BIRTH OF THE AMERICAN CRUCIBLE STEEL INDUSTRY

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This is an account of the birth of the crucible steel industry in the United States. Some day it may be published as part of a larger story—that of the Crucible Steel Company of America. The two stories are inextricably bound together in the fabric of Western Pennsylvania history.

For one thing, the first firm in America to engage successfully in the manufacture of crucible steel became part of the Crucible Steel Company of America on its founding in 1900. This firm was Hussey, Wells & Co. of Pittsburgh, later known as Howe, Brown & Co. For another, the second American firm to enter the business successfully, Park, Brother and Company, also of Pittsburgh, not only became part of Crucible Steel but provided the leadership that brought it into being.

There is, however, an even more important connection between the old crucible process, now outmoded, and Crucible with a capital "C." That connection is quality. The crucible process, originally and for more than a century and a half after its rediscovery by Benjamin Huntsman in England in 1740, was the only method known for making the "finest" steels. Until the crucible process was introduced in the United States, all tool steels, including the "best" cutlery steels, were imported. From its founding in 1900, when it initially incorporated the leading crucible steel producers, Crucible has been in the forefront of manufacturers of the "best" and the "finest" steels.

Down through the years common steel was made successively by cementation, Bessemer, and open-hearth processes. After 1840 it was increasingly easy to cast common or imperfectly refined steel. But from 1740 until 1906—from the time of Huntsman until the year a present component of Crucible Steel installed its first Heroult furnace—only the crucible process produced the best steels required for tools. Other processes might make tonnage steel for rails, and buildings, and plows; eventually even for saws and files and guns. But only the crucible process made the finest steel required for cutting and shaping the other, cheaper steels.

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Today, America produces and uses at least two-thirds of the world tonnage of tool, stainless, and other alloy steels. Perfected electric furnaces and precision-quality control have retired the old crucibles. Metallurgical scientists and engineers have replaced the skilled secretive melters. Today, Crucible leads the nation and the world in total tonnage of specialty steels as well as in the number of distinct kinds of specialty steels.

In the present article will be found separate accounts of both the firms that first successfully produced crucible steel in America, and the unsuccessful firm which failed for reasons beyond its control after conquering the purely metallurgical difficulties thirty years earlier. The writer will also attempt to explain just why the crucible process, after so many false starts in America, suddenly burst into full flower at a particular time, the early 1860's, and in a particular place, Pittsburgh.

Behind the Crucible Process

To understand the crucible process, quite simple in outline no matter how mysterious in detail, we must take a very quick glance at the chemistry of iron and steel. And we must remember that carbon, in various amounts or percentages, provides the key. For the moment we will forget about the various other minerals that play a vital part in specialty steels and alloys today. Their roles could be speculated upon only in the ancient days before quantitative analysis.

Since the fourteenth century almost all iron has been produced in blast furnaces. They are so called because a blast of air is forced through a mixture of iron ore, flux, and burning charcoal, coal, or coke. The high temperatures in the blast furnaces melt the iron so that it can be poured, or cast, easily into convenient shapes. In the molten state the iron has dissolved carbon and slag, much as sugar or salt is dissolved by water. Such cast iron, with its high mineral content, is extremely brittle and extremely hard. It is used today for furnace parts, stoves, motor housings, and many other purposes. Chiefly, however, it is now the raw material of which steel is made.

Long before the blast furnace was perfected, wrought or "bar" iron had been made in forges. In a typical ancient forge process the iron ore was spread on a bed of hot coals and covered and surrounded by more hot coals. Fanned by bellows, or by a draft provided by a chimney, the coals burned at a temperature just as high as that in the blast furnace. In the forge, however, the iron was not liquefied. It formed a spongy lump which, after being reheated and hammered several times to get rid of the imbedded slag, became a "bar." Wrought iron was almost pure iron. Virtually all the carbon was oxidized. It could be shaped and welded easily by hammering when red hot. Even when cold it was not brittle but could be dented by a hammer blow. Wrought iron is still used for artistic or architectural purposes and is often called malleable iron, meaning merely that it can be hammered easily. Until steel began to become cheaply available with the Bessemer process about eighty years ago, cast-iron "pigs" and wrought-iron "blooms" were the raw materials from which all rails, structural forms, and other heavy duty shapes had to be fabricated.

Steel, "bright iron" as Homer called it, has been made in small quantities since the earliest times. It customarily contains a very small amount of carbon, from less than two-tenths of one per cent to a maximum of about one and a half per cent. The ancients thought that iron from one place made steel good for certain purposes such as armor, and that iron from another place made steel ideal for knives or swords. We know now that quality differences really reflected the amounts of various impurities present in the iron ores or fuels. Manganese and silicon were often helpful, phosphorus and sulphur generally harmful. One relationship was constant, however; the more carbon present in the steel, the harder the edge it would take when properly tempered. A fine sword, for example, might have very little carbon in the center, for springiness, and more on the edge, for sharpness.

Almost all early methods of making steel involved "cementation." Thin strips of wrought iron were heated white while packed in a "cement" of animal carbon, charcoal or, later, coke. At high heat they absorbed carbon at every point of contact. After cooling, the mass was hammered, "tilted" or rolled to squeeze out the slag and stretch the crystals. The longer the duration of this "refining" process, the more carbon the steel picked up, and the harder it became. After final shaping, a dagger or sword would be heated one last time, cooled to the right shade of redness, and then quenched in oil or water. This quenching gave the steel its temper. The complexity of this tedious heat-treating process explains why a knight might have had to sell several farms to buy a single suit of armor.

Human judgment was all important at each stage in all the ancient steelmaking processes. Early smiths were priests or wizards. Later, guilds of armor and weapon makers were among the wealthiest in the Middle Ages. Their various skills were taught under conditions of the greatest possible secrecy. Many processes were discovered only to be lost again a generation later because of an epidemic or a massacre. Sudden death of the one man who possessed both the knowledge and required skill often destroyed the usefulness of a process insufficiently described in family archives. For example, when cast iron became available, no one knows who first thought of making steel by boiling thin pieces of wrought iron in the molten cast iron. Puddling of wrought iron from blast-furnace cast iron is another process that may have been invented and reinvented many times.

Gradual introduction of water-power hammers and, finally, of slitting and rolling mills, made cementation or blister steel cheaper and extended its use. Until the introduction of the mass-production methods of the Bessemer converter and the open-hearth furnace, most common steel was of this kind. The term "blister" steel was derived from the characteristic swellings where the carbon penetrated the thin strips of iron.

The Crucible Process Itself

As devised by Huntsman in 1740, the crucible process consisted of melting pieces of blister steel in a sealed pot or crucible set in a furnace. Also packed in the pot was other material that might serve as a flux or contribute desired qualities to the steel. The molten steel could be cast in ingots direct from the crucible, or the contents of several crucibles might be poured together and mixed before being poured into a mold to make a part of a machine or a cannon. The advantage of Huntsman's process was the even quality of the contents of a crucible. Depending upon the care with which the cementation steel was made initially, and the ores used, the crucible process was capable of great uniformity in output. Chief disadvantages were the cost of the crucibles and the tremendous consumption of fuel.

Crucibles used in England by Huntsman were made of a kind of clay, called Stourbridge, that had beneficial rather than harmful reactions with the English ores. This chemical affinity, entirely a matter of chance, made the Huntsman process successful initially. More than 150 years later, however, some of the English manufacturers were still under the mistaken impression that the quality of their finest crucible steel made in the Sheffield district was due to the chemistry of the waters in which the steel castings were quenched! But many individuals who moved from England to other parts of the world felt that the clay was the key to the process. As a result, particularly in America, attempts were made to make crucible steel whenever a clay resembling Stourbridge clay was found, as in Pennsylvania in 1831. These attempts failed for a variety of reasons, frequently not because of the clay but because the blister steel contained too many undesirable impurities derived from the ores, fluxes or fuels used in the blast furnaces or in the cementation process itself.

Joseph Dixon of Marblehead, Massachusetts, stepped into the picture here. His interest was aroused by a lump of natural graphite, "plumbago," he saw on a wharf in Salem as a young man. He had self-confidence as an innovator because of several mechanical inventions to his credit, and quickly found uses for the strange material which would not melt. It could be obtained quite cheaply in Ceylon where, it turned out, his original lump had been picked up as part of a load of rock ballast. In 1827 he established a regular business, making and selling graphite stove polishes and crude crucibles. Dixon's crucibles, unlike clay crucibles then available in New England, could be used over and over again. Their use considerably reduced costs and contributed largely to the success of the early New England copper and brass industry.

Dixon actually used his crucibles to melt iron and steel, and eventually took out two patents for steelmaking. His failure to produce high quality crucible steel immediately was evidently a matter of chemistry, but he did prove that his crucibles could stand repeated high steelmaking temperatures.

In 1831, according to James M. Swank, leading authority on the beginnings of the American iron and steel industries, there were in the United States fourteen blister-steel furnaces with a total production of 1600 tons annually. Their product equalled the total imported tonnage of all kinds of steel, but competed successfully only with the low-grade English agricultural steels. Imported steel in that year was either blister steel made from fine Swedish ore, naturally high in the desirable chemical qualities, or regular English crucible cast steel. Iron ore from the Juniata district of Pennsylvania and the New York-Connecticut border counties was found to be nearly equal to the Swedish iron. When converted by the regular process into blister steel, this was called shear steel, because shears could be made from it. The common American blister steel, like the common English blister steel of the same period, was suitable only for plowshares, shovels, scythes, and saws.

Many American firms, one after another, attempted to melt either blister or shear steel in crucibles and thus produce "fine" steel suitable for cutlery. From 1831 to 1859, however, only about a dozen firms were able to melt steel and cast it, without regard to any refining of the quality of the product. Of these, Garrard Brothers, of Cincinnati, for seven years beginning in 1832, was successful in all ways except financially. In 1848 the Adirondack Iron and Steel Company, of Jersey City, commenced to make blister steel from its own bar iron, puddled at Adirondack, Essex County, New York. The attempt to cast this blister steel in clay crucibles was a flat failure, but in February, 1849, the attempt succeeded when "black lead" crucibles were substituted. This "black lead," of course, was Dixon's graphite. Swank testifies that this cast steel was superior to all other American cast steels, excepting only the Garrard steel, but it was of admittedly uneven quality. Its virtues were apparently accidental and due to the excellence of the ore rather than to any improvement in basic understanding of the crucible process.

The Garrard Brothers

This account, adapted from Swank's, might well be subtitled "a study in prematurity." It is the story of the efforts of two young English-born brothers, Dr. William Garrard and John Hill Garrard, to launch the crucible steel industry in Cincinnati, Ohio, in 1831. The two brothers eventually moved to the Pittsburgh district and died there in the 1880's. Because their efforts in Cincinnati were unsuccessful financially there was no pressure to maintain secrecy, and we know more about their operations from first to last than about any of the later successful enterprises.

Dr. Garrard, the elder by two years, was born in Suffolk on October 21, 1803. His father brought the family to the Pittsburgh area from England in 1822. As a young man William was trained as a bricklayer but he also indulged a fondness for chemistry. While still under the parental roof in the Pittsburgh area he built with his own hands a small brick forge and converted small quantities of bar iron into blister steel. He had never seen an English steel works, as far as we know, but he conceived the idea that he could make steel equal to

English steel if he could assemble the facilities.

By 1831, he and his brother had accumulated enough money to build a steel plant of their own in Cincinnati. According to Swank, they built on Canal Street, on a site extending back to Providence Street. Their equipment included a furnace for converting bar iron into blister steel, two potholes accommodating a total of four pots or crucibles in which the blister steel was to be melted, and machinery for making saws and files. In August, 1832, they succeeded in casting their first steel and by November of that year they had made their first mill and cross-cut saws.

The first crucibles used by Dr. Garrard, made of "German plumbago," were failures and he continued expensive experiments until he finally settled on a mixture of clay from New Cumberland in "Western Virginia," with burnt material from old crucibles. For best cast steel, he first used Swedish iron bars and later Missouri charcoal iron. For saws and springs he also used Tennessee charcoal iron. All his materials were extremely expensive for the time and he never attained a price advantage over English competition.

What eventually drove the Garrards out of business was the fact that they could not charge less than the English competition and, worse, could not match the credit terms extended by the latter. They sold primarily to customers who needed good quality tools in a hurry, and had the cash in hand. To quote from a letter written in 1883 by a mutual friend to Swank:

> The enterprise was started during Jackson's first term of office, and about the time that the law was passed for a gradual reduction of duties on all imports for a decade, and with this gradual reduction of duties foreign importation increased, to pay for which the country was drained of money. Manufactures were closed, culminating in the great panic of 1837, at which time the enterprise of our venerable friend went down in the general wreck that engulfed the infant manufactures in their cradles all over the country.

After the enterprise was launched the younger brother dropped out, to be replaced by a W. T. Middleton of whom nothing more is known. Later a lawyer, Charles Fox, joined the firm. After 1837 and the failure of the firm, the plant itself was kept in operation by Garrard and Fox to produce blister steel. There is no record of regular production of cast steel after that year, however, and the old works was eventually taken over by a brewery. In later life both Garrard brothers returned to the Pittsburgh area. John Hill Garrard died in Pittsburgh in

1883 at the age of seventy-eight and Dr. Garrard died in Fallston, Beaver County, Pennsylvania, on March 18, 1889. How, why, and when Dr. Garrard acquired his title is now unknown, but it is believed he was entitled to it by reason of his knowledge of metallurgical chemistry. He, first in the United States and perhaps first in the world, had the wit to keep on hunting for materials of different chemical characteristics when his first efforts to cast steel were not successful.

Early Pittsburgh Attempts

The first attempt to cast steel in Pittsburgh, by Simeon Broadmeadow, in 1831, was a failure although he and his son had made acceptable blister steel as early as "between 1828 and 1830." In 1841 Patrick and James Dunn began a two-year unsuccessful attempt to cast the blister steel produced from Juniata blooms by the famous old Pittsburgh firm of G. & J. H. Shoenberger. Jones & Quigg and Coleman, Hailman & Co. both produced low-grade cast steel occasionally after 1845, the former firm rolling the first slab of cast plow steel in 1846. In 1852 McKelvy & Blair of Pittsburgh, file makers, commenced to cast steel of "good" but not "fine" quality and became the pioneers in continuous production of cast steel. Their plant shut down after two years and was later bought by Hussey, Wells and Co. Singer, Nimick & Co. and Isaac Jones's Pittsburgh Steel Works, both incorporated in Crucible in 1900, succeeded in casting saw, machinery, and plow steel in 1853 and 1855, respectively, both in Pittsburgh.

Thomas S. Blair prepared for Swank's history a flavorsome analysis of the Pittsburgh steel picture in the 1850's which deserves reprinting for its own sake.[2] He wrote:

> The blister steel made at Pittsburgh was sent all over the West, and was used by the country blacksmiths for the pointing of picks, mattocks, etc., and for plating out into rough hoes, etc. It was usually made from Juniata blooms, especially in the period anterior to 1850. After that date Champlain ore blooms were used to a considerable extent. German steel was simply blister steel rolled down. The two leading applications of German steel were springs and plow-shares. The business was very large at one time. G. & J. H. Shoenberger pushed this brand vigorously from about 1840 to 1860. Meanwhile quite a number of other concerns entered into the competition at various times.
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> The Shoenberger experiment in the manufacture of crucible steel failed on account of the inferior quality of the product. The firm were so confident that no iron could be found in this country that

2 Apparently he was the junior and Colonel Samuel McKelvy the senior member of the McKelvy & Blair partnership.

could in any respect excel the Juniata iron that, when that article failed to produce steel equal to that of Sheffield, they gave up the manufacture of crucible steel. In the light of the experience gained under the scientific methods which the Bessemer process has made a necessity we now understand that the Shoenbergers could not make good crucible steel out of iron containing two-tenths of one per cent of phosphorus.

McKelvy & Blair at first made their pots out of Darby and Stannington clay, imported from England. The brilliant success of Joseph Dixon, of Jersey City, New Jersey, in perfecting the manufacture of plumbago crucibles, for which the crucible steel interest in the United States owes him a monument, gave to that firm and to the Jersey City steel works a very valuable lift. With these crucibles and with Adirondack blooms Mr. Thompson[3] made some excellent steel. Along in 1853 and 1854 McKelvy & Blair made steel from the Adirondack blooms which was used in the nail factory of G. & J. H. Shoenberger. It may be added, also, that the knives and dies of nail-cutting machines afford an admirable test of endurance in tool steel. The American steel made from American iron was fully up to the English steel in every particular.

It was not possible for McKelvy & Blair to obtain the Adirondack blooms in any quantity, and they had no other resource than the Champlain and Missouri blooms, all of which produced red-short steel. This, notwithstanding that drawback, found a market so extensive that the firm sent to Sheffield and brought out several skilled workmen, and the business of manufacturing handsomely finished bars, plates, and sheets was fairly inaugurated. The drawbacks, however, of pioneer operations, chief among which was the abominable English system, imported with the skilled labor, of "working to fool the master," were too much for the financial strength of the firm, and in 1854 they were forced to drop the enterprise.

At this point it may be desirable to mention that Joseph Dixon moved his enterprises to Jersey City in the late 1840's and 1850's. This put him into close touch with the Adirondack Iron and Steel Co. and therefore indirectly with McKelvy & Blair of Pittsburgh, who were most nearly successful when they used Adirondack blooms and Dixon's own crucibles. Dixon's constant observation of the Adirondack works resulted in his obtaining patents for improvements in manufacturing steel in April, 1850, and in November, 1858. During this entire period, of course, Dixon continued to produce the crucibles used by the New England copper and brass industries. At an uncertain date he began to impart Klingenberg clays from Germany to mix with his graphite in forming both pencil leads and crucibles.

Also, during the 1850's two Pittsburghers, Dr. Curtis G. Hussey and James Park, Jr., separately and successively interested themselves in copper mining, smelting, rolling, and fabricating. Thus they were inde-

3 Identity unknown, probably an official or owner of the Adirondack Iron & Steel Co.

pendently aware of what Dixon was doing. It was probably Dr. Hussey, although there is no way of being sure, who first thought that the new Dixon crucibles made of graphite mixed with Klingenberg clay from Germany might change the crucible steel picture in Pittsburgh. At least we know that Dr. Hussey acted first, to what effect will be recounted later.

In 1858, then, there was a new-type crucible which was both more durable and more efficient than any in use before. It transmitted heat more quickly from the flaming gas of the furnace to the interior of the white hot crucible, saving much fuel, while there was less contamination from the material of the crucible itself. Durability became an overwhelming advantage because steel melted in a brand new crucible turned out to be of a lower grade than that produced in the same crucible the second and subsequent times it was used.

In 1858, incidentally, new and lower tariff rates, established by the Buchanan administration the year before to soothe Southern interests, almost destroyed the existing American blister steel industry. The effects were so marked that a ground swell of support arose for a tariff that would truly protect the native iron and steel industries. Men in Pennsylvania like former Congressman and banker Thomas M. Howe began to see that the continuing prosperity of Pittsburgh would require a new and positive approach to politics. Howe and Dr. Hussey and Park were all convinced opponents of slavery and therefore natural recruits to the burgeoning Republican party. As they became more and more active as Republicans, the party, for various reasons, became more and more a high protective tariff party. They gradually acquired confidence that eventually the new party would be able to take over the national government and draw up a new tariff act. When that day came they wanted to be ready to take full advantage of it, to make the Pittsburgh district at last begin to rival England.

We have then technological factors, primarily due to the inventive genius of Joseph Dixon; political factors, indirectly connected with the natural affinity of prominent Pennsylvanians for the new Republican party; and economic factors, due to the involved interrelationship of American and English industries. All of these combined to make Pittsburgh, on the eve of the Civil War, the birthplace of the American crucible steel industry.

As almost always under such a combination of favorable circumstances, there were also men of remarkable application and executive ability, notably Calvin Wells, who made the most of the opportunities that were opened up. It is interesting, however, before we pass on, to think of the humanitarian aspect of these beginnings of the crucible steel industry. The leading New England and New York and New Jersey industrialists of the period were on the whole friendly to slavery because of their Southern contacts. Their pro-slavery opinions kept them out of the Republican party, out of the main stream of knowledge of coming politico-economic events. They missed the ball on crucible steel in spite of the fact that the iron ores and fluxes were then in their own back yards. Of the necessary physical ingredients of crucible steel, Pittsburgh in 1858 had the advantage only in fuel.

Hussey, Wells & Co.

Hussey, Wells & Co. of Pittsburgh, organized in 1859, began in 1860 the first American manufacture of cast crucible steel of the best quality as a regular product. There were four original partners in the firm. Two of these, James M. Cooper and Thomas M. Howe, both bankers, were investors. The latter's son, George A. Howe, inherited his father's interest and was an owner and officer of the firm in 1900 with James W. Brown when it was incorporated into the Crucible Steel Company of America as Howe, Brown & Co.

Historically significant were Howe and the two active partners who gave the company its name. The senior, Dr. Curtis G. Hussey, was an American business genius of a type which still springs up occasionally. Born on a farm on August 11, 1802, he moved to Ohio as a boy.[4] Trained as a physician by the old apprenticeship system, he started a general practice in pioneer rural Morgan County, Indiana, at twenty-three. In four years he had accumulated a capital of some thousands of dollars and bought several general stores as investments. These expanded and their management soon required his full time. He began to buy pork from neighboring farmers, became interested in the pork trade to the East by way of the Ohio River to Pittsburgh, and in 1840 moved to Pittsburgh to supervise his marketing operations.

In 1842 Dr. Hussey heard of the copper ore strikes in the Lake Superior region. Unable to leave his own affairs, he chose an efficient

4 His birthplace is alternatively given by authorities as "near York, Pa.," or at Sandy Spring, Md. The birth date, however, is not challenged.

representative to check for him on the spot in 1843. This representative bought for him a full third of each of the first three United States permits to mine copper in the region. Dr. Hussey immediately organized the Pittsburgh & Boston Mining Corporation which opened the first mine. It ultimately earned $2,280,000 on an investment of $110,000. By 1849 Dr. Hussey saw further opportunities in the copper business and organized, with his friend and banker Thomas M. Howe, the firm of C. G. Hussey & Co. to roll and market copper. This firm, incidentally, is still in active and profitable existence in Pittsburgh in 1953. C. G. Hussey & Co. was not only the first copper-rolling company west of the Alleghenies, but also it provided a further close connection between the doctor and the New England brass industry which continued to expand as copper became cheaper and more available.

Early in 1849, incidentally, shortly before C. G. Hussey & Co. was launched, Calvin Wells left the Western University of Pennsylvania (now the University of Pittsburgh). He had been born in Byron, Genesee County, New York, on December 26, 1827, to a family poor but scholarly, with a tradition of college training. On leaving the university he became a bookkeeper for a wholesale merchant, Benjamin Glyde, who later became his father-in-law. In 1850 Mr. Glyde decided to retire, and began to liquidate his business. One day, while this was in process, young Wells met a man called variously John Hays or Hayes, Dr. Hussey's representative in the Lake Superior region. Hays, or Hayes, told Wells he was the kind of man Dr. Hussey could use, and recruited him at once. The following morning, at the first meeting with the doctor, Wells began a twenty-six-year connection.

For two years Wells worked in the copper business. Dr. Hussey, however, had in no wise lost interest in the pork business which had first brought him to Pittsburgh. In 1852, satisfied with young Wells's abilities, he started the firm of Hussey & Wells, pork packers on "Liberty Street," to market the products of his Gosport, Indiana, packing plant. This business, financed by Dr. Hussey but operated entirely by Wells, did well.

In 1858, about the time of publication of Dixon's second crucible patent, Dr. Hussey got his great idea of starting a crucible steel business in Pittsburgh. He detached young Wells from his pork duties and sent him to Jersey City to learn all he could about the crucible process. In 1859, with the financial participation of Howe and Cooper, the pork firm of Hussey & Wells was superseded by the newly organized Hussey, Wells & Co. Wells became general manager. The old plant of McKelvy & Blair, where attempts to cast crucible steel had been abandoned in 1854, was purchased. Calvin Wells bossed the erection of new buildings and equipment on the enlarged site at 17th and Penn streets and began experiments. In 1860, after the expenditure of several hundred thousands of dollars, Wells succeeded in producing crucible steel directly from iron bars, without having first to make and then remelt blister steel.

Dr. Hussey, like his great predecessor in crucible steel, the Englishman Huntsman, was a Quaker. He was against war and "for" temperance as much as he was against slavery. He served one term in the Indiana legislature before he became a full-time resident of Pittsburgh. In Western Pennsylvania he pioneered the training of women for industry when he established the School of Design for Women in Pittsburgh. He was the founder and first president of the Allegheny Observatory, now part of the University of Pittsburgh. He served the university as a trustee from 1864 until his death on April 23, 1893, when he was almost ninety-one years old.

Calvin Wells was a Presbyterian, a member of the Third Presbyterian Church from the year he came to Pittsburgh, 1847, until his death in 1909. During much of that time he was president of the board of trustees. His interests were multifarious, gradually encompassing railroad car springs (made from crucible steel), zinc, and banking. In 1876, his retirement from Hussey & Wells resulted in the firm becoming Hussey & Howe. Two years later he invested his accumulated savings in the ownership of the *Philadelphia Press* and the control of the Pittsburgh Forge & Iron Co., the latter of which he retained until his death. From 1900 until his death he was also a trustee of the University of Pittsburgh.

Congressman Howe, so called because of his election to the national House of Representatives in 1850 and 1852, was another example of a high-minded Christian industrialist. He was born in Williamstown, Vermont, and came to the Pittsburgh district as a young man. During and after the Civil War he was frequently called "General" Howe because of his service as assistant adjutant general of Pennsylvania. He was the first president of the Chamber of Commerce of Pittsburgh, and held the post until his death. He was a vestryman of Trinity Church (now Trinity Cathedral of the Protestant Episcopal

Diocese of Pittsburgh) for thirty years, a founder of Allegheny Cemetery, and a founder, warden, and vestryman of Calvary Episcopal Church. His association with Dr. Hussey continued active until his death at sixty-nine in 1877, the year after the old firm became known as Hussey & Howe with the retirement of Calvin Wells.

Park, Brother & Co.

The three important partners of Hussey, Wells & Co. were all typical Pittsburghers of their generation. All three were born elsewhere and came to the forks of the Ohio because of its natural advantages. Not so with the two partners of Park, Brother & Co., founded in 1860. They were Pittsburghers born and bred. The elder and leader, James Park, Jr., was born in Third Avenue, Pittsburgh, on January 11, 1820, and died in Allegheny City (now the North Side) April 21, 1883. He, with his younger brother, the first David E. Park, joined their father's china and metal retail business in 1840 as full partners. After James Park, Sr., died in 1843, the two young men were in full command.

James Park, Jr., was not an inventor, nor of an inventive type of mind. But he had insight and could grasp new ideas instantly when they were presented to him. He constantly encouraged the introduction of new industrial processes and, as has been mentioned earlier, he was among those instrumental in laying the groundwork for the first Republican tariff act, known as the Morrill Tariff, adopted in 1861.

One of his earlier decisions was to curtail the sale of china goods in his store and concentrate on metal products. This served to broaden his education in the limitations of the various types of steel and iron available for fabrication in the twenty years before the Civil War. When he bought a share of a cotton-goods factory he became aware of the deficiencies of cheap iron or steel when used for machinery parts. In 1857, observing the success of the Hussey and other copper works, Park founded the Lake Superior Copper Works to make copper for sheathing ships' hulls. This not only brought him into contact with both the New England copper- and brass-consuming industries, but also gave him a first-hand acquaintance with metal rolling mills and with all the other elements which had influenced Hussey and Howe and Wells. By 1860 he thought their example in starting a crucible steel business should be followed.

Accordingly, shortly after setting up Park, Brother & Co., ground was broken for the world-famous Black Diamond Crucible Steel Works. Here, on May 1, 1862, on a site still occupied by the Park Works of Crucible Steel, was poured the first steel to be cast by the firm. Production at first was only five tons a day, with only fifty "hands." By 1863, however, production had expanded under the stimulus of the Civil War and the tariff, working in conjunction. In addition to crucible cast steel of the "finest" quality, the firm began to produce fine iron and a new product, "soft center" cast steel. Tradition has it that the tool steel made by Park, Brother & Co. was produced at first primarily by English workmen imported for the purpose who used traditional English methods, and that costs were higher than at Hussey, Wells & Co. At any rate, the diversity of production made it possible to continue making crucible steel at a loss until all problems were finally surmounted.

Park's Pittsburgh interests included a suspension bridge company, McIntosh, Hemphill & Co., and various cotton mills. He followed the tradition of his fellow pioneers in the crucible steel industry by becoming a trustee of the Western University of Pennsylvania. He was also an elder of the First Presbyterian Church of Allegheny City, a director of the Western Pennsylvania Hospital, a director of the Humane Society, and an officer or director of several banks.

He influenced all phases of the steel industry to a remarkable degree, particularly by his tariff activities, which exceeded those of his business rivals in intensity. His comparatively early death was blamed on arduous labors in the winter of 1882-1883 as a member of the United States Tariff Commission and vice president of the American Iron & Steel Association. In the field of "common steel" he bought an early interest in the Kelly "pneumatic" process and in 1866 helped to force the consolidation of the patent rights controlling use of the Kelly, Mushet, and Bessemer processes. This made possible the full-scale production of Bessemer steel in the United States almost concurrently with the development in England. Park also brought to Pittsburgh Captain Alfred C. Hunt, to be superintendent of the Black Diamond Works open hearth department.

In the largely unwritten history of the Crucible Steel Company of America, James Park, Jr., figures primarily as the father of David E., William G., and James H. Park, main figures in the organization of the company in 1900. Their efforts and activities deserve separate treatment, which will be given in a later study of the growth of the crucible steel industry from 1862 to 1900, or in the projected history of the Crucible Steel Company of America.

From 1862 *to* 1952

Word that two Pittsburgh firms had successively mastered crucible steel production did not at first electrify the industry. In the beginning production was low. Most competitors, established firms which imported bars or finished products made from Swedish, German or English crucible steels, were wholly unaware that a new era was at hand. In any event, the importers reasoned, only the temporary combination of civil war and the new high Republican tariff had permitted the possibility of profit for the American companies. Either Southern victory or the election of a Democratic Congress (both anticipated by many acute observers at the time) was expected to deal a death blow to the infants.

In 1863, however, a third American firm got into production, in the old Jersey City cast-steel plant where both Dixon and Wells had experimented. In that year, Gregory & Co. purchased outright the works that the Adirondack Iron & Steel Co. had used until 1853 and had leased out for ten years afterward. Under the leadership of Dudley S. Gregory, who had been a partner in the original firm, the plant began to produce crucible cast steel equal to the best. This broke the log jam. All over the country established producers of wrought iron and cast blister steel sought to emulate the pioneer three while other firms were founded for the purpose. We have no accurate record of the order in which these other firms finally got into production.

Typical in Western Pennsylvania were four firms which were taken into Crucible in 1900. Singer, Nimick & Co., of Pittsburgh, founded in 1848, and Isaac Jones's Pittsburgh Steel Works (later Anderson-Depuy & Co.), founded in 1845, had cast steel for many years but failed to achieve best quality until after 1863. LaBelle Steel Co. (Reiter, Hartman & Co.), of Allegheny City, founded in 1863, and Crescent Steel, of Pittsburgh proper, founded in 1865, were organized with crucible steel production specifically in mind.

By 1863, too, a new factor arose which contributed significantly to the success of American crucible-steel producers. Raids upon American shipping by the Confederate cruiser "Alabama" and other less publicized vessels seriously curtailed imports of foreign tool steels. It thus became not only profitable but a patriotic duty to produce as much crucible steel as possible. Users of the foreign steels who had been more than willing to pay a money premium for imagined higher quality were forced to buy American steels in order to stay in business.

After the Civil War, the industry was solidly established. Minor depressions and two low Democratic tariffs, under Grover Cleveland, were only briefly disturbing factors. Tremendous expension in the use of rail and structural steel after the war, made possible by James Park's consolidation and prompt exploitation of the Bessemer-Kelly-Mushet patents, concurrently increased the demand for crucible steels. Cutlery, surgical instruments, fine firearms, and the like, made of foreign steel, continued to be imported because of their superior workmanship or low finished cost. But from 1865 on, crucible-cast tool and special-purpose steels used to cut and shape common steel, or for such supplemental products as springs, were available in the United States at a price and quality which generally defeated foreign competition.

By 1900 the Park Steel Co., successor to Park, Brother & Co., was the largest producer of crucible and special-purpose open-hearth steels in the world. It had attained that position largely because of the activities of the second David E. Park, eldest son of James Park, Jr. He effectively controlled the company's operations although he shared its ownership with many other members and friends of the family. In many ways the Park company dominated the special-purpose steel industry even more than the Carnegie interests dominated the production of common steel.

Park and a number of his competitors saw advantages for themselves and the industry if the leading producers of crucible steel would combine. For one thing, it would turn family holdings in obscure although valuable local businesses into shares in a large company, readily convertible into cash. Finally, a new company could assure adequate raw materials and permit its components to concentrate upon their specialties instead of feeling impelled to compete across the board.

The great consolidation in 1900 was quite naturally called the Crucible Steel Company of America. Many of the names associated with it since then have also been prominent in our community and our society. While its internal history remains to be written, there is now no doubt that the example set by the creation of Crucible inspired the similar consolidation on a greater scale which resulted in the founding of the United States Steel Corporation about a year afterward.

For some years after 1900 Crucible kept its headquarters in Pittsburgh. Later, as the Pittsburgh interest was diminished by death and liquidation, and as additional Eastern holdings were added, the head office was moved to New York. Today, however, fifty-three years after the consolidation, Crucible is again a Pittsburgh concern. Its operations again are directed from the city where both it and the old industry whose name it commemorates first saw the light of day.

A NOTE ON THE SOURCES

The primary authority for statements in this study is the 1892 edition of the *History of the Manufacture of Iron in All Ages* by James M. Swank, published at Philadelphia by the American Iron and Steel Association. Swank served the association as secretary and general manager from 1872 until long after the publication of his definitive history. The few inaccuracies and many omissions which marred his first edition in 1884 ironically testify to his primacy as a historian because they are repeated in so many popularized modern "histories."

Wherever possible, however, statements made here have been independently verified. It is to be hoped that an interested and competent person will some day bring out a new comprehensive history of iron and steel which will reexamine the material available to Swank in the light of the scholarship of the last sixty years. Such a work, if indexed, would make a study like this an hour's exercise in technique. As it is today, anyone using Swank as an authority has to prepare his own working index. The only index incorporated in the second edition as published confines itself to the names of pioneer iron and steel manufacturers. It refers to Andrew Carnegie once and to the author, with Victorian modesty, not at all.

The American Iron and Steel Institute, which replaced Swank's association, has produced many anonymous but definitive brochures and pamphlets as well as many bound volumes of formal papers. This material is invaluable for an understanding of the current state of any phase of the steel industry. Perhaps because of its preoccupation with the excellencies of the present it is not altogether satisfactory as a source of information on the intricacies and personalities of the past.

Primary source materials, in the strictest sense, are altogether lacking in connection with the actual operations of both the Park and the Hussey companies. Two circumstances are to blame, the courthouse fire in Pittsburgh in 1882 and the repeated floods which destroyed the company records in the old plants on the Allegheny River flood plain. Because of the courthouse fire it is often impossible today to make positive statements about degrees and dates of ownership. We are forced all too often to rely upon recollections collected many years after the events. Again, we have no direct evidence of just what processes were used at a particular time in a particular plant. Each plant developed its own refinements of the basic processes. Plant records, locked away in safes during the period when the ancient processes were in use, were stored in cardboard or wooden boxes when the processes became outmoded. What records were not ruined in the flood of 1907 were swept away without trace by the tremendous flood of 1936.

City directories, however, readily available for each year since 1858, when Hussey & Wells were still pork packers, provide a contemporary check upon memoirs and recollections. One isolated issue of an old city directory does not establish any fact in itself. There were too many omissions and typographical errors. Repeated insertion of a certain name in relation to a certain firm, however, does prove a connection. Wherever there has been a question of the accuracy of a certain sequence of events, the city directory has been accepted in spite of one or more contrary statements in any of the various city "histories" that have been produced down through the years.

A question that plagued the writer in connection with the current study—whether or not Hussey, Wells & Co. in 1859 actually took over the plant previously used by McKelvy & Blair—would have been easily cleared up if there had been city directories regularly issued by the same publisher every year after 1852. There were conflicting statements in various biographical sketches. County assessment or deed-registry records, of course, would have settled this and similar questions if they had been available. Admittedly somewhat less than vital, the matter remained obscure until the writer happened upon mutually confirming old real-estate maps and advertisements showing McKelvy & Blair at "Harrison and Pike" in 1854, and Hussey, Wells & Co. at the same address in 1859. That intersection is now approximately 17th and Smallman. Actually, the small old McKelvy plant was but the nucleus of the larger and rapidly expanded new Hussey, Wells & Co. operation, which by 1860 had its address at 17th and Penn.

The principal open-shelf collections of books consulted for this article are in the Carnegie Free Library of Allegheny, the Pennsylvania Room of the Carnegie Library of Pittsburgh, the Historical Society of Western Pennsylvania, the Science and Technology Library of the University of Pittsburgh, and the Princeton University Library. City directories, local histories, and biographical volumes are available in the three first-mentioned collections where they may be consulted by any serious researcher. The Union Catalog at the Library of Congress was used to locate several books not available on the library's own shelves. One such, in the New York Public Library, was a memoir of the life of Calvin Wells. Subsequent investigation, however, turned up another copy of this memoir in the possession of a surviving granddaughter, Mrs. James I. Marsh of Pittsburgh.

There is a good deal of material on the life and work of Joseph Dixon reputedly available in a library at Marblehead, Massachusetts, his birthplace. The company that bears his name, however, has not retained any records indicating exactly which Pittsburgh firms first ordered Dixon crucibles made of a mixture of graphite and Klingenberg clays. There may be documents in Marblehead that will settle this and many other questions in which the Dixon company itself is interested. They remain to be studied at some future time.

The closed-shelf collections of the Carnegie Library of Pittsburgh (particularly its Technology Department), the University of Pittsburgh, the Library of Congress, and the New York Public Library were consulted where the information in the card catalogs indicated checking might repay the effort. The open-shelf (loan) collection of the Technology Department of the Carnegie Library of Pittsburgh yielded a number of interesting older books on the technology of iron and steel that shed light on the relative antiquity of various processes, including the crucible process.

Newspapers and magazines were consulted sparingly. Bound copies of the *Scientific American* for the decade of the 1850's (when it performed several functions later taken over by the *Patent Office Gazette*) had many references to various improvements in the art of steel making. Assiduous reading, however, generally failed to uncover any immediate effective American utilization of these improvements. Use of such an improvement after 1862 does not concern this history but belongs to the history of the growth of the industry and the Crucible Steel Co. itself.

Other magazines of the period were checked by means of Poole's subject index. Newspapers were consulted in several cases to verify dates that were mentioned by Swank or by other less definitive historians. Because of the fragile condition of most of the older bound volumes of Pittsburgh newspapers it seemed wiser to limit research to those that have been microfilmed.

Patent applications are a fruitful source of information in most studies akin to the present one. Most significant changes in the crucible process, however, did not appear to be patentable from 1859 until the final triumph of the electric furnace in the era of World War I. In the absence of an adequate knowledge of what chemical reactions actually occurred in their crucibles, the early melters relied upon a careful record of trials and errors. What was successful once, whether by accident or design, was repeated until competition forced new experiments. In the absence of patent protection for a process, each company was dependent upon its melter personnel and its secret records for the quality of its output.

Recollections by participants in the events mentioned above are not generally available. Here and there, however, in the reports of engineers or in the proceedings or transactions of some society we get a passing glimpse of some personality. It is to be regretted that none of the old melters are living today. This leads up to the further hope that studies of some of the other steelmaking processes may be initiated and completed while there is still time to incorporate the recollections of those who took part in the events to be described.