n the latter half of the 19th century, the industrial world of wrought iron experienced a revolution: A process for making steel directly from blast furnace cast iron was being developed at two different locations. One was at a small iron mill in Kentucky owned by two brothers—William and John Kelly. As usual, the men soon encountered a fuel shortage after clearing all the timber near the plant for charcoal. With this in mind, William Kelly noticed that the cold air was not chilling the metal, but was reacting with it chemically to generate heat where the air blast impinged on the molten metal in the finery. Kelly immediately recognized the value of this reaction as a means of converting pig iron to wrought iron. Although this revelation occurred in 1847, he was delayed in building a converter until 1851.

The second location was in England where an engineer and inventor named Henry Bessemer—who had invented the artillery shell—was working on a way to replace the cast iron in cannons with steel. Bessemer’s finances were much better than Kelly’s, allowing him to pursue his ideas immediately.

Kelly moved his experimental operations to the Cambria Iron Company in Johnstown, Pa., the company where Daniel Morrell and John Fritz were laboring to develop their three-high mill to roll wrought iron into rails. Kelly received his patent in 1857, just as a U.S. financial panic was taking hold, and went bankrupt along with thousands of other businessmen. He sold the controlling interest in his patent in 1861, and two years later a company was formed to produce steel by his process. This entity—the Kelly Pneumatic Process Company—was located in a pilot plant in Wyandotte, Mich., outside of Detroit. At this point, the operation developed the same quality problem that plagued Bessemer in England.

During Bessemer’s experimental work, he had fortuitously used Swedish ore, which was low in impurities. Later, when his licensees were unable to control the carbon content and make steel that was not brittle, respected steelmaker Robert Mushet showed that manganese was a necessary ingredient to overcome the “hot shortness” caused by sulfur. He also determined that carbon content could only be controlled by blowing until it was completely removed, and then adding back the required amount. By this time, German iron and steelmakers had already developed a master alloy called “spiegeleisen” for adding carbon and manganese. Thus, Mushet was a major contributor to the success of the so called Bessemer process. However, the patent situation was now in gridlock with Bessemer and Kelly each holding a vital position in the process.

**Bessemer process makes headway**

During this period, America was in the throes of the terrible war between the industrial north and the agricultural, slaveholding south. Government agents as well as private individuals from both areas were combing Europe looking for armaments and other developments that would aid their cause. One such individual was a charismatic engineer and technical writer by the name of Alexander Lyman Holley.

Holley was born in Connecticut in 1832. He graduated from Brown University in 1853 in the first engineering class and started working on railroad locomotives. On a trip to Europe to observe...
the latest developments in ordnance and armor plate, he came into contact with the Bessemer steel-making process. Bessemer had a pilot plant where he was very busy in this period showing off his process to interested parties. However, Holley realized that the patent situation needed to be resolved before the process could become commercialized in the U.S. He accomplished this task and built the first Bessemer steel plant in Troy, N.Y., in 1865.

In the meantime, the first successful steel made by this process in the U.S. was cast at the little plant in Wyandotte, Mich., at the Kelly Pneumatic Process Company. An ASM historical marker pays tribute to this event. Ingots from this heat were shipped to the North Chicago Rolling Mill Company where they were successfully rolled into the first steel rails made in America.

**Patent release paves way for steel industry**

The release of the patent deadlock cleared the way for the domestic steel industry and Holley was the chief promoter and designer. He either constructed or consulted on nearly all 15 Bessemer plants built by 1875. These included the very early plant of the Pennsylvania Steel Company near Harrisburg, with J. Edgar Thomson and Thomas Scott of the Pennsylvania Railroad Company as principals; the Cambria Steel Company where Kelly received support from Morrell to develop the process; the first plant in Pittsburgh built for Andrew Carnegie and named for his benefactor (J. Edgar Thomson, president of the Pennsylvania Railroad); plants at North Chicago and Joliet, Ill.; a plant for the Vulcan Works at St. Louis, Mo.; and plants for Bethlehem Steel and Scranton Steel in eastern Pa.

These early steel plants were small enterprises by later comparisons. Bessemer converters had reached only five tons by the early 1870s. Also, their supply of molten metal typically came from remelting cast iron in separate furnaces. At this stage in America’s industrialization, mills simply were not equipped to handle large quantities of molten metal.

For his contribution to the development of the Kelly-Bessemer process, Alexander Holley has been called the “Father of American Steelmaking.” He was elected president of the American Institute of Mining and Metallurgical Engineers as well as the American Society of Mechanical Engineers, and named vice president of the American Society of Civil Engineers. After his death from peritonitis at age 49 in 1882, these engineering societies commissioned a statue of Holley that remains standing in Manhattan’s Washington Square Park. Engineers from all of the major technical societies attended the dedication, including members from France and Germany.

**Future forward for U.S. steel**

The U.S. was now positioned to experience an even brighter future for iron and steel. During the last 30 years of the 19th century, production would increase nearly tenfold for iron—from 1.7 million tons in 1870 to 14 million tons in 1900—and for steel, from 68,750 tons in 1870 to 10 million tons in 1900. Throughout the 1890s, the U.S. produced one-third of all the world’s steel, and half of that went into railroad rails.

Bessemer steel gradually became the material of choice for rails and beams because it was stronger, harder, and far more wear resistant for rails than wrought iron. In the final analysis, however, it was the much lower costs for manufacturing Bessemer steel compared to wrought iron that tipped the scales in its favor. In the 1890s, with competition high among the mills, the price of steel for rails hit a low of $11 per ton. Low-cost steel was the force behind America’s modern industrial growth, and the major force behind this growth was an immigrant Scotsman named Andrew Carnegie.

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