American Iron, 1607-1900
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Introduction

The Europeans who settled in North America from 1607 onward could apply their metallurgical skills to ore, wood fuel, and water-power resources far more abundant than those they had known at home.* A few decades after John Winthrop Jr. started his Saugus, Massachusetts, ironworks in 1641, many colonies had smiths, founders, or smelters among their inhabitants. By 1770 the American colonies had made themselves the world's third largest iron producer.

As they built ironworks, Americans created new communities and an industrial way of life. Artisans strove to run blast furnaces continuously for weeks or months. A dozen or more ironworkers charged and tapped the furnace at regular intervals all day, every day, for months on end. Failure of an individual to be at the right place at the right time disrupted production and could put others at risk of injury. Ironmasters found their organizational skills taxed. Artisans had to put tending the furnace above personal preferences about work times and methods. These Americans already accepted the industrial discipline we commonly ascribe to the textile mills started a hundred fifty years later.

Ironmaking was often dangerous work, and it required strength, stamina, and, at times, courage. It also took considerable intelligence. Artisans had to interpret subtle clues to follow the progress of the unseen chemical transformations inside the furnaces that extracted metal from ore. Ironworkers learned and

* Throughout this book, North America means the land north of Mexico, and Americans refers to the occupants of this territory.
refined their skills through experience. Unlike secretive European masters, or artisans in the closed African iron smelters’ camps, Americans let neighbors and children stop by their smithies, forges, and furnaces to watch and learn. Only in the extreme northern fringe of forests or on the coastal plain of the southeast did youngsters lack opportunities to experience iron-making. As young artisans learned the technique, they could practice their art as individuals at small forges or join the teams that ran blast furnaces. Artisans moved about, worked for different ironmasters, exchanged information with their peers, and displayed their particular skills to interested observers.

In the nineteenth century professional scientists and engineers gradually discovered the physical and chemical principles that described what artisans already knew how to do. Ironmasters nevertheless found it hard to convert artisans’ craft knowledge of the largely invisible processes that went on inside furnaces to scientifically controlled metallurgical technique. (Managers of manufacturing establishments had an easier time with the visible, tangible mechanical arts.) The cumulative knowledge of ironworkers remained essential to success with a forge, furnace, or foundry. Only in the large steelworks of the late nineteenth century did managers and union officials begin to insist on fine division of labor and job descriptions that restricted opportunities for workers to use their judgment and initiative in a wide-ranging way.

In contrast to their twentieth-century counterparts, earlier Americans, who often worked with hand tools in their everyday lives, admired and valued artisanal skills. They were prepared to judge the intrinsic worth of a product such as an axe or rifle and to pay for superior articles. Ironmasters who consistently made good metal built reputations that brought them business and earned them respected places in their communities. Artisans with metallurgical skills achieved economic security and empowerment over their own lives. In using their skills to improve the quality of their products and the efficiency of their processes, they improved the competitive position of American industry and so increased the opportunities for others to exercise their skills. Even slaves who learned ironmaking techniques could earn cash and free time working for the ironmasters who had hired them from their owners.

Americans had begun ironmaking with European technique. As they gained expertise, they modified Old World methods to suit their own natural resources and economy. By the early decades of the nineteenth century, American ironworkers were ready to pioneer new techniques and respond to the demand from the managers of the newly established metal-goods and machinery factories for more uniform, higher quality iron than had previously been made. Established customs did not inhibit their innovation, nor did formal work rules confine them to a single
step of the ironmaking process. The numerous small establish­
ments run by individual proprietors offered them opportunities
to try out their ideas. Only the South was an exception: there
ironmasters' desire to retain a closed social system blocked free
exchange of ideas between black artisans and white entrepre­
neurs. Skilled artisans brought American ironmaking to techno­
logical maturity by the middle of the nineteenth century. They
created new techniques for recovering waste heat from blast furn­
ces, smelting with anthracite and with bituminous coal, and
applying hot blast to forges. They developed the graphite cru­
cible for melting steel.

From earliest colonial times, American governments inter­
ested themselves in iron. Some tried to stimulate ironmaking,
as the Maryland legislature did with its early eighteenth-century
laws that helped ironmasters acquire property. Yet in iron
metallurgy, unlike manufacturing, military purchases and gov­
ernment-sponsored research did little to advance technique.
Instead, government influenced ironmaking through internal
improvements and tariff policy. Occasionally states undertook
internal improvements specifically intended to benefit the iron
trade, as was the case in Kentucky. Most ironmasters received
little or no direct government aid. Munitions purchases in war­
time created strong, though transient, demands for iron. Many
furnace owners undertook cannon founding in the Revolution
and gained valuable experience from it. Virginia and other states
set up their own armories. In the first half of the nineteenth cen­
tury states and the federal government bought ordnance from
the four American foundries that specialized in cannon casting.
Ironmasters who could make a satisfactory product sold gun iron
to the national and private armories making small arms. How­
ever, these suppliers of specialized products often found that the
extra costs of meeting the sometimes arbitrary military specifi­
cations outweighed the extra revenue they gained from higher
prices. Ironmasters and artisans found better rewards when they
applied the experience they had gained in military work to com­
mmercial products.

Throughout the first part of the nineteenth century, govern­
ment-sponsored metallurgical research yielded little of practical
value. Ironmakers largely ignored the U.S. Treasury's iron-testing
project in the 1830s at the Franklin Institute and the Ordnance
Department's analyses of the chemical composition of the cast
irons used in cannon. The early state-supported geological sur­
veys likewise failed to yield the benefits their advocates claimed
and their sponsors expected. Instead, the geologists' theoretical
speculations often reinforced artisans' and ironmasters' suspi­
cion of intellectuals, professors, and government officials.

American ironmasters interacted with government prin­
cipally through import-export rules applied first from London and
later by the federal government's tariff policy. Some nineteenth-
century ironmasters apparently devoted more energy to attempting to manipulate tariffs than to making competitive products. They made claims about the quality of their iron to further their political and economic ambitions, and asserted that they needed the protection of a high tariff to fend off foreign iron that was cheaper because it was badly made. Customers who did not care or who did not know how to evaluate a good product, such as the capital-short railway promoters anxious to complete lines any way they could, often bought the low-grade, imported iron. Yet American ironmasters sometimes failed to make the quality products that Americans wanted for their tools and their new industries. They found that the achievement of consistent quality overtaxed both their managerial capabilities and the limits of artisanal skill. Some were willing to hazard their reputations with sharp practices for short-term gains. Ironworks proprietors sought government protection and sometimes blamed foreign competition for markets that they lost through their own shortcomings, just as American steel makers sometimes do today.

Clearly, ironmaking depended on natural as well as human resources. It also altered the environment. As long as wood was the main fuel, most of the environmental consequences of ironmaking were local and short-lived. After woodsmen clearcut forests for charcoal, owners might sell the land for farms or retain it for coppice to be cut again when the trees reached the appropriate size. Miners left cavities in the ground where they dug ore and released tailings in streams as they washed it. Since their work was on a small scale, the remains of most pre-twentieth-century mines and ore separators are hard to find today. Often, only piles of inert slag mark early iron smelting and refining sites.

Ironmakers enlarged their environmental impact when they began using mineral coal in place of wood. Coal contained sulfur that made water draining from mines and waste piles acidic so that it destroyed life in the streams it entered. By using steam rather than water power to drive blowing engines and rolling mills, and mineral coal in place of charcoal in furnaces, ironmasters could locate their works in towns and cities, where canals and railways delivered fuel and ore to them. By doing so, they left at the mines many of the environmental consequences of getting their fuel and ore. Those who enjoyed wealth created from the industrial transformation of the continent’s rich and abundant mineral resources began to distance themselves from its environmental costs. In the late nineteenth century ironmasters west of the Appalachians got ore from as far away as the ports of Lake Superior and built works large enough to alter the environment for miles around. Along the Monongahela River and in Pittsburgh, smoke and soot from coke ovens and ironworks blackened the atmosphere, settled on farmers’ crops, and stunted the growth of trees.

Americans persistently believed in the value of particular ores
and fuels. After artisans had applied their skills to build a high reputation for a particular ironmaking district, reporters and visitors would write of the superior ores and fuels found there. Additionally, ironmakers’ incomplete understanding of metalurgy led some of them to add to the myths about ores. Founders believed that they had to have iron smelted from particular ores because they got the strength they desired in their castings when they used metal from specific furnaces. When metallurgists discovered that carbon was the essential alloying element in iron and that phosphorus caused brittleness, they were ready to help solve problems that artisans could not handle with their own skills. By the 1860s some ironmasters had realized that chemical analyses could be useful in dealing with their operating difficulties, and a few invested in chemical laboratories. Eventually, metallurgists learned how founders could get the properties they wanted in iron castings by controlling the composition of the metal and its cooling rate. Ore from any source would then do.

The ore myth in part reflected Americans’ fascination with getting rich quickly through control of a natural resource. Many hoped to exploit high-grade ore with little investment in technique or equipment. Investors who lacked reliable means of evaluating the economic potential of an ore or fuel deposit became easy prey for land traders and speculators. By the mid-nineteenth century, investors had begun to seek professional help. Professors at universities such as Yale, Pennsylvania, Columbia, and Brown now supplemented their modest salaries with fees for evaluating mineral properties. They protected investors from the worst deceptions.

Unlike the British government, federal and state authorities never tried to regulate the use of natural resources by ironmakers. As Americans of varied social, geographic, and ethnic backgrounds took up ironmaking, they brought with them differing ideas about the environment. Some used natural resources profligately with the intention of soon moving elsewhere. For many Americans, labor was the scarcest resource, and they compensated by a generous use of ores and fuels. Others settled in for continued production at one location and arranged for sustained yield from their woodlands and for supplies of non-renewable resources, such as ore, from distant places when necessary. Managers of charcoal-fired blast furnaces adopted techniques of woodland management developed by professional foresters well before lumbermen did. Many of the woodlands they assembled and managed are now private or state forest preserves. Toward the end of the century, however, as entrepreneurs began steelmaking with large, capital-intensive mills, people found that choices about resources and the environment increasingly were made by remote owners rather than by proprietors in their own communities.

In 1866 skilled American artisans with a hundred-fifty-year
tradition of ironworking were ready to staff the new steel mills that soon achieved world leadership in efficient metal production. The following chapters explore how Americans developed their ironmaking skills and how they used the continent’s natural resources in building their iron industry.