Co., and the Canadian company, Atlas Steel Corp. The alloys for each manufacturer were identified by trade names such as Ascoloy, Atlas Stainless, and No. 17 Metal. AISI numbers were not yet developed for stainless steels.

The entries for chemical composition were interesting and showed reluctance on the part of some companies to reveal what they may have considered to be trade secrets. One company listed no chemistry. One company listed only a chromium content, and several listed only chromium and carbon contents. One company listed a broad range for each element, such as "0.18 to 0.70% carbon." Only three companies gave values for carbon, manganese, chromium, and nickel. It was also noted that only one company, Firth-Sterling Steel, listed one of their two alloys as "stainless iron" but did not list the chemistry.

History and Patents

The second paper presented was by P.A.E. Armstrong (Fig. 5), Vice President of Ludlum Steel Co., Watervliet, New York. The Ludlum Steel Co. had been marketing its own stainless steels with the trade names Neva-Stain and Silchrome from the earlier work by Armstrong as a metallurgist with the Ludlum Company. These alloys were high chromium, low carbon, silicon, and iron and had been patented in 1919 by Armstrong.

At the symposium, Armstrong presented an excellent 13-page paper that covered a history of stainless steels and other corrosion-resisting alloys and included many references to patents, both American and foreign. Armstrong mentioned the Krupp patent for "alloys of chromium, nickel and iron, with chromium content of from 1 to 25 percent, nickel from 0.5 up to 20 percent, and carbon from zero up to 1 percent." It is stated in the patent that "these alloys remain bright even when subjected to damp air for a period of months."

Mr. Armstrong failed to realize the significance of the Krupp steel, probably because of the way the patent was written. Benno Strauss clarifies the importance of his steel, as shown subsequently in a discussion of the Krupp alloy.

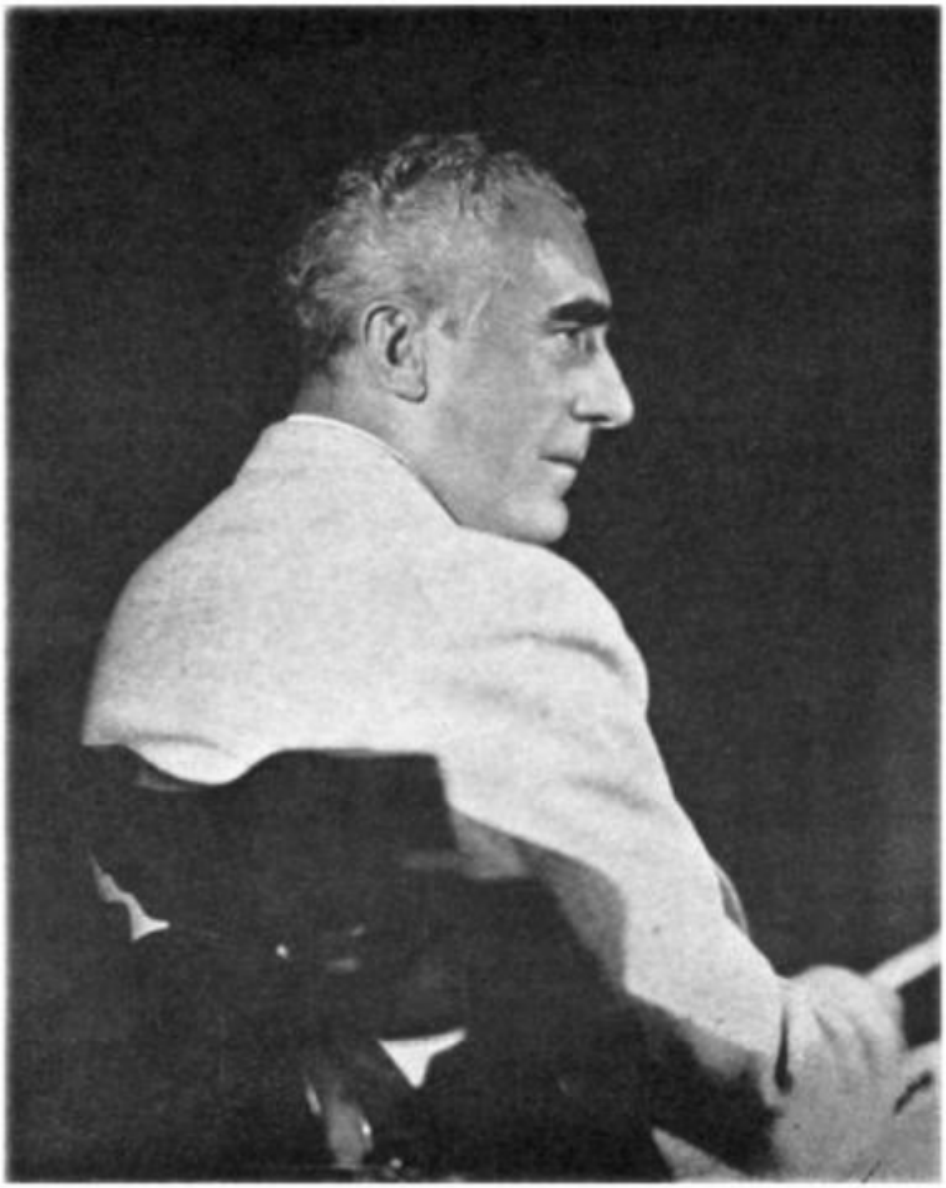

Fig. 5 P.A.E. Armstrong, who developed silicon-chromium steels used for gas engine exhaust valves. Source: Thum, 1933, p 486

loys and must have been of special interest, because this class of stainless steel had not yet been used in America.

Strauss actually discussed two alloys: V1M, a martensitic chromium alloy, which was a cutlery steel containing a small amount of nickel, and V2A, an austenitic alloy with 15 to 40% chromium, 1.0% maximum carbon, and 4 to 20% nickel (German Patent 304,159). He stated that it was especially useful for resistance to acids. (The alloy that Krupp was actually making was 20% chromium and 7% nickel, similar to the modern type 304 alloy. This information appeared under a micrograph that he displayed.)

Strauss described the V2A alloy and presented data indicating its complete resistance to corrosion in a 30% solution of boiling nitric acid. He also submitted a quarternary (carbon-chromium-iron-nickel) phase diagram that illustrated the required percentages of nickel to create a fully austenitic structure, with varying amounts of chromium up to 24%. He mentioned that "low carbon content increases corrosion resistance." He explained that goods made from his alloys were first shown at the Malmö Exhibition in April 1914.

He concluded in his paper that "austenitic V2A steel is used for acid pumps, valves of all kinds, piping, kitchen utensils, spoons, forks, table utensils, beer casks, Hollander knives, knives for cutting glue, surgical and dental instruments, and metal mirrors." He also noted that:

> "Mirrors and other polished articles when made of V2A steel retain their polish permanently. Owing to its ductility, V2A steel permits of being rolled, forged, stamped and drawn out in the cold state, so that it can be made into thin sheets, wire and wire gauze.
>
> "This brand is well adapted for a great variety of uses in the chemical industries, where it is called upon to resist the attack of nitric acid, ammonia, or hydrogen peroxide in the presence of steam. Its resistance to diluted sulfuric acid is not satisfactory."

The reaction to Strauss' presentation during the symposium is not known, but it must have been well received. Within four years, this austenitic alloy was being made in the United States under the German patent. A modified version of Krupp's 20-7 alloys was then under development in England, an alloy called 18-8 or type 304, which is today the most widely used of all stainless steel alloys.