CHAPTER I

The American Iron Industry: 1800-1850

Victor Clark claimed that "no single thing better measures the industrial standing of a nation than its use of metal."[1] There are, of course, other appropriate measures for industrial rank; the size of GNP, the amount of energy and types of fuel used, the degree of mechanization and the kinds of building materials employed have all been touted as yardsticks of industrialization. Still, for the nineteenth century, the output of metal is as good a measure as any other. However, to measure the production of iron in nineteenth century America is quite difficult in some periods, impossible in others, and subject to debate in all periods, until 1880 when census data became nearly as complete and reliable as they are today.[2] Hence many of the statements below about the early growth of the American iron industry must be tentative.

Just before the American Revolution, pig iron production was running at about 30,000 tons a year.[3] The industry was widely scattered; by the end of the Revolution every state produced except Georgia.[4] The American iron industry grew quickly after the Revolution as old works were repaired and new ones were established. According to Alexander Hamilton iron manufacturing was "prosecuted with much more advantage than formerly."[5] There is no statistical data available to show how well the iron industry was doing, but it was evidently prospering as the new century began.[6]

The first specific production data available after the Revolution is for the year 1810. The census of that year shows the production of 54,000 tons.[7] Unfortunately, there are no further census figures for iron production until 1840. Alternate sources of information are available, but the record is spotty and unevenly reliable.

The next available figure for pig iron output, for the year 1820, is only 20,000 tons.[8] The long commercial crisis of 1815-1820 is the obvious cause of the low production figure. A brilliant recovery lay not far ahead, for by 1828 pig iron production was up to 123,000 tons and by 1830 production was running at 180,500 tons a year.[9]

Crisis 1815-20

The rate of increase trailed off after 1830, and by 1840 annual production stood at about 300,000 tons.

Production then declined for two years before shooting up to 800,000 tons a year in 1847 and 1848. Output then declined, and the new decade of the 1850's opened with a run of 560,000 tons of pig iron.

One of the primary factors in the development of the American iron industry was the continued growth of the market. Population increase was one of the major elements of this growth. In 1800 the population of the United States was over 5.2 million and by 1850 it had expanded to 23.2 million. Per capita consumption of iron in 1810 was 16½ pounds, nearly all of it American made. By 1850 per capita consumption of iron rose to 86 pounds, of which 32 were imported.[10] Domestic production had increased ten times in forty years, while population had increased four and a half times in fifty years.

The increase in iron production was interrupted by the two great commercial crises of the first half of the nineteenth century. The first lasted from 1815 until 1820 and the second stretched from the panic of 1837 into the early 1840's. The 1815-1820 depression had a marked impact upon iron production, reducing it by 1820 to 36 per cent of the rate for 1810. The situation may have been better or worse than this percentage indicates, but the lack of production data of any kind between 1810 and

1815 crisis 36% of 1810

1820 does not allow close analysis. On the other hand, the Panic of 1837 had little immediate impact upon the industry.[11] By 1841-1842 however, iron was taking a beating and the ironmasters in 1842 called for and got tariff protection. The iron trade recovered in 1843, and the iron industry boomed along until 1848 when the year's make was 800,000 tons. Production then drifted downward to 560,000 tons in 1850 and the iron market continued flat for another two years. Temin warns us that the boom of the mid-1840's ought not to be tied too tightly to the tariff changes of 1842, and Clark says that the recovery of the economy at about the time of the enactment of the tariff of 1842 was probably an "assisted coincidence."[12]

The American iron industry achieved its early prosperity without the technological innovations that swept England during the late eighteenth century. That is to say, nearly all American iron was charcoal smelted and refined. Mineral fuels, almost exclusively used in England by 1800, were neglected in this nation until the 1840's. Even then, three quarters of the iron produced was made with charcoal fuel. By the end of the next decade a transformation occurred, for by 1860 only one third of the pig iron was charcoal smelted, one half was made with anthracite coal, and the rest was smelted with coke or bituminous coal.[13]

3/4 iron charcoal

1860-only 1/3

This apparent backwardness was not without advantages. Americans converted the bulk of their pig iron into sheets and bars of wrought iron. Charcoal smelted and refined wrought iron was superior in every respect, save cost, to puddled iron. In most cases the sheets and bars of wrought iron were semi-products which blacksmiths and mechanics made into a variety of finished products. They found that charcoal wrought iron worked easier and more consistently than puddled iron. These superior characteristics of charcoal iron assured it high levels of consumption.[14] Aside from quality, the survival of traditional methods in the early post-Colonial period is also explained by an abundance of wood for charcoal, and by tariff protection against cheap English puddled iron.

The early iron industry was faced with a broad number of demands. America required cast iron for hollow ware, stoves, machinery and plows, but the demand for wrought iron was far more important. From it we made our nails, tools, horseshoes, fire arms, machinery, engines and rails. By 1830, only 15 per cent of the pig iron produced was cast.

Domestic

INDUSTRIAL

Between 1830 and 1850, however, the ratio between cast and wrought iron production underwent a radical shift. By 1850 more pig iron was going into castings than into wrought iron. Cast iron had always been cheaper to make than wrought iron, but the shift in ratios was not simply due to costs, for the production costs of wrought iron was greatly reduced by a technological change between 1830 and 1850. This change was the introduction of the puddling process, with mechanization and the use of mineral fuels, approximately halved the cost of making wrought iron. Thus casting outstripped forging and puddling, in the face of the significant bettering of this cost position of puddled iron.

The ascendency of cast over wrought iron was due to new applications for cast iron. During this period, cast iron was increasingly used for structural beams and columns in fireproof buildings. Some buildings had enormous cast iron facades, and in 1848 James Bogardus erected a four story factory in New York whose primary structure was of cast iron.[15] A number of bridges were made of this material also, but most iron bridges were hybrids, using both cast and wrought iron.[16] Cities used an increasing amount of cast iron pipe for water and gas works.[17] In these forms, although the absolute number of projects was small, a great weight of iron was expended. Further, from the 1830's onward, an increasing amount of cast iron went into the production of steam engines. In 1832, Niles Register reported of engine shafts and bedplates that weighed between thirty and forty tons.[18] Some of the early low pressure steam engines were monsters with very wide bores and long strokes. A mid-century Philadelphia machine shop was equipped to bore castings up to sixteen feet in diameter and up to eighteen feet in length.[19] Again, the use of cast iron by weight was very high.

Even with the iron hungry applications mentioned above, most cast iron went for ordinary uses like pots, skillets and stoves. There is almost no systematic quantitative data to prove this, but one interesting fragment supports the arguments, for Clark asserts that by 1850 the market for stoves was running at about 475,000 units a year.[20] The continued rapid population growth surely maintained a high demand for domestic cast ironware. Domestic

While the foundries that made cast iron enjoyed an unprecedented business after 1830, it must be remembered that wrought iron manufacture was not only undergoing technical changes but also increasing its production. Further, in terms of value, wrought iron goods always exceeded the worth of cast iron production. But as was the case with cast iron, most wrought iron was destined for ordinary domestic purposes like nails, horseshoes, barrel hoops, edged tools, strap iron, hinges and stove-pipe. By weight wrought iron cost from two to four times the price of pig iron. The cost difference to the final consumer was greater yet because wrought iron was an intermediate product and required more labor to be forged or rolled into any kind of finished good.[21] By the 1840's the puddling process began to drive the price of wrought iron down to about twice the price of pig. This in turn tended to drag the price of charcoal wrought iron down. But for certain applications, notably boiler plate, high grade charcoal wrought iron remained sovereign and hence expensive, selling at four times the price of pig iron.[22]

While the bulk of wrought iron consumption went for domestic use, by the 1820's an increasing amount was going into the fabrication of steam engines. At that time there were steam builders located in Philadelphia, New York, Pittsburgh, Cincinnati, Louisville and Steubenville. The shops in these cities made both stationary and steamboat engines.[23]

These vessels required growing amounts of wrought iron for nails, bolts, sheet iron and boiler plate. By the early 1840's some of the large boats had batteries of nine boilers which used about thirty tons of boilerplate.[24] 9 boilers
The number of boats in operation also increased rapidly from 1820, when there were 69 in service, to 1850 when there were 740 in operation.[25] Finally, the boats and their

engines grew larger all the time. It was estimated that these boats lived short, hard lives, averaging only five years in service.[26] The boom in wrought iron consumption for steamboats, their growing numbers, and their high replacement rates was tempered in part by the fact that shipbuilders equipped many of the new boats with old machinery to drive them. For example, in 1849 it was reported that one third of the steamboats in use were running with old engines.[27]

Stationary steam engines also increased rapidly in number after the mid-1830's. In 1838 the Woodbury report indicated that the 1,860 steam engines in this country generated 36,319 horsepower.[28] Typically, a stationary steam engine powered a sawmill, flouring mill, or sugar mill, or it might serve as the power source for a machine shop. Such installations had an average of two boilers 18 to 20 feet long and two and a half to three feet in diameter.[29] Such an installation required two tons of boiler plate for the boilers. If every stationary engine used two tons of boiler plate, all the engines in use in 1838 would have required only about 3,720 tons of that material. While the amount of iron used is not impressive, certain trends were significant. Louisville, Kentucky had shops that had made 240 steam engines of all kinds betwee 1819 and 1838. Of these engines, 67 were for

2 boilers per

boats and the others were for mills and shops. In 1838 only 24 of these engines were more than ten years old. More important is the fact that 149 of them were no more than three years old.[30] A glance at the tables in the Woodbury report shows that there was a marked increase in steam engine production everywhere in the mid-1830's. The demand for boiler plate was good and it would get better. By 1850 engine manufacturers were selling standardized engines out of catalogues "like pumps, plows ... and sewing machines."[31] The trend was up, but as Clark confesses, there is no satisfactory way to determine the precise number and distribution of the steam engines produced before the Civil War.

It was the railroads, when they came, that prodigally increased the demand for wrought iron. They needed it for boilers, rails, spikes and wheels. In the 1830's Philadelphia, New York, Lowell, York, Baltimore and Patterson, New Jersey made locomotives. By 1839 there were 450 locomotives in service and out of these, 117 were imported from England, most of them before 1835.[32] By 1839, the United States had become its own supplier of rolling stock, and imports virtually disappeared. In fact, some imported locomotives crossed paths with American locomotives bound for Europe, for by 1840 American shops had produced locomotives for Russia, Austria, Germany and England.[33]

By 1844 99 engines had been exported, almost evening the imports.[34] Production for the domestic market progressed favorably in the late 1840's. By the end of 1850 American shops had produced at least 1,406 units.[35]

Locomotives, however, were the least important of railroad demands against the iron industry. Everything else the railroads needed, even spikes, used higher tonnages of wrought iron. But it was the demand for rails that taxed the capacity of iron makers most. Until 1857 the United States was a net importer of rails.[36] From the day the first American train rolled until the mid-1840's, imports from England supplied practically all this country's demands for rails.

Initially, the American iron industry simply lacked the capacity to do the job. Pennsylvania, the largest producer of all forms of iron, had an annual bar iron capacity of 21,800 tons in the late 1820's, at a time when the Baltimore and Ohio Railroad alone might place an order for twelve to fifteen thousand tons of wrought iron.[37] The owners of one rolling mill complained that they could not get enough blooms to meet their current demands for ordinary business, and another mill offered to roll rails for a prohibitive $100 a ton.[38] The inevitable result was that the rails came from England, and to ease the high initial cost of building a railroad, rails entered this country duty free from 1832 to 1842.

The depression of 1839 killed duty free imports and thereby created an incentive for American iron makers to go into rail making. But demand was not enough. The industry could not make rails economically so long as it remained tied to charcoal smelting and refining. As noted above, seventy five per cent of the pig iron made as late as 1847 was still charcoal smelted. The iron boom of the middle 1840's did not modernize all the industry and the tariff umbrella served in part to preserve antiquated methods. There was a technological shift in part of the industry, however, and it came in 1844 when the Mount Savage rolling mill started rolling rails. In 1845 a new rail mill started up in Trenton and the next year saw more rail mills opening in Phoenixville and Danville and another mill converted over to rail production at Brady's Bend. These new mills were technologically equal to the English mills; they were big and they were committed to the use of mineral fuel.[39]

Four more new rail mills were built by 1848 but they were too late, for the American rail boom began to collapse in the face of lower English rail prices.[40] The lower English prices were due to a decline in British railway building at home which forced down the price of English railway iron. By 1849 it was reported that only two American rail mills were in operation and that these were working at less than full capacity.

Though the American rail boom was of short duration, the rail mills had contributed more to the iron industry than a run of 200,000 tons of rails by 1850. They had modernized a part of the iron rolling business and by shifting to the use of mineral fuels to produce good cheap wrought iron, these mills signalled the imminent and precipitant decline of the old dependence on expensive charcoal. With certain exceptions, like boiler plate, charcoal iron quickly lost its dominant position.

Aside from locomotives and rails, railroads needed wrought iron for wheels, spikes and cars. Nearly everything save the rails were domestically produced. The estimated wrought iron tonnage used by the railroads in the decade of the 1840's is 387,000 tons.[42] This is a considerable weight, but Fishlow notes that railroads absorbed at best only 17 per cent of the increase in pig iron production in the period of 1846 to 1850. He also observes that it is a mystery where the rest of the increase in production went.[43]

It is evident then that the railroad's contribution to the growth of the iron industry in the first half of the nineteenth century was not simply a high demand for iron by tonnage. The railroad's need for wrought iron rails pushed a part of the industry into using mineral fuel and adoption of technological innovations in the rolling mills. Without these changes it would have been impossible for the iron makers to meet the still larger demands that faced them in the 1850's and during the Civil War. These future demands were enormous. In 1860 rails alone would account for more than 40 per cent of all rolled iron.[44] As Fishlow notes, however, it was the quality of the new demands that was vitally important to the growth of the industry.[45]

These technological changes pressed upon the iron industry by railroad demands seemed to come all in a bunch. In the period before the railroad boom innovations were rare. Indeed, for the first twenty-five years of the nineteenth century there were no significant innovations at all. Many of the old colonial furnaces remained in operation and new furnaces were modeled after the old ones. The Pennsylvania Society for the Promotion of Internal Improvements wrote in 1825 that "no improvements have been made here in it [iron manufacture] within the last thirty years" and "the use of bituminous and anthracite coal in our furnaces is absolutely and entirely unknown."[46] The same letter did note that unsuccessful attempts had been made to produce pig iron with mineral fuel.

Up to 1830 then, nearly all the blast furnaces used charcoal for fuel. This dependence upon charcoal meant that iron masters erected their blast furnaces in isolated areas, where wood was available on the spot because charcoal once made could not be transported any distance at all, or it would break up into dust in transit. This factor led to the development of a "plantation" system which survived until mineral fuel displaced charcoal.

These iron plantations varied greatly in size. Some of the large ones had holdings of ten thousand acres in 1830.[47] Most were smaller, and the average plantation held between two and five thousand acres of land.[48] In addition to land for fuel and working space, the iron masters needed water for powering the blast and for transport. These isolated establishments were organized rather like the southern plantations and the owners were "almost feudal lords", for besides being the economic masters of the area, they were often leaders in local political affairs and the captains of the local militia.[49]

On the other hand, those blast furnaces using mineral fuel were the technological leaders of the day. Indeed, without one crucial innovation, the hot blast, anthracite coal could not have been used as a fuel. The hot blast was an English invention of elegant simplicity. It was found that if the blast of air entering the furnace was heated, there would be a great saving in both time and the weight of fuel needed to smelt the iron. Ovens preheated the air on the way to the furnace or, even better, pipes located in the chimney of the furnace preheated the air. The preheaters cost little to install at any blast furnace. This innovation worked best with anthracite coal, and by 1839 a commercially successful hot blast anthracite furnace was making iron.[50]

Aside from using a hot blast, these new furnaces were quite large and used a high pressure for the blast. The blowers were steam driven. It was furnaces like these that made large scale rail production possible in this country in the 1840's.

These few innovations - the hot blast, use of waste gases for heat, and the use of steam engines at the furnace - did not sweep through the industry in the 1840's. Most blast furnaces remained wed to charcoal, and most used a cold blast, typically of low pressure and often powered by a water wheel. The widespread use of the new innovations was firmly tied to a simultaneous increase in the use of mineral fuel. Still the American rail mills demonstrated the potential of this new iron technology. Though few in number, they were large and technologically up to date and were integrated from blast furnace to rolling mill.

Rolling mills in the period up to 1840 were a separate branch of the iron industry. The rolling mills bought their blooms and slabs of iron from bloomaries and forges and then rolled the iron into sheets or bars. They either trimmed the sheets to size and sold them as they were, or cut them into strips or nail rods. During the decade of the 1840's some rolling mills became a part of the wrought iron refining branch of the industry. These mills became a part of the puddling process. Rolling and squeezing the iron in these mills was simply a substitute for the old method of hammering the impurities out of wrought iron. This innovation, combined with the use of mineral fuel, drove wrought iron prices downward. These changes had a marked effect upon the industry. In Pennsylvania in 1849 over 55 per cent of the rolling mills were less than ten years old and 75 per cent of all the rolling mills were puddling their own iron. These mills produced over 80 per cent of the wrought iron Pennsylvania made in that year.[51] Clearly the changes brought about by the railroad boom had been a real force in modernizing a segment of the industry. However, a warning: it was only

Seen AS A MIDDLE STEP

55 = 13/14
?? see next PAGE
75 = 18?

a handful of these mills that fully integrated and used all the available technology. But significantly, three quarters of the Pennsylvania mills were using mineral fuel for refining and were making other selective technological changes.

The other quarter of the Pennsylvania rolling mills stayed away from the puddling process. There were 22 of these mills in all, all but two in eastern Penn- 22 mills 20 eastern PA. sylvania. Of these 22 mills, all save one were making specialized irons. Fourteen of them were making boiler 14 Rolling B.P. plate, three made saw plates and rolled spring steel, and one mill produced wire. Further, only about one third of 1/3 steam these mills were steam powered and they were small businesses, averaging about 28 hands employed, as compared to the labor 28 people force for the mills with puddling furnaces, which averaged 103 employees.[52]

For the production of certain specialized goods, bigness and technological innovativeness were unnecessary. The process of making high quality wrought iron boiler plate remained fixed from 1815 to 1870. The blooms used for the production of boiler plate were charcoal smelted and refined. The blast furnaces producing pig iron for this purpose used a low pressure cold blast to give a superior iron.[53] The iron so produced was of high purity.

Puddled iron was never completely satisfactory for boiler plate. It was more likely to be contaminated by the coal used as fuel in the smelting and refining process. Further, rolling iron does not refine as well as hammering.

Where the highest quality was needed, the old process was still best in 1850 and remained unchanged until steel replaced iron for boiler plates. The introduction of steam power for the rolls was the only significant technological change made in these small plate mills. Finally, these mills were not integrated. They bought their fuel and blooms from outside suppliers and sold the plate through agents to mechanics who fabricated the iron into boilers.

STEAM

MIDDLEMAN

There was one rolling mill in 1850 which demonstrated the viability of this apparently backward part of the industry. It was no way remarkably different from its companion rolling mills in Pennsylvania. This mill was located on the Brandywine Creek in Coatesville, Pennsylvania. It was the Lukens rolling mill. A survey of its history follows.

CHAPTER I

[1]Victor S. Clark, History of Manufactures in the United States (New York, 1949), I, 496.

[2]Peter Temin, Iron and Steel in Nineteenth Century America (Cambridge, 1964), pp. 234-235.

[3]Ibid., p. 14. Figures given here and below for annual national production are in gross tons of 2200 pounds.

[4]Clark, I, 496.

[5]Ibid., p. 500.

[6]Ibid., p. 499.

[7]James M. Swank, History of the Manufacture of Iron in all Ages (Philadelphia, 1892), p. 378.

[8]B. F. French, Rise and Progress of the Iron Trade of the United States from 1621 to 1857 (New York, 1858), p. 20. Temin cautions that this figure is of unknown origin.

[9]Temin, p. 264, and Appendix A.

[10]Ibid., and Appendix C.

[11]Ibid., and Appendix A.

[12]Clark, I, 285.

[13]Temin, p. 20.

[14]Louis C. Hunter, "The Influence of the Market upon Technique in the Iron Industry in Western Pennsylvania Up to 1860," Journal of Economic and Business History, I (February, 1929), 241-281.

[15]Carl W. Condit, American Building Materials and Techniques from the First Colonial Settlements to the Present (Chicago, 1968), Chapter 6.

[16] *Ibid.*

[17] Clark, I, 504.

[18] *Ibid.*, p. 506.

[19] *Ibid.*

[20] *Ibid.*, p. 503.

[21] Temin, pp. 30-31.

[22] *Ibid.*

[23] Clark, I, 507.

[24] L. C. Hunter, *Steamboats on the Western Rivers: An Economic and Technological History* (Cambridge, 1949), pp. 156-157.

[25] *Ibid.*, p. 33.

[26] *Ibid.*, pp. 32-33.

[27] *Ibid.*, pp. 112-113.

[28] Levi Woodbury, *Letter from the Secretary of the Treasury Transmitting ... Information in Relation to Steam Engines* (Washington, 1838), p. 379.

[29] *Ibid.*, pp. 321-326.

[30] *Ibid.*

[31] Clark, I, 509.

[32] Albert Fishlow, *American Railroads and the Transformation of the Ante-Bellum Economy* (Cambridge, 1965), p. 149.

[33] Clark, I, 362-363.

[34] Fishlow, p. 415, note.

[35] *Ibid.*, p. 415.

[36] *Ibid.*, p. 138.

[37] *Ibid.*, p. 133.

[38] *Ibid.*

[39] Temin, p. 118.

[40] Fishlow, p. 136.

[41] *Ibid.*, p. 137.

[42] *Ibid.*, p. 142.

[43] *Ibid.*, p. 143.

[44] *Ibid.*, p. 145.

[45] *Ibid.*, p. 144.

[46] James M. Swank, *History of the Manufacture of Iron in all Ages*, Second Edition (Philadelphia, 1892), p. 365.

[47] Temin, p. 83.

[48] Harold F. Williamson, ed., *The Growth of the American Economy* (New York, 1944), p. 176.

[49] Swank, p. 189.

[50] *Ibid.*, p. 62.

[51] Convention of Iron Masters, Tables.

[52] *Ibid.*

[53] Frederick Overman, *The Manufacture of Iron in All its Various Branches* (Philadelphia, 1859), pp. 436-442.