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National Park Service

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National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

__x__ New Submission ____ Amended Submission

A. Name of Multiple Property Listing

The Iron Industry of Virginia, 1620 to 1920
George Washington and Jefferson National Forests, Western Virginia

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

The identifying context of this multiple property listing is the historic iron industry. Properties associated with the iron industry context may feature additional contexts including domestic, subsistence and agriculture, religion, education, transportation, recreation, commerce and ethnicity. Iron industry and extraction is the overriding context.

The geographic context is Virginia. Surveyed properties were located in the George Washington and Jefferson National Forests in western Virginia. This area was a focal point of the Virginia iron industry.

The associated chronological contexts are: Settlement to Society (1607-1750); Colony to Nation (1750-1789); Early National Period (1789-1830); Antebellum Period (1830-1860); Civil War (1861-1865); Reconstruction and Growth (1865-1914). The iron industry in Virginia began around 1620 and lasted into the 1920s.

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D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation. (___ See continuation sheet for additional comments.)

_____ _____
Signature and title of certifying official Date

_____
State or Federal agency and bureau

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

_____ _____
Signature of the Keeper Date

Table of Contents for Written Narrative

Provide the following information on continuation sheets. Cite the letter and the title before each section of the narrative. Assign page numbers according to the instructions for continuation sheets in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B). Fill in page numbers for each section in the space below.

VIRGINIA IRON INDUSTRY

The iron industry played a vital role in the historical development of the United States economy and society. The expansion of American industrialization began with the dramatic growth of the iron industry in the late nineteenth century, primarily in Pennsylvania. The growth of the industry depended on the development of large-scale high-output equipment and operations, and the management systems required to most effectively manipulate them. Although Pennsylvania and Ohio came to dominate the industry, much of the history of America's iron industry was played out in Virginia.

The more than 300 year development of Virginia's iron industry is marked by several distinct historical periods. Despite this, throughout most of its history in the state--and until the final phase in the late nineteenth century--iron manufacturing technology itself changed very little. At the same time that other iron centers of the world developed and implemented new technologies to increase furnace output or efficiency, most Virginia companies tended to be isolated by geography and restricted by the lack of adequate transportation. Virginia companies did not feel the need to develop improved technologies; they could easily meet the changing demand for their product with an increase or decrease in the number of furnaces. As a result of these factors, the state tended to maintain relatively consistent technologies.

Significant examples of the iron industry can still be found across Virginia. Ten iron furnaces on the George Washington and Jefferson National Forests in western Virginia were surveyed for nomination to the National Register of Historic Places as part of this multiple resource nomination. Figure 1 shows the location of these furnaces in relation to other historic furnaces in Virginia. The ten properties include:

Australia Furnace, Alleghany County (03-0098)

Callie Furnace, Botetourt County (11-0065)

Catawba Furnace, Botetourt County (11-0040)

Catherine Furnace, Page County (69-0130)

Elizabeth Furnace, Shenandoah County (85-0940)

Glenwood Furnace, Rockbridge County (81-00104)

Mt. Torry Furnace, Augusta County (07-0871)

Raven Cliff Furnace, Wythe County (98-214)

Roaring Run Furnace, Botetourt County (11-0063)

Van Buren Furnace, Shenandoah County (85-0051)

This context statement of Virginia's Iron Industry includes three sections: technology, chronology, and transportation. It begins with a discussion of the relevant technologies employed in the state. The discussion of iron working technology is followed by a chronological history of iron manufacture in Virginia from the colonial to the modern periods. The chronological periods identified by the Virginia Department of Historic Resources are used to organize the discussion. They are:

- **Settlement to Society (1607-1750);**
- **Colony to Nation (1750-1789);**
- **Early National Period (1789-1830);**
- **Antebellum Period (1830-1860);**
- **Civil War (1861-1865);**
- **Reconstruction and Growth (1865-1914); and**
- **World War I to Present**

Transportation played a key role in the history of the iron industry in Virginia, as iron manufacturers attempted to transport supplies to their furnaces and products to markets and foundries. The development of transportation improvements and its importance for the iron industry of Virginia are discussed following the chronological history.

THE PROCESS FOR MANUFACTURING IRON

Iron is produced by reducing ferric ores down to the raw metal and its by-products in the presence of heat. Historically, a high carbon fuel was burned in direct contact with the iron and a fluxing material, often limestone. As the fuel burned, it melted the ore and flux. At the same time, the carbon mixed with the oxides in the rock to form carbon monoxide and carbon dioxide, which were released into the atmosphere. The nonferric materials in the ore mixed with the melting limestone to form slag, the lighter waste product of iron ore smelting. Because of the silicon content of the ore, slag often appeared glassy when cool. Slag was easily skimmed or removed from the metal.

Most iron produced in the eighteenth and nineteenth centuries was either wrought or cast. **Wrought iron** was manufactured at bloomeries by reducing ore in the presence of a fuel and flux in a furnace called a forge, which was usually only walled on one side. The reduced material, a combination of iron and slag called a bloom, was removed from the hearth and separated by repeatedly hammering the metal into bars until all of the slag had been forced out of the iron. The primary advantage of wrought iron was its workability. Because it was strong, non-brittle, and easy to manipulate, it became the primary material used to manufacture tools, hardware, and weapons prior to the widespread availability and use of steel in the latter nineteenth century (Schenck 1992).

Cast iron, which was considerably more brittle than wrought iron, could be made in larger quantities, often continuously, in a blast furnace. Most American blast furnaces of the eighteenth and nineteenth centuries consisted of several components: a heat resistant fire-brick lined stack; a structural, usually stone, outer layer surrounding the stack; and a clay or dirt insulation separating the stack from the outer layer. The insulation layer prevented the high heat of

the furnace from degrading the exterior material.

Workers charged the furnace by depositing set quantities of fuel, ore, and flux through the top opening in the furnace stack. The furnace stack was often built adjacent to a ridge to facilitate transportation of material up to a charging bridge that led to the furnace top or charging deck. The fuel burned hottest in the lowest area of the stack, called the hearth, where the primary ore reduction and slag formation occurred. To increase the temperature and maximize combustion, air was forced into the hearth through a nozzle called a tuyere, creating a blast that ensured a more complete melt and a higher yield.

A major technical innovation was incorporated into furnace operation in the early nineteenth century. It was discovered that a heated blast dramatically increased the efficiency of the combustion and resulted in higher yields of iron for lesser amounts of fuel, especially when the heated blast was introduced into a hearth that was fueled by a cooler burning coke (Greenwood 1902). Most Virginia furnaces, however, continued to use a cold blast until late in the nineteenth century. This was primarily because charcoal fuel, which was the primary blast furnace fuel in the state for much of its history, did not require a heated blast; charcoal naturally burned hotter than other fuels like coke and anthracite.

Molten iron was tapped from the furnace at regular intervals. It usually flowed down channels carved into a graded sand-floor in the casting shed; the casting shed usually was attached to the furnace. The channels led to small pits which would fill with the molten iron. When cooled, these iron pits (called pigs) were separated from the cooled channels (called sows) and taken to foundries to be remelted and cast into usable shapes. Some furnaces, however, cast molten iron directly into functional forms rather than only producing only pigs and sows.

The furnace blast was often produced using a water powered bellows, or a steam piston. Furnaces were built on creeks or rivers. Water, tapped from falls or a built dam and transported along a head race, was used to power the waterwheel that sat below the head race. As the water fell, it filled buckets or fell against paddles on the wheel, creating a rotation that was linked to the bellows and blast equipment. This machinery was typically located adjacent to the furnace.

The efficiency and availability of steam engines improved in the late nineteenth century. Their ultimate geographical flexibility and lack of seasonal constraints led to their dominance as the primary power source. Virginia's furnaces remained relatively small, however, and water power proved sufficient and less capital intensive than steam power. Steam engines were not widely used in the state's iron industry, and furnaces, therefore, continued to be located near a source of swiftly running water.

Similarly, Virginia maintained its lower yield charcoal operations even as the use of coals and coke advanced in other regions of the country. Until the mid-1840s, all American iron was produced using charcoal as the fuel. Colliers made charcoal by roasting mainly hardwoods, without flame, for several days in an earth-covered mound. The roasting process continued until impurities were driven off, thus leaving a highly pure form of carbon. Because of its

purity, charcoal made a higher grade of iron than coal or coke. On the negative side, however, the cost of collecting sufficient amounts of hardwoods was high, as about one acre of hardwood had to be burned for each ton of iron produced. The forests did not replenish themselves for thirty or more years, the pace of production with charcoal was very slow, and the remaining forests were often located at a distance from the furnace. As a result of these drawbacks, the cheaper, more widely available coals replaced charcoal as the primary blast furnace fuel.

Eventually, once it was possible to compensate for impurities, coke was used as fuel in Virginia blast furnaces. Coke is made similarly to charcoal; impurities are slowly removed from bituminous or soft coal by a roasting process. This technology involved many changes to the furnace designs prevalent in the eighteenth and early nineteenth century in order to increase efficiency. Coke furnaces require a heated blast to increase the hearth temperature because coke burns at a lower temperature than charcoal (Swank 1891: 366). To heat the blast, early companies built separate charcoal or coke burners that warmed the air prior to its entrance into the furnace. Later designs, however, captured heat and the combustible gases from the furnace and used the gases to fuel the ovens. When furnaces were converted from charcoal to coke, brick, stone or metal structures were built to cap the charge deck opening of the former charcoal furnace. This cap redirected the gases from the stack to the ovens located on the ground. These caps are still visible on several of Virginia's converted furnaces; Van Buren and Callie are two examples of capped furnaces.

The iron industry in Virginia developed in the early period of American iron; the level of technology of its furnaces did not change much through most of its history. Water-powered, cold-blast, charcoal furnaces dominated the industry from its earliest production through its latter years. The shift to coke-fired furnaces around 1880, which occurred only in the face of dramatic changes nationally, temporarily rescued Virginia's then failing industry.

Although Virginia's iron industry improved with the introduction of coke fuel, the state's resources and furnaces ultimately could not compete technologically with other national production centers. Despite this, for almost 300 years, the state's furnaces adequately produced iron to supply distant markets, fight three major wars, and provide wares to migrants, planters, and merchants.

CHRONOLOGICAL HISTORY OF THE IRON INDUSTRY IN VIRGINIA

Settlement to Society (1607-1750)

Virginia was the first English colony established in the Americas; it fulfilled its role as a textbook colony through the early 1770s. Much of the colony was settled with the intention that unfinished raw materials, unavailable in the mother country, would be sent back to England for processing. To a much greater extent than was the case in the New England colonies, Maryland and Virginia were financed by English merchants and investors eager to increase their wealth by the importation of salable resources. Almost from the very beginning, these resources included iron.

The iron industry of the Americas began in the late 1500s as Sir Walter Raleigh's second expedition observed abundant ores and an "infinite surplus" of wood in the region of North Carolina. Anticipating a low-cost colonial labor force, the British expected good prospects for supplying Britain with bar and pig iron. Iron was increasing in cost in

Britain as the supply of wood (for charcoal) began to diminish. The forests decreased as a number of factors combined to put pressure on wood supplies: the growth of the iron industry and charcoal production, an increased population, and the rapid expansion of its naval and commercial fleets that used huge amounts of wood to build ships in the sixteenth century (Bining 1933).

Because of the growing shortage of wood, England's ironworkers had to import most of their iron. Merchants began to expand their horizons westward to locate new sources. Although the primary impetus for founding the first Virginia colony was to search for gold, the early settlers needed utensils, tools, and iron to survive and to develop the gold mining industry (Mulholland 1981). The English demand for iron grew and the local resources in America were abundant. The "metallic wealth of America, so long anticipated by Englishmen," wrote Mulholland, "first appeared in an unexpected form" (1981: 21). The first colonists were "expected to fill the mother country's need for raw iron" (Bruce 1930: 3). As early as 1608, the second year of English settlement, sample iron ores were sent back to England. By 1609, the East India Company had purchased seventeen tons of Virginia ore, smelted it, and produced a satisfactory iron (Mulholland 1981).

The first organized attempt to produce iron began in 1619. At that time the Virginia Company of London, as stated in their records, sent a crew to "set up three Iron workers; proofe having been made of the extraordinary goodnesse of that iron" (Hudson 1956: 5). The group, constructing only one of the three planned furnaces, located its works at Falling Creek, fifty miles north of Jamestown on the James River. This furnace produced only small batches of iron, according to Hudson. Although it was intended that they would go into full production by Whitsontide, the seventh Sunday after Easter, 1622, the venture was short lived. The Falling Creek settlement and the ironworks were destroyed in an attack by Native Americans who killed all but two of the Europeans (Hudson 1956: 5-7).

Initially, the attack did not deter the company from setting up an ironworks. As quoted by Mulholland, the company expressed its intentions in August 1622, to "againe resume that business so many times unfortunately attempted, and yett so absolute necessarie as we shall have no quiett Until we see it perfected" (1981: 24). However, due to funding and logistical difficulties, the effort was eventually abandoned (Mulholland 1981: 24). By 1627, the King revoked the company's charter and the property became a royal colony. As a result, Virginia iron production was delayed for almost a century (Bruce 1930: 5). Production did not resume until the 1710s.

The development of agriculture began to permeate the colony during this early period of iron production. Merchantilists continued to search for a resource that could be exploited easily for the benefit of the mother country (Mulholland 1981: 25). Raw silk, sugar, tea, and indigo were as exotic in Virginia as they were in England. As the settlers began to think of Virginia as a permanent home they also sought means to increase their own wealth, and "fairy gold awaited the energetic man who on his own account upon the vast stretches of free land up and down the rich river bottoms dared to grow tobacco" (Bruce 1930: 4).

Tobacco exploitation in Virginia began in 1619, the same year that organized iron production was initiated in the colony. Twenty thousand pounds of tobacco were exported to England in that year (Bruce 1930: 4). By the close of the century, a social order based on plantations dominated the colonial system, replaced indentured servitude with

African slavery, and provided the most immediate road to wealth in the colony. Tobacco imported into England increased to thirty-seven million pounds (including Maryland exports) by 1700 (U.S. Census 1976: 441-448).

Colonial iron production shifted to New England for the remainder of the seventeenth century. The first continuing successful ironworks in the Americas began on the Sagus River in Massachusetts in 1644; several other works were attempted in Rhode Island and Connecticut. However, the American iron industry overall was not very successful during the seventeenth century and only five ironworks existed in the Northeast in 1673 (Bining 1933: 13).

The eighteenth century, however, proved to be the actual beginning of the successful American iron industry. Colonial populations grew and this growth led both to a greater supply of newly immigrated skilled craftsmen and to an increased demand for iron wares. Several ironworks began in Pennsylvania, Maryland, New Jersey, and Virginia. To encourage iron production, many colonies exempted ironworkers from road building, taxes, and even militia service. Many ironworks owners were also relieved from property taxes and were granted unoccupied land for the establishment of new ironworks (Bining 1933).

The next phase of Virginia iron production began in 1710 with the arrival of the new lieutenant governor Alexander Spotswood and his plans for the industrial development of the colony. He attempted to encourage the Virginia Legislature and later the Board of Trade in London to develop ironworks, but failed to convince them. Spotswood decided to promote the industry on his own (Bining 1933).

In 1714, Spotswood helped a group of immigrants from an iron producing region of Germany to settle along the Rappahannock River in the northern frontier. The location soon would be named Germanna. After the discovery of nearby fields of iron ore, Spotswood took out patents on the land. In 1716, with the financial assistance of English partners, Spotswood built a blast furnace and put the immigrants to work (Bruce 1930: 10).

These initial efforts at personal gain cost him his colonial position in 1723. However, by 1732, he would own the Germanna blast furnace and the Rappahannock River Air Furnace and would be a partner in a blast furnace thirty miles southwest of Fredricksburg (Bruce 1930).

In 1732, a fourth blast furnace began operations in Virginia. It was located on the plantation of Augustine Washington, the father of George Washington (Bining 1933). Washington's furnace was operated by the group of English iron masters who had set up the Principio Iron Works in Maryland. Principio was the first works to be established by a consortium of English merchants and iron mongers in direct response to the changing conditions of European iron production (Mulholland 1981: 62).

Two major prewar iron developments in the Virginia iron industry occurred in Prince William County. John Tayloe constructed a blast furnace on Neabsco Creek in 1738; John Tayloe II and partners erected a blast furnace and forge in Occoquan in 1759 (Bruce 1930). With the exception of Vestal's furnace in Frederick County established in 1742, all furnaces erected before 1760 were located in the Piedmont. For most of the period, the Piedmont was at or near the edge of the western frontier, with limited or no established means of transportation.

The primary goal of these Virginia ironworks was to produce pig iron for export directly to England. These English investors were so determined in pursuing this goal that few forges were constructed in Virginia to process pig iron or blooms into usable bar iron to be sold to blacksmiths and tool smiths. Similarly, through the first sixty years of the century, the English proprietors of Principio in Maryland were engaged strictly to supply British ironworkers (Bining 1933: 21).

At the same time that the Virginia ironworks were increasing output and sending most of their iron to England, the New England and Pennsylvania furnaces were also reaching higher production levels. These firms, however, developed differently from those in the South. The South, with its growing agricultural economy, imported most of its finished goods. New England tended to develop independent manufactures that often competed closely with English merchants. This difference was due, at least in part, to the fact that New England geography was very similar to England's; they had similar natural resources and many waterways for transportation and power.

On the other hand, geography and an economy dominated by cash crop agriculture tended to limit the extent of manufacturing in the southern Colonies. The great distances to be traveled overland from iron deposits and other resources before reaching easily navigable rivers added such high shipping costs that industries were slowed because their wares were not cost competitive. Also, the southern colonies attracted a different type of immigrant from those in the North. At the same time that skilled industrial workmen went to the manufacturers in New York, New Jersey, Massachusetts, and Pennsylvania, the South attracted planters who brought slaves to fill agricultural positions.

The fastest and surest way to earn a large living on Virginia's rich soil was with agriculture. "[Tobacco] planting," wrote Kathleen Bruce, "furnished the quickest road to fortune and to social distinction" (1930: 259). Further, an economy based on slavery actually hindered industrial production and capital accumulation. This was primarily because the investment returns on large scale agriculture were much greater than those on industrial ventures. Planters tended not to invest in--and even to discourage--any form of enterprise that might eventually interfere with their lifestyle (Bruce 1930: 80).

Colony to Nation (1750-1789)

Major shifts in the iron industry began to occur by the mid century. Iron manufacturers in Pennsylvania and Massachusetts increased production, often directly casting products from their blast furnaces to supply the growing population. Shortly after the treaty of Utrecht (1714), industrial activity began to increase in the colonies. Because of the increased demand for iron and the steady growth of northeastern industries, most of the colonial iron remained in America rather than going to Britain (Bining 1933: 30).

In England, pig and bar iron production continued to decrease in the eighteenth century due to the continued fuel shortage. At the same time, manufacturing of iron products swelled. The combination of factors increased England's dependence on foreign iron (Bining 1933). With a growing crisis in its iron industry, English merchants continued to view the Americas as a source for those raw materials not available in England. With the growing

populations in the colonies, the colonies were seen as an increased market for English goods (Bining 1933).

The growing sophistication of American ironworks and manufacturers and the lack of the traditional colony-mother country exchanges frustrated British ironworkers. The British had to continue importing pig and bar iron from Sweden and Russia and did not have as ready a market for their goods as they would have liked. On the eve of a war with Sweden in 1750, English iron manufacturers persuaded Parliament to remove all tariffs on American bar and pig iron coming into England in hopes of decreasing their dependence on Sweden. To appease English blast furnace owners, who would have rather seen tariffs on their competitors continue, the act originally applied only to iron shipped directly to London. However, because the act was not initially successful, it was later expanded to include all English ports. To protect the iron manufacturers in England, the act also included prohibitions against erecting new slitting mills for nail making, plating mills for making sheet, and steel furnaces in the colonies. The goal was to eliminate all competition in the area of secondary iron manufacturing (Bining 1933).

The act apparently had little effect. American imports accounted for only six percent of England's total iron imports in 1761; that figure increased to only fifteen percent in 1771, mostly through expanded production and exports from Pennsylvania (Bining 1933: 85). Although total exports increased only slightly, pig and bar iron exports from Virginia and Maryland did rise (U.S. Census 1976: z348-353, z331-337).

The regulations were mostly observed through the end of the French and Indian war. Until the end of the war, it was possible to enforce the laws because of the high number of British soldiers stationed throughout the colonies. Later, however, the inability to adequately enforce the laws led to gross violations--violations that were often promoted by the colonial governments (Bining 1933).

Further, as the population continued to grow, demands for iron wares and implements continued to increase. This led to a more sophisticated and independent economy driven to disregard restrictive British laws and policies and eventually revolt against the crown. By the 1770s, this unchallengeable renegade attitude, coupled with high colonial demand for iron products and decreasing British production, led to the existence of more operating blast furnaces and forges in the Americas producing greater quantities of pig and bar iron than in all of Britain (Bining 1933).

Through this period, a mercantile arrangement continued between Virginia and England. Increasingly, because of slowly developing southern manufactories, Virginia also developed a merchantilist arrangement with the northern colonies. Northern companies often bought Virginia pig iron; in many arrangements with plantations, northern companies exchanged clothing, iron wares, and steel tools for pork or corn (Bining 1933 and U.S. Bureau of Census 1977).

The next development of the iron industry in the Virginia colony occurred in the 1760s. Furnaces were established along the Shenandoah River in Frederick County beyond the first mountain range in the northern part of the state, and in Augusta County in the middle valley region between the Blue Ridge and the Alleghany Mountains. These developments were primarily tied to the internal movements of German and Scotch-Irish immigrants traveling from Pennsylvania and New York toward the Carolinas. According to Bruce, they "pushed into the colony between the two

great walls of mountains, and having found beds of brown hematite ore about them started an iron industry parallel to that in lower Virginia" (Bruce 1930: 21).

As the revolution began and continued, iron production in all colonies increased to meet the demands of the army; trade with England was suspended. Although at least twelve furnaces operated in Virginia during the war, it does not appear that any new ventures were started as a direct response to war-time demand (Bruce 1930: 454).

Early National Period (1789-1830)

The next phase of iron production in the state began in the 1780s as the new nation began to resume its productivity. Following the war, a depression hit the new country as it tried to negotiate with Britain for the resumption of iron imports. Although these early postwar years were very difficult, production did expand in Virginia. According to Swank, "no state in the Union gave more attention to domestic manufactures after the close of the revolution than Virginia." He concluded, however, by warning that although industrial activity could continue for many years, it would be "checked in subsequent years by the greater attention given by the people of Virginia to agricultural pursuits" (Swank 1891: 269).

Following the depression, iron masters began to settle in the lower Valley of Virginia along the James River in Botetourt County and along the New River in Wythe County. By 1800, each of the primary iron producing regions in Virginia, the Piedmont and the upper, middle, and lower valley had begun production. Mt. Torry Furnace in Augusta County was constructed around 1804 as a cold-blast, charcoal furnace. Pig iron from this furnace was transported on wagon to the James River and floated down to Richmond. Output in the Valley of Virginia increased as the industry expanded and new furnaces were constructed. By 1810 Virginia had the third highest pig iron sales among states and territories in the union. Virginia's iron sales were behind only New York, which sold about fifteen percent more, and Pennsylvania, which, with its dominance in iron already firmly established, sold over three hundred percent more (French 1858: 19).

The end of the Early National Period was not a successful time for the iron industry in Virginia. National production slowed during the 1810s and 1820s (U.S. Bureau of the Census 1976). Canada Furnace in Augusta County was built around 1812. The history of this small furnace reflects the economic decline of this period; it only operated for a few days before being shut down due to technical problems. The ailing economy and negative prospects for success did not justify the investment that would have been required to make Canada a functional furnace.

Antebellum Period (1830-1860)

The industrial revolution in America led to an increase in the need for iron. During decades of the 1830s and 1840s, Virginia emerged from its slump, as seventy-five new furnaces opened in the valley beyond the Blue Ridge (Bruce 1930). Catawba Furnace began operation in 1830. This cold-blast, charcoal furnace was built on an unusual round plan (most furnaces were square in plan), and ran on water power provided by Catawba Creek. Roaring Run Furnace was built around 1832 by Samuel C. Robinson of Richmond. Catherine, Elizabeth, and Van Buren furnaces

were all built between 1836 and 1837 in the Shenandoah Valley of Virginia. Situated at the entrance to Fort Valley, Elizabeth Furnace was originally called Fort Furnace. Although it was built in an area that already contained seven furnaces, its exact location offered some advantages over the other furnaces.

Despite difficulties in transporting iron over the mountains, this area of Virginia offered many benefits to iron manufacturers. Important natural resources in the area included abundant forests, high quality iron ore, limestone quarries, and water power. The success of a particular furnace often depended on its proximity to these resources, transportation avenues, and forges to convert pig iron into more marketable wrought iron.

Although production increased over 10 percent between 1840 and 1850, the state dropped to rank as only the ninth largest producer in 1850, manufacturing only 4 percent of the nation's pig iron; by 1860 Virginia manufactured only 1 percent. The state's industry did not slow during this period, but great increases in production were made in other states as new ore fields were exploited. Pennsylvania production increased 150 percent, Maryland increased nearly 400 percent to surpass Virginia in production, and New Jersey more than doubled its production. Although Virginia iron furnaces had difficulty competing with the northern ironworks, they fared better than many other states, including Kentucky, New York, New Hampshire, and Vermont, which witnessed dramatic production decreases (French 1858: 141).

The period of Virginia iron production from 1830 to 1860 has been referred to by Barber as the Iron Plantation Era. The time of greatest furnace construction in the middle valley region of Virginia took place during the first two decades of this period (Barber 1994). Because of their mostly remote locations and the need to provide for all services required to make iron and sustain a labor force, iron companies were run similarly to agricultural plantations. Furnaces operated like the large tobacco plantations of the piedmont and tidewater and were almost self-sufficient.

Industrialists owned large tracks of land often including ore pits, limestone quarries, and vast timber stores. An iron master generally headed the operation. He was supported by an assistant and the several skilled workers required to maintain and tend the furnace and its associated processes--the blacksmith, collier (for making charcoal), wheelwright, overseer, and miller (Barber 1994).

Outbuildings on the plantation included worker housing, among other structures. An example is the Catherine Furnace complex which, in 1847, included an eight room house for the owner, servants' house, coal house, furnace, casting shed, steam engine, bridge house, office, pattern house, smoke house, blacksmith's shop, and housing for furnace workers (Rappleye 1981). Roaring Run Furnace included numerous livestock, a grist mill, and a sawmill (Capron 1968). Some iron plantations even included agricultural fields, forges and foundries for refining iron, as well as mines and charcoal pits necessary for the process of iron extraction. As a result, those facilities were nearly self sufficient (Bining 1933).

Although iron plantations employed many skilled workers, the vast majority of ironworkers were unskilled and were usually slaves. Unskilled workers were responsible for mining ores and quarrying stone, breaking rock into fist-sized pieces for charging, felling and hauling timber and producing charcoal, charging the furnaces (usually by hand

with wheelbarrows or carts) and building and maintaining roads (Barber 1994).

Slavery provided most of the unskilled labor in Antebellum Virginia iron plantations. Initially, slavery grew as a mechanism to tend and harvest crops, primarily tobacco in Virginia and later cotton in the Cotton Belt. Much of the southern economy remained fixed to low-cost labor-intensive ventures because of the dominance of agriculture, the large number of enslaved persons, a continued reliance on traditional technology, and the relatively high returns on using an unpaid labor force. While the northern industries developed an economy based on industrial capitalism and, with a higher labor cost, tended to industrialize at a faster rate, southern businesses tended to implement production machinery and technical improvements at a slower pace.

Captive workers for iron production were used as early as the 1720s by Alexander Spotswood. Slavery--with furnace companies actually owning their workers--probably persisted through the remainder of the eighteenth century. The use of impressed labor in the American industry was not unique to Virginia or the southern colonies. The Saugus Iron Works near Boston employed Irish war captives in its early years of operation.

Following production slowdowns and labor power reductions of the 1810s and 1820s, the 1830s recovery period required the assembly of a large labor pool to man the seventy-five new furnaces. Many of the new furnaces, however, were cautious about capital outlay because of the recent recession in the industry. Therefore, to provide an added measure of financial protection, many companies leased their workers, reducing the level of initial capital required (Arend 1990). This arrangement not only reduced the initial capital burden, but served as a means to induce agricultural investment in industrial endeavors. Often slaves were leased for shares of the furnace company. With the increased productivity of the 1830s and 1840s, this proved to be attractive to planters--especially during times of a depressed agricultural economy (Arend 1990).

Iron masters that leased slaves would often buy workers who were trained as skilled labor through their experience at the furnace, in order to provide consistency in production. Iron furnaces began to rely heavily on these skilled laborers (Bruce 1930). Ironworks that owned a skilled slave labor force proved to be most economical; in 1848 J. R. Anderson of Tredegar Iron Works wrote that slave labor "enables me, of course, to compete with other manufacturers" (quoted in Bruce 1930: 237-238). The skilled slaves in return often experienced greater control over their own lives, or at least as great amount of control allowed within the institution of slavery (Dew 1994: 191).

Industrial Revolution

During this period of high production in the United States, two major technological developments pioneered in England in the late eighteenth century made their way into the American iron industry. These were the development of the steam engine, and its use to process coke from soft coal. Because of the dwindling supply of available fuel wood, eighteenth century British iron smelters faced serious production problems. Some iron masters had experimented with coke as early as 1728. Most British coal seams, however, were very deep, usually far below the water table, and the recovery of coking coal proved prohibitively expensive.

Following the American Revolutionary War, the British developed an efficient steam engine that was employed to pump water out of coal mines. The technology provided access to extensive coal deposits, and, as a result, coke became widely available to blast furnaces. Its use not only rescued the British iron industry, but returned it to world dominance, a position it would hold until the mid-1890s (Campbell 1907: 621). The use of coke was so widely and quickly adopted by the English that by 1796 there were practically no charcoal furnaces operating in Great Britain (Swank 1892: 1366). Coke technology, however, did not cross the ocean right away, primarily because of the United States' abundant forests. Charcoal was more expensive to manufacture than coke, however charcoal is a purer fuel that naturally burns hotter and without sulphur or phosphorus, resulting in a higher grade iron (Greenwood 1907: 149).

As timber stores showed signs of depletion just prior to 1840, Americans began to search for mineral fuels that they could use as an alternative to charcoal. The first mineral use occurred in eastern Pennsylvania as furnaces mined the only anthracite or hard coal in the country. Because this fuel could be retrieved easily and burned without processing, its use, according to Swank, "at once created a revolution in the whole iron industry of the country" (1892). Iron manufacture was expanded; districts which had been closed to this industry because of a scarcity of timber were now fully opened; and lowering of prices, which was made possible by the increased production and the increased competition, stimulated consumption. Although hard coal required no processing, its use in the industry did not initially hurt the charcoal iron industry of Virginia, which saw production increases over the decade (Swank 1892: 352).

By 1840, only six furnaces were making iron with anthracite, all in Pennsylvania; that number jumped to forty-two in 1846. In 1856, 121 furnaces used anthracite: ninety-three were operating in Pennsylvania; fourteen in New York; six in Maryland; four in New Jersey; and four in New England (Swank 1892: 362). By 1856, anthracite iron production surpassed charcoal in tons of pig produced; it accounted for just under half of all pig iron manufactured in the United States (French 1858: 179).

Virginia iron plantations of the period were hindered in their ability to produce at the scale of the anthracite furnaces operating in the North. Because of the distance to anthracite beds, transportation costs prohibited the use of the cheaper material. At the same time, demand for charcoal iron remained high enough through the 1840s for Virginia furnaces to resist any major operating changes. A second primary hinderance to increasing iron production in the state was the lack of governmental support from the agriculture-dominated state legislature and constituency. Bruce wrote, "[Virginia] planting...developed a proud class whose ability for leadership has not been surpassed in history, but a class which, in the main, achieved a passion for the soil and an ignorance of industrial affairs" (Bruce 1930: 260). The planters established a legal and economic system based on slave labor that stabilized eighteenth century plantation life. According to Bruce, however, the plantation system fostered protectionism. Fears festered that laborers would be lost to industry and that additional taxation would be required to build railroads. The planters were fairly successful in slowing iron production and delaying the introduction of new transportation systems in the state. This occurred during the time that the canal building 'mania' was sweeping the nation, followed by a period of extensive railroad building.

The combination of transportation problems, dependence on charcoal, and dramatically increasing production

levels in the northern states led to a sharp decline in the Virginia iron industry from 1850 to 1860. Many northern charcoal furnaces were converting to anthracite (hard coal) and Pennsylvania's production increased nearly twenty-two percent per year. In Virginia, furnaces were renovated to compete with these northern iron producers. In 1854 the owners of Van Buren Furnace in Shenandoah County tried to increase performance by reducing the diameter of the stack. In 1847 Roaring Run Furnace was rebuilt in an effort to compete with Pennsylvania anthracite furnaces. Most of these renovations actually reduced output due to technical problems, and thus failed to match the competition from northern ironworks. In the 1850s a number of iron furnaces in western Virginia went out of blast. These furnaces included Roaring Run, Van Buren, Catawba, Mt. Torry, and Lucy Selina.

Virginia's iron industry did make some progress, however, by employing new techniques including the use of a hot blast. Australia Furnace was built on Simpson's Creek in 1854; it was larger than its predecessors in order to accommodate a hot-blast and increased production. Still, despite the use of inexpensive slave labor and improved technology, efforts to compete with the north failed and many of Virginia's furnaces went out of blast; Virginia's production dropped by fifty percent over the decade (Bruce 1930). In 1856 the state's thirty-nine operating furnaces and forty-three forges (Swank 1891: 271) manufactured less than one percent of the nation's iron (French 1858: 179).

Although the dominance of an agricultural economy slowed southern industrialization, some manufactures were able to develop and prosper. The Tredegar ironworks in Richmond, Virginia, became a major southern manufacturing concern. Begun in the early nineteenth century, the company grew rapidly. By 1860, Tredegar maintained four rolling mills, fourteen foundries and machine shops, one nail factory, six rail works, two circular saw works, and fifty 'iron and metal works' (Bruce 1930: 323). Even though the Tredegar operation was impressive by any standards, most of its customers were located in the southern states. This may have been because the cost of shipping iron to the north was prohibitively high. Overall, the southern secondary iron industry, which included the manufacture of bar, sheet, and rail iron, increased 194 percent during the 1850s, primarily in conjunction with growing demand from southern customers (Bruce 1930: 321). By 1866, Virginia manufactured 2 percent of the nation's secondary pig iron industry production of bar, sheet, and rail iron.

At the same time that the secondary iron industry in Virginia increased on the basis of a growing regional market, its primary industry faced dramatic reductions. This growth and decline occurred within the context of a regional economy. Southern iron makers could not compete with northern furnaces because of high transportation costs and because the resources were less easily available in the south. At the same time, its secondary manufacturers established a southern market for its goods primarily because it could do so less expensively than the North. The industry was growing but could not develop a nation wide market for its products.

Civil War (1861-1865)

As the divisions between the northern and southern economies widened, secondary manufacturers were positioned to take on new roles if and when the regions separated. With the viability of many of its furnaces still intact, the Virginia iron industry was able to re-establish itself during the Civil War. Much of the South was engaged in agriculture and had no industry; the established iron industry of western Virginia became essential to the Confederacy

during the Civil War (Bruce 1930).

When the Civil War began, demand for southern pig grew very quickly as managers at Tredegar, which was now the primary Confederate ordinance producer, scrambled for iron. In the fall of 1861, Joseph Reid Anderson, who owned and operated Tredegar Iron Works, sent letters to all Virginia iron furnaces that had been in blast in the previous twenty years. He made contracts with many of them for pig iron, and convinced many other furnace owners to bring idle furnaces back into blast.

Like many of its contemporaries, Glenwood Furnace supplied the Tredegar foundry in Richmond with iron throughout the Civil War. In 1861 Glenwood was one of the Virginia Furnaces to have a contract with Tredegar. During the Civil War iron prices in Virginia were at a premium; in 1859 and 1860 Anderson of Tredegar paid $30 a ton for car wheel iron from Glenwood Furnace (owned by his brother Francis); in 1862 the price was $45 a ton (Capron 1969). In addition to producing car wheels, the strong iron from Glenwood Furnace was used for Confederate cannons. Catawba Furnace also produced a strong, high quality iron that was used to produce cannons for the Confederacy. This furnace was brought back into blast in 1861, and the high-grade iron it produced was used to convert the warship Merrimack into the ironclad Virginian. Raven Cliff, Roaring Run, and Mt. Tory Furnaces were brought back into blast after Anderson wrote to the owners asking them to refire their furnaces to support the Confederate Army. During the Civil War, Catherine Furnace was enlarged and converted into a hot-blast furnace. In addition to Tredegar, the Confederacy also established a munitions works in Wythville, Virginia, and enacted exclusive contracts with several ironworks in the Valley of Virginia.

Initially, Tredegar Iron Works simply had contracts with iron furnaces in western Virginia. As the war continued, however, the need for iron became even greater. Tredegar bought or leased many furnaces in the Valley of Virginia in order to control quality, and have access to the entire output of iron from the furnaces. Elizabeth and Glenwood Furnaces were two furnaces leased by Tredegar early in the Civil War. Tredegar leased Roaring Run furnace in 1864 in order to control the entire output of the furnace, and supplement the iron produced in other furnaces that were damaged by General Hunter's Union Forces.

Despite the advantages Tredegar saw in leasing iron furnaces in the Valley of Virginia, it was also faced with problems in supplying manpower and transportation. The location of many furnaces required personnel to man barges to transport iron from the furnaces to Richmond. In 1863 Anderson asked the Secretary of War of the Confederacy for wagons and teams to haul pig iron from Columbia, Caroline, and Fort (Elizabeth) Furnaces to Staunton. He also asked for men to help work the furnaces, but the War Department only supplied a portion of the men requested. Slave labor was equally hard to come by as Tredegar had to compete with the Corps of Engineers, railroad and canal companies, and Richmond factories, all of whom saw increased levels of production and need for workers during the Civil War (Dew 1966: 138).

Tredegar lacked the experienced personnel to operate all the furnaces controlled by the Richmond ironworks. Production at Catawba Furnace, for example, was inhibited by the fact that Tredegar did not have enough experienced founders; the same men ran both Catawba and Cloverdale Furnaces and as a result one or the other was often out of

blast. Tredegar bought Mt. Tory in 1863 in order to control the entire output of pig iron, but had a hard time finding enough men to work the furnace. Anderson of Tredegar bought Australia furnace during the Civil War, but did not achieve high yields due to difficulties in transportation, shortages of men, and poor management. Tredegar stopped production at Australia in 1863, and put the furnace up for sale.

The labor profile changed during the war as many skilled workers were called to serve in the Confederate war effort. The iron furnaces began to depend on slave labor to a greater extent. Tredegar promised hiring agents positions as overseers at the furnaces if they acquired thirty or more hands from rural farms (Dew 1966: 251). The demand for slave labor intensified after 1863 when military service exemptions for white furnace workers were greatly reduced. In order to convince more people to lease their slaves to the iron industry, Tredegar advertised that slaves would be safe, well clothed and well fed. Tredegar also made provisions for whole families to move into the mountain sites, and employed women and children on farms at the furnaces (Dew 1966: 258). In addition, a large number of slaves had a history of working in the iron industry and many were able to increase their skill level and move into positions of increasing responsibility. Although many facilities were eventually depleted of workers (especially when men were needed to build defensive bunkers toward the end of the war) at its peak Tredegar employed 1,200 African-American and 1,200 white workers, divided among its Richmond ordinance works, coal pits, tanneries, and valley blast furnaces (Arend 1990).

Ironworks throughout Virginia fell victim to union troops during the Civil War. Generals Hunter, Averell, and Duffie of the Union Army burned furnaces in Virginia (Rappleye 1981). Elizabeth Furnace is believed to have been burned by General Hunter; there is no record of its operation between 1865 and 1883. Brigadier General Duffie burned Mt. Torry in 1864. Also in 1864 General Hunter burned Cloverdale Furnace; there is no evidence, however, that nearby Catawba Furnace was destroyed. Catawba Furnace may have been out of blast due to manpower shortages when the Union troops passed by. Van Buren Furnace was visited by Union troops, but never burned. This may have been because it was out of blast and dilapidated. Burned furnaces were easily and quickly rebuilt, as burning did not affect the actual furnace, but only the wooden support structures. Columbia Furnace was burned by Federal troops three times during the Civil War, and rebuilt each time (Wayland 1976: 175). Union forces further hindered furnace production by the end of the war by reducing the already low labor force. In 1864 General Hunter's cavalry took away large numbers of slaves from Cloverdale, Grace and Mount Torry furnaces (Dew 1966: 260).

The fact that not all furnaces were burned by the Union, even furnaces very close to ones that were burned, may reflect the problems Tredegar was having in keeping all furnaces supplied with men and in blast. The Union Army also did not seem to put the destruction of Virginia furnaces high on its agenda. A furnace in blast was easily located by the cloud of black smoke rising from its stack. Also, the location of all furnaces in the area was probably known to the Federal forces as these locations are found on historic maps prepared by Union forces. The troops may have felt the Confederate iron works posed little threat to the Union war effort.

Although iron furnaces in Virginia increased their production during the Civil War, this increase could not sustain the industry following the war. Many furnaces including Glenwood, Catawba, Roaring Run, and Mt. Torry again went out of blast after 1865. The character of southern ironworks contributed to the eventual decline of Virginia

iron furnaces, as well contributing to the defeat of the Confederacy in general. Before the Civil War, the economy of the South was based primarily on agricultural and slave labor, therefore allowing for large returns without impetus for improving methods or developing industry. Iron furnaces were likewise organized like plantations and based on slave labor. The cheap labor force kept production costs low; there was no need to develop more efficient or cost effective ways of iron production. Therefore, while the north was constantly incorporating new technology in iron working, the Virginia iron industry remained locked in the old methods of production. Industrial infrastructure of the northern states, including the transportation network, was more developed than that of the southern states. This failure to modernize production, coupled with transportation problems, a lack of anthracite coal or coke, and the increased availability of northern iron led to the decline of Virginia ironworks after the Civil War.

Reconstruction and Growth (1865-1914)

After the Civil War, the Virginia pig iron industry declined because of the increased availability of northern iron. Production in Virginia, which was listed at 22,163 long tons in 1850, had dropped to just 9,096 in 1860. Increases due to the war and the post war economy boosted 1870 production to 15,387 long tons, which, after peak production years in 1874 and 1875 fell to just 11,102 tons in 1877 (Gooch 1954: 2). The primary causes for this decline were the dramatically decreased regional demand for iron after the war, the increased costs required to pay skilled and unskilled former slaves, and the increasing availability of high quality iron produced in coke-fueled furnaces in Pennsylvania.

During the 1870s an attempt was made by the Virginia ironworks to reestablish a competitive industry. Many furnaces changed hands, and were renovated to incorporate a hot blast and better modes of transportation. Glenwood Furnace was rebuilt and reconditioned in 1874 as a warm blast furnace. Van Buren Furnace was rebuilt in 1873 on the site of the old furnace. This new furnace (also known as King Furnace) used charcoal and had a closed top to allow for either a hot or cold blast. Callie Furnace was built as a hot-blast furnace in 1873. The new owners of Catherine Furnace in 1871 installed a narrow gauge railway and a flume in order to increase production. Raven Cliff continued to produce pig iron during the reconstruction. The furnace was rebuilt in 1875 and sold to Crocket, Sanders & Co., which became Crocket & Co. three years later. In 1883 Elizabeth Furnace was leased to Knaver & Marette of Douglasville, PA, who rebuilt it, reducing the width of the stack, closing the top, and adding a hot blast stove. However, most of these renovated furnaces failed to produce adequate results and were soon abandoned in favor of coke burning furnaces.

Coke Period (1870-1900)

Although the first use of coke for iron production occurred in 1735 in Britain, this new technology was slow to take hold in the United States due to early transportation difficulties, the abundance of timber, and an American preference for charcoal iron. As has been discussed, however, the cost and structural benefits of coke drove iron masters to begin to experiment with using it.

Coke fuel was used in America as early as 1839, when the introduction of the steam engine and a hot blast

increased the furnace temperature. In 1854, coke accounted for less than eight percent of all iron produced in the United States. By 1861, however, it had grown to 17 percent and in 1869, it grew to 29 percent and surpassed charcoal fired iron in production. By 1875, coke fired iron became the most common type of pig in the country, accounting for 42 percent, compared to 40 percent for anthracite and 18 percent for charcoal (Swank 1891: 376).

In Virginia, coke use dates back to 1848, but only three furnaces (one actually located in West Virginia) used coke before the Civil War. Each of these was converted to coke from charcoal (Swank 1891: 371). Virginia was slow to adopt this new technology due to abundant forests and the high cost of conversion to coke-fueled furnaces.

Virginia finally shifted to coke-fired furnaces around 1870, after a period of economic decline. This shift in technology temporarily rescued Virginia's then failing industry. Following the low year of postbellum production in 1877, output began to increase dramatically as Virginia furnaces converted to the use of coke as furnace fuel. The period from 1870 to 1900 can be considered the era of coke production in Virginia, and the industries last major effort to compete with the northern iron producers. From the 11,102 tons of pig iron produced in 1877, production reached 78,331 tons in 1882, 176,246 tons in 1888, and 490,617 tons in 1900, peaking in 1903 with production levels of 544,034 tons (Gooch 1956: 2). A primary reason for this output was the ability of coke and a heated blast to dramatically increase the output of each furnace (Barber 1994). Improvements in transportation and increased accessibility to railroads also aided the Virginia iron industry. By 1902, only four of Virginia's 26 furnaces still used charcoal to make iron (most charcoal furnaces were abandoned by 1890). The state ranked ninth among iron producing districts, producing 2.8 percent of the country's pig iron (Campbell 1907: 442).

Callie Furnace is one example of a Virginia furnace which, at least initially, used coke firing productively. This furnace was built as a hot-blast charcoal furnace around 1873-1874 by D. S. Cook of Wrightsville, Pennsylvania. By 1876 it was enlarged and converted into a coke furnace. In 1883 the stack was raised an additional five feet, and a third tuyere was added. The addition of a new hot blast oven also increased the efficiency of the furnace. Advances in iron furnace construction were tried at Callie Furnace, while at the same time the basic early-nineteenth century trapezoidal design was retained. In October 1880 a spur railroad line was completed from the Chesapeake and Ohio Railroad, across Rich Patch Mountain to Glen Ellen near Callie Furnace, increasing the output potential of the furnace. However, Callie Furnace was abandoned in 1884 for newer furnaces, including Princess Furnace, built closer to resources and the railroad.

The Longdale Iron Company operated two productive coke furnaces in Virginia: Lucy Selina Furnace (also called Longdale Furnace No. 1) and Longdale Furnace No. 2. The company hoped to compete with northern and western iron companies from the Great Lakes area with these furnaces and the Longdale iron mines by positioning company operations along transportation routes. Lucy Selina Furnace, originally built in 1827 as a charcoal furnace, was renovated to use coke in 1874, becoming the first pig iron furnace to have the capability to use coke. The furnace's name was later changed to Longdale No. 1. The furnace was again enlarged to 60' by 11' from 1876 to 1889. Longdale Furnace No. 2 began production as a coke furnace in 1881. The Longdale Iron Company produced coke from its coal fields at Sewell, in Fayette County, West Virginia. In 1880 the Longdale Ore Railway was completed from Longdale mines to the new furnace. In 1884 this narrow gauge railroad was extended to a new ore mine and a

bed of Nuttail New River Coal. These two furnaces were highly productive for thirty years. Longdale Furnace No. 2 grew into a large complex and town including Longdale's offices, machine shops, and many more houses and associated structures. The success of the Longdale Iron Company prompted other manufacturers, like the Low Moor Iron Company, to adopt coke as a fuel (Giles 1985).

In addition to the advantages achieved by converting to coke, a second reason for the increase in Virginia's production may be that the growing availability of steel as well as iron resulted in increased demand. Rapid changes took place as the country's industrial base expanded during the late 1800s. By 1892 steel replaced iron as the most produced metal (Sisson 1992). Engineers designed and redesigned items with the widely available stronger and more flexible metal, which was produced in iron furnaces through the addition of carbon and other constituents such as magnesium. "Demand grew as railroads were built across the country, steel skeletons were erected to support buildings, plates were used to make ships, and barbed wire was strung to fence grazing land . . . [as] capitalists quickly adopted mass production technology to meet the burgeoning demand for steel" (Sisson 1992: 79-80).

Decline of the Iron Furnace Industry in Virginia (1880-1928)

Blast furnaces were redesigned to increase production because coke, which was structurally stronger than charcoal, could support a higher charge. This, in turn, led to greater output. In 1846 a standard stone furnace may have been 30 feet high and held 2000 cubic feet of charge. By the 1890s, steel construction shells were built into furnaces, enabling them to be built to over 100 feet high with an internal capacity of 18,200 cubic feet (Sisson 1992: 83). The iron industry grew primarily in Pennsylvania, Ohio, and Illinois. Vast, highly accessible fields of iron ore in northern Minnesota were exploited and shipped via relatively inexpensive Great Lakes freighters to centers of iron production that used coke burning furnaces.

Northern Alabama also began manufacturing in large steel shell furnaces, charged with coke. The region grew as an iron center after large fields of ore and coal were discovered in Alabama. Although Alabama had virtually no antebellum iron industry, it surpassed Virginia in pig production by 1880 (Swank 1891: 376). Alabama's iron industry continued to grow, becoming the third largest pig producing district by 1901. Alabama's 45 furnaces produced 7.7 percent of the nation's pig, two and half times that of Virginia (Campbell 1907: 442). Several Virginia companies considered constructing large, steel-shell coke-fired furnaces. In 1882 Harry L. Horton purchased the property that included Roaring Run Furnace; he made elaborate plans to operate a modern coke blast furnace, with a sixty-five foot high stack. However, this construction never took place and Horton only sent shipments of ore to existing furnaces. Continuing transportation problems probably factored into the decision not to build.

Virginia's later nineteenth century industry, especially in the middle and lower valley, was increasingly isolated. Lack of adequate railroads and water transportation became more detrimental as furnaces in the Great Lakes area continually increased output and reduced their costs. As new larger-scale operations were built with higher output furnaces that were able to meet the demands, Virginia's relatively antiquated furnaces could not keep up. Production began to wane. Many of the lower and mid-valley furnaces went out of blast just before the turn of the century. Between 1884 and 1892, Glenwood, Callie, Van Buren, Elizabeth, Raven Cliff, and Mt. Torry Furnaces all went out of blast permanently. Improvements in the railroad system of western Virginia came too late to rescue most Virginia furnaces from debt. Although several of these furnaces had been converted to coke, only the northern valley coke furnaces were able to remain competitive. This was probably because of their proximity to steel production and secondary manufacturers in Pennsylvania, Ohio, and Maryland, and because they were near bituminous coal fields in West Virginia (Campbell: 1907).

Iron furnace production in the northern Valley of Virginia revived briefly in 1917; World War I pushed nationwide production to near record levels. The post war depression, however, reduced production to less than one tenth of war time highs (Gooch 1954). Pig iron production again increased in 1926 and 1927 as the nation experienced a mid-decade economic surge. Despite this brief nationwide reversal, Virginia furnaces were only able to produce half of the lowest production levels that had been achieved between 1900 and World War I. By 1928 the state's marginally capitalized furnaces, faced with increased competition from Great Lakes ore, unfavorable shipping rates, antiquated furnace practices, and a pending national depression reached the end of their operation (Gooch 1954).