The "Age of Aluminium"

In this new series, historian Dr Andrew Perchard* provides an oversight of the development of the global aluminium industry within its context, showing how from modest beginnings aluminium became ubiquitous and the industry global giant.

Aluminium was inextricably linked to the modern age, and modernism. This was both because of the science and technology with which it was associated, and by design to cultivate markets for the metal and create a mystique around it. The first article in the series (*Out of Acorns Grow Big Trees*) outlines the scientific discoveries, that were the metal's midwife, and its early, precious beginnings. Born of the 19th century, it was the twentieth - what historian Eric Hobsbawm coined as the 'Age of Extremes' - , and especially the two terrible world wars (1914-18, and 1939-45), that would firmly establish aluminium. These conflicts, the subject of the second article in the series - *Le Déluge* - would also demonstrate the versatile properties and potential applications of the metal, opening up new and growing markets. In mature industrial economies, the postwar growth of 1950-1975 - the 'golden years' or 'les trentes glorieuses' - created a boom time for aluminium, as for other sectors. The 1940s and 1950s also witnessed some ruptures in the industry, with challenges to its early 'first movers' and leaders. President Richard Nixon's devaluation of the US dollar in 1971, followed by the OPEC crisis of 1973, created challenging political and economic conditions for the global aluminium industry. Aluminium's exponential growth and smelting capacity, as well as strategic stockpiling by the United States, resulted in a global glut. The launch of aluminium on to the London Metals Exchange in 1978 contributed to challenging new conditions for the industry. Out of necessity, the industry would become a leader in recycling and in seeking to manage energy consumption and emissions. From the 1980s into the 21st century, the industry underwent profound changes in ownership, structure, outlook and culture. The period from 1945-present is the subject of the third article, *The Age of Light Metal*. From the birth of aluminium, national aluminium companies had forged and identified with highly distinctive organisational cultures. Their global reach and networks forging what one historian of the industry has called an *Aluminium Civilization*, which concludes our series.

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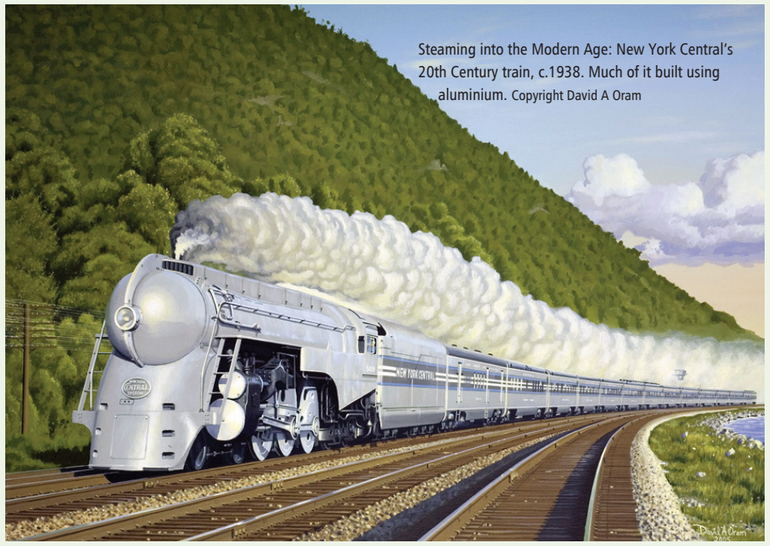


Steaming into the Modern Age: New York Central's 20th Century train, c.1938. Much of it built using aluminium. Copyright David A Oram

Out of Acorns Grow Big Trees

From the outset, aluminium transfixed audiences. The eminent English Victorian chemist Sir Henry Roscoe, for example, expressed his 'wonder' at the 'silver-white metal' in 1833. It was an endeavour that attracted the enthusiasm of leading scientists (as well as venture capitalists), such luminaries as Lord Kelvin and Robert Bunsen. If aluminium was a discovery of the 19th century then it was a product of the enlightenment, and its scientific and technological repercussions. First identified by the English chemist Sir Humphrey Davy (1778-1829) in 1809, further discoveries of the metal were advanced by the Danish and German chemists Christian Oersted (1777-1851) and Friedrich Wöhler (1800-1852), culminating in Henri Saint-Claire Deville's production of samples of aluminium in 1854. It was the auspicious sighting of Deville's aluminium ingots at the Paris exhibition of 1855 that attracted the patronage of the French emperor Louis-Napoléon III, and piqued the interest of French chemical firm, Produits chimiques d' Alais et de la Camargue (PCAC). The significance of these connections cannot be overstated in the history of the industry. Napoléon III's interest in the potential military applications of aluminium was important in transforming its perception as a precious metal of curiosity to a potentially versatile raw material. PCAC's interest in the metal inadvertently led to the discovery which signalled the birth of the modern aluminium industry.

A former PCAC chemist, Paul-Louis Toussaint Héroult (1863-1914) discovered an electro-metallurgical method for reducing aluminium from aluminium powder in 1886. It is indicative of the market for the fledgling metal that PCAC were not supportive of Héroult's discovery, and indeed abandoned their manufacture of the metal the very same year (only to return to be a market leader). Alfred Pechiney, PCAC's director, allegedly informed Héroult: "aluminium was a metal… for opera glasses." On the other side of the Atlantic, US chemist Charles Martin Hall (1863-1914) concurrently discovered a similar process for aluminium reduction. Hall was more fortunate in his industrial backers, the Pittsburgh Reduction Company (subsequently Alcoa) who had the backing of the mighty industrial bankers and venture capitalists, the Mellon brothers.

The discovery of the Hall-Héroult process, which continues to be the principal process for aluminium reduction to this day, was not altogether mere serendipity or singular scientific endeavour; it marked a concatenation of events reflecting developments of the second industrial revolution (roughly covering the period 1870-1914) in chemicals and electrical engineering. The aluminium industry also came to benefit from advances in transportation during the period. The French and US chemists' invention signalled the birth of the modern industry, transforming aluminium production from the chemical process that had predominated to electro-metallurgical production.

Previously the chemical reduction of aluminium had combined Henri Saint-Claire Deville's method, with that of American chemical engineer Hamilton Castner. The Hall-Héroult process transformed aluminium production from a metal produced in small quantities for luxury products to one that could be produced on a mass industrial-scale. Using the chemical process, aluminium ingot cost as much as $34,000 per tonne as late as 1859 (around $1 million at 2015 prices). Despite improvements in production methods, the chemical production of aluminium remained small and exorbitant. Nevertheless even with the advent of the Hall-Héroult process, aluminium production and consumption was modest, and prices high, prior to the outbreak of WWI (see **Figs 1** and **2**). As Deville observed in 1900, "Nothing is more difficult than to introduce into the pattern of men's lives and to get them to accept, a new material, however useful it may be". Despite his enthusiasm for the metal, Deville further conceded that: "aluminium had not until recently justified its reputation as a metal of the future." Britain's main producer, the British Aluminium Company (BACo), struggled in particular. Producers in France, Germany, and US were more fortunate in finding a receptive market for aluminium in the growing automotive sector and the electricity industries.

Coupled with a limited market for the metal were the high sunk capital costs involved (then, as now). No producer was self-sufficient in the necessary raw materials, although some (French producers) were better placed than others. In an energy-intensive industry, advances in electrical (and civil) engineering, coupled with the natural capital of water resources, provided the modern industry with its only commercially feasible source of power at the time – hydroelectricity. Nevertheless, in the early 20th century, it required around 30,000 kilowatt hours of electricity to make one tonne of aluminium. With some notable exceptions, for much of the 20th century, aluminium production would continue to be supplied by hydro-electricity; nearly 60% as late as the 1990s. The aluminium 'first movers', AIAG Neuhausen (Swiss-German), the Pittsburgh Company Ltd (subsequently Alcoa), BACo, the French producers (leaders PCAC, Société Electro-métallurgique Française (SEMF), and 'late movers', l'Aluminium du Sud-Ouest (ASO), La Société Electro-Métallurgie du Sud-Est (EMSE), and the Aluminium Corporation Ltd all relied chiefly on hydro-electric power. This often required them to locate reduction plants in remote locations (for example the Scottish Highlands, Vallée de la Maurienne (France), adding to transportation and habitation costs. The costs are illustrated by BACo's Highland hydro schemes and reduction works: Foyers, which opened 1896 and closed in 1967; Kinlochleven (opened in 1907, finally closing in 2000); and Fort William (the Lochaber smelter, which opened in 1929 and is still operating, although the smelter has been reconstructed and the power house modernised). By 1898, the construction and modernisation of Foyers had cost BACo £191,000 (£14.2M in 2015 prices). Even before the delays in completion, Kinlochleven was projected to cost the Company £500,000 in 1904 (£48.6M), and by its opening in 1929 (but not the completion of the scheme) Lochaber had cost £2.5M (£137.1M). Construction of these schemes was also labour intensive – with hydro-electric schemes being hewn by rock and explosives out of rugged landscapes – and the human cost of construction was appalling (the tunnel development for the BACo's Lochaber scheme claimed the lives of 48 navvies alone).

Accompanying the development of hydro power were also some of the first environmental battles. BACo (founded in 1894 with the British and Colonial rights to the Héroult process), chose to build their aluminium reduction works in the

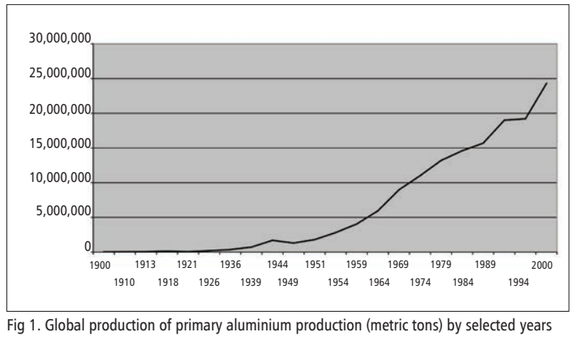


Fig 1. Global production of primary aluminium production (metric tons) by selected years (1900-2000). Source USGS

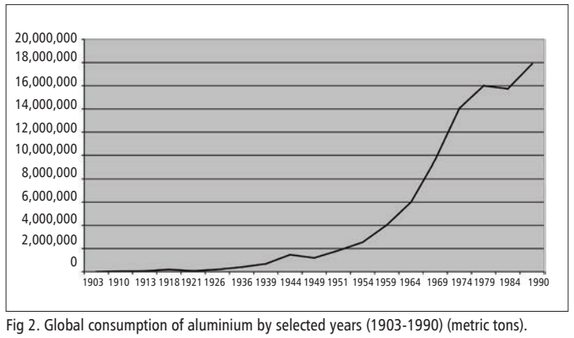
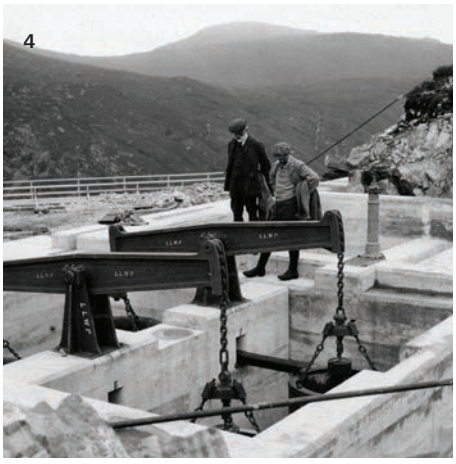


Fig 2. Global consumption of aluminium by selected years (1903-1990) (metric tons). Source: Grinberg and F. Hachez-Leroy,1997



1. The Falls of Foyers, c1895. Image courtesy of Glasgow University Archives Service/ CHECK GIVEN NEW OWNERS
2. Blackwater Dam, supplying the Kinlochleven reduction works, being flooded, c.1906. Image courtesy of Robert Cairns
3. Temporary reduction works, Kinlochleven, 1908. Image courtesy of Robert Cairns
4. BACo's scientific advisor, Lord Kelvin, inspecting intakes at Kinlochleven, c.1906. Image courtesy of Robert Cairns]
5. Interior of Foyers reduction works, opened in 1895, taken in 1920. Image courtesy of Glasgow University Archives Service

Scottish Highlands. The choice of their first plant at Foyers, on the shores of Loch Ness, harnessing the nearby falls made famous in the poetry of Robert Burns and Samuel Coleridge (and a popular tourist spot for wealthy Victorians), was immensely controversial bringing BACo into conflict with a powerful group of opponents, including the then Duke of Westminster, John Ruskin, and the newly formed National Trust.

The high costs and low return on investment in the early years of the modern industry claimed its victims; BACo and the Aluminium Corporation (a much smaller British company based at Dalgarrog in North Wales) were forced to recapitalise, and ASO and EMSE went to the wall. Two of BACo's founding directors, Emmanuel Ristori and Roger Wallace, were bankrupted.

This instability in global markets prompted the first two of a series of international aluminium cartels (1901-1908, 1912-1914) controlling production quotas and prices. For much of the industry's history, the high sunk capital costs, as well as a high degree of oligopolisation within the industry, eliminated new entrants. In 1913, seven companies controlled 94% of global aluminium production. By 1979, six still controlled: 54% of bauxite mining; 74% of alumina production; and 62% of primary aluminium production.

From a precarious start, and great risk, on the outbreak of the Great War, aluminium was established as a transnational industry. Many of the first movers in the industry, established in the 1880s and 1890s – Alcoa (and its Canadian, the Northern Aluminium Company, Ltd; after 1925, Alcan), AIAG, BACo, PCAC and SEMF, the most prominent – would dominate the industry for much of the twentieth century.

The outbreak of the First World War would dramatically change the global aluminium industry; as in so many other aspects of economic and social life, it represented a watershed.

A metal that was still an expensive commodity in 1913 ($9,000/ mt; $222,000/mt at 2016 prices) would become recognised as crucial for the conduct of modern warfare and subsequently demonstrate its utility in other areas.

The scarcity of supply of other important non-ferrous metals (such as copper, tin, and nickel) further underlined aluminium importance as a strategic raw material. This was also to transform the industry's relationship with the state in all of the combatant nations for much of the 20th century.

Biography

Dr Andrew Perchard is the author of Aluminiumville: Government, Global Business and the Scottish Highlands (Crucible, 2012).

For up to 20% off your own copy of 'Aluminiumville', use the code ALUM20+ either online: www.carnegiepublishing.com or by calling +44 (0) 0152484011.

Some related reading:

Grinberg, Ivan (2003), L'Aluminium: Un si léger Métal, Gallimard, Paris.

Grinberg, Ivan and Hachez-Leroy, Florence (eds.) (1997), Industrialisation et sociétés en Europe occidentale de la fin du XIXe siècle à nos jours, Armand Colin, Paris.

Perchard, Andrew (2012), Aluminiumville: Government, Global Business and the Scottish Highlands, Crucible, Lancaster.

_____ (2011), 'A "Micawber-like" Undertaking? Innovation, Intrigue, Entrepreneurship and "Dynamic Capabilities" in the Early British Aluminium Industry', Cahiers d'histoire de l'aluminium / 4 6 - 4 7 (2011), pp.143-155.

George David Smith (1988), From Monopoly to Competition: The Transformations of Alcoa, 1888-1986, Cambridge, Cambridge University Press.