The "White Metals" of Early-Twentieth-Century American Architecture

Richard Pieper

Nickel and aluminum alloys and other "white metals" came into wide use during the Art Deco and Modern period and transformed the look of American architecture.

Fig. 1. Straus mausoleum, Woodlawn Cemetery, Bronx, New York, Monel doors. While Monel was generally used for sheet-metal installations, some wrought and cast installations were produced. Photograph courtesy of Makenzie Leukart.

In New York City at the turn of the twentieth century, the metals used in the construction of new buildings were primarily steel, cast iron, zinc, and copper and copper alloys. Steel had largely supplanted unornamented cast and wrought iron as a structural material by the late 1890s. With the exception of a few prominent large facades, cast iron was reserved for storefronts, window surrounds, spandrels, gates, grilles, and fencing. A revival of decorative wrought iron, led by the master smith Samuel Yellin, resulted in the ambitious wrought-iron artistry of York and Sawyer's Federal Reserve Bank in 1924, but this was an unusually large installation of a metal that was passing into disuse. Copper, lead-coated copper, and galvanized or terne-plated sheet steel were the metals available for roofing and flashing. Stamped and brake-formed copper was the preferred material for durable roof cornices; cast and stamped zinc was used to ornament more modest cornices and facades of painted galvanized sheet steel.

While this tradition of metal use continued, the first four decades of the twentieth century would witness the introduction of several new architectural metals in New York City as the silvery-white nickel alloys Monel, nickel silver, and stainless steel and then aluminum came into large-scale use. At the same time, the introduction of a new alloy of lead (containing antimony) drove a brief revival of the use of lead ornament and roofing. Historically, the term "white metal" had been used to refer to easily-cast alloys of silvery appearance and unspecified composition, often alloys of tin, lead, or zinc. At the beginning of the twentieth century, the term came to be used in architecture for any silvery-white alloy, contrasting them with the polished and patinated brasses and bronzes of the nineteenth century. Most of these metals were alloys of nickel or of aluminum.

Nickel had been used for electroplating by 1870; by the end of the nineteenth century nickel plating was commonly used for lighting and plumbing fixtures, hardware, and tools. While nickel could be used unalloyed for plating, pure nickel was difficult to work in solid form. Two more malleable nickel-copper alloys, Monel and nickel silver, became popular for architectural applications early in the twentieth century, primarily in prominent commercial and public structures.

"Nickel silver" is a term used for a variable alloy of copper, nickel, and zinc (it contains no silver). This combination of metals, remarkably similar to silver in appearance, had been used for centuries in China, where it was called "white copper." The Cantonese word for this term was phonetically transliterated into English as "paktong." In eighteenth-century England paktong was used primarily for decorative objects such as candlesticks and tableware. European-fabricated alloys of similar composition were developed in the eighteenth and nineteenth centuries and were marketed as "German silver," as well as under various proprietary names. Early in the twentieth century, with the development of North American nickel deposits in Sudbury, Ontario, the International Nickel Company (INCO) popularized the term "nickel silver."

Table 1. Compositions for Uniform Color Matching

Referred to as	Extruded		Drawn Rolled and Tubing		Cast	
10% Nickel Silver	copper	49.50%	copper	65.00%	copper	55.00%
	zinc	40.00%	zinc	24.50%	zinc	20.00%
	nickel	10.00%	nickel	10.50%	nickel	12.50%
	lead	00.50%			lead	10.50%
					tin	02.00%
13% Nickel Silver	copper	40.50%	copper	55.50%	copper	55.00%
	zinc	44.75%	zinc	29.50%	zinc	18.00%
	nickel	13.00%	nickel	15.00%	nickel	15.00%
	lead	00.75%			lead	08.00%
	iron	00.25%			tin	04.00%
	impurities	00.75%			manganese	00.15%
20% Nickel Silver	not produced at this nickel content		copper	75.00%	copper	66.25%
			nickel	20.00%	nickel	20.00%
			zinc	05.00%	tin	03.00%
			(rolled and drawn material only)		lead	05.00%
					zinc	07.50%
					manganese	00.25%

Data from *Nickel Silver in Architecture* (1935)

INCO published a lavishly illustrated sales booklet in 1935 entitled *Nickel Silver in Architecture*, with a number of examples of the metal used for both interior and exterior architectural applications. Most of the buildings pictured were in New York City and included the Goelet Building at 608 Fifth Avenue (1931, altered 1966); the City Bank-Farmers Trust Building at 20 Exchange Place (1931); the Metropolitan Insurance Building on Madison Square (c. 1933); and the Waldorf-Astoria (1931). Most illustrated uses were interior elements such as elevator doors, signage boards, and such interior furnishings as tables, stands, and separation strips for terrazzo and stone flooring. Exterior entries, gates, and grilles are also pictured. Not pictured in the booklet, but also a prominent example of the metal in the same period, were the lobbies of buildings in Rockefeller Center (1931-1939).

As noted, nickel silver varies significantly in composition. While the most common alloy is 75% copper, 20% nickel, and 5% zinc (called "20% nickel silver"), the booklet lists the different alloys to be used for color matching extruded, rolled, and cast materials. These alloys are shown to contain as little as 40.5% copper and as much as 44.75% zinc. Nickel content is fixed at 10%, 13%, and 20%, with extruded sections available only in the 10% and 13% nickel alloys. While the most common alloy used was silvery white in color, yellowish and coppery alloys were often used for accent and contrast (Table 1).

Monel is another alloy of nickel and copper but one with more nickel (historically about 68%) than copper. At the end of the nineteenth century a major use of nickel was in nickel silver, which was produced by smelting the constituent metals separately, then combining them into the alloy. As INCO's Sudbury ore body was composed of a combination of copper and nickel sulfides, its metallurgists endeavored to produce a matte (an impure smelting product of metals and their sulfides) directly from the ore without separating the two metals. The first ingot cast from the resultant alloy (in 1904) was embossed with the last name of INCO's then-president Ambrose Monell. The name stuck, but trademark restrictions on the use of proper names required that it be shortened to Monel. As first produced, Monel's nickel content varied with the ore from 68% to 72%, with the remainder being copper. Monel has a very low coefficient of expansion and is quite fatigue- and corrosion-resistant. It develops a dull gray patina and does not stain masonry materials, making it extremely useful for roofing.

The first significant architectural use of the metal was for the roofing of McKim, Mead and White's Pennsylvania Station in New York in 1909 (demolished 1963-1966). Another prominent roof of Monel was installed on the New York Public Library at 5th Avenue and 42nd Street in 1936. Jan Hird Pokorny Associates has recently found Monel roofing (apparently from the 1930s) on the 1904 Enid A. Haupt Conservatory at the New York Botanical Garden and as roofing installed in the 1930s at the Battery Maritime Building in Lower Manhattan. Although Monel was most commonly used in sheet-metal installations, there are other uses to be found in New York City: in Woodlawn Cemetery, for example, the Straus mausoleum has entry gates of hand-wrought Monel fabricated by the firm of Samuel Yellin (Fig. 1). The natural patination of the gates (gray and gray brown in exposed areas, a gray green blush in sheltered areas) is instructive of Monel's typical weathered appearance.

While rust-resistant alloys of chromium and steel had been formulated in the first half of the nineteenth century, contemporary nickel-bearing "stainless steel" (typically about 18% chromium and 8% to 12 % nickel) was developed by metallurgists working in England, Germany, and the United States in the first decade of the twentieth century. Initial efforts were directed toward uses for industry and for products such as table flatware and gun barrels, but increased production of the alloy eventually allowed for architectural applications. Perhaps the best-known extensive early use of stainless steel in architecture in the U.S. was New York City's iconic Chrysler Building. Rolled sections and sheet (of Nirosta K.A.2, an alloy similar to contemporary 302 stainless) were used for exterior cladding and storefront frames. Interior and exterior ornament of the first floor made extensive use of cast stainless steel, much of it readily accessible to view at the ground-floor exterior and in excellent condition (Fig. 2).

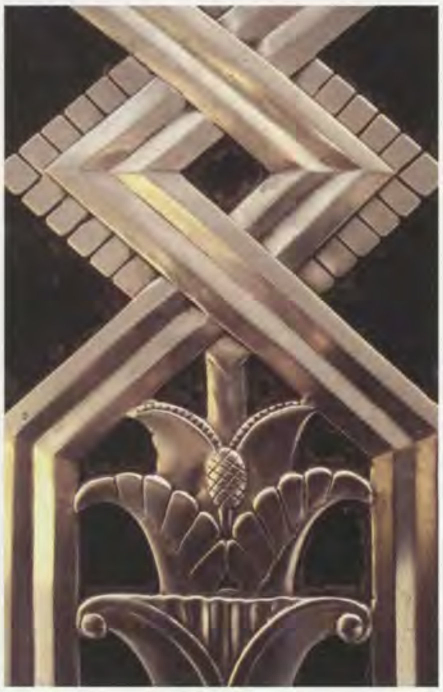

Fig. 2. Chrysler Building, New York City, cast stainless-steel ornament. Stainless steel remains bright without significant treatment but can develop self-sustaining pitting in areas of soiling and must be cleaned periodically. Photographs by the author, unless otherwise noted.

Unlike nickel silver and Monel, which patinate upon exterior exposure, stainless steel remains bright. It was also much lower in cost than both nickel silver and Monel and by the early 1940s had largely supplanted both of them for architectural use. While the nickel-copper alloys had typically been used for grand commercial and public structures, relatively inexpensive stainless steel lent itself to a considerably different demographic. It was commonly used in New York City and elsewhere for exterior and interior cladding for diners. A hygienic material for sinks and cooking appliances, it eventually replaced porcelain-enamel steel for many of these applications. Since it retained a bright surface, stainless steel also provided opportunities for mechanical finishes, such as brushed and "engine-turn" designs, which were not practicable for exterior applications of the other nickel alloys.

At the same time that stainless steel was being used for exterior cladding and ornament at the Chrysler Building, the use of aluminum in architecture was expanding dramatically. The production of the metal at that time was dominated by the Aluminum Company of America (Alcoa), headquartered in Pittsburgh.

In the late 1920s the company had a monopoly on aluminum-smelting operations in the U.S. and controlled most aluminum fabrication in the country. The company was making significant efforts to expand their markets. A 1929 Alcoa marketing pamphlet, entitled "Architectural Aluminum," pictured seven buildings that made significant use of aluminum for exterior applications. One of the early adopters of aluminum was the New York and Pittsburgh architect Henry Hornbostel, who designed three of the seven buildings pictured in the Alcoa pamphlet. Among them were Hornbostel's 1929 Grant Building in Pittsburgh, which was constructed with cast-aluminum spandrel panels, an application that was to become quite popular in the early 1930s. About three years after the Grant Building was constructed, aluminum castings played an important role in what is often called the first large-scale use of aluminum in architecture in the U.S.: New York's Empire State Building. In his history of Alcoa, *From Monopoly to Competition*, author George Smith stated that the Empire State Building utilized 750,000 pounds of aluminum from Alcoa. The spandrel castings of the Empire State Building were finished by "deplating," an early electrolytic oxide treatment that used a sulphuric acid bath and an impressed current to produce a dark gray color on the surface of the aluminum.

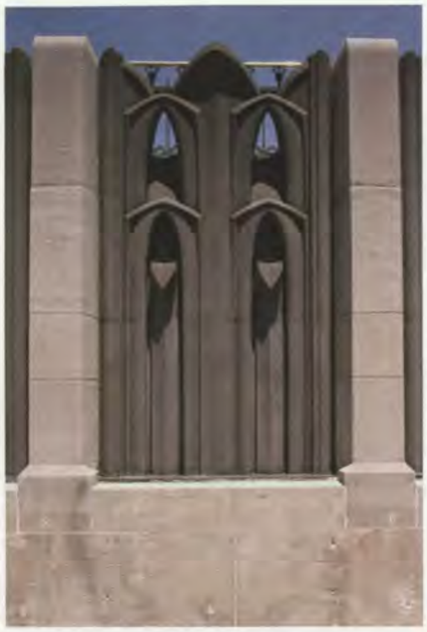

Fig. 3. 30 Rockefeller Center, New York City, cast-aluminum panel at viewing deck. Cast aluminum was used for spandrel panels at the Empire State Building and the towers at Rockefeller Center. Anodic "deplating" was a common treatment for early architectural cast aluminum.

The Empire State Building was just being completed when work began on a second significant use of aluminum castings in New York City: the complex of buildings at Rockefeller Center. According to Smith, Alcoa supplied 3 million pounds of aluminum for Rockefeller Center, which was used for window sills, copings, and spandrel panels. The dark gray appearance of the spandrel panels suggests that the aluminum castings were deplated here as well, although their treatment is not recorded in Smith's history (Fig. 3). Determining original finish and appearance, in fact, can be a major issue for aluminum conservation. Alcoa's publications of the period recommended that aluminum for exterior installations be treated for durability. A 1938 Alcoa pamphlet, "Finishes for Aluminum," devotes significant sections to what the company defined as chemical finishes, essentially chemical conversion layers, to which they gave names such as "caustic-etched," "diffuse reflector," "frosted," and their proprietary "Alrok" finish. Also included were electrolytic oxide finishes, what today would be called "anodized" finishes, but which Alcoa at that time called their "Alumilite" finish.

In the 1930s aluminum ultimately competed with nickel silver for interior applications. The Alcoa aluminum finishes pamphlet of 1938 depicts streamlined-design escalator housings in Marshall Field's department store in Chicago that are near replicas of the nickel-silver escalators in the lobby of Rockefeller Center's International Building (630 Fifth Avenue, 1934). Other interior installations of the period featured polished aluminum; one exceptional example is the remarkable entry lobby of the RCA Victor Building by Cross and Cross at 51st Street and Lexington Avenue, completed in 1931.

If you asked a building historian to list the "white metals" of the early twentieth century, the four alloys described above would quite certainly be on the list; less likely to be included would be lead. Lead weathers to a gray appearance not unlike that of deplated aluminum, however. As nickel alloys and aluminum rose to popularity, an alloy of lead with antimony, marketed as "Hoyt Hardlead" by the National Lead Company, sparked an unlikely revival in the use of lead (the addition of antimony supposedly overcame some of the creep and fatigue problems that plagued pure lead sheet). Much of this architectural lead was used in Gothic-style religious and university buildings, but a few Art Deco and Modern buildings in New York used lead as well. One of the most prominent is the Downtown Athletic Club, a tower at the lower tip of Manhattan designed by Starrett and van Vleck, which was completed in 1930. The tower is featured in the National Lead Company's pamphlet "Hoyt Hardlead: Architectural and Ornamental Leadwork," which pictures the sheet-lead spandrels on the street and secondary facades, depicting them with the diagonal "batten" seams so typical of ornamental lead work. Another Art Deco structure in New York City using lead is the 1936 Ferry Building on Ellis Island. Sheet lead was used for the decorative cupola at the center of the building, flanked by decorative cast-lead eagles (the sheet lead was replaced with zinc in 2007) (Fig. 4). For this installation, at least, the motivation to use lead is quite clear: in this marine environment nickel silver would require onerous maintenance; 302 or 304 stainless steel would eventually rust; and even Monel could patinate unacceptably. Lead was the "white metal" that would remain "white" in this location.

Conservation

The vagueness of the term "white metal" is consistent with a naïveté about relative performance that accompanied those materials' introduction. While unfinished surfaces of these metals may appear similar, nickel silver, Monel, lead, stainless steel, and aluminum have dramatically different conservation concerns. Absent special finishes and regular maintenance, Monel could be considered the most durable of the group. Monel's grayish patina on weathered surfaces is quite stable and requires no maintenance. However, care must be taken to perform repairs and

Fig. 4. Ferry Terminal, Ellis Island, lead cupola. Lead experienced a brief revival in the 1920s and 1930s and saw use in some Art Deco and Modern buildings. Photograph by Christopher Barnes, courtesy of Save Ellis Island Foundation.

alterations with Monel sheet and fasteners only, to avoid galvanic-deterioration problems.

Lead is remarkably durable on exterior exposure in urban and marine environments, but its high coefficient of expansion and susceptibility to fatigue cracking necessitate careful design and joinery. Lead is also subject to deterioration when in contact with alkaline mortars or concrete and is vulnerable to dissolution by numerous acids, especially tannic and acetic.

Unlike Monel and lead, which patinate upon exterior exposure, stainless steel remains bright. It is subject to rust pitting, however, especially in areas that become soiled or on surfaces contaminated with particles of mild steel. Once rusting starts, it is self-perpetuating. "Passivation," typically with sulfuric acid, or cleaning with an oxalic acid paste is necessary prior to installation and after repairs with mild-steel tools. Proper maintenance requires periodic cleaning to remove soiling and incipient rust spots in order to maintain a passive surface.

Because nickel-silver installations typically use alloys of different colors to accentuate design, it presents more complicated conservation concerns. Interior applications of nickel silver remain bright with minimal maintenance and no protective coating. When used outside without a lacquer finish, however, it will eventually patinate naturally to a dull brown (Fig. 5); this patina changes to green in areas at the bases of gates and doorways where the metal is exposed to deicing salts. This weathered surface is relatively stable and could be left untreated, but it does not reflect original architectural intent, which was predicated upon a bright finish. One common problem with maintaining a bright surface on exterior ornamentation of nickel silver is that a residue of polish may remain in the recesses of cast ornament. The need for periodic exterior maintenance sometimes prompts owners to paint the installation, or at least recessed portions of the installation, with a silvery paint rather than attempt to maintain a polished surface, especially on elements above ground level. This is the case with the gates at the Metropolitan Life Insurance Company building, upper entry grilles at the Waldorf-Astoria Hotel, and recessed panels of doors at 20 Exchange Place (Fig. 6). If the historic appearance is to be maintained, however, nickel silver requires a lacquer coating, similar to that used for bright architectural bronze.

Of all of the metals reviewed here, aluminum may present the greatest challenges for conservators. Even without treatment, aluminum can be exceptionally durable in exterior environments. It does have several significant vulnerabilities, however. Aluminum is quite sensitive to deterioration by alkaline materials, such as mortars and concrete, and must be protected from contact with alkalis with a coating of paint. It is also susceptible to deterioration by chlorides, as well as by hydrochloric and tannic acids, including those leached from wood. Aluminum is quite low on the galvanic scale and is especially vulnerable to galvanic deterioration, especially when in contact with copper but also with iron and steel. This vulnerability extends to runoff from copper flashings

Fig. 5. 20 Exchange Place, New York City, detail of nickel-silver doors, which have not been maintained. Nickel silver in exterior installations will patinate to a dull brown if not maintained with polish and a lacquer finish.

Fig. 6. 20 Exchange Place, detail of polished nickel-silver doors. Maintenance of exterior nickel-silver installations may be demanding. It is not unusual to see highly exposed installations (such as gates and grilles) or recessed ornament (such as the background behind the locomotive in this photograph) coated with a silvery paint.

and contact with copper-bearing materials, such as pressure-treated wood.

While the need to identify the alloy for conservation purposes is not as obvious an issue for aluminum as it is for the nickel-bearing metals, the presence of different alloying materials for aluminum can have important conservation implications.

Historic casting alloys were primarily mixes of aluminum, silicon, copper, and magnesium, but some contained small amounts of iron, nickel, zinc, and manganese. The alloys varied in fluidity and ability to anodize, and these factors governed their selection. Aluminum alloys also exhibit significant differences in general durability. Alloys containing metals strongly cathodic to aluminum, such as copper, perform poorly in marine environments.

As problematic as these vulnerabilities are, the most difficult of aluminum's challenges for the conservator is the identification and replication of chemical and electrolytic oxide surface treatments. Dozens of treatment options were listed in the 1938 "Finishes for Aluminum" booklet, and many of these were described in detail there to encourage implementation by local fabricators. Most of the listed treatments had protective as well as aesthetic functions; they improved resistance to corrosion, as well as abrasion. They are difficult to identify with certainty and, because they are shop-applied tank treatments, impossible to replicate in situ.

Perhaps because of the exceptional durability of the "white metals," methods for their refinishing and maintenance are not yet as standardized as treatments for iron, steel, zinc, and copper alloys. As these buildings age and more work is undertaken, new models will emerge for methods of treatment and identification of finishes.

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