Adirondacks, where the Precambrian bedrock contains numerous massive, rich magnetite deposits. Indeed, "The Lake Champlain region, both the Vermont and New York sides, was regarded industry-wide as containing the best-known [magnetite] deposits of the time."[16] Utilization of the rich Franconia magnetite ore body would have been highly desirable from the standpoint of bloomery forge compatibility, and as noted, blast furnace efficiency.

The slag squeezed out of a bloom was described as a viscous mass of inclusions. Victor Rolando describes the weight, appearance, and content of bloomery slag as follows: "Slag from early- to mid-19th century Vermont bloomery sites is likewise dark and heavy, loaded with wasted iron. Not shiny and light in weight like slag from blast furnaces, bloomery slag is dull-looking...."[17] Additionally, "The process of hammering blooms was known in some sectors of the industry as shingling. It was usually used more in terms of hammering to remove (or squeeze out) solid bits of impurities such as slag, small stones, or unburned charcoal."[18] The Franconia slag in question resembles bloomery slag described in these passages, and the New Hampshire Iron Factory Company chronology certainly supports the existence of a bloomery forge. The location and distribution of this slag suggest that it was generated at a nearby iron refining operation and regularly disposed of along the river's east bank.

In August 1996, further investigation at the slag dump on the east bank of the Gale River resulted in the discovery of numerous bloomery hearth "bottoms" and "skulls", masses of iron, charcoal, and slag that remained after creation of an iron "bloom", or "loup" (figure E1). Metallurgical laboratory analysis of examples of this distinctive bloomery waste from ironmaking sites in Connecticut indicates that information about efficiency and operations can be determined from these ironmaking waste products.[19]

A second type of refining slag, with distinctly different physical characteristics, occurs in abundance on the east river bank at Franconia. This slag is dense, heavy and submetallic, and is a dark, ruddy, bluish-purple-to-black color, with a smooth, satiny luster (figure E2). When it is broken open, the fracture sometimes exhibits a shiny, golden-to-steely metallic luster, tinged with a "peacock" sheen. There are also small gas bubbles and differential crystallization patterns in the slag as one might see in a broken iron casting. The slag sometimes contains inclusions of sand or small pebbles, and some pieces have perfectly flat bottoms and layered pour marks. This slag appears to have been collected in a molten state, and allowed to cool and congeal as clusters of molten drips and blobs, or ladled into a container. The "ropy" appearance of this slag, and its structure, indicate that it is a second kind of bloomery waste product, tap slag, a variety of slag that was run off the bloomery hearth in a fluid state.[20]

The general appearance of this second east bank Franconia slag also suggests that it could be a high-iron content silicate slag derived from an iron refining process in which pig iron was converted to wrought iron, such as the finery or puddling process; indeed, slags from this type of refining operation were historically described as "...always black or bluish-black, vitreous, or semi-metallic in lustre."[21] In 1810, according to Garvin's chronology, company agent David Smith "urged...the employment of forgers or refiners who could turn cast iron into wrought iron without the waste of time and fuel of current workmen, who were slow and inefficient...."[22] This statement can be interpreted two different ways. The term "forgers" connotes use of a bloomery forge—the word "forges" being commonly associated with, and technologically appropriate for, that process. The word "refiners" connotes the use of a finery or puddling furnace, a process that could "turn cast iron into wrought iron," as Smith stated. In these latter processes, raw pig iron was brought to a molten state in the hearth of a special furnace, carbon and all other

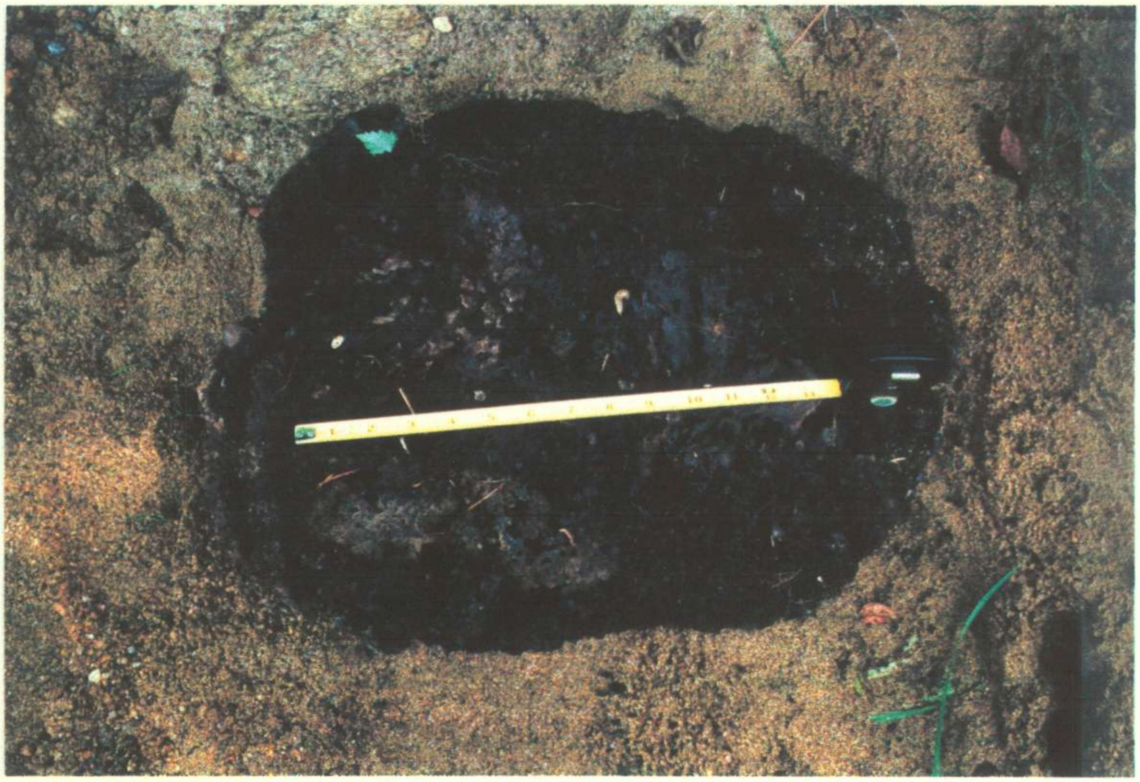


Figure E1. *Bloomery hearth "bottom" (Matt Kierstead photo).*

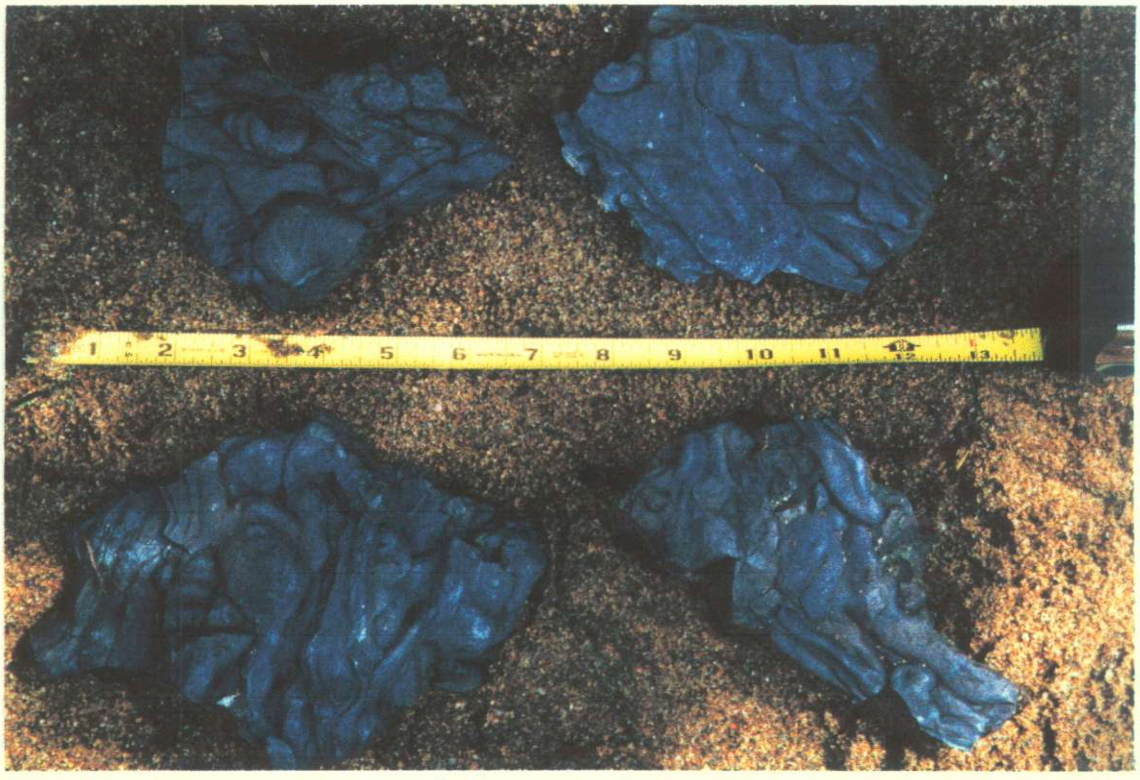


Figure E2. *Possible bloomery "tap slag" or puddling slag (Matt Kierstead photo).*

impurities in the molten pig iron were burned off, and silica in the slag combined with the pure molten iron and congealed as wrought iron.[23] The result was a high-silica iron, with the constituents in an intimate chemical solution, rather than in the discrete physical relationship found in wrought iron made in a bloomery forge.

The finery and puddling processes differed in several important respects. The finery used charcoal for fuel, and the puddling furnace used mineral coal. The finery hearth was simpler than the puddling furnace, which was of the reverberatory type. Reverberatory furnaces, varieties of which are used in modern nonferrous smelting operations, incorporate arch-topped refractory brick hearths in which the heat of combustion is reflected onto the molten metal, keeping it from direct contact with the undesirable chemistry of the burning coal fuel.

The finery and puddling process incorporated slagging procedures to facilitate removal of carbon and the addition of silica. Puddling furnace bottoms were lined with materials that interacted with the molten pig iron, which was manipulated in a bath of "liquid cinder" slag, causing the desired chemical changes, including removal of manganese, phosphorous, and sulfur.[24] (This is a good example of the importance of slag as an agent of purification and transformation in metallurgical chemistry—it is not just a useless scum floating on top of a bath of good metal.)

Puddling was a wasteful process, and the slag generated contained a high percentage of iron. In puddling, "The loss of metal was very large... This would mean the formation of a considerable amount of cinder...." The cinder, which runs from the hearth with the metal, is tapped from the surface...."[25] "Cinder," in this case, is synonymous with slag. Puddling furnace "bottoms" were usually lined with sand as a source of silica. This "dry puddling" process wasted as much as 30% of the iron in the charge. The later "wet puddling" process used iron oxide mill scale "bottoms," cutting iron losses down to 10% of the charge. The wet puddling process was more efficient, but it still generated a considerable quantity of slag.[26]

Slag generated by the puddling refinery process was a "clean," high-iron ferrous silicate slag collected as a molten liquid and cooled in vessels, or solidified in pools on shop floors, and then discarded in slag dumps. The fluidity and homogeneity of this type of slag, and the circumstances of its deposition and cooling suggest similarities to bloomery tap slag. The references to the two processes in the chronology and the expected similarities of the two slags suggest that at some time a finery hearth or puddling-type refinery may have operated at the Franconia Lower Works in addition to a bloomery. Further review of relevant technical literature, New Hampshire Iron Factory Company archives, and examination of known bloomery, finery, and puddling archaeological sites and slags will be necessary to reconcile the historical record with the evidence on site, and to confirm or rule out which metallurgical processes were used at Franconia.[27]

In addition to the references to bloomery, finery, and/or puddling operations at the New Hampshire Iron Factory Company, other iron refining technologies are indicated in the Franconia chronology. In 1816, in a New Hampshire Iron Factory Company report, William P. Page recommended that the company install an "Air Furnace," which according to Garvin's chronology, would "further refine the cast iron during remelting, permitting thinner and finer patterns to be used and producing a more refined cast product."[28] (Iron from an air furnace was also particularly desirable for use in the manufacture of malleable castings.) In 1817, the Lower Works were described as containing an "air furnace," which Garvin states was used "...for remelting iron for casting...."[29] The term "air furnace" is a common technical term for a type of reverberatory melting and refining furnace with some physical and operational similarities to a puddling furnace. An air furnace is charged with pig iron from a blast furnace, which is remelted and refined. According to Rolando, "The air furnace was a variation of the puddling furnace...used where melting [iron for castings which] required [metal of] great purity and strength...the greatest casting strength could be obtained with the air furnace because the iron could gain the highest percentage carbon with the lowest percentage sulfur [from the coal fuel]."[30] Since elimination of sulfur was a primary goal, a chemically basic, calcium carbonate flux such as powdered lime was used, which typically yields a rocky, chalky, light-colored slag.

The New Hampshire Iron Factory Company chronology indicates that by 1850, the company replaced their "air furnace" horizontal refining reverberatory furnace at the Lower Works with a vertical cupola-type pig iron melting furnace.[31] A cupola furnace is a tall, hollow, cylindrical iron column lined with refractory brick, constructed and operated much like a blast furnace. A cupola furnace is fueled with coke, a pure fixed carbon fuel obtained by driving off the sulfur and volatiles in a retort-type oven. A cupola is loaded with coke, pig and/or scrap iron and flux from an opening high on the side, and an air blast is blown through tuyeres into the bottom of the cupola, where molten pig iron collects and is tapped. The degree of refinement attainable in a cupola is comparable to that of an air furnace. The cupola makes a more free-flowing iron ideal for "thinner and finer patterns," as recommended by Page.[32] The characteristics of the iron can be manipulated in the cupola by the addition of silica; manganese, and other alloying agents. With the cupola, "...little difficulty [is) experienced in obtaining a mixture which ...should...give a very close approximation of the required composition."[33] The cupola furnace also uses a calcium carbonate flux. Why the New Hampshire Iron Factory Company changed from an air furnace to a cupola for melting pig iron is unknown; however, in many foundry applications, "The cupola furnace was more convenient, economical, and most generally used."[34] The air furnace did possess some disadvantages over the cupola; it took longer to melt a given quantity of iron, and under some circumstances the air furnace actually added sulfur to the iron, especially if less common, low-sulfur, "smokeless" semi-anthracite-type bituminous coal was not used for fuel. Coal was expensive to ship to Franconia, and the coke fuel used in the cupola was both lighter and lower in sulfur. The quality of the iron suffered if it was held in an furnace too long before it was tapped.[35] Cupolas are still commonly used in iron foundries today.

In 1810, the New Hampshire Iron Factory Company sought "...the employment of a practiced steel baker to use the new but idle experimental steel furnace...."[36] Blister steel was being manufactured at the Upper Works at this time.[37] By 1817, a steel furnace was listed among the equipment at the Lower Works.[38] "Blister" and "baker" indicate the cementation process, which does not generate slag.[39] In this process, iron bars are packed with carbonaceous material in a ceramic or graphite crucible or a cast iron vessel and held at a red heat for a specific length of time. This process imparts a carbon steel "rind" to objects, or "case hardens" them. If baked for a long enough time, the carbon penetrates the iron objects completely and a crude, "blister" steel is made, so called for its blistered surface appearance. This process is not to be confused with the crucible steel process, in which small batches of molten, liquid steel are made in crucibles.

The variety of cast iron, wrought iron and steel manufacturing processes which appear in the New Hampshire Iron Factory Company chronology indicates the utilization of a bloomery forge, an air furnace, a refining cupola, and a blister steel furnace (which does not generate slag) during the course of operations. The chronology certainly suggests the use of a finery hearth or puddling furnace. The two ferrous slags observed on the east bank suggest that at least some of these processes were performed in the area across from the blast furnace on the west side of the Gale River. The markedly different physical characteristics of the slags suggest that they are products of separate phases of the bloomery process, or possibly derive from the bloomery and/or pudding process. The air furnace and cupola used coal and coke for fuel respectively, which was brought in by wagon teams from the nearest railroad, nearly a dozen miles away. The availability of these raw materials played a large part in determining the chronology of ironmaking processes used at Franconia.

The specific ironmaking technologies used at Franconia may be revealed through archaeological excavation on the east bank of the Gale River. Further research on iron-making technology in mid-nineteenth century America, and the affairs of the New Hampshire Iron Factory Company are necessary in determining the changing metallurgical requirements and capabilities of this operation. Comparison of physical and laboratory analysis of slags from Franconia and other ironmaking sites might provide context and augment the findings of an excavation in identifying historic processes, materials, and efficiencies of operations at the New Hampshire Iron Factory Company.

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Endnotes

1. James L. Garvin, *Chronology of the Development of the New Hampshire Iron Factory Company from 1805 to 1884* (Concord, New Hampshire: New Hampshire Division of Historical Preservation, 1994). Garvin's chronology is a synthesis of available primary and secondary sources pertaining to the New Hampshire Iron Factory Company, and is the source of specific technological references to the Lower Works found in this essay.

2. John H. White, "Historic Blast Furnace Slags: Archaeological and Metallurgical Analysis," *JHMS* 14, No.2, (1980): 57.

3. Frederick Overman, *The Manufacture of Iron in All Its Various Branche*s (Philadelphia: H.C. Baird, 1854), 203.

4. White, "Blast Furnace Slags," 56.

5. Cornelius S. Hurlbut, Jr., *Dana's Manual of Mineralogy* (New York: John Wiley and Sons, Inc., 1971), 295.

6. Charles T. Jackson, *Final Report on the Geology and Mineralogy of the State of New Hampshire* (Concord, N.H.. 1844) as noted in Garvin.

7. T.L. Joseph, *Information Circular 6779: The Iron Blast Furnace* (Washington, D.C.: U.S. Bureau of Mines, May 1934), 5-8.

8. Garvin, *Chronology*, 5-6.

9. White, "Blast Furnace Slags," 56.

10. Garvin, *Chronology*, 1.

11. Garvin, *Chronology*, 2.

12. Victor Rolando, *200 Years of Soot and Sweat: The History and Archeology of Vermont's Iron, Charcoal, and Lime Industries* (Burlington, Vt.. Vermont Archaeological Society, 1992), 18.

13. Garvin, *Chronology*, 4.

14. Garvin, *Chronology*, 2.

15. Rolando, *Soot and Sweat*, 18.

16. Rolando, *Soot and Sweat*, 19.

17. Rolando, *Soot and Sweat*, 20.

18. Rolando, *Soot and Sweat*, 21.

19. Gordon, Robert, "Material Evidence of Early Ironmaking Techniques," *IA: The Journal of the Society for Industrial Archeology* 21, No. 2, (1995): 69–80.

20. Gordon, Robert, *American Iron: 1607–1900* (Baltimore: Johns Hopkins, 1996), p. 25.

21. John Percy, *Metallurgy: the Art of Extracting Metals from their Ores and Adapting them to Various Purposes of Manufacture—Iron and Steel* (London: John Murray, 1864), 626.

22. Garvin, *Chronology*, 2–3.

23. Percy, *Metallurgy*, 579–580.

24. James Aston and Edward B. Story, *Wrought Iron, Its Manufacture, Characteristics, and Applications* (Pittsburgh: A.M. Byers Co., 1939), 13.

25. J.H. Stansbie, *Iron and Steel* (London: Constable and Company, 1915), 120–121. Stansbie, pp. 119–134, describes the puddling process in detail.

26. Aston and Story, *Wrought Iron*, 11–12.

27. Walter Ryan, "A Brief Analysis of a Metal Sample from the Pittsford, Vermont Iron Furnace," *Society for Industrial Archeology—New England Chapters Newsletter*, 11, No. 2, 1991: 12–13. This article discusses the results of analysis of an iron smelting artifact recovered at an SIA recording event at Pittsford, Vermont in May, 1991 made at the metallurgy and physics laboratories at New Hampshire Technical College at Claremont, New Hampshire. The results of the analysis included the object's specific gravity, spark test pattern, Rockwell hardness, and iron-graphite composition from microscope photographs of acid-etched sections. The article concludes with the statement "Chemical analysis of this artifact and a thorough analysis of more samples and products from the Pittsford furnace are necessary before any meaningful generalizations can be made concerning the quality of the cast iron produced there." This is certainly true for analysis of artifacts from this or any individual site. Indeed, no meaningful generalizations about the broader operations and relationships of the New England iron industry in general can be made until similar analysis of iron smelting artifacts from other furnace sites is carried out. The laboratory analysis of industrial archaeological artifacts will become far more meaningful once the resources of a consistent and cooperative laboratory become available, and a data base begins to grow.

28. Garvin, *Chronology*, 4.

29. Garvin, *Chronology*, 4.

30. Rolando, *Soot and Sweat*, 36-37.

31. Garvin, *Chronology*, 9-10.

32. Garvin, *Chronology*, 4.

33. Stansbie, *Iron and Steel*, 108-112.

34. Rolando, *Soot and Sweat*, 35.

35. R.H. Palmer, *Foundry Practice—a Text Book for Executives, Molders, Students and Apprentices* (New York: John Wiley & Sons, Inc., 1929), 362.

36. Garvin, *Chronology*, 2-3.

37. Victor Rolando, "The New Hampshire Iron Works, Franconia, New Hampshire 1804-1864," *Society for Industrial Archeology—New England Chapters Newsletter* 13, No 2, 1993: 3.

38. Garvin, *Chronology*, 4.

39. Stansbie, *Iron and Steel*, 142-143.

## Appendix F

*Compass Survey of Grounds Uphill of the Stack*
by Walt Ryan and Krista Butterfield
September 11, 1994

A hand-held compass and steel-tape survey was made uphill behind the furnace stack to document locations of certain surface features. Compass accuracy was estimated at ±5 degrees.

Starting point (Station 1) of the compass survey was the southwest corner of a stone wall and is identified on Dennis Howe's field sketch of foundation walls with respect to the furnace stack (see "starting point for 9/11/94 survey" lower-left of figure 46, page 66). This starting point is also Sta 407 in the Theodolite Survey (see Appendix C, table C2, page 96).

| Station | Feature | Distance | Bearing |
|---|---|---|---|
| 1 | Start at SW corner upper stone wall | - | - |
| 2 | Tree | 41 ft 10 in. | 250 deg. |
| 3 | Wall | 8 ft 9 in. | 272 deg. |
| 4 | Stump (edge of collapsed wall) | 25 ft | 176 deg. |
| 5 | Wall | 34 ft 9 in. | 173 deg. |
| 6 (from 5) | Jog in wall | 9 ft | 72 deg. |
| 7 | Sight back to Station 4 | 24 ft 2 in. | 340 deg. |
| 8 | Table rock | 23 ft 5 in. | 22 deg. |
| 9 | Edge of wall (white birch) | 19 ft 11 in. | 326 deg. |
| 10 | Break in wall | 18 ft 4 in. | 0 deg. |
| 11 | Tree branch | 45 ft 11 in. | 354 deg. |
| 12 | End of wall | 26 ft 11 in. | 354 deg. |
| 13 | E. edge of driveway | 15 ft 7 in. | 284 deg. |
| 14 | W. edge of driveway | 10 ft 6 in. | 280 deg. |
| 15 | Mound | 33 ft 5 in. | 254 deg. |
| 16 | Corner of house foundation | 42 ft 10 in. | 254 deg. |
| 17 | Down driveway | 50 ft. | 4 deg. |
| 18 | " " | 50 ft | 10 deg. |
| 19 | " " | 50 ft | 18 deg. |
| 20 | " " | 50 ft | 19 deg. |
| 21 | Close loop to Station 1 | 34 ft 2 in. | 104 deg. |

Notes:

1. Stations 5 and 6 measured from Station 4. Station 8 continues from Station 5.
2. Distances for Stations 17 thru 20 corrected on field sheet from "50 inches" to "50 feet".

## Appendix G

FRANCONIA AREA HERITAGE COUNCIL
Post Office Box 169 Franconia NH 03580

July 27, 1993

Dr. William Taylor, Department of Social Studies
Plymouth State College
Plymouth, NH 03264

Dear Dr. Taylor,

I wish to draw your attention to the only surviving iron "blast" furnace in NH. Located in Franconia, it was built in 1805 and is deemed to be worth preserving and, if possible, purchasing. We have a 6-foot bellows that is said to have been used at the furnace or the forge, and a cart used for dumping ore and charcoal into the furnace.

My hope is that the NH Chapter of the Society for Industrial Archaeology may have some interest in the site and that you may have some advice to offer. Your name was suggested to me by John Frisbee, director of the NH Historical Society.

You may be aware that Dr. Duncan C. Wilkie, while associate professor at Plymouth State and a staff archaeologist for NH, inspected this furnace in 1989, along with Dr. James Garvin, state architectural historian. Dr. Wilkie drafted an application for nomination to the National Register of Historic Places. Dr. Garvin is considering following up on the application process now.

In a recent letter to me, Dr. Garvin said, "All of us in this office recognize the significance of the furnace and are eager to work with you to ensure its recognition and future safety and accessibility." However, there appear to be no state or federal funds for preservation or purchase of this site.

The owners, Mr. and Mrs. Kevin O'Brien, want to sell their house, which sits on the hill behind the furnace, along with the furnace site, as one package, totaling almost four acres. Small trees grow on top of the stack.

Dr. Garvin recommended procedures to keep moisture out of the furnace, but they have not been undertaken. Brush has been cut from in front of the furnace so that it is visible from a small town park across the Gale River, but the furnace itself remains unprotected from moisture, which allows growth of roots and frost heaving.

*To preserve and make available the historic heritage of the region*

Our goals are to protect the furnace from further deterioration due to moisture, and to acquire the site--at least 1/2 acre, preferably nearly two acres.

Dr. Wilkie wrote that the furnace played a major role in the development of commerce and industry in northern NH. He noted its unusual octagonal shape and its potential for significant research. The partial remains of the hot blast technology is preserved in the furnace today, he said.

Other excerpts from Dr. Wilkie's draft application, as it relates to industrial archeology, follow:

> Excavation would supply a number of important research questions about the state of technology in iron production then. Also it would reveal what kinds of technology were used in Northern New England as opposed to the great iron centers of the Mid-Atlantic. The furnace is a focal point for industrial development in the region north of the White Mountains. From the knowledge gained at the site, historical research could be developed for charcoal and limestone kilns, sandstone quarries, brick and fire-brick kilns, iron ore mining and much more....Examination of the ground surface around the furnace clearly shows the buried archaeological potential. Remains of the canal, foundations, casting bed, and piles of ore, slag and charcoal existed all over the two acre site. Falling debris from the standing furnace and dense bushes are actively preserving the buried archaeological remains.

Records of the firm, the New Hampshire Iron Factory Company, are available and provide great detail on the facilities and the operation.

Is it possible that the NH Chapter of the Society for Industrial Archaeology would be interested in helping to save this furnace? We think it likely that, were we to have the means to make an offer, the owner might sell the site separately.

At least, we would appreciate some guidance in determining the dollar value of the site, and in justifying it.

Sincerely,

Jewell A. Friedman

(Ms) Jewell A. Friedman, Researcher

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