The Aluminium Legacy: the History of the Metal and its Role in Architecture

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Introduction

> *"When I was a boy I first heard about aluminum. It was a precious metal.... It immediately captured my imagination. For a long time people have been extremely happy to claim heaviness and weight as a virtue and merit of design. I was quite in opposition to the idea that architecture should be measured by the pound or by the ton. On the contrary, I thought that if you could make it extremely light, it would be something of our own...."*
>
> *Richard J. Neutra*[1]

While aluminium comprises over eight per cent of the earth's crust and is the most abundant metal,[2] it was not until the end of the nineteenth century that an affordable method of extracting the metal from its ore was discovered. The material's combined qualities of light weight, versatility in fabrication, corrosion resistance, and silvery appearance were particularly suited to the new forms of expression sought by twentieth century architects. Original production of the raw material focused in western Europe and North America, but eventually other countries able to mine or purchase bauxite and to provide electric power joined the industry. Architectural aluminium is an international material and its built legacy is both rich and varied. Aluminium has been used for a wide range of applications from nineteenth century castings in the classical tradition to late twentieth century high-strength alloys in space frames. (Figs 1&2).

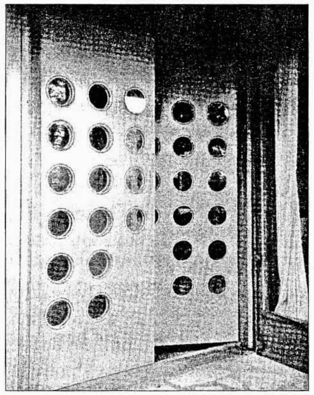

Fig. 1 Aluminium doors at Maison Prouve, Nancy, 1954, by architect Jean Prouve (Courtesy of Robert Lemon, MAIBC)

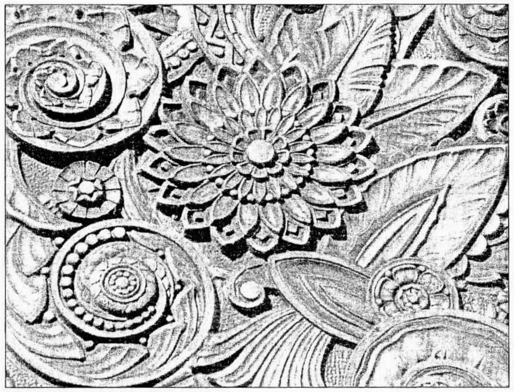

Fig. 2 Detail of cast aluminium spandrel panel in the Art Deco style, on the Consumers' Gas Showroom, Toronto, 1931 (J. Ashby).

The world's most renowned modern architects have incorporated aluminium in the design of their buildings: Richard Neutra, Ludwig Mies van der Rohe, Eero Saarinen, Frank Lloyd Wright, and others. These applications include roofing, cladding, structure, doors, windows, ceilings, and interior fittings. Building types include offices, houses, schools, factories, exhibition halls, shops, and others. Among the many significant buildings of the recent past which incorporate aluminium elements are: the Chrysler Building (New York, 1930); the Daily Express Building (London, 1931); the Dymaxion House (Wichita, Kansas, 1946); the Kaufmann residence (Palm Springs, 1948); the United Nations Secretariat (New York, 1950); the Lake Shore Drive Apartments (Chicago, 1952); and the Alcoa Building (Pittsburgh, 1953). However as this is our recent past, the comprehensive architectural history of aluminium remains largely unwritten.

This essay traces the history of aluminium, from the initial laboratory experiments through to its uses in the contemporary building industry, and focuses on the use of aluminium in building in North America and the United Kingdom. In outlining the history of architectural aluminium, it is intended that an appreciation may be fostered of the significance of this metal in the buildings of the modern era.

Source

As the second most abundant element in the earth's crust, aluminium is an important constituent of virtually all common rocks (except sandstone and limestone), but is never found in the metallic condition.[3] Alumina (Al_2O_3), the oxide of aluminium, is present in greatest abundance in feldspars, micas, and clay. The alumina content ranges from fifteen to forty per cent in these materials.[4] The principal ore of aluminium is bauxite. Bauxite derives its name from Les Baux, in Provence, where it was first discovered in 1820, by the French chemist Berthier.[5] Bauxite may be loosely defined as an aluminium ore of a varying degree of impurity, in which the aluminium is present largely as hydrated oxide, which is the single major component.[6] Bauxite is in plentiful supply with sources found world-wide. Bauxite is treated chemically to remove impurities and obtain aluminium oxide or alumina.[7] The transformation of alumina to aluminium is one of removing the oxygen. Despite the prevalence of alumina, it was a long time before aluminium achieved widespread commercial use, due to the fact that it was difficult to separate from its ores.

Discovery

The Latin name "alumen" was first employed by Pliny, but it was not until 1722 that Friedrich Hoffman concluded from experiments that the base of alum was a "*true and distinct earth*".[8] Before the end of that century, the name of the material was Anglicised to "alumina". In 1807, British scientist Sir Humphrey Davey was convinced that alumina had a metallic base and attempted to reduce it by heating it with potash and an electrolysing mixture. His efforts were unsuccessful, but he named the metal that he sought to obtain "aluminium".[9] Davey's other significant contribution was that he defined an approach to separating the metal from its oxide.[10]

The next contribution to the field was by H.C. Oersted, a Danish scientist, in 1825. By heating potassium amalgam with aluminium chloride, and then distilling the mercury from the resultant aluminium amalgam, Oersted obtained a small lump of metal with the appearance of tin.[11] Frederick Wohler worked with Oersted's processes in Berlin, initially achieving aluminium as grey powder. By 1845, Wohler succeeded in producing aluminium in pieces the size of pinheads. Wohler then measured the specific gravity, air stability, and ductility of the metal he had obtained.[12] The significance of these experiments was that the light weight of aluminium, one of its most important characteristics, was first revealed.

In France, H. Sainte-Claire Deville worked to improve Wohler's methods. By 1854, he had substituted sodium for potassium and obtained the largest pieces of aluminium to date.[13] These were the size of marbles. Sainte-Claire Deville's success marked the beginning of the chemical aluminium production industry.

Chemical Production

Napoleon III was an early and significant patron of the chemical production industry of aluminium. He was intrigued by the potential of aluminium as a lightweight material for armour in the battlefield. Napoleon III financed Sainte-Claire Deville to continue his aluminium production work. In 1855, aluminium forks and spoons on Napoleon's dining table were more valued than those in gold.[14] The same year was the first public viewing of aluminium. Bars of the new light metal, produced at the Javel Chemical Works, were displayed at the Paris Exposition.[15] In Europe in the following ten years, full-scale production facilities using the sodium reduction process were established in Nanterre, France by Deville and Morin; in Germany, by Wirz & Company; and in London, by W. Gerhard.[16] During this period aluminium was transformed from a precious to a semi-precious metal.

In America in 1884, Colonel Frismuth established an aluminium production facility based on the sodium reduction process in Philadelphia, Pennsylvania. That same year was the first recorded architectural use of aluminium in America. The Washington Monument, a stone obelisk, was topped with a cast aluminium pyramidal cap that weighed six pounds.[17] World-wide production of aluminium to 1886, the year that the electrochemical production method was invented, was about 100,000 pounds[18].

Electrochemical Production

In 1886, two men independently discovered the low-cost production technique to separate aluminium from its oxide, which is used to this day. The electrolytic reduction method was discovered by Hall in America in February, and by Heroult in France just two months later, and this production method is known as the Hall-Heroult process.[19] For electrochemical production, alumina is dissolved in a bath of molten cryolite (a sodium fluoride mineral) at a temperature of about 982 degrees Celsius. This molten bath, or electrolyte, is held in a cell consisting of a cast iron shell. The cell is lined with carbon which serves as a cathode, and has carbon anodes suspended within it. The electrical current passing through the electrolyte separates the dissolved aluminium oxide into aluminium and oxygen. The metallic aluminium is deposited at the bottom of the cell, and the oxygen is deposited on the carbon anodes.[20]

The breakthrough which Hall and Heroult achieved was to find an effective solvent for the electrolysis of alumina. While alumina was readily available at low cost and in high-purity form, its high melting point had deterred its electrolysis. It was determined that cryolite, with its reasonably low melting point, a low operating voltage, and lower specific gravity, allowed the reduction process to occur with the metallic aluminium sinking to the bottom of the cell.[21] In electrochemical production an inexpensive and reliable supply of electrical power is the key to low price and high-grade aluminium. In order to obtain one pound of aluminium, 10 to 12 kilowatts of electricity are required.[22] The development of the dynamo-electric machine by Siemens, Hopkinson, and Edison in 1881 allowed the possibility of producing aluminium with a reliable supply of affordable electricity.[23] Hydroelectric power was the earliest source, and the aluminium industry had its origins in areas where waterpower was available in abundance to be harnessed for the production of electricity. These areas initially included the Alps, Scotland, Norway, and parts of Canada.

Development of the Industry

The discovery of an affordable method to extract alumina from bauxite in 1888 by K. Bayer[24] in Germany, combined with the discovery of the Hall-Heroult process, and with the discovery of an affordable source for electricity set the stage for the modern aluminium industry. In the final years of the nineteenth century, manufacturers hastily abandoned the earlier sodium reduction processes and embraced the new more efficient production method. The twentieth century saw the development of the aluminium industry for mobile applications, and manufacturers found opportunities for the new metal in the modern building industry.

In America in 1888, the Pittsburgh Reduction Company was founded to develop the Hall-Heroult process, and seven years later they constructed a hydroelectric production plant at Niagara Falls, New York.[25] Britain's first production plant using the electrochemical process was built in 1895 by the British Aluminium Company at Foyers, Scotland.[26] In Canada, aluminium was first produced in 1900 at the Pittsburgh Reduction Company's plant at Shawinigan Falls, Quebec.[27] As the electrochemical production industry expanded rapidly at the end to the nineteenth century, aluminium emerged to compete with other common metals on the market. By 1892, the price of aluminium had dropped from its 1885 price of $11.33 a pound to just $0.57 a pound in America.[28]

The production capability of the industry provided opportunities for aluminium as a building material, and the end of the nineteenth century witnessed the first experiments in architectural aluminium. At the World's Fair in Chicago in 1893, architectural details in aluminium alloys were exhibited. Early American uses of aluminium in architectural applications were the Isabella Building, the Monadnock Building, and the Venetian Building. In these Chicago buildings cast aluminium was used for interior stairs, railings, and elevator finishes.[29] One of the earliest exterior uses of cast aluminium in Britain was the memorial statue to Lord Shaftesbury, known as Eros, erected in 1893 in London's Piccadilly Circus.[30] (Fig. 3) In Canada, one of the earliest recorded architectural uses of the material was the formed and pressed aluminium cornice on the Canada Life Building, in Montreal in 1896.[31] One of the earliest architectural applications of aluminium in continental Europe was the sheathing of the semi-cupolas of the church of San Gioacchino with aluminium roofing panels, in Rome in 1897.[32] The confidence of the building industry and its patrons in the industrial age at the end of the nineteenth century was manifest in the manner in which aluminium, a virtually untested material, was embraced for such significant architectural commissions.

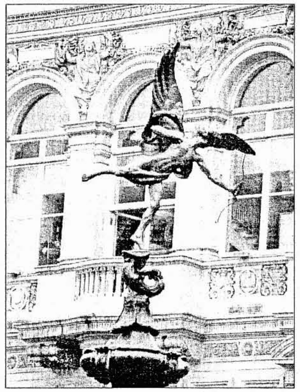

Fig. 3 Cast aluminium statue of Eros, commemorating Lord Shaftesbury, in Piccadilly Circus, London, 1893, by Alfred Gilbert (J.Ashby).

The First World War signalled a period of dynamic growth of aluminium production, with over ninety per cent of it consumed by the military. Due to the light weight of aluminium, it was used extensively in mobile applications, including bicycles, automobiles, and aircraft. "Duralumin", an aluminium-copper alloy invented by Alfred Wilm in Germany, offered new opportunities for the use of aluminium in high-strength applications.[33] During the war, architectural opportunities were limited and it was not until the war ended that the development of aluminium as a building material was able to continue. It was the success of aluminium in the First World War and the surviving aluminium production facilities that set the stage for non-military opportunities for the material in peacetime.

The Interwar Period

The 1920's and 1930's witnessed significant growth in architectural applications of aluminium, particularly in North America. Architects and engineers valued the unique characteristics of aluminium: its light weight reduced construction costs, because elements were more easily transported and erected. Its resistance to corrosion and its resistance to staining suggested reduced maintenance requirements. The adaptability of aluminium to the architecture of this period was exemplified in the use of the alloys for spandrels, mullions and pilasters, windows and sills, screens, doors and door jambs, store fronts, skylights, copings, roof crestings, cornices, fascias, grilles, and statuary. (Figs. 4&5)

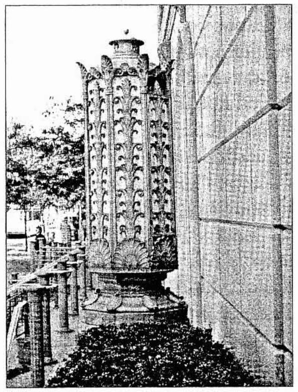

Fig. 4 Aluminium lamps at the U.S. Custom House, Philadelphia, 1933, by sculptor Edward Ardolino (Courtesy of Robert E. Linck).

Fig. 5 Highlighted finishes of the cast aluminium medallion on the entrance doors, Aeronautic Building, Ottawa, c. 1930 (J.Ashby)

In addition to the technical advantages offered by aluminium, its colour and surface qualities offered new opportunities for architectural expression. As the economy struggled to recover from the great Depression, architects and designers embraced Art Deco, Moderne, and the International Style. Hildreth Meier used cast and sheet aluminium with other metals in the colossal medallions at Radio City Music Hall in New York. Aluminium spandrels were used in William Van Alen's magnificent Chrysler Building in New York in 1930. Another New York landmark, the Empire State Building of 1931, incorporated aluminium spandrels and interior doors, bridges, and decorative trim. In Milwaukee, Wisconsin one of the first American buildings to be clad entirely in aluminium was the A.O. Smith Corporation Research & Engineering Building constructed in 1930. In England, the use of aluminium was less prolific. However, the 1931 Daily Express Building in London was an expressive modern use of the material both inside and outside. Aluminium alloy strips framed the flat and curved glass panels on the exterior, while inside panelling, balustrades, handrails, pilaster, and beam casings were formed in aluminium.[34]

The development of the modern extrusion process in the 1920s was of great significance to this growth of the architectural uses of aluminium. The extrusion process proved to be particularly adaptable to aluminium. Extrusion achieved displacement of the metal into almost any conceivable cross section. This period also saw the development of heat treatable, high strength alloys for both wrought and cast aluminium. The production of alloys that were comparable to steel in strength greatly expanded the potential uses of aluminium. Architects recognised the significance of these developments and in 1931 the Aluminaire House, designed by Lawrence Kocher and Albert Frey, was constructed at the New York Architectural League's annual exhibition to demonstrate the potential of aluminium as a construction material.[35] Innovations in the use of the new high-strength aluminium alloys occurred in civil engineering as well. In 1933, the steel decking of the Smithfield Suspension Bridge in Pittsburgh was replaced with an aluminium alloy, resulting in a reduction in weight of 700 tons.[36]

The anodic process for artificially thickening the natural oxide film on aluminium was another significant development, which occurred in the 1920s. Anodisation was developed to produce a hard, wear-resistant surface that improved resistance to corrosion. The process, which is unique to aluminium, allowed new colours to be introduced which were integral to the anodic film. These new colours offered new opportunities for architectural expression. For aluminium alloys with lesser corrosion resistance, the principle of anodic protection was applied for sheet products by cladding a thin layer of pure aluminium to each side of a strong alloy core. These products were known as "Alclad".[37] The first commercial clad sheet consisted of aluminium-copper alloy clad in aluminium.

As the industry matured, professional associations and development programmes were established. In 1935, the Aluminum Association was founded in the United States "*to promote the general welfare of the aluminum industry, of the members in it, and all others affected by it, and to increase the usefulness of the industry to the general public.*"[38] The Association initiated a campaign for standardisation of aluminium alloys and industry products.

During the interwar years, aluminium and the white metals were amongst the new building materials that came to characterise the spirit of the age. However it was the expense of aluminium (a 12.5 per cent premium over steel) which tempered its use in the construction industry.[39] In 1939, the beginning of the Second World War signalled a pause in the development of the decorative finishing of aluminium. The emphasis on research and development shifted to high strength alloys and to protective treatments for military applications.

The Second World War & Beyond

By the Second World War, aluminium was well established and its production and use ranked fourth among non-ferrous metals, by weight. However, when allowance is made for the lower specific gravity of aluminium its volume production was within five per cent of copper and zinc.[40] During this period, most wartime production was directed to aircraft construction. The war was a battle dominated by aircraft, and aluminium alloys constituted a high percentage of the construction of a typical aeroplane. Architectural uses and opportunities dramatically diminished during the war.

Production volume of aluminium grew dramatically to meet the requirements of the war, growing from 800,000 tons in 1938 to 1,250,000 tons in 1945.[41] Reynolds Metals Company, assisted by a government loan programme in America, entered the aluminium industry. While the war effort increased production of aluminium, many European production facilities were destroyed by bombing. Due to the destruction of these factories by air raids, the Defence Plant Corporation (an agency of the United States government) emerged as the world's largest owner of plants producing and fabricating aluminium. By 1946, the U.S. government had disposed of over 40 per cent of the total capacity to competitors of the Aluminum Company of America.[42] While the production of aluminium had grown exponentially during the war years, it remained an expensive material to produce: 492 per cent greater than the price of steel per ton in 1947. Yet its light weight allowed it to remain competitive: 109 per cent greater than the price of steel per cubic foot.[43] The

world-wide shortage of steel at the end of the war assisted the aluminium market. With all of the aircraft production plants ceasing operations, the situation in the post-war period was described as "*the aluminium industry in search of a market*".[44]

The postwar years witnessed extraordinary building programmes both in North America and in the United Kingdom. In Canada and the United States, construction struggled to meet demand with the arrival of soldiers returning from the war, and later with the arrival of immigrants from Europe. In Britain, the devastation of urban centres by the German air raids required an immediate demand to re-build. It was in the re-building of damaged cities in Britain that young architects found fertile ground to express new ideas about an emerging postwar society. These projects were conceived as an improvement to the cramped and unhealthy conditions that were a legacy of the industrial revolution. It was in this context that aluminium re-emerged as a building material.

Immediately following the Second World War resources for building materials in England were under restriction and scarce. Thousands of tons of aluminium alloys were reclaimed from wrecked aircraft to provide temporary housing. The pre-fabricated AIROH house (Aircraft Industries Research Organisation for Housing) was constructed with aluminium in sheet and extruded forms. One house employed approximately one and three quarters tonnes of sheet, strip, castings, and extrusions.[45] Over 75,000 temporary and permanent houses were produced in former wartime aircraft factories.[46] By 1949 the expense of these buildings could be no longer justified to the taxpayer and production ceased.[47]

Prefabrication also found opportunities in the demand for new schools following the Second World War, particularly in England.[48] The Bristol Aeroplane Company along with Richard Sheppard & Partners developed prefabricated systems for the erection of single storey primary schools and later multi-storey senior schools[49], in response to the demand created by the 1944 Butler Education Act.[50] These buildings comprised standardised aluminium elements such as light alloy trusses, roof sheathing, wall panels, and internal fittings.[51] By 1955 hundreds of schools had been constructed, but their expense led the Ministry of Education to abandon the scheme in favour of other materials.[52] The aircraft companies eventually returned to aeroplane production to meet the demands of the Korean War.

In America, the facilities for producing aluminium aircraft were also used for architectural initiatives. One such housing experiment was Buckminster Fuller's highly inventive Dymaxion Dwelling Machine.[53] By adapting production techniques from an aircraft plant, two prototypes of Fuller's futuristic de-mountable house were constructed by 1946. Fuller exploited the characteristics of aluminium in a more daring manner than any of his peers working in the field of pre-fabricated and mass-producible building. For ease of construction he strove to achieve a single family house with no individual piece weighing more than 10 pounds. The light weight material was used for floor beams (deck), purlins (carlins), roof panels (gores), and cladding (skin). The two-bedroom house weighed a mere three tons and could be shipped in a can on road, rail, or sea. Unfortunately, financial resources could not be found to take the project beyond the prototype stage into mass-production.

Of greater significance to subsequent architectural applications was the role that aluminium played in the development of the curtain wall[54], one of the greatest achievements in construction technology in the modern era. A curtain wall does not support vertical loads and is not part of a building's structural frame. Its primary function is to enclose the building and keep out the weather. The curtain wall transmits live loads, primarily wind, to the building frame.[55] Curtain walls brought a reduction of the weight of the cladding and eased erection. As compared to earlier claddings, the curtain wall was claimed to add at least 15 centimetres to the outside perimeter of the building, resulting in a net increase in building area.[56] (Fig 6)

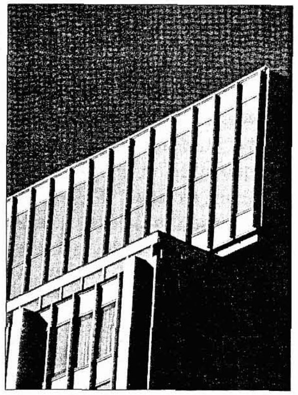

Fig. 6 Aluminium curtain wall, Sun Life Building, Toronto, 1961, by John B. Parkin Associattes (J. Ashby).

Aluminium alloys offered the characteristics of light weight and structural strength that engineers sought in designing external cladding. One of the first buildings in this period to be constructed with an aluminium curtain wall was Pietro Belluschi's Equitable Savings & Loan Building in Portland, Oregon, in 1948.[57] The potential of aluminium cladding was demonstrated by incorporating glazing into the aluminium panels.

In Pittsburgh, Harrison & Abramovitz created a contemporary showcase for architectural aluminium in their design for the 30 storey headquarters of the Aluminum Company of America (Alcoa) in 1953. The Alcoa Building is of particular significance because of the use of prefabricated aluminium curtain wall panels that incorporated glazing. The panels were formed of one-eighth inch thick aluminium clad externally with an aluminium-silicon alloy and electrochemically-finished grey.[58]

Civil engineers also began to exploit the properties of aluminium. One of the most significant achievements was construction of the De Havilland flight hangar in 1955 in Hatfield, England. The aluminium alloy trusses achieved a clear span of 200 feet and were erected with only two five-ton cranes.[59] The world's first all aluminium bridge was constructed in 1950 at Arvida, an aluminium processing town in Quebec, Canada. The span was 290 feet. Bridge design was analysed in a German study in 1953 and determined that aluminium should be more economical than steel for spans above 426 feet.

Aluminium producers saw an opportunity for the material in building services as well. The excellent conductivity of aluminium, along with its corrosion resistance meant it could be used in electrical systems. In spite of the expense of the material, it was used in mechanical systems as well. One of the most ambitious early examples was the Alcoa Building in Pittsburgh, where aluminium was used for radiant acoustical ceilings, plumbing, wiring, and ducts.[60]

The 1950s saw new forms of architectural expression in aluminium in England. At the Festival of Britain exhibition in London, the world's largest aluminium dome was constructed. The Dome of Discovery measured over 110 metres in diameter.[61] Rafters, purlins, roof sheets and canopy were all constructed of aluminium.[62]

In the 1950s, porcelain enamel finishes were first successfully applied to aluminium in the United States for architectural uses. These enamels, either porcelain or vitreous enamel, achieved new opportunities for hard, chemical resistant, and durable finishes in a variety of colours.

As the industry matured in the 1950s, increased standardisation was achieved. The Aluminum Association, which began a campaign to standardise aspects of the production industry in the 1930s, succeeded in establishing an internationally agreed universal coding system for identifying aluminium alloys.

With the advent of the Cold War, emphasis in the aluminium industry shifted to armaments again. This, along with the high price of aluminium and the reinstatement of the supply of traditional building materials in the postwar recovery period, had a particularly chilling effect on the use of architectural aluminium in the United Kingdom.[63]

The volume of aluminium production in the United States increased more than tenfold between 1939 and 1956, while steel production barely doubled.[64] That same year, 1956, the Reynolds Metals Company published John Peter's important book entitled "*Aluminum in Modern Architecture*". The volume highlighted 101 examples of international architecture that incorporated aluminium in their designs. Twenty-six international architects were interviewed and their comments on the potential of aluminium as a future building material were published. The book was a powerful piece of propaganda promoting the position which aluminium had come to occupy within the building industry, and suggesting that the work to date was only the beginning.

During the 1960s the architectural use of aluminium continued to grow. The Reynolds Aluminum Service Corporation developed a multiple unit residential complex in Washington, D.C. to showcase their building products.[65] Through the 1960s research and development continued to improve finishing techniques. Prior to that there had sometimes been a tendency to use aluminium alloys for purposes for which they were neither suitable nor intended. Aircraft engineers had not understood the requirements of the building industry, and manufacturers of construction products had not understood the aircraft industry. As a result, aluminium had developed a reputation for having finishes that were in some cases unstable. The use of aluminium was also tempered by its price as compared to other building materials. Its cost for both framing and panels was roughly mid-way between mild and stainless steel.[66] In spite of these problems, aluminium was favoured by architects commissioned to provide a modern image for corporate and institutional clients. Aluminium was used for high profile buildings such as the U.S. Air Force Academy in Colorado Springs, Colorado, in 1962 by Skidmore, Owings, and Merrill.[67] By the 1960s aluminium had reached maturity as a building material. Its qualities were understood and it was possible for designers to use the material effectively exploiting those characteristics. Aluminium was no longer used as a substitute imitating other materials.

In the following decades the commercial development of porcelain enamel finishes and powder coatings were among the most significant new affordable products widely available to architects. Further developments were made in improved anodised and organic finishes. Aluminium was described as the architectural peacock.[68] By 1992 aluminium ranked second to steel in production.[69] The use of aluminium continues to this day for a full range of applications which include both inexpensive windows and high performance curtain walls. Britain's Millennium Dome, the exhibition hall in Greenwich, has structural components in aluminium alloys.

The Legacy

While aluminium is typically associated with postwar curtain walling, it has been demonstrated that the aluminium heritage is one of extraordinary breadth and diversity. It ranges from nineteenth century castings that masquerade as traditional metals (the statue of Eros, Piccadilly Circus) to high strength alloys fabricated for structural elements (the Millennium Dome). Those who would divorce the architecture of the postwar era from that of the past are perhaps considering the intentions of the great modern architects, rather than the built legacy. The aluminium heritage includes traditional-looking buildings such as the former Ministry of Works at Whitehall with aluminium windows and doors (Fig.7), as well as the revolutionary experiments such as the Dymaxion Dwelling Machine. It is perhaps more appropriate to consider the aluminium heritage *"in terms of evolution rather than discontinuity"*.[70]

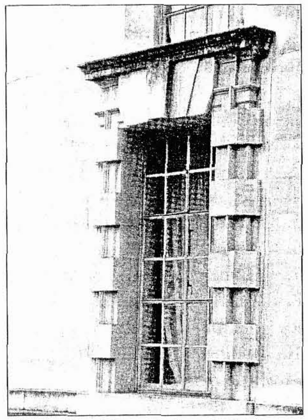

Fig. 7 Aluminium window at the former Ministry of Works, Whitehall (J.Ashby).

If one considers those who have used aluminium in their designs, the list includes the seminal modern architects of this century (i.e. Breuer, Eames, Neutra, Saarinen, etc.) This would indicate that there is a body of significant work that requires further academic research. In fact, some of these places have already been recognised as being of value, and have been afforded some degree of protection. In the United States, the Aluminaire House was placed on the National Register of Historic Places. In England, the Limbrick Wood County Primary School is among the aluminium buildings that are "listed". Decisions for selecting significant places in the aluminium heritage are hampered by the current lack of research. However, important work has been executed recently. An English Heritage study focuses on building types, and will assist in filling in another piece of the puzzle. Until such time as a fuller understanding of the significance of the aluminium heritage emerges, those advocating its conservation will be hindered. (Fig.8)

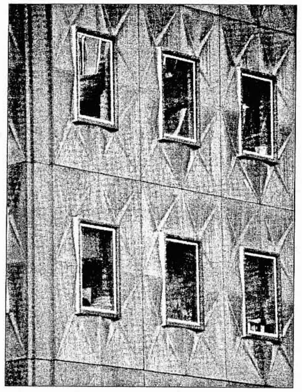

Fig. 8 An architectural grade anodised finish on the aluminium-silicon alloy panels of the H.K Porter Building, Pittsburgh (J.Ashby).

While a comprehensive architectural history of aluminium awaits future historians, it is clear that the metal and its history are unique among construction materials. The relationship with the military is where future historical research could continue to focus, in order to develop a fuller understanding of the role of aluminium within the broader economic, social, and cultural context of the modern era.

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