Before World War I began, a small amount of stainless steel cutlery and tableware was produced in Sheffield, England. Meanwhile in the U.S., the first heat of stainless steel was melted at the Pittsburgh plant of the Firth-Sterling Steel Co., a subsidiary of Thomas Firth and Sons, headquartered in Sheffield. However, the decade from 1910-1920 saw little progress in stainless steel production mainly because throughout World War I, all available metal was used to make exhaust valves for aircraft engines in both the U.S. and England. During the war, one of the major stainless producers was Carpenter Steel Co., a manufacturer of steel for Liberty aircraft engines.

Most production processes of this era used the heat-treatable martensitic grade—13% chromium and 0.30% carbon. These general martensitic grades were covered in the U.S. by patent applications in March 1915 from both Elwood Haynes and Harry Brearley. Rather than fight the conflict in court, Brearley and Thomas Firth and Sons formed a syndicate named The Stainless Steel Co. to hold all patents. Haynes agreed to a 30% share in the company and Brearley and Firth held 40%. Several other U.S. companies held the remaining 30%. This solved the problem for ferritic and martensitic grades of stainless, although Krupp—in Germany—held patent rights for the austenitic grades.

**EARLY APPLICATIONS**

Throughout the majority of the 1920s, only ferritic and martensitic stainless steels were made in the U.S. of austenitic stainless steel, from a total of 53,000 tons produced in 1929. The industry was just getting started with these new austenitic stainless offerings, with steel companies like Allegheny, Ludlum, Carpenter, Crucible, Lukens, Latrobe, and others as the major pioneers and producers.

Meanwhile, in England, W.H. Hatfield had modified the German austenitic alloy containing 20% chromium plus 7% nickel to the now familiar 18% chromium plus 8% nickel (18-8) that became AISI 302 in the U.S. He also added titanium to combine with the carbon for AISI 321, greatly improving weldability. 18-8 went on to become the single most important alloy in stainless steel because it offers the ideal combination of corrosion and acid resistance, formability, and the ability to be polished to a beautiful finish.

**1930s and 1940s**

The Great Depression of the 1930s impacted stainless steel as it did all metal making. Production decreased from 58,000 tons in 1929 to 23,000 tons in 1932. Only a few applications saw increased stainless steel consumption during the decade, mainly in the trans-
THE ARGON OXYGEN DECARBURIZATION (AOD) PROCESS WAS THE GREATEST TECHNOLOGICAL ADVANCE IN THE HISTORY OF PROCESSING STAINLESS STEEL.

Microstructure of roughly 50% austenite and 50% ferrite to improve strength and corrosion resistance.

**AOD PROCESS**

The major problem in ferritic and austenitic stainless steels production was the requirement for very low carbon content to avoid precipitation of chromium carbides, which lower the chromium content needed for corrosion resistance. This was a particular problem during welding, where a region in the heat-affected zone sits at the ideal temperature for carbide formation. Union Carbide Corp. (UCC) tried using an oxygen lance to reduce the carbon level, but was unsuccessful due to the uncontrolled temperature of the bath. They hired a recent MIT graduate named William A. Krivsky to work on improving the oxygen process. Krivsky tried adding the inert gas argon with the oxygen to control the bath temperature and carbon reaction. He successfully decreased the carbon to very low levels without excessive chromium loss. Following his laboratory success, UCC looked for a stainless producer to scale up the process to production levels. Only one company was interested—Joslyn Steel, a small producer in Fort Wayne, Ind.

Over many years and many heats of steel, Joslyn was unable to produce a satisfactory result. They had tried introducing oxygen and argon into the electric arc furnace using lances coated with ceramics. Joslyn and UCC finally realized that the refining was going to need a separate vessel where argon was blown through the bottom, but oxygen was still introduced with a lance. The new vessel was similar to the old Bessemer converter and the technique became the successful argon oxygen decarburization (AOD) process. Union Carbide started offering licenses in 1970. As industry began to learn about the new process, more than 100 vessels were installed within a dozen years with 75% of world production eventually using AOD. This was the greatest technological advance in the history of processing stainless steel.

**NEW AND NOVEL APPLICATIONS**

A major use for stainless steel after WWII was for the exterior walls of high-rise buildings. The austenitic grade with 18% chromium and 8% nickel was selected for its corrosion resistance, formability, and added strength when cold rolled. The first design was the Socony-Mobil Building in New York. Within a few years, it was common practice to clad skyscraper buildings with stainless steel.

It was also used for kitchen sinks in the late 1930s, later expanding to the exteriors of refrigerators, stoves, dishwashers, and other appliances. Although stainless has largely disappeared as auto trim and hubcaps, its current automotive use is for exhaust systems with catalytic converters and fuel injection systems. The chemical, pharmaceutical, and electrical power industries also use large amounts of stainless in piping, tanks, pumps, and other equipment. Stainless steel is the ideal metal alloy for designs requiring steel that does not rust. ~AM&P

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**ALLOY DEVELOPMENT**

Following WWII, several stainless steel producers developed alloys that respond well to precipitation hardening. Success was first achieved by The American Rolling Mill Co. (Armco). They kept the chromium content at 17%, but reduced the nickel to 4% and added 3.5% copper (17-4 PH) or 7% nickel with 1% aluminum (17-7 PH) and, a third alloy with 7% nickel, 2.5% molybdenum, and 1% aluminum. These alloys have design strengths of 200,000 to 220,000 psi after heat treatment. Another alloy system in development during this time was duplex stainless steels, which feature a microstructure of roughly 50% austenite and 50% ferrite to improve strength and corrosion resistance.

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