Charles Martin Hall – The Young Chemist

by Stephen Lindsay

Much has been written about the two ambitious, young inventors of the electrolytic reduction process for making aluminum. Charles Martin Hall, from Oberlin, Ohio at age 22, and Paul Louis-Toussaint Héroult, from Thury-Harcourt in Normandy, France at age 23, both discovered how to apply a driving force of the industrial revolution, electricity, to produce aluminium metal at a much lower cost than by all previously known processes. At that time, in early-1886, they were not alone in their efforts. Others, whose names history has mostly forgotten, were close on their heels.

These days with something on the order of 65 million metric tons per year of production and approximately 90,000 smelting pots in operation around the world it seems simple enough to produce aluminum metal. However, what if you had been the first one to make it and only had simple, borrowed lab equipment plus every-day articles of kitchen, camping and wood-shed tools available to you? This was the challenge that Hall, the young chemist, faced in the wood-shed that was in the back yard [1] of his parent's home. He had moved his experimentation there after having set the attic of his parent's home on fire (a small one) with one of his experiments the year before.

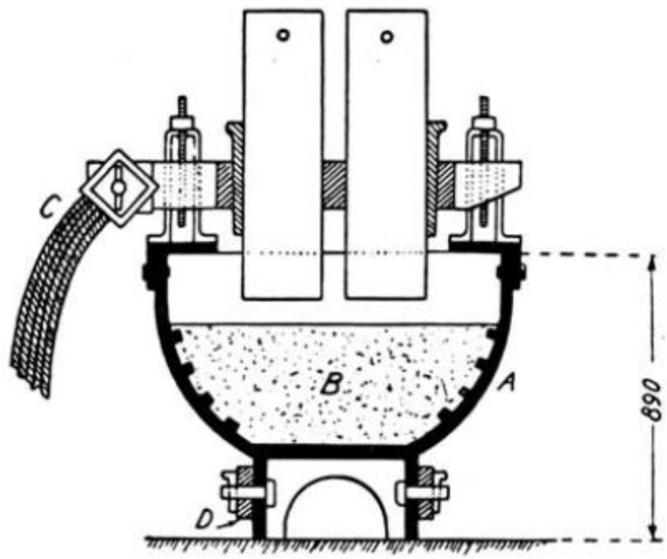
These days the electricity to produce aluminum comes from massive power developments, like the Moses-Saunders dam on the St. Lawrence River. The pots are complex constructions, often larger than mobile homes, filled with more than 50 tons of expensive lining materials that can resist the mixture of molten salts and liquid metal that they must contain. The molten salt mixture is more corrosive than pools of sulfuric acid. The raw materials for the process are made by large refineries producing aluminum oxide or facilities that produce blocks of carbon, up to one ton weight for each. Charles Martin Hall had nothing like this and he had to make many of his own chemicals.

Cast iron pots from the kitchen served as his vessels for experimentation. For his source of direct current he made his own Bunsen-Grove type batteries. Think of dozens of Mason jars filled with strips of zinc as the anodes, immersed in dilute sulfuric acid, using pulverized coal as the cathode all wired together.

Modern smelting pots produce an abundance of heat from all the electrical energy that they consume. The pot in the wood-shed had to be heated externally to keep his mixture of cryolite and aluminum fluoride hot enough to remain liquid while electricity from the homemade batteries was passed through it for hours at a time. Imagine yourself using a one-burner, white-gasoline type Coleman camping stove as your source of heat! The one that Charles Martin Hall used wasn't made by Coleman. It was just a simple cooking stove heating cast iron to yellow/red hot temperatures.

The cast iron pot needed to be lined with some sort of paste to keep the iron from being dissolved by the liquid salt mixture. At first Hall tried clay, but that only made an amalgamation of silicon that the molten salt mix dissolved out of the clay. Two weeks later he used a ramming paste of finely divided carbon dust and pitch to line his pot. This modification did the trick!

By the way, the term “pot” doesn’t come from Hall. It comes from the early days of Héroult’s first smelter in the village of Froges, near a small hydropower development in the French Alps. The round design, shown here, looked like soup tureens, or soup pots to the workers. The name stuck.



A “pot” with four anodes designed by Paul Héroult for the Froges plant in 1892 [2]

Charles Martin Hall did not have the luxury to use just any mixture of fluoride salts as his “bath”. He needed something that his stove could melt. He had to reject a few possible compositions only because the melting point was above the range of his simple equipment. The 50/50 cryolite and aluminum fluoride mix that he used was so poorly adapted to alumina dissolution that it has never been used in commercial cells. Fortunately for Hall his mixture melted and it had the capability to dissolve small amounts of alumina that he then reduced to small pellets of aluminum metal after a few hours of electrolysis. The alumina that he used was also likely to have been produced from cryolite as that was a common way to produce aluminum oxide in those early days.

Think about this for a minute. Would you want or encourage your 22 year old son to “experiment” in a back-yard wood-shed with dozens of jars full of sulfuric acid and a one-eye gasoline stove at its maximum in order to melt highly corrosive, liquid salt in a cast iron pot from your kitchen? Hall’s family not only let him do it, they encouraged him to do so, even after the little fire in the attic.

This earliest of successes to produce aluminum metal served as the foundation for an industry. The use of batteries was never adopted for the cells that followed. Dynamos served the purpose of early energy production and these were then replaced by hydro-electric dynamos by the time that the Pittsburgh Reduction Company set up shop in Niagara Falls, Shawinigan, Québec and Massena.

Our young inventor, Charles Martin Hall, also was a fortunate beneficiary of his own circumstances. Next time we will touch on a bit of Rich Dad, Poor Dad and how the better equipped and equally ambitious Paul Héroult had some of his own circumstances get in the way of being first at producing pure aluminum by the process that is still in use to this day.

1. Linda Hall Library & Prof. William B. Ashworth Jr. https://www.lindahall.org/charles-martin-hall/
2. The author wishes to thank and acknowledge Maurice Laparra and the Institut pour l'histoire de l'aluminium, and Revue Cahiers. For those who are interested in learning more go to:

https://www.cairn.info/revue-cahiers-d-histoire-de-l-aluminium-2012-1-page-84.htm

The author is a graduate of Clarkson College of Technology who began his 40 year career with Alcoa at Massena Operations in 1979 as a Process Engineer.