Contents

Chapter 7: Iron and Iron Alloys

The metallic element iron is called *ferrum* in Latin, hence the term ferrous metal for iron and steel. Iron ores constitute approximately one-twentieth of the Earth's surface; it has been known and used by many civilizations through the centuries. The role of iron has expanded from that of a material for tools, firebacks, pots and kettles, wagon rims, nails, cannons, and machines to that of an important architectural building component. It has been used in three common forms—as cast iron, wrought iron, and more recently as steel.

Cast iron was a major 19th-century building material of the Industrial Revolution, while wrought iron was used for minor structural and also decorative elements from the 18th century on. Introduced to the construction industry at the end of the 19th century, steel and its specialized alloys provide some of the basic structural materials for buildings of the modern world.

The tell-tale sign of a ferrous metal is rust. Application of a magnet to a painted or even rusted metal surface will reveal the presence of iron. It is found in a pure state in nature only in meteors. Iron used in construction is usually one of the three principal iron-carbon alloys. The percentage of carbon makes the difference: *wrought iron* contains little carbon (not over .035%); *steel* has a moderate carbon content (between .06% and 2%); and *cast iron* has a high carbon content (2% to 4%).

Wrought Iron

Iron that is worked or wrought at an anvil, or shaped by machines at a larger forge, is called wrought iron. Wrought iron constituted the major use of this metal until around the mid-18th century when in England, and to a lesser degree in France, new technologies increased the production and availability of cast iron. Wrought iron is tough and stringy; it has the elasticity and tensile strength needed for bolts, beams, and girders.

Wrought iron is also remarkably malleable, which means it can be reheated and hot-worked again and again to the desired shape. The more wrought iron is worked the stronger it becomes; it is also easily welded. The final product can be a thing of beauty, as in the case of hand-wrought gates and grilles. It can also be something as simple and utilitarian as a kitchen ladle, a spade, a plow, a fireplace spit, a shoe-scraper for a porch stoop, or a length of fencing.

Until the mid-19th century, the use of wrought iron in buildings was generally limited to relatively small items such as tie rods, straps, nails, and hardware, or to decorative ironwork in balconies, railings, fences, and gates. Around 1850 its structural use became more widespread as iron mills began to roll rails, bulb-tees, and eventually, true I-beams.

Decorative Wrought Iron

American wrought-iron artistry is the direct descendant of centuries of work in this medium in other countries where, besides making utilitarian equipment, the smiths made iron objects that sometimes displayed the quality of jewelers' work. Examples include "chased," carved iron boxes, ornamented by engraving or embossing; elaborate door hinges, locks, and doorknobs; and ingeniously wrought doorknockers. Sometimes the iron objects were "damascened" or inlaid with silver or gold, as in the best armor work.

Fences, gates, railings, and balconies have been traditional architectural uses of wrought iron. The iron combines the strength and ornamentation desired in each of these items. The wrought iron balcony at Congress Hall in Philadelphia (figure 51) was signed and dated by the craftsman, S. Wheeler, in 1788. Wheeler also made and signed the ornate gates of Christ Church in Philadelphia (figure 52). Although such identification became common for cast iron, it was rare for wrought iron.

Toward the end of the 18th century, small castings of rosettes, bows, spearheads, and anthemions—first in lead and later in cast iron—were made as part of wrought-iron fence designs. The influential British architects Robert and James Adam designed composite wrought- and cast-iron fences which became popular, first in England and later in the American colonies. Adam-style ironwork can still be seen in older American cities such as Boston, Philadelphia, and Charleston.

The visual effect achievable with wrought iron ranged from simple, straight, geometric designs to curvilinear, organic designs (figure 53). Since each part is individually hand made, no two are identical. The subtle variation in shape and tool marks adds to the unique artistic expression of each piece of ironwork. In general, wrought iron is light in appearance and uses only enough material to achieve the desired design. In contrast, cast iron usually appears more massive (larger designs were usually hollow but appear solid) with highly repetitive design elements.

Many nonstructural uses of wrought iron were only minimally decorative. Some utilitarian objects such as wrought iron shutters were made of rolled sheets of iron and were quite plain (figure 54).

Figure 51. Wrought-iron Balcony, Samuel Wheeler, blacksmith; Congress Hall, 1787–1789, Chestnut Street at 6th Street, Independence National Historical Park, Philadelphia, Pennsylvania. *Built as the Philadelphia County Court House, this building was used by the Federal Congress from 1790 to 1800. In 1961, the National Park Service removed many layers of paint from the balcony over the front door prior to its restoration. During the process, the name and date "S. Wheeler 1788" was discovered. The inscription was located on the inside of the balcony facing the window. Just a few layers of new paint have already obscured the marking. (Jack E. Boucher, NAER)*

a. b.

Figure 52. Wrought-iron Gates, Samuel Wheeler, blacksmith; Christ Church, 22-26 North Second Street, Philadelphia, Pennsylvania, 1727-1744; attributed to Dr. John Kearsley, builder-architect. *(a) The wrought iron was heated, hammered, bent, and twisted to achieve the various parts of the design. The verticals were split and then bent to form the scrolls, rather than bent and attached to the verticals. (b) Like the balcony on Congress Hall (see figure 51), these gates are signed and dated; "S. Wheeler 1795" appears on the edge of the gate, seen only when the gates are open. (Jack E. Boucher, NAER)*

Decorative work in wrought iron was popular throughout the United States. Beautiful grilles, galleries and stair railings, both interior and exterior, remain from the late 18th and early 19th centuries in many eastern seaboard cities and in towns throughout the South. An early surviving design, the grille on the Old City Hall and Market in Mobile, Alabama, combines wrought-iron woven wire with cast-iron fasteners (figure 55), a technique widely used for grilles and fences.

Later 19th-century buildings display decorative wrought-iron and cast-iron stair railings, porches, balconies, verandas, roof cresting, lamps, grilles, fences, and canopies (figure 56).

At the end of the 19th and beginning of the 20th centuries, there was a rebirth of the crafts in America, of which ironworking was a part (figure 57). Fine artistic expressions were achieved in wrought iron by blacksmiths such as Samuel Yellin in and around the Philadelphia and Washington, D.C., areas (figure 58). Wrought iron was used on every type of building from residences, to Art Deco office buildings and stores. Although most blacksmiths used traditional methods, commercial ironworking firms began to use welding instead of rivets and collars and to use machines to bend and twist bars.

Structural Wrought Iron

In addition to ornamental uses, wrought iron, was also widely used in small-scale structural forms such as the rods or strapwork for strengthening devices in buildings of stone, brick, or wood. The most pervasive use of wrought iron was for hand-forged iron nails, which were used until the 19th century. Craftsmen also devised wrought-iron cramps to hold stone veneer onto brick bearing walls and to anchor wooden elements into masonry walls.

Figure 53. Wrought-iron Fence, Frederick Ames Mansion, 306 Dartmouth, Boston, Massachusetts, 1872; John Sturgis, architect. *This fence was fabricated by hand from iron bars; square and round sections were hot-worked into spirals, circles, and scrolls. Even the fence posts are compact spirals of strong rods shaped about a central support to make them rigid. (Esther Mipaas)*

Figure 54. Wrought-iron Shutters, Arch Street Meeting House, 302-338 Arch Street, Philadelphia, Pennsylvania, 1803–1804; Owen Biddle, architect and master builder. *The shutter is on the window of the "fireproof" vault used to store records. The iron shutter has a frame of hand-forged rectangular bars to which a series of rolled sheets was riveted. (George Eisenman)*

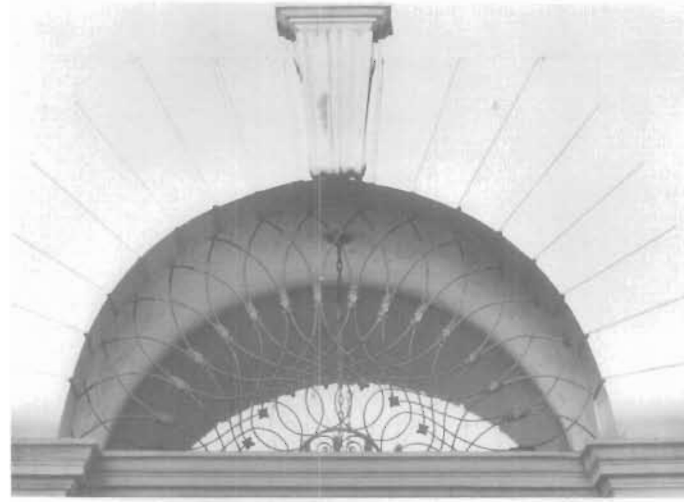


Figure 55. Wrought-iron Guard, Old City Hall and Market, 111 South Royal Street, Mobile, Alabama, 1853; ironwork by J. B. Wickersham, New York City. *Wickersham produced some of the earliest iron foundry catalogues, with his first published in 1855. It was probably through his catalogue advertising that he generated so much later business in the South. Although his catalogues carried everything from iron beds to verandas, his fences were most popular and can be found almost everywhere. Most of these designs were based on his patent for bending bars and then fixing them in place by casting rosettes onto the intersection of the bars. (NAER, Library of Congress)*

Figure 56. Wrought-iron and Glass Canopy, 1734 N Street, NW, Washington, D.C., ca. 1885. *Iron is found in a variety of forms from strap hinges to fragile glass and iron combinations—such as the canopy protecting the entrance of this elegant townhouse. Glass panels were set in an iron frame with fleurs de lis on the front edge and flourishes as supporting brackets. (David W. Look)*

Figure 57. **Wrought-iron Door, Joslyn Castle, 3902 Davenport Street, Omaha, Nebraska, 1902–1904; Winslow Bros., foundry, Omaha.** *The one-ton iron door to the entrance hall of this Scottish baronial-style mansion is precison balanced and swings easily. A hand-forged wrought-iron grille consisting of scroll and vine motifs is set in Gothic cast-iron framing. (Robert Peters)*

Figure 58. **Wrought-iron Entrance Gates, Packard Building, southeast corner of Chestnut and 15th streets, Philadelphia, Pennsylvania; 1924, Ritter and Shay, architects; Samuel Yellin, artist and blacksmith.** *In the 20th century, the name Yellin stands for excellence in ironwork in America. Although he called himself a blacksmith, he was much more—an artist with iron for his medium. An immigrant from Poland, Yellin executed most of his major commissions between 1920 and 1940. He used every method of metalworking—cutting, splitting, twisting, scrolling, punching, incising, repoussé, and banding—to achieve unique designs. (David W. Look)*

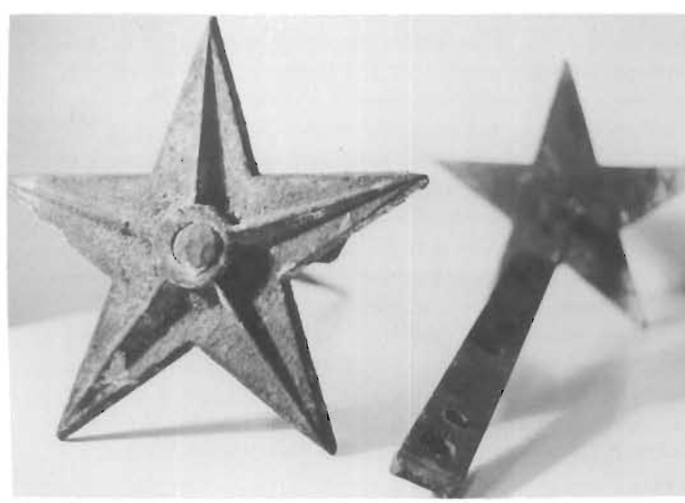


Figure 59. **Wrought-iron Tie Rods with Cast-iron Star Anchors.** *Wrought-iron tie rods were added to buildings to prevent the walls from buckling or separating from interior walls. The rods were bolted to cross beams or to a parallel masonry wall. They were always made of wrought iron to take tension. To prevent horizontal forces from pulling the tie rods through the wall, they were connected to cast-iron stars, rosettes, or "S" anchors on the outside of the wall. The anchors, which spread the force over a greater area, were the only visual evidence of the presence of the tie rods. As a precaution, tie rods and anchors were sometimes included in original construction; but the more usual use was their addition when an outer brick wall began to lean or buckle. The addition of a tie rod could not bring the wall back to its original vertical alignment, but it prevented the wall from moving further. (David W. Look)*

Often the hidden iron bars, straps, pins, U-shaped bridle-irons, and tie rods are revealed only at times of alteration or demolition. Star-shaped anchors on the exterior brick walls of old buildings mark the location of wrought-iron tie rods, sometimes called straps, which may be tied to wooden joists inside or may run through the structure to hold the wall in plumb. Often the anchors, which are of cast iron, take the form of stars, but they may be S-scrolls or fancier devices (figure 59). Occasionally tie rods are visible and are even ornamented, as in the Trolley Station in Seattle's Pioneer Square (figure 60).

Wrought-iron rods were universally used in mid-19th-century wooden and iron trusses for buildings and bridges where the structural member was put in tension. Also, flat link chain and cables of early suspension bridges were made of wrought iron (figure 61).

Cast-iron bow-string trusses with wrought-iron tension members were fabricated by John B. Wickersham in New York, for the Harper Brothers' printing plant with its block-long cast-iron facade, which was erected in 1854. Early that year, Peter Cooper produced in his Trenton, New Jersey, foundry the first large wrought-iron rail beams, which also went into Harpers' innovative building. Both the 7-inch-tall bulbed-T rails, so called becaused of their shape (the "Cooper Beams"), as well as the 8-inch "I" beams first rolled by Cooper and Hewitt about 1855, were eminently suitable for interior metal framing of large buildings (figure 62).

Soon iron beams were in great demand. John Jacob Astor wanted them for his new library on Astor Place in New York City. The beams were the prototypes of new, mass-produced framing for the trend-setting "elevator buildings" that architects were building taller than the traditional five- and six-story walk-ups. This usage lasted for several decades, certainly well after steel was available. The use of structural wrought iron gradually came to an end as the qualities of structural steel became apparent and as steel was produced in quantity.

From 1855 to 1890, the most frequent structural combination was rolled wrought-iron beams for the horizontal members with cast-iron columns for the vertical members. A great many commercial and public buildings were constructed with this type of framing, for example, the 16-story Manhattan Building, designed by William LeBaron Jenney in 1840, and still standing in Chicago's Loop.

The old Custom House in Wheeling, West Virginia, is an interesting pre-Civil War example of this. The specifications prepared in 1856 by Ammi B. Young, then Supervising Architect of the U.S. Treasury, called for a great deal of iron in its construction, although this is not evident in its three-story limestone exterior. Cast-iron columns and wrought-iron beams support the segmental brick arches which comprise the fire-resistant floor system and a corrugated iron roof that covers the building. Two-hundred thirty-eight iron beams and 44 iron girders for the building were ordered from the Trenton Iron Works of New Jersey.

Wrought iron served as a major structural material in the United States for more than 30 years. Its manufacture was always tedious, as production demanded exhausting labor even after the mid-19th century, when large rails and beams could be produced mechanically. In 1856, scarcely 3 years after the advance in the rolling of wrought iron, Henry Bessemer in England demonstrated his new means of steel production. About a decade later, William Siemens and his brothers devised their open-hearth steel-making process. Together, these British advances paved the way for the mass production of steel at a moderate cost.

Nonetheless, many American public buildings, particularly those from the period just after the Civil War, have structural wrought-iron framing. Today, very little wrought iron is produced and almost all that is sold as wrought iron is really mild steel.

Figure 60. **Iron and Glass Pergola, Trolley Station, Pioneer Square, Seattle, Washington, 1909.** *This station, which has become a symbol of the revival of the city's old commercial area, consists of glass panes held between ribs of wrought iron supported by cast-iron arches and columns, both of which are in compression. The wrought-iron tie rods (top of photo) take the outward thrust of the arches; thus, the rods are in tension. Iron members in tension had to be made of wrought iron because cast iron is suitable only for compressive loads. However, iron members in compression could be of either cast iron or wrought iron, whichever was more economical and convenient for the iron shop to fabricate. By the late 1960s, most of the glass in the pergola was broken and the iron was rusting. Preservationists, planners, and city officials worked together to rehabilitate Pioneer Square with the pergola as its centerpiece. Wooden patterns were carved from which sand molds were made to recast the lost and broken iron parts. With new lamps and fresh paint, the pergola was rededicated in 1973. (John Jochman, Seattle Office of Historic Preservation)*

Figure 61. Suspension Bridge, Public Garden, Boston, Massachusetts, 1867; Elemens Herschel and William Preston, engineers. *Popular among Bostonians, this small suspension bridge originally consisted of plank flooring hung from chains made of flat wrought-iron links. In 1921 the bridge's deteriorated wood was replaced with steel beams; the bridge was reinforced in 1975 with more steel and concrete. Although the deck has been replaced, the masonry piers and the chains hung between them are still largely original. (Carleton Knight, III)*

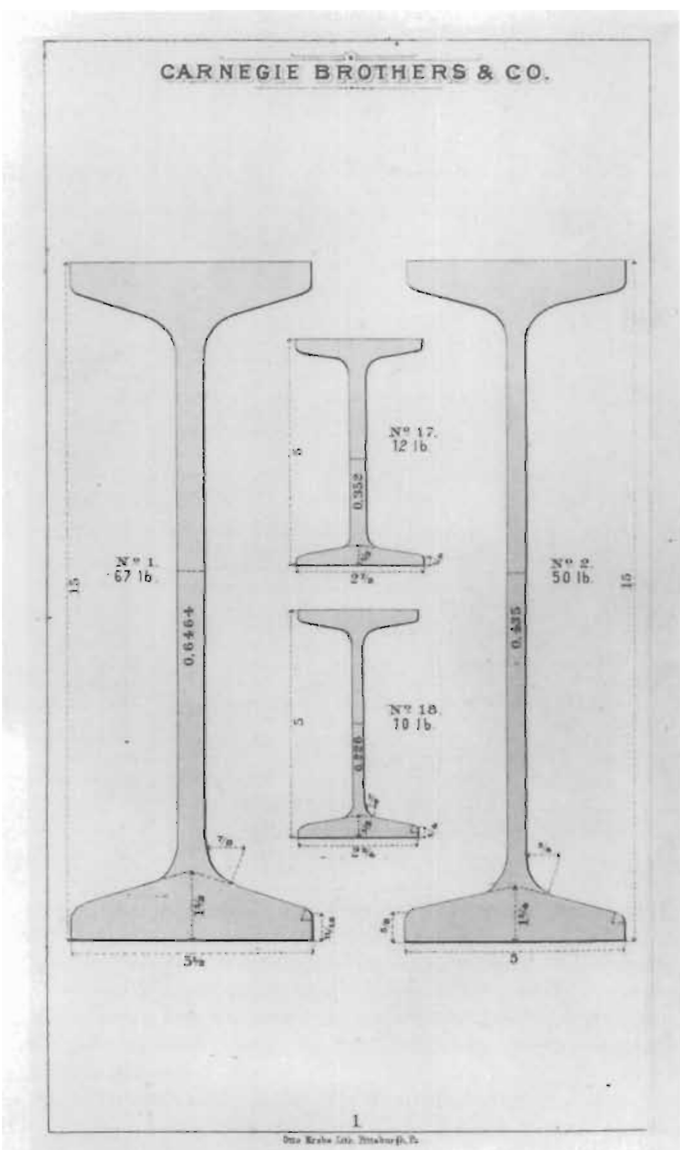


Figure 62. Wrought-iron Beams, Carnegie Brothers and Company's Pocket Companion . . . , 1876. *The earliest known wrought-iron handbook of wrought iron structural shapes was published by Carnegie Kloman and Co. in 1873, some 18 years after the first wrought-iron I-beams were rolled in the United States by the Trenton Iron Works, founded by Peter Cooper. Copies of the 1873 handbook are quite rare; however, the Library of Congress has a copy of the 1876 handbook of Carnegie Brothers and Co. The* Iron and Steel Beams: 1873 to 1952, *published by the American Institute of Steel Construction, Inc., is a valuable resource book because it documents the handbook dates, the sizes, weights, and properties of all rolled beams during this period. The largest beam in the 1873 handbook was 15 inches deep and 67 pounds per lineal foot, the same as the beam shown in this illustration at the far left. (Library of Congress)*

Cast Iron

Perhaps no metal is more versatile than the ferrous metal known as cast iron. Between the mid-1700s and the mid-1800s, improved technology for the production of cast iron increased the supply greatly, while the expanded technology for its use led to its full exploitation in architecture and engineering.

Cast iron is very hard and, because of the flakes of carbon it absorbs during production, it is brittle. At the same time, it is remarkably strong in compression—the reason it would be the standard choice for structural columns for over a century. Cast iron is much weaker in tension than in compression, thus it is not appropriate for structural beams. There are examples of disastrous failures of some overburdened cast-iron beams.

The first bridge of cast iron, completed in 1779 over the River Severn in England, gave its name to the adjacent community, Ironbridge, in Shropshire. All of the cast-iron arches are in compression. The bridge still stands and has been restored recently. Shortly before 1800, structural cast-iron columns were first used in the construction of multistoried factory buildings in England, especially for textile mills. The new iron columns were fire-resistant and strong, allowing for increased distance between columns, thus providing more floor space for looms and other machinery. In domestic buildings, the increasingly available cast iron was made into iron stoves and firebacks for improved heating, into pots and smoothing irons and into iron pipes to conduct water.

At first, English technology predominated, even in America. Many finished iron products were exported to the colonies, but numerous iron casting works were established in New Jersey, Pennsylvania, and Massachusetts before the Revolution.

After the Revolution, many blast furnaces were built which could remelt pig iron (refined iron poured into crude molds to form bars) and form castings in varied shapes. Typical of the work being done was that of New York founder Peter Curtenius who announced in the *Daily Advertiser* of October 17, 1787, that he could make many household items and save the purchaser "the duty of £6 being laid on foreign casting." He and many other founders saw a ready market for the Franklin-type open and closed stoves as well as other heating equipment, machine parts, wagon and other vehicle components, and cooking utensils. In the early decades of the 19th century, these foundries began to turn out cast-iron fencing, fence posts, and simple cast-iron columns for building purposes.

Structural Cast Iron

Columns

Builders started using cast-iron columns instead of the standard timber mill-type construction in early-19th-century industrial buildings. The oldest part of the Middle Mills near Utica, New York, erected in 1825, exemplifies this. The three-story mill with basement was an early example of the American industrial framing system following English models—a combination of iron and wood that would be widely used for more than a half a century. On each level there was a double row of 12 slender 11-foot-high fluted iron columns. There is no record of where these iron columns were cast. However, they supported wood girders and joists that held floors laden with machinery until recently when the mill was vacated. In the mid-19th century, the framing system became one of cast-iron columns with wrought-iron beams; wood beams were eliminated in favor of the stronger iron.

William Strickland was one of the first American architects to use cast-iron columns. In 1820 he employed them in Philadelphia's Chestnut Street Theatre to support three rows of box seats. A similar treatment was used later by architect Benjamin Latrobe in the gallery enlargement of St. John's Church, opposite the White House in Washington, D.C. In both cases, the new

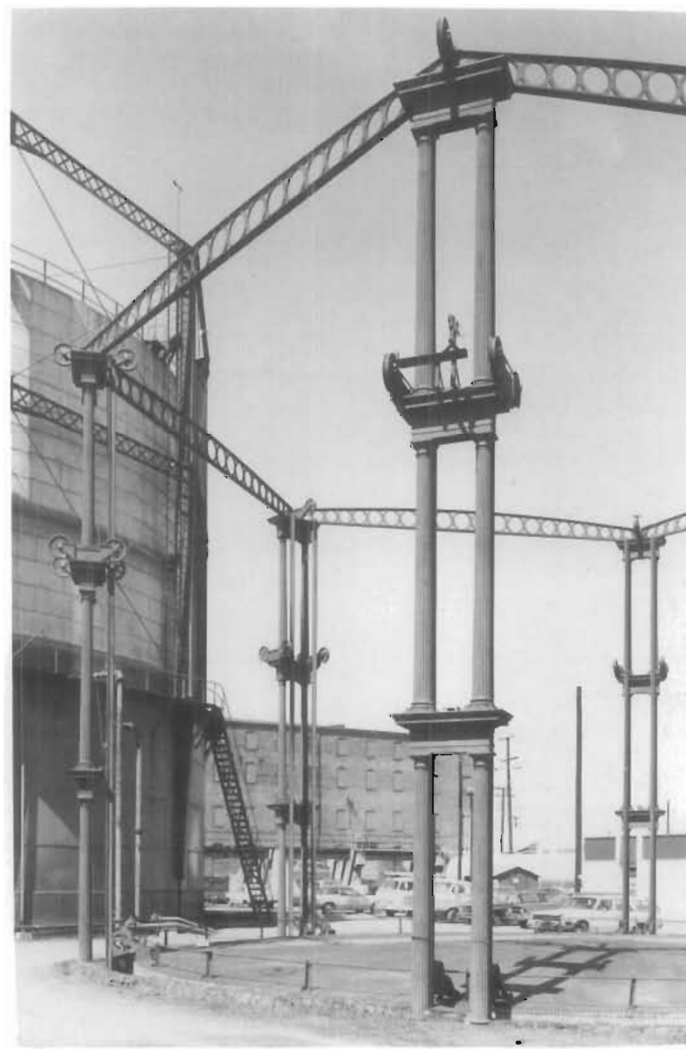


Figure 63. Cast-iron Gasholder, Petersburg Gaslight Company, Petersburg, Virginia, 1851-1852. *The Greek Revival style gasholder has six pairs of slender Doric columns three tiers high which served as "guides" for the expandable tanks. Cast-iron horizontal members, which provided stability and carried only their own weight, are widest at the centers to resist bending. In this case the top of the beam is in compression and the bottom is in tension. To reduce weight, the beams were perforated with circles graduated in size toward the ends. (Jack E. Boucher, NAER)*

material was strong enough to be used sparingly, permitting a larger seating capacity and better sight lines for the audience.

In 1833, the U.S. Naval Home in Philadelphia, another Strickland design, was opened. The two-tiered verandas were supported by hollow cast-iron columns, 8 inches in diameter, and the iron railings were a lattice of thin-woven wrought-iron strips strengthened with small rosette shaped cast-iron clamps.

Cast-iron columns (figure 63) were often secured from small local foundries. Later, if they could not be procured locally, they were ordered from catalogues published by a number of large firms, such as James L. Jackson Ironworks and Architectural Iron Works, New York (figure 64), Buffalo Eagle Works, and Tasker and Co., Philadelphia.

Building Fronts

In the last century, cast iron was used for building fronts (figures 65 and 66). Its function was both decorative and structural. The ironwork could comprise the entire facade or only the first-floor level (figure 67). It could support its own weight and part of the floor system when used in a building on a corner lot.

As early as 1825 there were cast-iron storefronts in Manhattan. An advertisement appeared in the *New York Evening Post* on March 29 of that year which told of two buildings under construction and soon to be available for rent that had ground floors, or storefronts, constructed of cast iron and upper stories of brick. The buildings stood on the south side of Burling Slip which was the waterside end of John Street at the East River. They were mid-block between Water Street and Pearl Street near the Seventh Ward Bank.

"Store to Let: The subscriber is now building two handsome four story brick stores with iron fronts three doors from Pearl Street in Burling Slip. They are intended for the dry goods or hardware business and will be let from the first of May next. For terms apply to: Richard Patten, Corner of Burling Slip and Water Street."

Buildings with iron fronts, like buildings with expensive stone fronts, displayed these facades to the street only. Behind the facades, the structures usually had walls of brick and floor systems of wood (figure 68).

The full iron front and the one-story iron storefront were American-type commercial structures not found, to any great extent, in other countries. Significant iron front buildings can be found in Louisville, Kentucky; Montgomery, Alabama; Galveston, Texas; Binghamton, Rochester and Cooperstown, New York; Baltimore, Maryland; Portland and Salem, Oregon (figures 69 and 70). Once there were many more of these serviceable and decorative commercial buildings, but thousands were demolished in the 1950s, 1960s, and early 1970s in urban renewal clearances of old business districts.

Virtually all cast-iron front buildings were erected during the mid- to late 1800s. In the late 1840s, James Bogardus introduced the cast-iron facade as a new building type and as a system of prefabricated "fireproof" construction. Although cast iron was known to be non-combustible, it was soon learned that it was not "fireproof." Columns, panels, and decorative elements were

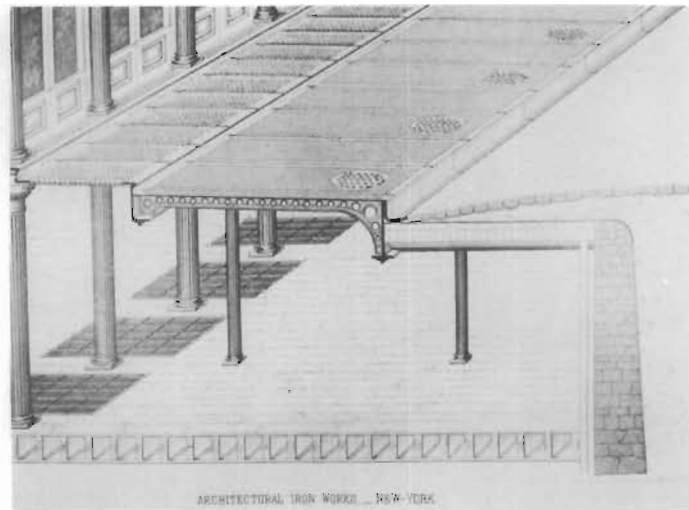


Figure 64. "Elevation and Section of Sidewalk Showing Vault Under Street," Plate LXXXIII, no. 45, from Daniel D. Badger's 1865 Catalogue, The Architectural Iron Works of New York City. *The basement areas of 19th-century commercial buildings often expanded into the space beneath their sidewalks and occasionally out under the street. To make this possible, heavy cast-iron columns carried the facade of the building, while additional cast-iron columns supported the sidewalk and vault roof. Getting daylight into the cellars or vaults required imaginative engineering, since lighting with gas or kerosene presented hazards in these enclosed spaces where ventilation was limited and the possibility of fire was ever present. The ingenious invention of the "vault light" Theodore Hyatt patented in 1845—a sturdy type of iron grating plugged with chunky glass blocks—allowed natural light to filter through the sidewalk into the basements yet provided a surface rigid enough to support pedestrian traffic. Such glazed grilles eliminated the need for basement window areaways and allowed passersby to step close to shop windows to examine merchandise. Vertical panels of vault lights were often set into foundations. Library floors and whole staircases were fabricated with this system. (Avery Library, Columbia University)*

cast, polished, checked for fit and given a protective coat of paint in the iron foundry. Then they were shipped as separate pieces to the construction site and bolted together to form an entire facade of iron. Assembly of the prefabricated pieces was much faster than traditional construction methods allowed. Often the foundry cast its name on a facade element, usually on the base of a column, pilaster, or pier (figure 71).

Such prefabricated iron facades could be made in numerous shapes and sizes, reflecting a wide range of architectural styles. Although some were very ornate, they were far less expensive than carved stone facades. To imitate stone, sand was stirred into paint of neutral stone colors to produce a stone-like texture on the cast iron. As cast-iron building designs became less imitative of stone buildings, more imaginative and varied color schemes were used. However, after the Columbian Exposition of 1893 in Chicago, popular taste returned to the more conservative stone colors.

Figure 65. **Cast-iron Haughwout Building, 490 Broadway, New York City, 1856; John P. Gaynor, architect; Daniel D. Badger's Architectural Iron Works of New York City.** *Some of the best iron front buildings stand in the SoHo area of the city. There are excellent examples of the quality and character of mass-produced 19th-century ironwork. Once foundry patterns were prepared, any number of like building fronts could be cast. The facade of the Haughwout Building consists of a single module, Palladian in character, repeated again and again. The result was an impressive design at a moderate cost. (Clover Vail)*

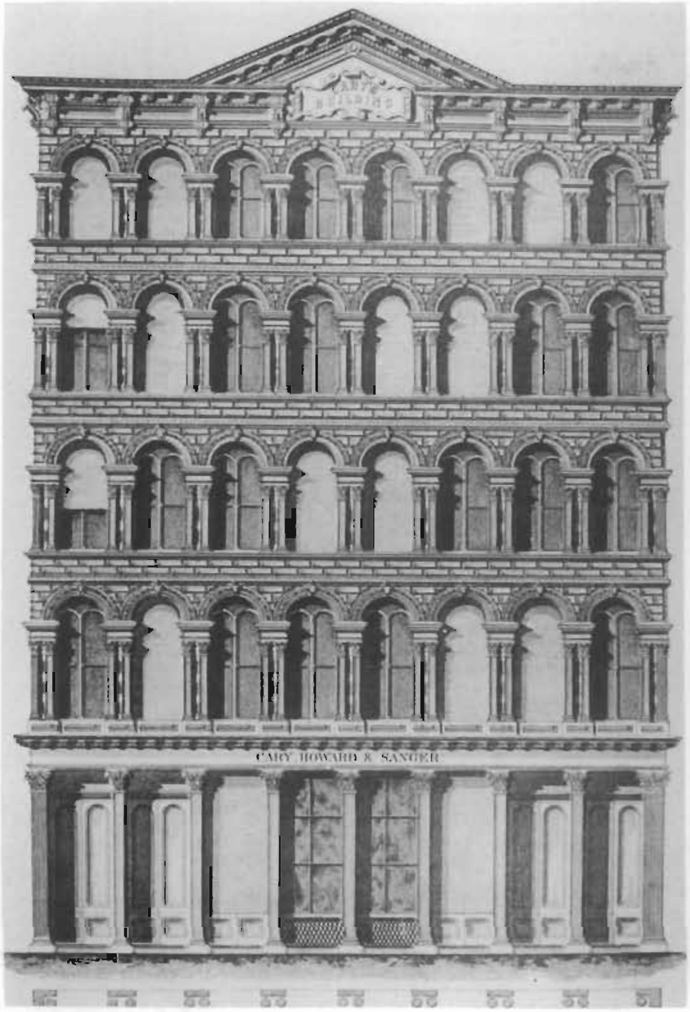


Figure 66. Catalog Illustration, Cary Building, New York City, 1856; John Kellum, architect; Daniel D. Badger's Architectural Iron Works of New York City. *This iron front design depicted in the 1865 catalog of Badger's foundry is still standing in downtown Manhattan. Although the iron is scored to look like ashlar, the slender freestanding colonettes between the windows reveal that the facade is metal, not stone. Many of the rolling metal shutters at the windows have been pulled shut. Badger sold rolled iron shutters before he started promoting cast-iron storefronts. (Avery Library, Columbia University)*

Figure 67. One-story Cast-iron Storefront, 75 Main Street, Cold Spring, New York. *This modest facade is typical of cast-iron storefronts popular for decades after their introduction about 1825. Fabricated by both small local foundries and large nationally known companies, storefronts were available in a variety of styles and sizes, and could be ordered from catalogs. The slender piers and columns could support the weight of several stories, usually masonry, while providing the framework for broad expanses of glass. The open front was perfect for the display of merchandise. (Otto Verne)*

Figure 68. Cast-iron Facade, Capital Hotel (originally the Denkla Office Building), 117 West Markham Street, Little Rock, Arkansas, 1873. *The Italianate office building was converted in 1877 into a hotel. Being located near the state capitol, it became popular with politicians and was often used as campaign headquarters. Note the difference in window size in the facade and the masonry sidewall. The larger windows of the cast-iron front provided a great deal of natural light, which the building's original use (offices) required. Although not apparent from a distance, the top story of the front facade and the cornice are pressed sheet metal, probably galvanized iron. (Earl Saunders)*

Figure 69. Iron Front Hildebrand Building, 730 Main West Street, Louisville, Kentucky, 1884; Charles D. Meyer, architect. *The elaborate iron front of this five-story commercial building in the old downtown section exemplifies the advantages of cast-iron construction. The tall iron columns and colonettes between windows, slender as they are, take the weight of the materials, allowing large openings and light rooms. Iron manufacturers linked the technical requirements of their material with aesthetically appealing design, a fact which is evident even in this unrestored building. (John Albers and Preservation Alliance)*

Figure 70. Ladd & Bush Bank (Branch of the U.S. National Bank of Oregon), 302 State Street, Salem, Oregon, 1869, Willamette Iron Works; addition by Skidmore, Owings and Merrill, 1967. *The elaborate iron elements of this bank in Salem were a near twin to the Ladd and Tilton Bank in Portland, also cast by the Willamette Iron Works in 1868. When the latter was demolished, its iron facade was saved and later used for expansion of the Salem bank. Additional parts were cast as needed by the original foundry. Note the bronze doors which were added in 1912. (Donald Sipe)*

The U.S. Army owns one of the most remarkable iron buildings in existence, it is nearly *all* iron. The structure was erected just before the Civil War to serve as a gun carriage storehouse. Measuring some 100 by 200 feet in size, it is located at Watervliet Arsenal, an Army installation on the Hudson River opposite Troy, New York (figure 72).

Domes and Cupolas

Even the most cursory look at the significant mid-19th-century public structures is enough to see how widely iron was used. The Old St. Louis Courthouse has an iron dome which predates that of the U.S. Capitol (1859-1862). It has iron elements from top to bottom. Although the building suffered two fires and underwent several alterations, the iron has survived intact. Architect William Rumbold's plan for the Italianate style iron dome, submitted in December 1859, called for strengthening the existing structure to receive it. He replaced stone columns with cast-iron replicas to support the first gallery in the rotunda. The second and third galleries have 20 slender cast-iron columns alternating with wooden columns painted to look alike (figure 73). This columnar system ran up through the building to the drum of the iron dome, which it supported. The drum itself consisted of a ring of iron columns with Italianate windows between them.

The great dome of the U.S. Capitol, completed in 1865, is the most monumental example of cast-iron architecture in America. Thomas U. Walter, Architect of the Capitol, designed the Renaissance style dome and engineer Montgomery C. Meigs made erection of the dome technologically feasible and supervised its construction. Several iron foundries handled the casting work; innumerable iron pieces were bolted together—smaller assemblies at the foundry, larger ones at the site—to create the pie-shaped sections, curving from base to tip, that form the exterior "skin" of the big dome.

The highly decorated skin was laid over a daringly conceived armature of 36 main radial ribs, each an open-web truss made up of 10 iron sections. These massive trusses can withstand the driving force of winds and the expansion and contraction resulting from temperature changes. The dome of the Capitol stands on an iron drum which is ringed by a peristyle of iron columns cast in Baltimore. Except for the bronze statue of Freedom at its apex, all of the dome structure above the roof of the center pavilion, in both framing system and covering, is iron (figure 74). The influence of the U.S. Capitol's design can be seen in the many state capitols which display Renaissance style domes. Some are totally of iron, while others are sheathed with copper.

Many city halls and county courthouses throughout America have cast-iron domes and cupolas. Built shortly after the U.S. Capitol dome and probably influenced by it, the Baltimore City Hall's cast-iron dome was recently restored (figure 75). The cupola of Brooklyn's Borough Hall burned in 1895; when it was rebuilt, the original wooden cupola was reconstructed in cast iron and sheet metal (figure 76).

Figure 71. **Foundry Label: "BARTLETT, ROBBINS & CO., ARCHITECTURAL IRON WORKS, COR. SCOTT & PRATT ST., BALTIMORE, MD."** *Foundries often attached labels to their work, a tradition started by bronze founders. A combination of pride and promotion, foundry labels can be found on architectural ironwork all over the country. This label appears on a building in downtown Baltimore. For some years the firm's name was Hayward, Bartlett and Co., under which it cast iron fronts for an attractive row of stores in Richmond, Virginia, recently restored as an office building. (David W. Look)*

Light Courts and Skylights

Before the introduction of electric lighting, it was difficult to illuminate adequately the interior spaces of large public buildings. Many 19th-century capitols, city halls, and other large structures, such as the Library of the Peabody Institute in Baltimore (figure 77), were designed to include ornamental light courts to bring natural light into the core of buildings. These three- or four-story-high spaces were covered by iron and glass skylights. Cast-iron columns typically supported these gallery-like openings in the floors.

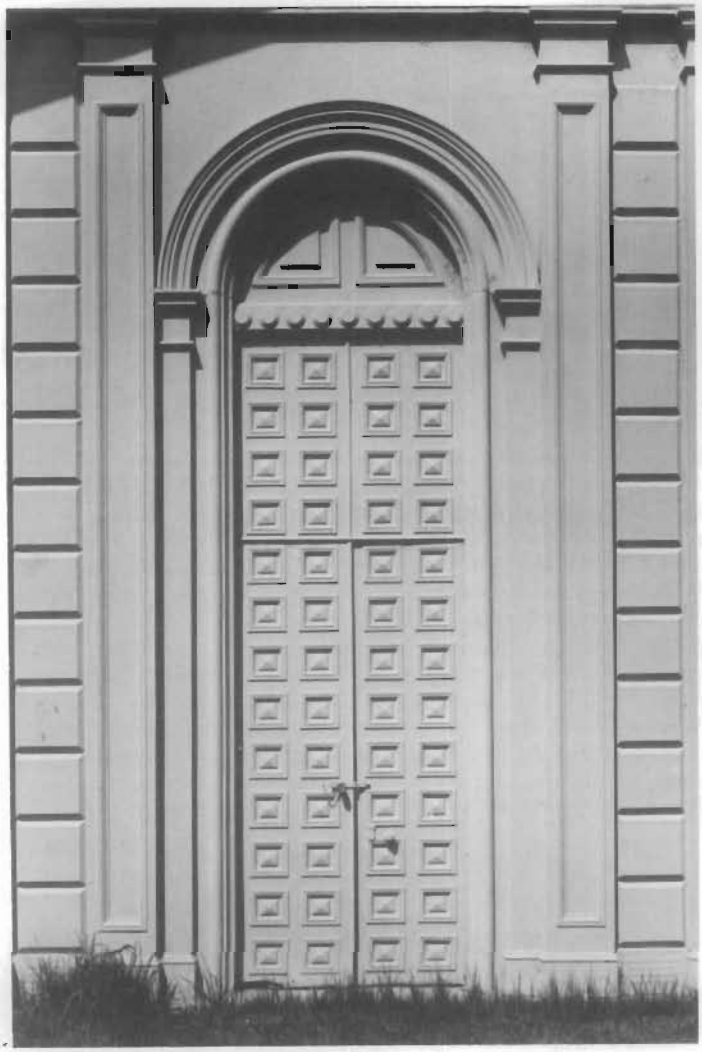
Richmond, Virginia's, Old City Hall was designed in 1882 by Elijah E. Meyers, architect of many public structures. The interior is almost entirely of cast iron, including cast-iron columns, galleries, and a monumental staircase (figure 78). The center hall rises to the skylight roof in 4 levels of Gothic pointed arches set on squat cast-iron columns resembling heavy stone.

In Burnham and Root's Rookery Building in Chicago, offices were wrapped around a large light court with an iron and glass skylight just above the foyer (figure 79). The upper floors surrounding the light court look onto an unroofed light well. Los Angeles' Bradbury Building is another instance of filigree cast-iron balustraded galleries (which serve as open corridors) and iron and marble stairs rising five stories. The entire light court is covered with an iron and glass roof (figure 80).

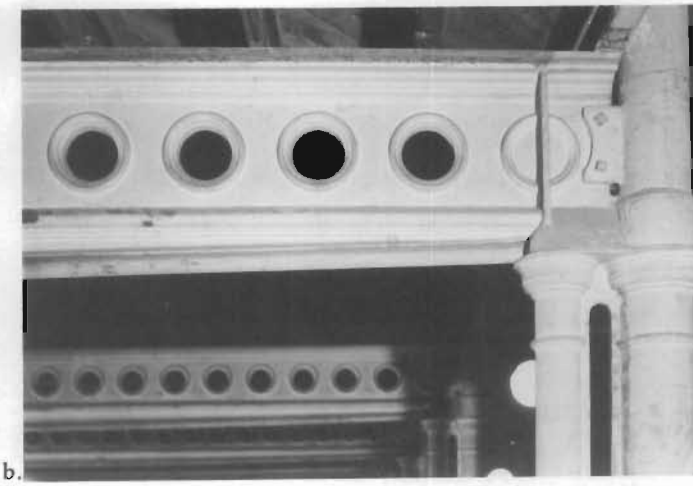
Decorative Cast Iron

Stairs and Elevators

Cast iron had immediate applicability as a fire-resistant material for use on interior stairs. There had been numerous catastrophic fires involving wooden stairs and the only alternative, stone, was too expensive and heavy to be practical. So, with the introduction of cast iron for building purposes, it was soon adopted for interior use on stairs and other elements with repetitive designs.



a.



b.

Figure 72. **Cast-iron Personnel Door (south elevation) and Girder-Column Detail (interior), Watervliet Arsenal, New York, 1859; Daniel D. Badger's Architectural Iron Works of New York City.** *(a) This military storehouse is the most nearly all-iron building in the United States: the walls, window frames, doors, and columns are all cast iron, and the roof trusses are wrought iron. Built as a "fireproof" warehouse for ammunition storage, this classical Greek and Roman building was cast in sections at Badger's foundry and shipped by barge up the Hudson River to be assembled on the foundation in less than three months. (b) The detail shows a cast- and wrought-iron girder connected to a cast-iron column. The cast-iron part of the girder, the top three-quarters, is perforated to reduce the weight of the load and slightly arched to take compressive stresses. The wrought-iron part is at the bottom of the girder to take tensile stresses. (Jack E. Boucher, NAER)*

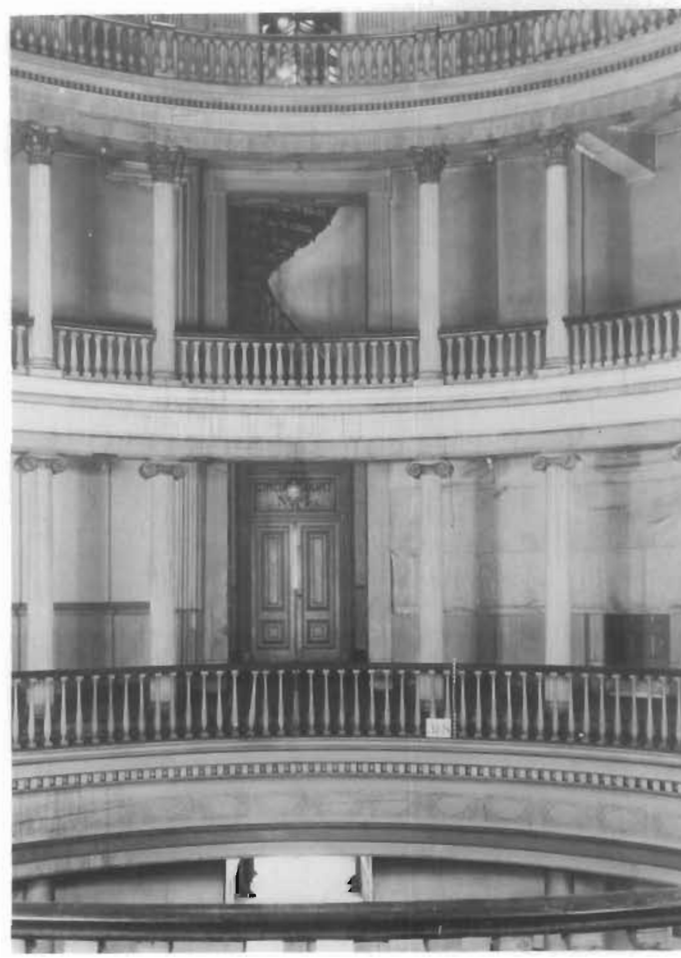
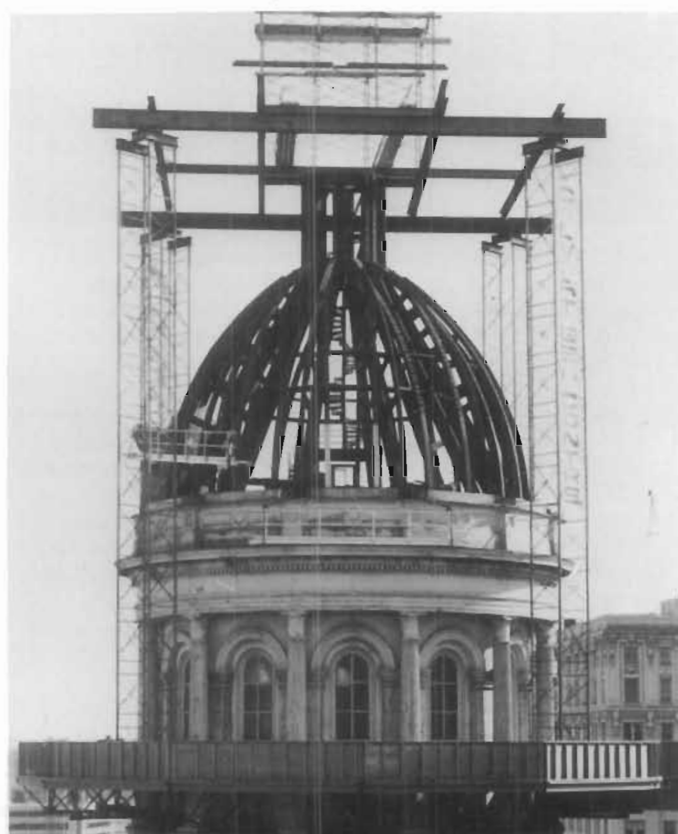


Figure 73. **Rotunda Galleries, Old St. Louis Courthouse, Fourth and Market Streets, St. Louis, Missouri, 1859 expansion; William Rumbold, architect.** *The courthouse has many iron elements, including the intricate elliptical cast-iron staircases in the wings and half of the Ionic and Corinthian columns which support the rotunda galleries. Every other column is wood. The cast-iron columns were added to take the increased load of the dome, a major feat of engineering and architectural design. William Rumbold accomplished the detailed engineering of the dome between 1859 and 1862, one and one-half years before the dome of the U.S. Capitol was completed. (Piaget, NAER)*

Figure 74. Stairs between the Inner and Outer Domes, U.S.Capitol, 1856–1865; Thomas U. Walter, Architect of the Capitol; Montgomery C. Meigs, engineer. *The double shell dome construction is supported by 36 radiating, arched trusses. In this view of the stairs to the lantern, every element is cast iron except the wrought-iron tie rods and bolts. To the right is the back side of one of the cast-iron coffers of the inner dome. The center of the coffer can be unbolted for inspection and maintenance of the inner dome. (David W. Look)*

a.

Figure 75. City Hall and the Restoration of the Dome, 100 North Holliday Street, Baltimore, Maryland; 1867–1875; George A. Frederick, architect; Wendel Bollman, engineer; restoration, 1975. *(a) This Second Empire building was designed by Frederick, but the dome and lantern were designed by Bollman, inventor of the Bollman truss and sole proprietor of the Patapsco Bridge and Ironworks of Baltimore, Maryland. By 1970 the dome was in a seriously weakened condition. The sentiment of the townspeople and the mayor to keep the dome and rehabilitate the building was so strong that an $8 million bond issue was approved for the project. (b) All parts of the dome pictured are cast iron. The outer plates were removed for strengthening the ribs. (Filip Sibley, Office of the Mayor, Baltimore; Robert M. Vogel)*



b.

Figure 76. **Cast-iron and Sheet-iron Cupola, Designed by C. W. and A. A. Houghton, architects, 1898; Hecla Ironworks; Borough Hall, 209 Joralemon Street, Brooklyn, New York, 1846–1851; Gamaliel King, architect.** *After the Old Brooklyn City Hall burned in 1895, it was rebuilt within the masonry shell, and a cast-iron and sheet-iron cupola replaced the wooden one that had been destroyed in the fire. It is typical of many such cupolas throughout America. (Esther Mipaas)*

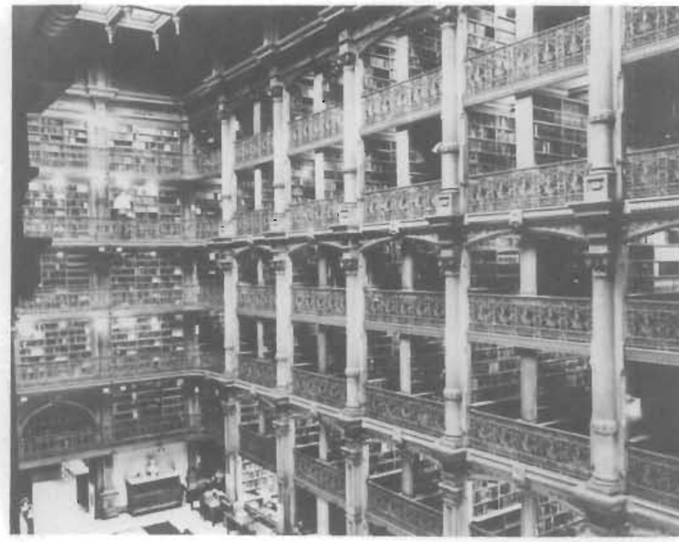


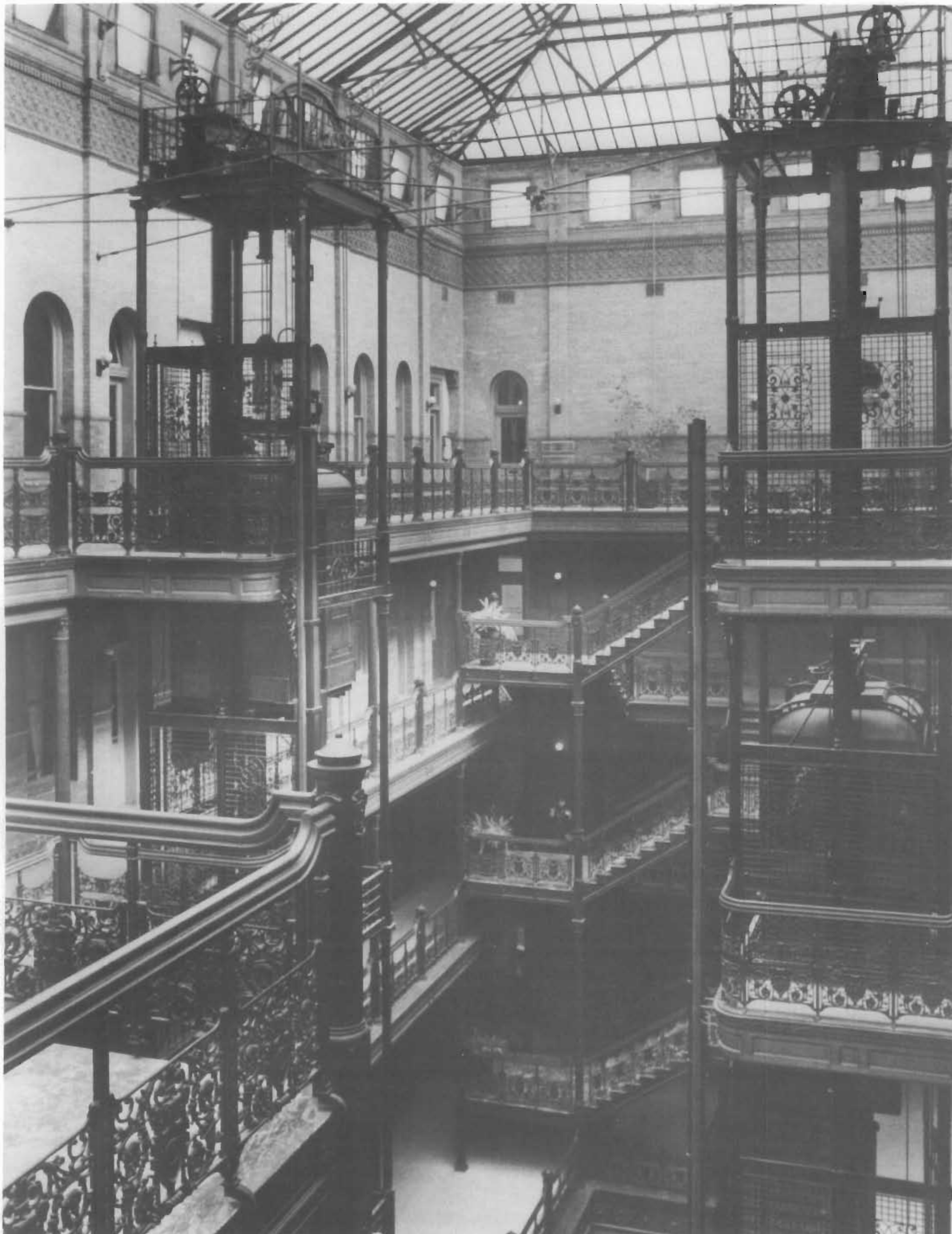
Figure 77. **Cast-iron Interior, Peabody Institute Library, Mount Vernon Place, Baltimore, Maryland, 1857–1878; Edmund George Lind, architect; Bartlett, Robbins and Co., Architectural Iron Works, Baltimore.** *A gift from the philanthropist, George Peabody, who started his career in Baltimore, the Peabody Institute included a library which is virtually all cast iron and glass. Although the building's exterior is a traditional Renaissance design in stone, the most innovative materials of the time were used on the interior to safeguard the collection of books and manuscripts from fire. The central area of the library is surrounded by five floors of cast-iron galleries and is covered by one great skylight of glass set in an iron frame. The floors of the five decks are of iron inset with blocks of translucent glass. The decks are supported by cast-iron piers with applied two-story fluted pilasters rising in three tiers from floor to roof. (Peabody Library)*

Figure 78. **Cast-iron Light Court, Old City Hall, bounded by 10th, Broad, 11th, and Capitol Streets, Richmond, Virginia, 1886–1894; Elijah E. Myers, architect.** *The great central light court with its tiers of enriched cast-iron columns, spandrels, railings, and brass fixtures ranks as one of the most impressive municipal interiors in America. In imitation of stone, the cast iron has a massive, solid quality consistent with the character of the exterior masonry. (William Edwin Booth)*

Figure 79. **The Rookery, 209 South LaSalle Street, Chicago, Illinois, 1886; Burnham and Root, architects; Hecla Iron Works, Brooklyn, New York.** *The central foyer of this early 11-story skyscraper is a fine example of the integration of structural and decorative cast iron. The vaulting beams are perforated to reduce the dead load of the structural members without reducing the strength—the same principle as the truss. The chandeliers were designed by Frank Lloyd Wright in 1905. Unfortunately, the glass roof has been painted over. (Becket Logan)*

b.

Figure 80. **Light Court and Detail of Cast Iron Stairs, Bradbury Building, 304 Broadway, Los Angeles, California, 1893; George Wyman, architect; Winslow Brothers, foundry, Chicago, Illinois.** *(a) Built for the successful miner Louis Bradbury, this conventional masonry building gives no hint from the outside of its remarkable interior light court with its iron and glass skylight. The five-story open space has bird-cage-like elevators moving in open shafts with the machinery and counterweights exposed. (b) The elaborate openwork design of the galleries was cast in bold relief on both sides of the panels. The railings were cast in many parts and then assembled. Slender beaded balusters take the form of clawed feet where they attach to the staircase. All parts of the railing and galleries are outstanding examples of the art of sandcasting. (Becket Logan)*



a.

For the Federal Custom House in Wheeling, West Virginia, and many Federal structures, architects turned to cast iron because it was not combustible and because the repetitive nature of steps and railings allowed for the efficient use of molds. Ornate designs could be cast rather than carved, and parts of the stairs could be perforated to reduce the weight of the cast iron (figure 81). Iron staircases, sometimes monumental in size and design, often dominate the lobbies and rotundas of large public buildings (figure 82).

Exterior cast-iron stoops, usually modest in scale, were commonplace in 19th-century domestic architecture. Their treads and risers were usually perforated both to save metal and to lighten their weight. This seemed to have been a popular feature in the South, and can be seen in Mobile, New Orleans, Columbus (Georgia) and Savannah and throughout the mid-Atlantic states.

The first passenger elevator was installed by Elisha Graves Otis in 1857 in the still standing iron front Haughwout Store in New York. Open-cage elevators soon developed an architectural style of their own. Because of changing tastes and modern fire and safety laws, however, only a few survive. Vestiges of the metal shaftway grillage can still be found in some older office buildings and public structures. Once out of style, cast-iron elevators are now admired and occasionally a way is found to preserve them in the rehabilitation or adaptive reuse of a building. One such example is the 1905 elevator in the Pioneer Courthouse in Portland, Oregon, where the architects of the 1973 renovation put fire-resistant panels behind the iron grillework of both shaft and elevator cab (figure 83). On the other hand, an original system still survives in the 1893 Bradbury Building in Los Angeles where cage elevators move up and down in open shafts (figure 80).

Lintels and Grilles

Iron was also used in 19th-century buildings for window lintels and sills. It was ideal for this use when the spans were short, no more than 3 or 4 feet across. Since decorative lintels were usually backed by brick arches they did not have to be very thick to hold their own weight. As the iron could be used sparingly, it was a relatively light and inexpensive building material, especially when compared to granite or marble. In the casting process, elaborate shapes could be incorporated in the mold and used repeatedly. Thus iron sills and lintels could be trimmed with Italianate brackets or incised with Eastlake trimming; decorative caps for over doors and windows might be almost florid with elaborate lacework (figure 84). Such iron elements could be bought in great variety from the foundry catalogs of

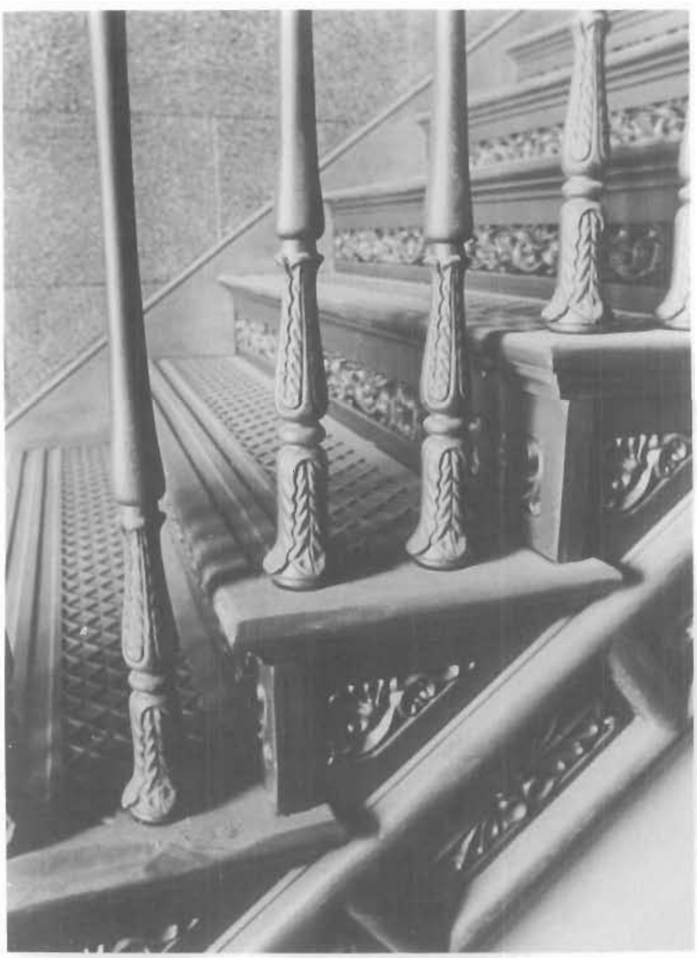


Figure 81. Restored Cast-iron Stairs, Old Customs House (now known as West Virginia Independence Hall), Wheeling, West Virginia, 1859; Ammi B. Young, Architect of the Treasury. *In this building the people of western Virginia declared their independence during the Civil War and joined the Union. These cast-iron stairs and balusters have recently been restored with the recasting of missing or damaged pieces. Perforated stairs were originally designed to combine decorative, functional, and economical detailing; to provide elaborate but strong construction; and to reduce the weight and quantity of iron required. (West Virginia Independence Hall Foundation)*

Figure 82. Grand Stairs and Detail of Cast-iron Railing, Georgia State Capitol, Capitol Square, Atlanta, Georgia, 1884–1889; Willoughby J. Edbrooke and Franklin P. Burnham, architects. *Monumental stairs in public buildings were not only a means of vertical circulation but also a source of public pride and often the site of public ceremonies. (James R. Lockhart, Georgia Department of Natural Resources, Historic Preservation Section)*

the day. Cast-iron window grilles were widely used on houses or public buildings for street-level or below-grade windows that had to be secured, yet where ventilation was desired. Philadelphia abounds in varied cellar window grilles of both cast and wrought iron (figure 85). The glass lights in exterior doors were often covered with custom-fitted ornamental cast-iron security grilles that were both effective and attractive. Many buildings built after 1840 used lacy ventilating grilles set under the eaves. These grilles could be ordered from catalogs, as could cast-iron hot-air registers (figure 86), grating, and panels for use under shop windows.

Figure 84. Cast-iron Lintel, Ben Whitmire House, 109 Jackson Street, Trenton, New Jersey, 1872. *The scrollwork of the foliated lintel is clearly of cast metal; execution of such a design in stone would be almost impossible. This house also has window lintels and sills of iron, all of which were probably cast at Bottom and Tiffany's Foundry in Trenton. They were often painted stone colors with sand added for the correct texture. Residences, commercial buildings, institutions, and even industrial buildings incorporated ornate lintels and sills in their design. (Ben Whitmire)*

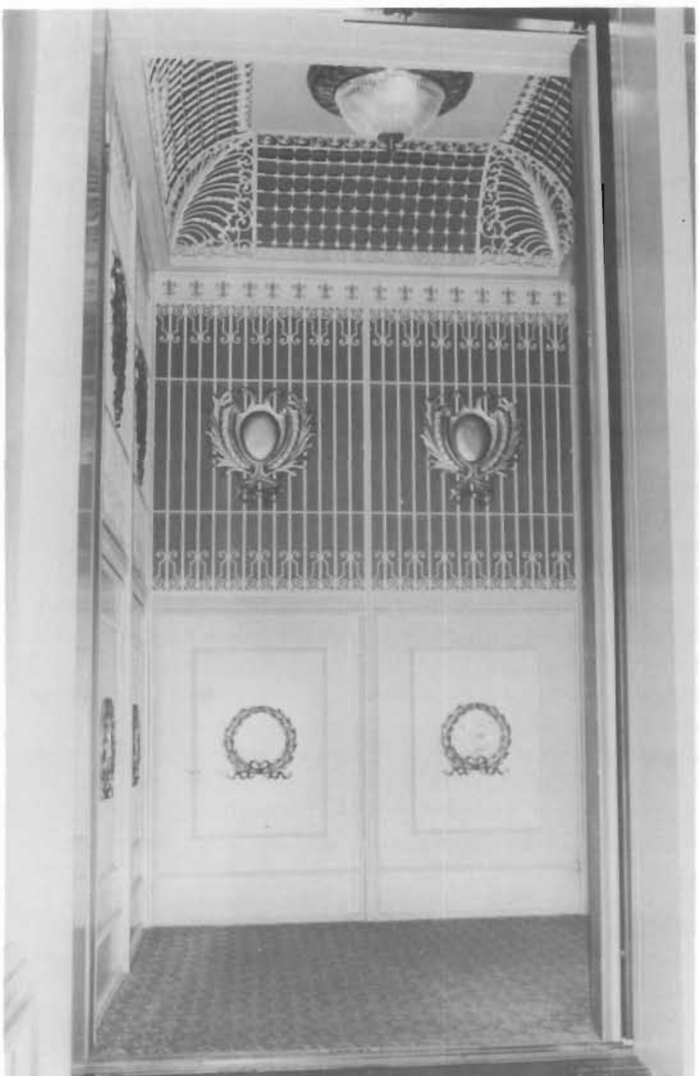


Figure 83. Cast-iron Elevator Cab, Otis Elevator Company, 1905; Pioneer Courthouse (U.S. Courthouse and Customhouse), 520 Southwest Morrison Street, Portland, Oregon, 1869–1873. *To meet fire code requirements, restoration architects McMath and Hawkins installed a new fire wall inside the elevator shaft in 1973. To give the illusion of openness, the elevator grille and cab were painted a cream color, with gilt shields and wreaths; the fire wall was painted a dark gray, creating the effect of a silhouette. (Mike Henley)*

Figure 85. Cast-iron Cellar Window Grille, Matthew Quay House, northeast corner of Spruce and 11th streets, Philadelphia, Pennsylvania. *Although little noticed, there is a seemingly endless variety of decorative cellar window grilles in Philadelphia. With the first-floor level several feet above grade and the sidewalks often extending right up to the facade, these articulated iron grilles were installed to protect exposed cellar windows while still allowing ventilation. The grille photographed here displays a motif of cast-iron vines set in a pair of arcaded panels. (Harley J. McKee, FAIA)*

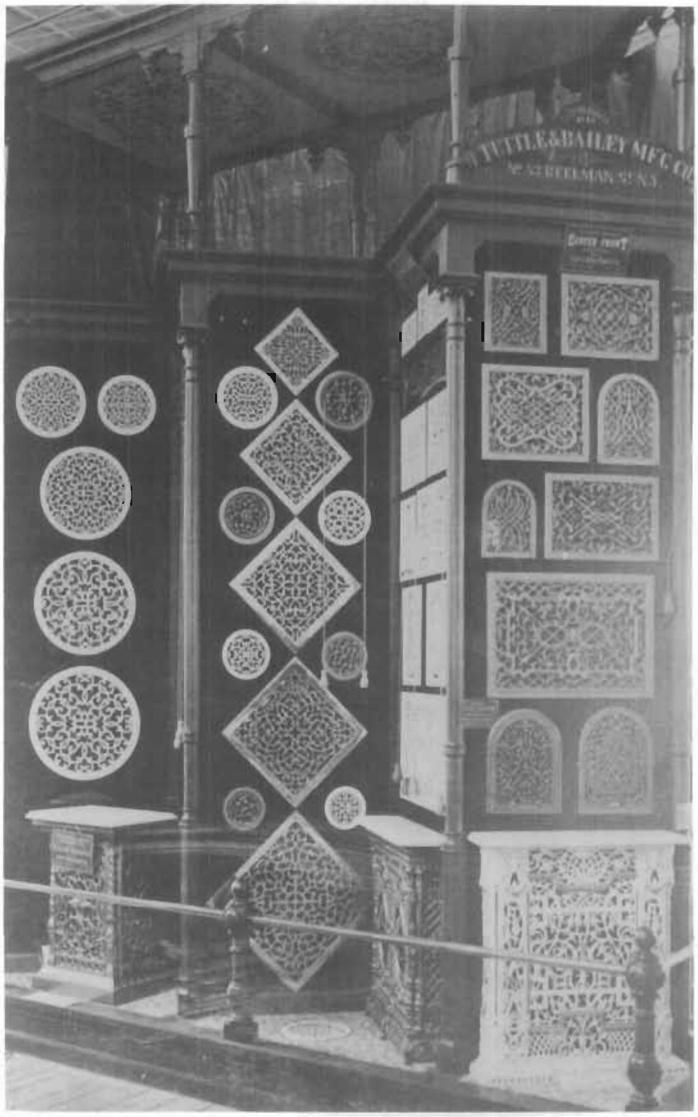


Figure 86. Exhibit of Cast Iron Furnace Registers, Centennial Exhibition, Philadelphia, Pennsylvania, 1876. *This historic photograph shows the wide variety of sizes and designs of furnace registers available from just one company, the Tuttle and Bailey Manufacturing Co. of New York City. (Smithsonian Institution)*

Verandas and Balconies

Cast-iron verandas and balconies are almost universally identified with the streets and courtyards of New Orleans and with other Southern cities such as Savannah and Mobile (figure 87); but they are also found in many other localities (figure 88). If kept painted, these balconies and verandas can be preserved indefinitely. Sections may deteriorate or get broken, but they can be recast and inserted.

Railings, Fences, and Cresting

In addition to verandas and balconies with railings, many American buildings had two-story spaces with railings on mezzanine levels, primarily department stores and hotel lobbies. Iron railings were not only less expensive and lighter than stone, but they were stronger and more fire-resistant than wood. Iron railings were both functional and decorative.

Closely related to railings in style and composition were the cast-iron fences and cresting. Molten iron could be cast in so many different shapes from simple to elaborate that designers and patternmakers had free rein. They made grapevine fences and fences resembling rows of swords thrust into the ground; there were also fences with Greek key designs for Greek Revival style houses. Railings, fences, and gates done in Gothic tracery were favored for churches, and a favorite cemetery gate motif shows lambs lying beneath a weeping willow tree. Other fences were made to look like a row of corn stalks (figure 89). Many custom designed fences carried symbols related to the structures with which they were associated.

Cast-iron cresting decorated the ridges of roofs and the edges of bay and porch roofs (figure 90). These decorative additions were mass produced and could be purchased in a variety of designs.

Street Furniture and Lighting

"Street furniture" is very much a part of the urban landscape. It applies to various objects on our streets that facilitate public activities, including metal mailboxes and fire alarm boxes, fire hydrants, street lamps, trash containers, and also such amenities as benches (figure 91), drinking fountains, flower planters, and occasionally tall sidewalk clocks. Until recent years, most of these amenities were fabricated of cast iron. A few manufacturers still cast street furniture in Victorian designs or popular later designs.

Gaslighting was introduced in the United States early in the 19th century, and by the Civil War had become the dominant form of street and home illumination. Most American cities chartered a local gas company and brought gas into their commercial districts via simple but utilitarian lampposts. Most of these lampposts were fabricated of cast iron. Churches, businesses, and private owners installed their own exterior iron fixtures, including elaborate and sculptural lamps which were tributes to the founders' art. By the 1890s, electricity was beginning to replace gaslighting. The two forms coexisted for some years, while many municipal gaslamps were converted to electricity.

In the mid-1890s, New York City installed tall iron double-pendant electric lamps along Fifth Avenue from Washington Square to 59th Street. In 1903 several companies contracting to light certain sections of the city adopted the cast-iron Bishop's Crook single-pendant electric lamp that became the basic street light for the city's five boroughs until recently.

Salt Lake City, one of the first American cities to have systematic electric street lighting, developed an elegant type of lamp standard with three lights on a tall fluted shaft. The cast-iron bases of these lamps bear four medallions displaying profiles of Indians in feathered war bonnets (figure 92). The city keeps old lamps and globes in good condition, replicates where necessary, and lines at least one central thoroughfare with them.

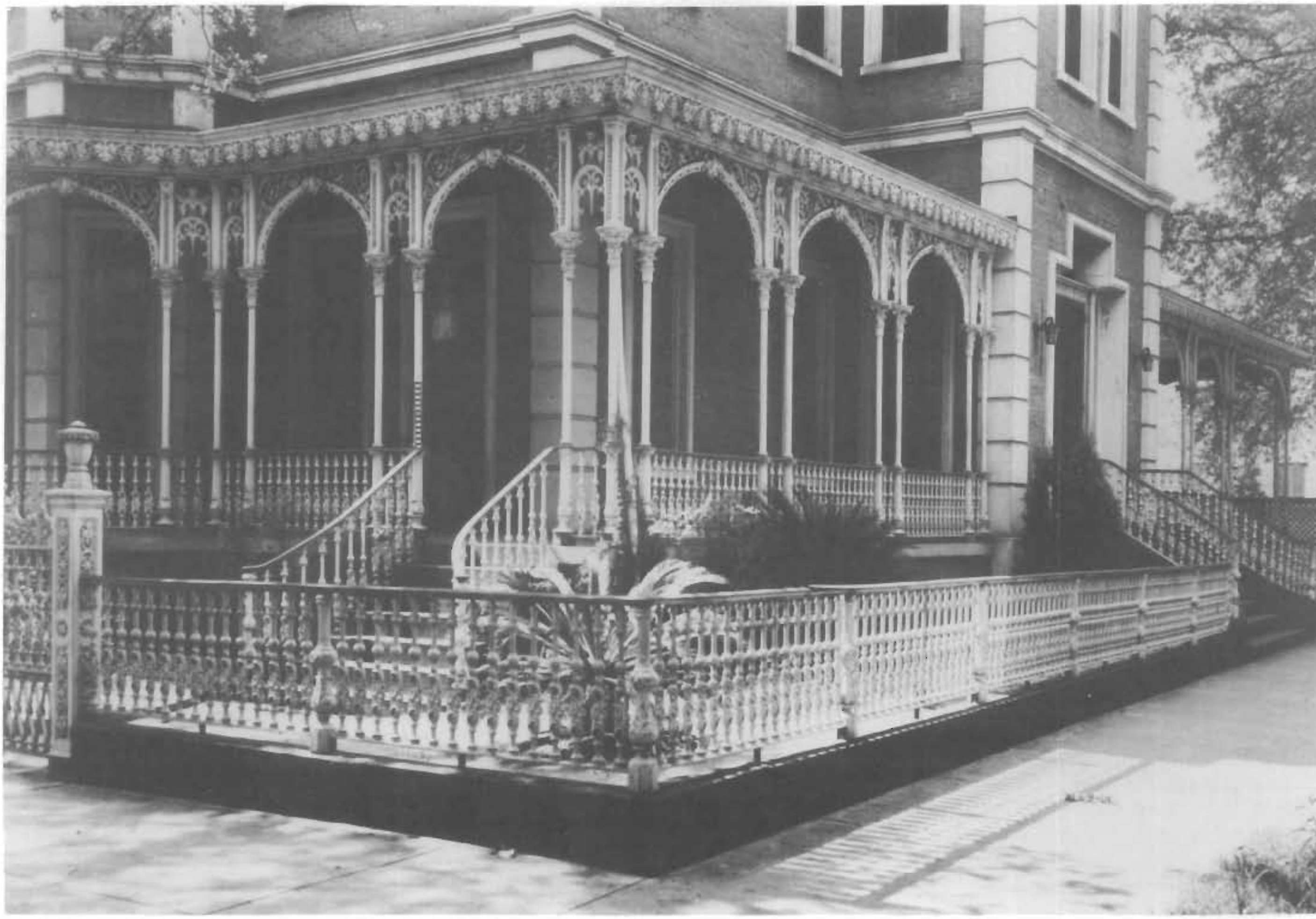


Figure 87. Cast-iron Veranda and Fence, Ketchum Mansion, 400 Government Street, Mobile, Alabama, 1861; Wood and Perot, foundry, Philadelphia. *This veranda, skillfully produced in decorative cast iron, as well as the cast-iron railing, fencing, gates, and gate posts, are painted white to contrast with the warm-colored brick of the Italianate mansion. (Jack E. Boucher, NAER)*


a.


b.

Figure 88. Cast-iron Veranda, Zephaniah Jones House, 1024 10th Street, NW, Washington, D.C.; Janes, Kirtland and Co., foundry. *(a) It is a rewarding experience to see an advertisement for an architectural feature in a foundry catalog, then to discover the original model is still extant. (b) This veranda appears in Janes, Kirtland and Company's 1870 catalog of ornamental ironwork. The caption reads, "Verandah made to order for Z. Jones, Esq. of Washington, D.C." The veranda, in need of repair, remains on the Jones House over 100 years after its installation. (David W. Look)*

Cast-iron lamps on Canal Street in New Orleans are especially memorable. Erected about 1910, they have triple lights on very tall shafts that rise from high, carefully detailed bases. The base of each lamp displays four sculptured plaques denoting the four national periods of Louisiana history under Spain, France, the Confederacy, and the United States. Lamps damaged in traffic accidents have been restored or replaced.

Sometimes lamps were added to a building many years after construction, but occasionally exterior lighting fixtures were designed as part of the building's facade. This is the case of the lamps on the Boston Public Library, which are an integral part of the building's composition (figure 93).

Tall cast-iron street clocks were popular at the turn of the century, especially as picturesque advertisements for banks and jewelry shops. But they also rendered a public service (figure 94). Many still exist, and several cities, including Milwaukee, San Francisco, and Portland, Oregon, have designated them official landmarks.

Fountains and Statues

Large cast-iron fountains, a feature of public squares and avenues in 19th-century towns and cities, were often opulent, tiered structures decorated with waterbirds, porpoises, tritons, cherubs, and even life-size human figures. Although they were often expensive items and represented a considerable civic investment (figure 95), they were less expensive and more common than bronze. Smaller iron fountains were produced for the lawns of institutions and for private gardens.

The Bartholdi Fountain in Washington, D.C., across Independence Avenue from the U.S. Botanic Garden near the Capitol is a cast-iron fountain of great sophistication. It was exhibited as a work of art at the 1876 Exhibition, after which it was purchased by the Federal government. Three iron classical style maidens hold aloft a large bowl, originally rimmed with gaslights (now with electric lights), from which water cascades. The sculptor, Frederic Auguste Bartholdi, is best known for the Statue of Liberty. His fountain is a rare example in the United States of the work of a major artist in cast iron.

Some Victorian cast-iron fountains were both utilitarian and ornamental. Such is the case with Lotta's Fountain in San Francisco (figure 96). This sentimental 1876 gift to the city from the famous actress Lotta Crabtree incorporates four spigots for drinking water along with a tall decorated column with a light on top. Its base is heavily ornamented with cast-iron medallions depicting gold miners and sailing ships.

The constant presence of water and leaky plumbing has caused trouble for many iron fountains, while others have been dismantled as old-fashioned relics and sold for scrap by shortsighted municipalities. Now these cast-iron extravagances are again being appreciated.

Figure 89. Cast-iron Fence, Cornstalk Hotel, 915 Rue Royale, New Orleans, Louisiana, ca. 1855; Wood and Perot, foundry, Philadelphia. *In the 1850s, Dr. Joseph Biamenti brought his bride to this New Orleans house, later converted to a hotel. In an effort to keep her from feeling homesick for her native Iowa, the doctor commissioned this cornstalk fence from the well-known Philadelphia foundry. Representing a field ready for harvest, the green and yellow fence sports ripe cast-iron ears of corn on their stalks. Pumpkin vines entwine the stalks and climb up the ironposts to the bundle of corn ears which make up the finials. Once a foundry made patterns, it would usually advertise the new design in its catalog and reuse the molds as orders were received; a rendering of this fence appeared in the 1858 Wood and Perot catalog. In 1859 another cornstalk fence was erected by Wood and Miltenberger, the New Orleans branch of Wood and Perot, at the Short-Favrot House in New Orleans Garden District. (Becket Logan)*

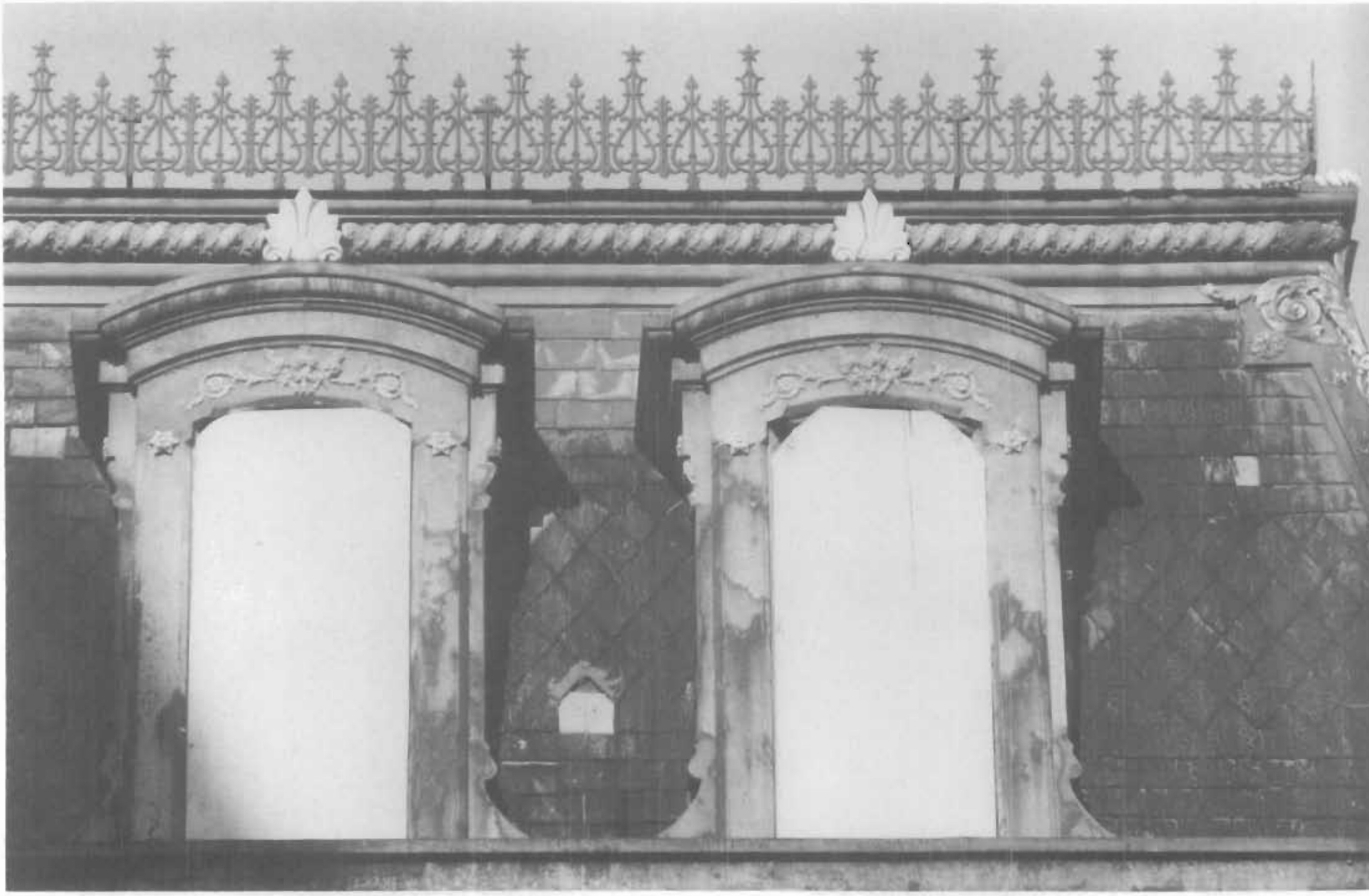


Figure 90. Cast-iron Cresting, Moran-Bogus Building, 501-509 G Street, NW, Washington, D.C., 1889–1890. *This slate Mansard roof was added in 1890 by George Bogus, the second owner, to a brick commercial building built the year before by J. E. Moran. Cast-iron cresting was a popular ornamental feature on Gothic Revival and Second Empire style buildings, but can be found on other styles of structures during the Victorian era. Note also the galvanized sheet-iron rope molding and dormers with cast zinc ornament. (David W. Look)*

Figure 91. Cast-iron Benches, Illustrated Catalogue of Ornamental Iron Works, Janes, Kirtland & Co., 1870. *Cast-iron furniture for both indoor and outdoor use enjoyed great popularity with the Victorians, especially for furnishing conservatories, porches, lawns, gardens, parks, public squares, and cemeteries. Benches such as these were cast in 10 or 12 sections, which were assembled and bolted together. After the rough edges were filed away to protect the user's clothing, the benches were painted several times to prevent rust from forming. This page of the catalog illustrates designs in the Gothic, grapevine, Rococo, and rustic styles. (Library of Congress)*

Figure 92. Cast-iron "Indian Head" Lamps, Salt Palace Complex, Salt Lake City, Utah. *(a) Electric street fixtures began to replace gas fixtures in the 1880s; many of the ornate electric street lamps were erected about the time of World War I. (b) Salt Lake City put up cast-iron street lamps with Indian head medallions on the bases. With the recent revival of interest in the downtown area, the Utah Power and Light Company refurbished the surviving lamps and had others made. (Hal Rumel Studio; Utah Power and Light Co.)*

Figure 93. Iron Lamps, Boston Public Library, Copley Square, Boston, Massachusetts, 1895; Charles Follen McKim, architect. *The Boston Public Library contains many forms of metal ornamentation: bronze doors by Daniel Chester French, wrought-iron gates and grilles, and Strozzi-type wrought- and cast-iron lamps which flank the three entryways. Repeated casting from the same molds made ornamentation worthy of a Renaissance palace affordable in the 19th century. (Esther Mipaas)*

Figure 94. Cast-iron Post Clock, Boylston Street, near the corner of Berkley, Boston, Massachusetts, ca. 1900; E. Howard Clock Co. *The iron post clock was a familiar item of street furniture for over a century, and was used nationwide as a form of advertising for merchants, especially jewelers, and for banks. This clock in the Boylston Street shopping area was manufactured by the noted New England clockmaker Edward Howard, whose company also made street clocks, steeple clocks, and watches long after his death in 1904. Other examples of such clocks can be found in Milwaukee, St. Louis, Salt Lake City, and Portland, Oregon. However, the post clock is a vanishing amenity, its useful life shortened by street widenings, abandonment of inner cities, and the ravages of the automobile. (Esther Mipaas)*

Figure 95. Cast-iron Fountain, Plate Number 5, Illustrated Catalogue of Ornamental Iron Works; Janes, Kirtland and Co., 1870. *Large cast-iron fountains became part of America's urban landscape after the 1851 London Crystal Palace Exhibition, where several iron fountains attracted attention. A French example was said to have inspired this design, which was first made for the city of Savannah, Georgia. In 1856, the fountain was installed in Forsyth Park where, with the benefit of a recent restoration, it exists today. Janes, Beebe and Co., maker of the fountain and forerunner of Janes, Kirtland and Co., offered it in the 1858 catalog for $2,500 plus the cost of the basin. Poughkeepsie, New York, and Madison, Indiana, have similar fountains. The tri-level fountain was made of hundreds of pieces of cast iron, which were shipped to the site, bolted together, then caulked and painted. The lowest level displays large trumpeting Tritons, the second waterfowl, and the top a figure holding a water-spouting torch. (Library of Congress)*

There are relatively few cast-iron statues that are not a part of a larger monument such as a fountain. A large statue of Henry Clay by Wood and Perot was erected in 1855 in Pottsville, Pennsylvania; and the residents of Eatonton, Georgia, honored native son Joel Chandler Harris by placing a cast-iron statue of Br'er Rabbit on the courthouse lawn. Also unique is the 56-foot-tall cast-iron figure of *Vulcan*, Roman god of the forge, standing on a mountain overlooking Birmingham, the iron and steel center of the South. Said to be the largest cast-iron figure in the world, *Vulcan* was cast in many sections by several Alabama foundries and shipped to St. Louis where the statue represented the state at the 1904 World's Fair. Small animal sculptures, such as dogs, deer, and lions, were quite popular in the Victorian era and were often ordered from catalogs.

Tombs

One of the finest examples of the founder's sculptural art is the 1859 iron tomb marking the grave of President James Monroe. In Richmond, Virginia's, Hollywood Cemetery on a prominence overlooking the James River, this Gothic style cast-iron masterpiece was designed by German-born Richmond architect Albert Lybrock and cast in the foundry of Wood and Perot in Philadelphia (figure 97). "Cast iron Mausoleums of beautiful design and finish" were advertised by Wood, Miltenberger and Co., the New Orleans branch of Wood and Perot. Several splendid iron tombs exist in New Orleans' historic cemeteries, while others, apparently stock designs, can be seen in Mobile, Alabama. Examples of modest-scale cast-iron architecture, these elegant little buildings were made of parts separately cast and bolted together by the same methods employed for iron front warehouses, hotels, and stores. Like their commercial counterparts, some tombs were individually designed and others could be ordered from catalogues.

The heyday of cast iron lasted well into the 20th century. As discussed, the metal had a wide variety of uses. Some architectural historians labeled the early popularity of cast iron as "ferromania" and dated its decline in the 1870s due to the discovery that it has limited fire resistance. Although non-combustible, cast iron can be weakened in a fire. Cervin Robinson has pointed out, however, that the vast number of cast-iron facades built in the 1890s testified to their renewed popularity. As late as 1904 multistory cast-iron facades were erected in the SoHo area of New York City. Their brief decline in the 1880s could be attributed to stylistic changes; buildings were being designed with fewer repetitive elements, which were so economical when mass produced in cast iron.

Other uses of cast iron continued uninterrupted until new styles eliminated their use or they could be more economically made of new materials. Two late examples are the Charles Scribner's Sons Bookstore on Fifth Avenue in New York City, which has an iron and glass storefront built in 1913, and the doors of the Cheney Brothers Silk Store, which were cast in iron in 1925 (figure 98). Cast iron was even used in the Art Deco period, when many new metals were becoming available.

Figure 96. Cast-iron Drinking Fountain, intersection of Market, Kearny, and Geary streets, San Francisco, California, 1875. *Cast iron took many shapes in the 19th-century urban landscape. One of the more interesting is this public drinking fountain given to the city by Lotta Crabtree, a grateful citizen who had acquired fame and fortune there as an actress. The fountain was restored and rededicated on its 100th birthday in 1975. (Becket Logan)*

Today, cast iron is used for plumbing fixtures and piping in new construction, and its structural and decorative use is being revived through the preservation of historic buildings.

Rolled Sheet Iron and Steel

Surfaces of iron and steel exposed to the atmosphere will develop a crust of iron oxide, commonly known as rust. Unlike bronze, which oxidizes to form a patina that generally protects the surface from further oxidation, iron and steel form a highly corrosive coating. Rust is a porous substance that allows deeper and deeper layers to oxidize until the entire object is consumed by it. In thin sheet metal, corrosion can be quite rapid, with resulting reduction of the object's strength and usefulness.

Figure 97. **Cast-iron Tomb Enclosure, Grave of President James Monroe, Hollywood Cemetery, Richmond, Virginia, 1859; Albert Lybrock, architect; Wood and Perot, foundry, Philadelphia.** *The ceremonial enclosure of the tomb of James Monroe is a particularly fine example of cast-iron design and craftsmanship. In the 1850s the state of Virginia took steps to move Monroe's resting place from New York to his native state. The Gothic Revival design chosen for the tomb was that of German-born Richmond architect Albert Lybrock. Perhaps more important was the selection of Wood and Perot, manufacturers of ornamental iron, to prepare the patterns, make the molds, and cast the separate parts that would compose this work of art. The words "Robert Wood, Maker" can be found at the edge of the enclosure. In later years, Wood and Perot presented sketches of the tomb cover in its sales catalog. It measures 7 feet wide by 10 feet long, with a perforated canopy rising 20 feet to a finial of crockets. Four miniature corner towers enclose side panels filled with Gothic arches and trefoil patterns. (F. Heite, Library of Congress)*

Figure 98.
Cheney Brothers Silk Store (now Merrill Sharpe, Inc.), 181 Madison Avenue, New York City, 1925; Howard Greenley, designer; Ferrobrant, foundry. *Originally fabricated under the direction of Jules Bouy for Cheney Brothers Silk Store. These doors were later moved in 1928 to their present location, the Madison Belmont Building. Edgar Brant of Ferrobrant fabricated the additional metalwork for the new building. Note that the parts of the frame and transom painted gold (the lighter color in the photo) are actually cast bronze, recently restored and polished. (David W. Look)*

In the United States, the first sheet iron was rolled in a Trenton, New Jersey, mill owned by Robert Morris. He roofed his never-finished home in Philadelphia with sheet iron around 1794. In 1814, architect Benjamin Latrobe wrote a Captain Wooley recommending sheet iron roofing rather than lead or tin. Latrobe assertedthat a sheet iron roof he had installed on Nassau Hall at Princeton College in New Jersey after a fire was "as good as the day when it was put on. . . ." Although he did not mention any protective coating, the roof was probably painted. The slate roof on the White House was replaced with sheet iron in 1804. How widespread sheet iron roofs became is not clear, but they were available until the end of the 19th century. Some of them had pressed designs (figure 99). Shingles and pantiles were also available in painted sheet iron and steel (figures 11 and 12).

As mentioned previously, a method for corrugating iron was first patented in England in 1829. As early as 1834, William Strickland planned to use corrugated sheet iron for his design of the market sheds in Philadelphia. Early corrugated iron was painted or blackened with pitch, but galvanizing, when discovered, was a better protection (see chapter 4). Corrugated iron was adopted quickly, as its extra rigidity and stiffness allowed for lighter roof framing, and horizontal roof supports could be spaced further apart and made smaller. Corrugated sheets as large as 2 by 5 feet were soon available, allowing for 10 square feet of roofing to be installed at a time. The sheets were placed on purlins with the furrows sloped downward to provide drainage.

Corrugated iron and later steel had other uses besides roofing; the most important was in floor construction. Arched sheets of corrugated metal were placed on the bottom flanges of beams spaced 4–5 feet apart (figure 100). Concrete was then poured over the beams and sheets to provide a flat floor. Previously, brick arches had been used between the beams, but the corrugated sheet iron or steel was faster to install. Both types were usually plastered to provide a finished ceiling for the room below.

As early as 1868, sheet iron was used for ceilings, probably to provide some fire protection. The early ceilings were corrugated, and sheet iron and steel was also sometimes stamped with designs (figure 101). Although commonly called "tin ceiling," these pressed sheets were not usually tin plated for indoor use, but were always painted to protect them from deterioration. Some galvanized sheet iron or steel ceilings were produced. Pressed metal ceilings were popular through the first two decades of the 20th century. They are still available today. At least one company now makes pressed metal ceilings that are tin-plated.

Steel

Structural Steel

In the mid-19th century, advancing technology had brought tall buildings into the realm of architectural possibility. Builders and manufacturers turned to steel, which was stronger than cast iron in compression and wrought iron in tension. Steel had been known and used to some extent for centuries. What was lacking was a way to produce it cheaply and in quantity. This challenge was met when the Bessemer process was developed in England in 1856. Shortly thereafter, the open-hearth process was invented.

The industrial application of the new methods and materials moved with remarkable speed, especially in England. In the United States, the Civil War held up the introduction of large-scale steel production; cast and wrought iron were the major construction materials until the 1870s. About 1865, Alexander Holley engineered a steel making system in America based on the Bessemer patents. Andrew Carnegie and others soon developed the industry further and laid the groundwork for the United States to become the largest producer and user of steel.

The first major American construction project in which steel was used was the Eads Bridge which crossed the Mississippi River at St. Louis, Missouri. In 1867 James Buchanan Eads designed and began construction of the 1,524-foot multiarched steel truss bridge. Although steel was a major component, some iron was used in this and other early steel bridges.

In 1868, John A. Roebling, having built several bridges with iron wire cables, designed steel cables for the proposed Brooklyn Bridge across the East River in New York. Roebling had patented the first traversely wrapped wire cable in 1841 and developed a method for galvanizing wire in 1876. He did not live to see completion of the Brooklyn Bridge, which at 1,596 feet was the longest suspension bridge in the world when it opened in 1883.

Railroad companies were among the first to recognize the superior qualities of steel. By the end of the 1880s, most rails and railroad bridges were made of steel; the last wrought-iron rails were rolled in 1884. For several years the railroads used so much steel that it was in short supply for building construction.

In 1885 William Le Baron Jenney used the first steel beams in the upper floors of his partially completed Home Insurance Building in Chicago. Regarded by architectural historians as the first skyscraper, the 11-story building was demolished in the 1930s. Its iron and steel framework carried the entire weight of the structure, including the exterior masonry walls which were supported at each floor level. This construction allowed for much thinner exterior walls, especially on the lower floors, and increased the available rental space. Steel framing made larger windows possible for better lighted shops and offices.

The transition from iron to steel was gradual, and for years many buildings used both iron and steel. The first completely steel-framed structure, the Rand McNally Building in Chicago, was completed in the early 1890s. Burnham and Root's Monadnock Block, completed in Chicago in 1891, illustrated the need for steel frame construction in urban settings. The traditional load-bearing masonry walls at the ground-floor level of the Monadnock Block were 6 feet thick. The materials and labor involved added to the expense of construction and the thick walls took up a large part of the rental space. Steel frame construction soon became the standard construction for structures of more than a few stories (figure

ILLINOIS ROOFING AND SUPPLY CO., CHICAGO, ILL. 33

Cluster Tiling or Shingles,

—FOR—

ROOFING, MANSARDS, GABLES AND SIDING.

Attractive. Cheap. Durable.

MADE OF SHEET STEEL PAINTED OR GALVANIZED.

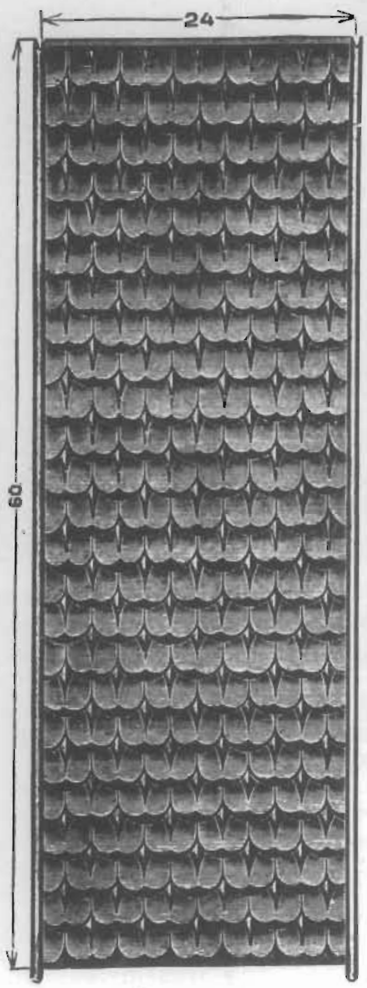


Fig. 139.

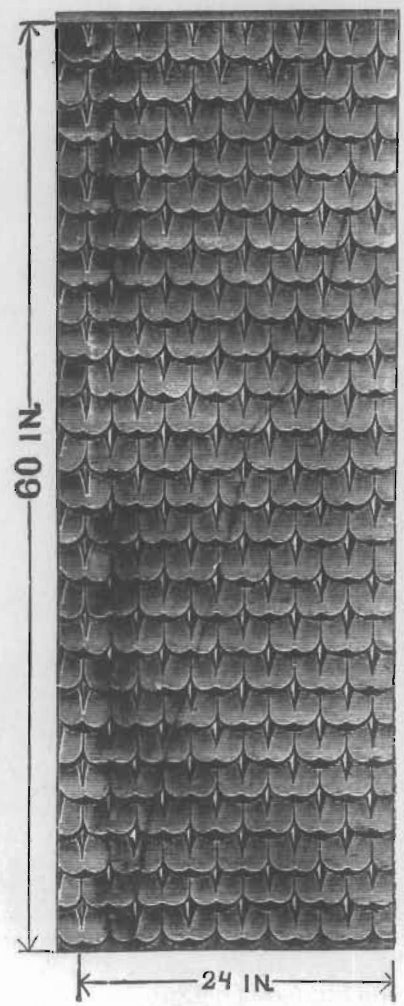


Fig. 140.

Fig. 139 shows Cluster Shingle, with pressed standing seam edges, applied with cleats.

Fig. 140 shows Cluster Shingle in sheets. This is particularly adapted for gables, mansards and siding. The side lap is made by lapping one-half of a shingle and is perfectly water-tight when properly nailed.

A Square consists of ten (10) sheets 60 inches long each by 24 inches wide, covering width.

Figure 99. Pressed Sheet Steel Roofing and Siding, Illinois Roofing and Supply Co., Chicago, Illinois, 1896, page 33. *Sheet metal was often pressed with decorative patterns to imitate shingles. These sheets, 24 by 60 inches, were available in either painted or galvanized sheet, and were recommended for gables, Mansards, and siding. (Library of Congress)*

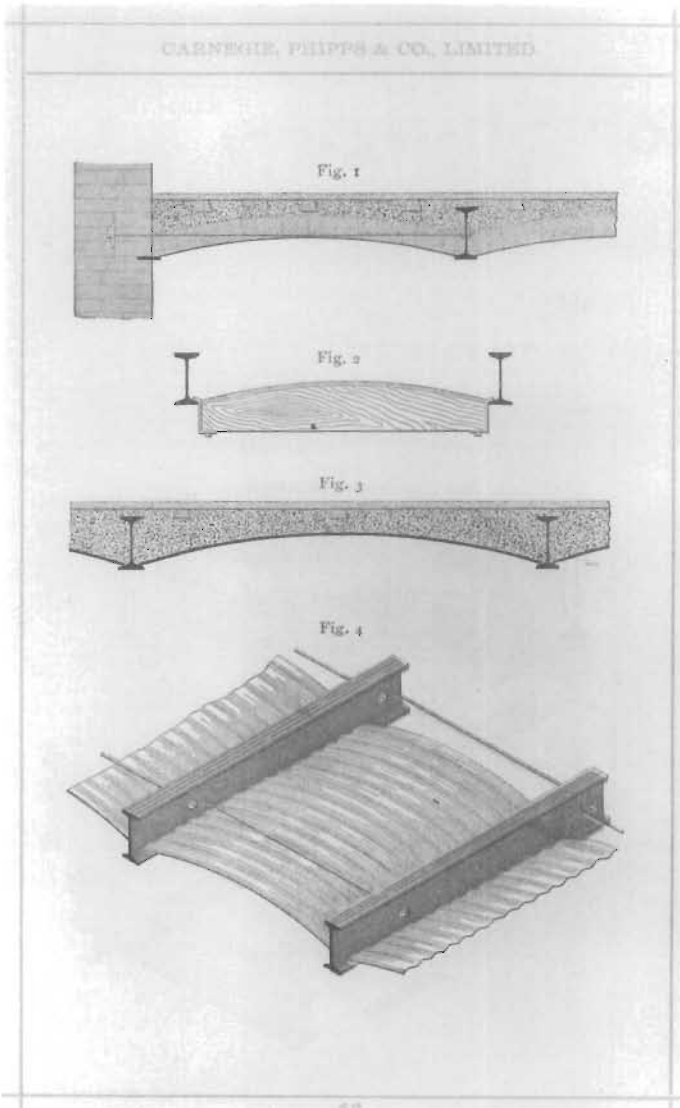


Figure 100. Corrugated Iron Arched Floor Construction Pocket Companion . . . , Carnegie, Phipps and Co., Ltd., Pittsburgh, 1890, p. 43. *In an effort to reduce the time needed for arch construction (figures 1 and 2), the corrugated iron arch was introduced (figures 3 and 4) with a concrete fill. The sheets of corrugated iron, bent to a radius, were sprung between the bottom flanges of the I-beams. Note the tie rods between the beams to keep correct spacing and beam alignment. Even though iron is noncombustible, these floors were not "fireproof" because the iron arches and beams lost their strength and collapsed when exposed to the high temperatures of a fire. (Library of Congress)*

Figure 101. Pressed Metal Ceiling, 212 West Main Street, Johnstown, New York. *Mistakenly called "tin ceilings," pressed metal ceilings were stamped sheet iron and later sheet steel; only one or two isolated companies coated them with tin. Pressed metal was sometimes galvanized with zinc, especially when used outdoors or as porch ceilings. It was sold by the sheet with the patterns fitting neatly together for covering ceilings and sometimes walls or wainscotting. Accessory pieces, such as ceiling medallions, were available. Cornices provided the transition from ceiling to walls. (Becket Logan)*

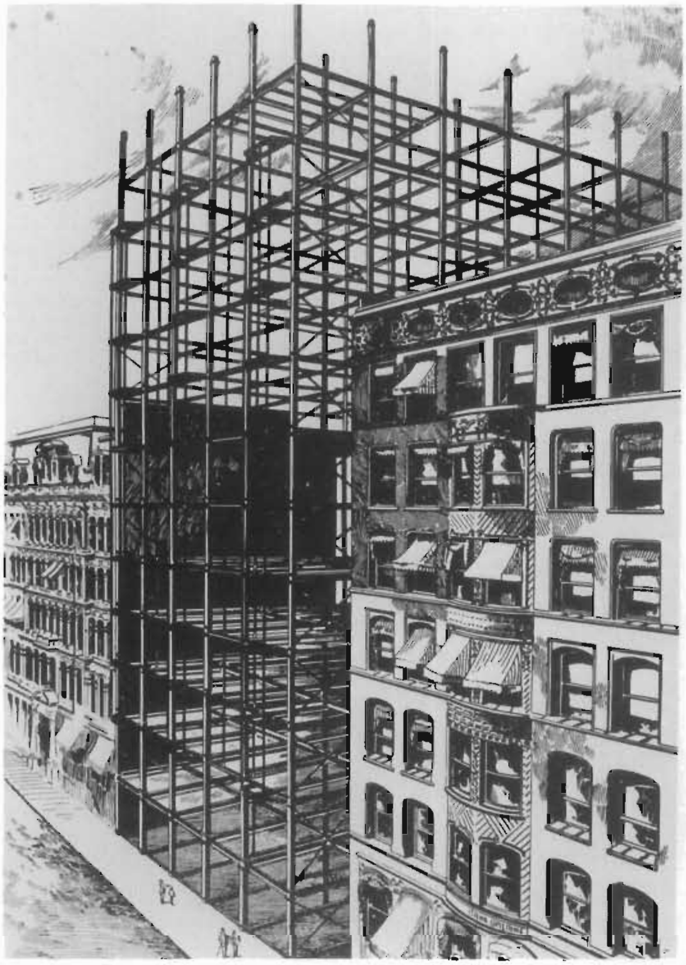


Figure 102. **Iron and Steel Skeleton Frame, Unity Building, Chicago, Illinois, 1891–1892; Clinton J. Warren, architect.** *One of the best-known contributions of Americans to the development of architecture is the skeleton frame, pioneered by architects of the "Chicago School" in the late 19th century. Before the steel skeleton, construction of buildings of even moderate height required thicker and thicker walls to bear the increased load. With the new method, the weight of the building is carried on the frame, not the walls. The skeleton frame allowed buildings to rise to tremendous heights without using increasing amounts of floor space for wall thickness, thus decreasing rental income. Construction documents of this period reveal other records. Construction of the Montauk Building was continued through the winter of 1881 by covering the frame with canvas and heating the space with steam. Electric lights allowed crews to work around the clock. Construction records were set when steel for the top ten stories of the Reliance Building were erected in 15 days, from July 16 to August 1, 1894. Once the frames are fireproofed, they are not seen again until a building is rehabilitated or demolished.* (Industrial Chicago, *volume 2, 1891, facing page 234, Library of Congress)*

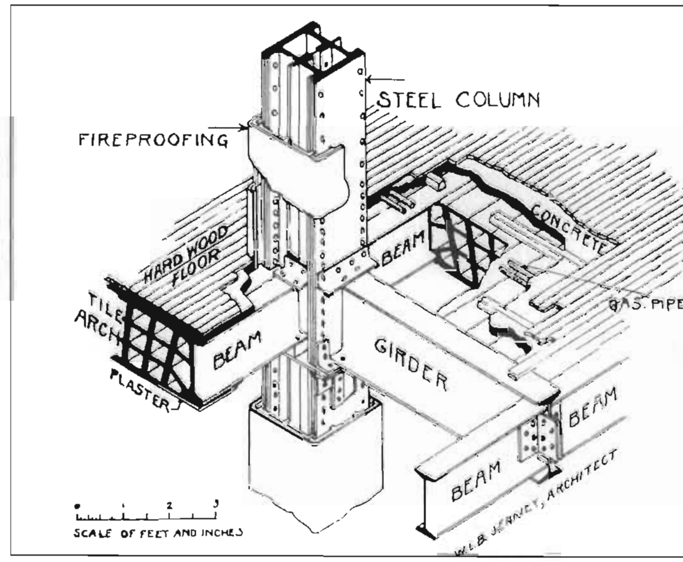


Figure 103. **Detail of a Column-and-Girder Connection and Floor Construction, The Fair Store, South State, West Adams, and South Dearborn Streets, Chicago, Illinois, 1892; Jenney and Mundie, architects.** *This is a connection of the type used in many iron and steel connections. Note the "fireproofing" of the columns, which consisted of terra-cotta tile and plaster. The floors were constructed of lightweight, flat tile arches covered with a concrete topping slab with wooden sleepers to receive the hardwood floor. The bottom of the flat tile arches was plastered to provide the finished ceiling of the room below.* (Industrial Chicago, *volume 2, 1891, facing page 842; Library of Congress)*

102). The exterior walls were "hung like curtains" on a lighter but stronger frame. A whole new vocabulary of building connections was developed for anchorage of the curtainwalls to the skeleton and for the complex connections between columns, beams, and girders (figure 103).

Although iron and steel are not combustible, they lose strength in a fire if they are not protected from the heat. Almost all structural steel has to be "fireproofed" in some manner, utilizing a cladding of terra-cotta, tile, plaster, poured concrete, sprayed concrete or sprayed insulation. Therefore, once covered most structural steel is not seen again until hit by the wreckers ball.

Ferro concrete, commonly called reinforced concrete, was developed in Europe in the late 19th century when steel wire was added to concrete. Concrete is good in compression but poor in tension, whereas steel is good in both tension and compression. Therefore, steel bars were imbedded in wet concrete where it had to take tension, as in floor slabs, beams, and girders (figure 104), and where there were large compression loads, as in columns. Ernest Leslie Ransome during the late 1880s, used reinforced concrete floors and iron columns in construction of the Academy of Science in San Francisco. The first large-scale uses of reinforced concrete for both floors and columns came at the Leland Stanford Jr., Museum in 1890 and later at the Pacific Borax Company, both by Ransome. In the 20th century, reinforced concrete buildings became as common as steel frame buildings.

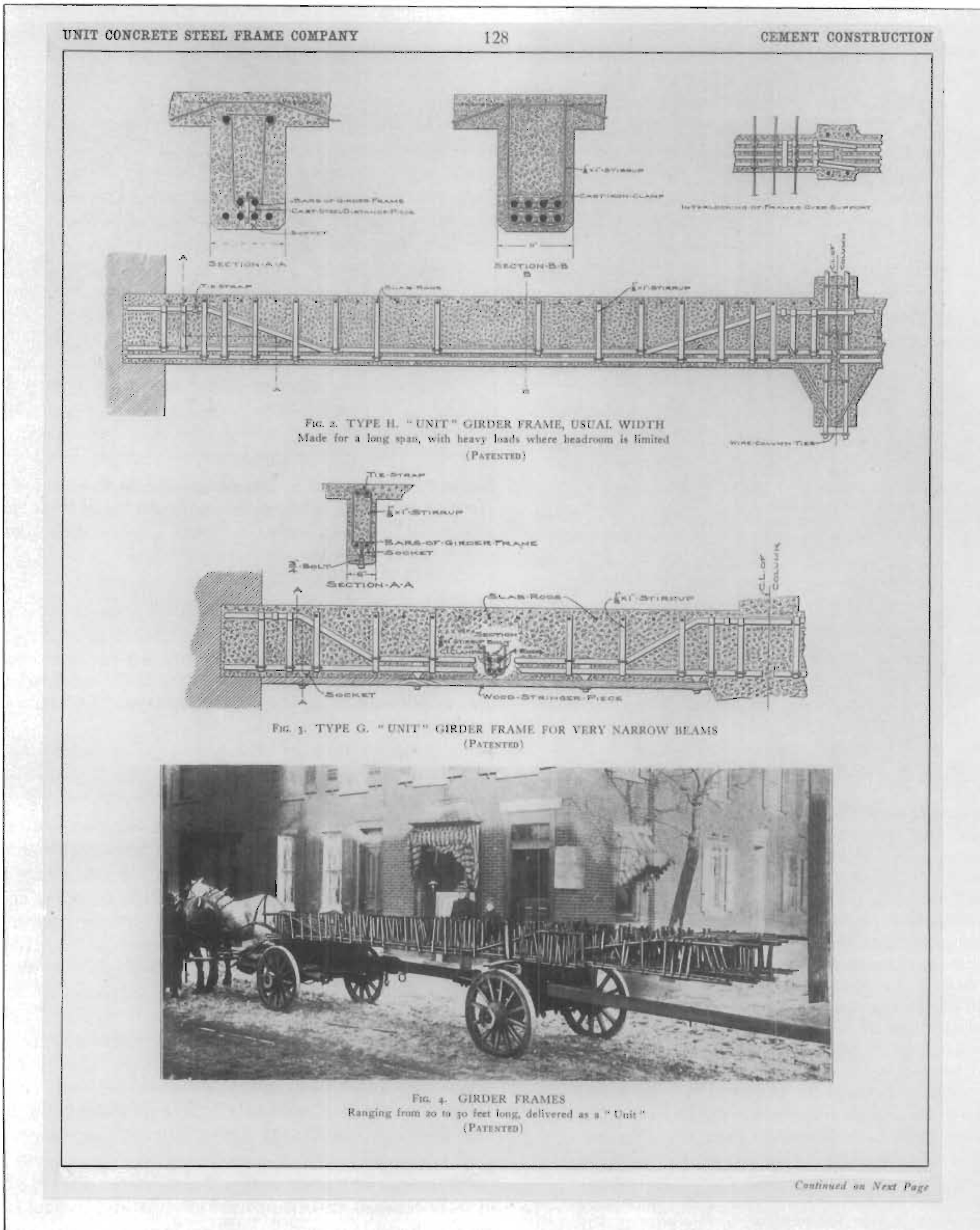


Figure 104. Reinforced Concrete, Advertisement of the Unit Concrete Steel Frame Company, Philadelphia, Pennsylvania, from "Sweet's" Indexed Catalogue of Building Construction, 1906, p. 128. *This company specialized in the prefabrication of reinforcing for concrete girders ranging from 20 to 30 feet long, delivering them as a "Unit" to the construction site by horse-drawn wagon. Reinforced concrete girders and beams, consist of concrete (which is good only in compression) reinforced with bars of steel (which is good in both compression and tension). Most of the steel bars are placed at the bottom of the girder at the center of the span where the top part of the girder is in compression (to be taken by the concrete) and the bottom part of the beam is in tension (to be taken by the steel rods). Slab rods are only for controlling shrinkage of the slab. The opposite situation appears at the ends of the girder where it passes over a support. There the bottom part of the girder is in compression and the top part is in tension, explaining why some of the bars are bent up at an angle toward the ends of the girder. Note the cast-iron clamp and cast-steel distance piece which hold the reinforcing bars in correct vertical and horizontal alignment when the wet concrete is poured around the bars in the temporary wooden formwork (not shown). The 1/8- by 1-inch stirrups take shear loads.*

In recent years, high strength, high carbon steels have been developed, as well as very sophisticated steel framing systems such as the massive diagonal bracing on the John Hancock Building by I. M. Pei in Chicago. Likewise, pretensioned and posttensioned conrete using steel cables in tension has been developed to keep the concrete in compression. In these materials the concrete is constantly in compression. Precast concrete also uses steel for reinforcement and for anchorage to the framework of buildings in a manner similar to the anchors designed to hold stone or glazed architectural terra-cotta curtain walls in place.

There are countless decorative uses of steel in construction including staircases, window frames, doors and door frames, elevator doors, railings, and grilles. Most of these elements come painted or primed from the fabricator, and many have baked-on finishes.

Stainless Steel

Since the late 19th century, metallurgists have performed countless experiments to test the characteristics of hundreds of steel alloys to find new metals with superior properties. Industry needed these metals for machinery that would be strong even at high temperatures, hard enough to take the wear of moving parts, and corrosion-resistant to reduce maintenance costs. Much research was done to find better metals for the automotive, airplane, and electric industries. Later many of these alloys were adapted to the construction field.

At the turn of the century, interest centered on nickel steel, chromium steel, and later chromium-nickel steel, now called stainless steel. Between 1903 and 1912, scientists Harry Brearly of England, F. M. Becket of the U.S. and Benno Strauss and Eduard Maurer of Germany shared in the initial development of chromium-nickel steel. Its most important property is its resistance to corrosion. Stainless steels containing about 18% chromium and from 8% to 12% nickel are the most widely made. Their tensile strength, ductility, hardness, and resistance to creep and oxidation at high temperatures vary slightly with the composition. They can be cold worked, heat treated, cast, forged, welded, brazed, and soldered. However, stainless steel is expensive; hence, it is used primarily as a nonstructural metal or where there is a high potential for corrosion.

In 1928 architects Howe and Lascaze specified stainless steel, because of its high strength, for the grille and gate to the safety deposit room of the Philadelphia Savings Fund Society (PSFS) Building, which is now a National Historic Landmark. The stainless steel makes a very subtle contrast with the copper-clad walls.

Stainless steel sheets have been used for roofing, flashing, gutters, leader heads, downspouts, and cladding. One of the most extensive early uses of stainless steel was in the Chrysler Building in New York City. Architect William Van Alen originally intended to use aluminum to clad the building's Art Deco pinnacle (figure 105a), but finally decided in favor of stainless steel. The gargoyles were cast of stainless steel; the main entrance and storefronts are fabricated of rolled sheets and extruded sections of the same material. The elevator doors are stainless steel inlaid with wood (see figure 105b). Also in the Chrysler Building is a branch of Manufacturers Hanover Trust which is a *tour de force* of cast stainless steel (figure 106).

In the late 1920s and 1930s, the use of white metals increased with the rise of Art Deco, Depression Modern, Streamline Modern, and the International styles. Mirror finish chromium-plated metalwork was frequently used, but the plating often wore through to the base metal in high traffic areas such as entrances and lobbies. Since stainless steel is very hard, can be highly polished, and requires little maintenance other than periodic washings, it was a good choice for doors and storefronts. Some designs for stainless steel doors that became standard stock models can be found on several buildings, including the Versailles Apartment Building in Brooklyn (figure 107). Others were custom designed such as the stainless steel gates on the Federal Trade Commission Building in Washington, D.C., modeled by sculptor William McVey (figure 108).

Although there has been a long search for a noncorrosive material for bridge construction, stainless steel has not been used extensively, probably because of cost. As early as 1909, some nickel steel was used in construction of the Queensboro and Manhattan bridges crossing the East River in New York City. In 1937, 3,680 tons of 3.5% nickel steel were used for structural members of the San Francisco-Oakland Bay Bridge and 370 tons of stainless steel were used for pins in the cantilevered portion of the bridge. However, a total stainless steel bridge has never been built. After World War II, stainless steel replaced Monel metal for dairy, hospital, kitchen, restaurant, and laboratory equipment for economy. During the 1940s and 1950s, the stainless steel diner became a familiar part of American cities (figure 109).

There are many other uses for stainless steel including louvers, screens, railings, fascias, and cables. Fastening devices of stainless steel are also useful as anchors for masonry and metal curtain walls, and for restoring terra cotta and cast iron architecture. In 1964 Eero Saarinen used stainless steel to clad the Gateway Arch at the Jefferson National Expansion Memorial in St. Louis, Missouri.

Frequently stainless steel is used in modern sculpture, such as "News" in 1940 by Isamu Noguchi at 50 Rockefeller Plaza, New York City. A new gold-colored stainless steel developed recently has been used for storefronts in London and may soon be available in America.

Copper-Bearing Steels

Copper-bearing steels contain from 0.15% to 0.25% copper. Compared to ordinary steel, these metals develop increased resistance to atmospheric corrosion by forming a protective oxide coating. This "skin" has a uniform deep brown color and texture.

Copper-bearing steels were perfected in the 1950s and used in culverts and railroad grain cars before an architectural application was found. Architect Eero Saarinen noticed some railroad grain cars with the rich brown color and pleasing texture, and upon closer examination found the surface was unpainted. He learned that the material was specially developed for loading and transporting grain. Because sharp edged grain such as shelled corn eroded the paint on railroad cars, causing expensive maintenance programs, the railroad industry used this special steel, which rusted to a limited depth. The rust then formed a protective patina which prevented any further oxidation. Saarinen used this copper-bearing steel in the exterior of the Deere and Company Administrative Center at Moline, Illinois, and carbon steel on the interior where it was covered with fireproof material (figure 110). This was the first extensive architectural use of "Corten" manufactured by U.S. Steel. Weathered copper-bearing steel is also produced by Bethlehem Steel under the trade name of "Mayari R."

a.

b.

Figure 105. Stainless Steel Dome, Gargoyles, and Elevator Doors, Chrysler Building, 405 Lexington Avenue, New York City, 1928–1929; William Van Alen, architect. *(a) The Chrysler Building was the first extensive use in America of chromium-nickel steel, now commonly called stainless steel, as an exterior finish on a large commercial structure. There are many types of stainess steel with different properties; the type used here was Nirosta, K.A.2 (Krupp's formula), installed by the sheet metal contractor, Benjamin Riesner, Inc. According to the architect, "The sheet metal covering for the needle or upper third of the spire (not shown) was attached directly to the structural steel frame. A base of "nailing" concrete was provided for the sheet metal work, completely covering that portion of the dome and spire below the needle, and extended down on both sides of the circular-head dormers to the 59th floor level. The sheet metal ribs were fastened to fireproofed wood nailing strips placed on top of the concrete and fastened to the structural steel frame. Standing or lock seams, made without solder, were used throughout, except where they were impossible or undesirable, where soldered seams were used. The radial ribs on the fronts of the metal-covered dormers of the dome and similar ribbed construction are formed by sheet metal-covered wooden battens. Contact between dissimilar metals was avoided by using Nirosta steel nails, screws, bolts, nuts, and rivets for fastening the sheet steel in position." (b) Influenced by the discovery of the King Tut's tomb, these stainless steel elevator doors are inlaid with rare woods in a stylized Egyptian design featuring a lotus blossom at the top. (Cervin Robinson)*

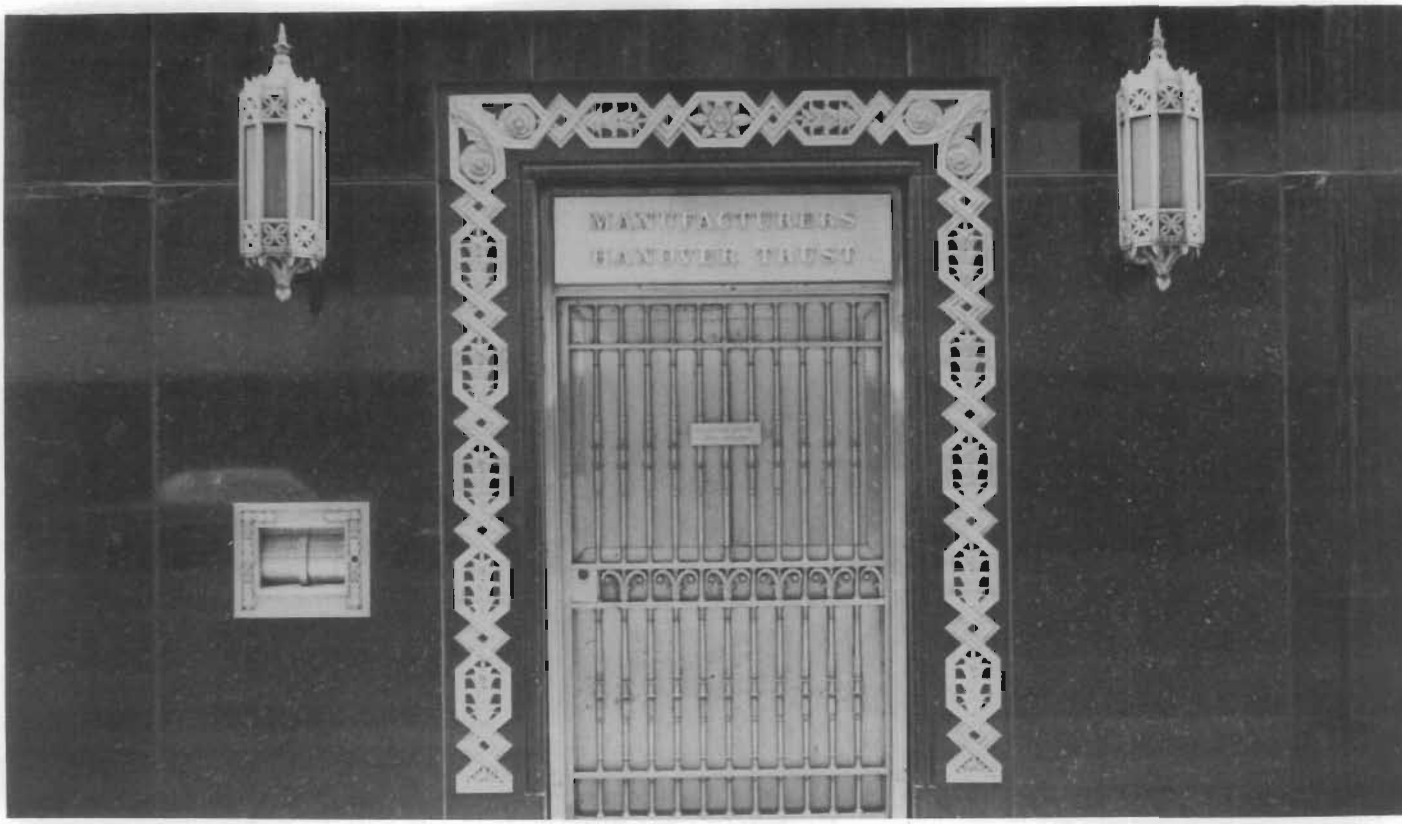


Figure 106. Cast Stainless Steel Entrance, Manufacturers Hanover Trust, Chrysler Building, New York City, 1931; Cooper Alloy Foundry, Elizabeth, New Jersey. *The gate, door, frame, lamps, night deposit, and lettering were cast in Nirosta stainless steel. (David W. Look)*

Figure 107. Typical Stainless Steel Doors, Versailles Apartment Building, 1717 Avenue N, Brooklyn, New York, 1936; Kavy and Kavovitt, Inc., architects. *The doors were fabricated from sheets of stainless steel with etched and frosted glass in the window. The stainless steel frame was produced from rolled sections and inset with glass blocks. Identical doors with clear glass can be found on the Majestic and Gynwood apartment buildings in Washington, D.C. (David W. Look)*

Figure 108. **Stainless Steel Gates, Lamps, and Lettering, Federal Trade Commission, Sixth and Constitution Avenue, NW, Washington, D.C., 1937; Bennett, Parsons, Frost, architects; William McVey, sculptor.** *During the 1930s stainless steel was frequently used for monumental doors and ornamental gates on government buildings. Noted sculptors were employed to design custom ornamental metalwork. The lamps, lettering, and window grilles (not shown) are all stainless steel. (David W. Look)*

a.

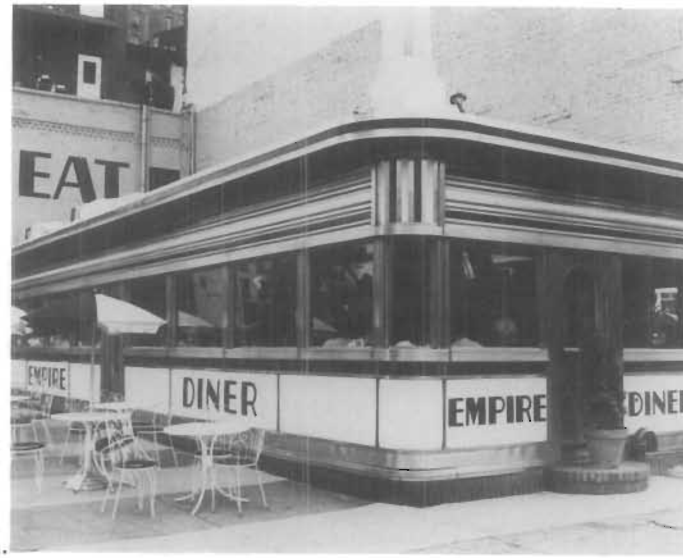


Figure 109. **Stainless Steel Empire Diner, 210 Tenth Avenue, Chelsea, New York City, 1943, altered, 1976; Carl Laanes.** *(a) Early diners were horse-drawn wooden wagons, but after the advent of the automobile they soon became stationary. Although companies built diners in a range of sizes and styles, and of various materials, the stainless steel diner became the ultimate expression in diners. The exterior of the Empire Diner has panels and strips of white and black enameled steel which contrast with the polished stainless steel. (b) Although some early diners had wooden interiors and Monel metal equipment, most diners were paneled with pressed stainless steel and had stainless steel equipment by the 1940s. (David W. Look)*

b.

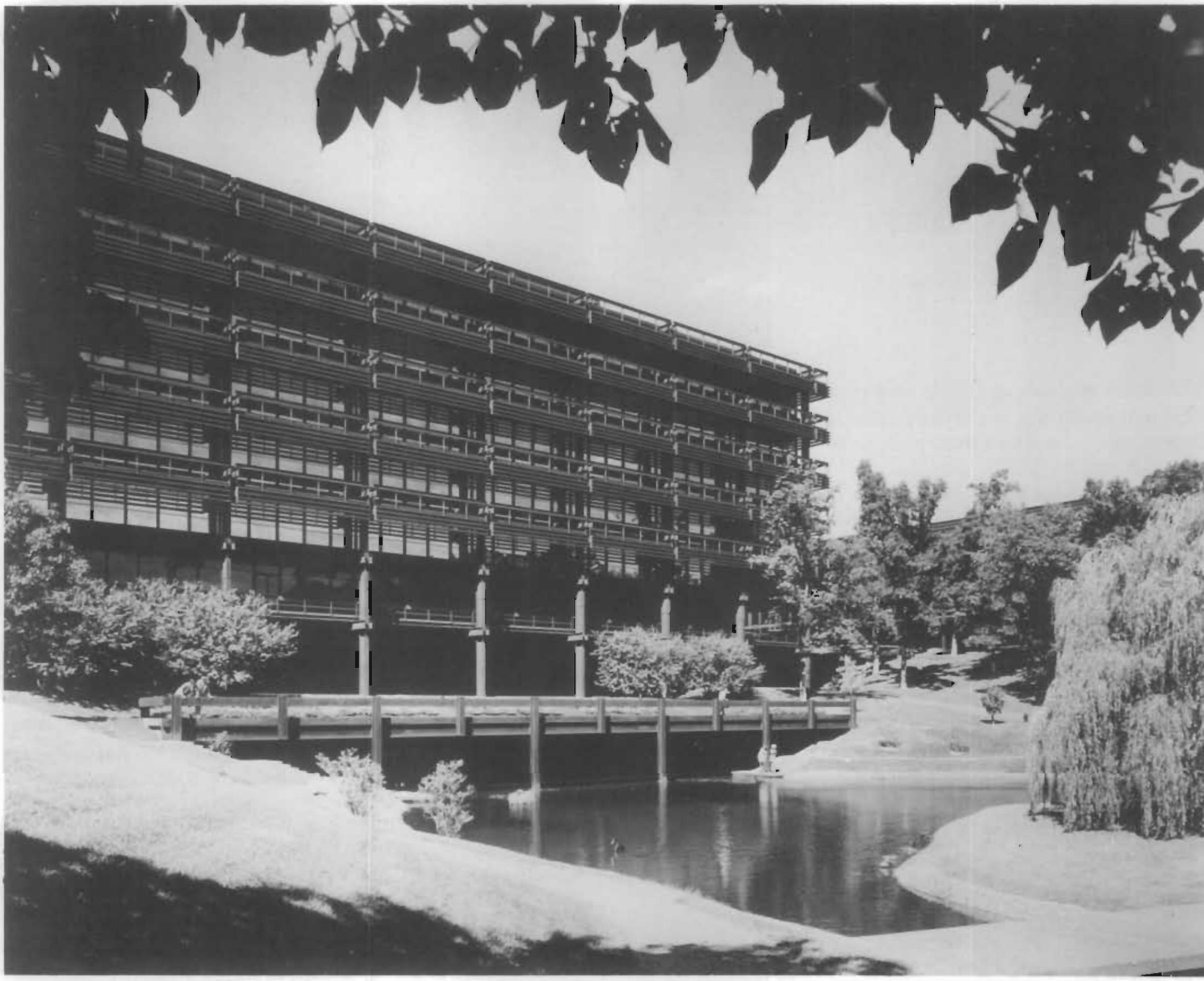


Figure 110. **"Corten" Steel, Deere and Company Administrative Center, Moline, Illinois, 1964; Eero Saarinen, architect.** *The Deere and Company building, which received many architectural awards, was among the first to make extensive architectural use of this unpainted, corrosion-resistant material for exterior steel members. (Deere and Company)*

Chapter 8: Aluminum

Aluminum was not available at a reasonable price or in sufficient quantities for architectural uses until after the beginning of the 20th century. It is the third most abundant element on Earth, exceeded only by oxygen and silicon. Like most metals, it never occurs in nature as a pure element but always as a compound. The name of the aluminum-rich ore, bauxite, came from the French village Les Baux, where a deposit was found in 1821. Four years later, Danish physicist Hans Christian Oersted produced the first few ounces of aluminum. It was considered so precious that Frederick VII, King of Denmark, had a royal helmet made of polished aluminum and gold.

Figure 111. The Setting of the Aluminum Tip on the Washington Monument, Washington, D.C. *The first architectural use of aluminum was the small pyramidal cap of the Washington Monument, which was set in place on December 6, 1884. At that time, aluminum was still considered a precious metal. (Engraving in* Harper's Weekly, *December 20, 1884; Martin Luther King Library)*

In 1855 at the Paris Exposition aluminum was introduced to the public. Napoleon III had pocket watches and a table service designed of it, and during the American Civil War, General Ulysses S. Grant received an aluminum medal from the U.S. Congress. One hundred ounces of the rare metal were cast to form the small pyramidal cap of the Washington Monument in Washington, D.C. Before ceremonial positioning of the cap atop the monument on December 6, 1884 (figure 111), it was displayed in Tiffany's window in New York City. The monument cap was the first American architectural use of aluminum.

Until a method was found to separate the pure aluminum from the bauxite ore in large quantities and at a moderate cost, it could not be used for anything other than small items. Metallurgists were intrigued by the attractive, lightweight, corrosion-resistant metal and foresaw many commercial and industrial applications. The modern electrolytic method of producing aluminum was discovered in 1886 almost simultaneously by Charles Martin Hall in the United States and Paul L. T. Heroult in France. The essentials of the Hall and Heroult processes were identical and have become the basis of the modern aluminum industry. Initially Hall found little support for the commercial development of his process, but fortunately he met another metallurgist, Captain Alfred E. Hunt, who convinced a small group of steel producers to establish the Pittsburgh Reduction Company in 1880. Early production soon reached 50 pounds of aluminum per day at the small plant; tea kettles and cooking utensils were some of the first products.

In 1893 Winslow Brothers, Company, of Chicago, Illinois, published a photographic essay of their previous work, probably for the Columbian Exposition. The book not only gives the names of buildings that contained their work and the architects who designed the buildings, but also identified in detail the metals, alloys, plating (if any), and other finishes. Of special interest are the Monadnock (figure 112) and Venetian (now demolished) Buildings in Chicago which contained cast aluminum stairs, elevators, and grilles dating from 1891 and 1892, respectively. Also listed, but not illustrated, is the Isabella Building of 1893 which also has original aluminum work.

As production increased and other companies were founded, the cost of aluminum decreased, but by 1895, aluminum was still five times as expensive as copper. In spite of the cost, aluminum was used in 1895 to sheath the dome and roof of the Church of San Gioacchino in Rome, Italy. Seventy years later, the roof was still in excellent condition.

The engine of the Wright Brothers' plane at Kitty Hawk was made of aluminum. By the time World War I began, aluminum was in use for military aircraft because of its relative lightness and strength. Production increased enormously and the costs continued to decline. Architectural use of aluminum slowly increased in the 1920s, mainly for decorative detailing. Aluminum was one of the white metals popular in the modern movements of architecture and art.

When it was proven that aluminum could be shaped by most known methods of metal working, its inclusion in architectural and industrial settings surged. Since it could be rolled into sheets, it was used for roofing, flashing, gutters, downspouts, wall panels, and spandrels; it could also be extruded into lengths of specialized profiles or cross sections for use in window mullions and frames, storefront surrounds, and doors. Because it was a favored color and could be cast, aluminum was chosen for interior trim in public buildings and commercial structures in the 1920s and 1930s.

Figure 112. Cast Aluminum Staircase, Monadnock Building, 53 West Jackson Boulevard, Chicago, Illinois; Burham and Root, architects; Winslow, Brothers, Co., foundry. *Although the Monadnock Building is widely known as the last skyscraper with load bearing walls, few people know that it contains the second known architectural use of cast aluminum in America. The first story staircase, including the newell posts, electroliers, balustrade railing, facias, and stringers, are all cast of aluminum. The lamps have been removed. Aluminum ventilation grilles near the exterior doors are also illustrated, but have also been removed. (plate 4,* Collection of Photographs of Ornamental Iron Executed by Winslow Bros., *1893, Library of Congress)*

Art Deco designs were often fabricated in cast aluminum, as can be seen in the Post Office in Cincinnati. Frequently neoclassical designs were executed in aluminum, as in the Mellon Institute of Pittsburgh. In both buildings, the ornamental door trim, window details, revolving doors, lobby fixtures, and elevator doors were fabricated of patterned silvery aluminum.

The perforated Gothic spire of the Smithfield Street Congregational Church was cast in Pittsburgh and affixed to the church in 1926 (figure 112). Another exterior use of aluminum was in the 1929 Springfield, Illinois, Post Office where decorative aluminum panels are set into the walls, and bold stylized anthemions stand along the roofline.

The first extensive use of aluminum in construction was the Empire State Building, completed in 1931. The entire tower portion is aluminum, and architects Shreve, Lamb, and Harmond also included it in their design of the entrances, elevator doors, ornamental trim, and some 6,000 window spandrels. Flanked by ribbons of stainless steel, these panels of "deplated" aluminum are a dark gray color.

In 1933 almost 65,000 pounds of aluminum sheets were used to roof the Union Terminal in Cincinnati. That same year the architectural firm of Ritter & Shay. designed the U.S. Custom House on Chestnut at Second Street in Philadelphia, which had aluminum light standards and sculptural bas-relief figures in tympanum panels over the doors (figure 113). In Washington, D.C., sculptor Carl Paul Jennewein modeled the aluminum work for the Department of Justice Building (figure 114).

During World War II, aluminum moved into fourth place among metals in production and use. Roofing of the Mormon Tabernacle in Salt Lake City, Utah, in 1947, was an important post-War example of the use of aluminum. Today aluminum ranks second to steel in production.

Although the process for anodizing aluminum was invented in 1923, it was not used for architectural elements until the 1950s. Anodizing is a special electro-chemical bath that provides a tough oxide coating for greater resistance to atmospheric corrosion, and can also be used to add a colored finish. Aluminum siding with a baked-on paint finish came on the market about the same time as anodized aluminum. The 30-story Alcoa Building, erected in 1951-1952 in Pittsburgh's Golden Triangle, was the first multistoried building to employ curtain walls of aluminum. Rising 410 feet, the walls consisted of 6- by 12-foot sections mechanically stamped from 1/8-inch aluminum sheets. Each section has a reversible pivot aluminum window above a pyramidal stamped panel, backed by aluminum lath and sprayed perlite plaster. The lighter weight of the curtain wall reduced the size of the structural steel members and the foundation, resulting in a 30% savings on these two items. The exterior panels were given an irridescent gray anodized coating. There was a deliberate attempt to make use of aluminum in as many ways as possible, even including aluminum strips in the terrazzo floors. Innovative major uses included all-aluminum wiring; aluminum pipes for plumbing, heating, and air conditioning; and an aluminum cooling tower (figure 112).

Figure 113. Cast Aluminum Spire, German Evangelical Protestant Church, Pittsburgh, Pennsylvania, 1926; Henry Hornbostel, architect. Also Alcoa Building (background, left), Golden Triangle, 1952; Harrison and Abramovitz, architects. *The perforated spire of the German Evangelical Protestant Church, now the Smithfield Street Congregational Church, consists of 22 filigree aluminum castings. The Alcoa Building is the first multistory structure with an aluminum curtain wall. The other tall building (right) is the United States Steel-Mellon Building. (Carnegie Library of Pittsburgh)*

Some 2,500 tons of aluminum were used in construction of the U.S. Air Force Academy in Colorado Springs, Colorado, in the 1950s. The chapel of the Academy has aluminum exterior panels, windows, handrails, and grilles, but the most spectacular aluminum members are the 17 roof spires made up of 100 giant, preformed tetrahedrons. In 1953, Henry Ford financed F. Buckminster Fuller's first aluminum and plastic geodesic dome. Within a few years, thousands had been constructed around the world.

Because of its durability, aluminum was used in construction of the Vehicle Assembly Building completed in 1965 at the NASA Launch Complex, Kennedy Space Center, Florida, which is listed in the National Register of Historic Places. Enclosing 10 acres of land and over 45 stories tall, the building is clad with ribbed aluminum sheathing specially designed to withstand 125 mph winds.

Today aluminum is used extensively in construction for everything except major structural members, and is available in a wide variety of colors and finishes.

Figure 114. **Aluminum Bas-Relief Sculpture in Tympanum and Lamps, U.S. Customhouse, bounded by Chestnut, Second, and Third streets, Philadelphia, Pennsylvania, 1933; Ritter and Shay, architects; Edward Ardolino, sculptor.** *In the 1920s and 1930s, architects frequently chose one of the white or silvery metals for their buildings; those designing in the Art Moderne, now called Art Deco style, especially considered gold or bronze colored metals "old-fashioned." The highly stylized bas-relief mural in the typanum is flanked by cast aluminum and glass lamps. (Esther Mipaas)*

Figure 115. **Aluminum Doors and Lamps, U.S. Department of Justice, Ninth and Constitution Avenue, NW, Washington, D.C., 1934; Zantzinger, Boris, Medary, architects; Carl Paul Jennewein, sculptor.** *The monumental doors, fabricated of cast lions and rolled sections of aluminum riveted together, are opened back into pockets of the walls of the entrance showing the inner set of aluminum and glass doors and transom. Flanking the entrance are cast aluminum lamps with stylized eagles, buffaloes, and dolphins. The work was executed by Anthony D. Lorenzo. (David W. Look)*

Conclusion

Much can be gained from studying trade catalogs and contemporary accounts on the subject of metals in America's historic buildings. The foundry catalog traditionally played an important role in the marketing of metals in the United States as prefabricated building materials, and was part of the revolution in building techniques that took place during the 19th century. Catalogs brought good-quality standardized products within the grasp of builders across the country and resulted in lower prices for products shipped directly from the iron factories and foundries.

The first foundry catalogs seem to have appeared in America in the 1850s. Most metal products were manufactured in cities where they contributed to both commercial and residential growth patterns. The products offered unquestionably added to the variety of buildings that could be constructed in every community served by railroad, canal, or coastal waters.

The items usually advertised were columns, storefronts, entire building fronts, stairs, brackets, window sills and lintels, overdoors, railings, shutters, verandas, balconies, posts, fences, and cresting. Some catalogs were also sources for heating, plumbing, and lighting equipment.

The best known catalog is that of the Architectural Iron Works of New York City, issued in 1865 (reprinted in 1970, see bibliography). Another reprinted foundry catalog is that of Janes, Kirtland and Company, which in 1870 was marketing decorative cast-iron fountains, urns, verandas, trellises, garden furniture, and lawn animals. Recently the 1857 J. B. Wickersham New York Wire Railing Company was republished by the Philadelphia Athenaeum under the title *Victorian Ironwork*.

For various reasons, few catalogs have survived to the 20th century. Some early catalogs were printed on poor quality paper little better than newspaper. Those that have survived are usually on quality paper. A few were beautifully done with hand-colored drawings, and some of the later catalogs included photographs.

A few catalogs list previous clients and their buildings to advertise their designs and satisfied customers. Examination of a collection of catalogs from a foundry such as J. L. Mott, J. W. Fiske, W. H. Mullins, or Wood and Perot shows the repetition of certain designs from catalog to catalog and can indicate which designs sold more and how long their popularity lasted.

Contemporary accounts give details on how these metal components were made, installed, and used. The bibliography lists these accounts to help architectural historians, historical architects, preservationists, craftsmen, and industrial archeologists find information on topics germane to preservation projects.

The second part of this report will discuss the physical and mechanical characteristics of these architectural metals, examine the reasons for their deterioration, and suggest methods of keeping them from environmental and human damage.

Opposite: Replication of the original c. 1815 Philadelphia gutter at The Octagon in Washington, D.C. utilized hand-cast lead sheets and traditional application techniques. (John G. Waite)