Aluminum Centennial

Shut the aluminum screen door of your house . . . which is probably covered with aluminum siding, and close the aluminum blinds. Outside, the kids are playing baseball with an aluminum bat. Overhead flies an airplane, constructed in large part from aluminum. In the kitchen several potatoes, wrapped in aluminum foil, are ready to be baked for dinner. Crunch an aluminum beverage can in your hand.

Little more than a century ago, any of these objects would have been worth its weight in gold.

One hundred years ago this year, the first major commercial factory for producing aluminum began operation. Run by a Pittsburgh metallurgist, Alfred E. Hunt, the Pittsburgh Reduction Company started production in November 1888. Its name was changed in 1907 to the Aluminum Company of America. Alcoa is still the largest such company in the world.

Although aluminum is the most abundant metal in the Earth's crust, it never naturally occurs not bonded to other elements. Bauxite ore consists mostly of aluminum hydroxide.

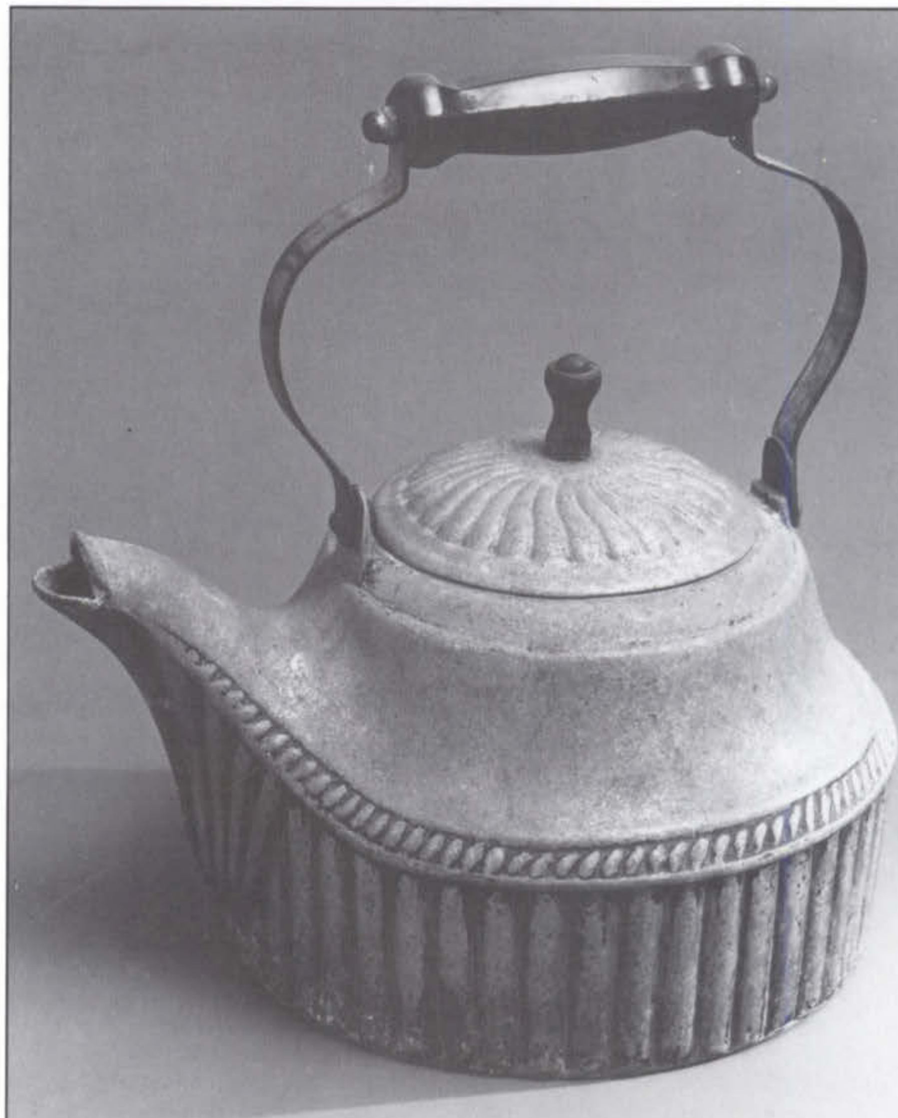
The name "aluminum" comes from the Latin alum, for a substance the ancients used to fix dyes in fabric. Prussian chemist Johann Heinrich Pott prepared alumina — aluminum oxide — from alum in 1746. Later, in 1809, British chemist Sir Humphrey Davy formed an alloy of aluminum and iron by melting alumina with iron. Davy named the new metal alumium, then changed it to aluminum, and later to aluminium (which remains the British usage today) to make it conform to other chemical names. Davy labored at the Royal Institution in London and proved very successful in his work — within a short time, Davy had also isolated (for the first time) the elements potassium, boron, magnesium, sodium, and silicon.

The search for metallic aluminum became a challenge for 19th century chemists, but it wasn't until 1825 that the first aluminum was actually created. Danish chemist and physicist Hans Christian Oersted prepared aluminum chloride from alumina, then heated the aluminum chloride with potassium and mercury. "It forms a lump of metal which in color and luster somewhat resembles tin," he wrote.

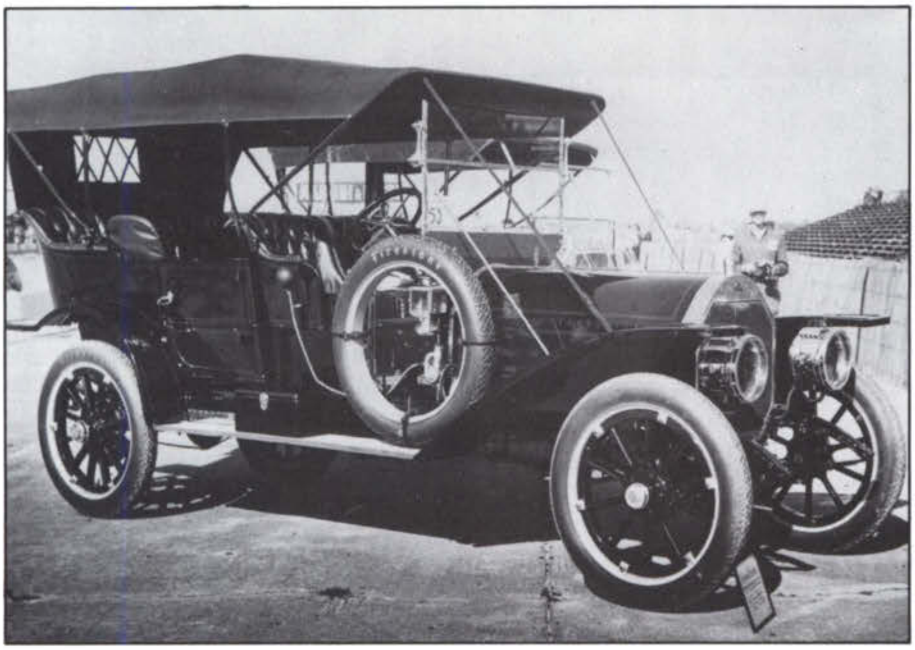
Two years later Friedrich Wöhler vaporized aluminum chloride and reacted it with heated potassium to yield a gray powder of aluminum. This powder, though, was too impure for any actual use. Nearly two decades later, in 1845, Wöhler returned to the problem and finally produced particles of aluminum large enough (the size of pinheads) so he could weigh them and investigate the metal's physical properties, such as its specific gravity, its ductility, its color, and its stability in air.

In 1854 French chemist Henri Étienne Sainte-Claire Deville used sodium instead of potassium to break down the aluminum chloride. This addition greatly improved the process, producing aluminum lumps the size of marbles. Simply attempting to make a new aluminum compound, Deville had stumbled on a profitable technique. Deville exhibited samples of his new metal (billed as "silver from clay") at the Paris Exposition of 1855. One of the first objects made from Deville's aluminum was a baby rattle for the French Emperor's new son.

In France, commercial aluminum producing facilities opened up, causing the



The first cast-aluminum tea kettles—manufactured by the Pittsburgh Reduction Company—appeared on the market in 1893. Photo courtesy of Alcoa archives.



This 7-passenger 1909 Stevens-Duryea had an aluminum body and 142-inch wheelbase. It had 6 cylinders cast in pairs, impulse starting, dual ignition, and an automatic oiling system. The price tag in 1909 was $4,000. Photo courtesy of Alcoa archives.

price of aluminum to drop from $115 to $17 per pound—still too expensive for all but the most extravagant uses.

Though no one knew quite what aluminum might be used for, many people in the scientific and industrial communities were intrigued by the prospects for the "miracle metal." Some saw its usefulness in surgical equipment; others proposed that one day leak-proof and noncorroding aluminum roofs could adorn most houses. Wealthy people wore aluminum jewelry and ate from aluminum plates, treating it as a fine and precious metal.

The first major customer of Hall's aluminum company was the Pittsburgh steel industry.

Not until the 1880s, though, was a commercially viable process discovered for producing aluminum. Two men—Charles Martin Hall of the United States, and Paul L.T. Héroult of France—discovered the process simultaneously. Both men were ignorant of the other's work . . . both had the ambition to become successful inventors . . . both were 22 years old. (Later, both would die in the same year, 1914.) Hall worked by himself in a crude workroom in Oberlin, Ohio; Héroult worked under similar conditions in the Paris suburb of Gentilly.

One of Hall's professors in college had inspired his interest in aluminum, telling how he had met the elderly Friedrich Wöhler in Germany and how Wöhler had spoken of the marvelous properties of aluminum. While other contemporary inventors tried to improve on Deville's method of producing aluminum from aluminum chloride, Hall—then a senior at Oberlin College in Ohio—dabbled in a small laboratory, trying at random any technique that came to mind. "Whenever I get temporarily stuck on any other process, I go to work on a cheap process for aluminum," he wrote. Hall began experiments with new copper alloys and an improved electric battery.

At about this time, in 1884, William Frishmuth of Philadelphia, using Deville's method, managed to produce a 100 ounce cast pyramid of aluminum, which was to be mounted at the top of the Washington Monument as a lightning conductor. The publicity generated by this large casting of aluminum only emphasized the demand for a more efficient process to produce aluminum.

The Hall-Héroult process uses electrolytic reduction to separate aluminum from the rest of a mixture. Sir Humphrey Davy had used electrolysis at the beginning of the century to do his landmark work of separating elements. But aluminum combines too readily with oxygen, and compounds dissolved in water would not break down through electrolysis. Hall—now graduated from college and working in a woodshed on his family home—experimented with dissolving alumina in other substances. He achieved success by using the soft mineral cryolite.

Cryolite turns clear when it melts, and Hall could see that the white alumina powder dissolved completely. Sending an electric current through the molten mixture at first produced nothing. Guessing that his crude clay crucible might itself be contaminating the reaction, Hall made a carbon crucible and repeated the experiment. When he poured off the mixture, he found small lumps of pure aluminum at the bottom of the crucible.

In France, Héroult followed much the same path to develop the process. Today, variations on the Hall-Héroult process are used for nearly all the world's production of aluminum.

Well timed with the Hall-Héroult discovery was the invention of another process by Austrian chemist Karl Joseph Bayer. Bayer patented an efficient method for extracting alumina from bauxite, which provided the crude material necessary to make the Hall-Héroult process a success. Bayer's process also has its centennial this year.

In America, Hall met up with a Pittsburgh metallurgist, Alfred E. Hunt, who had himself attempted—and failed—to discover a cheap way to make aluminum. Together with other investors, they founded the Pittsburgh Reduction Company, which immediately began producing 50 pounds of aluminum per day. Prices started at $5 per pound, only a third of the price of aluminum from companies using Deville's method. Twenty years later, the company (now called Alcoa) was producing 45 short tons per day.

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Aluminum alloys are very light and some are much stronger (per weight) than steel. When alloyed with copper, magnesium, or zinc, aluminum achieves increased strength and hardness . . . silicon lowers the melting point of aluminum for easier casting . . . aluminum-tin alloys are more malleable. Ironically, the first major customer of Hall's aluminum company was the Pittsburgh steel industry — adding aluminum to molten steel improved the steelmaking process.

World War I boosted worldwide demand for aluminum and aluminum alloys tremendously, as nations used the new alloys for military purposes. World War II caused an even greater expansion of the market. In 1941, the second major U.S. aluminum manufacturer — Reynolds Metals Company — was founded.

After the War, aluminum found its way into more domestic uses. The first successful aluminum foil appeared in 1947 . . . about the same time that aluminum was replacing brass for the bases of light bulbs. Aluminum cans began to take over the market in the 1960s. Today, aluminum seems so commonplace and humdrum that we forget it is the newest of the major metals used in manufacturing. Almost effortlessly crushing an aluminum can, we can scarcely credit the time and research it took to create the aluminum process.

KEVIN J. ANDERSON

Progress Report on the MS&E Study

Forum Scheduled at the 1988 MRS Fall Meeting

Merton Flemings of the Massachusetts Institute of Technology will give a 40-minute presentation on the progress of the Materials Science and Engineering Study during a special forum at the 1988 MRS Fall Meeting. The forum has been scheduled at the Marriott Hotel/Copley Place on Tuesday, November 29 from 9:00 to 10:30 a.m.

The presentation will be followed by a 40-minute period during which Flemings and other members of the MS&E Study Committee will answer questions.

Flemings, along with Praveen Chaudhari (IBM), is a co-chair of the MS&E Study commissioned in 1986 by the National Research Council. The co-chairs were charged to develop and present a unified view of recent progress and new directions in materials science and engineering.

The Study encompasses five areas—materials research and needs in MS&E, exploitation of MS&E technology for national welfare, international cooperation and competition, research resources in MS&E, and education in MS&E.