1 The Foundations of the Industry

The Nature, Use, and Early Development of Coke in the United States

Coke is the residue produced when great heat is applied to coal kept out of direct contact with air. The process is conducted either by covering the coal with a more or less impermeable layer or, more effectively, by enclosing it in an oven. Volatiles are driven off, leaving a product that is largely carbon. There are various types of coke. That made as a byproduct of gas production is derived from coals fairly high in volatiles and is rapidly processed in retorts at relatively low temperatures. The resulting coke is dull, spongy, and burns readily. In contrast, low-volatile coals produce insufficient gas to complete the coking process. Between these extremes are the so-called caking coals. "Burned" at higher temperature and with a long continued heat, the best caking coals—which should also have only a low ash and sulfur content—produce a coke much harder and denser than gas coke, a coke that is strong, fibrous, and silver-gray in color and has a semimetallic luster. Its hardness means it is resistant to abrasion and therefore free from fine particles. This kind of coke is porous, its structure vesicular—that is, having minute holes formed by the release of the gases that it once contained. Because it is admirably suited for use as a fuel in furnaces provided with a strong draught, this product of a limited, special group of coals with these highly distinctive properties and striking appearance is known as metallurgical coke.

Coke has been employed in a wide variety of metallurgical processes. In the nonferrous sector it was a major provider of heat and a reducing agent in the earlier stages of processing such important minerals as copper, lead, and zinc. It is used in steel making when high temperatures and chemical reactions with carbon are required, but it is essential not to risk the presence of the wider range of impurities so often present when raw coal is used. In quality steel making coke was for many years a fuel and source of pure carbon for the furnaces in which broken blister steel was heated, melted, and refined. The cupola furnaces, which melted pig iron and scrap for making iron castings, used coke. In the nineteenth century it was also burned in cupolas to remelt cold pig iron for the Bessemer converter, which itself was heated to make it ready for its first blow by burning coke within it. Collectively, these activities provided a considerable outlet, but far and away the major use of metallurgical coke, the category of consumption that transformed its provision into a great industry, was and remains the smelting of iron in the blast furnace. In the operations of this type of furnace, good quality coke is as important chemically as iron-bearing materials, and it is second only to the latter in tonnages consumed. In 1957, for example, the American iron and steel industry consumed 70.44 million net tons of coke. Of this total 0.13 million tons were used in foundries, 1.6 million for various purposes, and 68.69 million tons by blast furnaces.

In blast furnace operations coke performs an impressive range of functions. From its combustion is derived the thermal energy required to melt the huge material load, a mixture of iron ore, flux (the limestone that converts into slag such impurities in the ore as silica and alumina), and the coke itself. Chemically, the carbon in the coke acts as the reducing agent for the oxides of iron, which in a variety of chemical combinations and in differing degrees of iron content constitute the commercially usable iron ores. The porous structure of the coke provides an extended surface for chemical reactions, and its hardness enables it to support the huge column of mixed minerals as they slowly descend into the furnace's reduction zone. The large, blocky shapes of the coke keep open the ways for the passage of the heated air blown through the "tuyeres" into this lower part of the furnace. In short, iron smelting draws on a remarkable range of properties in the metallurgical coke. Given these functions, it is not surprising that it is now universally the main blast furnace fuel. However, in the United States coke was not the leading fuel in iron making until the mid-1870s, and before that its manufacture was not a major industry. Other abundant sources of energy were available but eventually proved inferior to coke. For a time, though, they too offered ironmasters a number of attractive features.

Raw coal, anthracite, charcoal, and—only as an energy-rich supplement to solid fuels within recent decades—oil have all been employed as sources of carbon in iron smelting. Even peat has been tried as a reducing agent. For century after century, through the long history of iron making in the western world since the introduction of the blast furnace, charcoal was the standard fuel. It was widely available, chemically pure, and, though rather soft, well suited for low-shaft furnaces. Until the first years of the eighteenth century, all pig iron made in Europe used charcoal. Long before that time, clearing of the continental forests meant that the large areas needed to provide furnace timber were becoming scarce. In Britain, where destruction of wooded areas had created serious problems as early as the Elizabethan Age, numerous attempts were made to substitute mineral fuel, coked or uncoked. As early as 1589 a patent was granted for making iron with "cooked" coal; a century later Dud Dudley claimed to have produced pig iron using uncoked Staffordshire coal. A technically and commercially successful breakthrough was at last achieved in the early eighteenth century. Even such a generally well-informed American authority as Joseph Weeks, author of the 1880 Census report on coke, was vague about the time of this breakthrough, citing either 1713 or 1735.[1] It is now known that it was in 1709 that Abraham Darby of Coalbrookdale, Shropshire, succeeded in smelting iron using coke made from local coal, an achievement that legitimately gave this small district its reputation as the hearth of the industrial revolution in metals. At first Darby's innovation spread relatively slowly even in his own country, partly because he had been producing special irons and partly because it was found that coke suitable for blast furnace use could not be produced from all coals.[2] In the second half of the eighteenth century, the pace of adoption of coke smelting in Britain increased, helped toward the end of the period by the new blowing power provided by the introduction of the Watt steam engine. A century after Darby's initial innovation, only a little over 6 percent of British blast furnaces were still using charcoal. In sharp contrast, until the 1830s United States furnaces, though already producing a quarter as much iron as those in Britain, remained wholly dependent on charcoal.

This difference between the two national industries in no sense indicated a lack of either knowledge or enterprise on the part of American ironmasters, but rather reflected the fact that their natural resource endowment was far greater. The efforts of such bodies as The Friends of Domestic Industry, the Franklin Institute, or various other organizations sponsoring economic development in the individual states and the easy routine transfer of knowledge of innovations in technical papers between two societies with the same language ensured there was no lack of information about the technical improvements being made in Europe. Indeed, some of the new processes pioneered there were adopted in the New World with remarkable alacrity. For example, the Scot James Beaumont Neilson patented the hot blast in September 1828; by 1834 his process was in use in a New Jersey blast furnace. In short, when commercial benefits could be anticipated, the American iron industry showed itself well able to accept new methods. For a number of reasons, as far as furnace fuel was concerned, there seemed to be little urgency to follow trans-Atlantic practice.

The forests extending from Ohio eastward over a huge area meant that charcoal could be procured for furnaces located near almost any of the widely scattered deposits of iron ore. Use of charcoal as a fuel meant low furnace outputs but, apart from a few large urban-industrial areas on the eastern seaboard, the United States was as yet mainly a rural society with widely spread and rarely intensive levels of demand. It is well to remember that as late as 1830, no city other than New York and Philadelphia was larger than 100,000 in population; of the rest Baltimore, Boston, and New Orleans alone exceeded 40,000. Even so, iron consumption was rising rapidly through the 1820s and 1830s, and although much of the metal supply was imported, home output too was increasing—later American Iron and Steel Association estimates put 1820 production of pig iron at 20,000 tons, rising to 130,000 tons in 1828 and 200,000 tons by 1832. A few years later the beginnings of iron-rail production provided a large, localized demand for pig iron to be processed in puddling furnaces. Such new mills at last made bigger blast furnace outputs desirable. The higher levels of production required more iron capacity, which in turn involved the hauling of charcoal supplies from ever-wider catchment areas, pushing up procurement costs. Under such circumstances, although additional charcoal furnaces were built and their output largely increased, many established iron works found fuel supply so difficult that they had to blow out furnaces and wait for a regrowth of their timber. In the longer term iron made with charcoal was unable to meet increases in demand. From 1854 to 1856 the average annual output of pig iron was 715,000 tons and from 1867 to 1869 1,482,000 tons; between these two periods charcoal furnaces raised their output only from 314,000 to 329,000 tons a year. In reality, their failure to keep pace was only in part due to raw material supply difficulties; it was largely because charcoal furnaces were less competitive than a new generation of ironworks using mineral fuel. The hot blast, introduced to the United States soon after its first application in Scotland, provided the blowing power necessary for the use of new, less easily fired but more concentrated sources of energy.

The first real successes in the use of coke in American blast furnaces were gained in the 1830s. Coke was tried in a furnace on Bear Creek, Armstrong County, Pennsylvania, as early as 1819, but at that time the air blown into the furnace was unheated and the blowing power available was too limited. A decade later, iron consumption was growing rapidly, technical resources for the use of mineral fuel were more favorable, and already charcoal was sometimes difficult to procure. In 1835 the Franklin Institute offered a prize for the first iron made with coke. By that year some ironworks along the Little Juniata River were having to haul charcoal ten to twelve miles; they apparently resolved to try coke when railroad extensions made it available. Some even reckoned that by coking the coal and using local iron ores, both minerals being carried by canal, it should be possible to make pig iron in the Hollidaysburg area for as little as ten dollars a ton as compared with over seventeen dollars in South Wales, then a major source of finished iron for the United States. As so often happens, proposing an idea on paper proved easier than realization. In 1835 for a short period—perhaps only a month—coke made from Broad Top coal was used by Mary Ann furnace, Huntingdon County. Two years later a furnace at Fairchance, Fayette County, made some iron with coke before reverting to charcoal. That same year the Lonaconing furnace in the Frostburg coal basin of western Maryland became the first important user of coke, to be closely followed by Mount Savage Ironworks in the same area and Brady's Bend Ironworks on the Allegheny River in northwestern Pennsylvania. However, these furnaces were not consistently successful in their pioneering. Sometimes there were problems with the quality of coke made from local coals, which meant the output of furnaces and mills was not of an acceptable quality. At Lonaconing transport costs proved a handicap. By 1849 not one coke furnace was at work within Pennyslvania.[3]

A vitally important reason for the slow take-off of the coke iron industry and therefore of large-scale coke manufacture was the powerful rivalry of another mineral-based iron industry. This competition was moderated for a time by distance, which provided for two distinct market areas for iron, one east and another west of the Appalachians. It was because of this division that Overman, writing in 1850, confessed himself unable to understand why coke smelting had not been able to succeed west of the Allegheny Mountains.[4] In the east, use of anthracite as a furnace fuel had only become possible with the introduction of the hot blast. Anthracite iron manufacture began a year or so later than the coke iron industry but established itself firmly and expanded much more rapidly. The first technically and commercially successful furnace operations using anthracite dated from 1839. By the following year there were six anthracite furnaces, all within eastern Pennsylvania. By spring 1846 Pennsylvania and New Jersey contained forty-two; ten years later these states had ninety-seven blast furnaces using anthracite, and twenty-four were in other eastern seaboard states. Production of anthracite iron reached 341,000 gross tons in 1855, for the first time exceeding the output of charcoal iron. At that time the tonnage of iron made from either coke or raw coal was only 56,000 tons, or 8 percent of national production.

Though long overshadowed, from the late 1850s coke iron began first to improve its position and then to overhaul the other furnace fuels. As with anthracite earlier, its advance accelerated. From an 1859 share of slightly over one-tenth, five years later it approached one-fifth of iron production. By 1869 the tonnages smelted with coke and raw coal exceeded that made with charcoal, amounting to almost 29 percent of national production (compared with 51 percent for anthracite iron). Within another

Table 1.1 Increase (decrease) in output of iron according to fuel, 1855–1880 *(gross tons in thousands)*

Years	*Bituminous and coke*	*Anthracite*	*Charcoal*
1855–1860	53	123	(55)
1860–1865	60	(36)	(15)
1865–1870	340	402	92
1870–1875	337	(19)	41
1875–1880	895	803[a]	113

SOURCE: Based on P. Temin, *Iron and Steel in Nineteenth Century America: An Economic Enquiry* (Cambridge, Mass.: MIT Press, 1964), 266.

a. From 1875 onward some coke was also used in anthracite furnaces.

Table 1.2 Output and productivity of various furnace fuels, 1890

Plant	*Furnace height (feet)*	*Iron output per month (gross tons)*	*Avg. iron content of ore used (%)*	*Fuel used per ton (lbs)*
Ashland, Wisc. (charcoal)	60	3,379	55	1,815
Secaucus, N.J. (anthracite)	65	2,698	55	2,244
Penna, Pa. (anthracite/coke)	80[a]	3,844	60	2,520
E. Thomson, Pittsburgh (coke)	90	10,536	59	1,737

SOURCE: J. Fulton, "Physical Properties of Metallurgical Fuels," *American Manufacturer,* quoted in *BAISA,* 24 November 1894, 267.

a. 1892

six years they were ahead of anthracite iron. Most impressive of all, though the pace varied, bituminous coal and coke iron proved able to sustain the advances they made whereas the production levels of charcoal iron and even those for anthracite iron were less consistent. By the mid-1870s the large outputs possible in furnaces fired with coke had conclusively proved that this was the fuel best suited to the increasingly common practice of hard-driving a blast furnace; that is, using the maximum blowing power in order to gain the largest output in the shortest time.

As coke became the prime furnace fuel, capacity to make it had to be extended. Though widely procured, it eventually came above all from a very small area. Some thirty years after the mushroom growth of anthracite coal mining set in train the transformation of a handful of eastern Pennsylvanian counties, coke manufacture began to make an even smaller area within its southwestern section into another of the nation's outstanding and most distinctive mineral districts. Before the middle decades of the nineteenth century, this area was largely agricultural, though for a short period it had also played a part of some significance in the iron trade.

Southwestern Pennsylvania before the Coke Age

The Connellsville region was opened by European pioneers, the military, and then by settlers a century before it became renowned for coke making. Fort Necessity, on the east side of Laurel Ridge, was a control point established by George Washington. Following the French and Indian Wars, settlers reached the Youghiogheny Valley. After a period of frontier settlement, southwestern Pennsylvania became a zone of passage and source of supplies for those moving farther westward. A route from the Potomac led northwest by a narrow portage to the Youghiogheny and from there to and beyond the Monongahela, a course that with further improvement became the National Road. Along this route Uniontown, settled in 1767, was one of the first small communities, nuclei that would grow into towns, and so become fixed points through the various stages of economic development. Connellsville and Greensburg were established two or three years later, Brownsville was laid out in 1785, and Mt. Pleasant in 1797. Westmoreland County was formed in 1773, and Fayette County ten years afterward.

Life in such frontier lands was hard in the last quarter of the eighteenth century. In 1791 the Reverend Thornton Fleming was assigned to Methodist service some way farther up the Monongahela Valley in the Clarksburg circuit of what was to become West Virginia. More than forty years later, he looked back on his early days in the area: "When I came to my appointment this whole country appeared as a howling wilderness. Settlements were quite thin, quite remote from one another in many parts, and little cultivated. In many places the living, manners, state of society and morals of the people seemed to correspond."[5] The fact that Fayette County was one of the centers of the Whisky Rebellion of 1794 was a sign it shared both the remoteness and some of the human characteristics of Fleming's Clarksburg.

A decade after the Whisky Rebellion, Thaddeus Harris, traveling in the areas west of the Alleghenies, found a happier situation. Along the valley of the Monongahela, economic development and diversification were underway: "The settlements on both sides of the Monongahela river are fine and extensive, and the land is good and well cultivated. Numerous trading and family boats pass continually. In the spring and fall the river seems covered with them. The former, laden with flour, whiskey, peach-brandy, cider, bacon, iron, potter's ware, cabinet work, etc, all the produce of the country, and destined for Kentucky and New Orleans or the towns on the Spanish side of the Mississippi. The latter convey the families of emigrants, with their furniture, farming utensils, etc, to the new settlements they have in view."[6] The region was becoming agricultural, but, though contemporaries such as Harris described the soil as fertile and well farmed, there is evidence—admittedly from many years later—that farming in this area was in fact not very prosperous. By 1850 the proportion of improved land in farms throughout Pennsylvania was 57.8 percent, and the value of implements and machinery per acre of improved land was $1.71; at that time the respective figures in Fayette County were 53.8 percent and $1.40. As a local paper recalled much later, during the 1830s the area was characterized by poor farmland.[7] By 1840 the population of Fayette County was 33,574 and of Westmoreland County, 42,669; though established seventy years, Connellsville was a diminutive town of 1,436 inhabitants, and Uniontown was populated by 1,710 people. Long before this some had realized that the natural wealth of the area could be found beneath rather than within its soil. The earliest of its mineral-based developments were in iron.

On 1 November 1790 the first blast furnace west of the Appalachians—though owned by a Philadelphia partnership—was blown in on Jacobs Creek, Fayette County. The Alliance Ironworks also included a forge. Five months later the Union furnace was at work on Dunbar Creek four miles south of Connellsville. In 1792 a forge was built along George's Creek south of Uniontown and five years later a furnace was established along the same stream. Plumsock Forge had been built in Menallen Township, Fayette County, by 1794. Two years later a sixth part of Laurel furnace, its ore bodies, and forests lying within two miles of the Youghiogheny was advertised in Pittsburgh.[8]

These furnaces and forges supplied a variety of markets. There was local demand in the expanding needs of the rural economy, soon a more concentrated and rapidly increasing consumption in the region's central point of Pittsburgh, and the requirements of the extensive areas to the west made accessible via the National Road and by water through the vast outlets of the Mississippi lowlands. Indeed, as Thaddeus Harris had recognized in the early years of the nineteenth century, southwestern Pennsylvania occupied an important position in a great system of exchange that, as far as possible, employed water transportation around the outer edges of the landmass of the whole eastern half—at that time the only economically "effective" part—of the United States. Nearly three-quarters of a century later, long after this pattern of commerce had been superseded by others, E. Pechin, the manager of the Dunbar furnace, vividly recalled the trade. In the early days the castings and forge products of ironworks between the Youghiogheny and Monongahela had been hauled in teams for fifteen to as much as thirty miles across country to Brownsville. From that river port the goods were taken on flatboats down the Ohio and Mississippi and traded in frontier communities for corn, pork, whiskey, and other products, which in turn were carried on to New Orleans and there exchanged for sugar and molasses. These were sent by sea to Baltimore, where they were disposed of for groceries, dry goods, and other items that, loaded on Conestoga wagons, were hauled some three hundred miles over the Appalachians to the furnace or forge communities from which the iron products had been dispatched. Barter was the basis of the whole system according to Pechin, who quoted an old furnaceman who conducted business continually for three years and in that time saw only ten dollars in money.[9]

The natural resources for the iron trade that helped southwestern Pennsylvania gain the various necessities of life were its numerous small deposits of iron ore and the cover of forests, which yielded fuel for the furnaces. Between 1794 and 1815, thirteen blast furnaces were built in Fayette County, most of them in the latter half of that period. In all about nineteen were built in that county, and others were constructed in Westmoreland County. The productive lives of these establishments were relatively short. By 1837 the area that later became the coke region contained four forges, rolling mills, and numerous foundries but only nine operating blast furnaces. Each of the latter made some five hundred tons of pig iron a year. Eventually, a swathe of idle furnaces, outnumbering those still at work, extended from east of the Youghiogheny through to the Monongahela. They had suffered from unreliable access to market due to the uncertainties of river movement, but the main reason for failure had been the exhaustion of supplies of readily accessible charcoal, partly as a result of their own past successes as well as the further advance of cultivation at the expense of forest. Estimates of the amount of charcoal required per ton of pig iron vary widely, from as little as ninety bushels to as much as twice that, but in any case the demands on the forest resources were large. Some years later Birkibine suggested that every thirty-five bushels of charcoal required the use of one cord of wood, an amount roughly representing the annual growth of one acre of woodland. In short, by his rough and ready generalization and utilizing the lower figure of charcoal use per ton of pig iron, the nine active furnaces in the region in 1837 would have used, if worked to their full capacity, the timber from about 11,600 acres of forest—one year's growth covering eighteen square miles.[10] Deforesting the area surrounding them, the furnaces increased their own costs and often had to be blown out to await regrowth of woodland, but in fact were never reactivated because trading conditions changed. By 1840 about three-quarters of all the furnaces built in the area had been abandoned; in the late 1850s only four were left.[11]

The charcoal iron industry played an important part in the peopling, settlement, economic growth, and landscape-shaping of many parts of Pennsylvania, a role eloquently summarized by John Birkibine at the first meeting of the Association of Charcoal Iron Workers: "To the charcoal iron-master we are indebted for the discovery of many superior iron mines. The business which the charcoal furnaces and forges drew about them encouraged the building of highways, canals, etc. They formed the nucleus for some of our most flourishing towns, and thousands of acres of the best farm lands were first cleared to make charcoal for iron works." These words were more applicable to the lowlands of the far east of the state or to the Appalachian uplands than to southwestern Pennsylvania. His valedictory for the industry seemed more appropriate for the latter section: "Many of the old-established sites are now abandoned. The ruins of a furnace stack, a coal-house utilized as a barn, or perhaps only a pile of cinder marks the place where years ago there was a thriving iron industry."[12] Indeed, traces of charcoal iron making persisted in those parts of the region that had been affected by especially heavy calls for wood: the uplands that remained unsuitable for cultivation, especially Chestnut Ridge and Laurel Hill. Half a century after the passing of the age in which charcoal iron manufacture was an important activity in southwestern Pennsylvania, one observer noted: "these mountain sides from base to summit are dotted with the old circular charcoal pits which yet lie as bare and barren almost as on the day of their abandonment."[13] In the second half of the 1850s, state geologist J. P. Lesley, compiling his magnificent guide to the ironworks of the whole United States for the American Iron and Steel Association, had visited the Ross cold-blast furnace on Laurel Hill in Fairfield Township, Westmoreland County. He recorded it had been abandoned in 1850 "for a second growth of timber or for bituminous coal."[14] The failure of this furnace as well as the collapse of the iron industry throughout Westmoreland and Fayette Counties for want of fuel was ironic, for underneath the farmlands stretching between their two main rivers lay the nation's greatest deposit of first-class coking coal. Exploitation of this incomparable resource began as the charcoal furnaces, one by one, reached the end of their working lives.

In 1836 the *American Journal of Science* published a long article on the Ohio basin.[15] After sketching the area's endowment in forests and fertile land, it turned to mineral wealth. The article quoted the opinions of a practical engineer and geologist, R. C. Taylor, on coal resources. In the upper portions of the region coal was being used by salt works along the Conemaugh River and in the steam engines of Allegheny County. Taylor also looked to other avenues of advance: "The coaking process is now understood and our bituminous coal is quite as susceptible of this operation and produces as good coak as that of Great Britain. It is now used to a considerable extent by our manufacturers in Center County and elsewhere." The essential complement to mineral availability was industrial demand. Together, natural wealth and favorable local and wider circumstances of consumption would promote around the headwaters of the Ohio a closely integrated network of industrial districts, developing the area into one of the world's greatest industrial regions. Already by the 1830s perceptive observers had vague anticipations of these exciting future prospects.

By the second quarter of the nineteenth century, Pittsburgh already was acknowledged as the natural source of iron supply for the nation's interior. As Grenville Mellen stated in 1839: "The situation of Pittsburgh is as advantageous as can well be imagined; it is the key to the western country, and excepting New Orleans and Cincinnati, is the first town of the whole valley of the Mississippi." The area's mineral wealth had "converted [it] into a vast workshop and a warehouse for the immense country below."[16] Three years earlier Taylor had recognized that coal "constitutes the life spring of western Pennsylvania, the pedestal of our great manufacturing emporium [Pittsburgh]." Hildreth added to this that the promise of coal and iron could "open to the imagination a long vista of power and greatness which the utmost stretch of the imagination is hardly able to equal."[17] Soon, conditions became favorable for this new, mineral-based iron industry. Its growth would transform economic and social life as well as the landscape of the district through which the Youghiogheny and Monongahela meandered down toward Pittsburgh.

Factors of Production

In the classic terms of the factors of production, the future coke region of southwestern Pennsylvania possessed the one outstanding asset that made it commercially attractive to bring together other essential inputs—a physical resource of exceptional quality. Capital, labor, managerial talent, and entrepreneurship were equally essential for building a great industry, but whereas its natural wealth was fixed, these other assets were mobile and were partly procured from outside the region. The essential technology, at least in the early stages, came wholly from elsewhere.

The modern commercial world commonly regards human ingenuity as the ultimate resource. To a large extent this is understandable, indeed incontestable, for without the know-how, efforts, and organizations of mankind over many generations, none of today's almost infinite diversity of material goods or range of services could exist. But whether in genetics, high-technology farming, or space research, the amazing inventiveness of humankind can only take place through the manipulation of matter—in other words by changing earth "stuff" into forms that supply human needs and go some way at least in meeting never fully satisfied wants.

Critical to this situation is the existence of suitable natural conditions. Another vital consideration, and one that society, in its headlong rush to produce wealth, has all too often ignored, is wise and effective resource management to maintain the natural systems on which human life ultimately depends. The life history of the Connellsville coke region provides more than a century of thought-provoking insights into many aspects of the whole, complex business of resource-development issues.

A mineral resource exists when a portion of the earth's surface is found rich enough in a concentration of a particular desired material to justify application of the other factors of production to its exploitation. Without these favorable conditions a mineral deposit is not a mineral resource. When such a resource is opened, the length of its working life is determined by the level of production, which in turn reflects the proportion of total demand the deposit is able to supply. If working becomes more difficult, perhaps due to increasing depths of operation or greater amounts of waste, costs will rise. This may price the product out of the market, encouraging the opening of new areas or the introduction of an alternative technology. On the other hand, if there are no or few rival sources of supply, rising prices may make it practicable to work less-rich deposits of the mineral, involving tracts and depths previously considered uneconomic. Sometimes there may be a knife-edge situation—prices must rise to extend the life of the mining operation, but if they rise too quickly, consumers will turn to other suppliers.[18]

Geological facts and growing knowledge of them clearly demarcated the core area of the Connellsville coking-coal region, but beyond it, north and south, were coals of very good, if slightly poorer, coking quality. Still farther away were large deposits of acceptable coals, though often in less accessible locations. Lurking in the wings through much of the history of the region was another method of making coke. It could use mixtures of poorer coals procurable over a much wider area and offer cost savings derived both from lower transport costs and from credits for valuable byproducts not available to the Connellsville industry. In addition, the life expectancy of the core coking area was limited by the tonnage of high-grade coking coal available and by the amount of it worked annually. In fact, demand rose rapidly on this strictly limited resource base. Tonnages available were reduced by waste in mining, though over the years this was gradually reduced. During the fifty-six years central to its most important period of production, the Connellsville region—both the "old basin" and "Lower Connellsville"—produced 500 million tons of coke requiring the extraction and processing of about 770 million tons of coal. In six peak years annual coal consumption exceeded 28 million tons. Both the coal and the mines from which it was procured provided exceptionally favorable conditions for the massive industry that mushroomed in this small area.

Bituminous coal is found over huge areas of the Appalachian plateaus from Ohio to Alabama and from the western counties of Virginia into western Kentucky. This is in fact one of the world's great energy stores. The quality of its coals varies considerably from place to place. In the west, where folding of the strata was much less intense than farther east, the coal is generally high in volatiles and has a relatively low carbon content. It often contains sufficient sulfur to create serious problems for those who try to coke it. Eastward toward the Allegheny Front, the coals were determined too "dry" to produce first-rate coke, their volatile content being very low and fixed-carbon content higher than in the west. The ideal coals for coking by the technology available in the mid-nineteenth century lay in the southwestern counties of Pennsylvania and in neighboring or not far distant areas of West Virginia and Virginia. Because of the tectonic structure and subsequent erosional history of the plateau, the finest and most accessible coking coals were found in a narrow basin running roughly north-northeast to south-southwest, straddling the Youghiogheny River. This area became the Connellsville coke region.

The Connellsville coal seam is part of the famous Pittsburgh bed, which when opened averaged seven feet in thickness and was persistent over a very wide area, extending into neighboring states. It was classed as a high-grade gas coal in the Irwin basin of Westmoreland County, a good steam coal in Allegheny County and the western parts of Washington County, and was later to prove an excellent coal for new methods of coking in southern Washington, Greene, and the western parts of Fayette Counties. Above all, it proved to be an outstanding coking coal in Fayette and Westmoreland Counties.[19] The long axis of the coke basin in these counties stretched for fifty to sixty miles—depending on the basis of definition; east to west its width was only two-and-a-half or three miles. When working began it contained some eighty thousand acres of coal land. The coal seam outcropped on the western side of Chestnut Ridge, but over much of the area it lay 60 to 150 feet below the surface. As the country was dissected by a network of streams—locally called "creeks" or "runs"—from the early days of settlement the coal had been worked where exposed by stream erosion in "country bank" mines. Later drifts and slopes were opened on the valley sides. Under such physical circumstances entry to the coal trade was relatively easy. As a local chamber of commerce account breezily put it in the mid-1880s, "while it takes from $300 to $400 thousands in the old world to reach a vein of coal whose thickness frequently does not reach over 1.25 to 2 feet, mining here requires no outlay whatever, or only an insignificant sum, since the coal crops out on the flanks of the hills and the banks of the rivers, the investment being simply that for transportation facilities from veins to carrier or market." Gradually, as the operations became bigger and more sophisticated, extraction by shaft was added. By 1892 there were thirty-six drifts and thirty-two slopes in the basin, but the coal was also worked at greater depths in twenty-one shaft mines, the deepest of which reached 542 feet. The workable seam, eight to ten feet in thickness, produced a coal that was generally of a resinous luster, though some of it was bright, shiny, and "crystalline." It was soft and clean, usually almost free from slate and sulfur, and generally of uniformly high quality. Because its extraction required neither powder nor machinery, the overhead costs of mining were low. In fact, the coal here could be so easily worked by the pick that in the mid-1880s as much as 10 tons could be cut and loaded in ten hours by a man and a boy, the miner's productivity being double that of his counterparts working the thinner, harder seams around Pittsburgh. At that time the cost of digging coal was about $.25 a ton: in the four years to 1887, the selling price of Connellsville coke averaged $1.37 per ton. In the differential between those two figures lies the clue to the wealth the region would yield to its enterpreneurs.[20]

In addition to outstanding advantages in the quality and workability of its raw material, this area possessed in high degree favorable conditions of what used to be called the economies of place. Coke is a commodity that is bulky and heavy in relation to its value. For the thirty-four years before 1914, its average price at the ovens was $2.078 a ton. Averaging only 2.93 million tons over the first five years of this period, the amount of coke shipped increased irregularly to reach an annual average of 18.58 million tons over the final five. Throughout the industry's long history, the growth of activities consuming its product within the immediate area was slight, but the resource was so advantageously located within the northeastern United States as to serve not only regional but also both western and eastern markets. All that was needed to underpin a highly localized growth of the industry was the provision of facilities to transfer very large tonnages of low unit-value products from the small area of production to the main areas of consumption, eventually spreading throughout the manufacturing belt. Transportation costs determined the ease with which the coke could be delivered to consumers and therefore how effectively it could compete with coke from other areas or with alternative fuels. Connellsville-area producers had good access to early outlets by water, and later suppliers were favorably located in the evolving rail systems of the manufacturing belt. The points at which transport routes entered the region and the course they followed within it closely influenced which sections of the coal field were developed at a particular time. Over the decades the progressive filling out of the railroad network was accompanied by a sequence of additions to the area of production until the whole of the geological basin was provided with rail facilities. Other aspects of freight movement that eventually became important in regional economic development were its physical equipment, particularly the provision of the necessary car capacity to handle an output that might vary drastically from month to month, and the charges made for railroad services.

The other essential prerequisites for the growth of the industry were enterprise, backed by technical expertise and capital, and a suitable labor force. In the early stages of the industry both were locally available; later, large contributions to each came from outside. The first entrepreneurs were farmers or tradesmen who ventured their usually meager capital along with slight technical ability, scant knowledge of markets, and therefore a great deal of dependence on good fortune. Their other lines of activity gave them the necessary security to meet the collapse of any hopes placed in coke. Though this local emphasis to investment applied particularly in the earlier stages, there were later examples as well, sometimes involving local bank capital. After the value of Connellsville coke had been proved, private individuals and iron firms from other areas came in either directly as new producers or by acquisition of interests in existing coke makers. Most were from Pittsburgh, but eventually distant centers were also involved, including the Valleys and Chicago iron districts and major sources of national capital in New York, Philadelphia, and Boston. Managers and overseers were initially procured within the area, but requirements for various kinds of technical expertise later caused an increase in recruitment from elsewhere. Even so, until a surprisingly late date many of the leading men in this sector of the coke trade were local.

In the early 1840s the provision of manual labor could scarcely be separated from that of the capital for the industry, the partners in the first firms taking a part in building and operating the ovens and in undertaking the transportation and sale of coke. As expansion occurred unskilled labor could be recruited from farming or the small service settlements. Presumably workforces, small as they would be, were only partially employed in coke making and largely worked in agriculture or other local jobs. As late as the 1850 Census, only one person in Connellsville, Silas White, chose to identify his occupation as that of "coaker." At that time too the enumerator listed only 51 persons born outside the United States in the township's population of 1,507. Then and later, no apparent evidence of large-scale inward migration of "native" American workers from other districts exists, certainly not on a scale to support the industry as it moved into its period of large-scale expansion. As the local supply of workers proved insufficient, it was supplemented by a significant influx of immigrants, particularly from eastern Europe. Over the next few decades, this gave a new, distinctive character to labor relations, social structures, and the reputation of what was now commonly referred to as the Coke Region.

Technically, nineteenth-century coke manufacture was fairly simple. In the earliest stages it was made like charcoal by merely heaping the raw material into a pile, covering it with a relatively impermeable layer of sod or clay, and setting it alight. Manufacture in such "ricks," or "meilers," continued for some time after improved methods were introduced, older processes occasionally going on side-by-side with newer ones, especially during periods of unexpectedly high demand. However, the exceptional reputation of Connellsville coke was built on the so-called beehive oven. It became a rule of thumb in the industry that each oven required two acres of coal lands from which to draw its supplies. With this, each oven in a typical battery of the style built about 1900 could be supported for twenty to twenty-five years, producing some seven hundred tons of coke per oven annually. But the life of the actual oven—

rather than the coke-making capacity that it represented—was only about five years. In the early decades of the industry, the beehive was commonly eleven to twelve feet in diameter and from five to seven feet in height; later its dimensions were often slightly larger. In the 1890s construction of the average oven required some 2,500 ordinary bricks and about 1,150 firebricks to provide its inner lining. These and the specially shaped bricks for arch blocks, jambs, and so on were made in the district. The coal was dumped through an opening—the "trunnel"—about two feet in diameter in the top of the oven and spread evenly over its floor to a depth of two to two-and-a-half feet. The top was then closed. There was a door in the side that, when the process was underway, was nearly closed with brick, "luted" with loam or clay. Heat from the previous charge started the coking process, and as it went on access for air through the door aperture was more and more completely closed off. An average charge of coal amounted in the early years to 100 bushels, but by the late 1890s ranged from about 120 to as much as 165 bushels. The coking process took about 48 hours for furnace coke; "72-hour coke" was also produced for foundry use. Because of the swelling that went on in the oven during the process, there was an increase in volume, every 100 bushels of coal making about 120 bushels of coke, but the expulsion of "byproducts"—at this time entirely waste products—also meant a sharp reduction in weight, from 1.6 tons of coal charged to 1 ton of coke produced. When the coking process was finished, the door was removed and the coke was cooled by water sprayed on it from a hose before being drawn from the oven with a scraper, a long metal rake with a curved head. Access to a large supply of water was essential for success, five hundred to eight hundred gallons being used at each oven every time it was drawn. Finally, the coke was either forked into or carried by wheelbarrow to the railroad car, in early days an ordinary boxcar and later an increasingly specialized item of rolling stock. The typical furnace coke dispatched from these yards contained few impurities, was cellular, had a silvery luster and almost metallic ring, and was described as "tenacious" as well as porous. As the coke expert John Fulton emphasized, to a greater extent than the product of any other district, the Connellsville district's product possessed the essential four properties of the finest coke: "hardness of body, well-developed cell structure, porosity, [and] uniform quality of coke."[21]

Each beehive-shaped oven in the coke region was linked with its next-door neighbor in a covering or outer coat of brickwork, which made a battery or row of ovens look like a continuous embankment. These were arranged in two distinct ways, both according to local topography. Those built against a hillside were in single rows and known as "bank ovens." Where there was more space, ovens were commonly placed back to back to form double rows, or "block ovens." In the former the railroad that carried away the coke ran along the front of the row; in the latter a rail yard would lie between two blocks. In the few years before World War I, the "rectangular" oven was introduced. Though different in shape and mechanical procedures, its operating principles were otherwise the same as conventional beehives.[22]

The processes of development in a coal and coke-making operation were relatively simple compared with those in many nineteenth-century industries. Even so, because the area in which the industry concentrated was rural, it was often necessary to provide facilities that in an urban context would already have been in place. In short, what elsewhere would have been external costs in this setting had to be provided by the enterprise. However, these investments often became additional sources of profit. An instance of the range of considerations involved was provided in 1891, when Chicago iron and steel interests requested information about the costs of large oven plants. An experienced coke superintendent provided estimates under the headings preliminary engineering, sinking the shaft, buildings necessary for the operation, ovens, yard and track, and equipment and tenements for workers.[23] An additional common cost was that for a company store. In total these ancillary expenditures exceeded the cost of the ovens themselves. Three hundred dollars per oven was then a common figure used in assessing the value of the beehive industry, but because of these additional considerations this was a deceptively low figure; other estimates placed costs at up to over twice that level.[24] In 1899 the president of the largest company made a valuation of his own enterprise and that of an associated firm. According to his reckoning each oven and the necessary outlay for shafts, tipples, bins, mine wagons, locomotives, railroad sidings, haulage, engines, boilers, electric light plant, larries, livestock, other equipment, tenement houses, and other buildings cost seven hundred dollars. He pointed out that the region's last large new plant had required eight hundred dollars per oven. In the late 1890s the manager of this plant had estimated that, in addition to construction costs, each oven required maintenance and repair work amounting to about twenty dollars a year. In 1895 the editor of the *Connellsville Courier* put the aggregate capital in the coke industry at sixty-five million dollars; a few years later the leading firm alone was valued at over forty-five million dollars.[25] Even though by this time coke manufacture represented a huge capital outlay, it had begun only a half century before as a small, uncertain business.

Origins of Connellsville Coke Production

The antecedents of a successful coke manufacture in western Pennsylvania are indistinct but may be traced back to the time of the second war with Britain. The conflict caused an interruption to imports of iron, and as a result the United States had to make about 80 percent of the bar iron it consumed in 1814. Prices were higher than in the early years of the century, and production too was probably at a record level—unfortunately there are no reliable estimates. This seemed a propitious time for innovation. In April 1813 a British immigrant addressed an advertisement in the *Pittsburgh Mercury,* "To the Proprietors of Blast Furnaces." Notwithstanding an antique style, his message was clear enough: "John Beal, lately from England, being informed that all the blast furnaces are in the habit of melting iron oar with charcoal, and knowing the great disadvantage it is to proprietors, is inducted to offer his services to instruct them in the method of converting stone coal into coak. The advantage of using *coak* will be so great, that it cannot fail to become general if put into practice. He flatters himself that he has all the experience that is necessary in the above branch to give general satisfaction to those who feel inclined to alter their mode of melting their oar. John Beal, *Iron Founder."* Despite the apparently commercially favorable circumstances, no one apparently took advantage of the offer of a new technology, presumably because charcoal supplies were judged more than sufficient to meet the fuel needs of the industry even at high levels of activity. On a number of occasions over the next quarter-century, there were further inquiries into coke making or reports of experiments with coking based on advice from experienced former British coalfield workers, but all of these trials had no firm, long-sustained commercial outcomes.[26] A few coking experiments, however, did occur in southwestern Pennsylvania.

In 1818 coke was used in the refinery at Colonel Meason's Plumsock Ironworks near Upper Middletown on Redstone Creek, Fayette County. After about two years, the colonel returned to the use of charcoal. Through the 1820s a large increase in iron production occurred, but the old fuel sufficed. The early 1830s saw new stirrings in the use of coke. There was a short-lived, small-scale output of it at Plumsock and in Connellsville under the guidance of a man called Nichols, who was said to have had some experience of beehive coke in Britain. By now commercial circumstances were becoming more favorable: Between 1820 and 1837 output of pig iron seems to have increased from twelve to fourteen fold; iron prices were again at fairly high levels. Large scale, localized production and further processing of iron began to grow in importance in association with railroad construction, though for many years most railroad iron was imported. Meanwhile, failure continued as the common fate of the pioneer. In 1834 Lester Norton bought the Plummer Farm for thirty-seven dollars an acre in the hope of building up a coke and iron business; nothing came of his vision.[27] According to F. H. Oliphant, iron was made with coke fuel at Fairchance near Uniontown in 1837, three years after a rolling mill had been built there. Oliphant was so proud of his success that he took specimens of the iron to the Franklin Institute, Philadelphia. After that, as with Meason at Plumsock, Fairchance reverted to use of charcoal. At both of these works, it is likely that, as later commonly reported, the coke was made on the ground in open piles, or ricks. However, over sixty-five years later, one man who had worked in the Plumsock yard claimed that some coke made there came from a stone-built oven holding forty-eight bushels.[28]

The first reliably recorded ovens were built during summer 1841. Again they were the outcome of local enterprise, this time from individuals lacking connection with the iron trade, without industrial experience, and possessing even smaller resources than some of their predecessors. Given such circumstances, it is perhaps not surprising that the time they chose was also not a favorable one. Following tariff reductions in the 1830s, pig iron output and prices were both falling. Perhaps it was just as well that the partners undertook the work as a speculation. Provance McCormick and James Campbell were both carpenters, though McCormick had also been a teamster leading goods between Philadelphia and Pittsburgh. With William Turner, they resolved to build a coke plant. McCormick drew the plans for the ovens, and a fourth man, John Taylor—who combined farming with the trade of stone mason—built two small ovens for the three entrepreneurs on his own land at a place, which was later known as Sedgwick Station, near the outlet of Hickman Run into the Youghiogheny River. Four other local men were engaged as coke workers.[29] This venture suffered a variety of setbacks, some reflecting its promoters' ignorance of the principles of coking. Their ovens were small, with a crown flatter than in later practice. The charge was about sixty-five bushels, which proved insufficient to make good coke. At last, in early winter 1841–1842, they succeeded in producing a tolerably good coke with regularity. By next spring they had made enough of it to load about eight hundred bushels (some 10.5 tons) onto two boats, or "arks," built by the two carpenters as their material contribution to the enterprise. At the first main rise of the river, they and their cargo traveled down the Youghiogheny into the Monongahela and along the Ohio to Cincinnati, where their product was unfavorably received, allegedly being denigrated by local foundrymen as "cinders." Apparently, it then had to be hawked around the area in coffee sacks before a sale was secured from a Mr. Greenwood, a foundryman, for 6.25 cents a bushel, or $4.70 a ton. (Many years later the *Connellsville Courier* suggested the price was 8 cents a bushel.)[30] Payment for this cargo was made half in cash and half in old mill-iron. Some of this coke was then later traded by Cincinnati parties to a foundry in Dayton owned by a Judge Gebhart, who had moved to that area from Pennsylvania and who, in contrast to the skeptical Cincinnati iron founders, was satisfied by its quality. Some reports state that Gebhart later traveled to Connellsville to ask Campbell and McCormick to make more coke for him, only to find that, disillusioned by their general experience as operators and salesmen, the partners were unwilling to try again. Yet despite their own scant commercial success, McCormick and his colleagues were the pioneers of a great industry. Nearly half a century later, in an official report, Edward McCormick of Greensburg (possibly a relative of one of the 1841 party, though unknown) was eloquent in the florid way of his time in celebrating their achievement: "The stones of these old ovens are long since torn asunder and scattered, the mortar in their old joints has crumbled away and mingled with the earth, but the fire lighted that day. . . . burns now in thousands of ovens, multiplying millions of capital, and supporting one of the chief of Pennsylvania's excelling industries."[31] That advanced stage of industrial development was only reached after many more, and initially at least, slow steps.

Coke was again made in the first ovens during autumn 1842, this time by the initiative of the Cochran brothers, Mordecai, James, and Sample, members of a family that would remain involved through the maturity of the industry. After coking about 1,300 bushels, they too boated their product to Cincinnati and sold it to Greenwood. By now he had recognized its value in foundry work, but even so seems to have paid only seven cents a bushel. Sometime that fall, Richard Brookins began to mine coal just across the river from the Cochrans and built five ovens. In 1844 the coal operator Col. A. M. Hill bought the Dickerson farm and put up seven coke ovens. These were bigger, with an increased diameter and raised crown, so that the charge of coal was increased to ninety bushels.[32] By 1845 there were three works and fourteen ovens in this core area of what would become the coke region. Far to the south near New Geneva on the Monongahela, the Shaler brothers, owners of a local foundry, built an oven of ordinary brick that they operated for some years.[33] During the mid-1840s Stewart Strickler, long engaged in boating agricultural produce downriver to Pittsburgh, put up six beehives at Jimtown, their output marketed by the Cochrans. Growth continued to be extremely slow, and as late as 1855, fourteen years after the first ovens were built, there were reportedly only about twenty-six ovens "above Pittsburgh." At that time the rest of western Pennsylvania probably contained nearly three times as many coke ovens as the Connellsville region.[34]

Before the mid-1850s the market for coke in iron smelting was limited by consumer resistance, by the relatively slow growth in the production of finished iron—and therefore in demand for pig iron—and by transport difficulties. The latter part of the decade was marked by changes in these and other circumstances that, taken together and working out over the course of only a few years, transformed the situation and set off a sharp spiral of growth.[35] The first two decisive developments altered the relationship between Connellsville and Pittsburgh. Louis Hunter pointed out how use of coal changed the iron trade from scattered, small-scale operations to a business conducted in bulk by a few great agglomerations of plant: "It was pointed out about 1850 that, whereas from 2,000 to 5,000 acres of timber were required to supply an ordinary charcoal furnace, a coal mine with a 6-foot seam, covering half an acre, would furnish a sufficient supply. The centralization of the iron industry was made possible by coal."[36] This was no doubt true, but the same principle worked in reverse—growth in a major, concentrated iron capacity like that of Pittsburgh justified the large investments of enterprise and capital that created the Connellsville coke industry. Growth in either location was impossible without reliable, all-season bulk transport between the two.

On first consideration it seems remarkable that the sales efforts of coke-region pioneers were directed to distant Cincinnati rather than to the much nearer metallurgical center. This was because Pittsburgh already had its own coke ovens dotted along the Monongahela that obtained their coal from "city" mines and served both the foundries and forges, which worked up charcoal-smelted pig iron brought in from country districts, and the city's crucible steel works. Cincinnati was a major foundry center lacking comparable local supplies. As far as blast furnace operations were concerned, the chief impetus to change to coke came from an increase in scales of production. In Pittsburgh this was delayed and when it came was largely due to a general extension in demand for finished iron products; in other instances it was often associated with large-scale production of wrought-iron rails, an activity requiring big and regular deliveries of pig iron of a consistent quality. In the East, anthracite could support such major operations, as for instance at the Lackawanna works in Scranton, established in 1846. Charcoal proved too dispersed and unreliable a fuel to sustain the tonnages needed for puddling furnaces and rail mills. Understandably, therefore, "western" iron-rail makers, distant from anthracite, were pioneers in using coke in blast furnaces. This happened at Mount Savage and Brady's Bend in the 1840s. However, construction of these iron-rail mills was not followed by a steady upward trend in coke consumption. After the reduction of import duties in the Tariff Act of 1846, production was so deeply depressed that by late 1849 only two of fifteen rail mills were still in operation, and even they were working well below capacity.[37] An interior location, which gave at least some extra protection against imports, a widened sphere of marketing provided by new railroad links, and higher blast furnace productivity derived from the use of coke were the basic assets of a new generation of rail mills, which began with the establishment of the Cambria Ironworks, Johnstown, in the mid-1850s. When coke made there from local coal proved inadequate, the management found Connellsville coke a superior alternative.

The transfer to coke was speeded by a new boom in iron. After highs in 1847 and 1848, national pig iron production fell in the early 1850s, but after 1855 there was a strong general revival, though this was interrupted by recession in 1858. A large part of this increase in iron production was taken by furnaces using mineral fuel, especially coke. At the end of the 1840s, not one coke furnace was in blast in Pennsylvania; by 1856 there were twenty-one, however, except for Johnstown, probably all were using local rather than Connellsville coke.[38] Though coke iron was mainly replacing the output of charcoal ironworks, it was already making headway more rapidly than anthracite iron. In 1856 raw coal and coke furnaces provided only 8 percent of national output as compared with 50 percent from furnaces using anthracite; during the next four years production from the latter rose 17.2 percent and from coal and coke furnaces by 75.8 percent. In Pittsburgh the breakthrough came a few years later than at Johnstown. At first it seemed less spectacular, but eventually the success of coke smelting there was seen to have provided the turning point for the coke region. Though it was to be a key player in rail manufacture, Allegheny County had been a late entrant to that trade. Not until late summer 1853 was its first rail rolled at the West Pittsburgh works of Bennett, Marshall, and Company.[39] This new business, but still more the growth in output of other finished products, meant increased demand for pig or forged iron. Previously, this had been satisfied by long and sometimes difficult hauls from distant points of production; now at last it called into being a local furnace industry. In 1859 the rolling-mill firm of Graff, Bennett, and Company built a blast furnace near the Point, in which they smelted the first pig iron produced in the city since a short-lived operation in the Shadyside district over sixty years before. This pioneer "Clinton" furnace used Connellsville coke. After its initial success, the owners tried to economize by substituting local coke. In spring 1860, recognizing this fuel as inferior, they reverted to coke from Connellsville.

This first use of Connellsville coke carried overland for some fifty miles was a practicable proposition because the relative isolation of the coking-coal district had now been broken by improvements in transport. In its earliest stages the coke districts' transportation facilities had depended on partially improved natural routes, specifically the rivers. Under those conditions coke consumption was largely limited to outlets at locations on or near the riverside, and the choice of sites for coke works and mines was similarly confined. There were only two substantial streams in the coking-coal area of southwestern Pennsylvania: the Monongahela beyond its western extremity and the Youghiogheny, which in the short stretch of its course below Connellsville cut across the coke region's middle section. Within Pennsylvania, the Monongahela was generally free from islands, bars, rocks, or rapids. It was improved, indeed effectively canalized in the 1840s, but was too far from the main area of what were in early years considered the best coking coals to have any significant impact on the coke industry until about sixty years later. Unfortunately, there were much greater physical difficulties on the Youghiogheny, including rapids and low falls. The Connellsville and West Newton Navigation Company was incorporated in

1841 to make the river navigable between the two towns but failed in this task. In contrast, by 1850 the Youghiogheny Navigation Company had “slackwatered” the river below West Newton by construction of locks and dams, making it navigable by steamer from there to Pittsburgh. Presumably as a result of the earlier experiences, no effort was made to extend these improvements above West Newton. Instead, a rail portage was planned between Connellsville and the head of navigation. Then, during the break up of heavy ice and a period of high water in 1855–1856, the log and stone dams and their accompanying locks along the lower part of the river were swept away. Until then the district’s small and slowly growing output of coke had been confined to both banks of the Youghiogheny in the narrow belt in which it cut across the coal basin. Now it was to be freed from these constraints.

Rail transportation was far less subject to the vagaries of the seasons, could provide ease of movement, eventually to a much wider range of destinations, and by making major extensions of both areas of consumption and of production possible, could service a greatly increased output. The railroad thereafter would dominate transportation throughout the life of the main area of the coke field. A rail connection between Connellsville and West Newton was opened in 1855, at a time when there were about twenty-five ovens in the region. By 1857 it reached Turtle Creek and four years later, when completed into the city, the Pittsburgh and Connellsville Railroad linked the coke region into the commerce of a much wider commercial world. Promoters had anticipated that agricultural produce and local iron would be the main sources of railroad business, and the first goods carried were in fact from district farms, but coke soon came to dominate its freight schedules. The first, excessive charge of twenty-two dollars for a rail car of coke—six dollars more than the cost of carriage by river—brought pressure from the industry and resulted in a reduction to a carload rate of nine dollars. Thereafter access to a railroad was a prerequisite for the success of any coke works. Almost immediately extension of track began. In 1857 the Fayette County Railroad was organized with local finance, and within three years had opened a 12.7-mile line along the eastern outcrop of the Connellsville seam from Uniontown to a junction with the Pittsburgh and Connellsville. In the first five years of railroad operations, the number of ovens in the region increased from about twenty-five to seventy. Most of this expansion was at existing coke works, but there were new plants as well. In 1855 Strickler bought eighty acres of coal on the Taylor lands near his Jimtown works and two years later opened the Sterling works on this tract. Its ovens and the tramway he built from them to the Pittsburgh and Connellsville tracks were impressive signs of a new scale of thinking. At about the same time, Philo Norton and two partners bought coal lands near Davidson station north of the Connellsville town limits from Norton’s father, sank a shaft to about eighty feet, made large tonnages of coke in ricks, and built four ovens. Before the end of the 1850s, the coke works of A. S. M. Morgan below Broad Ford station was making a reported one thousand bushels of coke a day and was shipping by the Pittsburgh and Connellsville to a large number of destinations in the interior of Ohio and Indiana as far west as Indianapolis. Coal land that had sold a few years before for thirty-five dollars an acre now fetched one hundred dollars.[40]

It was during the mid-1850s that there occurred another, apparently irrelevant but ultimately decisive, influence on the coke iron industry. In late summer 1856, far from the scene of these developments in Pennsylvania, Henry Bessemer announced his process for bulk manufacture of steel. The full impact of his discovery was delayed for many years, but eventually output of Bessemer steel would require the support of pig iron production on a scale almost beyond the imagining of furnacemen—and coke makers—at that time. The long-term implications for Connellsville would be far more dramatic than any that could have been anticipated by those who were then rejoicing in the convenience provided by a new railroad or, a few years later, in the enterprise of Graff, Bennett.