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- Electric Steelmaking Technologies
- AIST 2015 Electric Arc Furnace Roundup

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ADVANCING THE TECHNICAL DEVELOPMENT, PRODUCTION, PROCESSING AND APPLICATION OF IRON AND STEEL

Ternium Hylsa uses a conveyor belt to drop direct reduced iron into a chute installed on an electric arc furnace roof.

Water-cooled panels connected to a cooling system are mounted onto a device to identify water leaks.

Attention Eagle Eyes!

Be the first to post the correct location of this issue's hypocycloid on our Facebook wall and win an AIST coffee mug!

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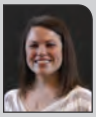


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Danieli's EAF specialized workshop: a new high-capacity EAF featuring original water-cooled panels that ensure extended panel life and energy savings.

Photo courtesy of DANIELI.

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Perspectives From a 50-Year Career in the Steel Industry

Dr. Queneau was scheduled to deliver his presentation, "Production of the Rotor for the First Million-KVA Nuclear Power Plant," during the *Ferrous Metallurgy: From Past to Present* session at MS&T14 in Pittsburgh, Pa., USA, on 13 October 2014. Due to unforeseen circumstances, he was unable to attend the conference. Dr. Queneau's presentation was delivered by Kester Clarke of Los Alamos National Laboratory in his absence, and Dr. Queneau has given *Iron & Steel Technology* permission to publish the presentation.

Author

Bernard Russell Queneau
retired, United States Steel Corporation, Pittsburgh, Pa., USA
(deceased)

Good morning! I am greatly honored to be here talking to a distinguished group of steel men about ferrous metallurgy: past to present. I joined the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in 1931. My wife Esther and I recently moved to a retirement facility in Mt. Lebanon, Pa., USA. Esther brought out all my steel mementos and firmly suggested that they had to go! So I sadly called the Rivers of Steel Heritage in Homestead, Pa., USA, and gave away some 14 artifacts — but I held on to one of my favorites: a scale model of a generator rotor for the first 1 million-KVA nuclear power plant.

What you might not know is that the science of physical chemistry was first applied in the steel industry to blast furnaces. The U.S. Bureau of Mines decided in the early 1920s to improve the efficiency of the blast furnace, and ordered the construction of a 3-foot-diameter pilot blast furnace — where else but on the campus of the University of Minnesota, which had an excellent School of Chemistry, with plenty of iron ore nearby. It was placed under the direction of P.H. Royster, who was a real genius, but had zero ability to get along with people, and had to be replaced, and so Prof. T.L. Joseph was put in charge. They did some outstanding work together, but Prof. Joseph got all the credit, and today we have the Thomas L. Joseph Award for Ironmaking.

The U.S. Bureau of Mines did not neglect the open hearth, and in the early 1920s hired Charles H. Herty Jr. to study the process scientifically. He really started the Physical Chemistry of Steel Making Committee by gathering together outstanding research men — such as John Chipman of M.I.T., W.O. Philbrook and Gerhard Derge of the Carnegie Institute of Technology, and L.S. Darken of U. S. Steel. With Herty's help, the various steel companies agreed to have open hearth conventions, and the exchange of basic knowledge was started. However, when I toured my first steel mill in 1927 at Donora, Pa., USA, all the melters had their own little black books, and melted heats to their own formulas. Since they were paid incentives, you can imagine that a fast heat was the best heat. This meant adding lots of ore, knocking the carbon low as fast as possible, then adding hot metal from the blast furnace to meet the carbon specification. Of course, this produced steel with the maximum amount of inclusions. Bessemer Steel had the same problem, because the hot metal was blown down to low carbon, and then brought back to specifications by adding pig iron.

One man who deserves a lot of credit for high quality control in the steel industry is John C. Kinnear Jr. of U. S. Steel. He set up an observation corps in the Homestead Works who collected a full history of each heat, including metal temperatures with optical thermoscopes.

This was in the early 1930s, the same time I graduated from Columbia Engineering School. Now, 1933 was not a good year to get a job, but I was fortunate to obtain a position with the Research Corporation, owned by Frederick G. Cottrell, the inventor of the electrostatic precipitator in 1907. Tennessee Valley Authority was intent on obtaining soluble phosphorous fertilizer for southern farms, and the plan was to produce a soluble oxide. It was decided to reduce the ore in a blast furnace and use an electrostatic precipitator to collect the liquid — yellow, pyrophoric phosphorus — from the blast furnace gas. So, a pilot 3-foot-diameter blast furnace was to be designed, built and erected on the American University campus in Washington, D.C., USA, with P.H. Royster as the chief engineer. We designed the furnace from foundation to hot top, the insulating lining and load equipment. I could spend the rest of my allotted time covering a most interesting winter with deadly yellow phosphorus. Birds would last a few seconds after drinking from our cooling water. Bunnies would make about 20 hops before they fell over dead. I soon decided that working with phosphorus wasn't for me.

Bernard R. Queneau at his desk at Duquesne Works in 1956.

So, I decided to gather further education, and was fortunate enough to obtain a teaching assistantship at the University of Minnesota. I obtained my Ph.D. in metallurgy in 1936, and then worked for U. S. Steel at its Research Laboratory in Kearny, N.J., USA. The reason I bring up this personal background is to let you know what an exciting time it was in steelmaking during the 1930s. In 1971, U. S. Steel published an excellent reference book called *The Making, Shaping and Treating of Steel,* covering the years 1920 to 1970. The earlier 1920 volume covers some elementary chemistry, whereas the 1971 edition has 122 pages covering the physical chemistry of iron- and steelmaking.

At Kearny, I soon found out that I knew very little about steelmaking by being with young trainees brought to Kearny for a one-year training program in fundamentals. All of my work had been with killed steel, and I knew nothing of semi-killed, capped and rimmed steels. So I asked for a mill job, and was transferred to Pittsburgh as general foreman of the metallurgical laboratory at the Duquesne Steel Mill. It was a great training experience in steelmaking, because there was a No. 1 open hearth where they made steel for sheets and tinplate, a No. 2 open hearth for killed alloy steels, and an electric furnace shop for production of quality ball bearing steels, etc.

In 1938, the Roosevelt Recession really hit the country, and especially the steel industry. My work continued, but my pay was cut in half. Along came a generous offer from Columbia University as assistant professor of metallurgy, and I couldn't say no. Then along came Adolf Hitler, and in 1939, I joined the U.S. Navy Reserves, and was ordered to active duty in June 1941 to be the senior metallurgist at the Navy's new Armor & Projectile Laboratory in Dahlgren, Va., USA, ending up in 1945 as a Commander and the Commanding Officer of the Armor and Projectile Laboratory. We worked extensively with the Naval Gun Factory in the continuing work of improving guns, projectiles and armor plate up to 18 inches thick. I was also sent to Homestead to help them in picking the representative plate for a group of plates. At that time, the test plate was picked entirely by a fracture test. We developed Charpy fracture tests, which gave us a numerical number for the quality of the individual plates, and thus had a much better selection process for the weakest plate in the group. At Homestead, I became familiar with large ingots being produced for this armor, I believe up to 200 tons, all made with hot-top killed steel.

In the early spring of 1945, I took part in the Naval Technical Mission to Europe, to visit the German steel mills in the Ruhr Valley, and to bring back any new technology relating to the field of guns, projectiles and armor.

After five years in the Navy, I rejoined U. S. Steel as chief research metallurgist at South Works in Chicago, Ill., USA. The following five years were most useful in rounding out my experience in steel production. The whole of U. S.

"When I toured my first steel mill in 1927 at Donora, Pa., USA, all the melters had their own little black books, and melted heats to their own formulas. Since they were paid incentives, you can imagine that a fast heat was the best heat. This meant adding lots of ore, knocking the carbon low as fast as possible, then adding hot metal from the blast furnace to meet the carbon specification. Of course, this produced steel with the maximum amount of inclusions."

Scale model of the generator field rotor forged from the first large steel ingot cast in the U.S., from Bernard Queneau's private collection.

Steel's mills and research laboratory lost a great advantage in not developing the basic oxygen furnace at that time. In an effort to improve the Bessemer process, the research laboratory had developed a side-blown Bessemer, called a Turbohearth, and actually put one in at South Works, and operated it for nearly a month. But within a few days, the lining had been all burned out by the use of oxygen being fired right across at the side wall. Now, why didn't one of us think of a vertical line? I include myself because I looked at this furnace, but I wasn't directly involved. Later, the Austrians placed the oxygen lance vertically, to blow down on the steel, and thus developed the basic oxygen furnace. We had to wait for the oxygen to do the natural thing of blowing down on the steel, and that became a worldwide standard and sounded the knell for the basic open hearth and Bessemer furnaces.

I was most active in both the Iron & Steel Society and American Society for Metals. I was able to apply the acquired knowledge to the various mill operations.

One of my first innovations was to change from thermoscopes to thermocouples, and thus greatly increase the accuracy of the steel temperatures. This was especially helpful to the electric furnace melters, because we found a much larger variation in temperature in the steel bath than we suspected. The melters had to paddle the bath to bring it to a uniform temperature before making furnace additions, and especially before tapping.

As an amusing sidelight, let me mention Larry Darken, a top research man in the field of the physical chemistry of steelmaking. Darken visited South Works and asked me to take him out to the electric furnaces. When he observed a heat being made, the furnace additions, the paddling operation and tapping, he thanked me profusely and admitted that he had never seen an electric furnace in his life!

In 1950, Robert W. Graham, assistant general superintendent of Homestead Steel Works, was made chairman of a committee to close down Duquesne Works, which, at that time, was losing more than US$1 million per month! He selected a committee, studied where the Duquesne Mill products could be made at other plants, and came to the conclusion that we could not afford to close down Duquesne without putting many of our customers out of business. Top brass told him, "Okay, you're the new general superintendent of Duquesne, and we give you three years to get out of the red."

Graham put together a great, new team of department heads, including a new chief metallurgist: me. He came to South Works to offer me the job personally. I laughed when he said Duquesne — I had worked there in 1937, and knew what a broken-down mill it was. He was not taken aback, but actually congratulated me in knowing what a tough job it would be. I was given the promotion, and I would be at the only other mill with electric furnaces in U. S. Steel, and that was what I knew and wanted. So I said, "Yes," and had the time of my life right here in Pittsburgh!

Fortunately, Duquesne already had a good metallurgical team, but they had to spend their energy on improving the quality of unprofitable products. I was quickly known in our downtown office as the "dollar metallurgist." U. S. Steel had increased the importance of the metallurgy departments by placing not only inspection, chemistry, quality control and research under the chief metallurgist, but also specifications. So every order that came to the mill went through specifications, and if it didn't make a profit, we rejected it as something we couldn't make. You can imagine that I was not very popular, but I was backed up totally by Bob Graham.

We took on some very profitable orders, especially in stainless steel. We were asked to produce 18-8 stainless to a 0.03% carbon maximum. To do that, we had to obtain ferrochromium from Union Carbide with the same strict limitation. With the help of D.C. Hilty, we obtained the low-carbon ferrochrome, and, using a chromite hearth in the electric furnace, we produced multiple heats to this tight specification.

The toughest sales order came up in 1956, with the request by General Electric for a two-foot-diameter alloy steel rotor, weighing some 250 tons, for its newly designed nuclear power plant motor-generator. Our five electric furnaces had a total capacity of 350 tons, so that was the weight of the ingot that we were going to cast for the steel rotor.

The ingot had to be a hot-top killed steel, with close to 100 tons in the hot top. Another requirement was that it had to contain less than 1 ppm of hydrogen. When milling electric furnace steel, the humidity in the air provides around 4 ppm of hydrogen, but by blowing argon through the liquid steel, the hydrogen can be reduced to the required 1 ppm. However, when you pour the liquid steel through moist air, it will pick up some hydrogen and oxygen and increase the number of inclusions, and there is greater opportunity for fracture development in the rotor. General Electric previously had two catastrophic failures of rotors when progressive fractures had been initiated, with hydrogen being released at an inclusion. We therefore decided that we had to pour the liquid steel in a high vacuum to prevent the liquid steel from being exposed to any moisture.

It so happened that Union Carbide had just our answer in a high-capacity vacuum pump. So this vacuum pump was installed over a 16-foot-diameter mold, also weighing 350 tons, and when the great day came — 6 September 1956 — we began by emptying all the furnaces, starting with No. 1, then No. 2, until all five furnaces were empty, and then started them up again, one at a time. We poured each heat through the vacuum at 7 tons/minute. Since the ingot weighed 700,000 lbs., it took exactly 70 minutes to pour. Now, there could have been a major problem in moving the ingot, but the electric furnace shops had been equipped with two 200-ton cranes, and thus would be able to pick up the 350-ton ingot.

"Although I ended up in Pittsburgh as general manager of quality control for U. S. Steel, it wasn't as much fun from an engineering standpoint as my years in the mills."

If the steel had been a "sticker," where it was fused to the mold, we would have had a major problem, and would have had to cut off the mold with torches. Since we had full control of our temperatures, we did not have a sticker; the ingot came out beautifully, and with the cranes, we were able to load it onto a flat car and ship it to Homestead, where it was forged and machined to General Electric's specifications.

The year 1956 was another great year for me, in that I was elected chairman of the Physical Chemistry and Steel Making Committee, which was a great honor in the steel game. I continued to be chairman until 1959, when I was promoted out of the mill and into a general offices position in the metallurgical department of the Tennessee Coal & Iron Division of U. S. Steel in Birmingham, Ala., USA. Although I had fun and progressed at the latter, and ended up in Pittsburgh as general manager of quality control for U. S. Steel, it wasn't as much fun from an engineering standpoint as my years in the mills. ✦

Remembering
Dr. Bernard Russell Queneau

1912–2014

Dr. Queneau passed away on 7 December 2014, one day after he received the Distinguished Eagle Scout Award from the Boy Scouts of America.

Queneau was born on 14 July 1912 in Liège, Belgium. In 1928, he graduated from New Rochelle High School in New York. He received his B.S. degree from Columbia University in 1932 and his master's degree in metallurgical engineering in 1933. In 1936, he earned his Ph.D. in metallurgical engineering from the University of Minnesota. In addition to his career in the steel industry as discussed above, from 1977 to 1983, he served as technical editor of *Iron and Steelmaker* magazine. He is a fellow of the American Society for Metals, and a distinguished member and fellow of the Association for Iron & Steel Technology.


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Top photo courtesy of Veteran Voices of Pittsburgh. 1. Queneau, at 15 years of age, was part of a team of three Scouts that traveled the Lincoln Highway from New York to San Francisco. Photo courtesy of the Lincoln Highway National Museum & Archives. 2. Queneau with his wife, Esther. Photo courtesy of University of Minnesota. 3. Photo courtesy of Columbia University.