An 1870s Iron Making Primer

by Vagel Keller

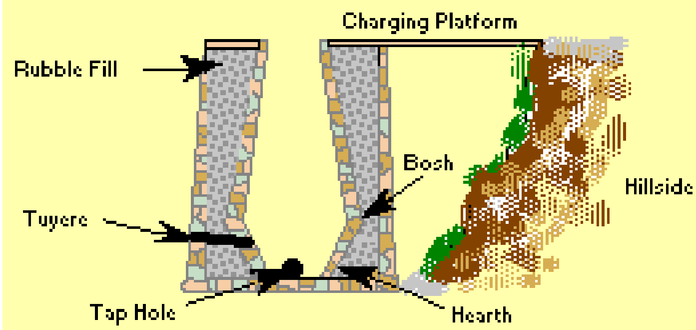
Iron is one of the earth's basic elements, but it is rarely found in a pure state. It is generally found embedded in rock (called *ore*), in which it is chemically bonded with other minerals. To produce workable iron this chemical bond must be broken down by heating, which reduces the components of the ore to their molten states, allowing the iron to be separated from the other useless minerals. The ancient process was to simply heat iron ore in a fire pit, using crude bellows to increase the heat. This yielded a very soft and malleable iron that was hammered into weapons and other implements.

Modern iron making traces its roots to the development of the *cold blast furnace* about 300 years ago. A cold blast furnace (Fig. 1) was essentially a four-sided structure enclosing a conical cylinder growing gradually wider from top to bottom to a point about 3/4 of the way down and then tapering inward from that point, known as the *bosh*, to its base, or *hearth*. Openings, called *tuyeres* (pronounced TWEERS), pierced the furnace wall between the bosh and the hearth to allow high pressure air (the *blast*) to fan the fire. The blast was supplied by a large bellows, usually powered by a water wheel. A *charge* consisted of proportioned weights of fuel, iron ore, and limestone -- from bottom to top -- in successive layers to the top of the furnace (or *stack*). The fuel, of course, provided the heat with which to melt the ore. Limestone was used as *flux* to aid in separating the impurities in the ore from the iron as it melted.

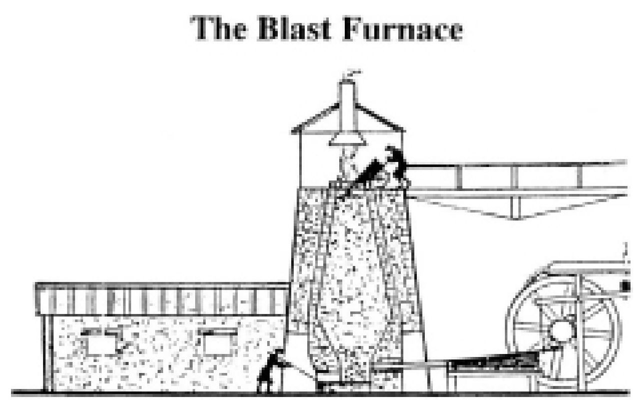
The furnace stack was first filled with fuel and ignited at the base. When the fuel at the top began to glow, successive layers of the charge were added as the whole mass settled toward the hearth, and the blast was applied; the furnace was then declared to be "*blown In*" or "*in blast*." The high heat passing up through successive layers of the charge created a very dynamic process; materials would be white hot at the hearth, while at the top of the stack they would glow a soft red. At the hearth, molten iron would settle to the bottom, while the impurities -- mixed with molten limestone -- floated above it as *slag*. When all the iron at the hearth level was judged to be melted, the molten slag was first tapped through an opening above the hearth and offset from the iron tapping at the hearth. and allowed to run into a waste pit. Then furnace was tapped at the hearth, and the molten iron allowed to run through troughs in the sand floor of the *casthouse* and into molds, called *pig*s.

The accepted source of origin of the term "pig" is that the sight of the molds attached to the long connecting trough resembled a litter of piglets suckling a sow. When

Fig. 1: Layout, Typical Charcoal Iron Furnace



cooled, the iron pigs were removed and stacked in open air storage areas to await shipment to forges, where they were used in manufacturing cast or wrought iron implements and weapons. Sometimes, specialty items were cast right on the Casthouse floor (such as at the Rockhill



This diagram shows the basic layout of a water-powered charcoal iron furnace typical of the mid-18th through mid-19th centuries.

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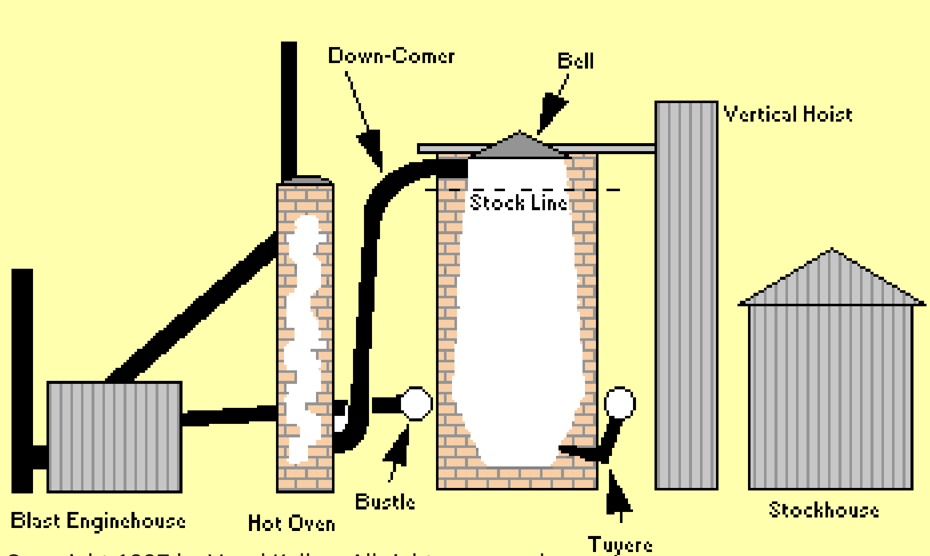
were used in manufacturing cast or wrought iron implements and weapons. Sometimes, specialty items were cast right on the Casthouse floor (such as at the Rockhill Furnace, where the East Broad Top Railroad stationed a molder for that purpose).

Basic blast furnace design has not changed much over the years, nor has the basic process. Furnaces simply increased in size and numerous additional devices were added to adapt to different types of iron ore and increase output. The most significant breakthroughs occurred in the period following the Civil War, with the invention of the *hot blast and* a change from charcoal to *coke* for fuel. Both of these innovations dramatically dramatically increased the amount of heat generated, which allowed the development of furnaces of massive size and output. Coke is to coal what charcoal is to wood; when burned in an oxygen-poor environment, the non-combustible ingredients of coal are baked off as gas, leaving porous, gray chunks of nearly pure carbon. Coke is lighter in weight (making for reduced transportation costs) and burns much hotter than coal. At the Rockhill Furnace, coke was originally made in experimental *Belgian ovens*. But these were soon abandoned in favor of the simpler and easy-to-use *Beehive ovens*.

Fig. 2: Typical Layout, 1870's Hot Blast Furnace

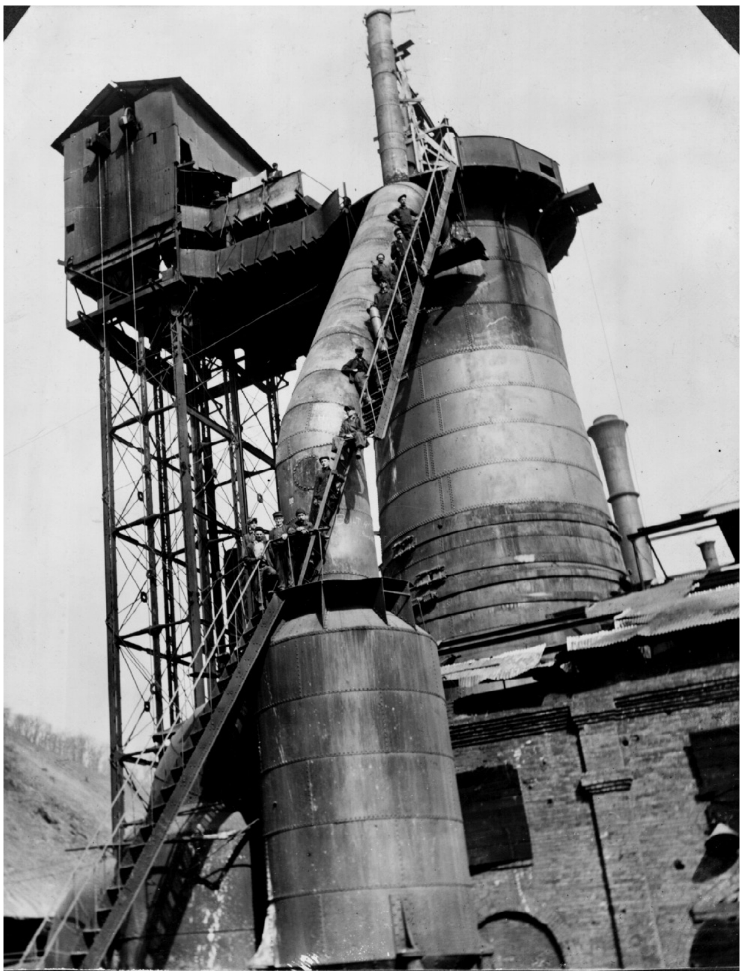


Over 100 Beehive ovens were used at the Rockhill Furnace, and their ruins remain today.

The hot blast was an ingenious way of further increasing the heat in the furnace without using any fuel (See Fig. 2). The top of the stack was closed off by a movable cover, called a *bell*. The hot gases, thus trapped, were passed from the furnace top into *hot ovens* by means of a *down-comer* (which was equipped with a safety release valve to prevent build-up of excess pressure). In the *hot ovens*, the furnace gases heated a fire brick lining that encased a maze of iron pipes through which the air from the blast engines was forced on its way back to the furnace. From the stoves, these gases (superheated to 800 degrees) were pumped under great pressure to the *bustle*, which encircled the Bosh and fed the Tuyeres . Even the steam for the immense blast engines was generated in boilers heated by these gases. So a state-of-the-art 1870's

blast furnace was, in many respects, an example of near perfect efficiency, in that it re-used its wastes gases as fuel for auxilliary functions.

From the 1870's through the early years of this Century, many independent iron furnaces of this type flourished throughout southern Pennsylvania. The Rockhill Furnace of the Rockhill Iron & Coal Company was such an operation. But the development of the steel industry, with its huge, integrated iron and steel complexes, made it difficult for operations like Rockhill Furnace to compete. Massive by post-Civil War standards, Rockhill Furnace was, by 1900, a relatively small operation that produced increasingly less marketable cold iron pigs, of little use to steel manufacturers who produced their own molten iron on site.



This view of one of the two coke-fired stacks of the Saxton Furance, located on the west side of the Broad Top Coalfield, ca. 1910, shows the downcomer and dust catcher, as well as an elevator for lifing the charge to the top of the stack. The hot ovens are off scene to the left in this view. Photo courtsy of Jon Baughman.