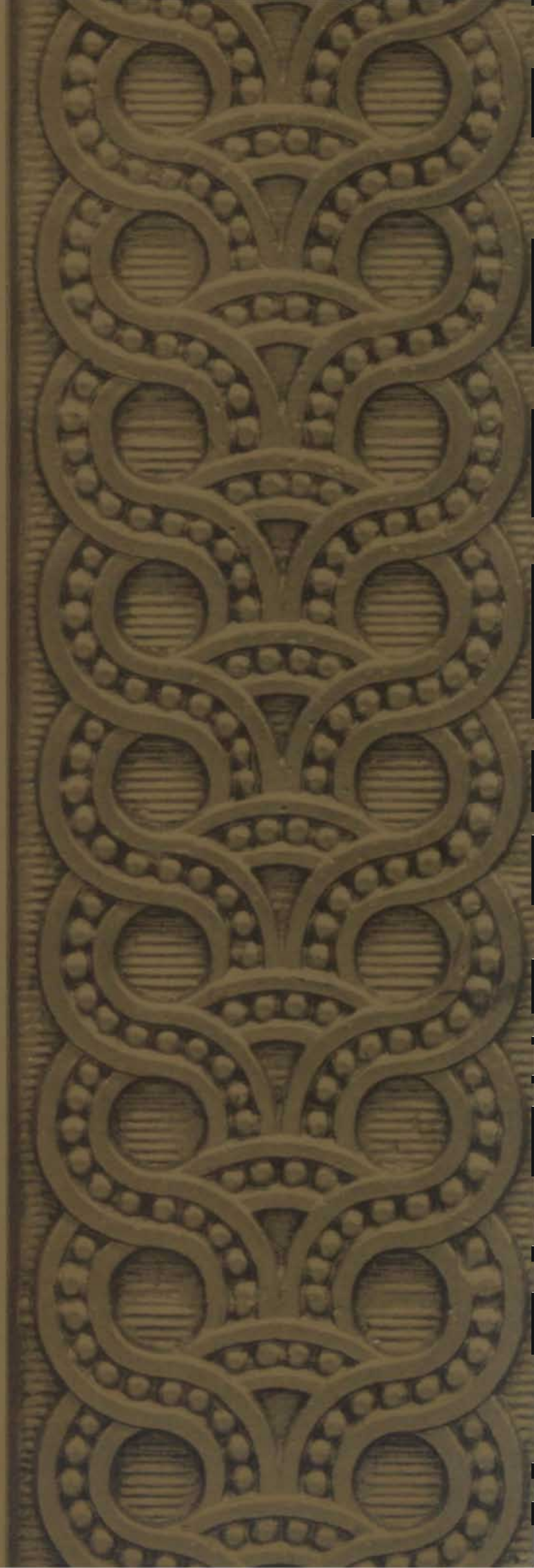
METALS

in America's Historic Buildings



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U.S. Department of the Interior
National Park Service
Cultural Resources

Preservation Assistance

Metals in America's Historic Buildings

Uses and Preservation Treatments

Part I. A Historical Survey of Metals

by Margot Gayle and David W. Look, AIA

Part II. Deterioration and Methods of Preserving Metals

by John G. Waite, AIA

U.S. Department of the Interior
National Park Service
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(1992 Revision)

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Contents

Foreword

Metals in America's Historic Building was initially developed in 1980 under the direction of Lee H. Nelson, FAIA, to promote an awareness of metals in the buildings and monuments of the United States, and to make recommendations for the preservation and repair of such metals. It is intended for use by owners, architects, and building managers who are responsible for the preservation and maintenance of America's architectural heritage. When metal building components need rehabilitation or maintenance, information on proper preservation techniques for each metal and its alloys has not been readily available. What has been needed is a general reference on metals used in architecture: where they are used, how to identify them, and when to replace them. This is intended to be such a sourcebook on historic architectural metals.

Part I of this report is by Margot Gayle, President of the Friends of Cast-Iron Architecture, New York City, and by David W. Look, AIA, National Park Service historical architect. Reprinted in 1992, it presents short, illustrated surveys of the architectural metals most often used in American buildings and other architectural features such as sculpture, foundations, and "street furniture." The photographs document common uses of metals such as copper roofing, zinc statuary, cast-iron storefronts, and so forth.

Part II has been updated in 1992 by its original author, John G. Waite, partner, Mesick-Cohen-Waite, Architects, Albany, New York. It examines the questions of how architectural metals deteriorate and concentrates on the techniques available to architects and conservators in preserving and maintaining the metal components. The various metallic elements and their alloys illustrated in Part I are treated individually in Part II according to their deterioration patterns and appropriate preservation treatments.

Taken together, the two parts argue for a heightened awareness of the metals in our buildings and call for more investigation of proper installation, maintenance, and conservation practices. Comments and suggestions regarding this publication are encouraged and should be sent to Preservation Assistance Division, National Park Service, U.S. Department of the Interior, P.O. Box 37127, Washington, DC 20013-7127

E. Blaine Cliver
Chief, Preservation Assistance Division

Part I. A Historical Survey of Metals

by Margot Gayle and David W. Look, AIA

Opposite: The stainless steel overdoor panel above the entrance of the Associated Press Building in Rockefeller Center, New York City, was designed by Isamu Noguchi (1904-1988). Installed in 1940, the 22 by 17 foot panel was the first piece of heroic sculpture ever cast in stainless steel. (Rockefeller Center, ©The Rockefeller Group, Inc.)

Chapter 1: Introduction

The metals in America's historic buildings, public monuments, and "street furniture" dotting the landscape comprise at least 15 distinctive metallic materials. They serve a wide range of uses, from nails to elaborate staircases, from streetlights and fire hydrants to fountains, from doorknobs to structural beams and trusses, and from domes to the statues on their pinnacles.

It is easy to take for granted the metals that make up the ordinary objects and structures of the everyday environment. The metals discovered by early civilizations—the bronze and iron of prehistory—are still in use. Trial and error brought refinements to the processing of older metals and produced new ones which machine power later made available in large quantities. Fabricators and designers put metals into a large array of domestic implements and building elements even before they knew the physical and chemical properties of the metals or the prospects of compatibility between one metal and another. The application of science to technology has brought a greater understanding of the optimum performance and limits of the numerous, indispensible metals in our surroundings. Metal elements add richness to the appearance of buildings and landscapes, often combining aesthetic appeal and utility. But it is the permanence and stability of metals, when properly cared for, which has led to their role as major building components of modern times.

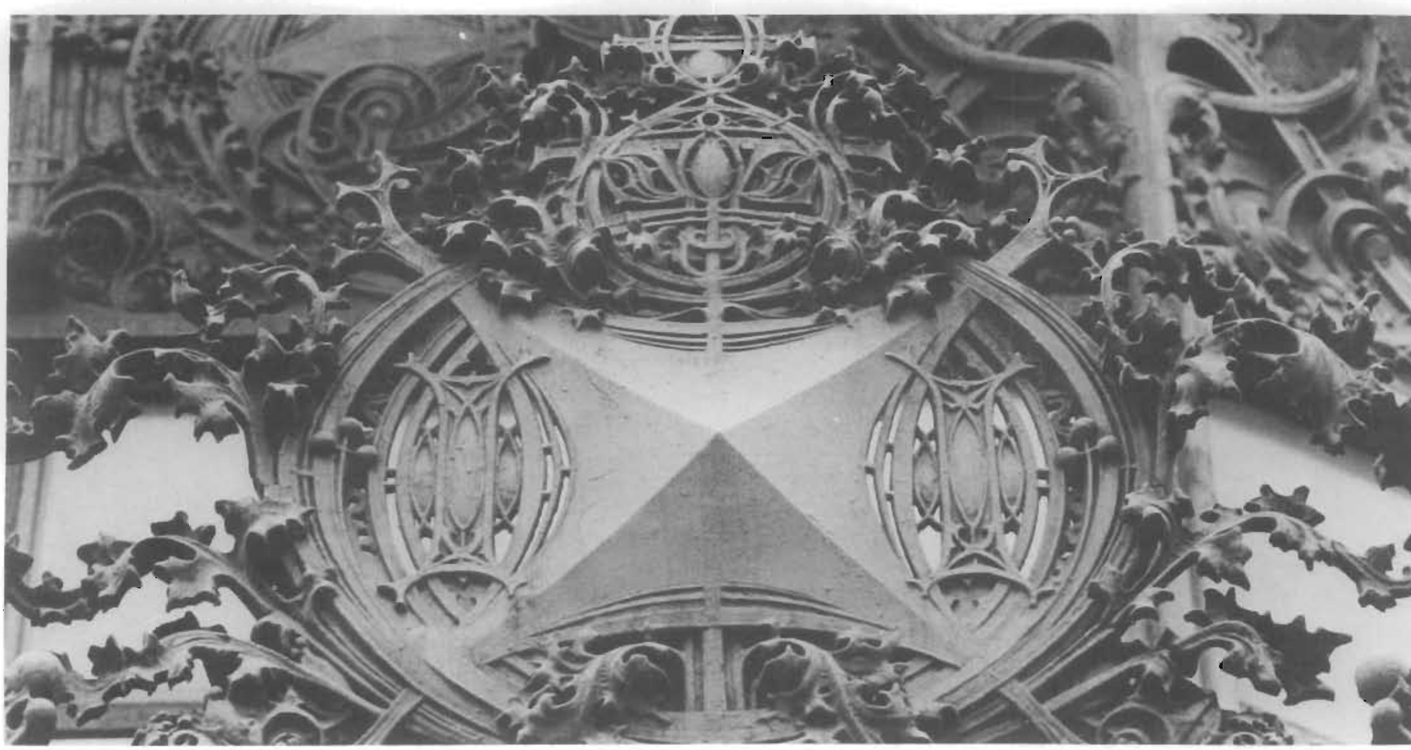


Figure 1. **Cast-iron Ornamentation, Carson Pirie Scott and Company Store, Madison and State streets, Chicago, Illinois, 1899-1906; Louis H. Sullivan, architect; Winslow Brothers, foundry.** *The two lower floors of this building are embellished by Sullivan's extraordinarily complex designs executed in cast iron which enframe the windows and curved corner entrance. Cast iron was used in every conceivable form in the 19th century; it was the utilitarian metal. Cast-iron columns, storefronts, whole building facades, and stairs appeared, as did cast-iron doors, windows, clocks, fountains, and furniture. What could not be made of cast iron was made of wrought iron or steel. Beams were made of wrought iron or steel, and metal ceilings and roofs were made of sheet iron or steel. Often ironworkers combined cast iron and wrought iron in a design, using each metal for the elements for which it was best suited. (Becket Logan)*

The first part of this report is a survey of the metals in architecture, with historical notes on their development into modern forms and usages. The discussion concentrates on metals in American buildings, streetscapes, parks, and monuments. The metals most frequently found in our built environment include lead, tin, zinc, copper and its alloys, nickel and its alloys, iron and its alloys, and aluminum. Dominance of the ferrous metals, especially cast iron, will be discussed in relation to technological breakthroughs that made iron and later, steel, available in such variety and at so moderate a cost that their use affected almost every aspect of American life.

A high degree of craftsmanship went into fabrication of the metals in older American buildings. Often it was local artisans who designed and built fine staircases, exterior light standards, railings, or metal sculptures. Such craftsmanship, which is for the most part irreplaceable, deserves recognition and preservation. The decorative, and, lately, the structural metal components of American buildings should be appreciated as part of the nation's artistic heritage.

It is clear that metal components of all types are fundamental to the appearance and integrity of our historic buildings; metal elements greatly influence their character, their basic form, and their interior spaces. Only with more of an appreciation of the variety of architectural metals in domestic and public structures can steps be taken to identify and preserve them.

Figure 2. Bronze Entrance Door, Bowery Savings Bank, 110 East 42nd Street, New York City, 1923; York and Sawyer, architects; William H. Jackson, foundry. *Cast in the boom era after World War I, this main entrance door reflects the aura of success and stability bank officials sought. The color of polished bronze probably accounts for its use as much as its permanence and molding qualities. This is a good example of a building in which art, architecture, and sculpture were combined in an overall concept down to the smallest detail. (Courtesy of the Bowery Savings Bank)*

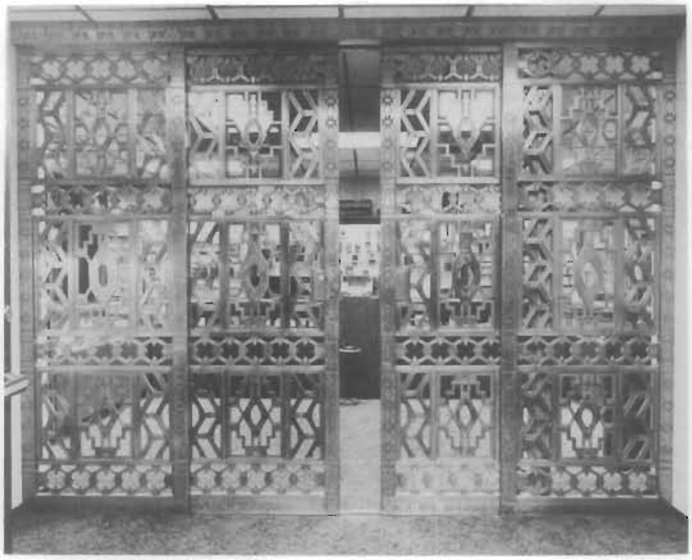


Figure 3. Monel Metal Gates, National Bank of Commerce (Guardian Building), 500 Griswald Street, Detroit, Michigan, 1929; Smith, Hinchman, and Grylls, architects; Gorham Co., foundry. *These geometric Art Deco style gates are fabricated from a nickel-copper alloy developed in the 20th century. Monel metal combined hardness and durability and was used for roofs and plumbing as well as decorative details in the 1920s and 1930s. It was one of the so called "white metals" popular during that period. The scarity of nickel during World War II accounts for its decline. In the 1950s, stainless steel, which is less expensive, supplanted Monel metal. (Alan Stross)*

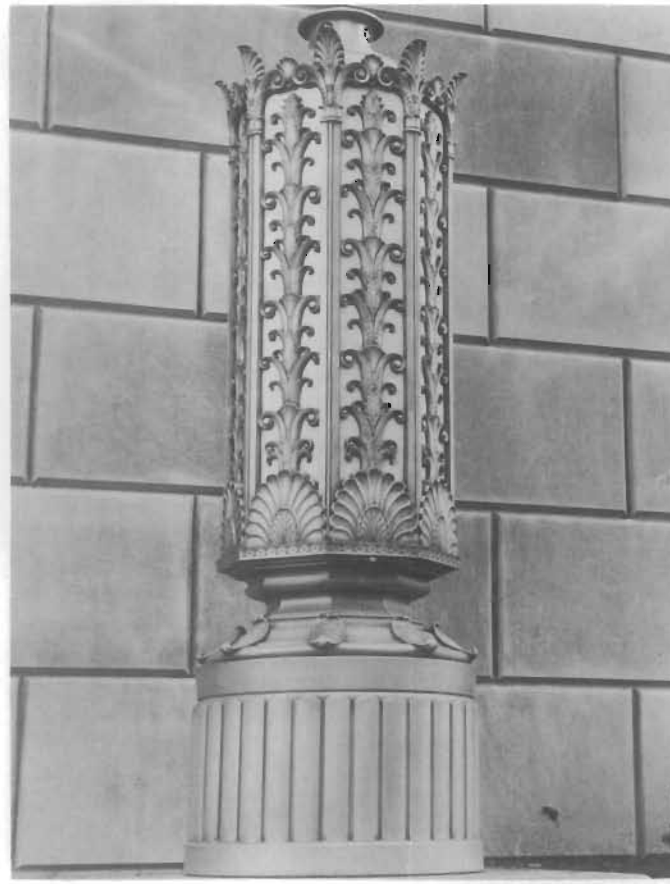


Figure 4. Aluminum Lamp, U.S. Custom House, Chestnut, Second, and Third streets, Philadelphia, Pennsylvania, 1933; Ritter and Shay, architects; Edward Ardolino, sculptor. *Aluminum was first refined from bauxite in the 19th century and was considered a rare metal. Its light weight and corrosion resistance were recognized as qualities appropriate for a variety of uses, but many years passed before sufficient quantities were produced at a reasonable cost. By the 1930s aluminum was in wide use for exterior, weather-resistant architectural elements as well as interior decorative details. (Esther Mipaas)*

Chapter 2: Lead

Lead ores, often found with veins of silver and zinc, are widely distributed around the world. The discovery and early use of lead predates recorded history. Reduction of a high-grade, concentrated lead ore to a pure metal is relatively easy because of lead's low melting point; the process could have been discovered by any civilization that had learned to use fire and was near an outcropping of lead ore.

At the time of the European discovery of America, native Americans mined and used lead to make utensils and to ornament ceremonial objects. French explorers had identified lead mines in the upper Mississippi region by the late 17th century. Colonial Americans sought lead for making shot and pewter, an alloy of lead and tin; however, American manufacture of lead was limited by the British. More lead was imported than mined or processed in the United States until the mid-19th century.

Until the end of the 18th century, lead pipes were made by bending sheets into tubes joined by leadburning, a form of welding. In a January 1800 advertisement in *New-York Daily Advertiser*, George Youle announced that he "manufactures lead pipes to convey the water from the logs in the street into the house." By logs, he meant the buried, hollow log mains the Manhattan Water Company had laid to distribute water from their reservoir. Seamless pipes were later made by extruding molten lead. (To *extrude* is to form heated metal into a desired cross-sectional shape by forcing it through a shaped opening, or die.)

The use of lead pipes was common in the United States until the harmful effects of lead poisoning became widely known. It was not until the late 19th century that the medical profession alerted the population to the danger through published articles. Legislation against the use of lead, and precautions in the handling and manufacturing of lead, were slow to materialize. Lead is still used in plumbing today, but not for water pipes; molten lead is used to caulk cast-iron pipe joints. Since lead is soft and malleable, the lead caulking is capable of withstanding movements from vibrations, settlement, and temperature changes.

Roofing and Related Items

The primary use of lead in historic buildings was for roofing. Since the 16th century, lead has been used in England for roofing, flashing, gutters, downspouts, and conductor heads—the latter often with decorative details such as shields, initials, and dates. Until the late 17th century, lead was hand cast on sand beds, which gave the plates a stippled surface. Molds could be pressed into the wet sand to produce decorative details in the castings. Later, cast sheets of lead were rolled in mills to produce smooth, thinner sheets which reduced the weight of lead roofs, making some of them lighter than tile or slate roofs.

Historically, lead was a logical choice for roofs with low pitches or for flat areas, and for built-in gutters behind parapets, because it could provide a watertight surface when the edges of the sheets were fused by lead-burning. Steeper slopes were often unwisely reroofed with lead. Lead was better suited for low roofs, as steep roofs provided little support for the heavy metal sheets. The use of lead for roofing important buildings and for other building components spread to the English colonies in America, since England was the prime producer of lead in the world.

The plantation house "Rosewell," near Whitemarsh, Virginia, is believed to have had the first roof in the American colonies entirely covered with imported English lead. The house was built by Mann Page I and his son between 1726 and 1744. An insurance record dated 1802 documents existence of the lead roof, which was removed in 1838 when the house was extensively remodeled and a new tinplate roof installed.

By the time of the American Revolution, large quantities of imported lead were used for flashings, gutters, conductor heads, and downspouts on public buildings and the homes of wealthy people. During the Revolution, many of these leaden architectural elements were removed and melted to make shot for the war effort. In Philadelphia, preserved inventories of these donations give documentary evidence to the extent of the use of lead, especially for rain conductor heads and downspouts (figure 5).

In the early years of the New Republic, a few of the Federal buildings in Washington, D.C., had lead roofs, which were reported to have leaked frequently. Architect Benjamin H. Latrobe recognized that the temperature fluctuations of the mid-Atlantic states caused lead sheets to tear; this damage from constant expansion and contraction is called *fatigue*. Lead on steeper roofs is also subject to the slow flow by gravity, called *creep*. (see part II, chapter 10.) Soft lead roofs were more suited to the milder climate of England and France where lead roofs have survived for 200–300 years. But lead roof

Figure 5. Lead Rain Conductor Head, Library Hall, Philadelphia, Pennsylvania, 1789–1790; from designs of Dr. William Thornton. *When the library was razed in 1884, this conductor head was saved and became part of the collection of the Library Company of Philadelphia. Many early rain conductor heads were constructed of lead, and frequently included date flanges, as seen here. However, this is the only known example of a lead conductor head with an "open book" motif. (Jack E. Boucher)*

Figure 6. Lead Roofing, Saint Thomas Church, Fifth Avenue and 53rd Street, New York City, 1909–1914; Cram, Goodhue, and Ferguson, architects; Henry Hope and Sons, lead craftsman. *Ralph Adams Cram designed St. Thomas Church using the spirit and many of the techniques of medieval builders, including the use of small overlapping sheets of lead for roofing curved surfaces. The decorative grapevine frieze and panel borders, also of lead, show the versatility of this material, which can be cast with sharp detail. (Becket Logan)*

construction still exists. The National Cathedral in Washington, D.C., which is still under construction, has a hardened lead roof made from an alloy of 90% lead, 10% antimony, and a trace of tin.

American architects sometimes specified lead finials, crockets, cresting, spires, or turrets for 19th- or early-20th-century Romanesque or Gothic Revival churches, municipal buildings, or university buildings. A fine example is the small, rounded turret with its ball finial on the 53rd Street side of St. Thomas Church in New York City (figure 6).

Lead-Coated Metals

Another durable roofing material used during the 19th century in America and sometimes specified by modern architects for restoration projects, is *terne* or *terneplate*—sheet iron or sheet steel coated with a lead-tin alloy. Terneplate roofing was first produced by Joseph Truman in New York City in 1825. As reported in the August 1889 issue of *Carpentry and Building*, the first terneplate roof was still in good condition after 64 years of weathering. Unfortunately, the article did not name the building or give its address.

Lead alone does not alloy with iron, as do tin and iron to make tinplate. Early terneplate was tinplate hot dipped in lead. Later it was learned that lead alloys containing 7% to 25% tin would wet the surface of the sheet metal sufficiently to allow the terne to alloy with the iron or steel. The best terneplate has a 15% to 20% tin content, with the remainder lead.

Terneplate is often confused with tinplate because they look alike, especially when painted, and because early terne was actually tinplate dipped in molten lead. Most 19th-century catalogues referred to tinplate as "bright tin" and to terneplate as "leaded tin." However, builders commonly referred to all roofing plates as tinplates regardless of their composition. Like tinplate, terneplate roofs were installed with soldered flat seams on low-pitched roofs (figure 130) and standing steams for steeper roofs (see chapter 3). Metal shingles were made of terneplate (figure 7) as well as tinplate, and from galvanized iron and steel. Terneplate was also used for flashing and gutters.

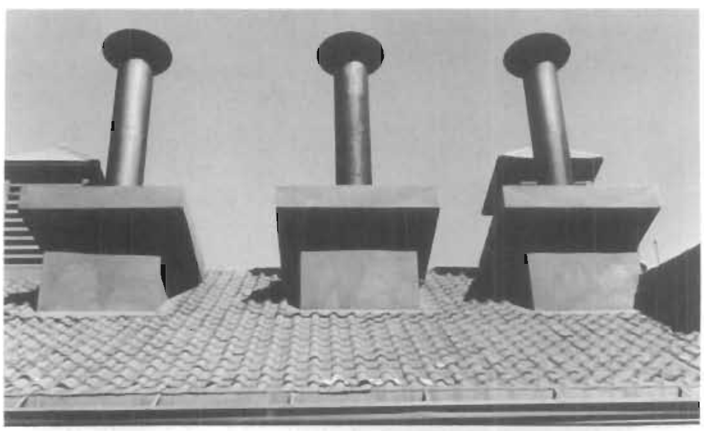


Figure 7. Terneplate Pantiles, Union Depot, foot of NW Sixth Avenue, Portland, Oregon, 1892–1894; Van Brunt and Howe, architects. *The pantiles are identical to the 1895 "Spanish Tile" advertised by Merchant and Company of Philadelphia and painted a terra-cotta color to imitate a real clay tile roof. (John G. Waite)*

Today terne-coated stainless steel is available. It was used to reroof the Jefferson Market Courthouse in Greenwich Village, New York City, when the building was adapted for use as a public library in the 1960s.

In the 1930s, Revere Copper and Brass Company introduced lead-coated copper. Reroofing of the main section of the Philip Schuyler Mansion in Albany, New York, in 1935 was an early application of it. Lead-coated copper combines the appearance and durability of lead with the workability and long-term economy of copper. The sheet copper is dipped twice—once in a lead-tin alloy and once in pure lead—then it is rolled. Since the copper is not exposed to the weather, it does not corrode or cause stains on other building materials. Lead-coated copper flashings and valleys are often used with slate roofs to provide extra protection against the erosive effect of broken-off slate particles. These flashings are also used on shingle roofs where painting the flashings is impossible because the metal is mostly covered by shingles.

Window Cames

Cames, or lead rods with an H-shaped cross-section, have been used to hold small pieces of glass together for window panes since the 12th century. Since lead is soft and easily worked, it could be bent around irregularly shaped pieces of glass for domestic or church windows. The edges of the glass pieces could be fitted into the top and bottom slots of the H-shaped cames, which could then be soldered where two or more intersected. Some early buildings in colonial America had casement windows; many fragments of both diamond-shaped glass and of lead cames have been found in Virginia and New England. When sash windows were first introduced to America in the 18th century, lead served as weights to counterbalance the sash. Forty pounds was the average weight required for large single-hung windows. The weights for single- and double-hung windows were made of cast iron when it became more available.

The skillful application of lead and glass in doorway fanlights and sidelights appeared in some late Georgian and many Federal houses. Later, during the Victorian era, stained-glass windows, doors, and decorative skylights became fashionable for public buildings and residences as well as for churches. The stained-glass skylight in the Capital Hotel in Little Rock, Arkansas, is a good example of this (figure 8).

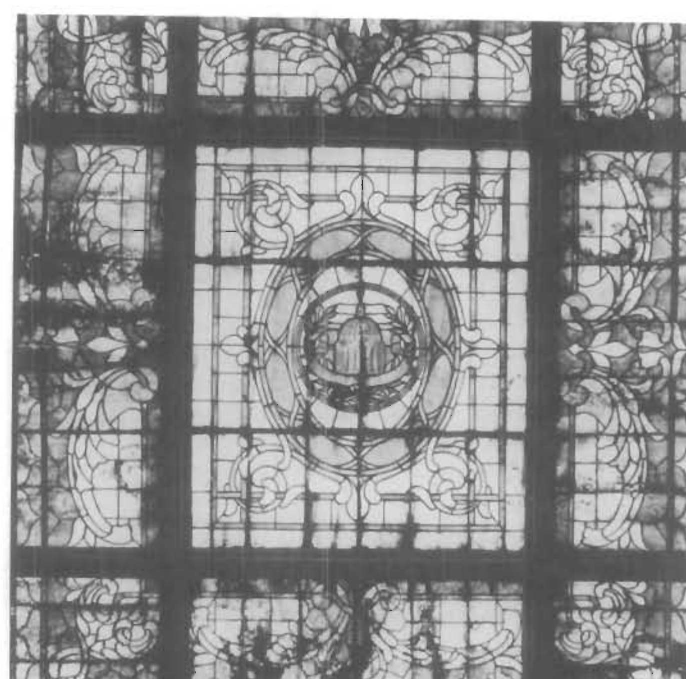


Figure 8. Leaded Glass Skylight, Capital Hotel, 117 West Markham Street, Little Rock, Arkansas, 1873. *Lead has long been used to join pieces of glass into windows utilizing lead "cames", which are H-shaped sections grooved to fit glass into the top and bottom channels with soldered joints. (Earl Saunder)*

Half-timber revival-style buildings of the 1920s and 1930s frequently had steel casement windows with diamond-shaped panes of glass set in lead; sometimes the decorative spandrels above and/or below the windows were made of cast, beaten, or stamped thin sheets of lead. Louis Comfort Tiffany used lead in producing ornamental windows, skylights, and lamps.

Sculpture

Both the Egyptians and Greeks used lead for small pieces of sculpture; however, it was not until the end of the 17th century that lead garden urns, statues, borders, planters, and basins became popular for formal gardens in Europe. Lead statuary was favored for garden ornamentation, especially for fountains, since it does not rust or corrode where water flows over the figures and does not need painting. Some lead fountains were gilded with gold. "Rosewell" is reported to have had a lead aquarium, and the garden at the Governor's Palace in Williamsburg, Virginia, may have had a few small lead urns. Joseph Wilton erected a large lead equestrian statue of King George III of England in New York City in 1770. Patriots destroyed the statue during the American Revolution, melting down most of the fragments for shot.

Unfortunately, lead is so soft that statuary, fonts, and fountains cannot be very large, because without support the cantilevered parts may sag and become distorted. Lead sculptures and landscape accessories were popular in the 19th and early 20th centuries (figure 9), and are still produced in traditional and contemporary designs.

Paint

Both the Greeks and Romans were acquainted with lead pigments, which were generally classed as either red lead (*minium*) or white lead (*ceruse*). For two centuries, the dominant use of lead in American buildings was in lead-based paints. Red lead was used extensively as an anti-corrosive pigment for iron, while white lead was more important commercially because of its widespread use in paints for wooden houses. White lead was not used in paint for iron, however, because it had been observed that white lead increased corrosion, especially on wrought iron.

Lead-based paint was one of the most durable materials developed as a protective exterior coating. Until very recently it was also used to paint interiors. A wide variety of colors was achieved by mixing lead oxides, linseed oil, and pigments. But the use of lead-based paints has largely been discontinued due to federal restrictions based on the high incidence of lead poisoning when children chewed woodwork or toys covered with lead-based paints.

Concern over lead poisoning from paints and the high cost of lead roofing has reduced the common use of lead for certain architectural elements; however, lead is still used in modern construction. Some contemporary uses of lead in buildings include lead extruded in a continuous length as sheathing for cables, the use of sheet lead in partitions for noise reduction, as pads for vibrating machinery, and as shielding for X-ray and nuclear radiation.

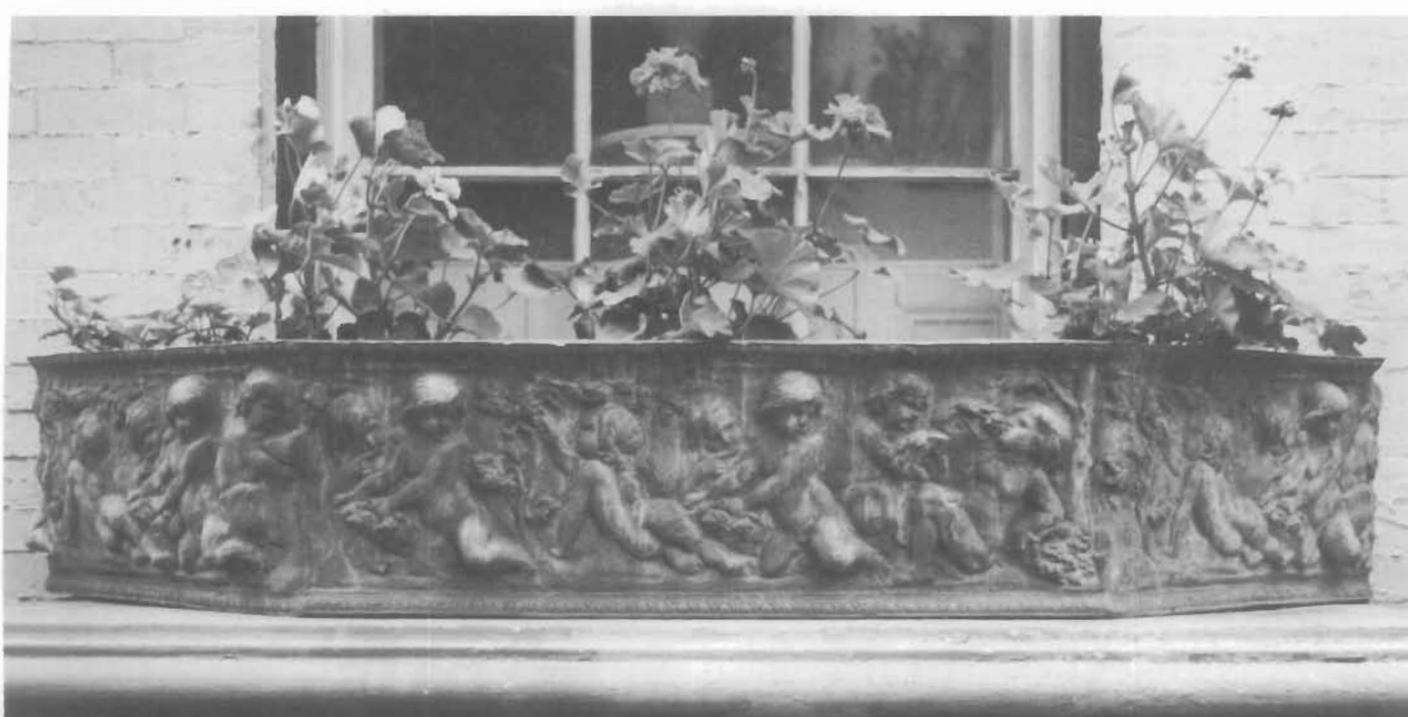


Figure 9. Lead Flowerbox, Adrian van Sinderen House, 70 Willow Street, Brooklyn, New York, ca. 1839. *This is one of three large lead flowerboxes, supported by huge cast-iron brackets, which were added later in the 19th century to the facade of this Greek Revival house. The brackets were painted with sanded paint to look like brownstone. (David W. Look)*

Chapter 3: Tin

Tin is a silvery-white metal that has been known since prehistoric times. Because it is a soft metal, it is rarely used by itself. Thus the principal architectural uses of tin fall into two categories: the alloying of tin with other metals such as copper to form bronze, and the coating of tin on harder metals, such as tinplated iron or steel.

Bronzes usually contain about 90% copper and 10% tin; however, the content may vary widely, and some bronzes have a high tin content. Historically, bell metal of the finest tonal quality has been a bronze which was one-fourth tin. Before glass mirrors were invented, primitive mirrors were made of "speculum" or "white bronze," an alloy of more than one-third tin and the remainder copper. (For further information on bronze, see chapter 5.)

Pure Tin

The architectural use of pure tin was and is rare; it is usually limited to very small objects or very specialized uses. The shiny, nontarnishing nature of tin made it suitable for lighting devices such as perforated lanterns, candle shields, wall sconces, and mirror frames.

Tinplate

Sheets of iron were first coated with tin in Bohemia in the 14th or 15th century. Tin-plated iron sheets may have originally been used for armor, but later usage centered on roofing. Until the 20th century, tin-plating was achieved by hand dipping sheets of iron in molten tin. The size of the finished sheets was limited by the dimensions of the vats holding the molten tin and the amount of material workers could hand dip easily. It was a cumbersome process, not substantially improved until electroplating—the depositing of tin upon a base metal with an electric current—came into use in the 20th century.

Small deposits of tin have been mined along the border between North and South Carolina, in the Dakotas, in California, and in Alaska; however, there are no commercially important deposits of tin in the United States today. Attempts to establish a tinplate industry in the mid-1870s in Ohio and Pennsylvania, soon met with economic failure when the price of tinplate dropped in 1875. The tinplate industry was finally established in America as a result of the McKinley Bill of 1890, which put a tariff on imported tinplate. By 1896 America produced 98% of its own tinplate using, of course, imported tin. Although tin is an expensive metal, so little of it is used in the process that tinplate has been competitive with other roofing materials, about a third the cost of sheet copper.

Tinplate Roofing and Related Items

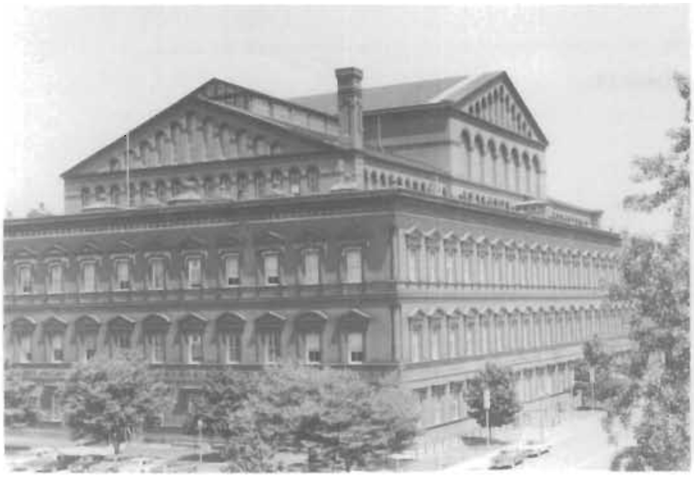
The prime use of tin in America has been as a coating on iron, and later sheet steel, for roofing. French Canada used tinplate roofing in the late 17th and 18th centuries, long before its southern neighbor.

Probably from his travels in Europe, Thomas Jefferson observed that tinplate roofs were lightweight and durable, some having lasted over 100 hundred years. About 1800, he chose tin for roofing his home "Monticello" near Charlottesville, Virginia. The Arch Street Meetinghouse in Philadelphia had tinplate shingles installed in a herringbone pattern on a "piazza" roof in 1804 and the Exchange Coffee House, built in Boston about 1808, had a tinplate roof. Tinplate roofs soon became popular for houses, especially in the cities, and gradually replaced wooden shingle roofs, which were considered fire hazards. Roofs of tinned sheet iron were often used on significant public buildings.

"Tin roofs," as they were commonly called, were noncombustible, lightweight, and durable. When kept well painted, tinplate roofs often lasted 50–100 years or longer. They were usually painted with "tinner's red," which had a red or reddish-brown color, although a few were painted light green, probably to simulate the appearance of more expensive copper roofs.

For the first third of the 19th century, tinned iron roofs were constructed from plates measuring a standard 10 inches by approximately 14 inches. In the 1830s, plates 20 inches by 14 inches became available. Most early tinplate roofs had flat seams and were soldered together to produce a continuous waterproof covering. These were used on both low-pitched roofs and steeper roofs. (figure 10a and b). Standing seam tinplate roofs did not come into common use until the Civil War era. Tinplates were soldered together with flat seams to form long strips, which were joined to other strips by standing seams. The pattern of the dominant standing seams gave the typical vertical pattern to these roofs. Standing seam roofs were not used on flat or on very low-pitched roofs where water might collect, since standing seam roofs are not watertight (figure 10c).

By the 1870s, technological improvements in production made possible plates 20 inches by 28 inches. Each time the size of the plates was increased, the number of



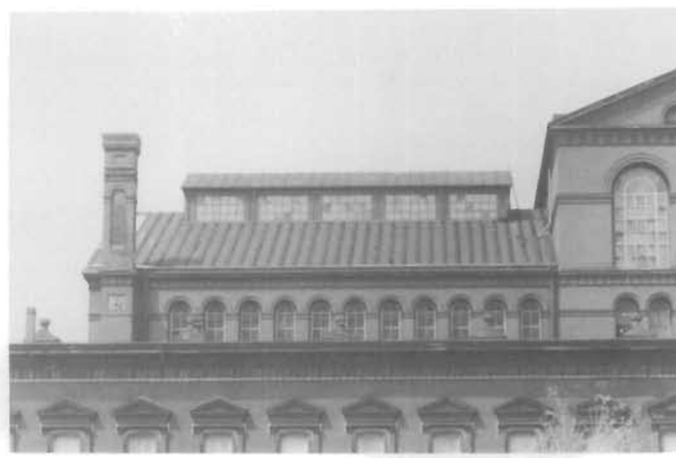


Figure 10. "Tinplate" Roofing, Old Pension Building, Fifth and G Streets, NW, Washington, DC, 1883; Montgomery C. Meigs, engineer. *(a) The building consists of offices around the perimeter of a large court. The roof over the offices has a very low pitch and is covered with flat-seam tinplate, while the steep-pitched roofs over the court have batten tinplate roofs. (b) Flat seam tinplate roofing was used on low-pitched roofs because the edges of the plates could be interlocked and soldered together to provide a continuous waterproof covering. Stamped on each plate of the Pension Building roof is "Holkinshee Forge Best Roofing, 40 lbs., Manion Process License." The metal is actually terneplate. Surviving examples of true tinplate iron or steel are rare.. (c) The batten tinplate roofs over the central court were typical of steep-pitched roofing of tin and other materials. They can be seen at a distance and provide a strong design element to the building. (David W. Look)*

seams was reduced, thus decreasing labor costs and the number of potential leaks. Eventually, rolls of tin-plated iron 28 inches wide and 96 inches long were manufactured. The first commercial electrolytic tinplate roofing line went into production at United States Steel Corporation in 1937. The electroplated rolls had a thinner layer of tin than hand-dipped tinplate. Today, continuous rolls of tinplate roofing are available. Continuous tin roofing has a slightly different appearance than roofs made of numerous tin plates or strips, and extremely long sheets may become wavy because of inadequate allowance for expansion and contraction.

In addition to plates and rolled strips, machine-pressed tinplate shingles became popular in the second half of the 19th century. Shingles pressed to form raised designs such as "Spanish Tile," "Merchant's Gothic shingles," "Diamond Tile," and "Gothic Tile" were used for Mansard and other roofs with sufficient pitch. Plates and rolled strips with flat and standing seams could be used on low-pitched roofs, but shingles depended on overlap and pitch to shed water (figure 11). Shingles were also used on vertical surfaces such as bulkheads on roofs, and as a covering for exterior walls. Tinplate was also used for flashings, valleys, ridges, hips, gutters, downspouts and dormers, as well as for fire-resistant coverings for wooden doors and shutters. Formed metal siding was stamped to imitate pressed brick, rock-faced stone, and even ashlar quoins.

Decorative Uses

Ornamental window and door lintels, balusters, cresting, finials, and urns were also tinned. What is commonly known as the "tin ceiling" is a misnomer as these decorative sheets were never tinned; they were almost always painted sheet iron or steel (see section on sheet iron and steel).

Builders have long attempted to find corrosion-resistant metals and to make commonly available metals such as iron and steel more corrosion resistant. Tinplate, in a way, created a market for metal building components. Later, the market was partially taken over by terneplate, pure zinc architectural elements, and galvanized sheet iron and steel.

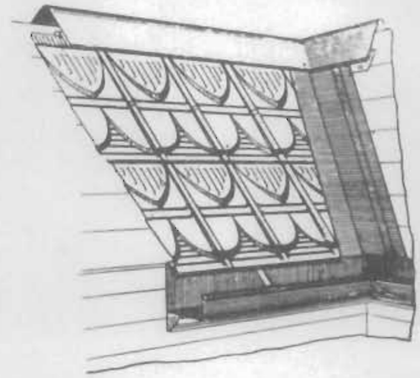
Although tinplate is still available today for roofing and flashing, it is generally considered expensive since the initial cost is more than that for common modern roofing types such as asphalt shingles or built-up roofs. However, since a well-maintained tinplate roof (maintenance consisting of inspection and periodic painting) will last several times longer than either of these types of roofing, it is more economical when the cost is prorated over the longer lifespan.

SAINT PAUL ROOFING, CORNICE AND ORNAMENT COMPANY

"ST. PAUL" METAL SHINGLES.
Made of Painted or Galvanized Steel, Tin or Copper.

A special feature of the "St. Paul" Metal Shingles is the **embossing,** which is very high, sharp and distinct, and gives a very ornamental finish to any structure.

All nails are covered. Made with a lock joint that gives perfect security in rain or wind.

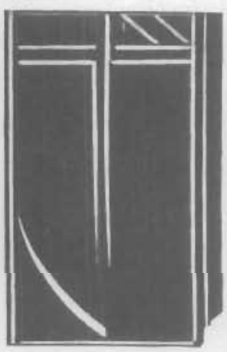


They are much superior to wood, slate or tin for steep roofs, being fire-proof, unbreakable and do not become loose by expansion. Can be used on roofs having 4 inches or more pitch per foot.

See instructions for laying on following page.

Showing Ridge, Valley and Gutter Finish with St. Paul Shingles.

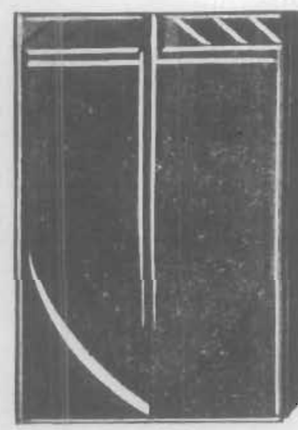
Smaller sized shingles are best adapted to small roof surfaces and spires, and hip roofs where considerable cutting is required at hips, valleys, dormers, etc., as they can be cut to less waste than larger shingles. The larger sizes are best adapted to larger, unbroken surfaces where little cutting is required, as they are more quickly laid and have a smaller proportion of joints per square. We can furnish with these all ridge rolls, crestings, hips, caps or shingles, eaves, course plates, etc., to give the roof a neat and complete appearance.



No 1.

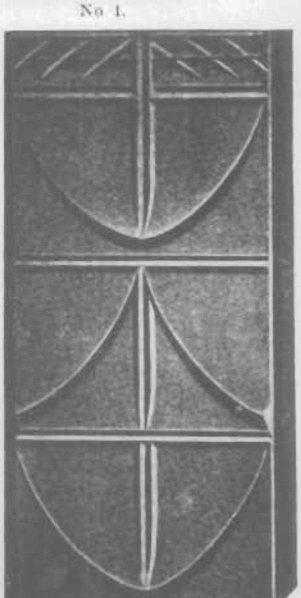
No. 1—Covering size 8x12 inches; 150 to a square (100 sq. ft.).

No. 2—Covering size 11x15 inches; 89 to a square (100 sq. ft.).



No. 2.

No. 4.

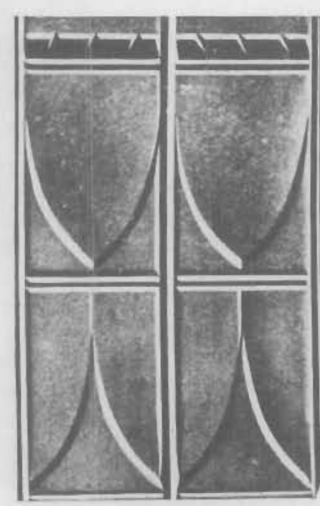


No. 3.

No. 3—Covering size 11x23 inches; 55 pieces to the square (100 sq. ft.).

No. 4—Covering size 11½x16½ inches; 75 pieces to the square (100 sq. ft.).

No. 5—Covering size 12x18 inches; 67 pieces to the square (100 sq. ft.).



No. 5.

Figure 11. Tinplated Steel Shingles. *"St. Paul" metal shingles ranged in size from 8 by 12 inches to 12 by 18 inches and were available in painted steel, galvanized steel, tin (plated steel), and sheet copper from the St. Paul, Minnesota, roofing company's 1905 catalog. Individual shingles were connected with interlocking joints to prevent uplift by the wind, a distinct advantage over strips of roofing made to resemble shingles (see figure 122). St. Paul was one of many companies producing metal shingles and roofing in the late 19th and early 20th centuries. (Library of Congress)*

Chapter 4: Zinc

Zinc is a bluish-white metal sometimes called "spelter." In refining copper-bearing ores, the Romans noticed that a white powder condensed on the flues of the furnaces. Now known as "zinc fume" or "zinc dust," this powder, a compound of zinc, was called *cadmira* by the Romans. They used it, probably accidently at first, to produce the first brass.

Pure metallic zinc was first produced in commercial quantities in 1738 by William Champion in Warmley, England. Although pure zinc is brittle at normal temperatures, it can be rolled when heated to temperatures between 212° and 300°F. because the hot rolling breaks down the crystalline structure. Sheet zinc was first hot rolled by Hobson and Sylvester of Sheffield, England, who patented the process in 1805. However, zinc production never became a big industry in England, nor was it used extensively there in construction, except for workers cottages.

Large deposits of calamine, a zinc ore, were discovered in Flanders in the 18th century; however, these deposits were not utilized until after the end of the century when that area came under French control. In 1807, a zinc-works was established by Abbe Daniel Dony at Liege (now in Belgium) and the first sheet zinc was rolled there in 1811. This was the beginning of the zinc industry, which experimented with sheet zinc as a roofing material. Soon there was a plentiful supply of high-quality zinc and new uses were sought. Although zinc deposits were abundant in the United States, no effort was made to develop the industry here until after 1838.

Pure Zinc Roofing and Related Items

The successful use of zinc roofing in Belgium led to its application in France and Germany, where it replaced more expensive copper and lead in roofing. Although the use of zinc roofing was popular on the continent, it never became popular in England. In the 1820s, Belgian sheet zinc was imported in America; and by the 1830s, builders in New York City and elsewhere had installed sheet zinc roofs. The St. Charles Hotel in New Orleans had a sheet zinc roof by 1837, and the dome and roof of St. Vincent de Paul Church in New York City was similarly covered by 1851. Although the popularity and use of zinc roofing in America varied greatly, its use was never as widespread as tinplate roofing.

Pure zinc is subject to creep at ordinary temperatures. After the corrugation process was patented in England in 1829 (see sheet iron and steel section), corrugated sheets of pure zinc were tried for roofing; but they sagged when placed on roof purlins and were therefore unsuitable.

Zinc-Coated Metal

I. M. Sorel, a French chemist, patented a galvanizing process in 1837, as did H. W. Crawford in England. Both methods employed a "hot dipping" process to coat sheet iron with zinc. By 1839 "galvanized" sheet iron roofing was being used in New York City. The Merchant's Exchange in Manhattan was one of the first buildings to have both a galvanized roof and galvanized gutters.

By the mid-1850s, galvanized sheets were available 24 inches wide by 72 inches long, much longer than any tinplate then on the market. Like tinplate, early galvanized iron was hand dipped. Early attempts at electroplate galvanizing were not successful; however, the process was eventually perfected and today almost all galvanized iron and steel is electroplated. Soon 50-foot rolls of galvanized sheet iron were produced.

Some galvanized sheet roofing was pressed with designs, a mode very popular in the Victorian era (figure 141). Galvanized iron and steel were used to make metal shingles (figure 11) and pantiles (figure 12) by forming them to imitate other roofing materials—wood shingles, slate, and terra-cotta tile. It was also used to make waterproof flashings and roof crestings and finials (figure 13).

By the 1850s, corrugated sheet iron was galvanized and was soon used on nearly every building type, from factories and train sheds to post offices and custom-houses. Galvanized iron roofing apparently did not prove acceptable for public buildings, though it had widespread application for industrial structures, farms, and temporary buildings.

Decorative Uses

Zinc was cast for sculpture and decorative elements in Germany as early as 1832. Zinc cemetery monuments and tombstones were manufactured in America, especially in Connecticut, in the latter half of the 19th century (figure 14). Probably ordered from catalogs, they can still be found in cemeteries. Even after a century of weathering and exposure, most still look new since they are protected by the gray layer of zinc carbonate that has formed on the surface.

SAINT PAUL ROOFING, CORNICE AND ORNAMENT COMPANY

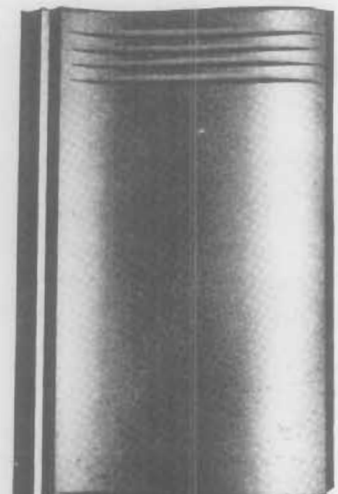
"SAINT PAUL" METAL TILES.

Made of Painted or Galvanized Steel, or Copper.

Showing Complete Roof.

"Saint Paul" Metal tiles are suitable for any building—stone, brick or frame, where the pitch is more than 3 inches to a foot. For a roof to be satisfactory, it must at all times be absolutely weatherproof. "Saint Paul" tiles affords perfect protection against rain, snow, hail or sleet.

Single.

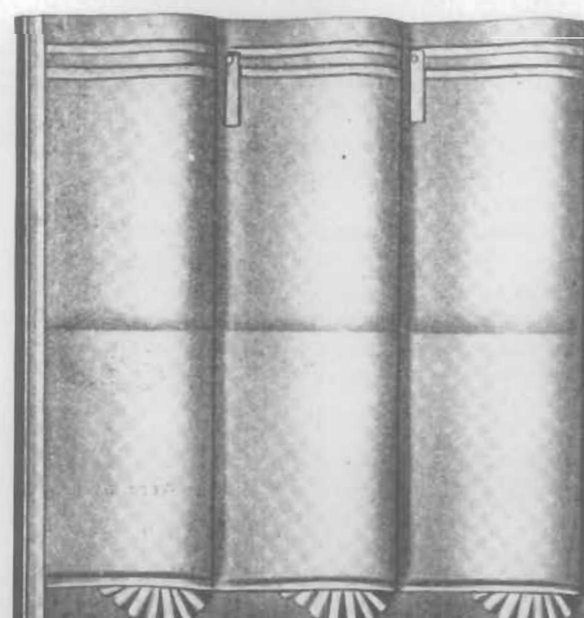


No. 1 Single—Covering size 11¼x16½ inches; 78 pieces to the square.

CLUSTER.

No. 6 Cluster—Covering size 17½x19 inches; 44 pieces to the square.

EAVES COURSE PLATE.

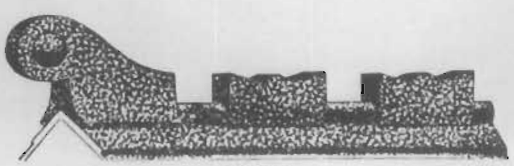


No. 7—This shows our "Saint Paul" eaves course plate or starter, used along the eaves for the first course of No. 6 metal tile. When ordering style No. 6, specify how many lineal feet of No. 7 you require. Covering size 19 inches wide by 20 inches long.

Figure 12. Sheet Metal Pantiles. *These pantiles, to look like terra-cotta tiles, could be installed one at a time or in clusters of six. A roof with these pantiles needed a pitch of at least 3 inches per foot. The special eaves course plates shown here had decorated edges. The pantiles were available in 1905 in painted or galvanized steel or copper. These are similar to the pantiles on Union Depot, Portland, Oregon (see figure 7). (Library of Congress)*

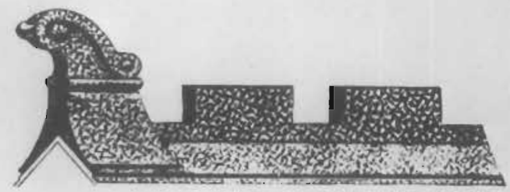
GALVANIZED IRON CRESTINGS.

WHEN ORDERING STATE PITCH OF ROOF.



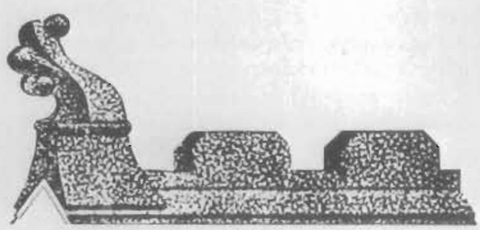
STYLE D.

CRESTING—Height, 7 inches; Width of Apron, 3 inches; Price, 30 cents per ft.



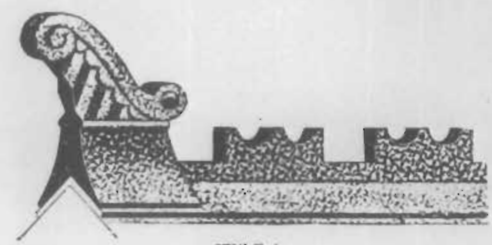
STYLE E.

CRESTING—Height, 11 inches; Width of Apron, 6 inches; Price, 40 cents per ft.



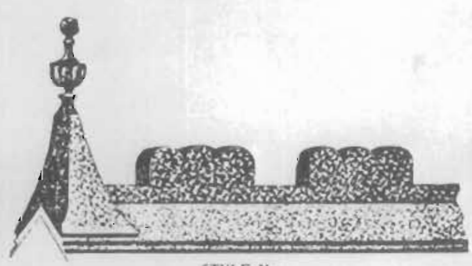
STYLE F

CRESTING—Height, 11 inches; Width of Apron, 6 inches; Price, 44 cents per ft.



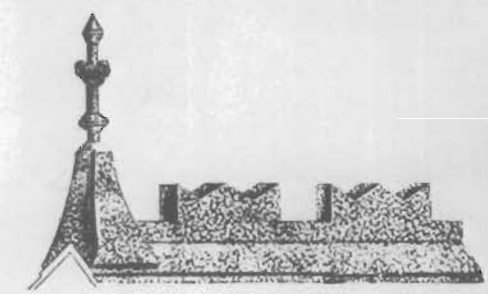
STYLE J.

CRESTING—Height, 11 inches; Width of Apron, 6 inches; Price, 46 cents per ft.



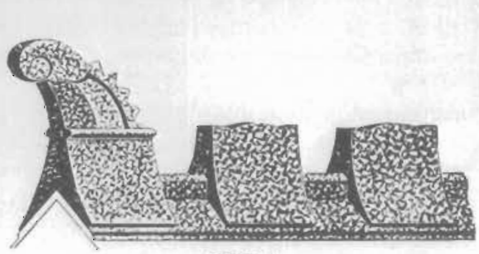
STYLE H.

CRESTING—Height, 11 inches; Width of Apron, 6 inches; Price, 48 cents per ft.



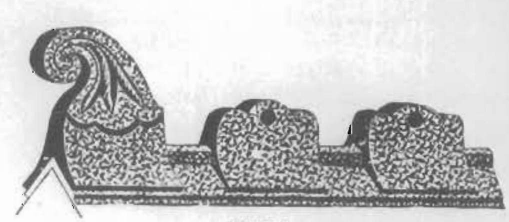
STYLE G.

CRESTING—Height, 11 inches; Width of Apron, 6 inches; Price, 46 cents per ft.



STYLE K.

CRESTING—Height, 10 inches; Width of Apron, 6 inches; Price, 60 cents per ft.



STYLE L.

CRESTING, Height, 11 inches; Width of Apron, 6 inches; Price, 70 cents per ft.

PRICE LIST OF FINIALS FOR CRESTINGS.

Style D—Galvanized Finial, Height 10½ inches, each $1.25
Style E—Galvanized Finial, Height 18 inches, each 2.00
Style F—Galvanized Finial, Height 22 inches, each 2.00
Style G—Galvanized Finial, Height 29 inches, each 2.25
Style H—Galvanized Finial, Height 25 inches, each 2.40
Style J—Galvanized Finial, Height 22 inches, each 2.50
Style K—Galvanized Finial, Height 16½ inches, each 2.00
Style L—Galvanized Finial, Height 20 inches, each 2.50

Crating charged for at Cost.

DISCOUNT............Per Cent.

Figure 13. Galvanized Iron Crestings and Finials. *Galvanized sheet metal cresting and finials for capping roof ridges could be purchased in a variety of motifs and from a number of catalogs. Finials were sold in 1896 individually and as cresting by the linear foot from the Illinois Roofing and Supply Company of Chicago, Illinois. (Library of Congress)*

Figure 14. Zinc Grave Marker, Herkimer, New York, ca.1874; Monumental Bronze Co., Bridgeport, Connecticut. *The manufacturer's name is discreetly recorded in small letters along the edge of the plinth. This company's 1882 catalog used the phrase "pure cast zinc" while insisting that "unlike commercial zinc ours is a pure metal, like gold or silver." The embossed epitaph is still crisp and new looking. In some respects the zinc monuments have survived in better condition than their stone counterparts. These light gray markers were cast in many sections, sandblasted to produce a rough stone-like surface, then bolted together with the connections disguised. (Margot Gayle)*

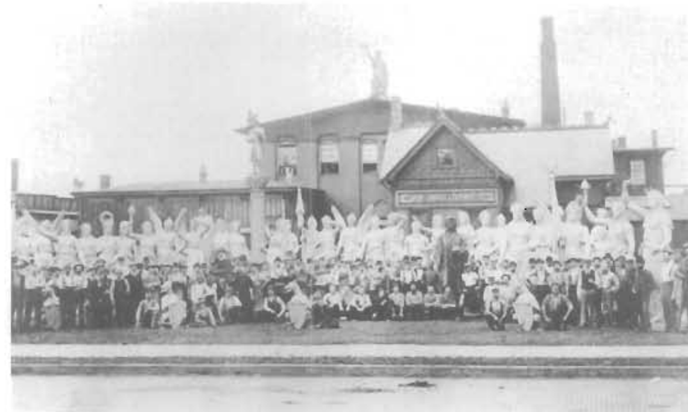


Figure 15. Zinc Statues, *Art and Architectural Metal Work Catalogue,* **W. H. Mullins, Salem, Ohio, 1896.** *Many of the statues of Freedom, Liberty, Justice, and the Muses that grace the tops of domes and cupolas were pressed in zinc and painted to match the stone of the courthouses, city halls, libraries, or other public or private monumental buildings on which they stood. A prime producer of these statues was W. H. Mullins whose employees posed for this group photograph with some 52 figures ready for shipment to the Cotton States and International Exposition in Atlanta, Georgia. In the foreground, note the four griffins, which are identical to those on the Waterworks in Peoria, Illinois. (Library of Congress)*

Zinc statues adorn many city halls, county courthouses, and post offices. Some may have been custom designed, but many were purchased from zincworks catalogues such as that of W. H. Mullins of Salem, Ohio. During the last quarter of the 19th century, foundries hired artisans and sculptors to model figures in clay and make the molds. Zinc statues were then fabricated from pressed and cast sections, some of enormous size (figure 15). A zinc statue of a fireman holding a rescued child stands on a cast-iron base in both Owego and Middletown, New York.

Decorative architectural elements were frequently cast in zinc, since it molded readily, was relatively inexpensive compared to stone, and could be painted to imitate more expensive metals. Urns, balusters, and letters (for signs) were often cast in zinc. Architectural brackets for cornices and capitals for columns and pilasters were cast in zinc (figure 16).

Moldings on late-19th-century American buildings that appear to be carved wood or stone are often cast or pressed sheet zinc or a combination of both. Even the balusters and rails on many balconies were fabricated totally of zinc.

According to the sixtieth anniversary issue of *Sheet Metal Worker* (January 1934, page 32), the first sheet iron cornice was made as a result of an accident witnessed by a sheet metal worker. In 1834 a heavy cornice stone being hoisted to the top of a tall building fell, killing two workmen. The witness, whose name was not given, began experimenting with the fabrication of a hollow cornice made of folded and pressed sheet metal. The first machine for shaping cornices, called a "cornice brake," was designed by "the predecessors of the J. M. Robinson & Co." The first galvanized sheet iron cornice made on this machine was erected on the old National Theatre in Cincinnati, Ohio, ca. early 1840s.

Other architectural elements such as window and door lintels were fabricated with pressed or folded galvanized iron (figure 17). Many later cornices, lintels, and bay fronts were further embellished with cast zinc ornament applied to the galvanized sheet iron (figure 18). Eventually, whole facades were made of galvanized sheet iron.

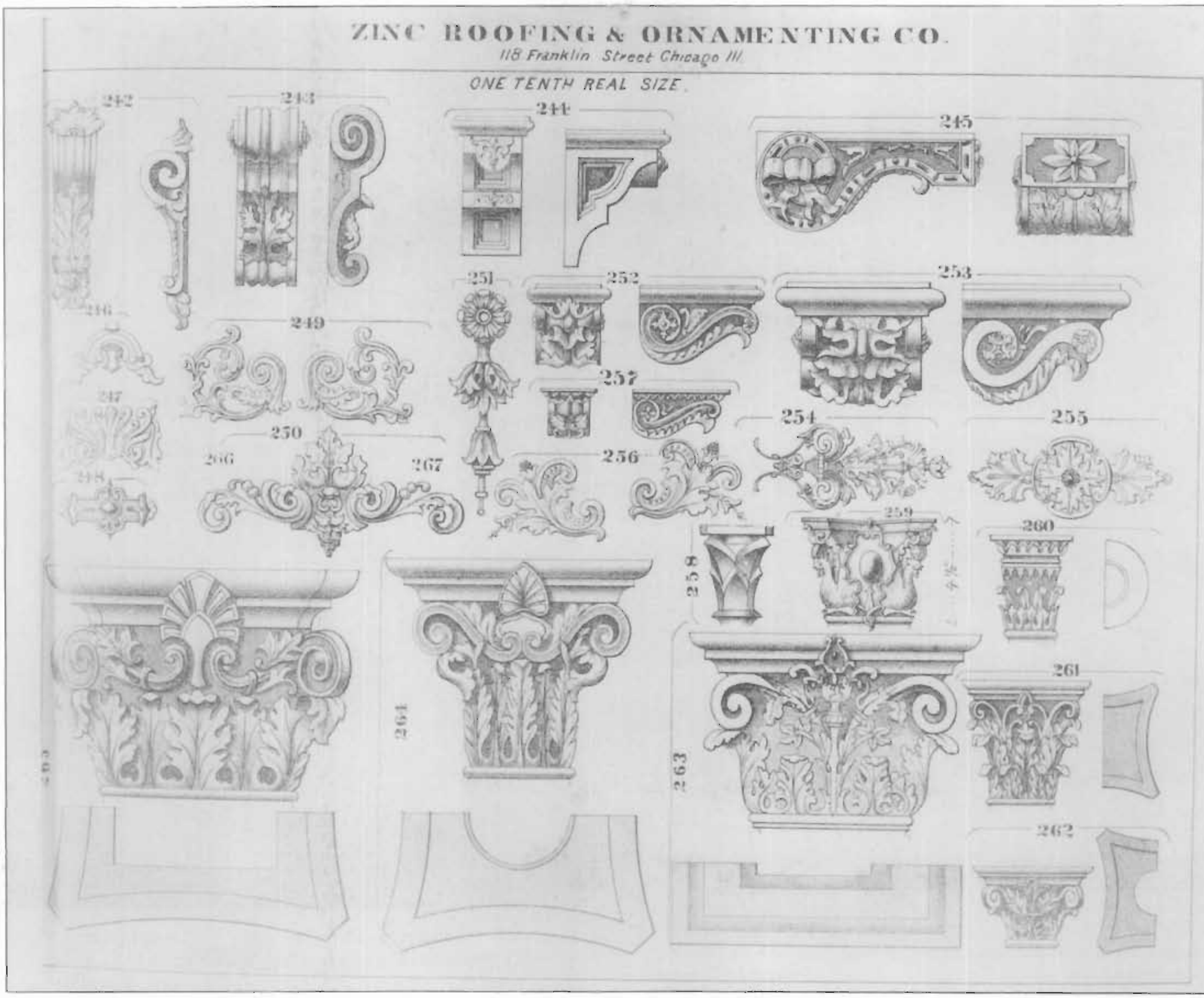


Figure 16. Zinc Brackets, Scrolls, and Column Capitals, Catalogue of Ornamental Designs in Zinc, Zinc Roofing and Ornamenting Co., Chicago, Illinois, 1871. *Although some of these pieces could have been stamped in one piece, most were cast or stamped in sections and applied to a pressed metal support. (Library of Congress)*

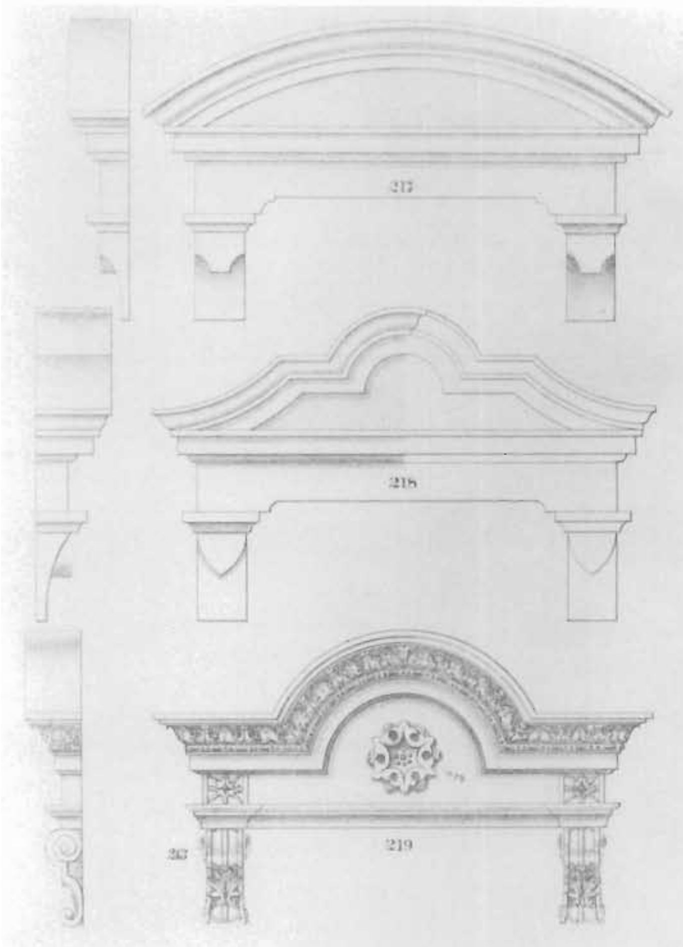


Figure 17. Zinc Lintels, Catalogue of Ornamental Designs in Zinc, Zinc Roofing and Ornamenting Co., 1871. *Many window and door lintels that from a distance appear to be stone or wood are pressed sheet metal, often coated with zinc. Sheet metal was lighter and less expensive than cast iron or stone, was easier to install, and could be painted to imitate stone or more expensive metals such as bronze or copper. The lintel designs were probably made up of galvanized sheet iron sections; the bottom design has applied cast zinc ornaments. Notice that the brackets and rosettes have separate numbers; they were probably ordered for the lintel or for other locations on the facade. (Library of Congress)*

Figure 18. Galvanized Sheet Iron Bay with Applied Zinc Ornament, 608 Indiana Avenue, NW, Washington D.C. *When sheet metal work is kept well painted, it is very difficult to identify it as sheet iron or steel, galvanized or tinplated. However, if the metal is not maintained, its composition becomes more obvious. Paint does not adhere well to pure zinc, or to galvanized iron or steel. When the paint peels, it usually comes off completely, including the primer, to reveal a clean metal surface. If the metal is galvanized, it will have a spangled appearance and may show some rust or rust stains from the iron base metal. If it is cast or pressed zinc, it will have a grayish-white appearance. This bay is covered with galvanized sheet iron with pure zinc ornaments on the surface. Even if well painted, a magnet test will reveal what is galvanized iron or steel (which is magnetic) and what is pure zinc (which is non-magnetic). (David W. Look)*

Pressed galvanized sheet iron and steel facades, cornices, lintels, and other components were in widespread demand from the 1880s to the 1910s. They were fabricated by many sheet metal companies; the two largest firms were George L. Mesker and Company of Evansville, Indiana, and Mesker Brothers of St. Louis, Missouri. These firms together sold over 12,000 storefronts and shipped them by railroad to practically every state. Each year the two firms and others sent out thousands of catalogues, one of which was reproduced in the *Bulletin of the Association for Preservation Technology* (vol. 9, no. 4, 1977).

These commercial facades generally imitated wood, stone, and cast-iron fronts at a fraction of the cost of the other materials. The pieces of sheet metal were riveted and/or soldered together and then nailed to wooden framing. They came complete with doors, windows, and glass—everything that was needed for a complete facade, including a set of instructions for erection. The first-floor columns and pilasters were usually cast iron to take the added wear and tear of street-level pedestrian traffic.

Although these mass-produced facades were not held in high esteem by architects, they brought ornament and "style" to countless business districts. In many small towns, especially in the West, the only buildings of any significance on Main Street may be the galvanized sheet iron storefronts purchased through a catalog. Like cast-iron facades, these storefronts were often painted stone colors and then dusted with sand to add a stone-like texture. It is not unusual to find a loft building with three stone or brick walls and a pressed sheet metal facade that imitates stone or brick.

Paint

In the mid-18th century, a German chemist named Cramer produced zinc oxide by burning pure zinc in air. In France, Courtois made the first zinc oxide paint in 1781; it was nontoxic and resistant to pollution. Although zinc oxide paint had whiteness, fine texture, and opacity, it lacked body and required several coats to cover the surface. Zinc oxide paint became commercially successful and readily available in America about 1850 when this deficiency was corrected. By the 1870s, zinc oxide paint was widely used here. Since then, zinc-chromate paint and zinc-rich paint, which contains metallic zinc dust, have been developed. Both of these paints are good inhibitors against rust on iron and steel.

During the early decades of the 20th century, the use of pure zinc roofing and ornament decreased and now, pure zinc as a building material is rarely used. However, zinc is still used in alloys such as brass and nickel silver (see chapters 5 and 6 for further information on brass and nickel silver), and in the electroplating of steel. Today, galvanized steel, usually corrugated, is used for roofing industrial and agricultural buildings, but seldom used on public buildings or residences of any significance. Galvanized nails and sheet metal ducts are common in modern construction.

Chapter 5: Copper and Copper Alloys

The "cupric" metals include copper and its alloys: especially *bronze*, an alloy of copper and tin, and *brass*, an alloy of copper and zinc.

Copper

Copper is usually found combined with other elements in sulfide and oxide ores; however, it does exist in a relatively pure state in nature. Naturally pure copper is known as "native" copper. The Neolithic people first discovered such copper about 8000 B.C.

The French and English explorers learned of large native copper deposits in what is now Michigan from the Indians in the 17th and 18th centuries. Exploitation of these deposits began in 1844, resulting in the first "mining boom" in the United States. After the 1880s, however, the center of copper mining moved west to Montana, Colorado, and Utah. Today, the United States is self-sufficient in its production of copper.

Copper is a very durable metal; it withstands corrosion to a remarkable degree. The characteristic green patina—actually copper sulfate that forms on its surface—acts as a protective coating against further reaction with the atmosphere. Pure copper is strong but ductile, which means it can be stretched or "drawn," as in making wire. It is also malleable and thus can be hammered, beaten, or rolled into sheets or shapes without breaking. Copper was first rolled in England in the late 17th century. Of the many utilitarian and decorative uses of copper, undoubtedly its use as sheathing for ships and as roofing and flashing material on buildings

Figure 19. Copper Roof, Old Senate Chamber, United States Capitol, 1819; Benjamin H. Labrobe, architect. *After the British burned the Capitol in 1814, the entire structure was rebuilt, including a new copper roof. Little is known about the roofing installed in 1819 since it was removed in 1900. It was probably all flat seams because the machine for forming standing seam roofing was not invented until about the time of the Civil War. When the surfaces were reroofed in 1975, every effort was made to duplicate the 1900 roofing patterns, configuration, and size of sheets. Sheet copper can be shaped to cover many types of curved surfaces. The dome has standing seams while the cupola and the area around the dome, which is flatter, have flat seams.* (Charles Parrott)

has been most important, followed by its use in ornamental details. In the 20th century, piping systems and electrical wiring became important new uses of copper.

Roofing and Related Items

Sheet copper used as roofing is lighter than wooden shingles and much lighter than slate, tile, or lead. Roofing copper can be folded readily into waterproof seams, or shaped over curved frameworks for cupolas and domes (figure 19).

Some of America's most important buildings had copper roofs, and many lasted for nearly two centuries. In 1795 the First Bank of the United States in Philadelphia was covered with a roof of English copper sheets (24 by 48 inches), with standing seams held in place by copper clips and cast nails. The section over the front pediment is still in service, although the rest of the roof was drastically altered in 1902.

Roofing material for the dome of the Massachusetts State House (1795-1798) was ordered from Paul Revere's newly opened rolling mill. But there was still not enough American production, for instance, to supply the sheet copper for the New York City Hall (1803-1811); most sheet copper was imported through the early decades of the 19th century. Copper roofs on public and important private buildings were not so rare by the time Old Christ Church in Philadelphia was roofed in copper in the 1830s. The copper on Christ Church fulfilled the builders' objective to install roofing material of great durability and longevity; the roof served its purpose until 1967.

The initial cost of copper was traditionally high, but its length of service more than compensated for the price. Because of these high costs, copper in quantity was used only on major structures, mostly public buildings. However, copper in small quantities was widely used on more modest buildings for roof flashings, gutters, and downspouts (figure 20), and decorative elements. Copper was also commonly used for weather vanes and finials (figures 21 and 22). The resistance of

Figure 20. Copper Conductor Heads and Downspouts, former U.S. Post Office, Bounded by Hamilton, Clark, Ward streets and Lee Place, Paterson, New Jersey, 1899; William Martin Aiken, Architect of the Treasury. *Rain conductor heads and downspouts are almost always made of metal, in some cases copper. The former post office, now an annex to the Paterson County Court House, includes copper conductor heads and downspouts as part of the rich Flemish architectural design. Twenty of these decorative devices are spaced on all four sides of the banded red brick and stone building. (Jack Stokvis)*

Figure 21. Copper Grasshopper Weather Vane by Shem Drowne, 1742, Faneuil Hall, Dock Square, Boston, Massachusetts. *The weather vane is wrought iron except for the grasshopper and the four points of the compass which are copper. The grasshopper, which is gilded and has glass eyes, measures 53 inches long, 6 1/4 inches wide, and weighs 38 pounds. The history of the weather vane is well documented. In 1755 it was damaged by an earthquake; it was later repaired by Thomas Drowne in 1768. On January 11, 1974, the weather vane disappeared only to be found a few days later wrapped in a blanket and hidden in the cupola. The weather vane had been damaged during the attempted theft, but it was repaired and reinstalled on February 15, 1974. (Index of American Design, Mass-Me-230, National Gallery of Art)*

copper to corrosion was valuable for these purposes, as was its malleability. It could be shaped to the bends and angles around chimneys and at roof edges and dormers. All nails, screws, bolts, and cleats used with sheet copper had to be made of copper or a copper alloy; otherwise "galvanic" action between the dissimilar metals would occur, causing deterioration (see section on deterioration in chapter 10).

Decorative Uses

Copper was hammered or stamped into decorative details to ornament the cornice lines of many buildings (figure 23), and to sheath oriel and bay windows as well (figure 24). Copper was also fabricated into running moldings, masks, lion heads, rain conductor heads (figure 20), and Greek-inspired anthemions at roof edges.

Occasionally, statues used as architectural ornaments were made of copper. Sections of sheet copper can be hammered over wooden or other forms to create statues. Once the copper sheets have taken the shape of the form, they are removed and soldered together over a wooden or metal framework. The most famous example of this type of statue is the Statue of Liberty, which consists of copper sheathing over a steel framework. The 152-foot-tall statue, erected in New York Harbor, was a centennial gift from France (figure 25).

Another widely known sheet copper statue of great beauty is Augustus Saint-Gaudens' "Diana," which he designed as a weather vane to top the tower of the old Madison Square Garden in New York City. The 13-foot gilded statue, a huntress poised on one toe with bow and arrow ready, stood silhouetted 347 feet above the street

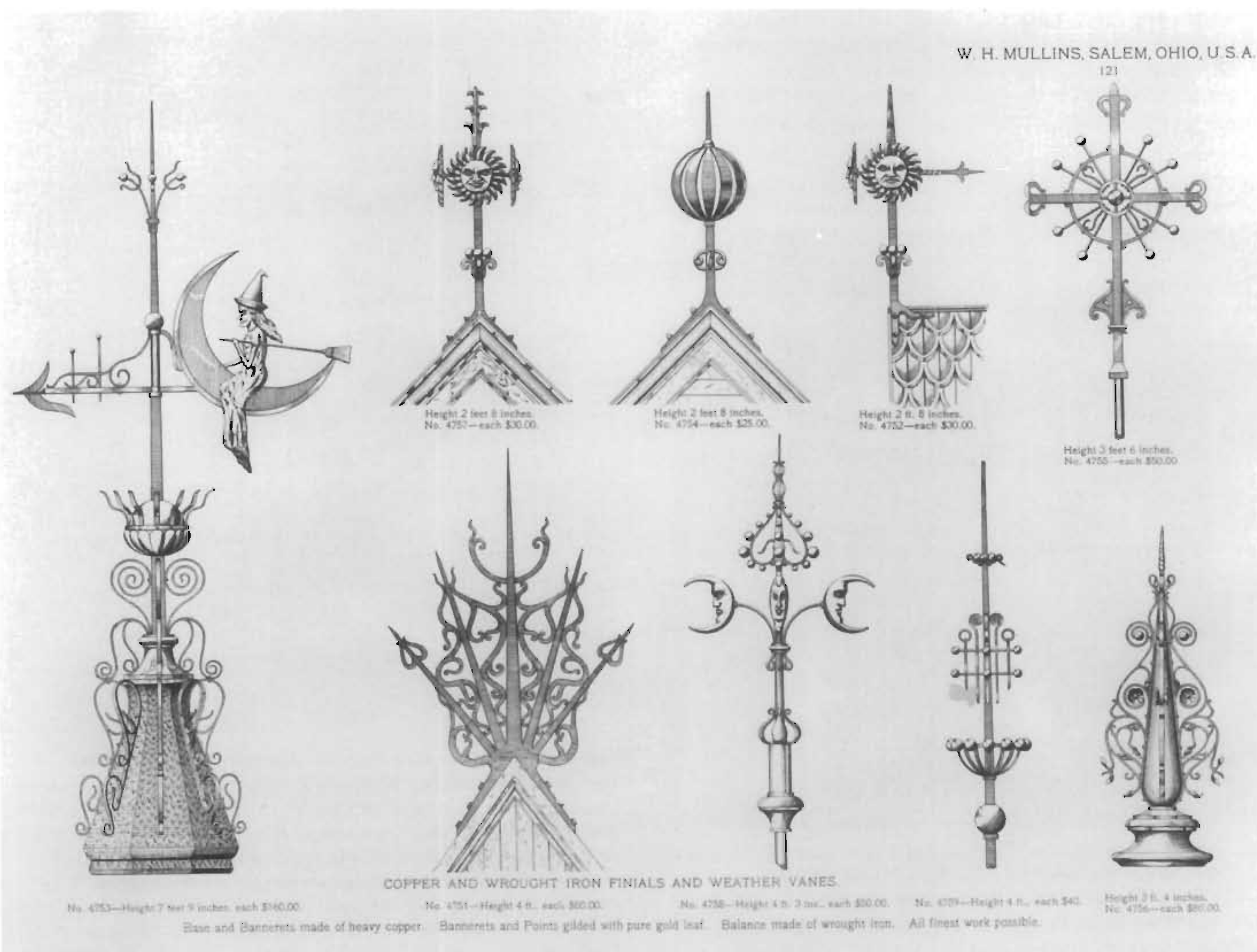


Figure 22. Copper and Wrought-iron Finials and Weather Vanes. *The bases and bannerets of the weather vanes were made of heavy copper, with the bannerets and points of the compass sometimes gilded with gold leaf. The rest of the material in these decorative objects was usually wrought iron. In 1896, these unusual designs, as well as the traditional rooster and eagle, were offered in the catalog of W. H. Mullins of Salem, Ohio. (Library of Congress)*

Figure 23. Pressed Copper Sheet Metal Cornice, Frieze, and Pilasters; Conservatory of the Christian Heurich Mansion, 1307 New Hampshire Avenue, NW, Washington, D.C., 1902; Appleton Clark, architect. *The copper work was assembled from many pieces of sheet copper pressed with low relief designs. (Jack E. Boucher, NAER)*

from 1895 until 1925 when the Garden was demolished. She was constructed of 22-ounce copper, die-struck in sections riveted together then braised to make the form smooth and waterproof. An armature centered on a 7-inch wrought-iron pipe that ran from the head through the toe and 9 feet into the tower supported the statue. With counterweights and a ball-bearing system that allowed her to rotate she weighed somewhat under 1,500 pounds. The statue can now be seen in the Philadelphia Museum of Art. An earlier 22-foot version weighing 2,200 pounds that had proved to be out of scale when placed on the Garden's tower in October 1891 was taken down and sent to the World Columbian Exposition of 1893 in Chicago to grace the dome of Agricultural Hall, which like the Garden was the work of the architectural firm of McKim, Mead, and White. The whereabouts of that statue since the close of the fair is unknown.

The color of antique copper, which is a little more orange than new bronze, was much admired in the late 19th century. Victorian cast-iron hardware was sometimes copper-plated, although brass-plated hardware was more common. Cast-iron stair railings and newel posts (figure 26) were sometimes copper plated. An excellent example is the copper-plated cast-iron staircase, designed by Louis Sullivan in 1894, that was saved from the demolished Chicago Stock Exchange and has been re-erected in the American Wing of New York's Metropolitan Museum.

Today the cost of copper prohibits its extensive decorative use, but it is still used for certain utilitarian systems because of its unique properties. Copper's high capacity for thermal and electrical conductivity accounts for its continued use in buildings in heating and air-conditioning systems, electrical systems, and telephone wiring. Also, its strength and resistance to corrosion by most types of soils and water make it appropriate for use in plumbing.

Figure 24. Copper-Clad Bay Window and Cornice, Thomas C. Whyte House, 1329 R Street, NW, Washington, D.C., 1892; George C. Johnson, architect. *From the first-floor window sills to the cornice above the second floor, the bay window is sheathed entirely with pressed sheets of copper, and there are slender two-story copper pilasters flanking the windows. The spandrel between the first- and second-floor center windows has a shell design and the side spandrels have winged sea creatures. Both the cornice of the house and the cornice of the bay window have copper classical dentils and modillions. (David W. Look)*

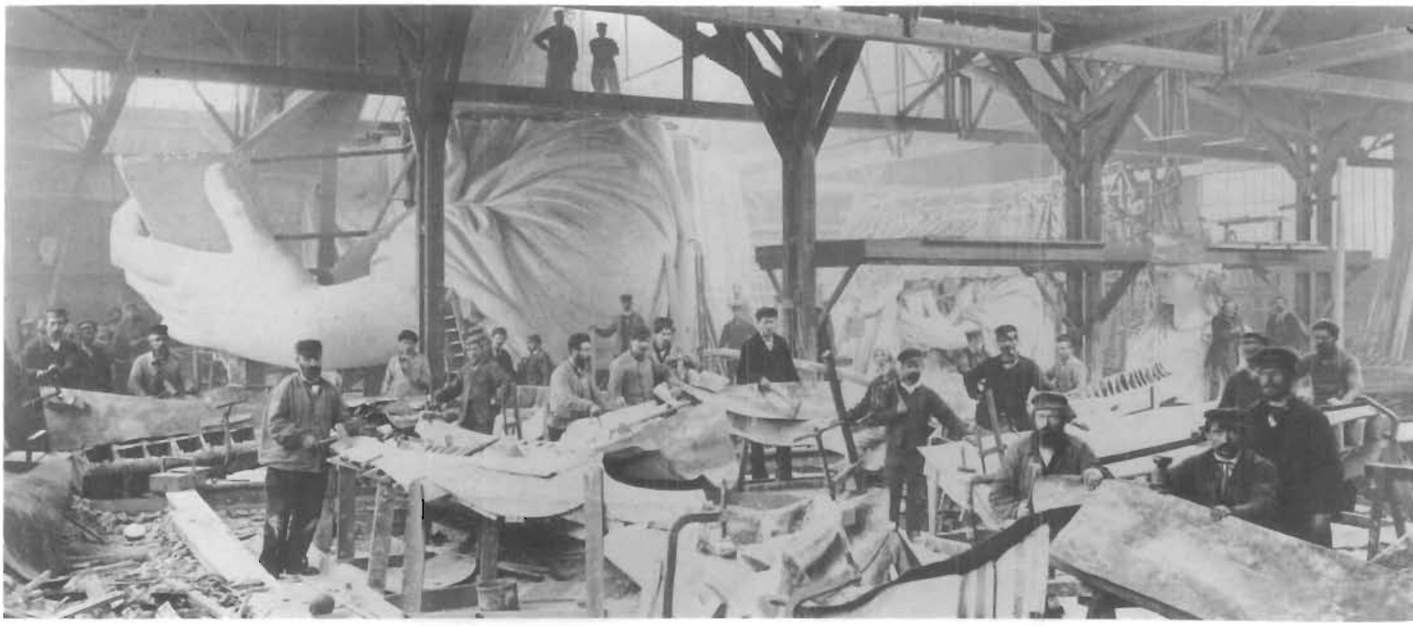


Figure 25. Copper Statue of Liberty, New York City Harbor, 1883–1886; Frederic Auguste Bartholdi, sculptor; Alexandre Gustave Eiffel, engineer. *This photograph was taken in the metal shop in France where the sheet copper was fabricated. In the foreground, sheet metal workers are hammering the copper over wooden forms. The temporarily assembled arm and shoulder in the background, were later disassembled and shipped to the United States. Eiffel, who later designed the 984-foot Eiffel Tower of the Paris Exhibition of 1889, engineered the steel armature to support the statue built to the design of Bartholdi. (Rare Book Division, New York Public Library; Astor, Lenox and Tilden foundations)*

Figure 26. Copper-Plated Cast-iron Stair Railing, Christian Heurich Mansion, 1307 New Hampshire Avenue, NW, Washington, D.C., 1892–1894; John Granville Meyers, architect. *This iron railing was sand cast in many pieces, and the flat areas of the design were ground smooth before the pieces were copper plated. Most of the parts were bolted together, but a few pieces of the newell post were brazed. The railing has a brass hand rail. (Jack E. Boucher, NAER)*

Bronze

Copper alloys have been of prime importance for several millenia, especially bronze, the alloy known and used the longest. Copper plus tin forms bronze, a salmon-colored metal seldom seen without a natural green patina or a brown artificial statuary patina. Bronze lent its name to an entire stage in the development of civilization; the Bronze Age was the point at which various groups of people learned to reduce ores and combine different metals to produce superior tools. Bronze was preferred to iron in early civilizations for its hardness and easier mode of production.

Bronze is remarkably impervious to the vicissitudes of time and weather. Old bronze is recognizable by its greenish-brown patina—a natural protection that sometimes occurs evenly on a surface. However, a bronze surface may be marked with grayish-green and black streaks which may detract from its appearance, if it is exposed to wind and rain from one direction for long. Lack of protection from polluted industrial air may endanger the integrity of exposed outdoor bronze sculpture or exterior building details, a danger not usually present with interior bronzework or doors.

The use of bronze in American buildings before the Civil War was very rare. American foundries did cast some bronze cannons, small sculpture, and bells, but large-size bronzework for churches and capitol buildings was still imported. Although American foundries had the capacity, they lacked the confidence and opportunity to produce fine pieces. Near the mid-19th century, sculptors Robert Ball Hughes and Clark Mills cast their own bronze and soon America was producing fine bronzework for art, architectural sculpture, and for architectural elements and details.

About 1845, Hughes modeled a life-size seated statue for the monument of astronomer Nathaniel Bowditch and cast it in his foundry in Boston. Erected in 1847 in Mount Auburn Cemetery in Cambridge, it was probably the first life-size outdoor bronze sculpture cast in America, although it had to be recast in the 1880s because of its deteriorated condition.

The first bronze equestrian statue was cast in America in 1848 when Clark Mills modeled a statue of Andrew Jackson, the hero of the day. Mills cast the statue and it was erected in 1853 in Lafayette Park, Washington, D.C. Cannons captured from the British at the Battle of New Orleans were melted to supply the needed bronze. Mills' work was important not only for the technical skill needed to cast the many pieces of bronze for the statue, but also for his ability to balance the mass on the horse's hind legs. Congress was so impressed with Mills' work that it commissioned him to model an equestrian statue of Washington (which had actually been proposed in 1783), which now stands in Washington Circle not far from Lafayette Park.

The first bronze doors installed in America were the "Columbus Doors" by Randolph Rogers at the U.S. Capitol, (figure 27), which were cast in Germany. The doors of the new Senate wing of the Capitol were the first bronze doors both commissioned and cast in America. Thomas Crawford received the commission for these in 1855. He had completed the plaster cast of one panel and clay models of four more panels before he died in 1857. The work was eventually turned over to William Rhinehart, who completed the last panel of the Senate doors and all of the House doors based on Crawford's designs. Although Crawford had planned to have the doors cast in Germany, it was later decided to send

Figure 27. Bronze "Columbus Doors," Rotunda of the U.S. Capitol, Designed by Randolph Rogers, 1858, installed 1863; Royal Bavarian Foundry, Munich, Germany. *Shortly after Thomas Crawford received his commission for the Senate doors in 1855, Randolph Rogers was commissioned to design the doors of the Rotunda. He proposed scenes based on the life of Columbus. Although Rogers was an American, he modeled the doors in his studio in Rome, sent photographs to America for approval, and had the doors cast in Munich in 1861. These doors were shipped to America and installed on the House side of the Rotunda in 1863, before Crawford's doors for the Senate were finished. Rogers' doors were later moved in 1871 to the main entrance of the Rotunda. (Courtesy of the Architect of the Capitol)*

them to the Ames foundry in Chicopee, Massachusetts, in 1866. The Senate doors were installed shortly thereafter, but the House doors, also designed by Crawford and Rhinehart, were not hung until 1905.

About the same time, the first large bronze statue was placed on top of a major building. Clark Mills cast Thomas Crawford's colossal statue of *Freedom* for the top of the U.S. Capitol dome and it was hoisted into position on December 2, 1863.

From 1870 to 1940, many public buildings included the integrated expressions of sculptors and architects working together, often using bronze as well as other costly materials. The City Hall of Philadelphia, designed by architect John McArthur in the Second Empire style, is a good example. Alexander Milne Calder and his staff modeled hundreds of pieces of sculpture for the building, ranging from architectural details such as carved pilaster capitals, to the gigantic bronze statue of William Penn (figure 28).

Public structures such as libraries, courthouses, post offices, and city halls often had custom-designed metal doors and other decorative features, which included appropriate historical themes. Bronze was frequently the choice for such features because of its strength, its capacity for casting in high relief, and its relatively high degree of weather resistance.

In the late 19th century, American architects used a great deal of bronze in the detailing and decoration of large neoclassical public buildings and commercial buildings such as Marshall Field and Company Department Store (figure 29). Sculptor Daniel Chester French created the large bronze doors of the Boston Public Library to complement the building's Renaissance Revival design by Charles Follen McKim. Bronze appeared in museums, libraries, university buildings, banks (figure 70), stores, and railroad stations, and other post-Columbian Exposition structures made possible by American affluence.

Many American foundries were needed to cast the intricate bronze work. Typical examples were the bronze grilles, tellers' cages, and elevator doors of several banks, such as those by York and Sawyer. Much of their bronze work was crafted by the William H. Jackson Company, and some of the finest work is still extant at the Bowery Savings Bank in New York City (figure 30). McKim, Mead,and White's bronze light standards and detailing, crafted by Hecla Company, ornament their Columbia University buildings, while the Cunard building on lower Broadway presents a vast floor seal created by the Gorham Company. Architect Cass Gilbert used bronze for the stately ornamental gates in the New York Life Insurance Building in 1928 (figure 31), as did Paul Phillipe Cret for the window grilles on the Old Federal Reserve Bank in Philadelphia in 1932.

The surface treatment of bronze works can be varied from a polished finish with high reflectance to a matte finish. One of the oldest treatments is the gilding of bronze to imitate gold, such as the brilliant gold-leafed "Prometheus" designed by Paul Manship and installed in 1934 above the ice skating rink at Rockefeller Center in New York City.

The lobby of the 35-story Koppers Building in Pittsburgh, designed in 1929 by Graham, Anderson, Probst & White of Chicago, contains a wealth of Art Deco bronzework complemented by polished marble, as do many Art Deco buildings in New York City, including the Chanin Building (figure 33).

Figure 28. Bronze Statue of William Penn, City Hall, Philadelphia, Pennsylvania, 1886–1894; Tacony Iron and Metal Works, Philadelphia. *Bronze was chosen by sculptor Alexander Milne Calder, the grandfather of the 20th-century sculptor, for his monumental statue of William Penn, founder of Philadelphia and the colony of Pennsylvania. When Calder had completed the clay sections, his assistants executed a huge plaster model. However, the model stood idly in City Hall for a year and a half because there was no foundry in the United States capable of casting the statue, which would be the largest cast bronze statue in the world at that time. By 1889, the newly founded Tacony Iron and Metal Works was able to handle the project. On November 6, 1892, the completed statue, measuring 36 feet 4 inches tall and weighing 27 tons, was erected in the courtyard of the City Hall for public viewing while the iron clock tower was completed. Two years later, the statue was hoisted in sections to the top of the tower. (Historic photograph courtesy of George Eisenman)*

Metallurgists have added other metals to the tin-copper mixture to produce special qualities for specific uses. Additions of zinc and lead make a more ductile alloy that allows for very crisp castings. The fine molding quality of bronze is important for architectural detail work and statuary. Aluminum or iron in the bronze mixture makes a harder substance. To achieve bronzes with different colors, the proportions of each metal can be changed.

Like copper and brass, bronze was used for plating cast iron. Sir Henry Bessemer made a small fortune bronzing cast iron by using a "gold" powder. This was before he invented a process for making steel. There were other methods for coating iron ranging from bronze paint to bronze plating. As mentioned in the November 1904 *Architectural Record*, the lamps on the old U.S. Mint on Spring Garden Street in Philadelphia had "wrought-iron electro-bronze plated brackets" fabricated by John L. Gaumer Company. Several catalogues offered bronzed cast iron as well as cast iron ready for painting.

Figure 29. Bronze Clock, Marshall Field and Company Department Store Addition, corner of State and East Washington Streets, Chicago, Illinois, 1907; Graham, Anderson, Probst & White, architects. *This huge bronze clock, weighing 7 3/4 tons and hanging 17 feet above the sidewalk, was designed by Pierce Anderson for the addition to Marshall Field's store. With a 46-inch face and a minute hand measuring 27 inches, the clock and its twin on another corner of the building can be seen for blocks. These magnificent works of art have become part of the city's landscape as a fourth generation of Chicagoans meet "under the clock." (Margot Gayle)*

Figure 30. Bronze Teller Cage and Mailbox, Bowery Savings Bank, 110 East 42nd Street, New York City; 1923, York and Sawyer, architects; William H. Jackson Co., foundry. *The Bowery Savings Bank has been relatively unscathed by "modernizing" and is literally filled with bronzework: doors, elevators, check writing desks, window trim, tellers' cages, gates, and even mailboxes. (a) Although the function of tellers' cages was to provide security, they were transformed into decorative features. (b) During the late 19th and early 20th centuries, functional items such as letter boxes were custom designed for each building and integrated into the total design. (Bowery Savings Bank)*

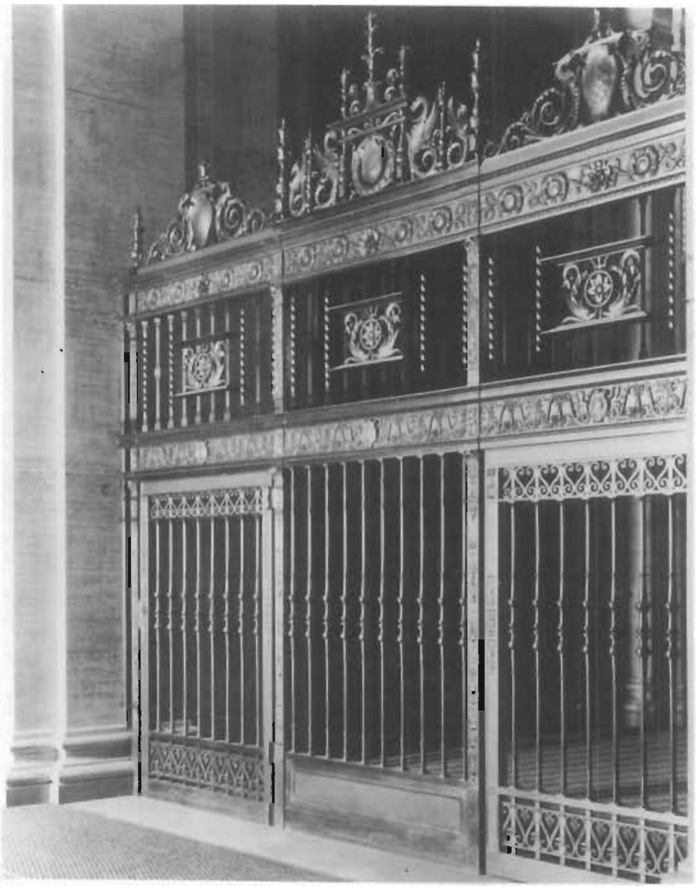


Figure 31. Bronze Screen and Gates, New York Life Insurance Company Building, 51 Madison Avenue, New York City, 1928; Cass Gilbert, architect, William H. Jackson Co., foundry. *The bronze gates in the foyer guard the broad stairway to the first basement and subway entrance. (New York Life Archives)*

Figure 32. Bronze Storefront, Grilles, Spandrel Panel, and Window, Southern Railway Building, 912 Fifteenth Street, NW, Washington, D.C., 1928; Waddy Butler Wood, architect. *This building is typical of many large commercial buildings with extensive use of bronze. Everything from the grilles to the windows and spandrels to the storefronts were fabricated of bronze. Although many storefronts have been remodelled beyond recognition, this one still has its original design and materials. (David W. Look)*

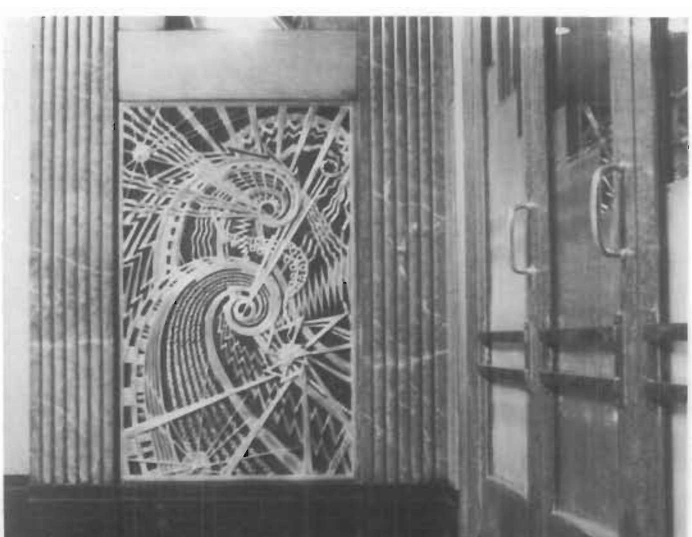


Figure 33. Bronze Ventilation Grille, Chanin Building, 405 Lexington Avenue, New York City, 1929; Sloan and Robertson, architects; lobby design by Jacques Delamarre. *The foyer of this Art Deco style building contains four highly modeled ventilation grilles in an abstract design, in what some designers called the "Futuristic" style. (David W. Look)*

Bronze is still used for doors and windows, frames, railings, elevators, escalators, lamps, and hardware. Today, commercial "bronze" and architectural "bronze" contain zinc rather than tin; these materials are actually brasses but are marketed as bronze because bronze is generally considered a more prestigious metal. One example of this is the "bronze" clad Seagram Building (figure 34) in New York City by Mies Van der Rohe.

Brass

Brass is an alloy resulting from the mixture of copper and zinc. The color of brass varies, depending upon the amount of zinc in the mixture and whether or not other metals are added. Brass with relatively large amounts of zinc are yellow in color; the addition of aluminum makes a light golden color; a small percentage of manganese produces a bronze-like color; and the addition of nickel results in a silvery metal called nickel silver (for further information on nickel silver, see chapter 6).

Figure 34. "Bronze" Curtain Wall, Seagram Building, 375 Park Avenue, New York City, 1958; Ludwig Mies Van der Rohe, architect. *The curtain wall consists of 4 1/2- by 6-inch extruded architectural "bronze" (really brass: 57% copper, 3% lead, and 40% zinc) I-beam mullions (2 1/2 inches larger than the largest bronze sections extruded to that time), Muntz metal spandrels (brass also: 60% copper and 40% zinc), and pink-gray, heat- and glare-resistant glass in story-high architectural bronze frames. The 26-foot-long architectural bronze I-beams were extruded rather than built up with welded plates to avoid waviness in the sections. The architectural bronze, which only resembles real bronze with a statuary brown patina in color, is regularly rubbed with oil to prevent the bronze from forming a natural green patina. (Ezra Stoller)*

A hard, durable, and utilitarian metal, brass makes excellent castings, can be worked hot, and extruded. A very workable brass can be made by adding a little lead. The process of extrusion is most commonly used, especially to produce large architectural pieces, including doors and elevators, and in such elements as window frame sections, hand rails, and balustrades. Brass was also used for architectural members because of its corrosion resistance.

In colonial America, public buildings and fine homes often had brass hinges, door knobs, door knockers, chandeliers, and fireplace andirons; however, almost all of the brass hardware was imported from England until after the Civil War. In the Victorian era in England and America, brass was used for light fixtures, plumbing fixtures, and every type of builder's hardware. Although much of the hardware (figures 35 and 36) was solid brass, some was cast iron plated with brass. Even such mundane fixtures as siamese connections were crafted from brass (figure 37).

The Commercial Style buildings that appeared with the increase of commerce and manufacturing in the late 19th century brought new uses of brass and other metals. The great architects of office buildings and early skyscrapers, such as Burnham and Root and Adler and Sullivan, used large quantities of brass to enhance the appearances of theaters, company headquarters, banks, and stores. Corporations and municipalities commissioned craftsmen and architects to beautify their structures; polished brass was a favorite for handrails on stair railings and in elevators, lobby furniture, bulletin boards, lobby mailboxes, name plaques, and building directories (figure 38).

As the Beaux Arts and Neoclassical styles became popular in the early 20th century, apartment buildings, hotels, and government offices were often decorated with brass in the private as well as the public spaces. It was the beauty of brass, its gleam and color, that influenced the choice rather than its more practical quality of resistance to corrosion. The Beaux Arts City-County Building in Pittsburgh (1915-1917) displays a traditional use of brass in its elevator doors, and an innovative and visually powerful use of brass-sheathed columns (figure 39). The Utah State Capitol of the same period (1913-1916) has exterior brass doors (figure 40).

In the 1920s and 1930s, some architects preferred using white metals (see nickel silver, Monel metal, stainless steel, and aluminum) to accent their designs, but other architects used brass in nontraditional ways to achieve special design effects such as the brass strips on the interior of the Hotel Edison in New York City (figure 41).

Today brass is still used for hardware, plumbing fixtures (usually chrome plated), doors, windows, elevators, and escalators. It is available in a variety of finishes—highly polished, stained, brushed, and so on. Usually the finish is protected with lacquer to prevent tarnish and eliminate the need for polishing.

Figure 35. Brass Doorknob and Escutcheon Plate, Old United States Mint, San Francisco, California, 1869–1874; Alfred B. Mullet, architect of the Treasury. *Throughout most of the 19th and into the early 20th centuries, hardware was often specially designed for significant public and some private buildings. This doorknob displays the seal of the U.S. Treasury and reflects the tastes and styles of the time by combining classical and Victorian motifs on the escutcheon plate and keyhole cover. (General Services Administration)*

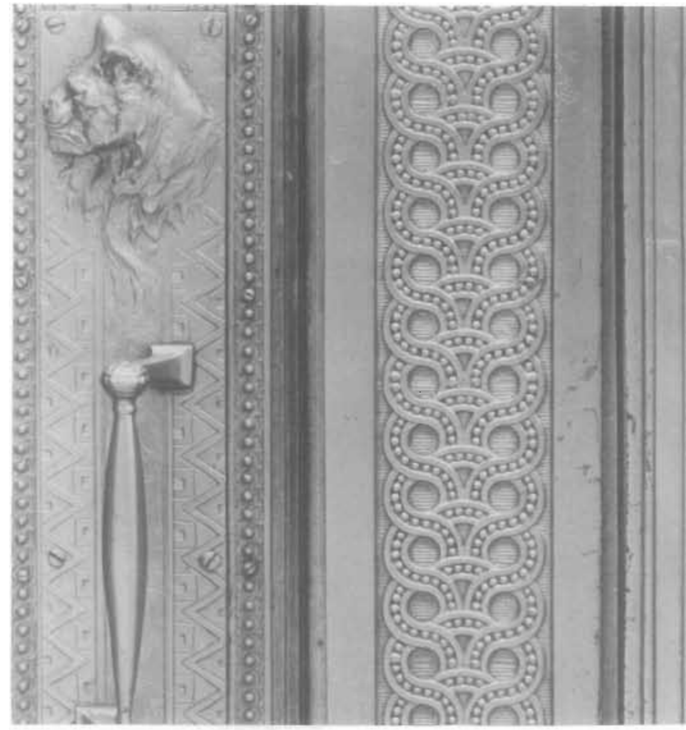


Figure 36. Brass Puma Pushplate, Door and Surround, Marquette Building, 140 Dearborn Street, Chicago, Illinois, 1893–1894; Holabird and Roche, architects; Edward Kemeys, sculptor. *The entrances and lobbies of early skyscrapers were not only finished in high-quality materials, but also were sometimes decorated by well-known artists and sculptors who were commissioned to design individual elements and details. Kemeys, who created animal sculptures for the 1893 Columbian Exposition in Chicago including the lions in front of the Art Institute on Michigan Avenue, sculpted the puma heads for the pushplates on the doors leading into the Dearborn Street lobby. (Barbara Crane, Courtesy of the Commission on Chicago Historical and Architectural Landmarks)*

Figure 37. Brass Siamese Standpipe Connection, Rookery Building, 209 South LaSalle Street, Chicago, Illinois, 1886; Burnham and Root, architects; W. D. Allen, manufacturers. *Brass fittings can be functional and very attractive when kept well polished. Even though the natural weathered dark patina on brass is protective, it is generally considered to be unsightly and great effort is expended to recapture the metallic gleam. (Margot Gayle)*

Figure 38. Brass Lobby Directory, City Hall and County Building, Chicago, Illinois, 1911; Holabird and Roche, architects. *A dual purpose lobby directory and light standard, this piece of brass lobby "furniture" displays the capacity of brass to take the most opulent and ornamental cast shapes. This design is in keeping with the elaborate style of many neoclassical buildings erected in the early years of this century. (Office of the Mayor, City of Chicago)*

a.

b.

Figure 39. Brass Elevator Doors and Brass-Sheathed Columns, City-County Building, Pittsburgh, Pennsylvania, 1915–1917; Palmer, Hornbostel and Jones, architects; Edward B. Lee, associate architect; Tiffany and Co., designers (for columns only). *(a) Brass was used extensively for interior decorative features in 19th- and 20th-century buildings, and was especially popular for statuary, large-scale furniture, and elevator doors in government and office buildings. This set of highly modelled brass doors tells the story of Pittsburgh's development as reflected in its important buildings. (b) The large structural steel columns that support the barrel vault of the lobby are sheathed in brass—an unusual choice of material for columns. Over the years the fluted shafts and stylized capitals had acquired a dull, dark patina, but when the lobby was restored in 1972, the columns were polished and lacquered to return them to their original appearance. (Pittsburgh History and Landmarks Foundation)*

Figure 40. **Brass Doors, Utah State Capitol, Salt Lake City, 1913–1916; Richard Kletting, architect.** *Brass was not used for exterior doors as often as bronze, although many doors that are reportedly bronze may actually be brass. These highly polished exterior brass doors, make a strong architectural statement reinforcing the overall design of the building. Classical motifs include Roman grate windows, circular shields in the lower panels, and a scallop design in the transom. (Margot Gayle)*

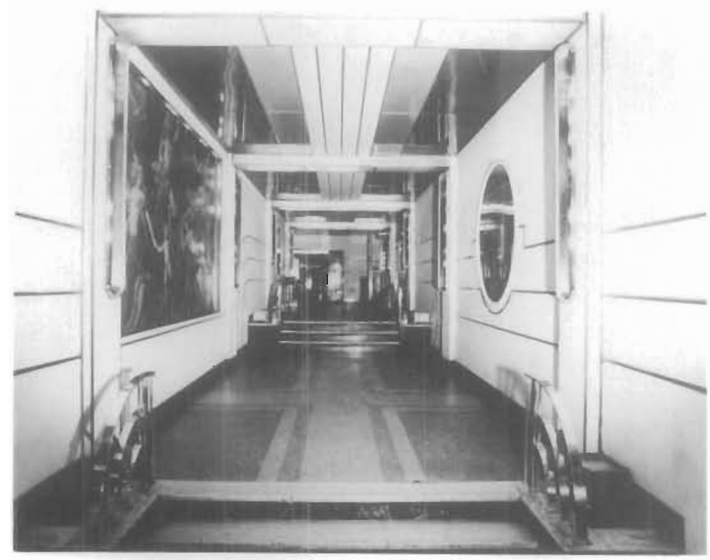


Figure 41. **Brass Wall Trim, Edison Hotel, 228 West 47th Street, New York City; 1929–1930, Herbert J. Krapp, architect.** *Here is a very unconventional use of brass. Thin strips of brass on the walls and ceiling along with mirrors, murals, and chrome-plated railings, all contrast and contribute to the precise composition of this Art Deco interior. (Stan Shaffer)*

Chapter 6: Nickel and Nickel Alloys

Nickel is a hard, silvery-white metal familiar to most Americans because of its use in coinage. However, the U.S. 5-cent piece, commonly called a "nickel," is an alloy of 25% nickel and 75% copper. Canada is by far the world's largest producer of nickel; the United States has only minor deposits in Missouri, Oregon, and Alaska.

Although electroplating with nickel was accomplished as early as the 1840s, the nickel plating industry was not established in America until the 1870s. Although somewhat rare, nickel has been used for plating architectural details, such as religious decorations, letters for signs, and hardware. The copper-plated facade of the cast-iron building designed by Richard Morris Hunt in New York City had sections that were nickel plated. Designed by Long and Kees and completed in 1889, the Minneapolis Public Library (demolished in 1950s) had nickel plated stair railings fabricated by Winslow Brothers Company of Chicago. Architects Hollabird and Root used a stair railing of "flat" nickel for the LaSalle-Wacker Building in Chicago in 1930.

Nickel is more frequently used for building components in the form of alloys: nickel silver, Monel metal, and stainless steel. Today over 50% of the nickel produced goes into the fabrication of nickel-steels and nickel-chromium steels, commonly called stainless steels. The properties and uses of stainless steel will be discussed in a later chapter (see chapter 7).

Nickel Silver

The ancient Chinese developed a nickel-copper alloy called "Paktong," which was first imported to England in the 17th century. Decorative items made from this metal, such as fireplace screens and candleholders, became popular in England and its colonies. In Charleston, South Carolina, the Miles Brewton House has a nickel silver fireplace screen purchased in 1730. By the early 19th century, English and German metalworkers were producing the white metal in their own countries. "Merry's Metal Blanc" was produced in Birmingham and "German Silver" in Berlin. The latter name was in common use until World War I, when the generic term nickel silver replaced it. Both of these terms were misnomers because the alloys contained little nickel and neither contained any silver, but each had a silver-white appearance.

Nickel silver sometimes has been called "white brass" but probably should be termed "nickel brass" because it generally contains 75% copper, 20% nickel, and 5% zinc. Different percentages result in a range of colors and improved properties for specific fabrication methods such as casting or extrusion. Shades of nickel silver can range from silvery-white to pale yellow but can also be produced with a slight blue, green, or pink tone to harmonize with other building materials or to contrast with other metals. For instance the Squibb Building at Fifth Avenue and 58th Street in New York City has a pink-toned nickel silver specially formulated by Anaconda Brass. Designed by architects Buchman and Kahn in 1930, the entrance, elevators, stair railing, and elevator doors were fabricated of nickel silver to harmonize with the warm tones of the lobby's stone veneer.

When nickel silver was cast earlier in this century, a small amount of tin and lead were added and the zinc content was kept below 20% to improve the casting

Figure 42. Nickel Silver Doors, Manufacturers Hanover Trust, 481 Seventh Avenue, New York City, 1930; Sugarman and Berger, architects. *Cast in yellow nickel silver, the Art Deco style doors on this bank look like brass and are in striking contrast to the bronze door surround and red granite walls. (David W. Look)*

properties. The metal was popular for sculpture, decorative panels, plaques, chandeliers, doors, grilles, and railings (figures 42, 43, and 44). The terms *white bronze* and *nickel bronze* were used for cast nickel silver hardware, not necessarily because of the low tin content (2½% to 4%), but because of a cultural preference for the more prestigious bronze.

Nickel silver hardware was popular in the United States during the Art Deco and Depression Modern periods. Architects and designers preferred nickel silver because it could take and retain appropriate finishes, and it resisted corrosion. For the same reasons, cast nickel silver was used for fine plumbing fixtures and water fountains in monumental public buildings, hotels, and even custom-designed homes. It was also usually the base material for nickel-plated fixtures.

Strips of nickel silver have been used to separate different colors of terrazzo flooring. Nickel silver door frames, window frames, and parts of storefronts were usually fabricated from extruded sections that contained 8% to 15% nickel and 40% to 50% copper, with a large percentage of zinc making up the balance. Doors and spandrels, above and below windows, generally were rolled, pressed, or cast. Many companies have produced and promoted nickel silver under numerous trade names, such as "Nevada silver," "Queen's metal," "White metal," and "Wolfram brass." F. B. Howard-White gives a partial list of trade names in his book *Nickel: An Historical Review*.

Designed by architects Schultz and Weaver, the Waldorf Astoria Hotel in New York City is a *tour de force* of nickel silver works. The entrance, fabricated from cast, rolled, and extruded shapes, displays a great variety of color and finishes from white to a brassy yellow and from satin to a highly polished finish.

In addition to its having a wide range of natural color, nickel silver was frequently contrasted with other metals. In the U.S. Post Office Department Building on Pennsylvania Avenue at 12th Street, in Washington, D.C., architects Delano and Aldrich in 1934 set up a progression of color and contrast to achieve a varied design experience. This progression included exterior ornamental doors of bronze; ventilation grilles of nickel silver with bronze stars immediately inside the doors; inner vestibule doors of nickel silver, bronze, and glass; "Pony Express Rider" elevator doors of nickel silver; and identical bronze doors adjacent to the stair tower. The nickel silver used in the building is very white and the bronze is yellow, without a brown statuary patina.

In the first National City Bank in New York City, pale yellow nickel silver is contrasted with red bronze (figure 45). Probably the most elaborate set of nickel silver doors were those of the Goelet Building. The tympanum above these doors used the contrasting colors of nickel silver, copper, bronze, and brass (figure 46).

Two fine outdoor sculptures displayed at the Museum of the City of New York were made of nickel silver containing 16% nickel. The two statues, weighing about one ton each, are of Alexander Hamilton and De Witt Clinton. They were designed by Adolph A. Weinman and cast by the Roman Bronze Works. Today, these statues have a patina similar to the bluish-green color of weathered bronze.

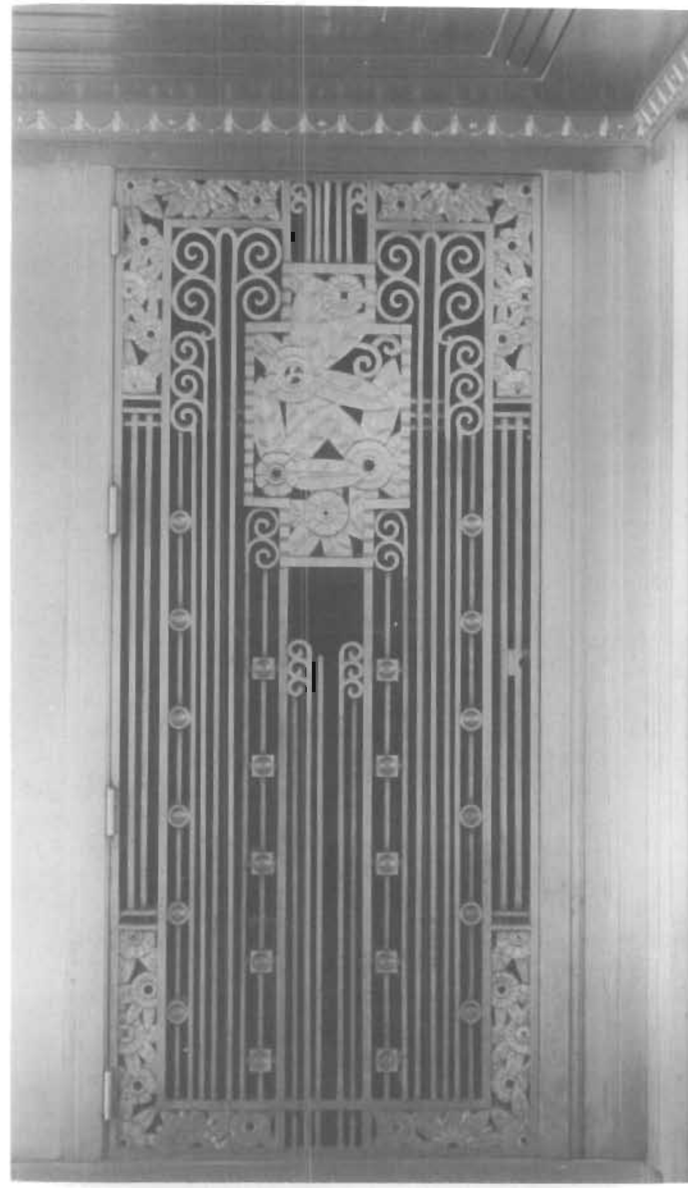


Figure 43. Nickel Silver Art Deco Grille, Chicago Daily News Building (now Riverside Plaza Building), 2 North Riverside Plaza, Chicago, Illinois, 1929; Holabird and Root, architects. *Nickel silver, one of the polished "white metals" popular in the Art Moderne movement, now called Art Deco, was used in this building for radiator grilles, elevator doors, directory cases, and stair railings. (Margot Gayle)*

Nickel silver is still used for a variety of architectural elements, but not as frequently as it was in the 1920s and 1930s. Today only a white alloy of nickel silver is readily available; however, other colors can be custom ordered to match existing original work. For cast nickel silver, manganese is now substituted for tin in the formula.

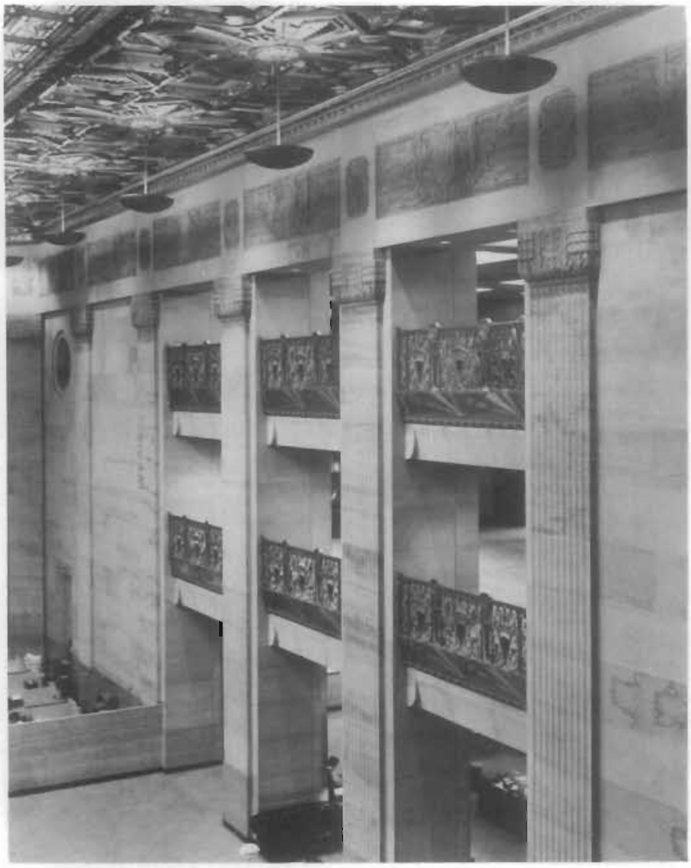
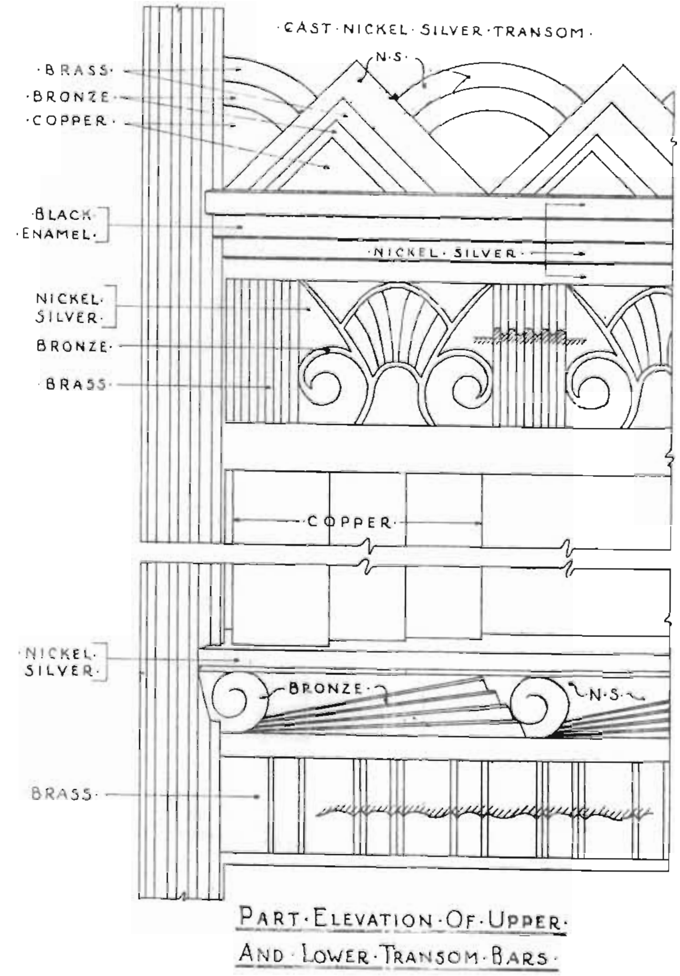


Figure 44. Nickel Silver Railings, Texas Commerce Bank, Gulf Building, Houston, Texas, 1929; Alfred C. Finn, Kenneth Franzenheim, J. E. R. Carpenter, associated architects; Gorham Co., foundry, Providence, Rhode Island. *The doors to the banking rooms, elevators, and shops and all radiator grilles were cast by the Gorham foundry, well-known for its fine art metal work. The nickel silver railings in the lobby galleries reflect the enthusiasm for Egyptian designs in Europe and America following the discovery of Tutankhamen's tomb. (Ed Stewart Photography and Associates, Inc., courtesy of Texas Commerce Bank)*

Figure 45. Nickel Silver Check Writing Desk and Teller Cages, City Bank Farmers Trust Company (now First National City Bank), 6 Hanover Street, New York City, 1931; Cross and Cross, architects. *To achieve subtle definition and emphasis, architects frequently contrasted materials and colors in Art Deco designs. The nickel silver entrance doors and transom (not shown) of this building are accented with red bronze plaques. The grille of the teller windows (background) also has details in bronze, while the desk (foreground) is monochromatic, using only nickel silver. (David W. Look)*

a.



b.

Figure 46. Nickel Silver Doors and Tympanum, Goelet Building, New York City, 1932; E. H. Faile, architect; General Bronze Corp., foundry, Long Island, New York. *(a) This Art Deco-style entrance features silvery-yellow geometric doors which are almost overshadowed by the exuberant swan and fountain design in the tympanum with its array of colorful shapes. (b) The effect was achieved with a combination of copper, bronze, brass, nickel silver, and black enamel as indicated on the original drawing. When the first-floor facade was remodeled in 1966, the doors were removed and stored; the tympanum was taken to Newport, Rhode Island, to be reinstalled in a private club. (International Nickel Company)*

Monel Metal

Monel metal is an alloy of approximately two-thirds nickel and one-third copper. It is not a nickel silver because it consists of more nickel than copper and does not contain any zinc. It is similar to platinum in color.

Until the 20th century, nickel from Canadian mines was sold mainly for the production of nickel silver. Before that, copper-nickel alloys were produced by refining the copper and nickel separately and then recombining them. Later an effort was made to refine the copper and nickel at the same time and produce nickel silver or a metal to compete with it.

Early in 1905, Robert C. Stanley succeeded in driving off the sulphur through a roasting process, and then smelted the copper-nickel ore together to produce a sample of a new nickel-copper alloy. The first bar was stamped "Monell Metal" in honor of Ambrose Monell, then president of International Nickel. When the name was registered as a trademark one "l" was dropped because the law prohibited the use of a family name as a trademark.

Monel metal has been called a natural alloy since the proportion of nickel to copper is the same in the ore and metal; each contains roughly 68% to 72% nickel and 28% to 32% copper. The properties of this new alloy, its methods of production, and its possible uses were studied simultaneously.

Monel metal was ductile, yet stronger than mild steel and more resistant to corrosion from sulfuric acid or saltwater than bronze. In fact, Monel pioneered many of the present uses of stainless steel. The first architectural use of Monel was for roofing of the Pennsylvania Railroad Terminal in New York City in 1909 (figure 47).

Over 300,000 square feet of rolled sheets were used to cover the station. Although the iron and steel bridges and skylights on the roof had deteriorated and were replaced with ones made of Monel in 1936, the roof was still in excellent condition when the building was demolished.

The Chicago Northwestern Railroad Station, also built in 1909, has Monel metal skylights, ventilators, and smoke hoods, features which through the years were exposed to a polluted atmosphere produced by steam engines belching smoke and soot. In 1936 the copper roof on the New York City Public Library at Fifth Avenue and 42nd Street was replaced with a Monel metal roof.

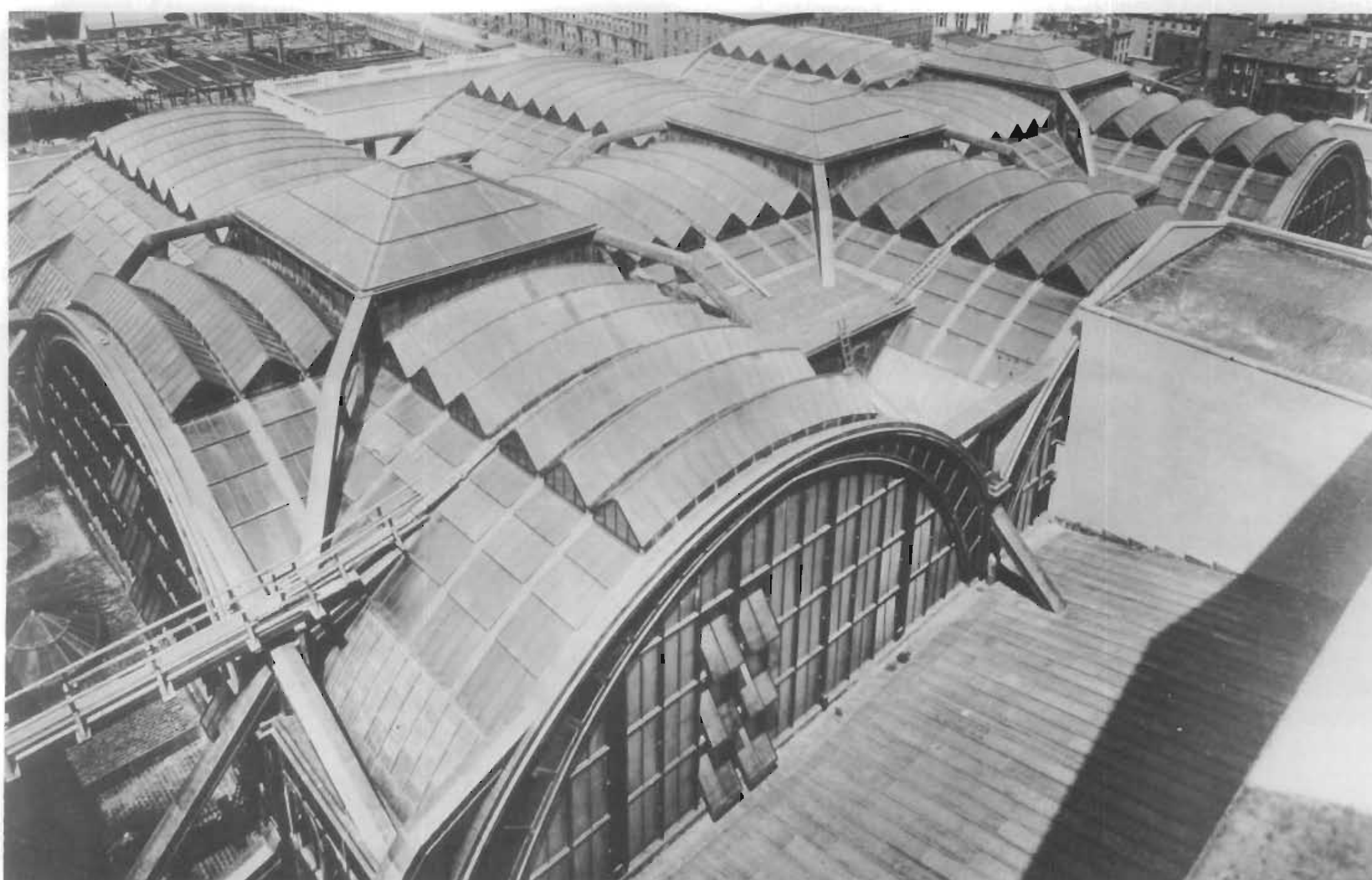


Figure 47. Monel Roof, Pennsylvania Railroad Terminal, New York City, 1907–1910; McKim, Mead and White, architects; International Nickel Company. *The first architectural use of Monel metal was the sheet roofing of the Pennsylvania Station, which was completed in 1909. When the station was demolished in 1965, the Monel roof was in excellent condition, having needed no major repairs since its installation. (International Nickel Company)*

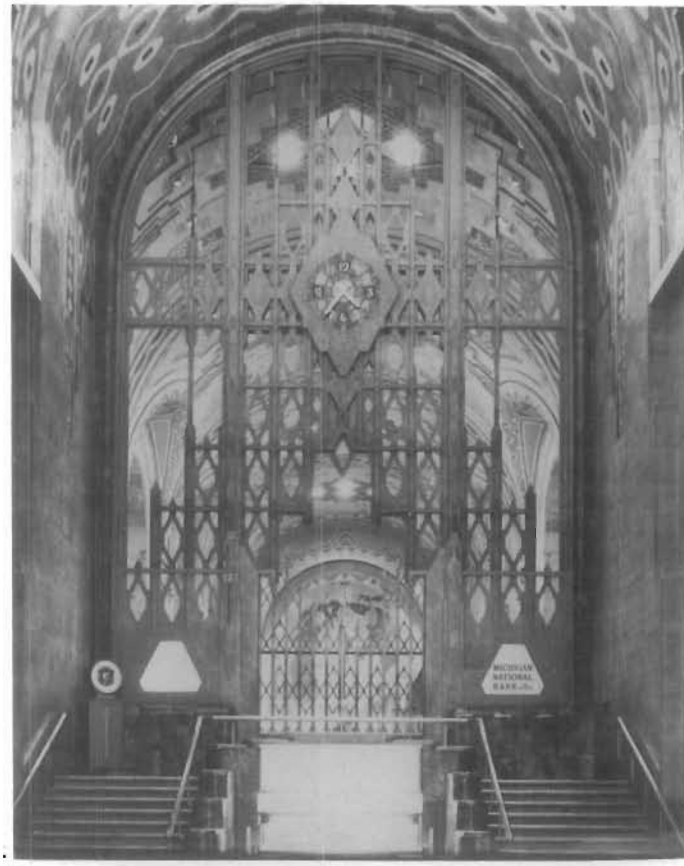
There were several advantages of Monel roofing: it could be brazed, welded, or soldered in place to provide a watertight, continuous cover; it had a low coefficient of expansion and, with proper expansion joints, resisted fatigue failure well; and it could be seamed if desired, using double-lock seams similar to those used for soft metal roofs, such as copper. Monel did not corrode and stain adjacent materials; it was stronger than mild steel, which permitted wider spans and fewer structural supports; and it was durable, permitting the use of lighter-gauge metal sheets. Monel metal flashing has also been used with other roofing materials such as lead as at the National Cathedral in Washington, D.C., and with built-up roofing as at the Pentagon.

Monel metal can be worked by every other method of metalworking except extrusion and joined by every known method of connection. The finishes of Monel can range from highly polished to hammered and sand-blasted, or from etched to brushed. All of the Monel metal doors in the nonpublic areas of the National Archives Building in Washington, D.C., have mirror-like finishes.

Designers in the Art Deco and Depression Modern periods strongly favored the white metals, especially when contrasted with yellow metals such as bronze. Monel metal, like nickel silver, was very popular for decorative exterior and interior metalwork. The Union Trust Building in Detroit is an extravagant example of Monel metalwork (figure 48). A monumental screen of Monel metal separates the bank from the lobby entrance, and all the other metalwork—elevator doors, grilles, gates, teller cages, and check-writing desks—are of Monel.

Artistic effects could be achieved with Monel metal. The sculptural panels on the nickel silver doors of the United Nations Building in New York City were cast of Monel (figure 49). Like bronze, Monel can be etched, as the elevator doors were in the Walker Building in Washington, D.C. (figure 50).

Monel-clad steel was first introduced in 1930, but its use does not appear to have been very extensive, probably because of cost. During World War II, large quantities of nickel and copper had to be diverted to the war effort and the supply of Monel was greatly reduced. After the war, stainless steel and aluminum replaced Monel because of their lower production cost. However, 42,000 pounds of Monel and 42 ounces of gold leaf were used in 1959 to cover the dome of the Georgia State Capitol in Atlanta. The drains, downspouts, and sheathing of the base of the dome were also of Monel. Today Monel metal is still produced, but it is not frequently used in architecture since it is more expensive than stainless steel.



a.

Figure 48. Monel Entrance Screen, Elevator Door, and Tellers' Cages, National Bank of Commerce (now Michigan National Bank), Union Trust Building (now Guardian Building), 500 Griswold, Detroit, Michigan, 1928; Smith, Hinchman and Grylls, architects; Gorham Co., Providence, Rhode Island. *(a) Over 40,000 pounds of Monel metal were used in this Art Deco bank and office building for such features as the Monel clock, two-story grille, gates, railings, and signs of this monumental entrance screen. (b) The design of the elevators was executed in Monel metal and colorful favrile glass from Tiffany. (c) In the banking area, Monel was used for tellers' cages, grilles, gates, check writing desks, screens, and even switch plates. The commercial areas were similarly enriched with Monel. (a and b) Smith, Hinchman and Grylls, architects; (c) Allen Stross, NAER)*

b.

c.

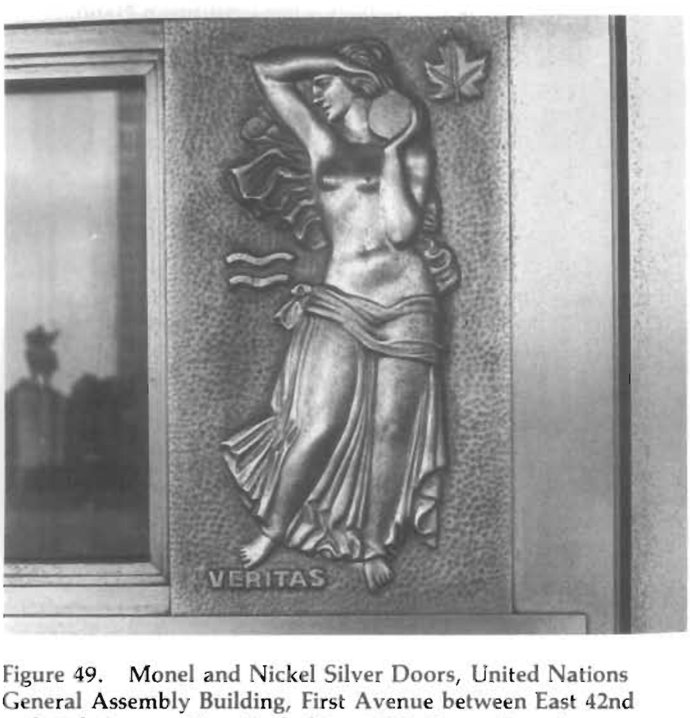


Figure 49. Monel and Nickel Silver Doors, United Nations General Assembly Building, First Avenue between East 42nd and 48th Streets, New York City, 1953; Ernest Cormier, designer, Montreal. *The contrasting pale yellow nickel silver and platinum-colored Monel metal doors were a gift from Canada to the United Nations. The seven nickel silver doors were fabricated from extruded sections by the Anaconda American Brass, Ltd.; and the Monel metal sculptural panels representing Truth, Peace, Justice, and Fraternity were cast by Robert Mitchell Company, Ltd. (David W. Look)*

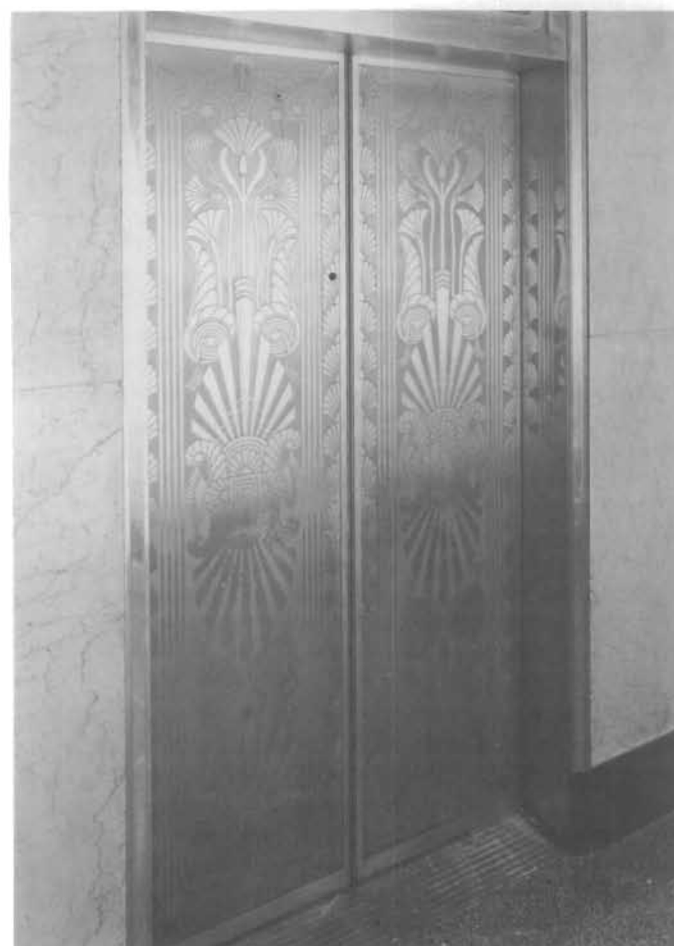


Figure 50. Etched Monel Metal Elevator Doors, Walker Building, 734 15th Street, NW, Washington, D.C., 1937; Porter and Lockie, architects, Baltimore. *The Egyptian Revival design was etched into the highly polished Monel metal doors, providing a subtle decorative effect. (Walter Smalling, Jr.)*