Anthracite Iron Blast Furnaces in Lancaster County 1840-1900

By John Ward Willson Loose

I. General Description

Unlike the charcoal furnace, the anthracite furnace was a product of the age of steam power; indeed, it was a symbol of a whole new era in which the trinity of coal, iron, and steam reigned supreme. Although charcoal was practically the only fuel used to any extent for smelting iron ore prior to 1840, and few innovations were made in the designs of blast furnaces and their auxiliary equipment in more than a century, some of the later charcoal furnaces were larger and produced more pig iron. But, according to Birkinbine, the use of mineral fuel, hot blast and steam-powered blowing machinery prior to 1840 were experimental only.[1] The earliest anthracite furnaces frequently were remodeled charcoal stacks, and occasionally the blast machinery was water-powered.

The furnace structure evolved from a prehistoric form containing the essential core and crucible.[2] The transition from the mid-fifteenth century European blast furnace to the early nineteenth century charcoal furnace of Pennsylvania was gradual. Technological changes occurred chiefly in the shape and size of the furnace stack, and in the blast.[3]

Early nineteenth century furnaces were constructed of heavy masonry, and had the form of a truncated pyramid. The interior of the furnace was a core in the shape of two frustums of cones, placed base to base, and set over a square or cylindrical chamber, called a hearth or crucible. The widest part of the core, where the frustums connect, was termed the bosh; its size is important in making camparisons of furnace size, capac-

ity, and technological development. The upper frustum tapered to the top of the stack; this area was called the inwall. Charcoal furnaces were left open at the top, but anthracity furnaces soon were equipped with a mechanism designed to permit the charging of the stack so an equal distribution of ore, fuel and flux could be maintained, and also to retain the hot waste gases so they could be conducted to the hot blast stoves and boilers.

The crucible at the bottom of the furnace was pierced with holes for the tuyeres and notches for drawing off the molten iron, and slag or cinder. Tuyeres were nozzles or jets which supplied the blast of air to facilitate combustion of the fuel; they were connected to large pipes which conducted the air blast from the blowing machinery. Near the base of the furnace stack were two openings, either on opposite sides or at right angles, set under arches in the masonry. These were the working arch and tuyere arch, and their purpose was to permit entry to the crucible openings. Refractory material lined the interior. Frequently the stone exterior of the furnace was bound with iron bands to counteract the forces of expansion. This, then, was the typical furnace used for charcoal iron smelting, and became, about 1840, the basis for anthracite iron furnace design.[4]

Manufacture of pig iron consists of a chemical process in which iron ore, fuel, and limestone flux are subjected to an air blast and the heat of combustion. Stated simply, the iron ore, which is an oxide, is reduced in the furnace by carbon monoxide gas and heat; that is, the ore gives up oxygen and takes on carbon from the fuel, resulting in metallic iron containing quantities of carbon and some slag. Inasmuch as silicon and aluminum oxides and other impurities are present in the ore, most of which have higher melting points than iron, a limestone flux is employed to reduce the melting points, and to carry the impurities into fusion, producing slag or cinder. Approximately halfway down the stack, or where the temperature reaches 1300° F., the iron oxide is reduced to metallic sponge iron by solid carbon which is dissolved and taken into the iron, thereby lowering the melting temperature of the iron.[5]

II. Technological Development

Birkinbine found the evolution of anthracite furnace design fell into two eras comprising five distinct stages: all of them are represented by Lancaster County establishments.[6]

Developmental Era (1835-1864)

According to Temin, ironmasters rarely introduced changes during this period which were designed to increase output or decrease costs of material

handling at the furnaces; they concentrated instead on innovations which would better exploit the use of mineral fuel. A few furnaces prior to 1865 used mechanical lifts to get the charge to the top of the furnaces, but these were exceptional cases.[7] Birkinbine tends to agree with that observation.[8] Nevertheless, seven anthracite furnaces erected between Marietta and Columbia from 1845 to 1854 were equipped originally with steam-powered mechanical skip hoists according to sketches and descriptions of these works. Moreover, their location on level ground necessitated some means of elevating the charges mechanically. We must conclude the majority of Lancaster County furnaces were "exceptional cases," and were of advanced design.[9]

Records of local furnaces tend to confirm the statements of Birkinbine and Temin that the primary concern of ironmasters from 1835 to 1864 was the redesign of furnaces to exploit the advantages of mineral fuel. This effort was divided into two stages.

During the decade following 1835, ironmasters tried to apply the hot blast principle to their furnace stacks. Anthracite coal had been used in a mixture with charcoal for iron smelting in Maryland as early as 1815, but with little success. Peter Ritner used the anthracite coal-charcoal mixture in a Perry County furnace in 1824 and 1828 with slightly more success. An attempt to use anthracite coal exclusively as fuel by the Lehigh Coal and Navigation Company in 1826 was a dismal failure.[10] All these experiments were conducted with a cold blast. From 1830 to 1833 Dr. Frederick W. Geissenhainer, a Lutheran pastor living in New York, applied a hot-blast under strong pressure to his experimental anthracite furnace, and discovered iron could be smelted both successfully and economically. A patent was granted to him by the patent office at Washington on 19 December 1833, for "a new and useful improvement in the manufacture of iron and steel by the application of anthracite coal."[11]

Three Lancaster County anthracite furnaces—Shawnee (1844), Chikiswalungo (1845), and Henry Clay (1845)—were erected near the end of this experimental stage. The Sarah Ann Furnace, a charcoal furnace converted to anthracite in 1845, and the three aforementioned stacks were equipped with hot blast ovens at the top of the furnaces. The furnaces originally were furnished with three tuyeres except Shawnee Furnace which had only two, owing to its small bosh and crucible.[12]

In the decade following 1845 furnace stacks were increased in height and diminished in wall thickness. Development of more effective refractories or fire bricks permitted thinner walls and increased bosh diameters, a factor that coincided with the discovery that larger capacity furnaces could be operated more efficiently.[13] Ironmasters were reluctant to experiment with higher blast temperatures and greater air pressures, thereby

proventing the realization of increased production and economy of fuel. Prior to the Civil War, ironmasters thought blast temperatures should not exceed the melting point of zinc, and, preferably, should remain within the range of 612° to 787° F. to prevent the "burning" of the iron.[14] Lancaster County ironmasters at this stage were careful to keep blast temperatures under 612° F.; in fact, the Shawnee and Safe Harbor furnaces were furnished with a 450° F. blast.[15] Part of such reluctance of furnace operators to increase blast temperatures depended on ignorance of chemistry and metallurgy, but the lack of suitable refractories for lining hot blast pipes and waste gas conductors was a valid contributing factor.[16] Experience also suggested the efficiency of constructing larger, circular crucibles of brickwork, bound with wrought iron bands, instead of smaller, square hearths surrounded with massive stone piers and arches. This development paved the way for the radically different structure of the later era.[17]

Closure of furnace tops, and conducting of the hot waste gases downward to boilers and hot blast stoves at ground level were viewed by many ironmakers with suspicion; they feared the quality of the pig iron would be affected.[18] The lingering traditions of charcoal furnace technology continued to haunt the pioneers of anthracite iron furnace development until the conclusion of the Civil War when demand for more and better iron, and eventual competition from steel, required more courageous action on the part of the entrepreneurs.[19]

Technical Era (1865-1900)

Aside from the non-technical aspects of furnace development such as integration,[20] multiple stacks, and specialization of production, the era following the Civil War saw the introduction of tall, nearly cylindrical stacks, jacketed with iron plates and lined with fire bricks and cooling devices; more powerful blast machinery; stoves of greatly increased efficiency; and mechanized materials and stock handling.[21]

The use of Connellsville coke about 1865 in western Pennsylvania promoted the growth of the coke pig iron industry in that region after many years of latency, owing to the inferior quality of iron produced in furnaces using high-sulphur content coke.[22] Anthracite and charcoal iron, because they were purer and less brittle, were preferred by foundries. Much of this objection to coke pig iron was removed after 1865; by 1872 more than one-third of the pig iron manufactured in the United States was smelted in coke furnaces, an amount double that of 1862. After 1872 a gradual decline occurred in the percentage of iron smelted with anthracite coal. Only four per cent of iron smelted in 1889 was produced in anthracite furnaces; eighteen per cent came from furnaces using a mixture of anthracite and coke.[23]

Coincident with the introduction of Connellsville coke in pig iron manufacture was a change in the iron market. Heretofore most pig iron manufacturers produced iron capable of maintaining high quality standards in a great variety of applications, in short, iron able to meet universal minimum requirements.[24] Following the Civil War, according to Temin,

> The newer market was typified by large-scale sales to purchasers buying for specific purposes. Each lot of iron had to satisfy only a few of the qualifications formerly imposed, and the sum of these individual demands produced a total demand that was less sensitive to differences in quality and more responsive to changes in price.[25]

The growth of the American economy resulted in increased rail and coke pig iron production, both oriented toward western Pennsylvania,[26] and neither helpful to Lancaster County iron makers.

The last anthracite furnace built in Lancaster County was erected in 1867; five others were enlarged during the decade, 1865 to 1875, mainly by mounting sheet iron thimbles above the furnace stacks. Bell-and-hopper devices were installed on the furnace tops to facilitate charging.[27]

During the decade following the American Centennial Lancaster County iron manufacturers came to the crossroads of their industrial futures: to abandon or rebuild their furnaces. Five owners enlarged or rebuilt their plants while four ironmakers abandoned their furnaces.[28] Competition grew as corporate giants emerged as a result of integration, mergers and consolidations. Safe Harbor Iron Works and the Chestnut Hill Iron Ore Company were examples of early integration; both companies controlled ore deposits, blast furnaces and rolling mills. Later integration of iron works would include mills producing rails, tubes, pipes, forgings, structural shapes and plates.[29]

An example of innovations made at old furnaces occurred at the Shawnee Furnaces in 1882. Stack No. 2 was rebuilt according to the "most modern plans" following which the furnace produced more than 200 tons of first grade foundry iron weekly. Chemical analysis showed the iron to be ninety-six per cent pure, a grade "rarely attained anywhere" according to *The Columbia Spy*. A hydraulic elevator was installed to lift materials to the furnace tops, the only apparatus of its kind in use at iron works in Lancaster County. Water discharged from the hydraulic lift was used to cool the furnace tuyeres and cooling blocks set into the refractories.[30]

By 1886, new and completely rebuilt furnaces no longer resembled the old charcoal furnaces. The stack was an iron shell, refractory-lined, resting on a circular colonnade or peristyle of cast iron pillars. The crucible and bosh rested on a heavy foundation in the center, and tapered upwards to the stack.[31] Chickies Furnace No. 1 was rebuilt in this manner in 1886.[32]

III. Raw Materials and Transportation

Iron Ore

Presence of good quality iron ore in sufficient quantity, and its ability to be mined without difficulty were important factors in the location of blast furnaces in Lancaster.[33] Four areas of the county held deposits that were exploited commercially: (1) Chikiswalungo Ridge, (2) Safe Harbor-Conestoga area, (3) Providence-Eden area, and (4) Caernarvon area. The first three groups of deposits were used largely to supply the anthracite furnaces of Lancaster County; the Caernarvon ore deposits were mined for iron works in Berks and Chester counties.[34]

Geologists and iron manufacturers preferred the ores from the banks and mines situated along the slope east of Marietta to Silver Spring, to those located in the southern portion of the county. Most of the latter were less pure and the deposits were smaller. Several of the mines in the Providence-Eden area did have high quality ores; Geiger's and Cabeen's deposits were reputed to yield excellent ores. The iron ores mined in Lancaster County generally were brown hematite (or limonite) and magnetite; red hematite and iron carbonate existed but were not suited for commercial exploitation because the deposits were small and the ore quite impure.[35]

Limestone

Limestone quarries were numerous across the broad central plain of Lancaster County during the nineteenth century. A plentiful supply of limestone near the surface in the vicinity of iron ore deposits increased the desirability of locating furnaces near these raw materials.[36] From the reported tonnages of iron ore mined and used in local furnaces in 1870, and the ratio of ore to limestone employed by E. Haldeman and Company, we may calculate the amount of limestone quarried in that one year for furnaces to be approximately 75,000 tons.[37]

Coal

Anthracite and bituminous coal were demanded in vast quantities for operation of the blast furnaces, rolling mills, and their power requirements. The account books of the Donegal Furnace near Marietta disclose that in 1866, a total of 9,851 tons of anthracite lump coal was purchased from the Baltimore Coal Company; that it was delivered by canal is indicated by the payments of fifteen cents per ton to the "captain" for unloading the boat. Cost of the lump coal ranged from $3.50 per ton in January to $4.70 in December, 1866. Much smaller quantites of coal graded from No. 4 to No. 6 were bought from Wilkes-Barre coal merchants.[38] Possibly these relatively smaller tonnages were used for ore roasting. Although coal was

not mined in Lancaster County, canal facilities served most of the furnaces, and railroads reached to all the furnaces after 1877.[39]

Transportation

The Pennsylvania State Works Canal linked northern and western Pennsylvania to Marietta and Columbia in 1830; its usefulness was increased in 1834 with the construction of the Columbia and Philadelphia Railroad which terminated at the canal basin in Columbia. Connecting Lancaster with the Susquehanna River, and the Susquehanna and Tidewater Canal, the Conestoga Slackwater Navigation canal was begun in 1828.[40]

In 1838, the Harrisburg, Portsmouth, Mountjoy and Lancaster Railroad completed the triangle of transportation with points at Harrisburg, Columbia and Lancaster. It permitted some freight to by-pass Columbia, precipitating a demand for a railroad joining Columbia to Harrisburg directly; this was done in 1850. A major objective of those who promoted this branch of the Harrisburg, Portsmouth, Mountjoy and Lancaster Railroad was the iron trade at Marietta.[41]

Columbia iron manufacturers supported a proposed railroad from the Broad Top coal fields in western Pennsylvania to Columbia in 1864, but nothing came of this plan. This would have given the local ironmakers a competitive transportation system against which the Pennsylvania Railroad freight rates would be pitted.[42]

As soon as the word leaked out that the proposed Hanover Junction and Susquehanna Railroad would connect the iron industries at Marietta and Columbia to another East-West rail line running in competition with the Pennsylvania Railroad, the iron men lost no time in pressuring the railroad to cross the river at Columbia or at Chickies Station.[43] At an election of directors of the new railroad company, J. G. Hess, Samuel Musselman, WIlliam M. Watts, and Paris Haldeman—all iron manufacturers—were chosen.[44] As soon as the grading began on the York County shore the Pennsylvania Railroad commenced similar operations. The new railroad then withdrew, and concentrated on completion of that portion extending from Chickies Station near Marietta to a junction with the Reading and Columbia Railroad near Landisville. This, too, soon ceased, and the Hanover Junction and Susquehanna Railroad passed out of existence, smashing the hopes of the freight-rate conscious iron manufacturers.[45]

In 1883, a branch was built from the Reading and Columbia Railroad's main line near Landisville to Chickies Station and Marietta. Coal, ore, and pig iron now could be transported over a shorter route.[46]

The central and southern portion of Lancaster County were not served by a railroad until 1875 when the Reading and Columbia Railraod acquired

a bankrupt narrow-gauge "paper" corporation, and built a branch to Quarryville from Lancaster. This served the Conestoga Furnace and numerous ore deposits in southern Lancaster County.[47]

Columbia's iron manufacturers eagerly promoted the construction of the Columbia and Port Deposit Railroad in 1877; it joined Columbia to the Philadelphia-Baltimore main line of the Pennsylvania Railroad, and served the Safe Harbor Rolling Mill.[48]

Canal transportation was unpredictable; floods and wash-outs were common, closing the canals for months at a time.[49] Railroad transportation was more flexible, but the iron masters frequently struggled with the railroad companies over freight rates, causing the manufacturers to promote competitive lines.[50]

Sarah Ann Furnace

Located along Big Chikiswalungo Creek two miles northwest of Silver Spring, Sarah Ann Furnace was erected in 1839 by John Gamber as a charcoal furnace. Following the custom of the day, Gamber named the furnace in honor of his wife.[51] No sooner had the furnace been completed when Gamber was forced to make an assignment to Abraham Peters and his father, Jacob H. Gamber.[52] On 9 December 1844, Jacob Gamber leased the property to Governor David R. Porter who had scattered interests in iron furnaces. The terms of the lease provided for a payment of $400 for the first two years, and $500 annually thereafter. Porter was permitted to rebuild the engine and machinery to make use of anthracite fuel.[53] John B. Hertzler bought the property from the Gamber assignees in 1847, and reaffirmed the agreement with Porter.[54]

At the time of its conversion to anthracite coal in 1854, the furnace was thirty feet high with an eight-foot bosh. Although its rated capacity was 2,000 tons of iron annually, at no time did it produce more than 1,664 tons in a year. Only 200 tons were produced in 1849, and the following year the furnace was out of blast.[55] The Sarah Ann Furnace was not successful as a charcoal furnace; its remoteness from rail and canal facilities made it less promising as an anthracite furnace.[56] The property did carry with it the right to mine ore without payment of ore leases on a 131-acre tract on Chestnut Hill.[57] John B. Hertzler owned the ore deposit in the 1860s; later the ore was used in the Chickies furnaces near Marietta.[58]

Shawnee Furnaces

Robert and James Colvin have the distinction of building the first anthracite furnace in Lancaster County. Named the Shawnee Furnace

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NOTE: Picture of Shawnee Furnaces is shown in L.C.H.S. Jounral, Vol. 86, No. 1, P. 12.

because the Shawnee Run passed through the lands of the furnace in Columbia, the furnace was relatively small and was charged from a bridge that joined the furnace top to a hill south of Union Street. Traditional accounts state Shawnee Furnace was erected in 1844, but Robert K. and James Colvin had their "new furnace" sold by the sheriff at public sale as early as 12 October 1842.[59]

The property was conveyed to James Myers, John Strimpfler, and Augustus Holmes, trading as Holmes, Myers and Company, with the firm obtaining a mortgage for $3,000 from the Lancaster Bank.[60] Four years later Holmes, Myers and Company went into assignment, and the furnace was purchased by Archibald Wright and Nephew, as the firm styled itself. Success finally crowned the venture for Messrs. Wright for nearly a decade during which time a second stack was added. Archibald Wright and Nephew had its office in Philadelphia and depended upon Columbian-based management.[61]

The original furnace stack—the smallest in Lancaster County—was twenty-eight feet tall with an eight-foot bosh, having an annual rated capacity of 2,000 tons. Two tuyeres supplied a blast heated to 450° F. Archibald Wright and Nephew offered to their customers only the first two grades of foundry iron until 1856 when the furnace was enlarged to thirty-three feet in height with a ten-foot bosh, and using a stronger blast heated to 600° F. Production of Grade III foundry iron was begun after the remodeling.[62]

The second stack, constructed in 1853, was forty-seven feet high and had a fourteen-foot bosh; its rated annual capacity was 5,500 tons. The furnace had four tuyeres, and shared with Stack No. 1 the blast machinery.[63]

On 11 March 1851 the Pennsylvania General Assembly granted articles of incorporation for "The Chestnut Hill Iron Ore Company." Its incorporators included Moses Taylor, W. S. Wetmore, Samuel Joudon, W. F. Havermyer, and August Belmont, all New York financiers; and Simon Cameron, Charles A. Hecksher, Jacob Haldeman, Samuel Schoch, James Mehaffey, Philip Doughtery, Dr. Edwin Haldeman, George N. Eckert, Daniel Stine, Henry Fry, Daniel Herr, and Archibald Wright. Capitalization consisted of $150,000 to be raised by the sale of 3,000 shares of stock at a par value of $50. The company was granted the right to hold a maximum of 1,000 acres.[64]

Meanwhile, Archibald Wright and Nephew became indebted to The Chestnut Hill Iron Ore Company for purchases of iron ore, and failing to cover their notes, execution was entered against the former, causing the furnace property to be sold by the sheriff. A prior judgment given by

Wright forced the ore company to purchase the furnaces to protect their interest.[65] This necessitated an amendment to the corporate charter, which, when granted 26 March 1859, permitted The Chestnut Hill Iron Ore Company to acquire the furnace property and operate the iron works.[66] From this time until the Chestnut Hill Iron Ore Company went into receivership in 1893, it operated the Shawnee Furnaces.[67]

From the time a furnace was ignited until it was "blown out" after a blast was called a campaign; the length of a campaign always attracted much attention. In the days when a furnace could go bad in a day or two, an endurance record of two years was a newsworthy event. Lacking modern knowledge of chemistry, early ironmasters and their employees tended to regard what occurred inside the furnace as a combination of luck, Calvinistic predestination, and black magic. The gods that brought floods and famines were akin to the spirits operating within the fiery stacks. When a furnace was "blown in" the wife or daughter of the proprietor or of one of his honored employees performed the ceremony of igniting the furnace.[68] Congratulations and best wishes would be offered, toasts occasionally would be drunk, and the local press would comment optimistically, as *The Columbia Spy* was wont to do:

> The Shawnee Furnace "blew in" last week, and under the judicious management of Colonel W. C. Bradley, we trust they will have a long, successful and profitable blast. Mr. L. McMichael is the founder and he has proved himself competent.[69]

Shawnee Furnace records always refer to the stacks as No. 1, No. 2, or No. 3; apparently they were known locally by more colorful names, as revealed by a citation in the *Spy:*

> Chestnut Hill Iron Ore Company's furnace "Josephine" which chilled about six weeks ago was blown in this week, being the shortest time on record in which a furnace has been repaired when chilled.[70]

With the demand for pig iron increasing after the Civil War, much of it for use in local rolling mills, Shawnee Furnace No. 3 was erected in 1868; it was forty-six feet in height and had a bosh of eleven feet.[71] It was the last furnace stack to be constructed in Lancaster County, although others were enlarged and rebuilt from time to time.

By this time the Shawnee Furnaces had become a large rambling collection of stacks and buildings clustered at the base of the Union Street hill. The Chestnut Hill Iron Ore Company acquired most of the land bordered by Union, Fifth, Mill, and Shawnee streets—the site of the furnaces—as well as extensive holdings south of Mill Street, and east of South Eighth Street. Inasmuch as the furnaces had to be charged from the Union Street hill, an elaborate private railway system was constructed by the Chestnut Hill Iron Ore Company to transport ore, coal and limestone

from the tracks of the Reading and Columbia Railroad, the Pennsylvania Railroad, and the Columbia and Port Deposit Railroad to the furnaces, and to ship pig iron from the cast houses and warehouses at the bottom of the Union Street hill.[72] The topographical position of the early furnace stack provided a natural incline to the furnace top; later, when a hydraulic hoist was installed to lift raw materials to the furnace tops, the Chestnut Hill Iron Ore Company continued to stockpile materials on the higher level. Ore brought from the Chestnut Hill Iron Ore Company's ore pits and mines in West Hempfield Township by railroad could be delivered just as easily to the furnace tops as it could be dumped on the lower level of the furnaces near Shawnee Run after which the materials would have to be elevated to the level. Moreover, the railroad operated by the Chestnut Hill Iron Ore Company afforded the firm connections to three public railroads, a not inconsiderable factor in negotiating freight rates.

The Chestnut Hill Iron Ore Company's railroad was constructed in the shape of "U" with one end serving the cast houses and warehouses, and the other end terminating at the furnace tops off Union Street. The end of the Loop occurred near Eleventh and Blunston streets, at which point the connection was made with the Reading and Columbia Railroad. The latter's tracks passed the ore company's mines four miles east of Columbia. It should be noted, furthermore, that the Reading and Columbia Railroad was a major anthracite coal carrier, with direct connections at the coal fields, over the tracks of the Philadelphia and Reading Railroad. Recent generations may find it difficult to imagine the intersection of Lancaster Avenue and Union Street in Columbia covered with railroad tracks and sidings.[73]

After nearly forty years of production Shawnee Furnace No. 1 was taken out of service in 1880 after a troublesome twelve-day campaign.[74] Stack No. 2 was in blast for only eighty days in 1879, after which it was enlarged in 1881 to dimensions of sixty feet in height and a fourteen-foot bosh.[75] Furnace No. 3 operated throughout 1879, yielding along with Furnace No. 2, a total of 12,000 tons of pig iron.[76] After enlargement Furnace No. 2 produced 7,700 tons during a 150-day campaign in 1881.[77] The Shawnee Furnaces employed seventy-five men during most of the time in the late 1870s and early 1880s. In 1881 the men received total wages of $35,420 or approximately $472 per employee.[78] Following the general financial recovery of 1879 and the prosperity of 1880 to 1883, Lancaster Countians were pleased to note Shawnee Furnace No. 3 "made the largest yield of pig iron ever produced by it yesterday."[79] Within a fortnight, however, Columbians received less favorable news:

> Shawnee Furnace No. 2 is about to be closed for the present, on account of the limited demand for iron. As soon as the iron business revives again, work will

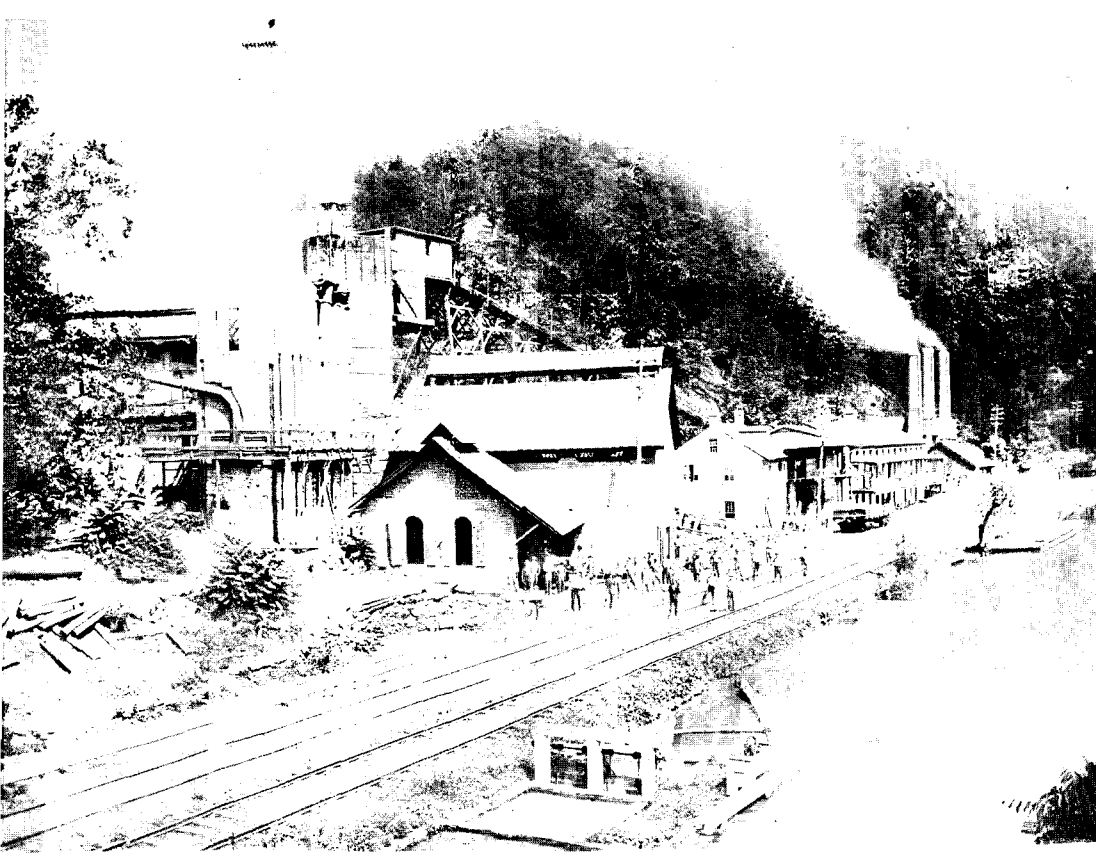
be resumed. In the meantine none of the employees will be discharged from the company's services, but will be engaged in making repairs and improvements to the furnaces.[80]

A mild recession occurred from 1883 through 1885 but in the iron industry the term "depression" seemed more appropriate. The *Spy* soothed its readers 8 March 1884, with the report "One of the Shawnee Furnaces is to be put in blast soon after the long depression."[81] Long before that hope materialized Columbia's gloom deepened with the announcement the Chestnut Hill Iron Ore Company would move its offices to Reading to be nearer "those interests" who controlled the company.[82] Finally, on 25 October 1884, the Shawnee Furnaces were blown in once more.[83] Despite the depressed condition of the iron market the Shawnee Furnaces were in full blast.[84] Thanksgiving in 1884 brought with it the happy news that the Chestnut Hill Iron Ore Company had received orders for "large quantities" of iron.[85] Between 1885 and 1890 a fairly vigorous prosperity was enjoyed in the iron industry, and the Shawnee Furnaces were in full operation until May, 1888, when Furnace No. 2 was banked and eventually blown out.[86]

During the prosperity Furnace No. 3 was enlarged, with the height being increased to sixty feet, and the bosh being widened to fourteen feet.[87] At this time the stack was designed with an iron shell lined with fire bricks. Both furnaces were started at the end of 1889, and by the middle of February, 1890, the *Spy* reported "Shawnee Furnaces are making an excellent record. The yield is very satisfactory and the iron is of a higher grade than in the past."[88] Limited stability of the iron market continued through 1891 and 1892, but the Panic of 1893 caused the Chestnut Hill Iron Ore Company to pass into receivership. The furnaces continued to operate through 1894 in which year a total of 40,500 tons were produced.[89] By 1899, the furnaces and all other structures of the iron works, including the railroad tracks over Union Street to the heads of the furnaces were removed.[90] Even the cinder banks of the furnaces were removed in 1901 and used for construction of the Pennsylvania Railroad's low grade line between Atglen and Enola.[91]

Henry Clay Furnace

Peter Haldeman, a prosperous merchant of Columbia, built the Henry Clay Furnace along the Susquehanna River at the Western base of Chikis Rock in 1845. The stack originally was thirty-five feet in height and nine feet across the bosh. Its annual capacity was rated at 2,800 tons. Hot blast was supplied through three tuyeres with three and one-half inch nozzles under a pressure of two and one-half pounds per square inch, at a temperature of 612° F.[92] In its first year of operation the furnace yielded 2,678 tons. By 1854 the production was 3,300 tons, and in the two successive years the yield dropped to 600 tons and 157 tons respectively.[93] In



Henry Clay furnace, later known as St. Charles No. 2, at Jones Hollow near Chickies Rock. The Pennsylvania Canal is at lower right. The three stacks to the right of workers' homes (right of the picture) are part of the ore roaster. This photograph was taken in August 1883.

1856 Mr. Haldeman found himself under heavy obligation to John Cooper, Joseph W. Cottrell, and Washington Righter, who entered execution against the furnace property. At the sheriff sale held 21 April 1856 Stephen F. Eagle, a fellow ironmaster at Marietta, purchased the furnace property which included eleven two-story stone dwellings for $10,400.[94] One week later Eagle sold the property to Thomas E. Franklin and Charles B. Penrose for $10,900.[95] Franklin, scion of a distinguished Lancaster family, served as Pennsylvania's Attorney General at the time he became a silent partner in the firm of C. B. Penrose and Company. Franklin was a Whig.[96] Charles B. Penrose, a Cumberland County pro-Bank, high-tariff Democrat, perhaps is best known for his hasty retreat through a window of the Pennsylvania Senate, of which he was speaker, during the "Buckshot War."[97] After holding the property nearly one year, Franklin and Penrose conveyed the furnace tract on 28 March 1857, to James and Henry McCormick, ironmasters of Dauphin County, and Charles Ross Grubb, iron manufacturer of Burlington, New Jersey, for $16,000.[98]

The Panic of 1857 and the resulting depression in the iron trade caused the furnace to be closed until 1863 when the McCormicks and Grubb sold

the property to Henry McCormick, son and nephew respectively of the grantors; John Q. Denney; and John Haldeman.[99] On 31 March 1864, Henry McCormick sold his undivided one-third interest for $20,000 to Jeremiah G. Hess, a coal merchant of Columbia.[100] Haldeman soon passed into the background as an active partner, and the firm was known as Denney and Hess. After a long period of idleness, the Henry Clay Furnace was blown in October 1865. Despite the war demands, several of the local furnaces were closed because there was a "slump in the iron trade."[101]

Jeremiah G. Hess, Columbia coal merchant and ironmaster. He was a partner in the Henry Clay furnace and was treasurer of the Susquehanna Rolling Mill, as well as serving as president of the Columbia Board of Trade.

After John Haldeman's death in 1873, his heirs sold his interest to John Q. Denney and Jeremiah G. Hess.[102] By 1875, annual production had been increased to 10,000 tons,[103] Clement Brooke Grubb purchased the Henry Clay Furnace in 1875, renaming it St. Charles Furnace No. 2.[104] Grubb was a great-grandson of Peter Grubb who discovered the Cornwall ore deposit. Active in banking, commerce, and ironmaking, Clement Grubb erected a large mansion in 1841 on North Lime Street, Lancaster.[105]

The old furnace was rebuilt, increasing the stack to fifty-seven feet with a twelve-foot bosh. In 1876, pig iron worth $81,871 was cast.[106] After several years production at the furnace tended to decrease until 1880 when only 2,500 tons were produced in a campaign lasting 180 days.[107]

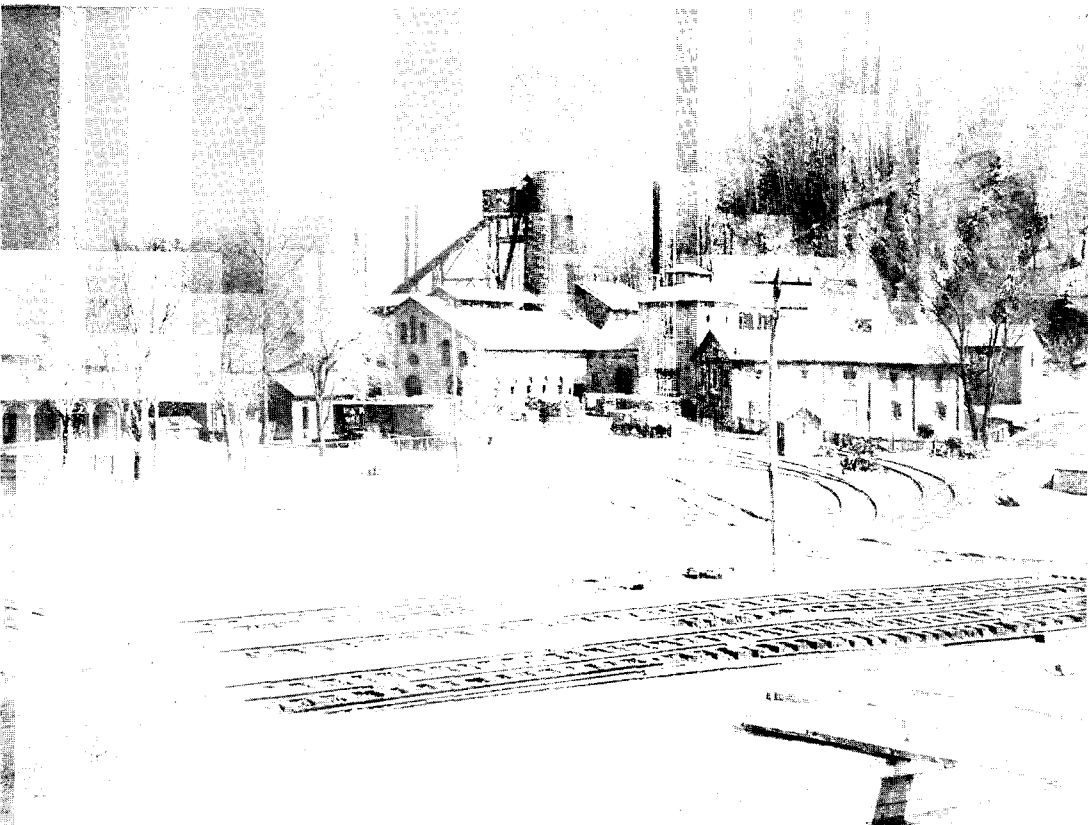
During October and November of 1887 the furnace was remodeled and put back into blast under the management of E. B. Eckman.[108] But the works were outmoded, and late in 1889 the furnace was abandoned.[109]

Chikiswalungo Furnace (Chickies Furnace No. 1)

In 1828 Henry Haldeman purchased a large tract of land from the estate of Christian Hershey along and near the mouth of the Chikiswalungo (of Chiquesalunga, a corruption thereof) Creek in West Hempfield Township. After a successful term in the lumber business, Haldeman and his eldest sons, Dr. Edwin Haldeman and Professor Samuel Steman Haldeman, trading as E. Haldeman and Company, decided to enter the iron industry.[110]

Of German-Swiss ancestry, the Haldemans made their mark early in local politics, Jacob Haldeman being a member of the Committee of Public Safely in 1775 for Rapho Township. Although he did not hold any elective office, Henry Haldeman, Jacob's grandson, was a trusted lieutenant

Chickies furnace No. 1, West Hempfield Township near base of Chickies Rock, as it appeared in 1887. This Haldeman furnace was one of the most productive and advanced in technology. Route 441 goes through the site of these buildings today.



in the Democratic Party of Pennsylvania and was a power to be reckoned with in legislative matters.[111] During the struggle over the chartering of the United States Bank at Harrisburg in 1836, Henry Haldeman was opposed to the notion of chartering the bank. To overcome his opposition, supporters of the Bank Bill assured Haldeman a portion of the $550,000 earmarked for extension of state works (to be taken from a bonus of $2,000,000 given by the United States Bank) would be used to build the Marietta Railroad. Haldeman desired to have a railroad extend from the state works (Columbia and Philadelphia Railroad) near the Centerville Road to Marietta, generally following the Marietta Turnpike. A railroad connection to Lancaster and Philadelphia would enhance the commercial and industrial value of Haldeman's property. Unfortunately for Henry Haldeman, the Marietta Railroad never materialized other than a few hundred feet of grading on his property.[112]

In 1845 Henry Haldeman built an anthracite iron furnace in the western shadow of Chikis Rock and east of the Chickiswalungo Creek. On 4 July 1845 he presented the furnace and his other commercial holdings to two of his sons. Professor Samuel S. Haldeman, one of the nation's most respected orthographers, was given the task of naming the iron works. He decided the Indian name of the nearby creek, meaning "place of the crabs," was appropriate, hence Chikiswalungo Furnace. Later, the awkward name was abbreviated and corrupted to Chickies or Chiques; in June, 1858, Professor Haldeman reluctantly approved changing the name to Chickies Furnace.[113]

According to Horace Haldeman, later secretary-treasurer of the firm,

> The furnace first went into blast 15 January 1846. It was originally but thirty-two feet high and eight feet across the boshes, but was modernized from time to time, the original stack remaining until 1886, when the old plant was, practically, dismantled and a new one erected, including machinery, boilers and hot blast stoves.[114]

Its rated annual capacity was 2,500 tons, and in 1848 it produced 2,464 tons. A blast heated to 612° F. was furnished through three tuyeres under two and one-half pounds per square inch pressure.[115] Birkinbine and Pearce claim the furnace was originally forty feet high, a discrepancy which can be explained by an eight-foot iron extension installed a year or two after the furnace went into blast.[116] Pearce described the structure in some detail in 1876 from papers and sketches prepared by Professor Samuel S. Haldeman for publication in *The American Journal of Science and Arts* in 1848. Haldeman explained how the boilers and hot ovens were constructed, and how the waste gases were conducted through the heat transfer tubes.[117]

Furnace records reveal that during the first blast, lasting from 15 January 1846 to April 1846, 2.26 tons of anthracite coal and 2.47 tons of

ore were required to yield 1 ton of pig iron.[118] During the next blast *The Spy and Columbian* waxed exuberantly:

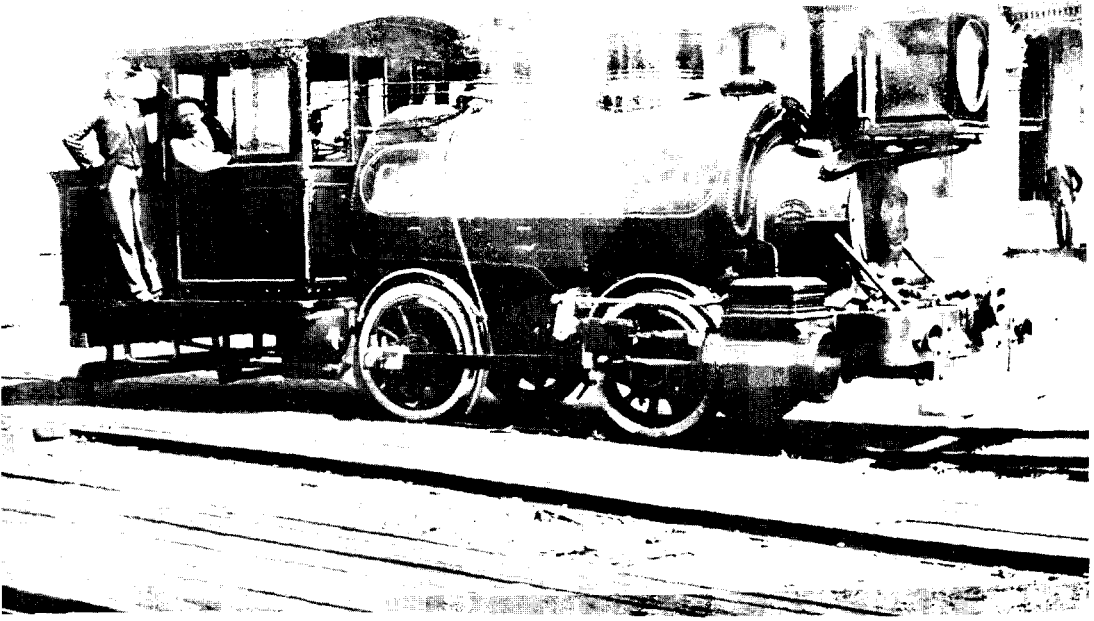
> Who can beat it? E. Haldeman's furnace at Chiques [sic] is 8 feet across the bosh, and is driven by a 40 horse-power engine. For the 3 weeks ending Saturday last (October 2nd) the amount of iron made was as follows—1st week, 74 tons; 2nd week, 72 tons; and the 3rd week, 72 tons, or a total of 218 tons. This, for the size of the furnace, is considered an extraordinary yield.[119]

Thirteen campaigns occurred in the next nine years, varying from twenty-one days to twenty months duration.[120] In 1855 the bosh was widened to ten feet, ten inches. Following this alteration within the original stack only five campaigns were made during the next six years. The height of the furnace was raised to forty-five feet in 1861 after which two campaigns occurred, the first lasting from 16 October 1861 to June 1865, and the second from August 1865 to July 1870.[121] Campaign No. 20 endured from 13 December 1870 to October 1873 with a newly-designed eleven-foot bosh.[122] Pig iron prices dropped in the autumn of 1873, and a general depression in the trade was felt in Lancaster County. E. Haldeman and Company seized upon this occasion to increase the stack to fifty-seven feet, accomplishing the work between 1 November and 14 December 1873 when the twenty-first campaign of Chickies Furnace was started.[123]

E. Haldeman and Company reported to the Secretary of Internal Affairs of Pennsylvania in 1874 that the cost of producing one ton of No. 1 foundry grade pig iron at Chickies Furnace No. 1 was $23.55, compared with costs of $19.52 at Grubb's St. Charles Furnace and $20.00 at Kauffman's Cordelia Furnace, all in western Lancaster County.[124] Pig iron of that grade was being sold in 1874 in eastern Pennsylvania for $30.25, indicating a gross profit of $6.70 approximately for E. Haldeman and Company.[125] Haldeman's ore costs were $3.00 per ton of pig iron higher than the other furnaces cited; their labor costs also were approximately $1.00 per ton over Grubb's and $1.50 over Kauffman's.[126]

In 1881, Chickies Furnace No. 1 was fitted with an advanced design of bell and hopper mechanism for the furnace top. Installation of the new device was accomplished without taking the furnace out of blast, regarded as an exceptionally difficult task.[127]

Economy of production no longer was possible with the often-remodeled plant, regardless of progressive management techniques, good employee relations, and efficient materials handling equipment. Accordingly, in 1886, the entire plant was rebuilt. The stone stack which had served since 1845 was removed completely, and a furnace built of iron plates riveted into a cylinder, and lined with refractories and cooling blocks, took its place. Six cast iron columns supported the mantle ring upon which rested the furnace stack. The lower bosh and crucible were



The Haldeman firm, owners of Chickies furnaces No. 1 and No. 2, purchased this Baldwin saddle tank locomotive in 1890 to move ore and pig iron cars around their properties. Chickies Station of the Philadelphia and Reading Railroad (Marietta Branch) is at right background.

supported independently on a concrete foundation. Now sixty-five feet tall with a twelve-foot bosh, the furnace had an annual capacity of approximately 17,000 tons. The plant was fitted up with new blast machinery, stoves and boilers. A new cast house of brick and in Romanesque style replaced the earlier structure.[128] Undisturbed was an office building erected in the summer of 1873, which could boast of a telegraph apparatus which "placed the works in telegraphic communication with the rest of the world."[129] Ten electric arc lights were installed in 1889.[130] By this time Chickies Furnace No. 1 and its mate across the Chikiswalungo Creek, Chickies No. 2, were connected to each other and the Pennsylvania Railroad, and the Chickies Branch of the Reading and Columbia Railroad, by a system of tracks. A four-wheel switching locomotive, class 4-240C, with an 850-gallon saddle tank, was purchased from the Baldwin Locomotive Company in 1890 for the purpose of moving ore and stock cars around the furnace properties.[131]

The iron industry of Lancaster County was affected severely by the depression of 1893, necessitating for the first time the closure of the Chickies Furnaces in July of that year.[132] Work was resumed in 1894, but the day of the anthracite furnace had passed, and the economy of the independent, non-integrated blast furnace company raised serious questions of survival in the face of the industrial giants. Making a realistic appraisal of their futures as anthracite iron producers during the next four years, Horace L. Haldeman and C. Ross Grubb decided in 1899 to retire from the iron business.[133] The properties were sold or leased, and in 1911 the furnaces

were demolished with the exception of the engine house of Chickies Furnace No. 2, which survives today.[134]

None of the other anthracite furnaces in Lancaster County apparently were managed with the enterprising skill and success that characterized E. Haldeman and Company and the Chickies Iron Company. The men behind this business were noteworthy. Already mentioned were Professor Samuel S. Haldeman and Dr. Edwin Haldeman, both well-educated in the sciences and in the classical studies. Professor Haldeman was the senior partner of E. Haldeman and Company, and upon his retirement in 1869, his brother, Edwin, became the managing director, having given up his medical practice many years earlier. Dr. Haldeman died in 1872, whereupon the mantle of leadership was placed on the shoulders of his youngest brother, Paris, who had entered the firm 1 October 1852. Another brother, Cyrus Summerfield Haldeman, became a partner in 1848, but never assumed an active role in the works, having been crippled when a furnace arch collapsed on him. When Professor Haldeman retired, he sold his interest to the heirs of Edward B. Grubb who had just purchased the Eagle Furnace from Stephen F. Eagle. The exchange of interests of the Haldemans and the Grubb heirs facilitated the common ownership and operation of both furnaces. E. Haldeman and Company became the owner of Eagle Furnace, renamed Chickies Furnace No. 2, in November, 1869.[135]

Horace L. Haldeman, a son of Cyrus, purchased an interest in the firm on 6 April 1872, and became its secretary-treasurer. E. Haldeman and Company was dissolved as a partnership on 13 March 1876, and was reorganized as a corporation, using the style, "Chickies Iron Company." Paris Haldeman was the president, and his nephew, Horace, continued in the new firm as secretary-treasurer. In 1888, another corporation was formed by Paris and Horace Haldeman, and C. Ross Grubb under the style, "Haldeman, Grubb and Company," to serve as an operating company.[136]

Conestoga Furnace

Conestoga Furnace was built in 1846 as a charcoal furnace near the Conestoga Slackwater Navigation at the foot of South Prince Street in Lancaster. George Ford, an enterprising Lancaster attorney, and Robert and James Colvin erected the furnace, hoping to make use of the canal to bring cordwood from York County to the furnace where it would be converted to charcoal. Burning the cordwood in the vicinity of the furnace was the traditional practice when Lancaster County was fairly covered by woodland. The Colvins already had established a record of failure at the Shawnee Furnace in Columbia; soon George Ford's money was not sufficient to keep the works in operation.[137]

On 7 November 1850 a deed of trust was executed to Henry Reed, a banker, and Thomas Baumgardner, a prosperous coal merchant of Lancaster.[138] Mathias Graeff acquired the property next, and leased it to Christian Kieffer. At that time the blowing apparatus was powered by water supplied from a 16-foot head. On 31 March 1853 John Frederick Shroder and John Black purchased the furnace.[139] Shroder was a private banker and promoter of industrial enterprises; Black was an officer of the Lancaster Locomotive Works, the foundry of which required much pig iron. After thirty days of rumination, Shroder and Black sold the furnace to Christopher Geiger, George M. Steinman, and John C. Hager, trading as Geiger and Company.[140]

Geiger and Company converted the furnace to use anthracite coal. The original 36-foot stack was extended two feet. The 11-foot bosh was retained. The blast machinery, although now powered by steam, did not include any innovations found among the furnaces having progressive management. Air pressure and temperature were less then those employed at furnaces along the Susquehanna River near Marietta. Its annual rated capacity was 4,000 tons.[141]

Iron ore was obtained from several deposits in the lower end of the county, and limestone was carted to the furnace from East Petersburg.[142] Transportation facilities were a problem to the Conestoga Furnace until 1875 when the Quarryville Branch of the Reading and Columbia Railroad was constructed adjacent to the furnace, connecting it to the ore pits, and to economical sources of limestone and coal. The Conestoga Slackwater Navigation failed and ceased operation during the Panic of 1857, and with it the Conestoga Furnace.[143] On 10 November 1865, Geiger and Company sold the furnace to Benjamin B. Thomas of Philadelphia for $22,500.[144] A. H. Peacock, a native of Reading, and experienced in furnace and forge operation, purchased an interest in the furnace in 1867.[145]

In 1872, Thomas and Peacock enlarged and remodeled the furnace, increasing its capacity to 6,500 tons.[146] Thomas died in 1878, and the firm was reorganized as Peacock and Thomas, the former owner's son, Robert, having succeeded to his father's interest. Additional remodeling brought the furnace capacity up to 7,500 tons, and during the 1880s the works were in blast most of the time, giving employment to 150 men.[147] Among Peacock's business interests were the Penn Iron Company of which he was a director, several iron furnaces elsewhere in Pennsylvania, and the Lancaster and Reading Narrow-Gauge Railroad of which he was an incorporator, and later president.[148] This railroad eventually became the Quarryville Branch of the Reading and Columbia Railroad. On 15 July 1890, the Conestoga Furnace was damaged extensively by fire.[149] The furnace was blown out for the last time on 26 August 1892.[150] Shortly

after the furnace closed, Mr. Peacock died, and the City of Lancaster condemned much of the furnace property for the extension of South Prince Street directly south to the Conestoga River at Engleside.[151]

Marietta Furnace No. 1

Marietta Furnace No. 1 was erected in 1848 by Henry Musselman and Dr. Peter Shoenberger, a physician of Pittsburgh who had a number of iron furnace interests. Shoenberger was Mrs. Musselman's uncle, and father-in-law of Henry Miller Watts, another Marietta ironmaster.[152] Originally Marietta Furnace No. 1 was thirty-three feet tall, with a ten-foot bosh. Its annual capacity was 3,800 tons. In its first full year of operation the furnace yielded 3,763 tons.[153] Dr. Shoenberger died in 1854, and Henry Miller Watts acquired his interest. Musselman and Watts enlarged the furnace slightly in 1856, but generally the furnace was representative of its neighbors east of Marietta. In 1867, after two additional furnaces had been built by Musselman and Watts, the firm dissolved its partnership, dividing the furnace properties into two equal shares. Henry M. Watts and Sons took Marietta Furnace No. 1 and No. 2; and Henry Musselman and Sons kept the newest furnace, then called Musselman Furnace.[154] Henry M. Watts and his two sons, Henry Shoenberger Watts and Ethelbert Watts, operated Marietta Furnace No. 1 in conjunction with No. 2 furnace, thereby exploiting labor and raw material purchasing advantages. The financial difficulties of 1873 caused Marietta Furnace No. 1, along with nearly every other local furnace, to go out of blast until the iron trade recovered.[155] Ethelbert Watts announced in February, 1866, that he planned to rebuild the Marietta furnaces, and possibly add a rolling mill.[156] The furnaces were enlarged, Marietta Furnace No. 1 being raised to fifty feet in height, with a twelve-foot bosh. No rolling mill was built, however.[157]

Late in January, 1889, rumors were heard in Marietta that the Marietta furnaces had been sold to the Columbia Rolling Mill Compnay which planned to construct a rolling mill on the site, making use of pig iron from the adjacent Vesta Furnace, then owned by the rolling mill firm.[158] These plans failed to materialize. The property then was purchased by George Dawson Coleman, who died 16 October 1891, in Paris, France. His death precipitated a spectacular law suit in which his widow sued Coleman's mother for a rightful share of the Marietta furnaces.[159] In all probability the "rightful share" was not worth the court and attorney fees because the furnaces had been abandoned and were obsolete.

Donegal Furnace

Situated immediately east of Marietta Furnace No. 1 and west of Stephen Eagle's furnace, Donegal Furnace was erected late in 1847 by three

experienced iron investors, James Myers of Columbia, Dr. George N. Eckert of Schuylkill County, and Daniel Stine of Lebanon County.[160] The latter two men also were stockholders and incorporators of the Chestnut Hill Iron Ore Company. Stephen Eagle sold three tracts amounting to thirteen acres to the three men for $5,326.63½.[161] According to the firm's account books, the first coal was purchased on 15 April 1848, the first iron ore (from the Chestnut Hill ore banks) on 30 April 1848; and the first pig iron sold to Curtis and Hand of Philadelphia on 2 August 1848.[162] From these accounts it may be assumed the furnace was blown in during May, 1848. Also revealed by the firm's old ledgers and journals was the frequent buying and selling of raw materials and pig iron between the neighboring ironmasters. Donegal Furnace was financed by notes on the Lancaster Bank in addition to the partners' other resources. Occasionally notes were taken on the Lebanon Bank. Sales of pig iron usually were covered by drafts and notes, the latter advanced by the factors who operated as commission merchants.[163]

On 15 January 1856, George Eckert sold part of his interest to James Myers for $17,000.[164] D. E. Benson later became Myers' partner until Myers' retirement at the end of 1872, following which Dr. Joseph F. Cottrell, a son-in-law of Myers, formed a partnership with Benson.[165] Benson and Cottrell operated the furnace until 1887 when it was taken out of blast and allowed to deteriorate. According to reports submitted to the Commonwealth and to the American Iron and Steel Association, Donegal Furnace never was enlarged or remodeled extensively.[166] Its maximum annual production was reached in 1879 when 5,333 tons of iron were smelted in 360 days.[167]

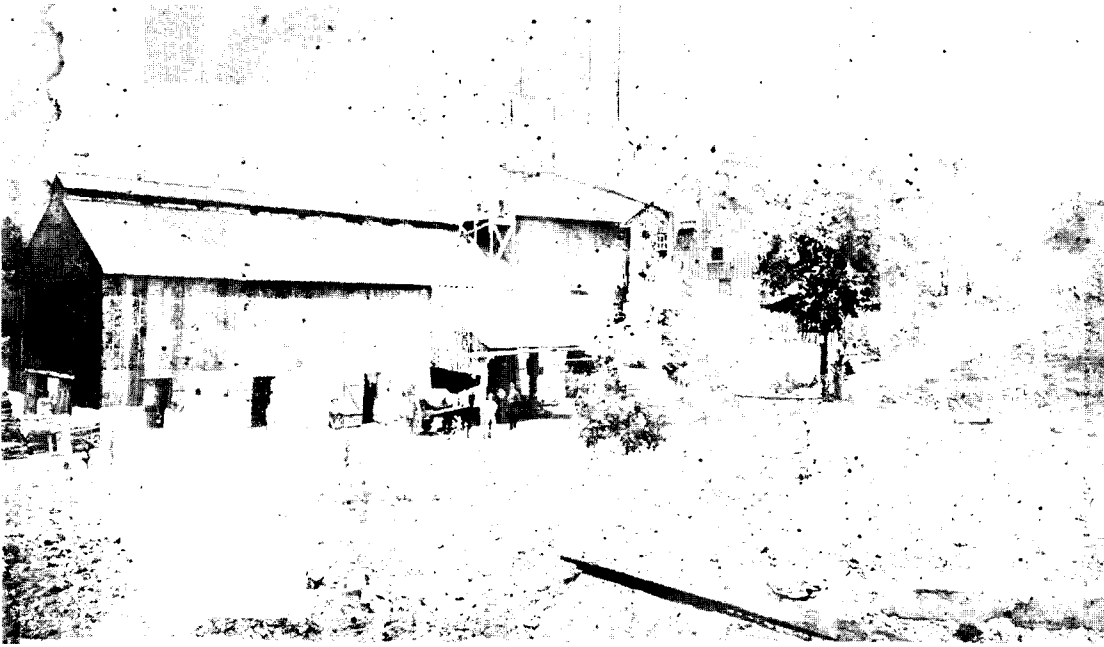
Cordelia (Rough and Ready) Furnace

Cross and Waddell built an anthracite furnace in 1848 at Cordelia, a hamlet located one-half mile southwest of Ironville in West Hempfield Township. Originally the stack was thirty-one feet tall, and had a bosh of eight and one-half feet. Annual rated capacity was 2,000 tons. In 1849, the furnace produced 250 tons.[168]

Acquiring the property in 1849, the firm of Bryan and Longenecker (George S. Bryan and David Longenecker) tried to better the record of the previous owner but without success.[169] In 1855, Kauffman, Sheaffer and Company purchased Cordelia Furnace, and immediately rebuilt the stack, increasing its height to thirty-five feet, and its bosh to ten and one-quarter feet.[170] During a campaign of forty-eight weeks in 1856, 3,471 tons of iron were produced, despite a destructive fire which ruined the boilers and engine house.[171]

Christian S. Kauffman reorganized the firm in 1866 as a corporation. Kauffman Iron Company, as it was styled, was capitalized for $100,000.

C. S. Kauffman, B. A. Price, M. M. Strickler, Hiram Wilson, and Andrew Jackson Kauffman were the incorporators.[172] A value of $75,000 was set on the furnace at the time of incorporation.[173] C. S. Kauffman, a native of Washington Borough, rose from errand boy to proprietor of the Safe Harbor store before his entrance into the iron business. Kauffman served two terms in the Pennsylvania Senate, and in 1874 was the unsuccussful Anti-Cameron Republican nominee for Congress.[174] Among his interests were the Reading and Columbia Railroad, Columbia and Port Deposit Railroad, Columbia Iron Company, and the Susquehanna Iron Company.[175]



Cordelia or Rough and Ready furnace near Ironville about 1880. Ruins of this furnace survive adjacent to the Twin Oaks swimming pool.

The iron depression of 1873 struck hard at Cordelia Furnace, bringing to an end a campaign begun over three years before, in 1869.[176] In November, 1874, Kauffman's Cordelia Furnace was still out of blast, and *The Columbia Spy* was of the opinion the furnace had deteriorated beyond repair.[177] Finally, Kauffman's assignees sold the furnace property at public sale on 20 September 1876.[178] The Cordelia Iron Company was formed in 1881 by Hugh M. North, Esquire, to rehabilitate and operate the furnace. After six years the firm took the furnace out of blast, and pursued only the ore-mining rights attached to the property.[179]

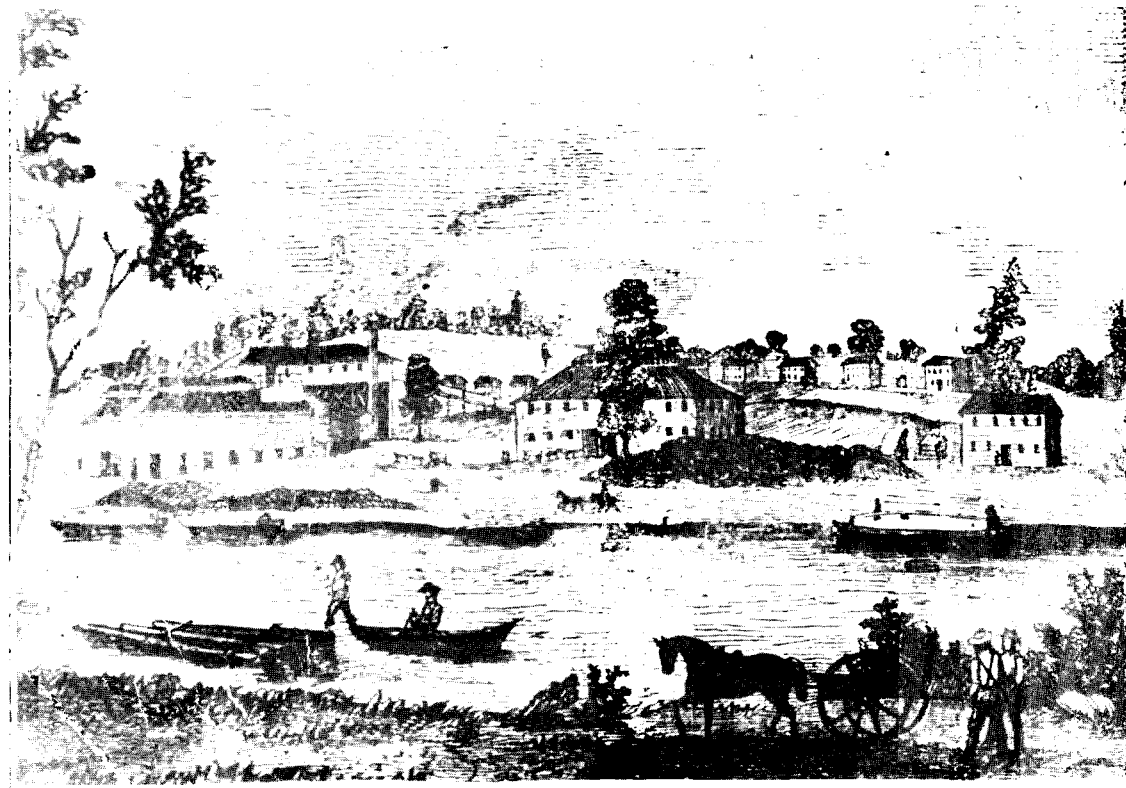
Safe Harbor Furnace

Two factors—large deposits of iron ore nearby and canal transportation—convinced a group of Philadelphia investors and iron manufacturers that Safe Harbor would be an exceptionally desirable site for an integrated iron works. They envisioned a large anthracite furnace, a rail rolling mill, and numerous ore pits within easy transportation of each other. David and Samuel J. Reeves, Dr. Joseph Pancoast, and Charles and George Abbott organized the Safe Harbor Iron Works, which was operated under the firm name of Reeves Abbott and Company. To obtain a commercial waterway and water supply, the firm purchased the franchise of the Conestoga Navigation Company in 1846.[180]

Erection of the furnace structure and rolling mill buildings began in 1846, but pig iron production did not begin until August, 1848. More than $200,000 were invested in the construction. The furnace stack was forty-five feet high, with a fourteen-foot bash. Waste gases were used only to heat the air blast, the builders evidently deciding the size of the mechanized operations would require more steam power than could be obtained solely from waste gases. Eight forty-foot boilers with thirty-eight inch tube sheets provided steam to operate engines for the blast machinery and a coal hoist from the canal boats. Raw materials were transported to the furnace top by means of a bridge from a nearby hill. Fitted with six tuyeres, the furnace was supplied with a blast heated to 450°. Annual rated capacity was 5,000 tons although contemporary accounts describe the weekly output as 120 tons, and reports submitted to the ironmakers' association show the maximum annual production to have been 2,879 tons.[181]

One unusual feature of the furnace was the shape of its inwalls which were perfectly plumb rather than tapered inward above the bosh.[182] Whatever benefit the plumb walls may have had in that early furnace was lost by rapid attrition of the fire bricks until fire clay from North East, Maryland, was discovered to resist the fiery blast.[183] Production of pig iron from the furnace could not keep pace with the demand of the rolling mill, necessitating expensive transportation of pig iron from other furnaces, mainly the Shawnee Furnace in Columbia, and the Chulasky and Franklin furnaces near Danville, Pa.[184] Foundry iron and mill iron were not the same, and not all furnaces produced the latter. Meanwhile, the company decided to enlarge its rolling mill capacity to produce rails needed by the Pennsylvania Railroad, but to purchase additional pig iron rather than build another furnace as had been proposed earlier by Reeves, Abbot and Company.

Creditors of the company became somewhat uneasy in 1855 while the expansion was in progress despite nominal solvency of the firm—approxi-



The Safe Harbor Iron Works as it appeared in 1853. The anthracite iron furnace is at the left.

mately $2,000,000 in assets over liabilities. After learning the Safe Harbor Iron Works employees had agreed to work without pay until the cash solvency situation improved, the creditors agreed to a plan where the liabilities, such as invoices for coal and pig iron, would be discharged over a twenty-seven month term.[185]

The Safe Harbor Iron Company was incorporated by an act of the General Assembly 5 May 1855, with David and Samuel Reeves, George and Charles Abbott, John Griffin, Joseph Pancoast, Charles W. Morris, James and Samuel Millikin, Isaac Pennock, WIlliam Stokes, Wyatt Miller, Bertram A. Sheaffer and George M. Steinman as incorporators. Capitalization was set at $500,000.[186]

A freshet in February, 1857, caused a temporary suspension of the rolling mill but not the blast furnace; rumors began circulating at once, however, that the furnace had chilled and would be closed indefinitely.[187] By September, 1857, the Panic of 1857 had struck railroad expansion projects, cutting orders for Safe Harbor rails. The company defaulted on payments to its creditors who did chill. Again a meeting of creditors was held in Philadelphia with Christopher Hager, a Lancaster merchant and industrial promoter, presiding. And again the creditors were impressed by the ratio of assets to liabilities, and the possibility of the Safe Harbor Iron Works reaching a more favorable cash position within the following twenty-

The rolling mill is at the right.

nine months.[188] Mid-January of 1860 was to be the target date for the discharge of all except current liabilities. Little did the creditors expect that date to herald the rumblings of secession, but general revival and recovery in industry enabled the company to honor their obligations.[189]

The Civil War presented a new demand to the iron manufacturers. The Safe Harbor Iron Company turned to the production of heavy ordnance for the Union forces, smelting pig iron from the Camargo ores of Eden Township favored by U. S. Navy Admiral John A. Dahlgren for naval guns. Conewingo Furnace, using charcoal, made pig iron from the same ore, allegedly for the Safe Harbor Rolling Mill.[190]

Whether the Safe Harbor Iron Company would have returned to the production of railroad iron after the Civil War is a matter of conjecture, for the Susquehanna River in a raging flood on 18 March 1865, tore out the dam across the river at Safe Harbor, destroying the facilities of the Conestoga Navigation and the Susquehanna and Tidewater canals, thereby ending canal transport of materials and stock. After the construction of the Columbia and Port Deposit Railroad in 1875, consideration was given to reopening the rolling mill, but the Safe Harbor Furnace never went back into blast after 1865.[191] A portion of the stone stack remains as a lonely sentinel of what the *Pottsville Miners' Journal* called "a town which gives promise of becoming one of the most important manufacturing cities in the United States."[192]

Marietta Furnace No. 2

Erection of Marietta Furnace No. 2 occurred in 1849, a year after its sister furnace, No. 1, was constructed by Shoenberger and Musselman. Originally the same size as its earlier twin, thiry-three feet in height with a ten-foot bosh, Marietta Furnace No. 2 was not enlarged and modified to the extent of the other stack.[193] Early production records indicate No. 2 furnace was a "stand-by" stack, used to meet peak demands of the iron trade.[194] Inasmuch as it was operated in conjunction with Marietta Furnace No. 1 with the same ownership, which has been described previously, Marietta Furnace No. 2 offers little of individual merit to justify extended commentary.

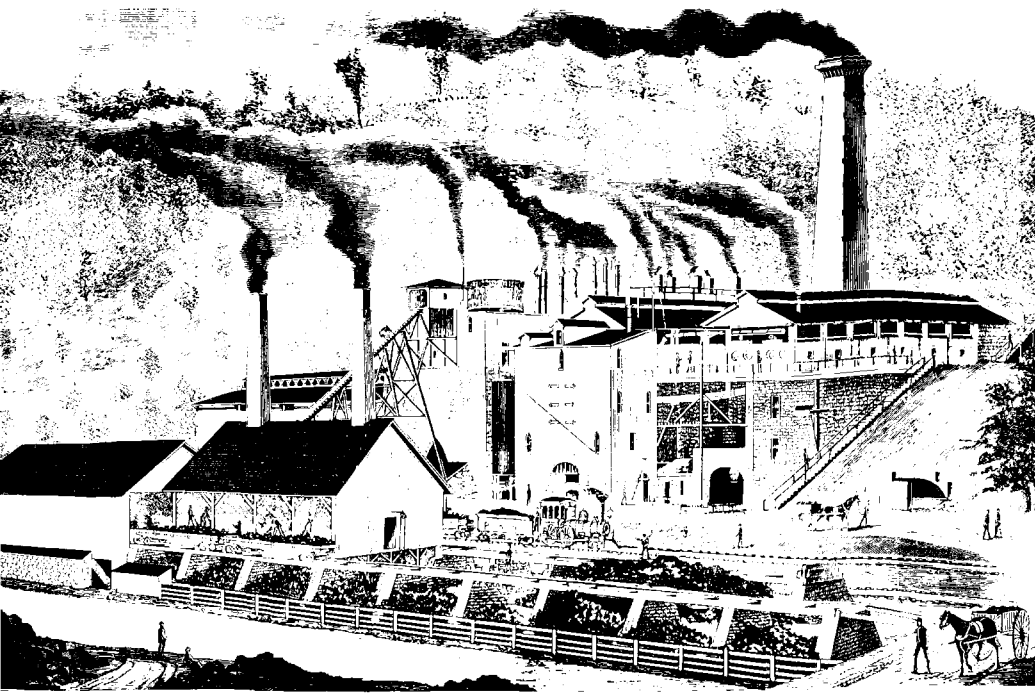
St. Charles Furnace

Clement Brooke Grubb, an ironmaster from a family long identified with the mining of iron ore and the manufacture of iron, built St. Charles Furnace north of Columbia, along the Susquehanna River in 1852. The furnace came by its name as a result of the Grubb family's affection for the "Martyred King," Charles I, who had borrowed two hundred pounds from Lord John Grubb "to aid the King in defending the realm and the church against his enemies." The Grubbs were "High Churchmen," a tradition that persisted down to and including Clement Brooke Grubb with few deviations. Grubb, in addition to his many iron interests, was president of the First National Bank of Lancaster. He served as a vestryman of St. James's Episcopal Church in Lancaster, and was an early member of the Union League of Philadelphia.[195]

St. Charles Furnace, when erected, was forty-two feet high, with a fourteen-foot bosh. The annual rated capacity was 5,500 tons. Its blast was heated to 612° and was supplied through three tuyeres under four pounds per square inch pressure.[196]

On 14 June 1856, *The Columbia Spy* reported, "The St. Charles Furnace has again been put in blast under the most favorable auspices. The way she started off was most satisfactory."[197] A month later the cast house was destroyed by fire, but skillful handling of the furnace by Mr. Reed, the founder, enabled repairs to be made and the furnace put back in blast within seventy-two hours. Observed the *Spy,* "At the time of the fire (July 17) the furnace was working badly, and now is doing quite well."[198] By 23 August the furnace was yielding about 100 tons of iron per week.[199]

Examination of photographs of St. Charles Furnace reveals the presence of a large ore roasting oven. This was the first among the Lancaster County furnaces, and was erected in November, 1863, to remove the high



A print of St. Charles furnace about 1880. This print appeared in Ellis and Evans "History of Lancaster County (1883)". The furnace was located just above Columbia and along the Susquehanna River at the eastern approach of the Wright's Ferry Bridge. The Pennsylvania Canal is in the foreground.

sulfur content of the ore used locally. Grubb prepared ore in the roaster of other furnaces.[200]

Events occurring at the furnace always were grist for the newspaper mills; then, as now, newspaper stories "played up" the distressing news, and occasionally they did not allow the facts to stand in the way of a good story. One such instance concerned St. Charles Furnace in 1871:

> St. Charles Furnace unfortunately became chilled one day last week, and in consequence had to be blown out. This will necessitate a great deal of labor and expense, as the cupola contains about 6 feet of solid iron, and to remove the salamander the entire front of the stack will have to be torn away. This is very unfortunate for Mr. Grubb, as well as the many workmen who are thrown out of employment by the accident.[201]

After some sleuthing, the *Lancaster Daily Express* reported:

> The article in the *Columbia Courant* is incorrect. There is not 6 feet of solid iron in the stack, nor the third of it, as Mr. Reed, the manager, is more of an expert at conducting business than to allow any such gross neglect as that to occur. The fact of the matter is, that the furnace has not been working well lately and consequently, the chill could not have occurred at a more seasonable period.[202]

In 1872, Clement B. Grubb took his only son, Charles Brooke Grubb, into the firm which then was known as C. B. Grubb and Son.[203] Columbians read with satisfaction to their *Spy* on 8 March 1873 that St. Charles Furnace had produced 146 tons of iron during the previous week, that being the

best week in the history of the furnace; moreover, no scrap metal had been worked into the furnace.[204] Three weeks later *The Spy* announced St. Charles Furnace was to be sold and torn away, and that C. B. Grubb and Son would erect a new furnace east of Columbia on the Strickler tract. There was the possibility that two furnaces would be built.[205] Grubb and Son apparently changed their minds, because St. Charles Furnace remained a landmark on the northwestern edge of Columbia until 1892. Ruins of the stack are visible beneath the approach piers to Wright's Ferry Bridge.

At the conclusion of 1873, the furnace management reported production of 6,590 tons—244 tons of which were high phosphorus content "white metal"—was the greatest yield of the stack up to that time.[206] Joseph Eckman was furnace manager during this period.

C. B. Grubb and Son in 1877 purchased the Henry Clay Furnace located at Jones's Hollow about 1½ miles upstream and renamed it "St. Charles Furnace No. 2." Clement B. Grubb began losing his sight in 1881, and he retired from active management of his various interests. He had built a fine mansion in 1845 in Lancaster in the block bordered by North Lime, East Chestnut, North Shippen, and East Marion streets; and in this handsome Greek Revival townhouse Grubb lived out the rest of his life. He died 31 October 1889.[207] He was survived by his widow, Mary Brooke; his unmarried son, Charles B., who died 12 November 1911; his unmarried daughter, Daisy E. B., who continued to live in the mansion until her death 11 September 1936: Harriet Brooke Grubb Irwin (1842-1906); Mary Lilly Brooke Grubb Beall (d.1916); and Ella Jane Grubb Smith (d.1920). Mrs. Smith's husband, Colonel L. Heber Smith, was an ironmaster. Their son, L. Heber Smith, Jr. married Nellie Baer, daughter of George F. Baer, famous president of the Philadelphia and Reading Railroad, thus binding tighter the iron, coal and railroad interests of Pennsylvania.

A serious accident occurred at the furnace on 3 May 1883:

> A twier [sic] burst at the St. Charles Furnace about 1:00 a.m. this morning and opened a rent in the cupola through which the molten iron escaped. The roof of the casting house was destroyed and several adjoining buildings were destroyed. A horse was swallowed up in the molten metal. Columbia firemen put out the fire.[208]

Despite the suspension of operations at the Chestnut Hill Iron Ore Company's furnaces and mines, which left 700 men unemployed, St. Charles Furnace No. 1 and No. 2 were working at capacity with a full complement of workmen.[209] The stack of No. 1 had been increased to fifty-two feet in 1880 by the addition of a sheet iron stack top and thimble, and now the furnace was able to produce as much as 276 tons in a week, or nearly 14,000 tons annually, which the *Spy* thought was a record few anthracite furnaces could match.[210] Three years later St. Charles Furnace

was blown out for the last time, a victim of technological obsolescence and the depressed iron trade. Nearly 100 men were thrown out of work.[211]

Eagle Furnace (Chickies Furnace No. 2)

Stephen Frank Eagle owned much of the land east of Marietta to the Chikiswalungo Creek, and sold parcels on which were erected the Marietta furnaces and Donegal Furnace. In 1854 he decided to build an anthracite furnace in the point of land between the Pennsylvania Railroad and the Pennsylvania Canal, a short distance west of the Chikiswalungo Creek. When the Eagle Furnace was blown in during 1855, it was thirty-five feet high, with a twelve-foot bosh. To finance and operate the furnace, Eagle formed a partnership with Peter Haldeman and Joseph W. Cottrell, a hardware merchant, both of Columbia.[212] A few years later the firm was dissolved, and Eagle, Beaver and Company replaced it; Beaver was the manager.[213] The heirs of Edward Bates Grubb purchased the furnace in November, 1869, and formed an alliance with E. Haldeman and Company, bringing the Eagle Furnace under the latter's management.[214] At this time the furnace was renamed Chickies Furnace No. 2. In 1870, the stack was raised to forty-five feet, and in 1889 the furnace was rebuilt extensively.[215] At this time the engine house which is now used by the Marietta Metal Products Corporation was built; its distinctive fenestration has been likened to a giant "face" peering balefully over the wasteland that once was a bustling industrial center. Operations at this furnace ceased after 1899.[216]

Vesta Furnace

The last complete blast furnace to be constructed in Lancaster County, Vesta Furnace, or, as it was known originally, Musselman Furnace, and later Codorus Furnace, was built in 1868 by Henry Musselman and Henry Miller Watts. Until 1879, the stack was forty-one feet high, with a thirteen-foot bosh. The following year it was raised to sixty feet, with a fourteen-foot bosh. [217] Henry Musselman and Sons sold the furnace in 1879 to a limited partnership association trading as Watts, Twells and Company, Ltd. for $40,000. Ethelbert Watts, John Steel Twells, and Eugene Borda each had $23,333.33 invested in the partnership, including the purchase cost of the property. The partnership was to run for a term of twenty years.[218] Borda was a Philadelphia iron works speculator, and by 1886 he came into control of the furnace.[219] Remodeling of Vesta Furnace in 1886 increased the stack height to sixty-five feet, after which the annual rated capacity of the furnace was 22,500 tons.[220]

In 1887 Vesta Furnace was owned by the Columbai Rolling Mill Company. Within a year, on 4 April 1888, the furnace was blown out and "a large number of workmen" were made idle.[221] Several attempts were made to resume operations, but the Panic of 1893 and competition

Vesta furnace about 1882 during the ownership of Watts, Twells & Co., Ltd. The office building at right is still standing.

from modern blast furnaces owned by integrated corporations precluded any enduring success. When the Susquehanna Iron and Steel Company was formed in 1898 to acquire and operate blast furnaces and rolling mills in the lower Susquehanna valley, Vesta Furnace received a new lease on life. The stack was rebuilt in 1900 and two Whitewell stoves were installed to provide a more effective hot blast. A combination of coke and anthracite coal was used for fuel. Neutral forge and foundry pig iron was produced. The furnace had a capacity of 30,000 tons annually.

The Susquehanna Iron and Steel Company had acquired the Columbia Rolling Mill, Susquehanna Mill, East End Mill and Union Street Mill, all in Columbia; and the Aurora Furnace in Wrightsville as well as the Vesta Furnace at Marietta. The Aurora Furnace was nearly identical in age, size and design to Vesta, and it received the same modernization. In addition to these plants the Company installed a pipe mill near the Columbia Rolling Mill. Pig iron from the two furnaces was converted to muck bar and skelp in the rolling mills after which the skelp was manufactured into buttweld and lapweld wrought iron pipe.[222]

Hopes of the incorporators failed to materialize, and in 1902 the Corporation executed a mortgage to secure an issue of $300,000 in bonds. When this step failed to rescue the floundering company a receiver was appointed who sold the properties in 1907 to the newly-incorporated Susquehanna Iron Company. Officers of the Susquehanna Iron Company were Charles Brock, president; Edward T. Edwards, vice president; Martin N. Klepper, secretary; and Michael Blake, treasurer. Directors were P. B. Shaw, T. C. Detweiler, Congressman William W. Griest, Blake and Edwards.[223] Most of the efforts of the new corporation were directed to

selling off the various properties. The Vesta Furnace was sold in 1917 to E. J. Lavino of Sheridan, Pa. During World War I the furnace was used to smelt scrap and to produce spiegeleisen, a variety of pig iron containing 15 to 30 percent manganese and 4.5 to 6.5 percent carbon. Furnace buildings and stack were removed about 1934.[224] Only the office building, the foundation of Watt's Station, and a row of workers' houses survive.

Conclusion and Commentary

Technological advancements in iron smelting in Pennsylvania lagged about a half century behind that of England, and such improvements seemed to occur primarily as a result of pressures from the economic factors of demand, supply and price. After the first decade of anthracite iron blast furnace experience in Lancaster County the ironmasters paid more attention to price and profit differentials than they had previously.

As the depletion of woodlands near the old charcoal furnaces made the costs of transportation a significant factor, the development of canal and railroad networks facilitated the construction of anthracite iron blast furnaces along such avenues of commerce. Moreover the means to transport the pig iron to foundries and rolling mills were at hand.

Although charcoal iron was thought superior to anthracite iron, the changing requirements of production permitted the use of anthracite iron in making machinery, rails, and castings. The local blacksmith and country works, using charcoal iron for agricultural implements, already were becoming a thing of the past.

Beyond the purview of this thesis are several important questions it may aid in finding answers. We should know more about the character of the market forces that stimulated and governed the anthracite iron industry of Lancaster County. Absence of most financial and manufacturing records frustrates most efforts to learn what impact income, cost advantages, and price elasticity had on the local iron industry. To these we could add the interesting factors of social costs and influence on country life and culture as, for example, the great influx of Welsh immigrants to work in the local rolling mills.

A Note on the Sources

Most documentary sources of information for the blast furnaces and rolling mills are to be found in the U. S. Census reports for 1850, 1860, 1870; reports and directories of the American Iron Association and American Iron and Steel Association; and the Industrial Reports of the

Secretary of Internal Affairs of the Commonwealth of Pennsylvania. The veracity of these data depend almost entirely on the willingness of ironmasters and corporation officers to provide accurate information. That some were unwilling to make this effort is evident when cross-checking the records. Moreover, census enumerators were careless in obtaining information in many instances, and the records themselves have been lost for some townships—an indictment especially of the 1850 census. Past writers working from these records have been misled. An example of such discrepancies will illustrate the problem:

	Anthracite Blast Furnaces	Rolling Mills
U. S. Census of Manufactures, microfilm from National Archives		
1850	7	0
1860	7	1
1870	7	3
U. S. Census of Manufactures, enumerator reports in State Library, Harrisburg		
1850	6	1
1860	8	3
1870	10	3
Actual count from documented research		
1850	10	1
1860	12	3
1870	13	5

Notes

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2. Theodore A. Wertime, *The Coming of the Age of Steel,* (Chicago, Ill.: The University of Chicago Press, 1962), pp. 44-46.

3. Birkinbine, *op. cit.,* p. 66.

4. *Ibid.,* pp. 10, 25.

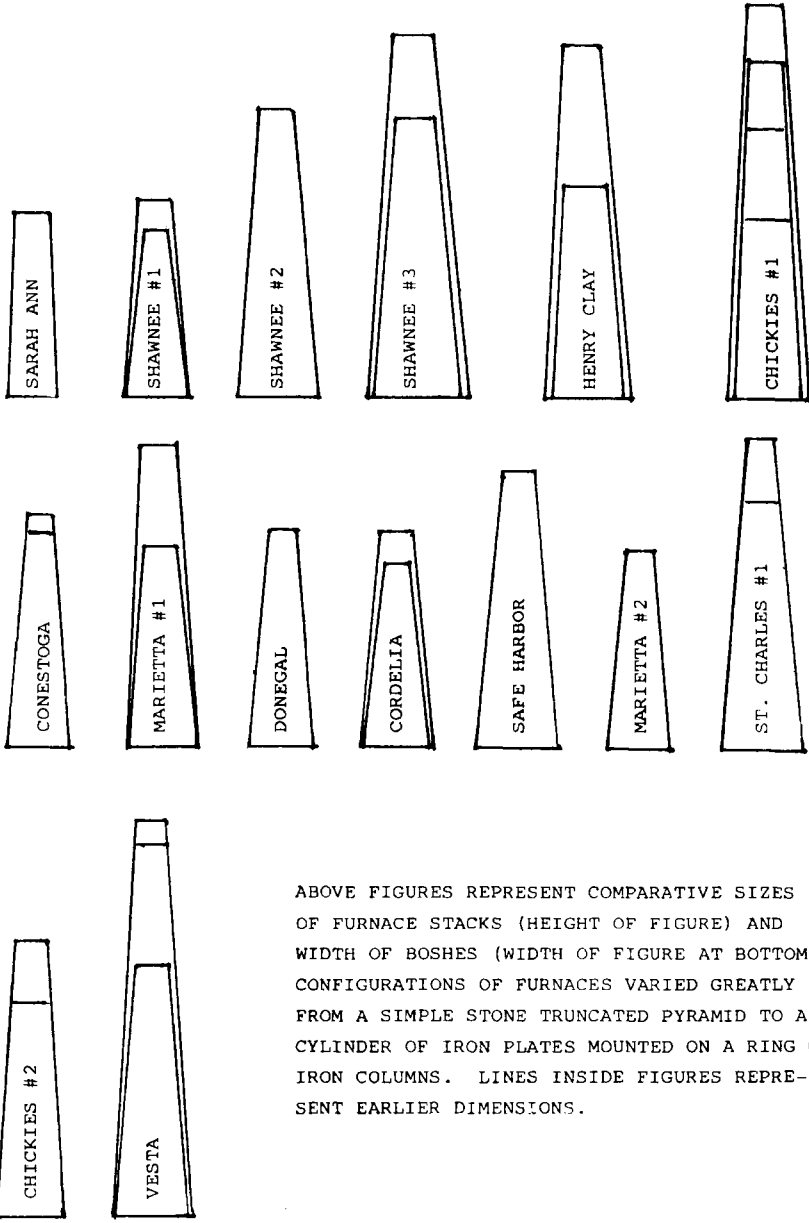
5. Ernest J. Teichert, *Introduction to Ferrous Metallurgy* (The Pennsylvania State College Mineral Industries Series, Vol. I; New York, N.Y.: McGraw-Hill Book Company, 1944), pp. 338-343.

6. Birkinbine, *op. cit.,* pp. 50-51.

7. Peter Temin, *Iron and Steel in Nineteenth-Century America, An Economic Inquiry* (Cambridge, Mass.: The Massachusetts Institute of Technology Press, 1964), p. 96.

8. Birkinbine, *op. cit.,* p. 66.

9. Furnaces equipped with mechanical hoists were the Marietta No.'s 1 and 2



ABOVE FIGURES REPRESENT COMPARATIVE SIZES OF FURNACE STACKS (HEIGHT OF FIGURE) AND WIDTH OF BOSHES (WIDTH OF FIGURE AT BOTTOM). CONFIGURATIONS OF FURNACES VARIED GREATLY FROM A SIMPLE STONE TRUNCATED PYRAMID TO A CYLINDER OF IRON PLATES MOUNTED ON A RING OF IRON COLUMNS. LINES INSIDE FIGURES REPRESENT EARLIER DIMENSIONS.

Donegal, Eagle, Chickies No. 1, Henry Clay, and St. Charles. Photographs, sketches, and lithographic illustrations are in possession of the writer.

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11. *Ibid.*, p. 267.

12. *Lancaster Daily Express,* April 2, 1858.

13. Birkinbine, *op. cit.*, pp. 49-50.

14. Joseph G. Butler, Jr., *Fifty Years of Iron and Steel* (Cleveland, Ohio: The Penton Press Co., 1923), p. 14.

15. Convention of Iron Masters, *Documents Relating to the Manufacture of Iron in Pennsylvania, Published on Behalf of the Convention of Iron Masters which Met in Philadelphia on the 20th of December, 1849* (Philadelphia, Pa.: The General Committee, 1850), Appendix, Table 2. Hereinafter referred to as *Convention of Iron Masters.*

16. Frederick Overman, *The Manufacture of Iron* (Philadelphia, Pa.: n. n., 1854), pp. 428-442.

17. Birkinbine, *op. cit.*, p. 50.

18. Frank Firmstone, "Comparison of Results from Open-Topped and Close-Topped Furnaces," *Transactions of the American Institute of Mining Engineers,* IV (October, 1875), 128-132.

19. Temin, *op. cit.*, p. 97.

20. Integration refers to bringing together under one ownership or control ore and fuel supplies, pig iron production, and manufacturing of wrought iron or steel therefrom.

21. Birkinbine, *op. cit.*, pp. 64-67.

22. Franklin Platt, "Special Report on the Coke Manufacture of the Youghiogheny River Valley in Fayette and Westmoreland Counties," *Second Geological Survey of Pennsylvania* (Harrisburg, Pa.: Board of Commissioners for the Second Geological Survey, 1876), pp. 61-64.

23. Temin, *op. cit.*, p. 56.

24. *Ibid.*, p. 55.

25. *Ibid.*

26. *Ibid.*, p. 80.

27. *Infra,* p. 40.

28. *Infra,* pp. 30, 40, 46, 48.

29. Douglass C. North, *Growth and Welfare in the American Past* (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1966), pp. 149-151; Victor S. Clark, *History of Manufactures in the United States* (Washington, D. C.: Carnegie Institution of Washington, 1929) II, 221-228; *infra,* p. 76.

30. *The Columbia Spy,* January 21, 1882.

31. Birkinbine, *op. cit.*, pp. 64-65.

32. *Infra,* p. 41.

33. Wittlinger, *op. cit.*, p. 176.

34. Persifor Frazer, Jr., "The Geology of Lancaster County," *Second Geological Survey of Pennsylvania* (Harrisburg, Pa.: Board of Commissioners for the Second Geological Survey, 1880), pp. 203-245. See Appendix D.

35. *Ibid.;* Jack Locher, "A History of Mining in Lancaster County: 1700-1900," *Journal of the Lancaster County Historical Society,* LXIV (Winter, 1960), 6-8.

36. Wittlinger, *op. cit.*, p. 168.

37. Locher, *op. cit.*, p. 6; *Annual Report of the Secretary of Internal Affairs for 1874-1875* (Harrisburg, Pa., B. F. Reyers, 1876) III, 334.

38. *Donegal Furnace Ledger* (1865-1873) and *Journal* (1865-1873), in possession of author. The Baltimore vein of coal near Wilkes-Barre was the origin of the fuel purchased at Donegal Furnace.

39. See Appendix D.

40. James W. Livingood, *The Philadelphia-Baltimore Trade Rivalry: 1780-1860* (Harrisburg, Pa.: Pennsylvania Historical and Museum Commission, 1947), pp. 62, 70.

41. *The Columbia Spy,* October 5, 1850.

42. *Ibid.*, January 20, 1864.

43. *Ibid.*, January 23, 1873.

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48. Ernest Schuleen, "The Story of Safe Harbor," *Journal of the Lancaster County Historical Society,* LXIII (Spring, 1959), p. 89.

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53. Lancaster County, Office of the Recorder of Deeds, *Deed Book,* H-7-26, hereinafter referred to as Deed Book; Charles McCool Snyder, *The Jacksonian Heritage, Pennsylvania Politics: 1833-1848* (Harrisburg, Pa., Pennsylvania Historical and Museum Commission, 1958), p. 123.

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59. Ellis and Evans, *op. cit.,* p. 306; *Deed Book,* Q-7-12. Among the "traditional accounts" are Ellis and Evans; J. I. Mombert, *An Authentic History of Lancaster County, Pennsylvania* (Lancaster, Pa.: J. E. Barr and Company, 1869), p. 491; and John B. Pearse, *A Concise History of the Iron Manufacture of the American Colonies up to the Revolution, and of Pennsylvania until the Present Time* (Philadelphia, Pa.: Allen, Lane and Scott, 1876), p. 221.

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69. *The Columbia Spy,* 14 June 1856.

70. *Ibid.*, 14 September 1867. See entries in *A Directory of Iron Works in the United States, 1874* (Philadelphia, Pa.: The American Iron and Steel Association, 1874), p. 19, hereinafter referred to as *Directory of Iron and Steel Works, 1874; Directory of Iron and Steel Works, 1894, op. cit.,* pp. 17-19.

71. *Directory of Iron and Steel Works, 1894, op. cit.,* pp. 17-19.

72. *Centennial Map of the Borough of Columbia, Lancaster County, Pa.* (Philadelphia, Pa.: H.J. Toudy Co., 1888); *The Columbia Spy,* 21 January 1882.

73. *Ibid.*

74. Commonwealth of Pennsylvania, *Annual Report of the Secretary of Internal Affairs for 1880-1881* (Harrisburg, Pa.: Lane S. Hart, 1882) IX, Part 3, p. 30, hereinafter referred to as *Annual Report of the Secretary of Internal Affairs.*

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76. *Annual Report of the Secretary of Internal Affairs for 1879-1880* (Harrisburg, Pa.: Lane S. Hart, 1881) VIII, Part 3, p. 44.
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80. *Lancaster Daily Intelligencer,* 18 April 1883.
81. *The Columbia Spy,* 8 March 1884.
82. *Ibid.,* 17 May 1884.
83. *Ibid.,* 25 October 1884.
84. *Ibid.,* 22 November 1884.
85. *Ibid.,* 6 December 1884.
86. *Ibid.,* 13 August 1887; 26 November 1887; 19 May 1888.
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90. *Atlas of Surveys of Lancaster County* (Philadelphia, Pa.: Graves and Steinbarger, 1899), pp. 64-65.
91. *The Columbia Broadcaster (Sesquecentennial Edition),* 29 April 1938, section 6, pp. 2, 7.
92. *Convention of Iron Masters, op. cit.,* Appendix, Table 2.
93. *Lancaster Daily Express,* 2 April 1858.
94. Lancaster County, Office of Prothonotary, *Sheriff's Deeds Book,* 2, p. 252.
95. Lancaster County, Office of Recorder of Deeds, *Deed Book,* F-8-217.
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97. Snyder, *op. cit.,* pp. 77-79.
98. *Deed Book,* Q-8-171.
99. Ellis and Evans, *op. cit.,* p. 307.
100. *Deed Book,* M-9-59.
101. *Lancaster Daily Express,* 14 October 1865; *The Columbia Spy,* 30 September 1865. Apparently the depression in the iron trade was localized; generally the iron industry prospered in 1862-1865. See Reginald C. McGrane, *The Economic Development of the American Nation* (Boston, Mass.: Ginn and Company, 1942), p. 308.
102. *The Columbia Spy,* 20 September 1873.
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106. *Annual Report of the Secretary of Internal Affairs, 1876-1877* (Harrisburg, Pa.: Lane S. Hart, 1878) V. Part 3, pp. 46-47.
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111. Alexander Harris, *A Biographical History of Lancaster County: Being a History of Early Settlers and Eminent Men of the County* (Lancaster, Pa.: Elias Barr and Company, 1872), pp. 256-258.
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143. *Lancaster Daily Express,* 14 January 1857.

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157. *Directory of the Iron and Steel Works of the United States, 1894, op. cit.,* pp. 17-19.

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161. *Deed Book,* G-7-548.

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and Stine, Donegal Furnace, 21 September 1852, in possession of the author.

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165. *Donegal Furnace Account Books;* Gramm, *op. cit.*, pp. 145-146.

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167. *Annual Report of the Secretary of Internal Affairs, 1879-1880, op. cit.*, p. 44.

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211. *The Morning News* (Lancaster), 16 September 1891.

212. Gramm, *op. cit.*, pp. 144-145.

213. *Lancaster Daily Express*, 2 April 1858.

214. Haldeman, *op. cit.*, p. 17.
215. *Haldeman Furnace Papers* (copies)
216. Gramm, *op. cit.*, p. 166.
217. *Annual Report of the Secretary of Internal Affairs, 1879-1880, op. cit.*, p. 44.
218. Lancaster County, Office of Recorder of Deeds, *Charter Book* 1, pp. 62-67.
219. Lancaster County, Office of County Commissioners, *Tax Assessment Records*, East Donegal Township, 1886; hereinafter referred to as *Tax Assessment Records*.
220. *Directory of Iron and Steel Works, 1894, op. cit.*, pp. 17-19.
221. *The Columbia Spy*, 7 April 1888.
222. *W. W. Griest Papers*, Lancaster County Historical Society,
223. *Ibid.*
224. *Tax Assessment Records, East Donegal Township*, 1886 to 1939.