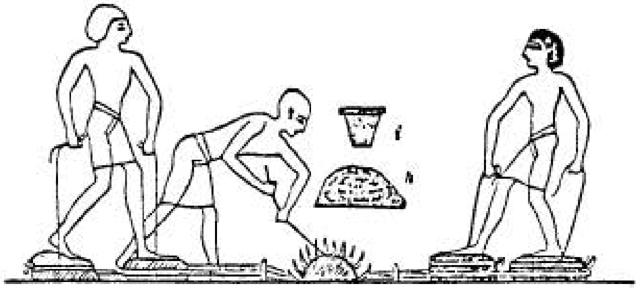
Chapter 1 Historical Overview of Iron Making

Pre-American Ironworks

The distinction of being the earliest person in recorded history to work iron goes to Tubal Cain, who was born in the seventh generation from Adam and is described as "Tubalcain, the ancestor of all who forge instruments of bronze and iron" (Genesis 4:22). The first evidence of iron implements actually transmitted to us from ancient times comes from Egypt, the joint between two stones revealing a tool that had been lost.



1-1. *Depiction of a small furnace (center) and foot-operated bellows (left and right) on the wall of an Egyptian tomb dating to about 1500 BC (Wilkinson 1883:312).*

This was perhaps 5,000 years ago (Moldenke 1930:2-4). Recent investigations in Africa have disclosed that prehistoric civilizations in what is today Tanzania practiced a method of smelting iron and making carbon steel that was technologically superior to any steelmaking process in Europe until the middle of the 19th century:

> At the request of the scientists and working entirely from memory, the Haya [of Tanzania] constructed a traditional furnace. It was 5 feet high, cone-shaped, made of slag and mud and built over a pit packed with partially burned swamp grass; these charred reeds provided the carbon that combined with the molten iron to produce steel. Eight ceramic blowpipes extended into the furnace chamber near the base, each connected to a goat-skin bellows outside. Using these pipes to force air into the furnace, which was fueled by the charcoal, the Haya were able to achieve temperatures higher than 3275° F, high enough to produce their carbon steel.
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> In excavations on the western shore of Lake Victoria, they discovered remnants of 13 furnaces nearly identical in design to the one the Haya had built. Using radioactive-dating process on the charcoal, they found that these furnaces were between 1500 and 2000 years old, which proved that the sophisticated steelmaking techniques demonstrated by the contemporary Haya were indeed practiced by their ancestors. This discovery, the scientists conclude, "will help to change scholarly and popular ideas that technological sophistication developed in Europe but not in Africa" ("Africa's Ancient Steelmakers" *Time* Sept. 25, 1978:80).

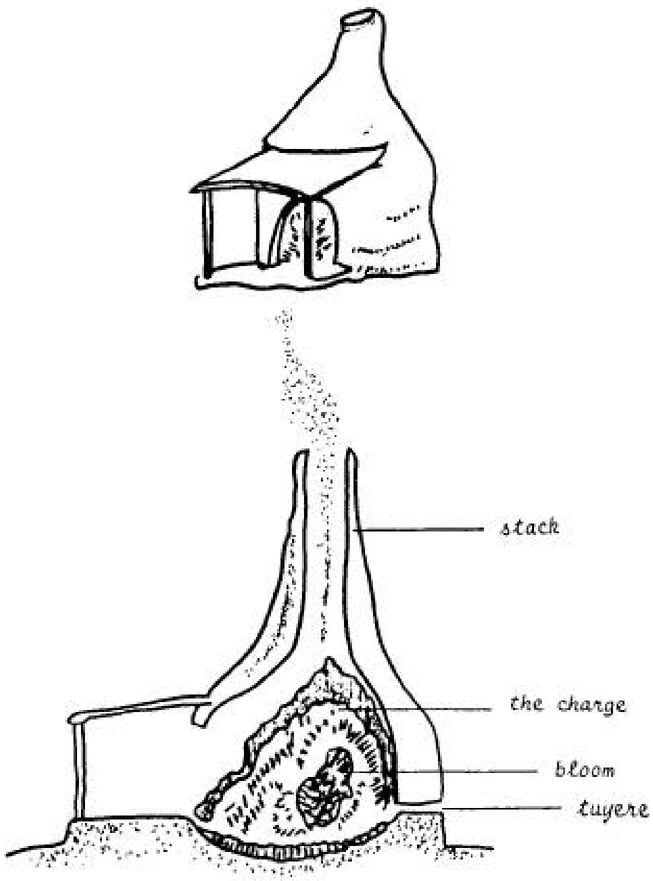
True cast iron is a relatively recent achievement, but it was occasionally made in prehistoric bloomeries existing at the close of the Dark Ages. The process, conducted in an ancient form of hearth and blast furnace combined, was the prototype of our modern developments in these directions. The remains of some 400 of these prehistoric furnaces were discovered about a century ago in the Jura Mountains, which border France and Switzerland. The enormous amount of charcoal used as fuel compelled the selection of locations rich in wood, charcoal being made on the spot. Iron ore came from nearby, and the mining operations conducted by these primitive men, rediscovered by the German miners of the Middle Ages who found stone implements in the tunnels, gave rise to legends of dwarfs and gnomes, implicitly believed then, and current in those regions to the present day.

A careful study of the furnace ruins, which were found by tracing the paths of slag backward into the mountains, indicates that a hearth of fireclay from 6 to 8 inches thick was laid on the ground. Material of the same kind and thickness formed the furnace lining, which was reinforced by a heavy stone backing, the total thickness varying from 18 to 27 inches. About 2½ to 3 inches above the bottom of the hearth a door was provided for, a substantially arched entrance having the full width of the shaft of the furnace and carried outward through the earth covering of the furnace proper. This shaft, or chimney, was 8 to 12 feet high, and had on top of it a ring of stones to prevent damage while charging. The general shape of the furnace was that of a truncated cone leaning forward somewhat, so that in throwing in charcoal and iron ore on top, the door below would be kept free from spilled accumulations.

After drying out such a furnace, it was charged with alternate layers of charcoal and ore, ignited, and left to the action of the natural draft. The temperatures obtained were such that only the front of the furnace became red hot—the rear was merely glazed. The fire cracks thus produced necessitated repairs. One man would remain with such a furnace constantly. As slag appeared on the hearth, he would pull it out with a hook, slice up the fire, eventually draw out a red-hot cake of iron, and immediately forge it into bars. As everything was done by hand and only 30 to 60 pounds of iron were produced at a time, the metal was highly expensive. Hence, even some of the hammers used and found in these excavations were of stone. Furnaces of this kind were still in existence in the time of the early Romans. In fact, the Romans took the art with them into their colonies, and both Spain and Britain saw the making of arms from the iron of native ores.

While the furnace men, who were held in high respect for their indispensable knowledge, were only aiming at the production of wrought iron, unquestionably they noticed occasional molten metal. Indeed, this knowledge was old even though the use of cast iron in the arts is of very recent date. There is a record of a bridge with cast-iron chains being built in Japan in AD 70. The Greek geographer Pausanias spoke a century later of cast-iron statuary introduced by Theodorus (of Samnium, an ancient country in central Italy). Possibly the crucible figured considerably in these early developments, with wrought-iron scraps and charcoal being melted together. But the first recorded example of making pig iron harks back to AD 1311, in the Siegerland of Westphalia (a region of Germany bordering the Netherlands). Knowledge of the subject must have spread widely in spite of the secrecy then prevailing, most likely through the medium of journeymen operatives, because cast-iron castings were made about 40 years later in Sussex (southeastern England). While molten iron was known by the Romans in Britain at a very early period, however, the actual first recorded English example of cast iron is a gravestone dated 1450 at Burwash Church.

A small forge operating in the mountains of Catalonia in northeastern Spain during the 8th century represented one of the early significant metallurgical advances in iron making. The Catalan forge was a stone-built cup, called a hearth, about 3 feet high and 2½ feet in diameter. A short distance above the front of the base was a small opening that allowed the tuyere (nozzle) of a leather bellows to supply air. The hearth was filled with charcoal to the level of the tuyere.



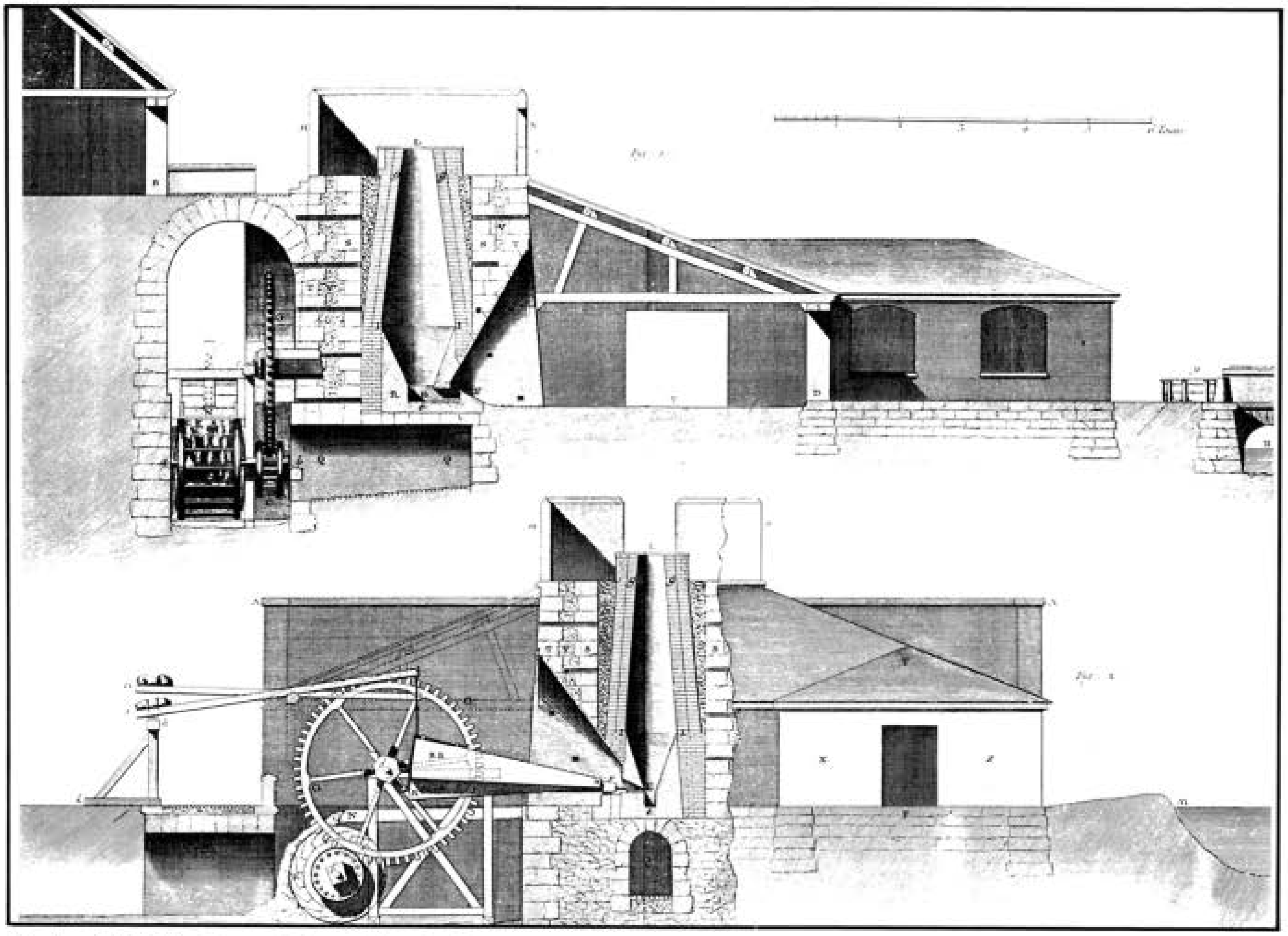
1-2. *A representation of an early Catalan forge.*

On top of this, more charcoal filled the front half and iron ore filled the back half (nearest the tuyere). Air from the bellows forced hot carbon monoxide from the burning charcoal to combine with the oxygen in the iron ore, reducing the ore to a hot, pasty (non-molten) mass of iron. The lump of iron was removed from the hearth with tongs and was alternately hammered and reheated, both to squeeze out pieces of stone and charcoal, and to fashion the iron into a manageably shaped bar called an ancony. The product was a relatively low-carbon iron capable of being hammered (wrought) into many useful shapes. It was also resistant to rust since the charcoal (unlike today's high-sulfur coal) did not introduce sulfur into the iron (Kauffman 1966:32). The Catalan forge could yield 350 pounds of iron in the same 5 hours it took predecessor forges to make only 50 pounds.

By the 9th century, variations of the Catalan forge were operating in central Europe. At forges along the Rhine River, a stone shaft (chimney) 10 to 16 feet high was built above the hearth to increase the capacity of the forge. It became known as a stuckofen (pronounced stook-ofen), which means stack-oven. It was also known as a wolf furnace, but it was basically still a Catalan forge. The Catalan forge, however, did not evolve into a furnace everywhere. In England it was called a bloomery forge (or bloomery). In France, the product of the forge was called a loupe (loop). As the size of the forge increased, so did the size of the bellows. Whereas the forge location formerly was determined primarily by accessibility of wood for charcoal, the switch from manual (or animal) to waterpower, to drive the larger bellows, forced the forges out of the deep forests into the valleys near swift-running streams and rivers.

The wolf furnace, meanwhile, which was a European attempt to utilize the waste heat of the old Catalan forge, did not replace the bloomery forge. Its larger bellows did succeed, however, in heating the charge to a temperature sufficient to melt the iron and allow it to trickle to the bottom of the hearth where it cooled and solidified. Having been subjected to higher temperatures, this iron chemically absorbed enough carbon (from the charcoal fuel) to transform it into a hard iron. However hard, it was too brittle to be worked at the hammer. Production of molten iron in the furnaces in use during these very early days was considered a serious detriment. It was looked on as a waste and an annoyance by many ironworkers; some threw it away and others recycled it back into the furnace. The operatives were heavily fined for the latter (Moldenke 1930:3).

The transition from bloomery to blast furnace was never a "great leap forward." Rather, it varied geographically with time, as the technology stimulated it or market conditions demanded it. And not all bloomeries evolved into blast furnaces. While the blast furnace concept of making cast iron branched away from the bloomery process, the bloomery process itself continued to thrive, advance, and evolve. In fact, during the medieval period, it was difficult to distinguish a blast furnace from a bloomery. "The blast furnace and the bloomery process are usually described as distinct, but [it was] 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, *renn-*



1-3. *A ca.-1760s blast furnace (Diderot 1763: plate 87).*

ofen-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" (Gordon and Reynolds Jan. 1986:113).

The stuckofen (wolf furnace), therefore, was an attempt to increase the output capacity of the old Catalan forge. Its distinctive tall chimney, to increase its draft, earned it the name of high bloomery; and it was this furnace that could, at the whim of the ironmaster, produce either cast iron or wrought iron. In an analysis of medieval and early modern processes in the manufacture of iron, it was noted that:

> The wolf furnace, or stuckofen, was a high bloomery, and as such was simply an enlargement of the primitive low bloomery or forges. The stuckofen was only a Catalan furnace extended upwards in the form of a quadrangular or circular shaft. The Germans call it a "stuck" or "wolf's ofen" because the large metallic mass which is extracted from the bottom is termed "stuck" or "wolf". . . . These furnaces, or bloomeries . . . are generally 10 to 16 feet high, 2 feet wide at the top and bottom and about 5 feet wide at the widest. . . .
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> The transition from the old bloomery to the modern blast furnace was very gradual, and the stuckofen is the final development of the furnaces in which iron in the malleable state was produced direct from the ore. By increasing the dimensions of the stuckofen, especially its height, the conditions favorable to the formation of cast iron are obtained; and, indeed, in the stuckofen cast iron was generally, if not always, produced in greater or less degree, to the annoyance of the smelter.
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> The stuckofen itself was gradually superseded by the blast furnace, the first furnace which replaced the stuckofen being the blauofen, or blow oven. Originally there was no essential difference between them, these names being applied according to the nature of the metal they yielded, and not in consequence of difference of construction; malleable iron being obtained with much less charcoal than was used when cast iron was desired. When the blauofen was used as a stuckofen it was only necessary to make an opening

in the fore part of the hearth large enough for the extraction of the lump.

The blauofen, which is not entirely extinct on the Continent [in 1884], dates from about the beginning of the fourteenth century. The flussofen was substantially the same furnace as the blauofen. "Blast furnace" may be properly substituted for either term. Hochofen was another German name that was applied to the blast furnace, and it is still retained (Swank 1892:57-60).

Only when it was found that this metal could be successfully cast into cannonballs (1388, in Memmingen, Germany) was there the dawning of a new industry. Then for a while the furnaces were alternately used for production of cast and wrought iron by proper draft regulation and air blast. As experience was gained, higher temperatures were realized and low-manganese ores brought into use. Gray iron castings could be made, with cannon and stove plates being the almost-exclusive products. This change from a puddling process to the actual making of pig iron, called direct casting, took place in the 14th century.

Although early blast furnaces did some direct casting at the hearth, later techniques of remelting and casting at a cupola furnace designed specifically for this purpose allowed blast furnaces to specialize in smelting the ore and molding the iron into easily transportable ingots. Some iron-making communities contained a blast furnace plus one or more bloomery forges. These, plus the charcoal kilns for the reduction of wood into charcoal to fuel the furnace and forges, and the various associated ironworks-related buildings, made up these pioneer industrial complexes. Until the blast furnaces developed to a practical state of technical and economic efficiency, however, bloomeries supplied nearly all mankind's iron needs. The few exceptions to this rule were those iron objects hammered directly from high-grade ore outcroppings or from meteorites. Bloomery forges in Vermont evolved from a long metallurgical history dating back to antiquity and progressing with inconsistent speed for about a thousand years to the Catalan forge (Bining 1973:55-68; Fisher 1963:25-29; Harte 1935:31-69).

Early Euro-American Ironworks

The first known ironworking in the Western Hemisphere by European explorers/settlers took place at an inlet on the northern tip of Newfoundland about the year AD 1000. At L'Anse-aux-Meadows, a small, short-lived Norse settlement struggled with the harsh elements before retreating back across the ocean, probably to Iceland or Greenland. Archeology at the site in the 1960s uncovered slag, iron artifacts, and a charcoal kiln site, leading to the conclusion that the Norse had worked some iron from local bog ore (Ingstad 1977:93, 392-403).

Nearly 600 years after the Norse settlement, an expedition to North America by Sir Walter Raleigh in 1584 discovered iron ore at Roanoke, Virginia. Analysis of the ore showed that it was comparable to European quality, and in 1609 a boatload was shipped to England where it was reduced to about 25 tons of cast iron. A number of attempts to set up an ironworks in the James River area failed until James Berkeley succeeded in constructing a forge at Falling Creek, near today's Richmond (Fisher 1963:67-68). In the spring of 1622, however, just as the furnace was fired up, the settlement was attacked by Indians and the ironworks destroyed.

Farther north, the Pilgrims had discovered bog ore in many coastline marshes and inland ponds, mainly Monponsett, Sampson, and Assawompsett ponds in eastern Massachusetts (Bishop vol. 1 1868:479). Ore samples sent to England led to the formation of the Company of Undertakers of the Iron Works of New England. Their first venture at Braintree failed, but the second at Saugus succeeded (Hartley 1957:56-57). The blast furnace at Saugus was fired in the spring of 1648 and the works operated until 1675. Although it operated intermittently, it has been recognized as the birthplace of the American iron and steel industry. Saugus Ironworks is today a National Historical Park, containing the reconstructed blast furnace plus a forge, finery, rolling mill, and worker housing.

In 1700 the king of England was called on to mediate a border dispute between New York and Connecticut. Part of the settlement included a survey of the border, which ran along the top of the Taconic Mountains, separating the two colonies.

1-4. *Making cannonballs by hand-pumped draft in a small, late-18th-century blast furnace* (American Malleable Iron *1944:197*).

1-5. *Ira Allen, builder of some of Vermont's earlier ironworks, is immortalized by his statue at the college he founded (University of Vermont) at Burlington.*

In the process of the survey, some high grades of iron ore were discovered near the tri-state corner with Massachusetts. A bloomery was built in 1734 by Thomas Lamb nearby at Lime Rock, Connecticut. More forges soon followed at Canaan, Colebrook, Kent, Cornwall, and Salisbury. Ore for Lamb's forge came from Ore Hill in Salisbury. Business was profitable, and Lamb bought additional mining property and the water rights to Wononscopomuc Lake. Around 1760, he sold it all to the Owen brothers, who in turn sold it in 1762 to the partnership of Samuel and Elisha Forbes of Canaan, John Hazeltine of Uxbridge, and a 22-year-old adventurer from Cornwall named Ethan Allen. The partnership constructed a blast furnace at the outlet of Wononscopomuc Lake, which was the first blast furnace built in the Taconic Mountains of western New England. A small prosperous community called Furnace Village (today's Lakeville) developed around the furnace (Smith 1946:257-259). Allen soon tired of staying put, sold his share in the successful ironworks to Charles and George Cadwell in 1765, moved on to Northampton, Massachusetts, and went into the silver mining business.

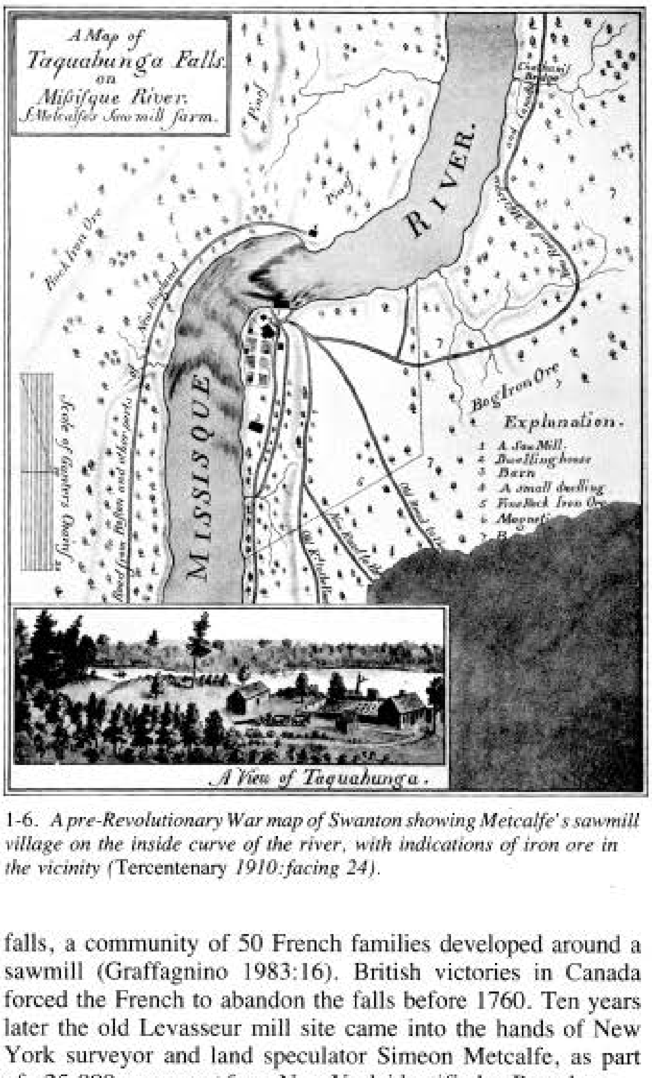
Meanwhile, dozens of blast furnaces sprang up all over the Taconics of Massachusetts and Connecticut, many providing valuable ordnance during the Revolutionary War. One of these, the Lakeville furnace, provided iron that was cast into guns and cannon at the nearby Salisbury cannon foundry. At Ancram, New York, an ironworks cast parts of the huge chain that was initially planned to block British access to Lake Champlain at the head of the Richelieu River near the Canadian border; it was finally strung across the Hudson River at West Point. Continuing his ever-northward migration, Ethan Allen followed the frontier into Vermont and kept himself (plus New York and the British) busy in other ventures.

Some of Ethan Allen's ironworks experience and abilities rubbed off on younger brother Ira Allen, who in turn became one of the progenitors of Vermont's iron industry. The Allens, maintaining their former contacts in Connecticut, ordered much iron hardware from the Salisbury forges for the construction of an anchor shop at Colchester and other forges in northern Vermont. Down at Lakeville, meanwhile, the furnace continued in operation until 1823. It had outlived not only Ethan and Ira Allen, but all its founding partners. (There are no visible remains of Ethan Allen's furnace at Lakeville, although his house still stands.)

Early Vermonters

Exhaustive research has not been made into the matter, but it does not appear that Indian inhabitants of Vermont ever worked iron. Chance finds of bits of meteoric iron might have been pounded into ornaments, but judging from published archeological work done in Vermont, the only prehistoric working of metal was that of copper. But the Indians did know of red ocher, an oxide of iron that takes the physical form of a reddish powder. They used it in burials, relating the red powder to blood. "When the first white men came to America, the natives had no knowledge of working iron. Now and then they picked up a bit of meteoric iron and fashioned it into some charm of iron. Copper and bronze were used, but no iron" (Perkins 1971:61). "The red stained soils [of the Indian burials at Swanton] are undoubtedly due to the liberal use of red ocher. Evidently all but two burials were accomplished by this 'red paint'" (Haviland and Power 1981:119). If the Indians noticed the outcrops of iron-bearing stone, they either could not learn how to extract and work it, or its lusterless appearance as compared to their bright copper beads did not encourage them to investigate it. It was left to the next wave of settlers, the Euro-Vermonters, to discover the iron resources of the land and to become the first Vermont iron makers.

The first non-Indian Vermont residents were the French. In the century-and-a-half following Samuel de Champlain's 1609 exploration of the lake that today bears his name, the French sent missionaries up the lake in attempts to enforce their claims to it and by the 1750s had granted patents for vast tracts of land, called seigniories, along lands bordering both sides of the lake. One seigniory, to Rene-Nicolas Levasseur, included what is today the falls of the Missisquoi at Swanton. At the falls, a community of 50 French families developed around a sawmill (Graffagnino 1983:16). British victories in Canada forced the French to abandon the falls before 1760. Ten years later the old Levasseur mill site came into the hands of New York surveyor and land speculator Simeon Metcalfe, as part of a 25,000-acre grant from New York identified as Prattsburg.



1-6. *A pre-Revolutionary War map of Swanton showing Metcalfe's sawmill village on the inside curve of the river, with indications of iron ore in the vicinity* (Tercentenary *1910:facing 24).*

Metcalfe's holdings in the vicinity of the falls at Swanton are depicted on a 1772 map that shows the Missisquoi River and the sawmill farm on the east side of the falls (*Tercentenary* 1910:24ff, 29). The falls were known as Taquahunga Falls at the time (Huden 1971:65). In addition to showing the falls at today's Swanton village, the map also shows roads north to Canada, south to Boston, and eastward. Symbols indicate the sites of the sawmill, a house and barn, and a small house across the river. The map also indicates "fine rock iron ore" northwest of the falls, magnetic iron ore to the southeast, and bog iron ore to the east and northeast. With all the iron ore deposits around the falls, it is difficult to believe that no iron ore was worked here in the early 1770s, if not previously by the French in a small bloomery. When Metcalfe returned after the Revolutionary War, settlers holding leases issued by Ira Allen (from the New Hampshire charters) were already occupying the area of the falls (Graffagnino 1983:17). The stage was now set for the third wave of settlers.

Following the end of the Revolutionary War, settlers and land speculators by the thousands came into Vermont from all directions. Many were families of men whose introduction to Vermont had been military action at or near Hubbardton or Bennington. With the clearing of land and opening of farmlands, the natural resources of the countryside were immediately exploited by settler and speculator alike. The latter attempted, in some cases, to capitalize on these resources as inducement to sell tracts of land, and either leased already-built mills or advertised the proximity of potentially excellent mill sites to available acreage. Whatever the method, a Vermont population that was about 7,000 people in 1771 became 85,000 by 1791; 155,000 in 1800; and 218,000 by 1810 (Holbrook 1982:xii; U.S. Census).

As steady as the growth of population was, it was geographically irregular. The valleys containing good farmland and abundant resources were settled first; the balance went to late arrivals. Accordingly, the development of Vermont's pioneer industries reflected this irregular pattern that found sawmills and forges commencing operation in widely scattered locations. During the 1780s, for example, a forge operated at Colchester 3 years before one of similar size opened 125 miles to the south in Bennington.

Commercial Empire of the St. Lawrence

This pioneer period was affected by political as well as geographic and economic factors. At the end of the Revolution much of Vermont was still being claimed by both New York and New Hampshire, a situation that discouraged many from investing capital and effort there. Since Vermont was not a British colony before the Revolution, no colonial authority was displaced. Whereas patriot governors replaced colonial governors in bordering New York and New Hampshire, a political vacuum existed in Vermont. Into this vacuum came outside people with all their political, religious, and family prejudices, each jockeying with the other for position in the power struggle. Nowhere is this more obvious than in the antagonisms that existed between Ira Allen, Nathaniel Chipman, and Matthew Lyon. The state of political warfare that prevailed affected not only the lives of those concerned, but also their struggling attempts to develop the timber and iron resources of the emerging state.

Industrial production activity in New England in general, which for a time was given a boost by the Revolutionary War, dropped off following the war, and 10 years of unhindered international trade cut into markets of domestic products (Robertson 1955:183-185). Manufacturing output could do no more than keep pace with the population increase. National production fluctuations, however, did not fit the Vermont experience.

A number of factors unrelated to the national production and trade picture had a direct effect on early industrial expansion in Vermont. One was the character of the state itself. Vermont in 1780 was essentially still a wilderness with settlers just starting to trickle in, joining those who had settled before the Revolution. Pre-1800 mills generally supported the needs of these settlers, with sawmills to cut lumber, forges to make nails, horseshoes, and wagon hardware, and gristmills to grind grain. What production surplus remained (and in the area of grain and lumber, early Vermont had a significant surplus) found ready markets outside the state. The character of this market was the second factor.

The nature of Vermont's trading with the outside world was molded by its geography. Its external geographic characteristic was its land-locked situation. Vermont was the only such state in New England until the construction of the Champlain Canal. Internally, the Green Mountains essentially divided Vermont down the middle. The eastern towns identified with New Hampshire and the Connecticut River Valley, using the port of Boston. But the western towns were further fractured, north and south. The latter, mostly in Bennington County, were economically oriented over poor roads to the Hudson River Valley ports of Albany, Troy, and New York City. Central and northwestern towns on the Champlain plateau found their economic future gravitating more and more toward strong ties northward—with British Canada.

Ira Allen was not the first to take advantage of Lake Champlain and funnel lumber and bar iron northward to the natural markets at Québec. Philip Skene and William Gilliland, two prominent colonial New Yorkers who were developing respective estates at Skenesboro (Whitehall) and Willsboro, New York, were also buying supplies in Québec with shipments of lumber in the 1760s and 1770s. But Ira Allen's shipments of lumber and iron northward were needed so badly by Québec merchants that in 1787 they persuaded the Canadian government to no longer consider Vermont as being part of the United States (Williamson 1949:142). This exempted Vermont from Britain's Navigation Acts and drew it closer into the commercial empire of the St. Lawrence.

The Champlain Canal

The realization in Albany that Canadian markets were attracting an increased amount of Champlain Valley trade that might otherwise profit New York prompted action in 1792 to build a canal connecting the lake with the Hudson River. Vermont had been interested as early as 1790 in such a canal. A committee representing Rutland and communities bordering on the lake surveyed the region through which a canal could pass and reported that it was not only practical but the advantages of the canal would be "almost inconceivably great." It recommended the Vermont legislature and governor afford reasonable encouragement and aid to New York to build the canal. But the recommendations were largely ignored by both (O'Hara 1984:30). A New York company went on alone with the canal, and actually succeeded in digging many miles of it before going bankrupt in 1796. Repeated appeals to Vermont failed at upper levels, although some help was afforded on a lesser scale. One such form of aid came from Matthew Lyon, who owned forges at Fair Haven, and who accepted a contract to construct one section of the canal (O'Hara 1984:31). But even this was too little effort to have any effect. Other leaders such as Ira Allen did much to discourage official support for the canal and instead supported the construction of a canal from the lake northward to the St. Lawrence River. Allen argued that the lake's flow northward showed that nature never intended New York as a seaport for Vermont (O'Hara 1984:322).

Not until after the War of 1812 was the canal to the Hudson River finally built. And as it turned out, the first boat to pass the entire length, in September 1823, was a Vermont boat named the *Gleaner*, out of St. Albans. On its return trip from New York City it carried lobster, oyster, crab, and other shellfish as witness that the vessel had found her way to the ocean (O'Hara 1984:114-115). That same month some 59 tons of nails, 78 tons of iron, 2 tons of iron castings, and 95 tons of ore were locked through (O'Hara 1984:268). The effect of the canal on trade with Canada was immediate and significant. The amount of lumber passing down the Richelieu River to Québec in 1821 from both New York and Vermont was 780,000 feet. The next year, after only a portion of the Champlain Canal had opened, only 22,000 feet went north to Canada. And soon after, lumber trade with Canada was reduced to practically nothing (O'Hara 1984:211).

The effect of the canal on Vermont's iron industry, however, was quite different from that on its logging industry. As early as 1792, the high-quality ore and smelting facilities of the Champlain Valley caused many to agree that this part of the country was to become the seat of the nation's iron and steel industry (O'Hara 1984:265). At that time, a few forges operated on the New York side of the lake, but more forges plus blast furnaces and rolling mills were already operating on the Vermont side.

The initial rush to capitalize on Vermont's resources died out in the early 1800s when the state's economy was affected by such national events as the Embargo Act of 1807, the War of 1812, and, finally, the Tariff Acts starting in 1816. Forges that initially produced for purely local needs now became concerned about costs of transportation needed to carry heavy iron products to marketplaces much farther away. Mining operations that at one time could just pick-and-shovel ore from an exposed ledge now were required to weigh practical and economic considerations involved in expensive shaft-digging and hoist machinery. Works operating marginally were abandoned in favor of more promising ventures that required larger outlays of capital. And though an amount of this early capital came into Vermont in the form of out-of-state capitalists who developed substantial ironworks at Vergennes, Plymouth, Shaftsbury, and Troy, other ironworks at Sheldon, St. Johnsbury, Bennington, Pittsford, Dorset, and Brandon were initially developed through local means.

The opening of the Champlain Canal resulted in a dramatic change of commercial activity on Lake Champlain: it finally drew Vermont trade from the St. Lawrence. Whereas its timber had been choking ports at Québec, it now jostled Adirondack logs for price and position at the head of tidewater navigation at Albany and Troy, New York. Davey's ironworks at Fair Haven were unshackled from strictly local demand as a result of the canal and could now ship iron south and west. Conant's ironworks at Brandon found new markets in New York for stoves and castings. The canal also opened new paths to market for Barney's forge at Swanton (O'Hara 1984:278).

New York, however, thought it sound policy to encourage its own manufacturing production through light tolls, and to derive as much canal revenue as possible from "foreign" ones. New York interests recognized early on the potential for a major iron industry in the Adirondacks and undertook to encourage its development through a preferential canal toll system. Toll collectors classified iron, nails, etc., made in New York "not enumerated," the toll being one cent per hundredweight per mile. But non-New York, or "foreign," paid three times the rate per mile (O'Hara 1984:268-269).

The Vermont legislature had shown as much disdain toward the construction of the Champlain Canal as it had during the earlier 1792–1796 attempts. It spurned every appeal for cooperation by New York before the canal was built, yet both knew that Vermont was also destined to reap benefits that the canal would provide (Swanton's marble industry and Burlington's transshipping facilities, for example). And by the 1830s, the Lake Champlain Transportation Company, incorporated by Vermont in 1826, enjoyed a virtual monopoly of the lake business (O'Hara 1984:125). But the Vermont iron industry came under the canal's classification of "foreign iron," and so was forced to pay the higher toll. What more benefit might the industry have gained had legislators at Montpelier cooperated earlier? What might the character of the Vermont (and New York) iron industry have been had preferential tolls not been established?

It has been the contention that coincident with the opening of the canal, New York and Albany money "discovered" the iron ore and water resources of the Adirondack Mountains. The numbers of ironworks in New York's Essex County increased from 4 to 24 with the canal's opening (O'Hara 1984:310-311). The canal did in fact stimulate some renewed ironworks activity at Vergennes with the construction of Rathbone's new blast furnace there and Ward's purchase and reopening in 1828 of what remained of the ill-fated Monkton Iron Company. But Crown Point and Port Henry, New York, some 20 miles up the lake from Vergennes, came to be the new seat of the iron business in the Champlain Valley. Port Henry became the largest shipping port for ores mined in the region, and by 1865 could boast of 8 blast furnaces, 20 forges, 3 rolling mills, and 2 foundries (O'Hara 1984:269-270). Within a few years of the canal's opening, the output from ironworks on the New York side of the lake appeared to have mortally wounded Vermont's earlier, significant position in the industry. But at whose profit and at whose expense? Surely not at the expense of some sharp-eyed, ambitious Vermont industrial families, who respected no state boundaries and who eagerly made their own killing in the industrial market alongside the Yorkers.

The Marriage Connection

Family interrelationships found in industrial expansions throughout the nation were also obvious in the iron industry in Vermont. The Penfield and Hammond families, for example, both involved in mills in the Pittsford area, were also involved in ironworks operations at Crown Point. They became closely related through marriage: Allen Penfield to Anna Hammond in 1810, Thomas Hammond to Sarah Penfield Stewart about 1820, and Augustus Hammond to Mary Penfield in 1839. Whether any of these marriages were arranged with business gain in mind is unknown, but they do indicate the tendency of families with similar industrial pursuits to socialize. In the process, loose business alliances were made between families, some capital may have supported either or another in-law's pursuits, and technical "family secrets" were probably discussed and shared.

John Penfield, born in Fairfield, Connecticut, in 1747, married Eunice Ogden, also of Fairfield, in 1770. Their 10 children were born before they arrived at Pittsford in 1795, at which time they purchased some land and a gristmill. A son, Allen Penfield, built a sawmill and later a gristmill at Crown Point in 1808. Two years later he married Anna Hammond and, together with his brother-in-law Charles F. Hammond, commenced to build an ironworks empire in New York. In 1812, Allen, John, and Sturgis Penfield (brothers), Thomas Hammond (Allen's father-in-law), and others formed the Pittsford Manufacturing Company, which carded and dressed woolen cloth.

Allen sold his shares in the mill in 1827 and the next year constructed his homestead in Crown Point at Ironville. He built the first forge at Ironville that year and a blast furnace a few miles west, nearer to the mines, in 1845. The works were operated by a company formed that year and composed of Allen Penfield, his brothers-in-law Charles F. and John C. Hammond, and Jonas Tower (of New York). In 1851, Tower sold his interest in the company to William H. Dike and Edwin Bogue, both of Pittsford. Dike's mother was the former Tamesin Hammond; Edwin Bogue was Dike's brother-in-law. Vermonters all, they organized the Crown Point Iron Company, and turned much iron into gold over the next decades.

Allen Penfield died in 1871 and was buried at Ironville, and the blast furnace was soon after shut down. His shares in the iron business and properties were sold to John and Thomas Hammond, who reorganized the company, built blast furnaces along Lake Champlain, and laid dozens of miles of railroad track between the mines and the furnaces. The community of Hammondville grew around the mines, located about 4 miles southwest of Ironville. When the ore ran out in 1893, everything shut down.

Thomas Hammond, progenitor of the Hammonds of Pittsford, arrived there in 1785. He was born in Newton, Massachusetts, raised at Leicester, Vermont, and served during the Revolution in the Continental Army. Returning to Vermont, he married Hannah Cross in 1784. The marriage accounted for much of his success, although he persevered also due to his own wits and skills in the wilderness and hardships of early Vermont. An active Congregationalist, he served in many local and state offices, and rose to the rank of colonel in the state militia by the War of 1812. The Hammonds, like the Penfields, had 10 children. Besides Anna, who married Allen Penfield, her brother Augustus married Mary Penfield, Allen Penfield's niece, in 1839. Augustus and Mary stayed in Pittsford, inherited the family homestead, and eventually purchased the homestead of Mary's father, Sturgis Penfield.

Another daughter of Sturgis Penfield was Eleanor B., who married Henry F. Lothrop of Pittsford in 1848. His father, Howard Lothrop, had worked at Israel Keith's blast furnace at Pittsford, rose to be its operating superintendent, and eventually, through wise investments, became owner of the works. He sold it to Gibbs & Company in 1809, retiring with a good profit. He arranged for his son, Henry F., to manage his investments (Huntington 1884).

When 57-year-old Thomas Hammond's wife Hannah died in 1819, he married Sarah Penfield Stewart, the oldest daughter of John and Eunice Penfield. The senior John Penfield, who had only recently become father-in-law to one of Thomas Hammond's children, had finally become father-in-law to Thomas Hammond himself (Hammond 1900).

Related to Wait Rathbone, Jr., who owned a blast furnace at Tinmouth, was cousin Joel Rathbone, who owned a stove foundry at Albany, New York, along with Lewis, John F., and Clarence Rathbone. These works were in the northern part of the city, where little Rathbone Street still runs parallel to Broadway, a few blocks northeast of the Colonie Street and Broadway railroad bridge. Also operating stove foundries in Albany about the same time was John S. Perry (no known relation to Abner Perry, partner to Wait Rathbone). The wife of John S. Perry was Mary J. Willard of Plattsburgh, no known relation to Elias Willard, another blast furnace owner at Tinmouth (Tenny 1886:140-149). Elias Willard shared a common great-grandfather with Dr. John Willard, husband of Emma Hart Willard of Berlin, Connecticut; Middlebury, Vermont; and Troy, New York (Willard 1858:395). Dr. William Willard (Elias Willard's brother) was husband of Mary Rathbone, sister of Wait Rathbone, Jr. (Cooley 1898:626-627).

John Conant came to Brandon in 1784, originally planning on settling in western New York State. But when he got as far as Brandon and met Charity Broughton, his travels were over. In addition to his ironworks activities, he was a leading force in the Baptist Church in the village, held a number of elected and appointed town and county posts, and built a number of mills. He married Charity the same year he arrived in Brandon and, along with his father-in-law Wait Broughton, established his early mills and ventures into the iron business in Brandon. John and Charity had nine children; two sons succeeded their father at the ironworks. One of them, John A., was the leading stockholder of the Rutland & Burlington Railroad when it opened in 1849, held several public posts, was part or full owner of a number of industrial interests, and was president of the Brandon Bank. He married Adelia A. Hammond, granddaughter of Thomas Hammond, in 1869. This was the second marriage for both, he then 69 and she 49 years of age, each by then quite wealthy. Adelia's mother was Paulina Austin, daughter of Appolos Austin, co-owner of the ironworks at Vergennes in 1836.

Other Vermont families involved in ironworks activities in New York were the Dikes and Bogues. Tamesin Hammond, sister of Anna Hammond Penfield and Augustus Hammond, became the wife of Jonathan Dike in 1808; Francis M. Hammond, daughter of Augustus and Mary Penfield Hammond, married C. F. Dike in 1868. Jonathan and Tamesin Hammond Dike moved to Crown Point where Jonathan died in 1870. Daughter Loraine H. married Dr. George Page, brother to the Vermont governor; another daughter, Mary E., married Edwin S. Bogue, whose cousin Catherine Bogue married Dr. Ebenezer H. Drury, nephew to Abel Drury (Barker Oct. 1942).

Members of the Fuller family worked at the Lenox Furnace, Massachusetts, and left in 1785 along with Gamaliel Leonard for Hampton, New York, just across the Poultney River from Fair Haven. Roger and Harvey Fuller worked a forge at Brandon in 1810. The year 1818 found four brothers of Ferrisburgh—Stillman, Sheldon, Heman, and Ashbell Fuller—operating Herreshoff's Forge at "John Brown's Tract," somewhere deep in the northern Adirondack Mountains. They were at the Rossie Iron Works in 1820, where David Parish entered into a contract with S. Fullers & Company to run the furnace and forge for a term of five years. In 1832, the four brothers were in the Town of Fowler in southern St. Lawrence County, where they built a blast furnace that went into operation in 1833. The settlement that grew around the ironworks included Fuller's store, with Heman Fuller as Postmaster in 1832, and came to be called Fullerville, later (1848) Fullerville Iron Works. The name is still on New York State highway maps. Successive companies were S. Fuller & Company, Fullers & Maddock, Fullers & Peck, and H. Fuller & Company. Stillman Fuller was Town Supervisor in 1830 and 1833–1834; Heman Fuller served that office in 1846–1847. Under later owners, the Fullerville blast furnace ran until 1882. Another Fuller enterprise was in the Town of Brasher in the northeast corner of the county, where Stillman Fuller built a blast furnace, put into operation in 1836. He sold it two years later and the community is still known as Brasher Iron Works (R. S. Allen letter to author Sept. 20, 1988).

A ca.-1835 blast furnace north of Crown Point near East Moriah, New York, was built by a Mr. Colburn, possibly Edward or Edmund Colburn (spelled Coburn by some). This Colburn may have been related to the Colburns of Fair Haven. John Peabody Colburn built a blast furnace along the Poultney River in 1825 just below Carver's Falls in West Haven. After the death of his first wife, he married Lucy Davey, daughter of Jacob Davey who was then major owner of the vast ironworks at Fair Haven. The Colburns came to Vermont from Canada about 1787, settling in Fair Haven, and became involved with the Davey families in many activities. Descendants of John P. settled in various parts of Vermont and the United States (Gordon and Coburn 1913).

Gamaliel Leonard, whose 1788 forge in Fair Haven along the Poultney River was one of the earliest forges in Vermont, was a descendant of the same James Leonard who landed about 20 years after the Pilgrims and is credited with building the first forge in this country. Gamaliel was also involved with blast furnaces at Lenox, Massachusetts, and New Haven, Vermont. His son Charles married John P. Colburn's sister Betsey, and at her death he married the other sister (Adams 1870:428).

The first blast furnace erected in northern New York State was built about 1809 at the mouth of the Salmon River, just south of Plattsburgh. It is thought to have been the work of Alfred Keith (Israel Keith's brother), who was also involved with a furnace at Rossie, New York, in addition to his own ironworks at Sheldon. Jacob Saxe (spelled Sax by some), the son of John Saxe (Saxe's Mills, Highgate), became a partner in the furnace at Salmon River under the name Keith & Saxe. Jacob Saxe was sole owner in 1820 and acquired land up and down the west side of the lake, including an ore bed at Crown Point that supported the needs of his furnace. Saxe's furnace and works were washed away by a freshet in 1830. He married Rowena Keith in 1812. Jacob W. Saxe, one of their sons, married Grace B. Drury. Matthew Saxe, brother to the senior Jacob Saxe, was also involved in the iron business in northern New York. His family settled in the Town of Chazy, near what became Saxe's Landing, today's Chazy Landing, New York (Seavor 1930).

About the time Keith was building the furnace at Salmon River, Abel Drury was operating the first blast furnace at Highgate. The Drury family had settled in Pittsford about the same time as the Keith family, striking up an acquaintance and apparently discovering their mutual interest in the ironworks business (although no previous connection can be found between the Drury family and iron making). Hannah Drury married Alfred Keith in 1793 and within five years some of his sons plus some of the Drurys moved north to Sheldon and Highgate. In addition to Drury's 1807 furnace at Highgate and Keith's 1798 and 1823 furnaces at Sheldon, they cooperated in a furnace at Highgate in 1820. Abel Drury married Sarah Keith and two of their children, Zephaniah Keith Drury and Sarah Keith Drury married Hannah Saxe and Peter Saxe, niece and nephew to Jacob Saxe. Besides being closely related to each other, the Drury, Keith, and Saxe families were all very active in town and county government, serving in various elected and appointed posts from 1800 to 1864 (Anderson Sept. 1939; Saxe 1930). In 1798 members of the Keith, Gibbs, Leach, and other families emigrated to Canada to settle on a tract of land "on which to erect an ironworks for several persons who intend removing to the province [Ontario], 1,200 acres for the use of the works, 600 acres for Union Keith, Unite Keith, Jonathan Keith, Ruel Keith . . . Rufus Leach . . . Nathan Gibbs . . . Ebenezer Gibbs . . . Scotland Keith . . . each of these 17,200 acres . . . most all were Loyalists. . . ." (Blanchard Jan. 1956:63-64).

All these Keiths were probably brothers of Israel and Alfred Keith. Ebenezer Gibbs and Ruel Keith had land transactions at Pittsford in 1795; Ruel returned from Canada and died at Sheldon in 1837. Nathan Gibbs, who had bought Israel Keith's furnace at Pittsford in 1795, returned and died there in 1824. Rufus Leach might have been Andrew's brother, who owned the Pittsford furnace after the death of Nathan Gibbs (Chessman 1898).

Many of the individuals and families mentioned, all involved to some degree in the iron business from the 1780s to 1850s, became related or interrelated in time. With similar industrial interests, they were able to capitalize on the iron industry outside Vermont and on both sides of Lake Champlain. Table 1-1 shows these families and their family ties and ironworks affiliations in Vermont, Massachusetts, and New York State. Other Vermont families not previously discussed (for example, the Granger family) also had ironworks activities outside the states included in the table.

Up and Down the Iron Roller Coaster

By the 1840s the period of Vermont ironworks expansion had peaked and in the midst of the national economic slump of the 1850s had come to a near halt. Only the needs of the Civil War offered stimulus to drag a handful of Vermont iron-making operations along with it. The prominence of iron manufacture in Vermont had been lost (Swank 1892:99).

During its formative years, however, Vermont rivaled neighboring New York, Massachusetts, and New Hampshire in the mining and smelting of iron. It might be difficult to prove that during that early period the Monkton Iron Company was the largest ironworks in the United States, although it was so claimed (see chapter 4, AD-146); but that wrought and cast

Table 1-1. Vermont Families—Ironworks Affiliations

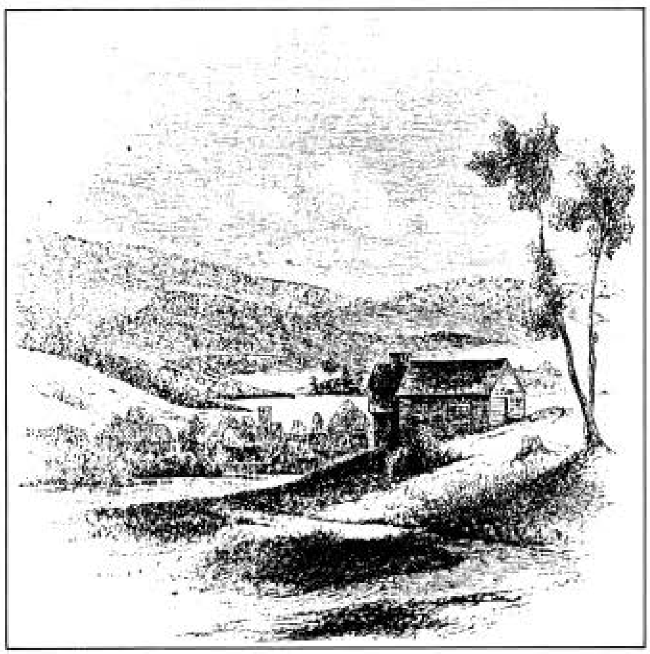
Vermont Family Name	Vermont Ironworks	New York Ironworks	Massachusetts Ironworks
Hammond	Bennington(?) Forest Dale(?)	Crown Point	
Austin	Vergennes		
Conant	Brandon		
Broughton	Brandon		
Penfield		Crown Point Troy	
Lothrop	Pittsford		
Harwood		Crown Point	
Bogue		Crown Point	
Drury	Highgate		
Saxe	Highgate	Plattsburgh	
Keith	Pittsford Sheldon Highgate Vergennes(?)	Plattsburgh Rossie	Easton
Page		Crown Point	
Dike		Crown Point	
Cooley	Pittsford		
Sutherland	Proctor		
Perry	Tinmouth	Albany	
Willard	Tinmouth	Albany(?)	
Rathbone	Tinmouth Clarendon Vergennes	Albany	
Davey	Middlebury Fair Haven Salisbury	Troy(?)	
Colburn	Fair Haven West Haven	Moriah(?)	
Leonard	Fair Haven New Haven		Lenox
Fuller	Ferrisburgh Vergennes(?)	Fowler Rossie Brasher Troy(?)	Lenox

iron were reduced in forges and furnaces located in over 50 towns and cities in Vermont may come as a surprise to those whose impression of this state's early history was one of strictly agriculture and rural industry. Blast furnaces and molten iron definitely are not rural industry. Yet the character of the iron industry in Vermont and in most surrounding states in that period was rural. Although physically large, blast furnaces were usually operated by workers who lived within sight of the stack, and who tended backyard gardens and animal pens to augment their needs during the non-productive winter months and the ever-threatening cycles of economic depression. These iron-works communities were located as near to the mines as available waterpower permitted, thus further isolating many of them from the centers of population growth and further contributing to their rural character.

During the 10-year period following the end of the Revolutionary War, 16 forges and 3 blast furnaces were erected in Vermont for the production of wrought and cast iron. These were this state's initial iron-making industries and they signaled the entry of the state into nearly a century of sometimes successful (but usually frustrating) battle with nature, politics, and economics. The fortunes of these works rested on 18th-century educated estimates of the probable quantity and quality of a local ore bed, and political foot-dragging that caused a 20-year delay in building the canal to connect Lake Champlain with the Hudson River. By the early 19th century, ironworks had to deal with special interests that ran import tariffs up and down, causing all manner of havoc in the national economy. In his economics analysis of 19th-century America, Stuart Fleming wrote:

More than technological limitations, however, it was quirks of economic events that held back the American iron industry in the first half of the nineteenth century.

Three recessions, one in 1808 stemming from the trade embargo imposed a year earlier by the Jefferson administration, and one each in 1819 and 1837 (caused by business panics), did not help. Nor did the protective tariffs enacted by Congress in 1815 to foster "infant industries" and help make the American states more self-sufficient. The tariffs actually subsidized inefficiency and technological stagnation in the iron industry, and failed to encourage the formation of the kind of corporate groups which, by 1825, made the English ironmasters such a major political force. The English could (and did) sometimes dump their iron on the iron market at below cost, just to ensure nervousness among investors in American concerns. Who was going to put up capital for a furnace of say 600 cubic meter capacity, if a year later a slackening of demand would force it to run about 60 percent effectiveness? (Fleming Sept./Oct. 1985:71, 77).



1-7. An 1830s blast furnace deep in the Adirondacks of New York; typical of contemporary Vermont blast furnaces (Masten 1923:facing 132).

When the United States Congress directed the 1809 census to include the manufacturing companies of the country, the Vermont General Assembly appointed a committee of one from each county in Vermont to prepare a statement of the state's manufactures. Their November 7 report on ironworks included the following data:

Counties	Furnaces	Forges
Bennington	1	3
Rutland	3	6
Addison	2	15
Franklin	2	2

The furnace and forge at Vergennes, which are included in the above statement, have been erected by a company from Boston. The furnace has been in blast for some time, and it is said to yield from 60 to 70 cwt. of pig iron and ware each 24 hours. The forge is calculated for eight fires, solely for the purpose of refining, all of which fires it expected will be ready to commence the business in a few weeks. The owners of the works have it in contemplation to extend them to the manufacturing of steel and iron-mongery in their various branches. There is also a slitting mill at Vergennes, and one at Fairhaven, where the rolling and slitting of iron is carried on to a large extent, and it is believed with handsome profits to the owners. . . . Jacob Galusha (Walton vol. 5 1877:500-501).

U.S. Census returns of 1810 indicated Vermont forges and furnaces produced about 1,300 tons of pig and bar iron that year, amounting to 36 percent of New York and 55 percent of Massachusetts output. And although Vermont iron production increased more than five times by the 1840 census, it had slipped to 48 percent of Massachusetts and well back of New York, which had increased its iron output 23 times. Of its neighboring states, only New Hampshire remained behind Vermont in iron production:

	Blast Furnaces		Bloomeries		Iron Output	
	1810	1840	1810	1840	1810	1840
Massachusetts	--	48	--	67	2,340	15,336
New Hampshire	--	15	--	1	--	1,420*
New York	11	186	7	120	3,671	83,781
Vermont	8	26	2	14	1,300*	7,398

*estimated by author

Breakdown of 1840 census data of Vermont ironworks reveals the disposition of these works, but some of the data are misleading. The census listing of the furnaces, for instance, includes blast, forge, and foundry furnaces. Lack of responses from some works to census takers (usually the local federal marshal) or exaggerated claims by others (to impress the stockholders?) distort the numbers. Results of the census, however, as shown in table 1-2, do provide a sense of the disposition and magnitude of the Vermont iron industry for the 1830–1840 period.

Vermont never was destined to become a major iron-making region. Its harder magnetic ores, for example, contained just enough manganese impurity to affect the quality of the cast iron. Mountain streams that afforded some of the best water-power sites to drive waterwheels and turbines also plagued mills with flash floods:

1783: Poultney River
1811: Poultney River
1813: Missisquoi River
1828: Lamoille River
1830: New Haven River
1831: Middlebury River
1847: Middlebury River
1852: La Platte River
1869: New Haven River
1898: Roaring Branch (in Woodford and Bennington)

These floods, called freshets when occurring in springtime thaws, were usually triggered by heavy rains in the local mountains, which washed away everything in their paths. (One particularly devastating torrent in west-central Vermont in 1783 caused the Poultney River to flood and wash across a half-mile bend in the river and erode a new path to Carver's Falls, leaving one West Haven sawmill high and dry along the old riverbed.) Forges and mills that had been operating only marginally but might have been able to survive a pressing economic slump to better times could not afford to rebuild after being washed away.

Then there were the long Vermont winters. In the 1850s, at the end of the disastrous economic depression, 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 principal furnace district again" (Lesley 1858:76).

Table 1-2. Ironworks Census of 1840

County	Furnaces	Tons of Iron	Number of Forges, Bloomeries, and Rolling Mills	Tons of Iron	Tons of Charcoal	Number of Workers	Capital Invested
Addison	1	100	8	360	1,716	32	$ 44,000
Bennington	5	1,829	--	--	380,880*	184	165,000
Caledonia	1	30	--	--	200	15	6,000
Orleans	1	382	1	5	930	25	100,000
Rutland	11	3,365	5	290	2,832	363	275,050
Washington	1	100	--	--	150	11	5,000
Windham	2	87	--	--	29	2	4,800
Windsor	4	850	--	--	1,670	156	64,300
Totals:	26	6,743	14	655	10,084**	788	$664,150

*most likely bushels of charcoal
**author's estimate; includes (*) above