

A Survey of Historic Finishes for Architectural Aluminum, 1920–1960

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Fig. 1. Satin finish is in the upper left corner and right side. Sandblasted finish is on the upper right and middle. A replicated deplated finish is on the bottom. Samples are from a subway station in New York, New York. Images by the authors unless otherwise noted.

Technical papers published in 1883 presented aluminum as “the metal of the future,”

stating that “aluminum, we are satisfied, is the coming metal, destined one day to play as prominent a part in the arts of civilization, perhaps, as iron.”¹ This statement was realized fifty years later, when aluminum for architectural use was hailed as a modern marvel, a new wonder material capable of withstanding weathering and structural stresses. Prized for its light weight and white color, aluminum has been used for a wide variety of elements, including architectural features such as windows, spandrel panels, and other decorative elements. Aluminum may be used without a finish or protective coat, as it forms a natural protective oxide layer on its surface (Fig. 1). The spandrel panels in New York City’s Rockefeller Center are unfinished aluminum. However, most often a supplementary coating or finish is applied to impart corrosion protection while establishing a desired surface appearance. Recognizing these finishes and how they are applied will aid in making appropriate restoration decisions. This survey is limited to popular architectural aluminum finishes utilized in the United States from the 1930s to the 1960s.

This article looks at historic aluminum finishes and conservation issues affecting each finish.

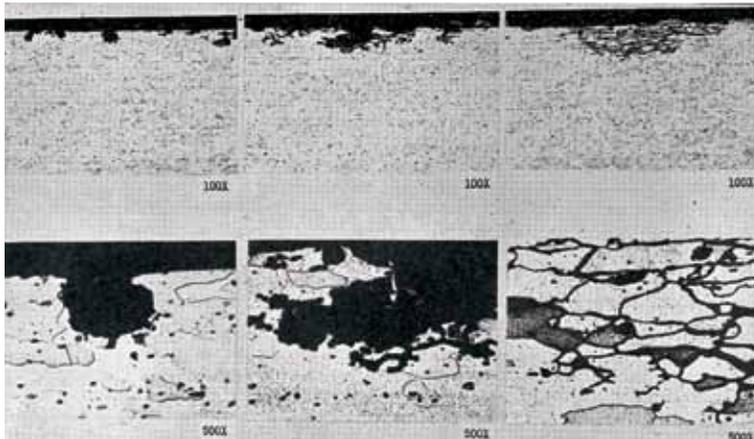


Fig. 2. Cross sections illustrating the different types of corrosion in an aluminum copper alloy. From *The Surface Treatment and Finishing of Aluminum and Its Alloys*, p. 18.

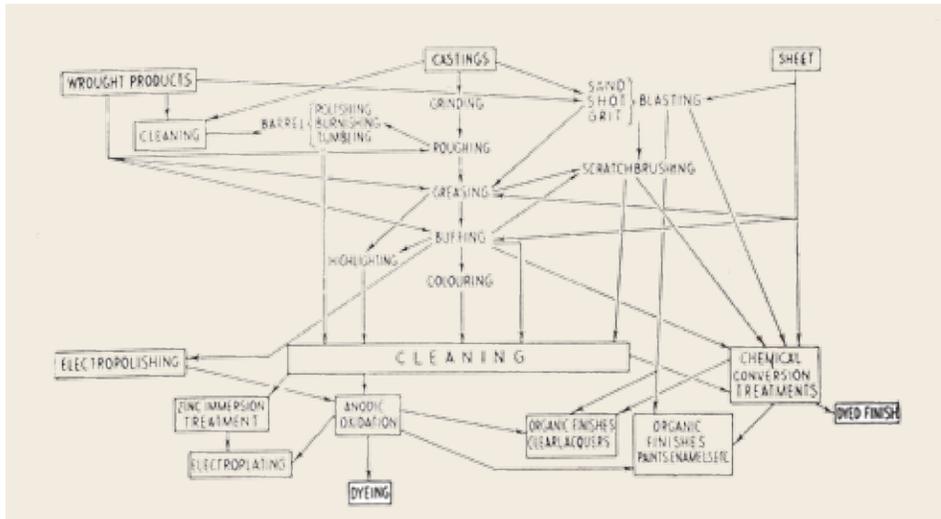


Fig. 3. Finishing techniques for aluminum. From *The Surface Treatment and Finishing of Aluminum and Its Alloys*, p. 43.

Aluminum Production

Compared to other metals, the discovery and use of aluminum is very recent. Common metals such as copper and iron are ancient. Copper was discovered c. 9000 BCE, and iron was discovered c. 5000 BCE. Aluminum, on the other hand, was not discovered until 1825.

Aluminum is the third most abundant element on Earth, after oxygen and silicon. Like most metals, it never occurs in nature as the pure element. Pure aluminum is extracted from its naturally occurring ore, bauxite. Aluminum was first processed in 1825 by Danish scientist Hans Christian Oersted using a chemical reduction method, which was further developed by German chemist Fredrich Wohler. Both methods were difficult and yielded only small amounts of aluminum. In 1855 Henri

Sainte-Claire Deville refined the process and was able to produce a full bar of aluminum for the Exposition Universelle in Paris. Due to the difficulties in extracting aluminum, it was treated like a precious metal, more costly than gold or platinum, and its use was limited to novelties and jewelry.² In 1886 Charles Martin Hall in America and Paul Héroult in France independently discovered a low-cost extraction method that is still used today. Called the Hall-Héroult process, it involves dissolving aluminum oxide in cryolite and then passing an electrical current through the molten solution.³ By the turn of the twentieth century, more than 6,800 tons of aluminum were produced annually.⁴

Pure aluminum is not used for architectural applications as its mechanical strength is too low. Therefore, deliberate alloying with other metals, typically

silicon and copper, is required to increase strength.⁵ Aluminum alloys can be either wrought or cast. Wrought products can be divided into two groups: standardized and engineered. Standardized products include sheet, plate, foil, rod, bar, wire, pipe, and structural forms. Engineered wrought products include extruded shapes, forgings, and impacts. Cast-aluminum products are produced by pressure-die, permanent-mold, green- and dry-sand, and plaster casting.⁶

Aluminum Corrosion

Pure aluminum, when exposed to the atmosphere, is immediately covered with a thin oxide film of hydrated aluminum oxide.⁷ This natural oxide film is between 0.005 and 0.015 microns thick. It can appear on the surface as a

white powder. While the oxide film is protective under ideal conditions, the breakdown of the film is accelerated by salts (anions) present in mortar, rainwater, seawater, guano, and deicing salts; through contact with materials such as masonry and other metals; and by surface agitation and preferential runoff.⁸

There are many different corrosion mechanisms for aluminum alloys. For each, the process is complex, incorporating many factors, and varying according to the metal and specific operating conditions.⁹ The most common types of corrosion encountered in architectural aluminum include galvanic attack, pitting, intergranular corrosion, exfoliation, and filiform (Table 1 and Fig. 2).

Finishes

Between the 1920s and the 1960s architectural aluminum was finished in a variety of surface treatments, including mechanical, chemical-conversion coatings, electroplating, electrolytic conversion coatings, and organic finishes — all of which continue to be used today. The finishing of aluminum was done to impart corrosion resistance and/or a specific appearance. Mechanical finishes remove the oxide layer; conversion treatments and anodizing change the oxide layer; and organic finishes are coatings applied over the oxide layer (Fig. 3).

Mechanical finishes. Mechanical finishes were the first finishes used on aluminum. Mechanical finishing is usually the first step undertaken after fabrication to eliminate scratches, pits, or other superficial blemishes resulting from the manufacturing process. These types of finishes are achieved by various grinding and polishing operations that remove the high spots of rough surfaces by using the cutting action of the abrasive. A mechanical finish leaves the aluminum without a protective oxide layer; therefore, it is employed as a preparation for anodizing or the application of organic coatings.¹⁰

As the mechanical finish is often the desired finish, a clear lacquer coating must be applied. Proper maintenance of the coatings is essential to preserve the

Table 1. Common Types of Aluminum Corrosion

Corrosion Type	Mechanism for Corrosion
Galvanic Corrosion	Galvanic corrosion is a form of localized electrochemical corrosion that occurs between two metals. In the presence of an electrolyte, which creates a closed circuit, the least noble of the two metals will become the anode and corrode preferentially. Aluminum is less noble than most commonly used architectural metals, including steel, copper, lead, stainless steel, and bronze. The use of these metals in direct contact with aluminum will cause the aluminum to corrode preferentially. Galvanic corrosion occurs most frequently where ferrous fasteners or framing systems are utilized and where lead-containing primers are applied directly to the metal. The two dissimilar metals should be isolated either by a coating, such as a bituminous paint, or rubber gaskets.
Intergranular Corrosion, Pitting, and Exfoliation	Intergranular corrosion, pitting, and exfoliation are symptoms of galvanic corrosion occurring within the aluminum alloy itself. Alloys containing copper have poor corrosion resistance. Intergranular corrosion occurs along the crystalline boundaries between the alloyed metals, manifesting as microcracking invisible to the naked eye. Intergranular corrosion is usually not evident until pitting occurs. Pitting appears as small divots, usually filled with a fine white powder or gel, and is present in the exposed surfaces of the aluminum. Exfoliation is a type of advanced intergranular corrosion that occurs parallel to the surface of the aluminum and along the grain boundaries, giving it a layered appearance.
Filiform Corrosion	Filiform corrosion appears as worm-like channels under an organic coating on aluminum. It usually propagates from a site where the protective coating has been compromised. The organic coating separates from the substrate and is pushed up by the aluminum oxide corrosion products. It is often misidentified as a cosmetic problem only and is left untreated. Not addressed, it can rapidly develop into pitting and intergranular corrosion.

original finish. Abrasion and ultraviolet degradation are common causes of lacquer failure. Failure of the lacquer coating encourages corrosion of the aluminum substrate and deterioration of the mechanical finish.

Mechanical finishes are easily replicated in the field. Degraded lacquers must first be removed using solvent-based strippers before the mechanical finish is reinstated. The new mechanical finish must again be protected with a lacquer coating.

Common mechanical finishes on architectural aluminum include sandblasted

and satin, which can be found on buildings from the 1930s.

Sandblasted. A sandblasted finish is achieved by bombarding the aluminum surface with an abrasive medium under pressure to create a matte, even, rough, pocked surface.¹¹ The texture of the surface is determined by the blast media used, the air pressure employed, and the distance and angle of the blast nozzle from the work.¹² Silica sand was traditionally used; however, other abrasive media include alumina, emery, steel particles, corn cobs, rice hulls, and walnut shells.¹³

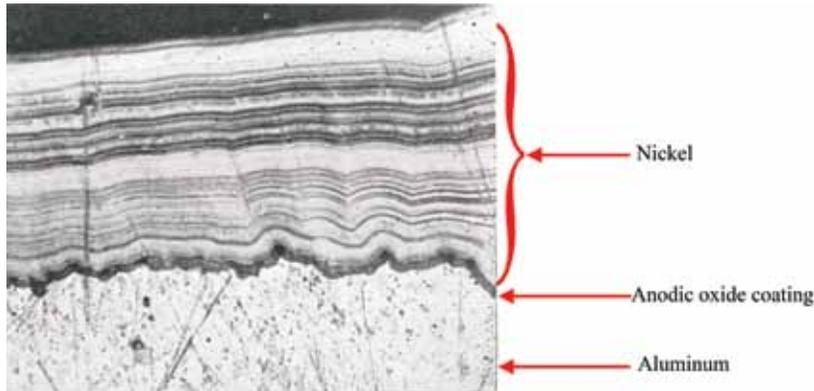
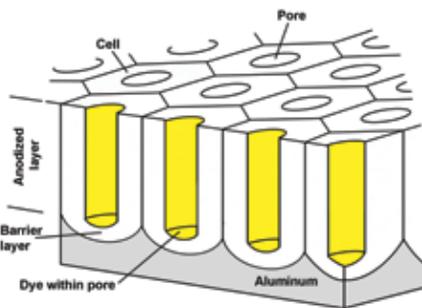


Fig. 4. Cross section of electroplating over an anodized surface. From *The Surface Treatment and Finishing of Aluminum and Its Alloys*, p. 595.

Fig. 5. An anodic oxide layer.



The sandblasted finishes are divided into three grades: coarse, medium, and fine. Heavy abrasive blasting can warp thin sections of aluminum. The finer finishes are often used decoratively or as a preparation for satin-finished work, as the milder abrasive action reduces the subsequent grinding or polishing.¹⁴ The surface is then protected from atmospheric corrosion by an oxide treatment or coating. Sandblasted finishes can be seen on the entrance doors to the Alcoa Research Laboratories (now referred to as A-K Research Park) located in Kensington, Pennsylvania, as well as the 4th Avenue subway station at 9th Street and the Broadway Fashion Building at Broadway and West 84th Street in New York City.

Satin finish. A satin finish is produced by imparting a series of minute paral-

lel lines into an aluminum surface by scratching it with successively finer abrasives or rotating wire brushes until a soft, smooth sheen is achieved.¹⁵

After the use of number 180 emery, the surfaces are buffed with muslin or felt wheels and a greaseless polishing compound. Various grades of compounds give a coarser or finer finish, depending on the grain size of the abrasive contained in the compounds.¹⁶ Again, this finish must be protected from corrosion by an anodized or applied coating. Satin finishes can be seen on the First National Bank Building (now called the First National Center), located in Oklahoma City, Oklahoma, and the 4th Avenue station in New York City.

Chemical treatments and conversion coatings. Chemical-conversion coatings alter the aluminum surface through either immersing or spraying the surface with a chemical solution. Chemical-conversion procedures were patented in Germany as early as 1915 but are a topic whose history requires additional research.¹⁷ In some cases, chemical treatments etch the surface, but in others, specialized films are formed.¹⁸ Some of the most important types of chemical treatments are intended to thicken the natural oxide layer present on the aluminum surfaces.¹⁹

In the United States, chemical-conversion coatings were used to prepare the aluminum surface for an additional treatment, such as an organic finish or electroplating. The conversion coating is inert and unreactive and helps inhibit corrosion if the secondary coating is damaged. The main benefit of chemical-

conversion coatings is the speed and economy at which they can be executed.²⁰

The presence of the chemical-conversion layer can be identified using a scanning electron microscope or through metallogurgical analysis of a cross section of the metal; however, in addition there has been limited success with determining the chemical process used to create the conversion layer using X-ray photoelectron spectroscopy.²¹

Conservation of conversion coatings includes removing porous oxides and sealing the surface. Harsh abrasives, like glass beads and pressures higher than 100 psi, remove the oxide coatings. However, softer plastic abrasives and low pressures (15 psi) can remove the porous oxides while leaving the conversion coating intact.²²

Severe deterioration of a chemical-conversion coating may require removing all remnants of the original coating and re-treating the surface. Most chemical-conversion treatments rely on submersing the metal in a bath, which may not be possible for large architectural pieces. Applied conversion coatings may be viable options. There are several types of chemical-conversion treatments that are performed.

Modified Bauer-Vogel (MBV) and Al-rock processes. The first chemical oxide treatment was developed in 1915 by O. Bauer and O. Vogel in Berlin, Germany, where the aluminum piece was submerged in a bath of potassium carbonate, sodium bicarbonate, and potassium dichromate for two to four hours at temperatures between 90° to 95°C, then rinsed and dried. A light gray iridescent film is produced, which turns dark gray with longer exposure in the bath. This film can also be dyed. This treatment was ultimately patented in 1923.²³

In 1930 Dr. Gustav Eckert altered the process using sodium carbonate and sodium chromate, making it easier and faster to complete in three to five minutes. It was renamed the Modified Bauer-Vogel Process, or MBV Process. Depending on the alloy of aluminum, a light to dark gray coating is produced

on the surface, which makes a suitable base for an organic coating. A version of this same process was patented by Alcoa and named Alrock.²⁴

Caustic etch or frosted finishes. Frosted finish or caustic etch is a decorative silvery-white finish chemically produced on aluminum. Caustic etching is derived from metal pickling, which utilizes a strong acid to remove surface impurities from metal. However, unlike pickling, a strong base is used to perform a caustic etch. Sources as early as 1909 mention caustic etching or caustic dipping as a finishing treatment for aluminum but caution that it does not result in an even appearance; if an even appearance were desired, a mechanical satin finish was to be utilized instead.²⁵

Caustic etching removes the natural oxide film from the surface of the aluminum, preparing the surface for plating. The specimen is immersed in a 180°F solution of sodium hydroxide for approximately one minute. The piece is then rinsed with cold water and immersed in a bath of nitric acid to remove the dark smut deposited by the alkaline solution and to neutralize the surface. Finally, the metal is rinsed again with cold water.²⁶

Phosphatizing, Parkerizing, and Bonderizing. Phosphatizing, or the phosphate process, forms a thin, inert phosphate coating on a base metal. The original process was first applied to steel in 1859 and was patented in 1906.²⁷ It is used mainly to prepare aluminum surfaces for painting, anodizing, and electroplating. This treatment is accomplished by immersing or spraying the aluminum with a 5 to 10% solution of phosphoric acid at room temperature. The aluminum is left in the bath/spray for approximately five minutes, then rinsed and dried.²⁸

The process was further refined by the Parker Company in 1918, when manganese phosphate was added to the bath, a process known as Parkerizing. In the 1940s Bonderizing or Bonderite 170 was developed; in this process a complex fluoride is used to accelerate the film formation of a crystalline iron-metallic phosphate film on the aluminum.²⁹



Fig. 6. Empire State Building, New York City, designed by William F. Lamb and built between 1929 and 1931. Aluminum spandrel panels were designed with a deplated finish.

Fig. 7. Empire State Building, deplated aluminum spandrels. Some of the finish has deteriorated and the aluminum is corroded, but it appears that the dark gray deplated finish was in the recessed portions of the design.



Chemical polishing. Chemical polishing is a process by which aluminum is given a bright, reflective finish without mechanical polishing. Developed by the Battelle Memorial Institute of Columbus, Ohio, in 1948, the aluminum pieces are dipped in acid baths containing a mixture of typically phosphoric, nitric, and acetic acid at temperatures between room temperature and 200°F for 10 seconds to 10 minutes. Following dipping, the pieces are rinsed and dried. The resulting surface can either be plated or left as is.³⁰

Electroplating. Electroplating uses electrical currents to form a coherent metal coating on another metal. Modern electroplating started with the opening of the first electroplating plant, Norddeutsche Affinerie, in Hamburg, Germany, in 1876.³¹ By 1894 experimentation was taking place in the United States to plate steel with aluminum.³² However, electroplating of aluminum did not become common until the mid-1930s, when it was used mainly for small household items and interior elements in noncor-

rosive environments such as door knobs and hardware.³³

There are four basic types of electroplating: plating over another base metal, direct plating, plating over chemically etched surfaces, and plating over anodic and chemical oxide coatings. For all types the surface of the aluminum is prepared by first removing or thickening the natural oxide film through chemical etching, anodizing, chemical conversion, or zinc immersion/disposition and then buffing the surface to remove any scratches or unevenness and thoroughly cleaning the surface of contaminants. The piece is then dipped in the electroplating bath and a current is applied, thereby depositing the desired metallic finish on the surface. The current amperage and the bath contents are dependent on the metal to be deposited on the aluminum.³⁴

Successful electroplating of aluminum is difficult because of aluminum's immediate oxide film formation, which can reoccur during the surface preparation stage; aluminum's position in the electrochemical series, which can easily



Fig. 8. U.S. Plywood Building, 777 Third Avenue, New York City, designed by William Lescaze and built between 1961 and 1963. The facade is clad in glass and dark anodized aluminum.

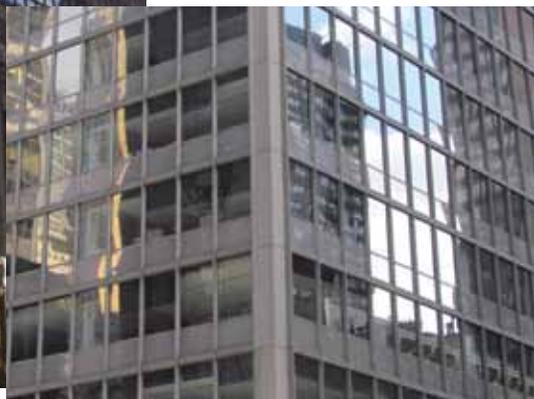
Fig. 9. U.S. Plywood Building, dark anodized aluminum.

form immersion deposits in plating solutions; and the differences in coefficients of expansion between aluminum and its alloys.³⁵

Because aluminum is anodic to most coating metals, the corrosion resistance imparted by the deposited metallic coating can be drastically decreased if there are discontinuities in the coating. If chemical etching solutions are not properly rinsed from the surface prior to plating, a galvanic cell can form between the aluminum and the plating metal.

Failure is manifested as blistering followed by exfoliation of the plating.³⁶

Before treatment, proper identification of the base aluminum alloy, the base metal, and plating metal is required. Analytical techniques, such as X-ray fluorescence (XRF), metallurgical analysis, and cross-section microscopy, can be performed. Subsequent treatments should be based on what is best for the element and its surrounding components. If the item cannot be maintained in a controlled environment, and the plating has failed (blistering or exfoliation of the plating metal), it may be necessary to replating the item.



Plating over a base metal. Electroplating over another deposited base metal (usually zinc) is the most common method of electroplating aluminum in the United States, most often to deposit chrome onto aluminum items. The aluminum surface is cleaned and then immersed in a zincate solution to produce a very thin coating of pure zinc on the surface.

In the United Kingdom, most electroplating employed the Vogt process (named after the developer, B. Vogt). The Vogt process relies on electrodeposition of the zinc onto the surface of the metal instead of immersion. The consistent zinc layer produced by this process is particularly important when electroplated items are to be subjected to cold-working and heat treatment.³⁷

Direct plating. Direct plating involves plating aluminum with another metal — usually copper, chromium, tin, or zinc.

The aluminum is first vapor-degreased and cleaned in a phosphate bath. The metal is then placed in the plating bath and a current is applied.³⁸

Plating over anodized or chemically oxidized surfaces. Plating can be performed over an anodic or chemically oxidized surface. Similar to plating over a chemically etched surface, the anodic or chemically oxidized layer provides a key onto which the deposit metal can hold. The success of the plating depends on the quality of the oxidized layer (Fig. 4).³⁹

Electrolytic oxide coatings. An important and once-revolutionary finish for aluminum is the electrolytic oxide coating, or anodizing.⁴⁰ Anodizing aluminum on an industrial scale was first performed in 1923 to protect of Duralumin sea planes, but it was not used for architectural elements until the 1950s.⁴¹ Today, anodizing is used to treat a wide array of aluminum products from architectural elements to jewelry.

The oxide finishes are created by treating the metal anodically in various electrolyte baths to obtain a thin, inert, and durable aluminum oxide film on the metal surface. The oxide film is very hard and offers excellent abrasion and corrosion resistance for the underlying aluminum. Some of the films are clear and transparent; others are colored in varying degrees of brown, gray, or silver. The color and hardness of the film will depend somewhat on the type of aluminum alloy anodized. The films possess good absorption qualities for dyes and paints since most are minutely porous.⁴² In anodizing, aluminum is the anode. It is placed within a bath with an electrolyte (an acid) capable of yielding oxygen on electrolysis. A cathode is mounted inside the anodizing tank. When the electric current is passed, oxygen ions are released from the electrolyte and an oxide coating is formed on the surface of the aluminum. Progressive oxidation takes place beneath the film just formed: that is, the film formed last is against the metal surface, while the film formed first is the outermost layer. The outer part of the film is less dense, since it has been subjected to the most

severe solvent action of the electrolyte. The aluminum oxide film is also slightly porous. Thus, the current is able to pass through the electrolyte and into the pores of the metal without much resistance.⁴³ Due to the porosity of the oxide film, dyes can be applied before the final sealing stage (Fig. 5). After treatment, the anodic coating is “sealed” by submerging the piece in boiling water. This treatment converts the aluminum oxide coating into the monohydrate as shown in the following formula: $\text{Al}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$. The monohydrate has an increased volume, which essentially closes the pores and destroys the absorptive characteristics of the coating.⁴⁴

Cleaning anodized architectural aluminum is very important to retain the finish. If dirt is allowed to remain on the surface, corrosion cells can form. Anodized finishes on accessible surfaces that are maintained, e.g. shop fronts, window frames, etc., have been shown to have an appreciably longer life than surfaces that are cleaned infrequently. Maintenance-cleaning products with abrasives are unsuitable for anodized aluminum, as they will damage the coating.⁴⁵ However, if the anodized aluminum has been neglected, heavy-duty restoration cleaning will be required. Abrasive cleaning methods can be employed to remove heavy pollutants, contaminants, and oxidation, followed by the application of a coating.⁴⁶ The coating can be clear or colored to match the original anodized layer.

If the piece can be removed or disassembled, the worn anodized coating can be abrasively stripped and reanodized. Unfortunately, this process removes metal and can affect profiles and details.⁴⁷

Although aluminum may be anodized in phosphoric, boric, sulfamic, oxalic, and other acids, the chromic and sulfuric acid processes are the most common. The chromic and sulfuric acid processes are similar, but employ different electrolyte concentrations, bath temperatures, voltage, and exposure times.

Deplating. The term “deplated” appears in books and references from the 1930s.⁴⁸ The deplated finish is a dark gray, electrolytically formed oxide

coating. The aluminum surfaces are first sandblasted, followed by anodic oxidation by electrolytic treatment in a sulfuric acid bath of low concentration, to produce a very dark gray color, then coated with clear lacquer.⁴⁹ The term disappears from use by the 1940s. It is likely that the term and the concept of deplating fell under the process of anodizing.

The Empire State Building, completed in 1931, contains aluminum window spandrels finished with a dark gray “deplated” finish (Figs. 6 and 7).⁵⁰

Chromic acid. The chromic acid process was first patented by G. D. Bengough and J. M. Stuart in 1923, and they are

Coatings provide protection either by creating a physical barrier from the atmosphere or by active corrosion inhibition provided by pigments in the coating.

recognized as being the inventors of anodizing.⁵¹ The chromic-acid process produces a thin film particularly well-suited to the anodizing of assembled parts as the corrosion resistance of the aluminum surfaces is not appreciably affected by any chromic acid trapped in the joints. The film also serves as an excellent paint base.⁵² Depending upon the alloy used, chromic acid films vary from light gray on pure aluminum to dark purple-gray on alloys rich in silicon.⁵³

Sulfuric acid. The sulfuric acid process is the most common anodizing process performed on aluminum. The first sulfuric acid anodizing process was patented in England by C. H. R. Gower and Stafford O’Brien in 1927.⁵⁴ Alcoa (Aluminum Company of America) patented its own process called Alumilite in 1923.⁵⁵ The oxide films vary from clear and transparent to translucent and opaque, depending on the alloy composition, timing, and solution concentrations.

The transparent films produced by the sulfuric acid process make it the ideal process for subsequent color dyeing.⁵⁶ The U.S. Plywood Building in New York City contains dark, possibly originally brown, anodized aluminum piers and belt courses under the windows (Figs. 8 and 9). Films produced with sulfuric acid are thicker than those produced with chromic acid.⁵⁷ The sulfuric acid process is not recommended for use with assembled parts subject to stress or containing recesses or joints, as retained traces of sulfuric acid may cause corrosion.⁵⁸ The escalators located in the Marshall Field’s store in Chicago have an Alumilite finish.

Electropolishing/Brytal process. Electropolishing, while referenced as early as 1912 for silver, did not become a systematic treatment for aluminum until after World War II.⁵⁹ Electropolishing results in a reflective surface on the aluminum. The degree of reflectivity depends on the purity of the alloy. This technique essentially removes any rough edges of the metal, thereby lessening the differences between the valleys and peaks on the surface. Electropolishing, also known by the trade name the Brytal process (developed by the British Aluminum Company in the early 1950s), consists of degreasing the aluminum and then immersing it in a carbonate/trisodium phosphate solution for 30 seconds or less to remove the natural oxide film.⁶⁰ An electrical current is then applied, and the voltage slowly raised and lowered. This process produces a thin film on the surface of the metal visible as interference colors. The film is usually reinforced by anodizing.⁶¹ Electropolished and Brytal process-finished items are usually found as smaller architectural elements, such as hardware or sculpture.

Organic coatings. Aluminum is often painted both for protection against corrosion and for decorative purposes. Coatings provide protection either by creating a physical barrier from the atmosphere or by active corrosion inhibition provided by pigments in the coating.⁶² Organic finishes are often popular, due to the low cost of modern application techniques and their ability



Fig. 10. McGraw-Hill Building, New York City, designed by Raymond Hood and built in 1931. The first-floor entrance is decorated with black and blue bands of enameled aluminum panels.

Fig. 11. McGraw-Hill Building, black and blue bands of enameled aluminum panels.

to produce smooth, lustrous surfaces without polishing.

Various types of coatings can be easily applied to aluminum. Coating formulations change almost daily; however traditional coating materials include lacquers, enamels, varnishes, paints, and porcelain. Normally, all that is required to prepare the aluminum for treatment is cleaning the surface with a solvent to remove any grease, oils, or other contaminants that might affect the adhesive qualities of the finish coat. Improved adhesion can be obtained by first applying chemical conversion coatings,

mechanically or chemically roughening surfaces, or applying a suitable primer, such as zinc chromate or titanium dioxide.⁶³ Coatings are applied to aluminum in the same manner as to other metals, including brushing, dipping, spraying, electrostatic spraying, roller coating, and thermal spray.

Alkyd, vinyl alkyd, vinyl, and thermosetting acrylic paints have been applied to aluminum awnings and curtain walls. Baked enamels have been applied to aluminum panels to provide vibrant color, such as on the McGraw-Hill Building in New York City, constructed in 1931 (Figs. 10 and 11). Bituminous paints, which are made from asphalt, driers and drying oils in a solvent, have been applied to aluminum to protect it against highly corrosive conditions, including embedment in soil or concrete, or immersion in salt water. Clear lacquers are most often applied over mechanically polished or anodized surfaces to prevent oxidation from altering the appearance of the finish.

Proper maintenance of the coating is essential to preserve the original finish. Abrasion and ultraviolet degradation are common modes of failure. Failure of the coating encourages corrosion of the aluminum substrate and deterioration of the finish. After addressing any underlying corrosion issues and completing a paint analysis to determine original colors, organic finishes can be reinstated to match the historic appearance.

Conclusion

Finishing techniques provide both performance and aesthetic benefits for aluminum and its alloys. They serve the dual purpose of increasing the corrosion resistance of the metal and achieving a desired surface appearance. This paper provides an overview of the common finishes applied to architectural aluminum from the 1920s to the 1960s and associated conservation and maintenance issues.

In the 1930s Alcoa and The Reynolds Company advertised aluminum as being resistant to corrosion by “defying the corrosive attacks of smoke and fumes.”⁶⁴ However, aluminum is not

resistant to corrosion, and an entire chapter in Alcoa’s 1932 book entitled *Aluminum in Architecture* is devoted to maintenance.⁶⁵ Deterioration of protective finishes can cause the underlying aluminum to corrode. Conversely, corrosion of the underlying aluminum can cause the finishes to fail.

Restoring deteriorated aluminum finishes in situ can present several challenges and requires some creative thinking. Severe corrosion, layers of over-painting, and inappropriate repairs can obscure the original finish. Several finishes are created in a shop by dipping the aluminum piece in an oxidizing bath and sometimes by also introducing an electric current. Often the aluminum structure or element cannot be dismantled and refinished off-site in a shop.

Before any restoration or conservation efforts are undertaken, technical and historic information must be combined with accurate material analysis in order to develop appropriate conservation strategies.⁶⁶ Documentary research, on-site investigation, and laboratory examination of samples must be performed to identify the type of aluminum alloy used and the original finish installed. Armed with the knowledge of the original finishing technique and the limitations of field conditions, decisions regarding conservation and replication can be made. However, the best method of preservation and conservation of these finishes is appropriate periodic maintenance, including gentle cleaning to prevent abrasion of the coatings or oxide films and limiting access to water, salts, masonry, and strong acids or alkalis.

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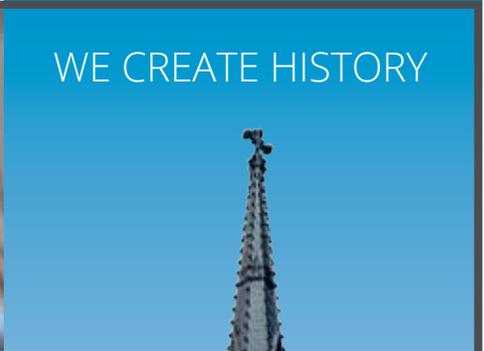
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Notes

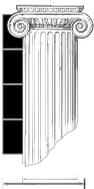
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10. Wernick and Pinner, 42-43.
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17. David Hallam, "Preventive Conservation and Maintenance of Aluminum Artefacts and Collections," presentation given at "Aluminum: History, Technology, and Conservation" conference, Washington, D.C., April 7-9, 2014.
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