Iron & Steel

[These entries are taken from the publication *Engines of Change, The American Industrial Revolution 1790 – 1860,* by Brooke Hindle and Steven Luber. Smithsonian Institution Press, 1986.]

"The iron industry of this period involved coke ore reduction and new methods for making malleable iron (or iron that was not brittle but could bend and be machined). These methods, called puddling and rolling, replaced more expensive and more labor-intensive processes toward the end of the eighteenth century. Puddling involved heating pig iron, or iron that had been reduced from the ore, in a reverberatory furnace and having a man stir or move about the molten iron in order to remove impurities and some of the carbon. Rolling was the next step, which ran the iron through a set of rollers that could produce different shapes, but usually turned out bars of malleable iron similar to those previously hand produced by heating and hammering the molten pig iron.

Coke iron was not as generally useful as charcoal iron, but because it was so much cheaper, it became very successful. In many ways, iron was the key material of the Industrial Revolution. Because England had good supplies of iron ore and coal, its solutions to the economical production of iron gave the country a growing advantage."

(p. 15)

The English Iron Revolution

"One major aspect of the Industrial Revolution was transferred to the U.S. only after a remarkably long delay. This was the iron revolution, sometimes called the first iron revolution. It began with Abraham Darby's successful reduction of iron ore using coke rather than charcoal as the fuel, at what is now Ironbridge, England, in 1709. That achievement followed from England's depletion of wood and the success it had already met in using coal for other heat-based industries. Iron was the last to yield, and it soon turned out that not all ore could be successfully reduced in the manner Darby demonstrated. More important, the iron produced was not as generally useful – fine for castings, but not as convertible to malleable iron. Partly for these reasons Darby's process was not immediately applied elsewhere. Not until the 1780s did coke reduction begin to dominate the scene.

By then two other processes had begun to have a major impact on iron production. These were puddling and rolling, more mechanical methods of converting pig to bar iron, that is, to malleable, workable iron. Both processes were first patented in 1783, but had come into use earlier. Together with coke ore reduction, they gave England a clear advantage over its competitors in iron production."

"Why did the American colonies and the new United States not move quickly to gain these advantages? To begin with, the mother country had encouraged the production of raw, pig and bar iron in the colonies. England offered a good market with no duties. On this basis, a large iron industry grew in America, using the plentiful wood supply to make the charcoal required for ore reduction. By the Revolution, when the colonies were producing more iron than the mother country, Britain put to use its new techniques for making iron more cheaply – and the new U.S. lost its advantage of duty-free exports. British iron was imported, despite the high cost of transporting so heavy a product. American iron production declined as a result of falling exports, and no immediate incentive or financing was available for introducing the new techniques."

"Not until 1815 did conditions change sufficiently to encourage the importation of the English advantages. By then American industrial needs had diversified sufficiently that different sorts of iron were needed. Also bituminous coal became available for coking near Pittsburgh, where the changes first succeeded. Coke iron was less generally satisfactory, but because it was cheaper and could be used just as well for some needs, an American market began to emerge. Knowledgeable British immigrants, working with American innovators, transferred puddling, rolling and coke ore reduction – but not nearly as early as they might have been imported had those changes been needed."

(pps. 69-71)

"An American, Jacob Perkin, emigrated to England in 1797 and introduced a nail-making machine there. This was a device that cut and headed nails in a single mechanized machine. Such machines became important in both countries.

(p. 71)

"The location of most waterpower sites in the countryside, far from commercial centers where workers lived, helped to reinforce the paternalistic tradition of American industry. Factory owners often felt that they had to provide housing and a company store where the factory was located out of easy reach of cities and towns."

(p. 158)

Fulling Mill

"This was a machine, usually powered by a water wheel, that pounded woolen cloth immersed in water in order to make it clean, compact and strong."

(p. 18)

The following is from the Encyclopedia Britannica, 11th edition:

"In the *puddling process* molten cast iron is converted into wrought iron, *i.e.* low-carbon slag-bearing iron, by oxidizing its carbon, silicon and phosphorous, by means of iron oxide stirred into it as it lies in a thin shallow layer in the "hearth" or flat basin of a reverberatory furnace (fig. 14), itself lined with iron ore. As the iron oxide is stirred into the molten metal laboriously by workmen or "puddler" with his hook or "rabble," it oxidizes the silicon to silica and the phosphorous to phosphoric acid, and unites with both these products, forming with them a basic iron silicate rich in phosphorus, called "puddling" or "tap cinder." It oxidizes the carbon also, which escapes in purple jets of burning carbonic oxide. As the melting point of the metal is gradually raised by the progressive decarbonization, it at length passes above the temperature of the furnace, about 1400° C., with the consequence that the metal, now below its melting point, solidifies in pasty grains, or "comes to nature." These grains the puddler welds together by means of his rabble into rough 80-lb balls, each like a sponge of metallic iron particles with its pores filled with the still molten cinder. These balls are next worked into merchantable shape, and the cinder is simultaneously expelled in large part, first by hammering them one at a time under a steam hammer or by squeezing them, and next by rolling them. The squeezing is usually done by using an eccentric revolving squeezer consisting of a large fixed iron cylinder, corrugated within, and an eccentric cylinder, also

corrugated, which, in turning to the right, by the friction of its corrugated surface rotates the puddle ball, which has just entered so that, turning around its own axis, it travels to the right and is gradually changed from a ball into a bloom, a rough cylindrical mass of white hot iron, still dripping with cinder. This bloom is immediately rolled down into a long flat bar, called "muck bar" and this in turn is cut into short lengths which, piled one on the other, are reheated and again rolled down, sometimes with repeated cutting, piling and re-rolling, into the final shape in which it is actually to be used. But, roll and re-roll as often as we like, much cinder remains imbedded in the iron, in the form of threads and rods drawn out in the direction of rolling, and of course weakening the metal in the transverse direction.

EB, 11th ed. (1911), vol. 14, page 817

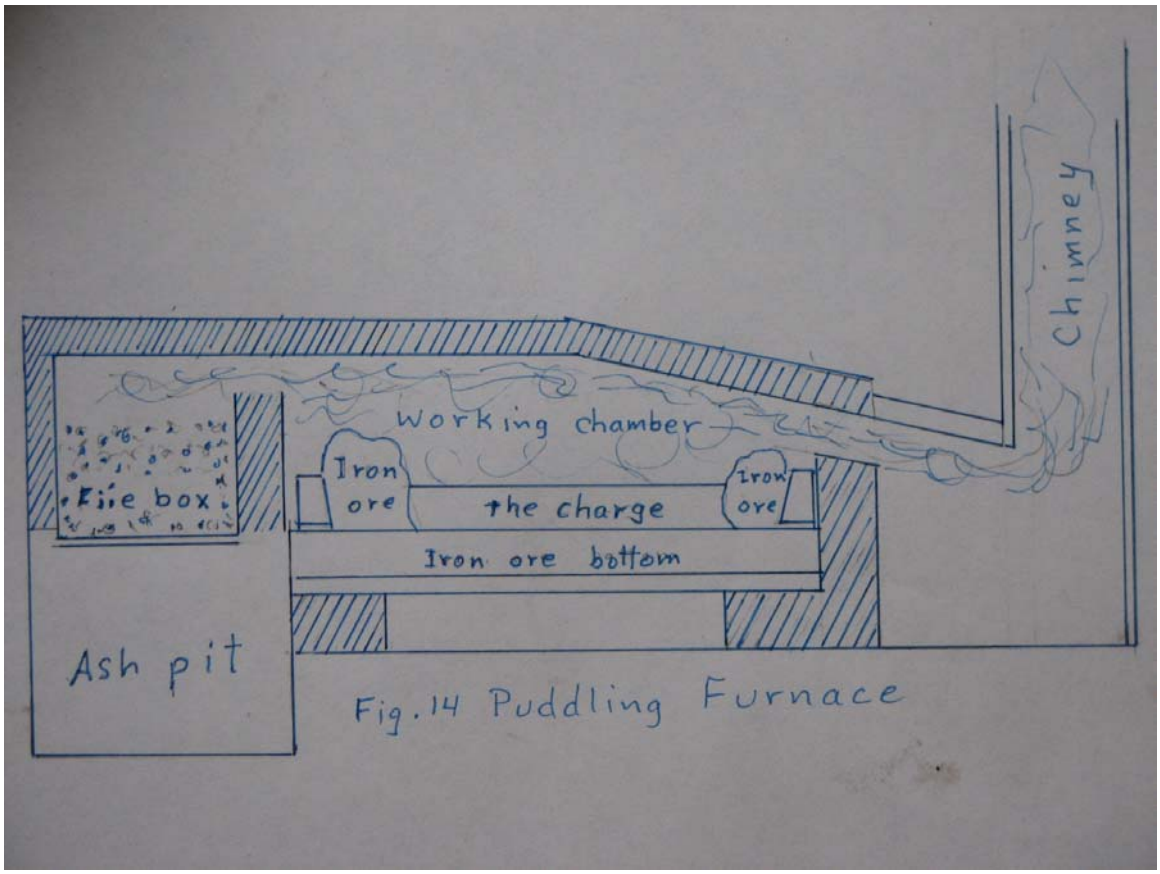

Fig. 14 Puddling Furnace