

Hopewell Furnace

Hopewell Furnace
National Historic Site
Pennsylvania

National Park Service
U.S. Department of the Interior



In America's industrial infancy, tall stone structures venting smoke and flames were a familiar part of the rural landscape. These charcoal-fueled iron furnaces produced the versatile metal crucial to the nation's growth. For over a century, Hopewell was one of hundreds of "iron plantations" built around this technology. Here generations of ironmasters, craftsmen, and workers produced iron goods during war and peace—ranging from cannon and shot to the well-known Hopewell stove and domestic items such as pots and sash weights. Shared social and family bonds in an atmosphere of reasonable cooperation made these plantations stable and productive communities, the base on which America's iron and steel industry was founded.



Photographs by George Fistovitch

In a climate of disintegrating relations between England and its American colonies, Mark Bird, already an important figure in the booming colonial iron industry, built Hopewell Furnace in eastern Pennsylvania in 1771. When open conflict erupted in 1775, England's ministers regretted not having been more successful in their efforts to rein in the American ironmasters. They knew the iron industry was now going to be turned against the mother country. Ever since colonists had carried blast furnace technology to America in the mid-17th century, England had been worried by the rapid expansion of the industry and the increasing skill with which American ironmasters turned out cast and wrought iron products. Crown officials wanted to limit them to producing raw pig iron (rough cast bars), which would be shipped to England and processed into profitable goods—which could then be sold back to America. But the colonies weren't about to give up such a lucrative enterprise. When Parliament prohibited the building of more ironworks, Americans defied the law. They both cast iron and refined it into wrought iron, from which they made a broad range of competitive products. By the time of the Revolution, American furnaces, forges, and mills were turning out a seventh of the world's iron goods.

Pennsylvania's combination of abundant raw materials, water power, and religious tolerance drew enterprising ironmasters from other colonies and from Europe. By the time Mark Bird built his furnace in the Schuylkill Valley, Pennsylvania was on its way to becoming the most important iron-producing colony. Bird immediately began casting stove plates despite the British ban, and when the war began he was a steady supplier of cannon and shot to the Continental Army and Navy. As the war drew to an end, however, Bird's troubles began to mount: He had difficulty collecting debts from the young nation, and he suffered reverses in the general depression that followed independence. A flood in 1786 severely damaged the operations. These setbacks eventually ruined Bird, and in 1788 he was forced to auction off "Hopewell Plantation" at a sheriff's sale. Bird fled his remaining creditors, moving to North Carolina.

Beating swords into stove plates, new owners converted to peacetime production, but the operation remained unprofitable. The partnership of Daniel Buckley and his brothers-in-law Mathew and Thomas Brooke bought the furnace in 1800 and invested in major repairs. But natural disasters, a national recession, and litigation

closed the furnace in 1808. When it was fired again eight years later, Hopewell benefited from protective tariffs, a rapidly improving transportation system, and large numbers of immigrants looking for work. These national developments and the Hopewell owners' decision to concentrate on castings, especially stove plates, provided the foundation for success. But it was the imaginative leadership of a partner's son, Clement Brooke, that brought the operation to the peak of its prosperity. Brooke was resident manager of the furnace from 1816 to 1831, when he inherited a share and became ironmaster. He presided over Hopewell during its best years, when the furnace supplied a wide variety of iron products to cities along the east coast.



Clement Brooke

The Panic of 1837, which occurred at the zenith of Hopewell's fortunes, undermined the community's prosperity. The markets for castings shrank, and Brooke was forced in 1844 to abandon production of the popular Hopewell stove. Although

the demand for pig iron, especially during the Civil War, gave the furnace a temporary reprieve, it never again achieved the success of the 1830s. Hopewell's decline was hastened by the coming of America's mature industrial age. Iron making was being transformed from the old rural charcoal-fired and water-powered furnaces to urban concentrations of steam-powered, hot-blast coke and anthracite furnaces. Complexes in Pittsburgh and Birmingham were fed by train loads of ore and coal from huge western deposits. New processes of integrated iron and Bessemer steel production further rendered the old ways obsolete.

After Brooke retired in 1848, Hopewell's owners found it increasingly difficult to compete. They made efforts to keep up, building an anthracite hot-blast furnace and installing a backup steam engine for the blast machinery. The new furnace was a failure, and in any case their efforts only delayed the inevitable. Iron plantations like Hopewell, overtaken by the shift from the age of iron and water power to the age of steel and steam, were unable to follow the industry into the 20th century. In the summer of 1883, Hopewell Furnace made its final blast.

Both rural Pennsylvania community and "iron plantation," Hopewell turned out products for a growing nation.

Touring the Park

- 1 The **anthracite furnace** was Hopewell's failed attempt at hot-blast technology.
- 2 At hundreds of **charcoal hearths**, colliers turned 5,000 to 6,000 cords of wood a year into charcoal.
- 3 Charcoal, sometimes still smoldering, was dumped by teamsters in the **cooling shed** before being moved to the charcoal house.
- 4 Fillers carted charcoal, limestone, and iron ore through the **connecting shed** to the **bridge house**. Below, at the base of the furnace, the **water wheel** drove the **blast machinery** (not visible in picture).
- 5 Employees' purchases at the **office store** were charged against credits for work.
- 6 In the **cast house** that surrounded the furnace stack, moulders cast iron into stove plates and other products.
- 7 The **blacksmith shop** provided hardware and horse-shoes and was an informal gathering place.
- 8 Education at the **school-house** (foundation is visible) was democratic though rudimentary.
- 9 Some workers with families rented **tenant houses** owned by the company. Single men boarded with them or at the **boarding house** across the road.
- 10 The **barn** sheltered up to 36 draft animals and held a year's worth of feed.
- 11 In the **springhouse** and **smokehouse**, meats stored and cured foods.
- 12 The **ironmaster's mansion** was built in three stages, starting ca. 1770-1800. Some remodeling took place as late as 1870.

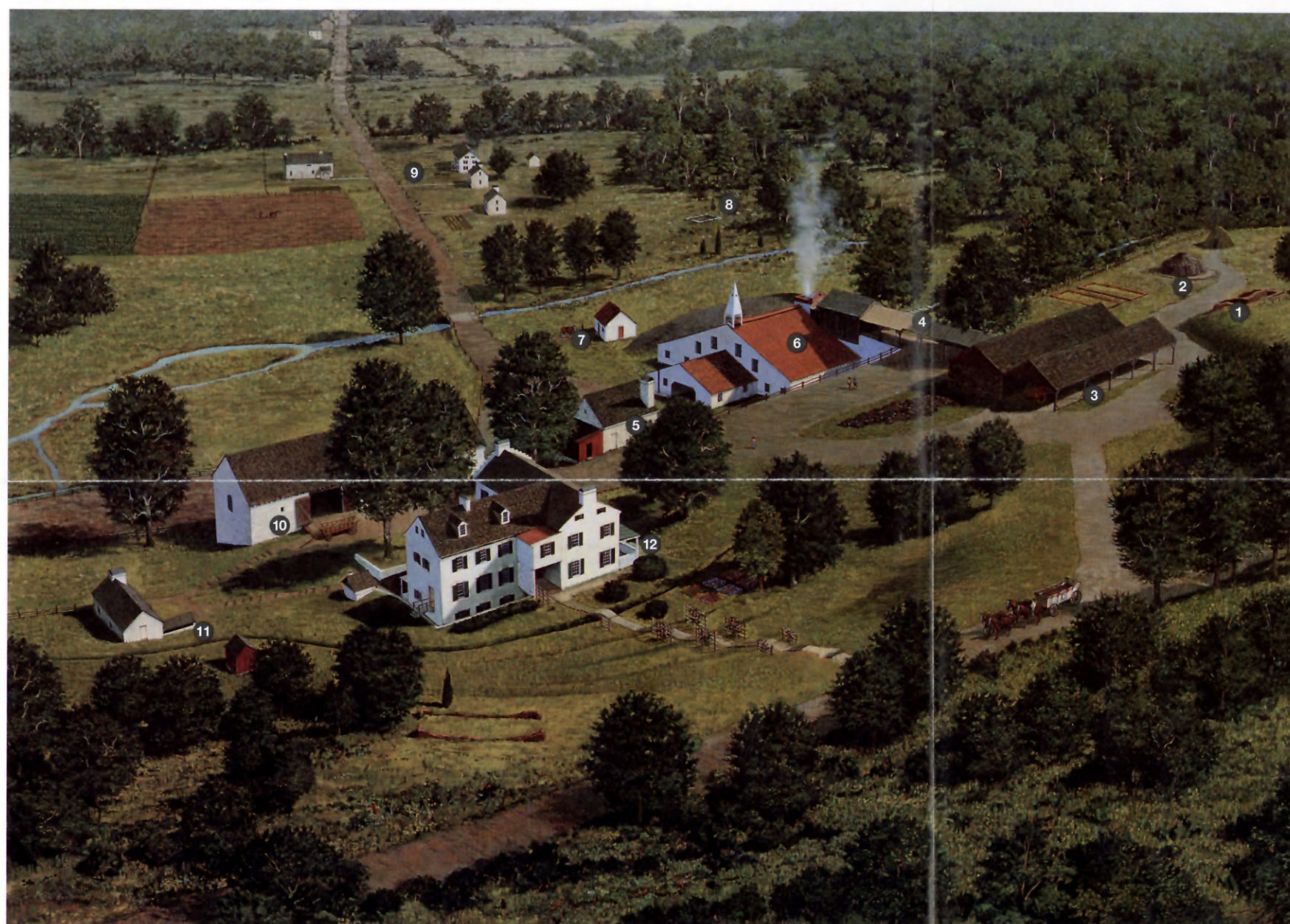


Illustration by L. Kenneth Townsend

About Your Visit

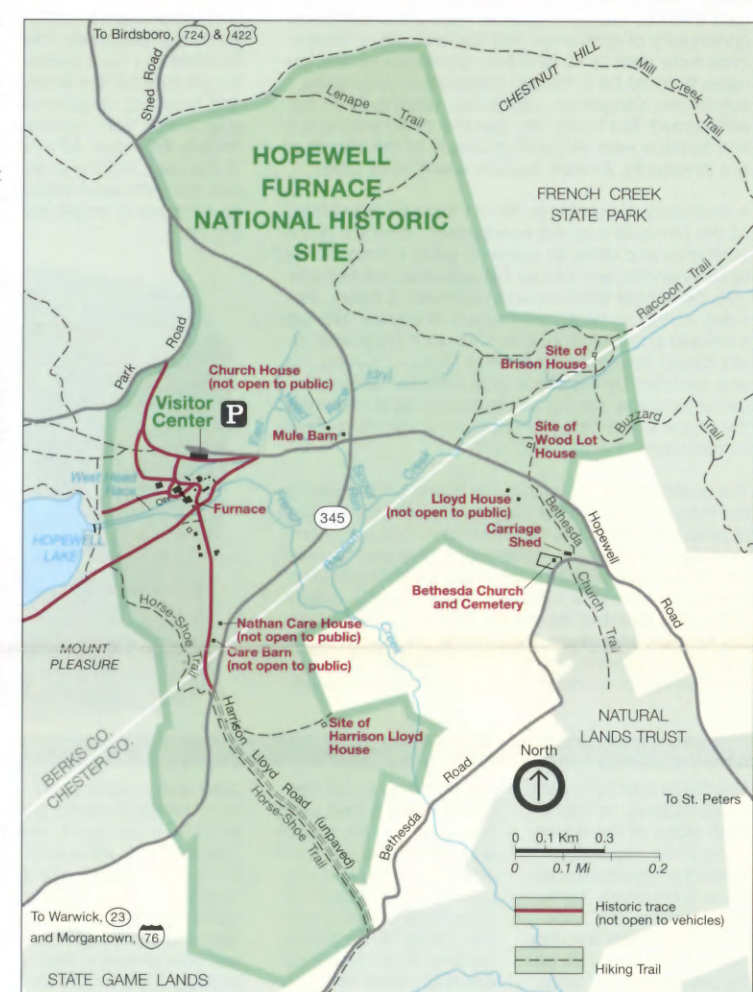
The park represents Hopewell Furnace in the years 1820-40, though some structures were built later. In summer, activities depicting village occupations are presented. The site is open daily except for most federal holidays. Hopewell Furnace is five miles south of Birdsboro on Pa. 345. It is 10 miles from the Morgantown interchange on the Pa. Turnpike, via Pa. 23 East and Pa. 345 North. For more information write: Superintendent, Hopewell Furnace National Historic Site, 2 Mark Bird Lane, Elverson, PA 19520; call 610-582-8773 (TDD 582-2093); fax 582-2768; visit www.nps.gov/hofu; e-mail hofu_superintendent@nps.gov. Nearby French Creek State park has picnicking, camping, and swimming facilities. The state park's address is 843 Park Road, Elverson PA 19520; 610-582-9680.

For Your Safety

Please do not climb on the unstable anthracite furnace ruins, fences, or other historic structures. Sharp slag can cut severely. Do not enter fenced areas or feed or handle livestock. Watch out for bees; about 30 visitors are stung each year. **Do not smoke in the historic area.**

Hopewell Restored

By the 1900s many of Hopewell's abandoned structures had succumbed to the elements. In 1935 Louise Clingan Brooke sold the decaying property to the U.S. Government, and three years later it was designated



a national historic site. Because the structures had been altered many times over the years and the furnace's 18th-century appearance was too poorly documented to reconstruct, the site was mostly restored to the period of

1820-40. The badly deteriorated water wheel and blast machinery were almost completely rebuilt and were in operation by 1952. Some structures, such as the ironmaster's mansion and blacksmith shop, were in reasonably

good condition. Others had to be reconstructed, using hand-hewn beams and wooden joining pins. Work continues on the restoration of this rural industrial landscape.

An Iron Furnace at Work

The founder was boss, technician, and trouble-shooter, directing the ceaseless round of activity at Hopewell Furnace. Raw materials—iron ore, limestone, and charcoal—were supplied by miners, woodcutters, and colliers and transported by teamsters. Fillers carted the materials from the charcoal house area to the bridge house and dumped them at the tunnel head. Guttermen and moul- ders stood ready below to skim off the slag and cast the molten iron when it was tapped by the founder.

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Cast House

Tunnel Head

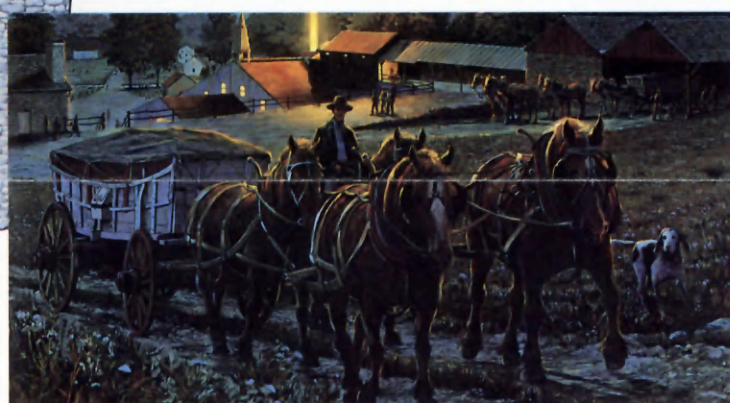
Bridge House

Connecting Shed

Cooling Shed

Charcoal House

Founder



Illustrations by L. Kenneth Townsend

Hopewell Furnace was sustained by an ancient alchemy: the transformation of mineral into metal. Since the second millennium B.C., when humans first learned how to free iron from ore, the basic process has not changed. Iron oxide is heated in an intense flame fed by a carbon fuel. The oxygen in the ore combines with carbon monoxide released from the fuel and is expelled as CO_2 . What is left is iron. The height of the blast furnace allows the rising gases to preheat the ore and gives the iron a greater distance to descend as it softens. It thus absorbs more carbon from the fuel, and because the melting point of iron falls as its carbon content rises, it becomes fully molten. A calcium-based "flux"—usually limestone—is added; it combines with the impurities in the ore and forms slag.

They tended the furnace, the glowing heart of their community; it yielded iron and a way of life.

The Raw Materials of Iron Making

The basic ingredients of iron making—iron ore, limestone, and carbon fuel—are among the most common materials found on earth. They are not everywhere, however, so the location of an early furnace was determined by the availability of these materials. Iron is usually found in combi-

Iron Ore



nation in the form of hematite, magnetite (used at Hopewell), and other iron ores. Most iron ore was dug in small surface mines. Any substance containing calcium, such as sea shells, could be used as a flux, but for most furnaces, limestone was cheap and abundant. Because of the great tracts

Limestone

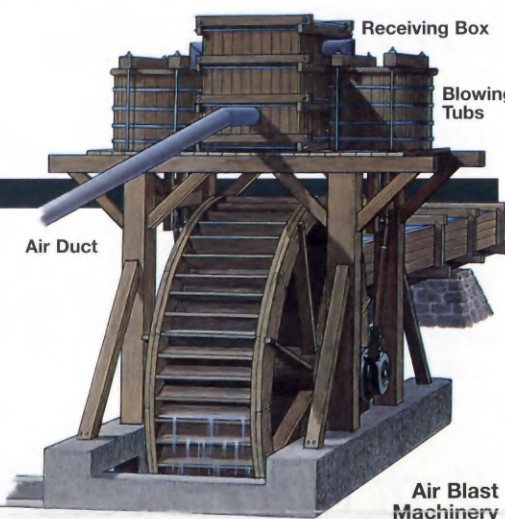


of forest land in America and the expense of bringing in coal before the advent of the railroads, early iron plantations like Hopewell made their own fuel. They slowly burned carefully constructed piles of wood to create charcoal, a fuel that is almost pure carbon and burns with intense heat. Due to the

Charcoal



need for great quantities of charcoal, early furnaces were located on woodlands. One other ingredient was needed: air. It was directed into the hearth under pressure by the water-powered blast machinery, raising the fire in the furnace to smelting temperature.



Air Blast Machinery

The Work Force

Rural iron making operations like Hopewell were called "iron plantations." Historians have characterized them as feudal. Hopewell was a self-sufficient community of craftsmen and laborers, all of whose lives were directly or indirectly governed by the furnace. It could be a difficult taskmaster, dirty, noisy, sometimes dangerous, constantly needing to be fed and tapped. But these very features of life around the iron furnace were reassuring tokens of the community's prosperity. A silent furnace meant lean times.

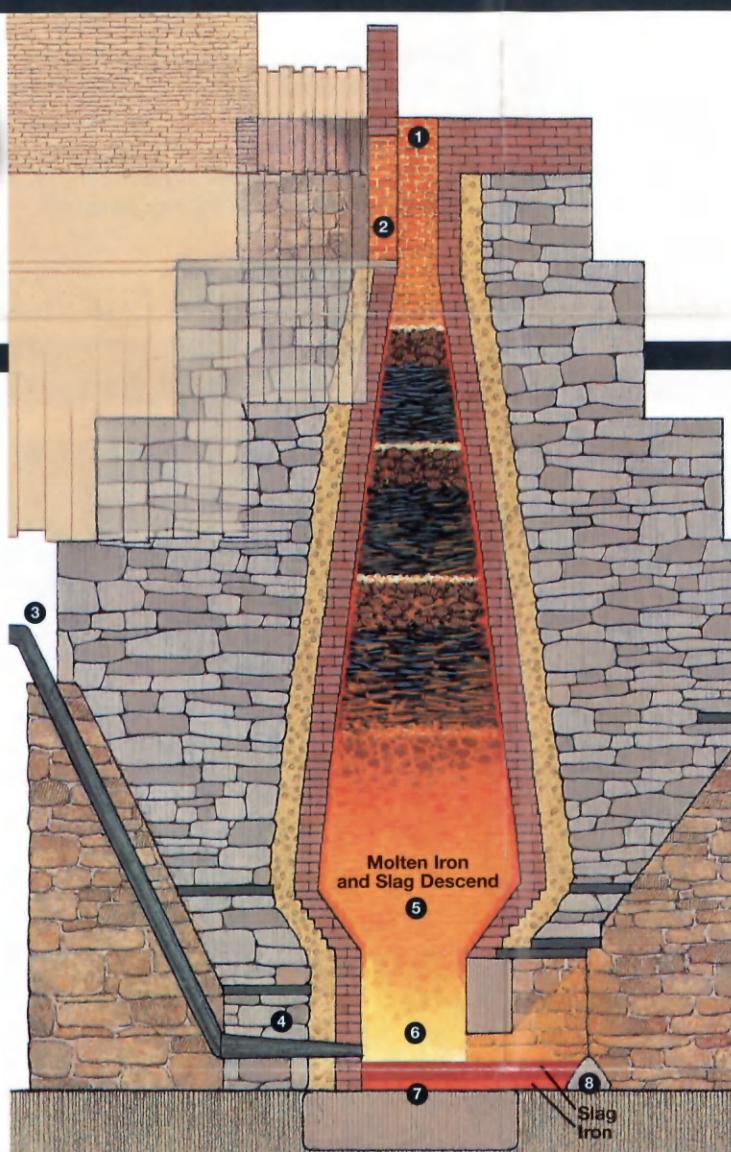
A traditional hierarchy governed furnace operations. At the pinnacle was the **ironmaster**—director of the enterprise and often an owner. A good ironmaster had to be financier, technician, bill collector, market analyst, personnel director, and purchasing agent, besides acting as host to prospective buyers. His was a volatile profession: bad luck or poor judgment usually meant failure; success often brought wealth. He was assisted by the **clerk**, who kept the books, ordered supplies, served as paymaster, and managed the office store. This job could be a stepping stone to ironmaster if performed well.

The quality of the iron was in the hands of the **founder**, the man responsible for keeping the furnace blowing at peak efficiency. The founder supervised the others working at the furnace: **keepers**, who helped him monitor the furnace and took the night shift; **fillers**, who charged the furnace with raw materials, and **guttermen**, who directed the molten iron as it flowed from the furnace. **Moulders**, the highest-paid workers, performed the exacting job of casting the iron. The **colliers** (charcoal makers), **miners**, and **woodcutters**

provided the raw materials for the furnace. Other members of the work force included **teamsters**, who drove the wagons carrying raw materials and finished products; **cleaners**, often women and children who finished the cast products, and **teachers**. **Women** supplemented the family income by sewing, lodging and boarding single workers, and laundering. Some augmented their income working as woodcutters and miners. **Farmers**, some of them furnace workers part of the year, fed the community. The work force also included African-Americans—first as slaves and later as temporarily employed runaway slaves and free blacks.



Collier



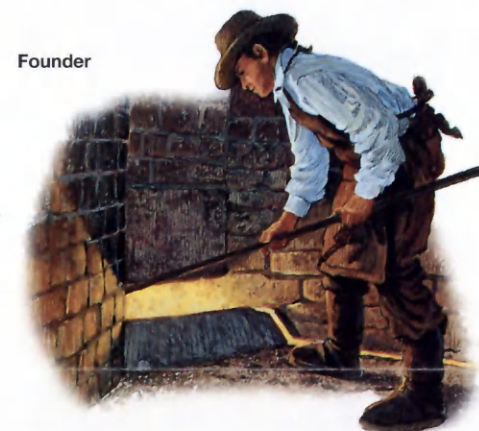
Furnace Operations

- Chimney:** Smelting by-products—CO and CO_2 gases and smoke—are expelled.
- Tunnel Head:** Limestone, iron ore, and charcoal are dumped into the furnace.
- Air Duct:** Air under pressure is brought from air blast machinery.
- Tuyere:** Narrowing pipe directs air blast into the crucible, where temperature is boosted to 2,600°–3,000°F.
- Bosh:** Iron is becoming molten; with slag, it descends towards crucible.
- Crucible:** Narrowest and hottest part of furnace, where iron becomes fully molten.
- Hearth Stone:** Molten iron and slag settle on this stone.
- Dam Stone:** Holds molten iron and slag in hearth until slag is drawn off and iron is tapped.

The life of an iron plantation revolved around the roaring furnace. It ran continuously, shutting down only about once a year for refurbishing of its inner walls and hearth. While the furnace was "in blast," its cycles of filling and tapping established the rhythm of life at Hopewell. It demanded close attention, as the workers constantly fed it, watched its flame, and listened to the sound of its blast. For those working around the furnace, it was a hot, physically demanding job that required protective shoes and aprons. Every half-hour fillers dumped into the tunnel head 400 to 500 pounds of iron ore, 30 to 40 pounds of limestone, and about 15 bushels of charcoal. Working without a gauge, the founder used his practiced eye

to judge the shape and color of the flame coming from the chimney and the color and consistency of the molten iron to determine whether the temperature was right and the proportions of the ingredients were correct. In temperatures that could reach 3,000°F, the molten iron flowed down toward the hearth, to be tapped when it was judged ready by the founder. At Hopewell, he generally tapped the furnace every 12 hours, at 6 in the morning and 6 in the evening. After the gutterman drew off the slag, the iron could be tapped in two ways: It could flow directly into the "pig bed" in the cast house floor (so named for its resemblance to a litter of nursing pigs), where it hardened into pig iron ready for market. Or it could be tapped into large ladles and then cast in molds (see Moulder, bottom center). This process was repeated twice a day for as long as the furnace was in blast.

Founder



Gutterman



The Moulder's Art

The "flask casting" method of casting, in which both sides of the stove plate were molded, allowed the moulder to produce a relatively light, curved plate. The flask consisted of two wooden frames. The moulder laid the bottom half, the "drag," on a piece of wood called the "follow board" and

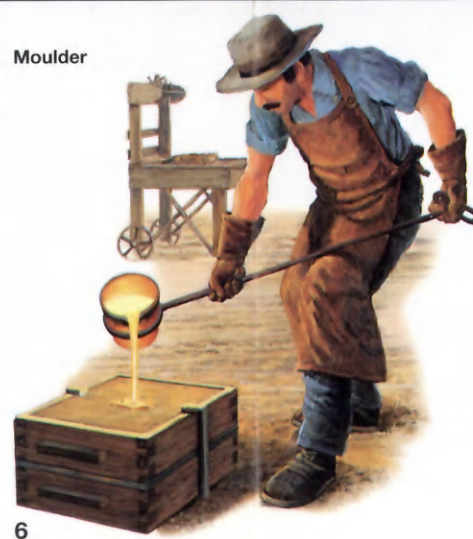
placed the wooden pattern inside. He then sifted fine sand over the pattern and packed the rest of the drag with coarse, damp sand 1. After scraping away excess sand with the "strike" 2, he placed another follow board on top and turned over the drag. Then he removed the first follow board,

blew away loose sand from the edges of the pattern with a bellows 3, and "dressed" the edge with a moulder's spoon. He attached the "cope," or top half of the flask, to the drag and again added fine and coarse sands. Before packing the sand he inserted a wooden wedge to form a "gate" 4, allowing

entry of the molten iron. Next he removed the wedge, separated the drag and cope, and carefully removed the pattern with a pair of lifters 5. He then secured the two halves of the flask with iron clamps. The final step was pouring the molten iron 6 through the gate. After the iron cooled, he

separated the halves of the flask and removed the gate from the plate. Other workers brushed off sand and filed rough edges to ready the plate for market.

Moulder



The Finished Products



Photographs by George Fistrovitch

Molten iron took its most profitable form in products cast at the furnace. Moulders cast a variety of items: plowshares, pots, sash and scale weights, cannon and shot. But as iron stoves grew increasingly common in 19th-century homes, stove plates became the product on which Hopewell built its operation.

Cast products were profitable, but the age also demanded goods for which the furnace's brittle high-carbon iron was unsuitable. The tough, malleable wrought iron needed for plow moldboards, nails, and horseshoes had to be obtained through an

indirect process not performed at Hopewell. The molten iron was cast into transportable pig iron bars and shipped elsewhere for refining. At a finery forge, the iron was remelted and much of the carbon was oxidized, raising the melting point. The iron partially solidified into a pasty lump, which was beaten to drive out the slag and align the fibers, producing wrought iron. Additional processing converted this iron into the bars and rods used by blacksmiths. A lengthier process was used to convert iron to steel. Hopewell's owners frequently held interests in local forges and mills.

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