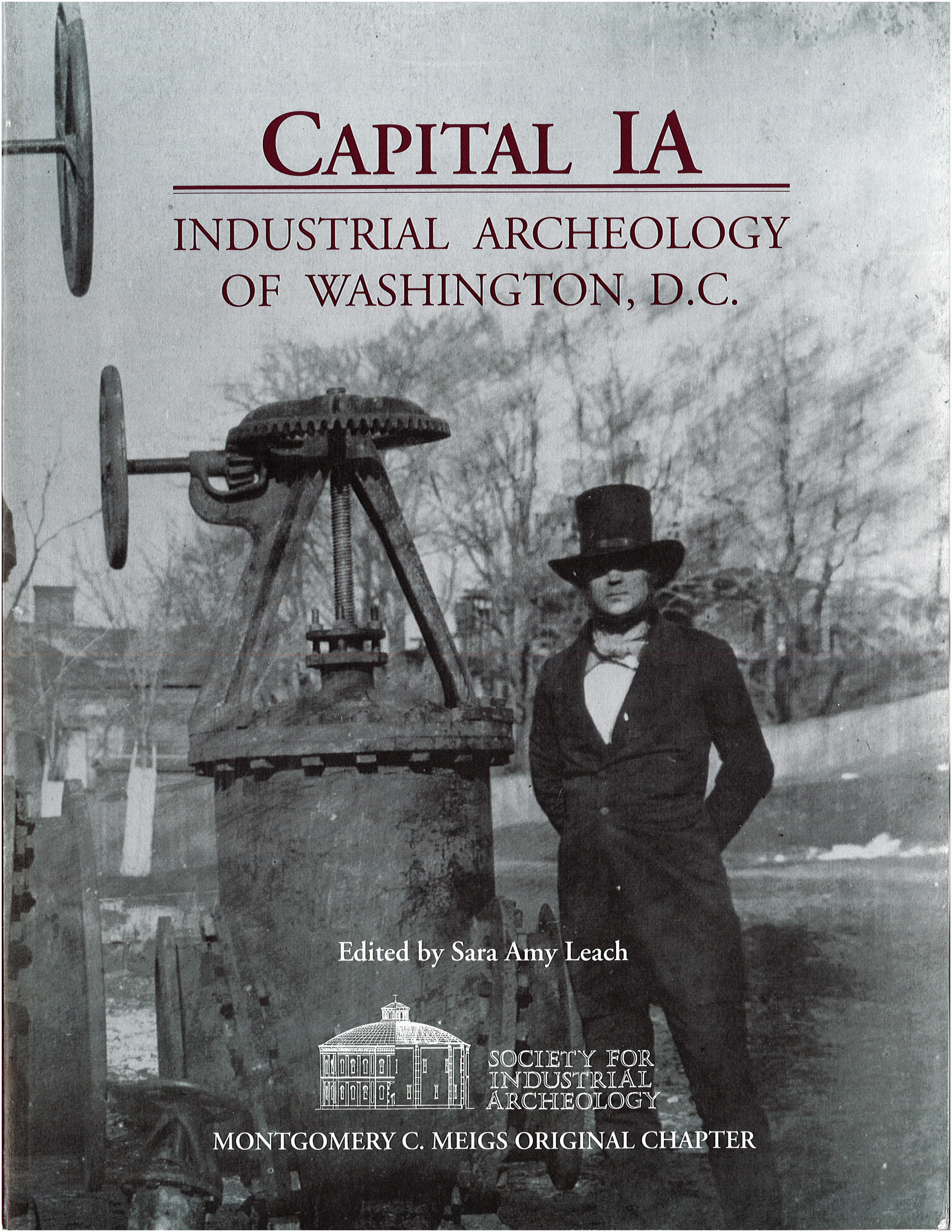
CAPITAL IA

INDUSTRIAL ARCHEOLOGY OF WASHINGTON, D.C.



Edited by Sara Amy Leach

SOCIETY FOR INDUSTRIAL ARCHEOLOGY

MONTGOMERY C. MEIGS ORIGINAL CHAPTER

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WASHINGTON, D.C.
2001

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Cover Image: *Captain Montgomery C. Meigs, Chief Engineer, inspects valves at the Washington Aqueduct wharf in Georgetown, 1859. Courtesy Washington Aqueduct, U.S. Army Corps of Engineers.*

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Preface

by Robert M. Vogel

It is a trifle ironic that while the Montgomery C. Meigs Original Chapter of the SIA is indeed the original of the society's chapters—it is one of the few chapters that never has hosted an Annual Conference or even a Fall Tour. The reason for this seeming inhospitality will be obvious to most: a pervasive perception that there is not, and never has been, any real industry in the nation's capital—and thus, by definition, there can't be any industrial archeology worth the name or the time to look for it.

Then how did the SIA come to be organized in this IA wasteland—much less the original chapter? As with so much in life, it was the people. Thirty years ago there happened to be in town two of the three men who joined in believing that the time had come to assemble everyone they could think of who might be expected to take a more formalized interest in the relatively new field that had come to be known as industrial arch(a)eology. The initial idea had been put forth by Paul E. Rivard, then director of the Old Slater Mill Museum in Pawtucket, R.I. With Theodore A. Sande, teaching fellow and doctoral candidate at the University of Pennsylvania, and myself, he sent out the pre-e-mail word by telephone, post, and grapevine. The result was a meeting on 16 October 1971, at what then was called the Museum of History and Technology, of some fifty architectural historians, historical arch(a)eologists, historians of technology, museologists, preservationists, students, a handful of folks who could almost have been seen as professional industrial archeologists, and even a number of interested "amateurs"—altogether a reasonably representative cross-section of people involved in one way or another in, or almost in, the field.

Following general discussion and a series of short accounts of work currently being undertaken, things came down to nearly unanimous agreement on three goals that ought to be met:

- Interdisciplinary exchange of information;
- Generation of bibliographical information of pertinence to the field; and
- Outreach: creation of public awareness of the need for surveys, preservation of sites and structures, and the other broad aims of IA.

That established, discussion continued on the most likely means by which these aims could be achieved, leading quite naturally to a poll of the room that showed a heavy majority favoring the establishment of an entirely new organization, inasmuch as no existing society or association—while several of them were more or less concerned with the needs and ideologies of IA—quite met them in their entirety. Hence, then and there was created the Society for Industrial (diphthongless) Archeology. In fully democratic fashion a provisional "executive committee" was formed of volunteers, including as Canadian liaison R. John Corby of Ottawa's National Museum of Science and Technology. From this distinguished panel officers and a newsletter editor were appointed—or were they also volunteers?—memories are dim on this.

The point is, it worked, as indicated by the fact that thirty years later the society lives on, in the meantime grown in terms of: membership (1,800 in North America and abroad); chapters (currently twelve); publications (the journal *IA* in addition to the *Newsletter*); activities (Fall Tours and Study Tours in addition to the Annual Conferences); awards (General Tools Award for major contributors to IA and the Norton Prize for critical articles in *IA*); and in other ways. And this is a point worth noting: the SIA was the world's first international IA society.

And wherefore the Montgomery C. Meigs Original Chapter? Much the same sort of organizational impulse: a small group of SIA members gathered in a Washington-area living room for purely social purposes about 1974, it occurring to someone that as many societies have geographically-based chapters—why not the SIA? Splendid notion! And for a name, what more appropriate than to memorialize the city's leading 19th-century polymathic engineer?

Finally, what of the Washington region as an IA wasteland? Read on for the answer to that. This may not be Troy, Pittsburgh, Baltimore, Cleveland, Philadelphia, Chicago, Detroit, Buffalo, or even New York or Toronto—but with a vast number of historically interesting engineering and even industrial sites and structures, MCMOC's home turf is hardly an IA wasteland!

Acknowledgments

Guidebooks are notoriously difficult to write, and the Montgomery C. Meigs Original Chapter of the Society for Industrial Archeology gratefully acknowledges the industrial-strength assistance received in preparing this book. First and foremost Sara Amy Leach worked long hours to fashion a mass of data into a readable text, and we are all indebted to her efforts. Kim Hoagland wrote the introduction, and Justin Spivey copy-edited, proofread, and formatted the entire book. Dean Herrin, Christopher Marston, Robert Vogel, and Helena Wright contributed significant sections; other contributors included John Austen, Lisa Davidson, Eric DeLony, Marc Howell, Bob Kapsch, Zachary Schrag, David Shayt, Barry Virts, and Esther White.

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The Society for Industrial Archeology

SIA is a nonprofit, international, interdisciplinary association that brings together people of varied backgrounds having a shared interest in the archeology—the physical remains—of industry, engineering, and technology, mostly above-ground. To learn more about the Society visit its web site: www.ss.mtu.edu/IA/sia; request a brochure from SIA Headquarters, Department of Social Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931-1295; phone (906) 487-1889; or send e-mail to sia@mtu.edu.

Capital IA

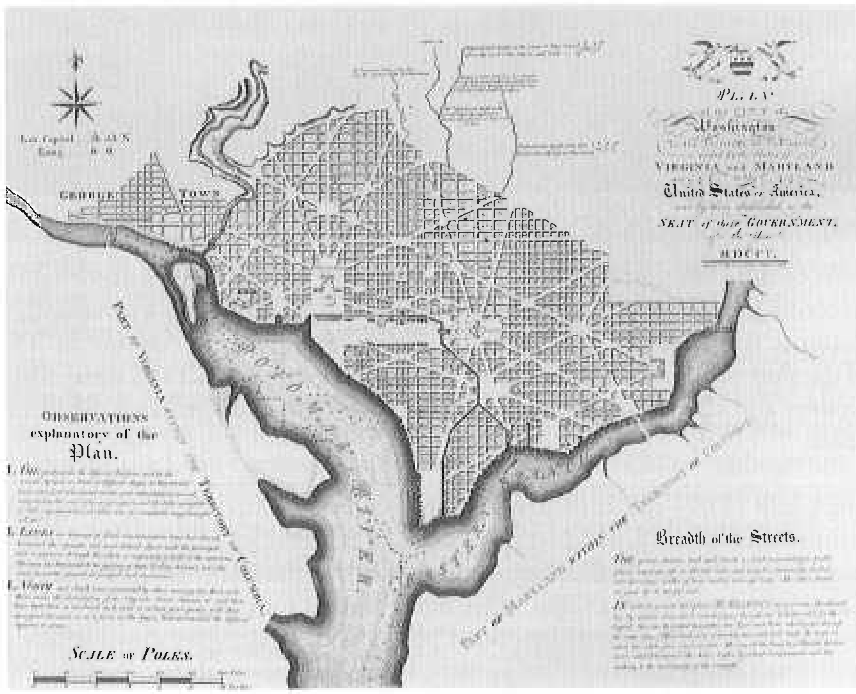
Capital IA is the tour guidebook for SIA's 30th Annual Conference, held 10-14 May 2001 in Washington, D.C.—site of the Society's founding meeting in October 1971. This book is intended to provide a reference for those sites visited as part of the conference, but it does not claim to be a comprehensive catalogue of all the industrial sites and structures in the area.

Introduction: Industrial Archeology in Washington, D.C.

by Alison K. Hoagland

Washington's role as the nation's capital accounts for its origin, development, and dearth of manufacturing industries. The city's monumental buildings, wide avenues, generous amount of parkland, and magnificent works of civil engineering all can be attributed to the federal government. The government also formed the basis of the local economy and guided the course of the city's industrial development.

Established as the seat of the new federal government in 1790 and occupied in 1800, the District of Columbia comprised a 10-mile square, located just below the fall line of the Potomac River. Pierre L'Enfant, a French architect and military engineer, produced an elaborate city plan consisting of an irregular grid of streets overlaid with diagonal grand avenues. He located the President's house on one hill, Congress's house on another, and the judiciary on a third (which was occupied instead by city hall). The streets and avenues were wide, ranging from 85 feet to 165 feet, and intersections of avenues remain public space, eventually landscaped as parks.



Within the 10-square-mile that was the District of Columbia, Pierre L'Enfant laid out the city of Washington in a grid plan overlaid with diagonal avenues that converged on sites of significance. Map by Andrew Ellicott, engraved by Thackara and Vallance, 1792.

The District was not unoccupied when the government selected it as its new home, however, as the port towns of Alexandria, Va., and Georgetown, Md., were included within its boundaries. Both had been established in the mid-18th century as tobacco-inspection stations and developed as entrepôts, transferring agricultural products to ocean-going vessels. Access to the hinterland was key, and even before the site for the capital was selected George Washington had founded the Potowmack Company to enhance the river's navigability upstream from Alexandria. Besides removing obstructions in the river, the company built five canals to take river traffic around falls. The largest of these, at Great Falls, used five locks to overcome a 76-foot drop in the river. James Rumsey was the chief engineer and Leonard Harbaugh the construction superintendent on the project, which was completed in 1802. The upper Potomac proved resistant to improvements though, and despite the expenditure of about $500,000, the river was navigable only about two months of the year. In 1828 the Potowmack Company's charter was transferred to the Chesapeake & Ohio Canal Company.

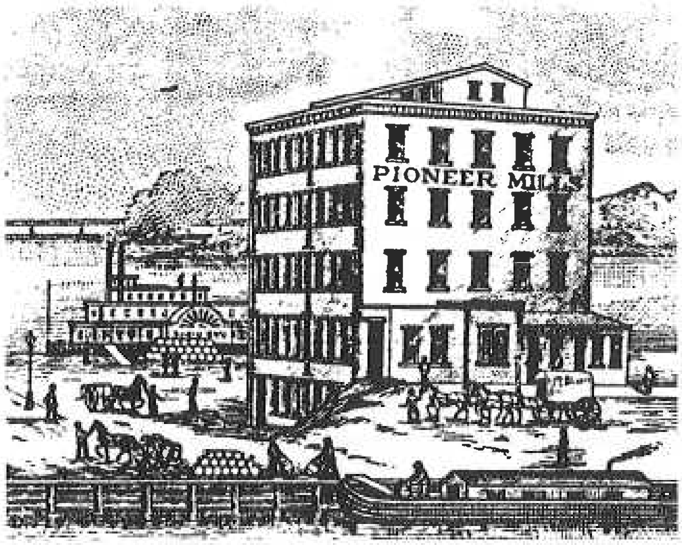
The C&O Canal took a different approach, remaining separate from the river for its entire 185-mile length. But the goal was the same, to reach the Ohio River. Funded by Washington businessmen, the canal broke ground in 1828 and reached Cumberland, Md., in 1850 by employing seventy-four locks, eleven aqueducts, and one 3,118-foot tunnel. Georgetown felt the effects almost immediately, with an enhanced role as a regional transshipment center. Alexandria, whose shippers had exported eight times the amount of cargo as Georgetown in the first fifteen


Aqueduct Bridge and the C&O Canal, intersecting on the Georgetown waterfront, ca. 1860.

years of the 19th century, saw a precipitous drop soon thereafter and eyed Georgetown's prosperity jealously. Accordingly, in 1831-43 the Alexandria Canal Company built a seven-mile spur off the C&O Canal, crossing the Potomac with Aqueduct Bridge and bringing canal traffic to Alexandria. The effort to reestablish the preeminence of the port of Alexandria was unsuccessful, however, and in 1846 Alexandria County (present-day Arlington County and city of Alexandria) was retroceded to Virginia, cutting the District of Columbia down to 71 square miles.

On 4 July 1828—the same day Washington businessmen broke ground on the C&O Canal—Baltimore businessmen broke ground on the Baltimore & Ohio Railroad and the race to the Ohio valley was on. Railroads turned out to be the technology of the future and the B&O insured Baltimore's viability as a port. The C&O Canal never reached the Ohio valley but it thrived for several decades after reaching Cumberland in 1850. In 1880, for instance, five hundred canal boats plied the canal bringing down wheat, wood, limestone and, most important, coal. The Georgetown waterfront was a hive of activity with two iron foundries, two lumber yards, and six coal companies. A trade in ice began in the 1880s, with ships from Maine bringing ice to Georgetown and returning home laden with coal from western Maryland. The canal also provided water power to Georgetown, where millers took advantage of the 35-foot drop between canal and river and erected five flour mills and a paper mill. But Georgetown's port was harmed by silting in the Potomac, created in part by deforestation of the area. Damage was also incurred by the 1808 construction of Long Bridge, which connected 14th Street in Washington and Virginia with a wide-piered span that obstructed water flow. Georgetown's charter from Congress prohibited it from building a bridge, bringing in a railroad, or dredging its own harbor—all preventing the port community from developing modes of transportation that would have facilitated industrial development.

Yet another canal was internal to the city. Washington City Canal, which channeled Tiber Creek along present-day Constitution Avenue and then south in front of the Capitol, connected port facilities in the southwest quadrant of Washington to the C&O Canal. Built by a private company in 1810-15, the canal quickly silted up and by 1818 was usable only at high tide. The lockkeeper's house at 17th Street and Constitution Avenue is today the most visible remnant of this venture. In the 1830s Congress, realizing that some investment in its hometown was justified, provided funds for the capital city to buy the Washington City Canal, underwrote the paving of Pennsylvania Avenue, and assumed the debts of Georgetown, Washington, and Alexandria for the C&O Canal.

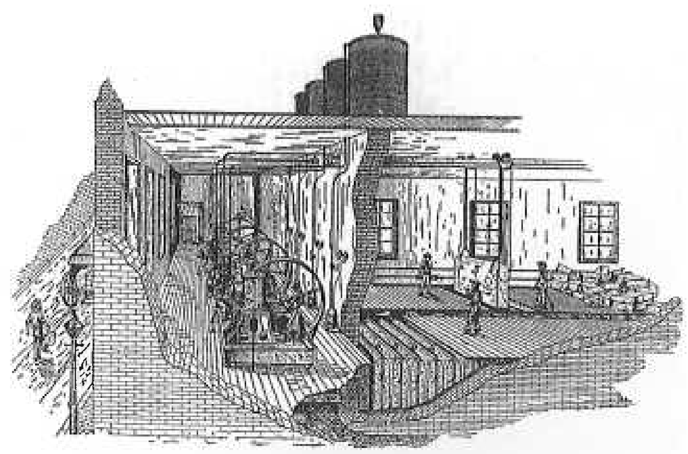


Built in 1832 as one of several flour mills in Georgetown, fifteen years later this building was converted to a cotton mill with 2,560 spindles and 84 looms.

In general, however, Congress impeded the city of Washington from developing its economic potential, just as it had Georgetown. The B&O built a Baltimore-to-Washington branch in 1835, although Congress prohibited steam locomotives from running in the District until 1852, insisting that animals tow the cars instead. Baltimore businessmen also encouraged Congress to prevent any other railroad from serving the city until 1872. Without competition and with its heart in Baltimore, the B&O effectively stifled industrial development in Washington.

In 1850 the average manufacturing firm in the city of Washington was capitalized at only $5,000 and all relied on manpower except for four printers, three foundries, one brewery, one lumber mill, and one small machine shop. Water-power sites included not only the canal in Georgetown, but also Rock Creek. In Foggy Bottom, east of Rock Creek along the Potomac, a collection of lime kilns, a shipyard, a lumber yard, an icehouse, a fertilizer plant, a brewery, and a gas works made this an industrial area by 1860. The Navy Yard in the southeast quadrant was the District's chief manufacturing establishment, employing 175 civilian workmen and keeping two ropewalks busy. But in 1850 construction fell off when officials determined that the site was too far from the ocean to be a practical shipbuilding location. During the Civil War construction at the Navy Yard resumed; the Navy employed 1,700 workers in 1862 and the next year built a new foundry.

As much as Congress handicapped Washington, it also gave the capital advantages no other city could claim. The construction of major monuments and the clearing and draining of the vast spaces created by L'Enfant's plan required sophisticated engineering. Buildings for the U.S. Treasury, Post Office, and Patent Office—all begun in the 1830s—employed new fireproof construction that avoided the use of wood. Concern that government buildings be fireproof was borne out after the purposeful burning by the British of the Library of Congress in 1814, when it was housed in the Capitol, and the accidental burning of the Patent Office in 1836, when it was housed in Blodgett's Hotel, a privately constructed building downtown. If the government's main product was paper, then that product should be protected. Accordingly, in 1836 President Andrew Jackson named Robert Mills, who had built a fireproof county records office in Charleston, S.C., to the post of Architect of Public Buildings. Mills oversaw construction of the U.S. Treasury, Patent Office, and Post Office buildings, all employing essentially the same plan: masonry central barrel-vaulted corridors flanked by groin-vaulted cubical offices. Mills' use of cast iron for stairways foreshadowed the use of cast iron in other buildings devoted to paper preservation, such as the libraries in Alfred B. Mullett's State, War, and Navy Building and Georgetown University's Healy Building library. The Capitol's cast-iron dome is perhaps the most conspicuous use of this so-called fireproof material, which was selected for qualities of cheapness and ease of erection as well as its incombustability.



Ice from Maine was one of Georgetown's imports. Concerns such as the New York-based Transparent Ice Manufacturing Co. produced it at factories located in cities including Washington, D.C., where the C&O Canal provided waterpower to drive ammonia refrigeration compressors.

Accomplished scientists and engineers were drawn to Washington not, as is usually the case, by a premier university, but instead by the government's diverse roles. Joseph Henry, the first head of the Smithsonian Institution, founded in 1846 by an act of Congress, argued to devote the institution exclusively to research, but later its U.S. National Museum assumed center stage. Joseph G. Totten, appointed head of the U.S. Army Corps of Engineers in 1838, sat on the Smithsonian's first board of regents and maintained a social relationship with Henry and other scientists. The Patent Office began research on agriculture that developed into a cabinet-level department. The Geological Survey, the Coast and Geodetic Survey, the Naval Observatory, and the Army's Signal Corps, which collected weather data, all were founded in the 19th century. The Bureau of Standards, the largest testing laboratory in the world, dates from 1901.

In 1850 Totten raised the profile of the Corps of Engineers, involving it in the extension of the Capitol and the provision of a steady supply of water for the city. Both projects ended up in the hands of young Army engineer Montgomery C. Meigs who, in declaring "Let our aqueduct be worthy of the nation," set the pace for grand works of civil engineering. Meigs' ambitious plan did not merely respond to the city's growth, but anticipated it, and incorporated several innovative features. Drawing water from the Potomac upstream from Great Falls, Meigs brought it more than 9 miles in a conduit measuring 9 feet in diameter. To cross Cabin John Run he built the largest masonry arch in the world; to cross Rock Creek he used two 48-inch cast-iron tubes that served as water mains as well as supporting arches for the later Pennsylvania Avenue Bridge. At the Capitol, Meigs made changes to architect Thomas U. Walter's plans, introducing fireproofing, ventilation, and even interior decoration. He and Walter also collaborated, not always happily, on the ingenious cast-iron dome.

Washington's infrastructure was badly strained during the Civil War by a population influx. Faced with sentiment for moving the capital west after the war, a reorganized city government devoted its efforts to paving streets and generally modernizing the city. Although vast corruption is attributed to Alexander "Boss" Shepherd, as head of the Board of Public Works he did succeed in transforming the city: grading and paving streets, laying gas and sewer mains, and planting trees. He also caused Congress to terminate territorial government. From 1878 until 1967, three appointed commissioners governed Washington, and one of them was always a member of the Corps of Engineers. Due to the placement in the Corps of Engineers, 1867 to 1933, of the Office of Public Buildings and Grounds, which controlled all government buildings and open spaces in the District, coupled with the location of the headquarters of the Washington District of the Corps in the city, 1875 to 1953, federal engineers have long played an important role in the appearance and function of the District of Columbia. The federal role in District affairs was further solidified by congressional provision of half of the municipal budget until World War I (with lesser proportions in the remainder of the 20th century), in compensation for the fact that more than half of the capital city's land is off the tax rolls.

Foggy Bottom remained an industrial area well into the 20th century, as shown by the Washington Gas Light Company's West Station, on the Potomac waterfront at Virginia and New Hampshire Avenues, NW.

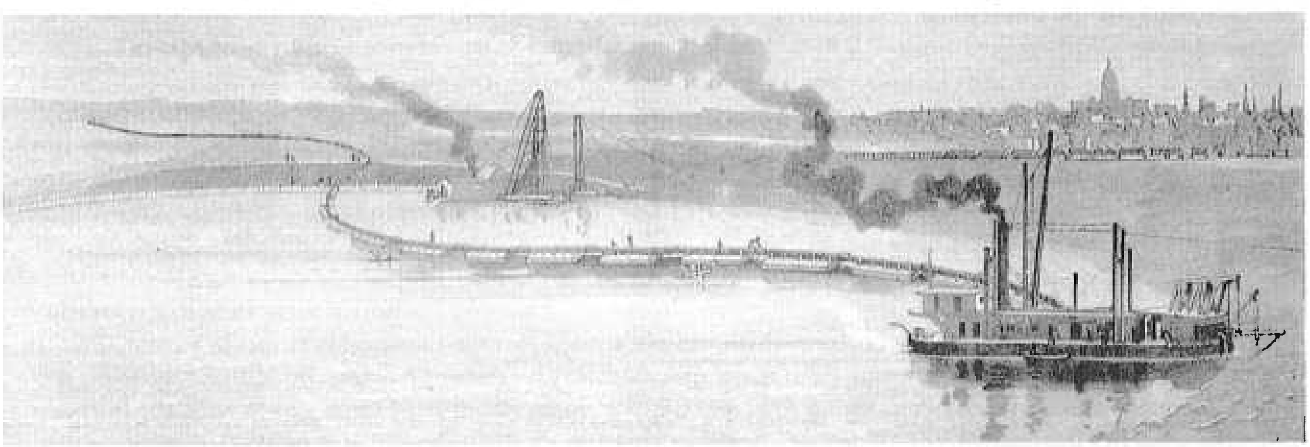
In 1872 the B&O's monopoly on Washington was broken when the Pennsylvania Railroad finally ran a branch line, the Baltimore & Potomac, into the city. By the 1880s industry prospered with, for example, iron foundries (eight in 1880, eight in 1900, six in 1920) and breweries (fourteen in 1880, twelve in 1900). Nine model makers clustered around the Patent Office in 1880. The presence of the government fostered an impressive printing industry; it also fostered the oldest local trade union in continuous existence in the United States, the Columbia Typographical Union, established in 1815. In addition to the Government Printing Office and the Bureau of Engraving and Printing, city directories list 62 printing firms in 1880, 88 in 1900, and 112 in 1920. Book publishing and job printing gave way to newspaper and magazine publishing, but printing remained the city's second-largest industry after construction. Industries tended to locate along the water, with southwest Washington continuing as a port and Georgetown as an industrial sector. In Foggy Bottom a gas works established in 1856 stood for a century, employing a largely Irish-born workforce, while breweries there employed German immigrants. By 1890, an estimated 2,300 industrial establishments employed 23,000 workers, according to the Census of Manufactures, but most of their products were for local consumption, made in small shops without power-driven machinery.

The government and related businesses dominated the employment scene. In the decade of the 1880s, federal employment in the District jumped from 13,124 to 20,834. Perhaps because of the lack of heavy industry, European immigrants did not move to Washington in the numbers experienced by other cities; the District's foreign-born population remained less than ten percent of the whole from 1880 until 1990. Washington's African-American population ranged between one-quarter and one-third from 1800 to 1950; in 1860, 16 percent of them were slaves.

As intercity transportation turned increasingly to railroads, intracity transportation also relied on rails. As early as 1830 an omnibus ran between the Navy Yard and Georgetown. In 1862 the first three horse-drawn railways appeared. Conversion to electricity was hampered by Congress's prohibition of overhead trolley wires within city boundaries. Railway companies experimented with storage batteries and cable before turning entirely to underground conduits by the end of the century. By 1900 more than half of the trolley, electricity, telegraph, and telephone wires ran underground in Washington, preventing the unsightly aerial mess seen in most downtowns.

After a severe flood in 1881, in which the Potomac rose 2 feet above the deck of Long Bridge, Congress appropriated $400,000 to dredge the channel in the Potomac River and eliminate the Potomac flats west of the Washington Monument. For thirty years engineers dredged and filled, creating Potomac Park and the Tidal Basin, which was used to flush out a channel in the river. As a result, the harbor in southwest Washington was much improved and superseded that of Georgetown—even stealing its passenger-steamship lines. Even better, in 1897 Congress decreed that the 621 acres of reclaimed flats and 118 acres of tidal reservoirs would be held forever as public parkland.

Public lands in Washington received close attention and steady funding. In 1876 Congress appropriated $200,000 to complete the privately funded Washington Monument, which had languished unfinished for thirty years. Lt. Col. Thomas L. Casey of the Corps of Engineers strengthened the foundation and designed a new top for the



The Corps of Engineers spent thirty years reclaiming the Potomac Flats west and south of the Washington Monument. The dredging, pictured in 1891, created more than 600 acres of land and improved navigation on the Potomac. From Frederick Gutheim, Worthy of the Nation: A History of Planning in the National Capital.

obelisk, completing it in 1884. In 1900 Senator James McMillan created a commission to rationalize planning in the District. Headed by Chicago architect Daniel Burnham, the well-appointed McMillan Commission produced a Beaux-Arts plan that arranged public buildings along a redesigned National Mall and an extensive park system. In accordance with the plan, the Lincoln Memorial was built on the reclaimed land west of the Washington Monument. Also at the turn of the century, the city adopted a strict height limit in order to preserve the qualities of light and air at street level. Regulatory bodies have carefully preserved the height limit, producing a skyline and density unusual in American cities.

In 1920, when the city directory counted 514 factories employing 11,323 workers, Washington adopted its first zoning law that confined industry to areas along the river. That year Congress also banned heavy industry outright. In the 1930s while the rest of the country suffered through the Depression, Washington flourished thanks to new government programs initiated by Franklin D. Roosevelt. Research institutions such as the National Institutes of Health in Bethesda and the Beltsville Agricultural Research Center continued to attract scientists as well as bureaucrats to the region. The 1937 Works Progress Administration guide describes Washington as "the most important scientific center in the United States." Federal employment in the District burgeoned, from 63,000 in 1933 to 166,000 in 1940. The printing industry in Washington also rode this wave; its products were valued at three times that of any other industry. During World War II Washington continued to boom. The construction of the Pentagon—1.6 million gross square feet, with 17.5 miles of corridors, in sixteen months—ranks as one of the engineering achievements of this period.

As Eisenhower cautioned against the "unwarranted influence" of the military-industrial complex, research institutions in Washington increasingly addressed military concerns. Congress established the National Science Foundation in 1950 with its mission including "to secure the national defense." The progression of research and testing from military to private concerns and to sites outside the city is illustrated by the advancement of experiments with ship performance, from an Experimental Model Basin at the Navy Yard beginning in 1896, to the David Taylor Model Basin in suburban Maryland in 1937-40, to Computer Sciences Corporation's Advanced Marine Center in suburban Virginia, which has modeled ship behavior "virtually" since the 1990s. Defense-related consulting firms tend to locate near the Capital Beltway and along the Interstate 270 corridor in Montgomery County, Md.; suburban high-technology firms also abound, most notably in the founding of America Online in 1985 in the Northern Virginia suburbs.

In the post-war period, various federal policies encouraged "white flight" into the suburbs. Washington became a majority-black city in the 1950s with its African-American population peaking at 70 percent in 1980; today it is down to 60 percent. Many of the political refugees permitted to immigrate by the Refugee Act of 1980 came to Washington, driving the foreign-born quotient of the population up to 12 percent in 1990. The greater Washington area boasted the largest concentration of African-born people in the United States in 1990, and Southeast Asians are also drawn to the region in large numbers. The city was granted limited "home rule" in 1973, but its citizens still are not represented in Congress, as testified by license plates that proclaim "Taxation without Representation."

As the city has experienced out-migration and the economy has become more regionally based, workers commute longer distances. Washington's Metrorail is one attempt to counteract the automobile-dependent commuter surge. The first section of Metro opened in 1976 in anticipation of Bicentennial crowds; the 103-mile, 83-station system was completed twenty-five years later in January 2001. Metro has been so successful that officials are considering its extension into areas not originally planned.

In the post-war period, federal policies encouraged the "renewal" of the city. Industrial areas were redeveloped, most dramatically in southwest Washington, which was obliterated by urban renewal between 1954 and 1960. In Foggy Bottom, redevelopment has come from many directions, with expanding federal buildings, highways, the John F. Kennedy Center for the Performing Arts, and the Watergate mixed-use complex occupying the formerly industrial area. In Georgetown, the Whitehurst Freeway cut through the industrial area in 1949, provoking the neighborhood's designation as a historic district in 1950, but gentrification and high land prices have precluded the survival of industry there.

Most of the industrial sites that survive in Washington have been preserved in the capital's extensive parklands, such as Pierce Mill and Godey Lime Kilns in Rock Creek Park. While the conversion of Rock Creek valley to a manicured park, beginning in 1890, enabled the preservation of historic sites, it also prevented further industries from developing there and effectively put a stranglehold on industrial development. Conversion to parkland invariably benefited adjacent residential property values and it has often been noted that Washington's biggest industry is real estate. As the nation's capital, Washington has received funding and attention unavailable to other metropolises. On many occasions Washington has served as a model for the nation, a role that justifies congressional expenditures for infrastructure and parklands. At the same time, Congress has impeded Washington's development of industrial endeavors, often in the interest of preserving the beauty and spaciousness that it has cultivated. Washington has been home to many industries over the years, but the presence of the federal government has affected them in ways not experienced in other cities. Washington's industrial history is like none other.

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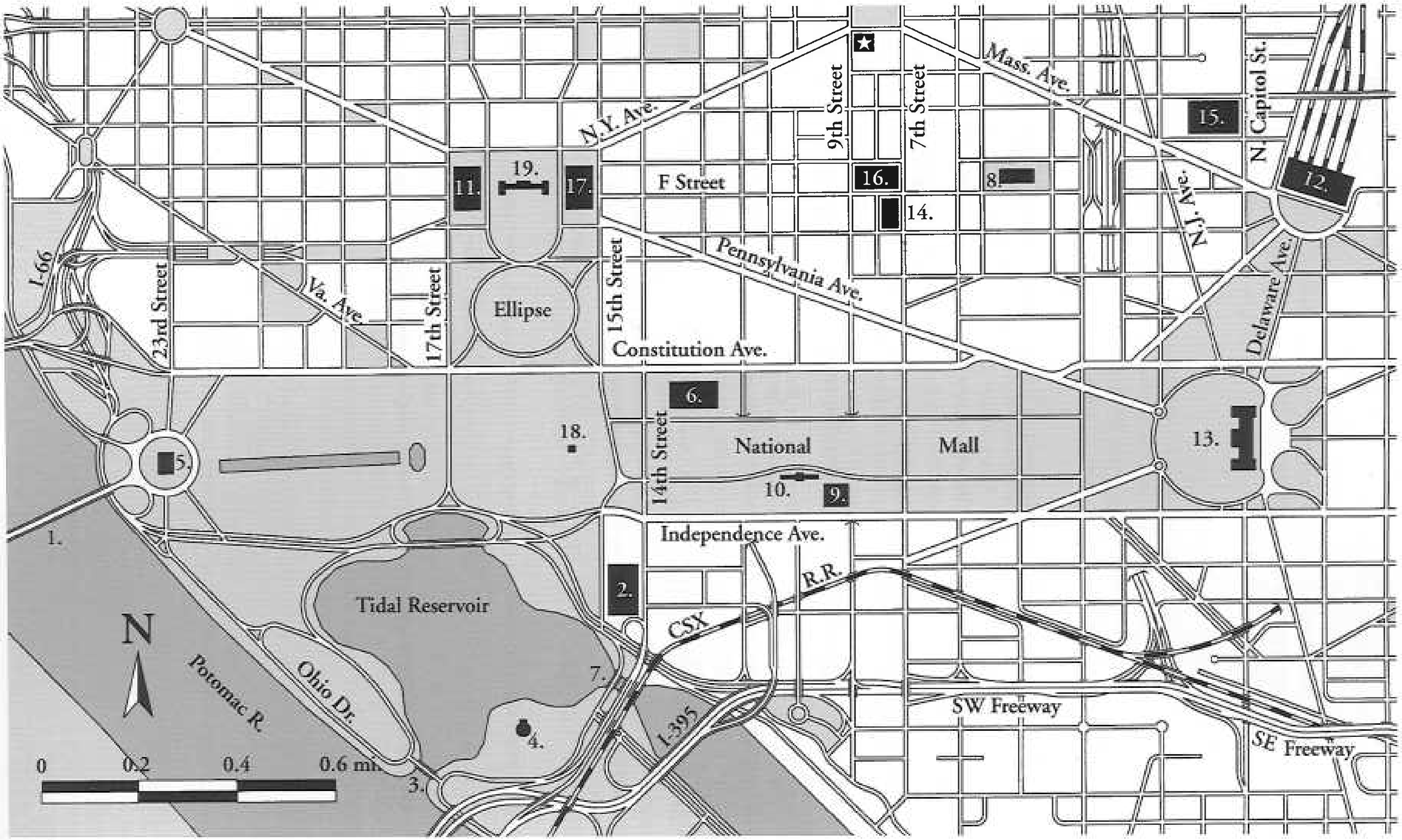

Downtown Washington

1. Arlington Memorial Bridge
2. Bureau of Engraving and Printing
3. Inlet Bridge
4. Jefferson Memorial
5. Lincoln Memorial
6. National Museum of American History
7. Outlet Bridge
8. Pension Building
9. Smithsonian Arts & Industries Building
10. Smithsonian Castle
11. State, War, and Navy Building
12. Union Station
13. U.S. Capitol
14. U.S. General Post Office
15. U.S. Government Printing Office
16. U.S. Patent Office
17. U.S. Treasury Building
18. Washington National Monument
19. White House

★ Renaissance Hotel

U.S. Capitol
Washington, D.C.

The U.S. Capitol is among the most symbolically important and architecturally impressive buildings in the nation, having housed the meeting chambers of the House of Representatives and the Senate for two centuries. Under construction from 1793 to 1865, it has been through many construction phases and two expansions—as late as the 1960s—but the erection of its second dome as an elegant cast-iron skeleton is the building's most technically interesting feature.

Construction of U.S. Capitol dome, ca. 1860. Courtesy National Museum of American History, Smithsonian Institution.

An example of 19th-century Neoclassical architecture, the Capitol evokes the ideals that guided the founding fathers as they developed the new republic. Pierre Charles L'Enfant (1754-1825), author of the city plan, was expected to design the Capitol, but he was dismissed in 1792. In search of an architect, Secretary of State Thomas Jefferson and President George Washington suggested a competition that would award $500 and a city lot to whomever produced the winning plan. None of the seventeen plans submitted were satisfactory until October 1792 when Dr. William Thornton (1759-1828), a Scottish-trained physician living in the British West Indies, asked permission to submit his plan after the competition had closed. The commissioners accepted his plan.

The initial work progressed under the direction of three architects in succession: Stephen H. Hallet (1755-1825), George Hadfield (1763-1826), and James Hoban (ca. 1762-1831). Hoban had won the competition for the President's House, and he saw to the completion of the Capitol's north wing in time for the first session of Congress on 17 November 1800. In 1803, construction resumed under Benjamin Henry Latrobe (1764-1820), who completed the south and north wings, though they were connected by only a temporary wooden passage. In August 1814 British troops burned what there was of the Capitol during the War of 1812. A rainstorm prevented its complete destruction and Latrobe returned to make repairs, which included the introduction of marble on the interior. Charles Bulfinch (1763-1844) succeeded Latrobe in January 1818, and readied the Senate and House chambers; he also redesigned the central section to heighten the dome which, constructed of wood covered with a copper skin, was completed in 1824. But by 1850, the Capitol could no longer accommodate the increasing number of legislators.

Another competition was held for the best plan to extend the Capitol. Unable to decide between designs, Congress divided the prize money among five architects and selected Thomas U. Walter (1804-87) to complete the task. In 1853 the superintendency of the Capitol was shared between Walter and Montgomery C. Meigs (1816-92) of the U.S. Army Corps of Engineers, who worked on the structural aspects of the Capitol extensions that were built between 1851 and 1865. Marble instead of sandstone was used for the exterior, and the interior decoration was High Victorian. Meigs moved the chambers to the center of each wing and added sculpture-filled pediments to the east porticos.

As the wings progressed, they more than doubled the length of the building—making the dome too small for the new proportions. In 1856 the old combustible dome was removed and work began on a cast-iron replacement. Cast iron was selected because it was lighter, less expensive, and faster to erect than traditional masonry—and most important, it was fireproof. Meigs is credited with devising the dome's structural system, although there is some evidence that the major role in the design was Walter's. As work commenced, a steam-powered boom and derrick in the rotunda lifted the iron framework into place. Wood for fuel came from the discarded dome. The Brooklyn foundry of Janes, Fowler, Kirtland & Company delivered 1.3 million pounds of cast-iron parts that were bolted together at a cost of seven cents per pound "complete and put up," while several other foundries furnished the remaining castings. The dome's double-shell system featured thirty-six continuous trussed ribs. Including a 19-foot 6-inch statue of "Freedom" at the top, the sum of the ironwork was nearly 4,500 tons. The dome—the only one of its kind retrofitted to an existing building—has a base 135 feet in diameter. Its 287-foot height is about 13 feet shorter than originally planned, to accommodate a "Freedom" that was about 3 feet taller than planned. A 14-foot iron base ring was cantilevered out from Bulfinch's octagonal masonry drum, supported by seventy-two 15-foot brackets. The metal support system permitted a dramatic openness for fenestration at all four levels of the dome, which illuminates the building interior. In 1859 engineer William B. Franklin replaced Meigs.

Cast-iron interior framing of ribs and circumferential bracing in U.S. Capitol dome. Courtesy National Museum of American History, Smithsonian Institution.

Construction on the wings was suspended for only a year, 1861, so the building could be used as a military barracks, hospital, and bakery during the Civil War—but work on the dome continued. President Lincoln believed that the Capitol construction must go on as a symbol that the Union would also continue. The work on the dome and extensions was completed in 1868 under Edward Clark (1822-1902), Walter's assistant until 1865 and subsequently Architect of the Capitol until 1902. The interior of the new rotunda was completed in 1866. The dome cost slightly more than $1 million.

After a fire in November 1898 the need to fireproof the balance of the building was evident. Elliot Woods (1865-1923), Clark's successor, saw to the reconstruction and fireproofing of the damaged wing. The 20th century has also seen the extension of the east front, enlarged to add 102 more rooms, 1959-62; the stonework was changed from sandstone to Georgia marble during the process. More recently, during the 1990s, a dome-renovation plan was initiated as a result of water-leak problems caused by cracks and breaks in the dome's cast-iron sheathing. The second phase will target cracks and leaks in the dome's plating and joints; the condition of the interior canopy, which holds Constantino Brumidi's 4,664-square-foot "Apotheosis of Washington" fresco; removal of lead paint; installation of lighting improvements between the inner and outer domes; and replacement of the bird-proofing system.

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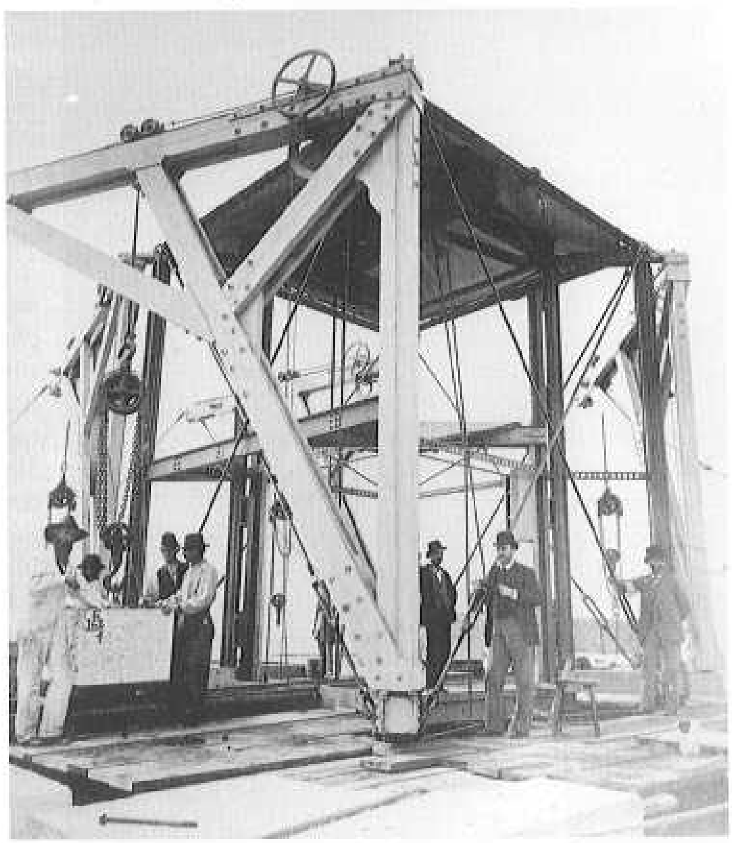
Washington National Monument
National Mall, Washington, D.C.

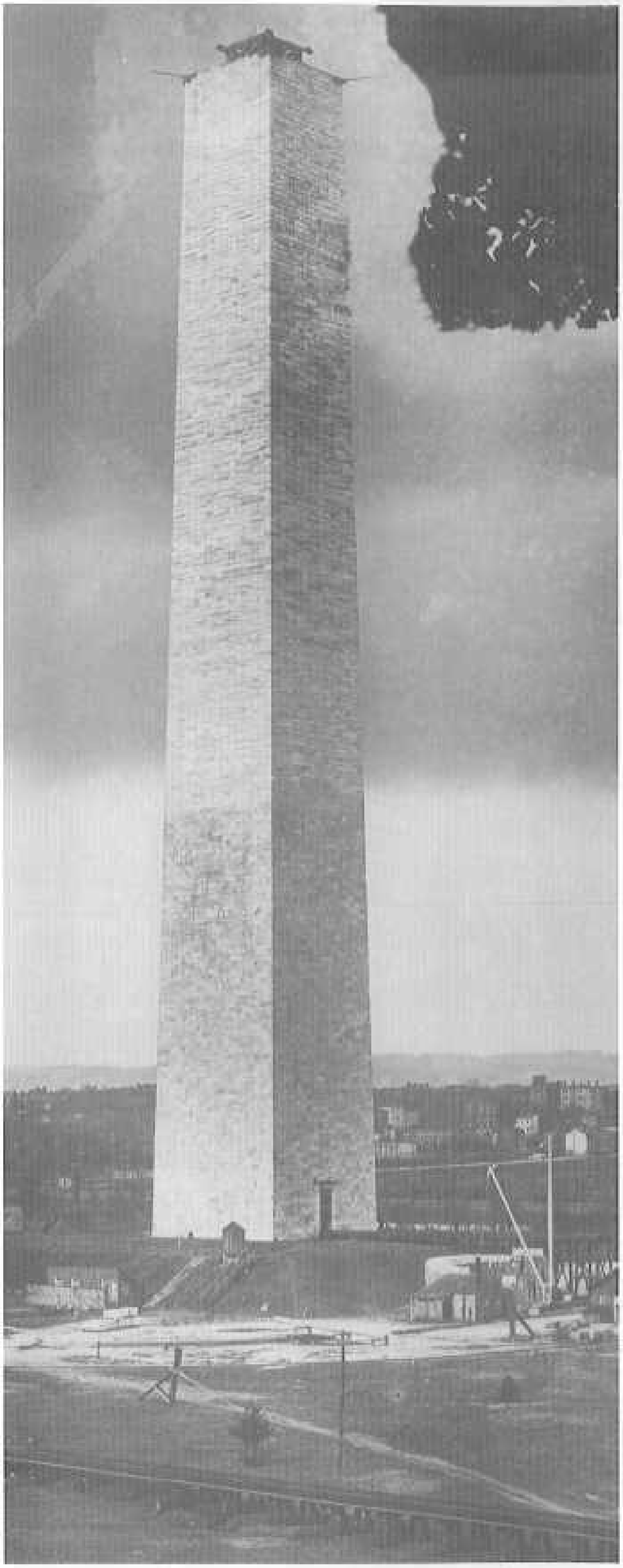
In 1800, the year the U.S. government moved into its permanent capital city, the considerably smaller National Mall as conceived by city planner Pierre Charles L'Enfant sat unimproved. In honor of his service during the Revolutionary War, a statue of George Washington (1732-99) was envisioned for the junction of the Capitol and White House axes. But it would be nearly three decades before a memorial to the nation's Founding Father would even be initiated—on the centennial of his birth—and another forty years before it was finished as the then-tallest structure in the world.

Just a year after Washington's death in 1799, the first of many proposals to memorialize the much-apotheosized president was a pyramidal mausoleum 100 feet square at the base. This and other efforts were unsuccessful, however, until 1833 when the Washington National Monument Society was formed to pursue a "People's Monument," which they attempted to fund by soliciting $1 public subscriptions. The competition for a design was held in 1836, with Robert Mills' (1781-1855) 600-foot obelisk surrounded at the base with a colonnade the winner. The selected site, Federal Reservation No. 2, was almost the same as that proposed by L'Enfant, and 37 acres were granted to the commission. Builders avoided a marshy area in favor of a more stable site, placing the monument slightly southeast of the true intersection of axes. Construction was delayed for lack of private funds, but finally in 1845 work commenced on the obelisk portion. After nine years of progress and reaching a height of 152 feet, construction was halted again for lack of money. Work stalled for years after the political orientation of the organization changed, to be dominated by the anti-Catholic Know-Nothing Party. A further setback was the death of Mills just two weeks after the coup. Coupled with the political and economic turmoil leading to the Civil War, construction would not resume until Congress voted to take over the project in July 1876, the occasion of the nation's centennial.



Stone-setting machine, Washington Monument, 1880. Courtesy National Museum of American History, Smithsonian Instition.

Monument construction was subsequently assigned to the U.S. Army Corps of Engineers with $2 million appropriated by Congress to complete the work. A staging area was built, composed of a blacksmith shop with three forges, a carpenter and rigging shop, a cement storehouse, two concrete mixers, and steam engines to power them. Lt. Col. Thomas Casey, who first reinforced the tower's stone foundation with massive concrete footings, resumed work on the shaft in 1880. By this time, the slightly modified design called for a true obelisk 500 feet tall with a 55-foot pyramidion, a 55-foot square base and walls 15 feet thick at the base. First, Casey demolished some of the structure to enlarge the interior space to 31 feet 6 inches. This was followed by installation of two wrought-iron frames manufactured by the Phoenix Iron Company: the outer one to carry the weight of the stairs, the inner to accommodate the elevator shaft. A system of I-beams and channels tied the columns together and anchored the framework to the stone walls. The Phoenix-column framework also supported the crane at the top, used to set the massive stones hauled up by a steam-powered hoist installed by Otis Brothers.



Construction of Washington National Monument, ca. 1880.

The exterior of the original section of obelisk, erected up to 1854, is white crystal marble from Beaver Dam Quarry north of Baltimore, with Potomac bluestone gneiss used on the interior. When work resumed, Maine granite was used on the interior but the same Maryland quarry provided the exterior stone (with a slight color differentiation seen at the 150-foot level). Of the fifty-seven individuals working on the monument in December 1849, fifteen were stonemasons earning $1.75 to $2 per day, and thirty-three were laborers earning $1 a day. Beyond the 425-foot level, the walls narrow to a single stone 7 feet wide, joined by galvanized-iron clamps. Each masonry course is made up of thirty-two blocks of marble and twenty-four blocks of granite, with the pace of construction largely determined by the material available from the quarries. At this time, about a day and a half was needed to hoist one course of stone to the top. In 1884, approximately 118 workmen were at the site of the monument; 68 were marble cutters earning $3.50 to $3.75 per day and 20 were laborers earning $1.60 to $1.75 per day.

At 500 feet, the walls are 18 inches thick. Here the pyramidion begins, with its 7-inch walls supported by structural stone ribs that spring from the 470-foot point. The pyramidion is topped by a 3,000-pound capstone and its 9-inch apex of aluminum that weighs 100 ounces—the largest single casting of what at the time was considered a semi-precious metal. The monument interior features numerous carved and cast stones and wall plaques donated by states, cities, other countries, and societies over the years. The monument cost $1.5 million to build, and with 897 steps it is slightly taller than 555 feet. It remains the tallest masonry structure in the world.

Subsequent to completion of the monument in February 1885 there have been modifications. These included, almost immediately, installation of electric lights and perfection of the lightning-conduction system, sealing of the west entrance, removal of the Egyptian surrounds from both east and west portals, completion of the stairs, and conversion of the hoist to a passenger elevator. Around the turn of the century, tie rods joining the Phoenix columns were reinforced and the steam-powered elevator was replaced with an electric one. In the 1920s and early 1930s, the elevator was replaced again, the monument was rewired, and safety features such as guard rails and screening were installed around the elevator shaft. Metal bars were superceded by airplane warning beacons in the pyramidion windows. In the 1950s the monument received a major overhaul that included replacing the elevator and floor plates, and adding a second stairway.

The most recent and well-known restoration occurred between 1996 and 2000. Not only was the $5 million project an early partnership between the National Park Service and a corporate entity, Target Stores, but the stylish Michael Graves-designed scaffolding that enshrouded the shaft attracted its own constituency of fans. Work on the Washington Monument included sealing 500 feet of exterior and interior cracks, pointing 3,900 linear feet of interior and 64,000 linear feet of exterior joints, cleaning 59,000 square feet of interior wall surface, repairing 1,000 square feet of chipped and patched stone, and preserving or restoring 192 interior commemorative stones. The structure has been designated a National Historic Civil Engineering Landmark by the American Society of Civil Engineers.

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Lincoln Memorial

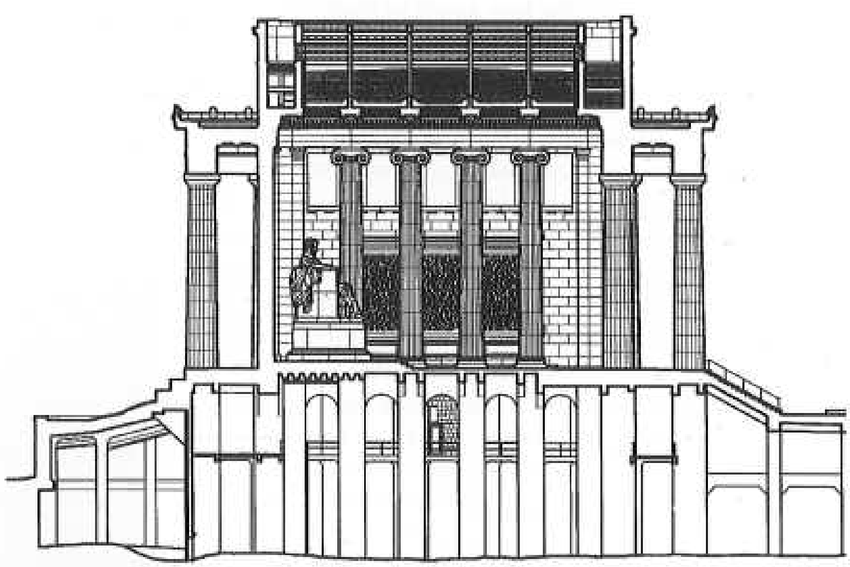
West Potomac Park, Washington, D.C.

The Lincoln Memorial, 1922, a rectangular temple of white and pink marble, anchors the west end of the National Mall, "its dignity enhanced by being so placed ... as an object worthy of rank with the Washington Monument and the Capitol," according to the Commission of Fine Arts. Its construction coincided with the implementation of the McMillan Plan, a citywide program of monumental Beaux-Arts design in which the Lincoln structure was key. Besides the aesthetic challenge of designing an appropriate homage to the slain president, its placement on unstable land reclaimed by the U.S. Army Corps of Engineers provided a construction challenge.

The massive structure rests on 12 feet of fill added to the memorial site between 1882 and 1908, and is supported on a subfoundation (below the level of the original park) and an upper foundation (above the new grade). The subfoundation consists of 122 concrete piers formed in steel cylinders approximately 3 to 4 feet in diameter that were sunk using water jets and superimposed weight to a bedrock depth of 44 to 65 feet below the original grade. The earth was manually removed from the cylinders, the bedrock excavated another 2 feet, and the whole area filled with concrete; each cylinder is reinforced with one dozen 1-inch-square metal bars. At ground level the cylinders are splayed out to rectangular and square forms connected by a grillage of reinforced concrete 1 foot thick. The upper foundation consists of concrete columns about 45 feet tall—some hollow, some reinforced—set atop the subfoundation piers, and joined at the top by integrally poured concrete arches. The result is an eerie underground catacomb of floating concrete arches.

Even before the structure was complete, the east side approaches and terrace wall suffered from settling, although the memorial itself was unmoved. The walls of the terrace were built separate from the main building to accommodate as much as 8 inches of movement. The original plans for a concrete pier foundation had been scrapped to save money, and a slab foundation chosen instead. But by 1921 the average change was 12 inches—attributed to the overall lowering of the reclaimed Mall rather than something specific to the memorial. The commission successfully requested funding of $363,000 to go back and erect foundation piers to underpin this section of the building—which postponed its dedication.

Underpinning the terrace wall required further excavation between the existing columns, and the creation of 12- to 14-foot-deep pits with concrete bottoms and sumps in each corner. As the caissons were excavated about another 12 feet using pick and shovel, timber was used to shore up the existing piers, foot by foot. Concrete was poured continuously into the caissons, 14 to 20 square yards per shaft, which measure 40 to 60 feet deep. To complete the stabilization, reinforced-concrete struts were formed to connect the foundation wall of the memorial structure to the freestanding columns, and from there to the terrace wall. To stabilize the approach, the columns were supported by a system of 24-inch I-beam girders extending to bedrock, topped by a complementary system of I-beams supporting each side of each column. Ten-inch needle beams extend through the column and carry the load transmitted to the piers. All exposed steel was encased in



Section through Lincoln Memorial, looking north. From HABS drawing by Mark Schara, Dana Lockett, Jose Vasquez, and Mellonee Rheames, 1993.

concrete. The project encompassed 176 piers, 68 struts, and 210 tons of steel. A road around the memorial and the 2,027-foot by 160-foot by 3-foot deep reflecting pool in which it is mirrored, were built in conjunction with the building within a year of its completion.

The first effort toward creation of a monument to Lincoln began two years after his death in 1865 when Congress created the Lincoln Monument Association. Nothing occurred until 1902, when a bill was proposed to form a commission to "secure plans and designs for a monument or memorial." Meanwhile, in 1901 the McMillan Commission extended the Mall westward beyond the original L'Enfant Plan boundary and Washington Monument as part of an effort that would transform the National Mall into a public greensward studded with memorials, pools, and plantings. Congress authorized construction of a monument to Abraham Lincoln to anchor the western terminus of the Mall at the Potomac River in 1911, along with a commission funded by $2 million, making it the first major improvement to this space after the removal of a train station at the foot of 6th Street. Architects Henry Bacon (1866-1924) and John Russell Pope (1874-1937) were asked to submit design proposals for this and other locations. Although the designs shared many like elements, Bacon's scheme for a partially enclosed peripteral temple won; it was not unlike an earlier design by his mentor, Charles F. McKim, generated in 1901 as part of the McMillan Commission proposals.

The cornerstone was laid in 1915 and the memorial—measuring 188 feet long, 118 feet wide, and 74 feet tall–was dedicated seven years later. Bacon envisioned the Neoclassical structure, built at a cost of nearly $3 million, to embody four aspects of Lincoln's life: a statue of the man; as memorial to the Gettysburg Address and his Second Inaugural Address; and as symbol of the union of states he fought to preserve. The thirty-six Doric columns standing 44 feet tall represent the number of states at the time the Civil War erupted, and the forty-eight festoons in the recessed attic represent the number at the time of construction. The base is raised because Lincoln is characterized as being above political pettiness. The interior cella contains the seated figure by Daniel Chester French (1850-1931) as well as text from the Gettysburg and Second Inaugural addresses. The structure also functioned as part of a symbolic triad that began with the U.S. Capitol as representative of American government, the Washington Monument dedicated to the founder of that government, and the Lincoln Memorial dedicated to the Great Emancipator and the preserver of the Union. It is also the eastern anchor of the axis formed by Arlington Memorial Bridge, balanced on the opposite side of the river by the Custis-Lee home in Arlington Cemetery—a monumental composition symbolic of healing the wounds between North and South.

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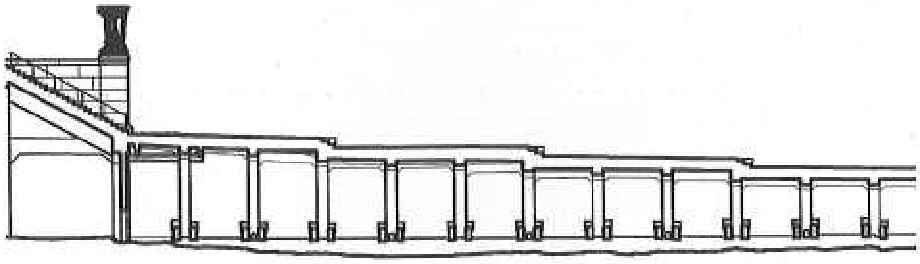


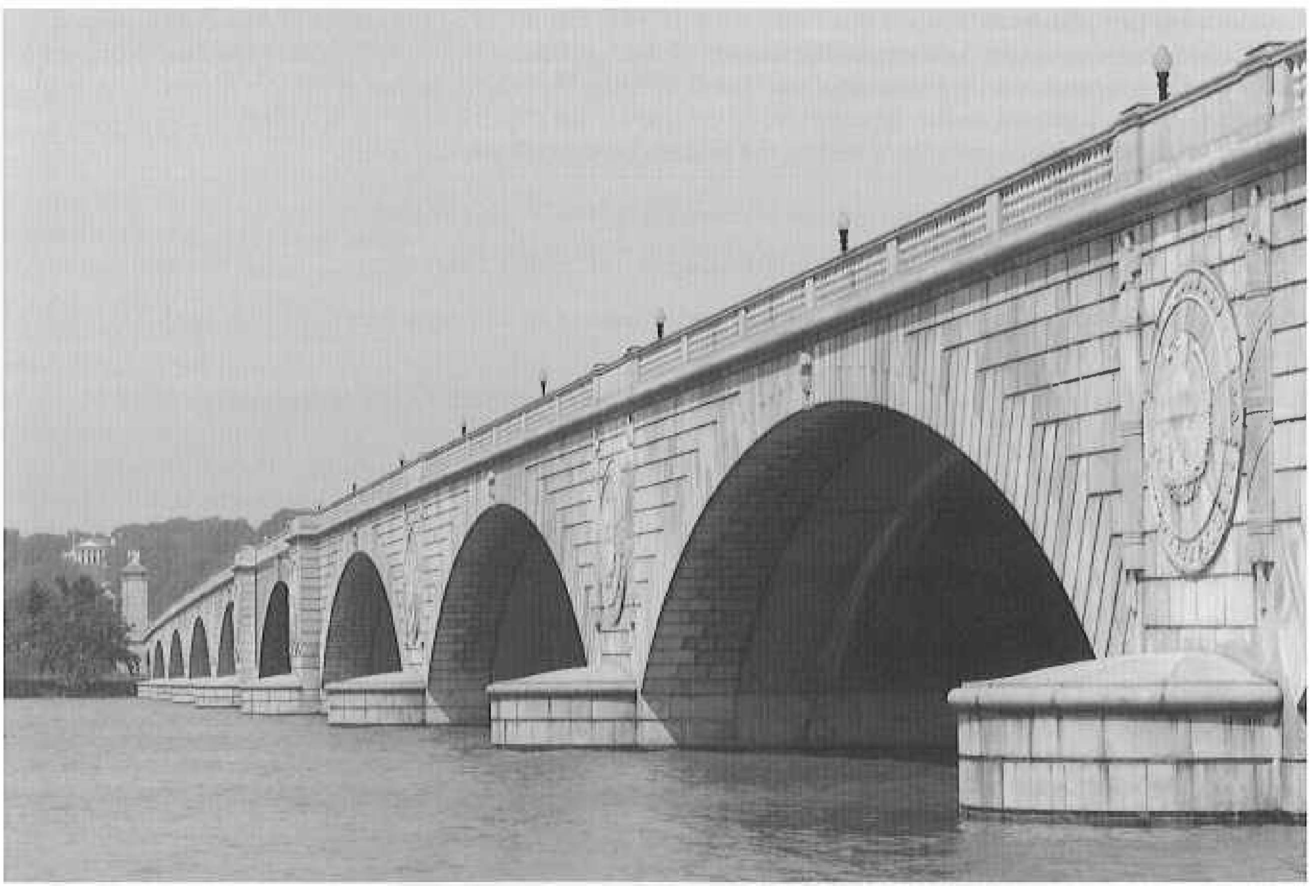
Arlington Memorial Bridge

Spanning Potomac River between Washington, D.C., and Arlington, Va.

Arlington Memorial Bridge, 1932, is the national capital's most elegant, formal, and symbol-laden bridge, connecting the Lincoln Memorial and National Mall with Arlington National Cemetery across the Potomac River. After the length of the National Mall was extended three-quarters of a mile westward beyond the original L'Enfant Plan boundary, Congress authorized the construction of a monument to Abraham Lincoln, which was built from 1912 to 1922. A bridge linking the two shores had been proposed during the 19th century, with this location specified by President Andrew Jackson. It was not until 1901, however, that the McMillan Commission firmly fixed it at this location.

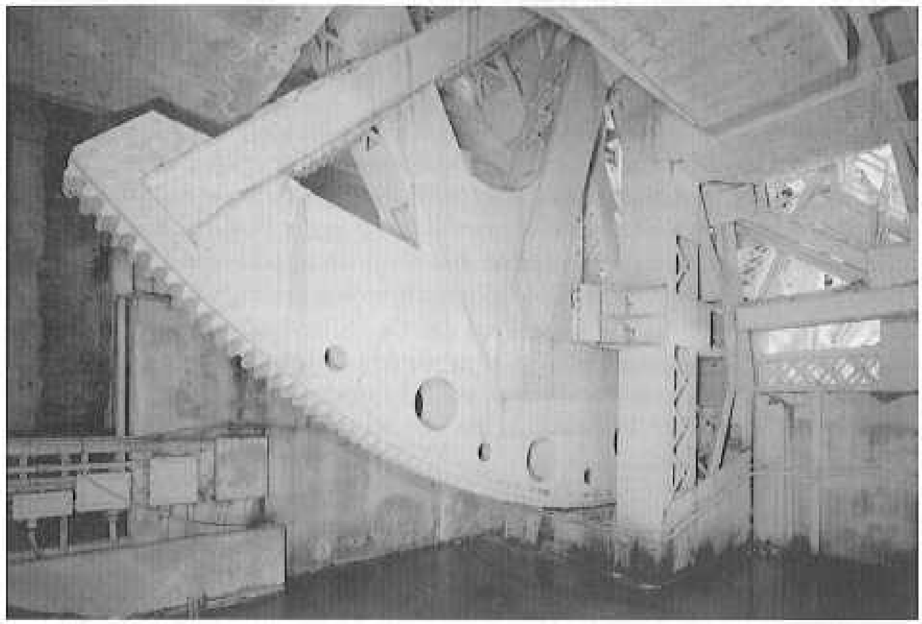
The absence of a bridge created grueling traffic conditions during the 1921 Armistice Day procession to Arlington Cemetery's Tomb of the Unknown Soldier. The next year, Congress created the Arlington Memorial Bridge Commission, which envisioned the span as a monumental approach to both the capital city and cemetery. The short list of would-be architects for the project included Charles Platt and Paul Cret, but the well-known New York firm McKim, Mead & White won the commission.

The span is 2,138 feet long and 90 feet wide, built as low as possible so as not to impede the vistas to and from the Lincoln Memorial, extending between 28 and 35 feet above the water. The reinforced-concrete structure is composed of nine low arches with an electrically operated double-leaf bascule span at the center. Each leaf measures 92 feet. It purportedly required only one minute to open and close the span; however, it has been welded shut since renovations in the 1980s. The 32-foot-wide piers are set on bedrock 35 feet below the surface.



Arlington Memorial Bridge, south elevation with Custis-Lee House in background on left. HAER photograph by Jet Lowe, 1987.

The bridge's voussoirs and rusticated spandrels are covered with dressed North Carolina granite. The bas-relief eagles and fasces on the piers are the work of C. Paul Jennewein; the 6-foot-high bison head keystones the work of Alexander Proctor. Two pairs of monumental sculpture are located near the Washington terminus of the bridge: "Arts of War" by Leo Friedlander, and at the nearby connection with Rock Creek & Potomac Parkway is James Earle Fraser's "Arts of Peace." Although commissioned in 1925, they were not cast and erected until 1951. Ancillary features designed in conjunction with the bridge include the seawall along Riverside Drive and the nearby "water gate" with granite steps 215 feet wide. Three traffic circles to collect and disperse motorists were part of the original plan, located on the D.C. shore behind the Lincoln Memorial, on the Virginia shore to connect with the George Washington Memorial Parkway, and at the Arlington Cemetery entrance. The route continues to the cemetery as Memorial Avenue, itself lined with markers and sculptures on axis with the Custis-Lee House on the hillside.



Arlington Memorial Bridge, rack mechanism beneath eastern bascule leaf. HAER photograph by Jet Lowe, 1989.

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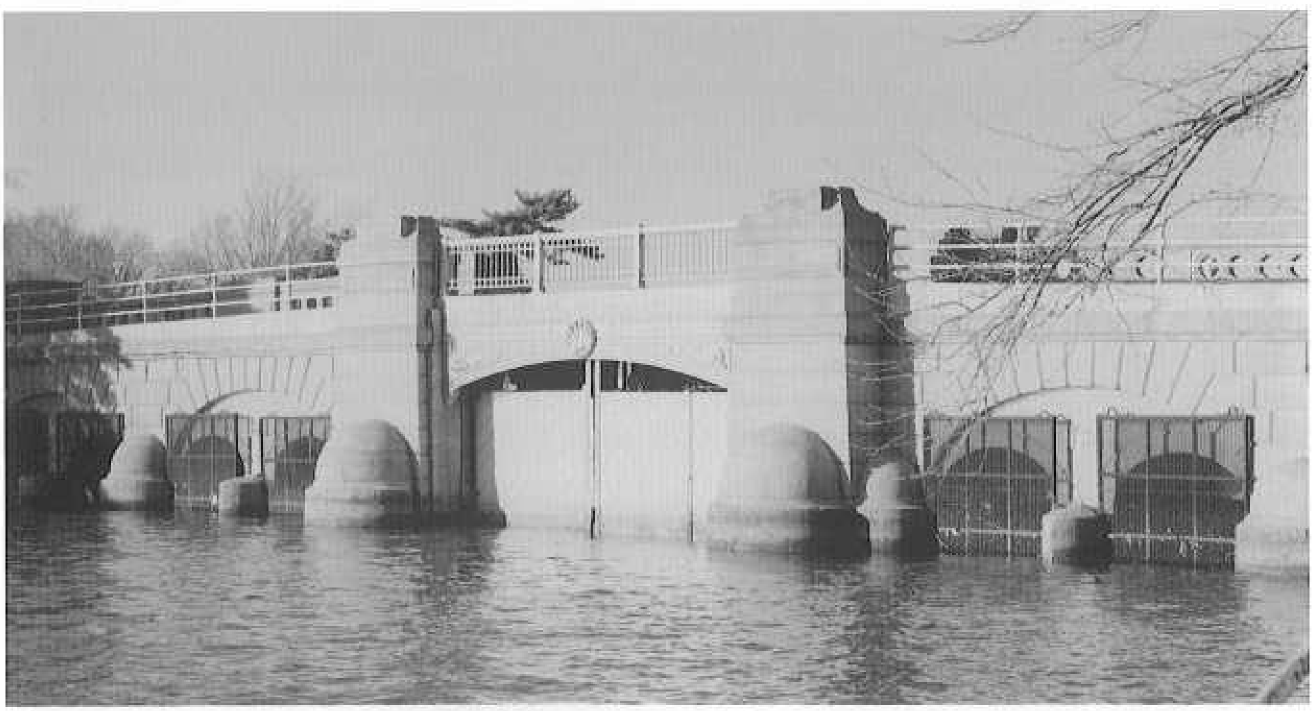
Tidal Reservoir and Inlet/Outlet Bridges

East and West Potomac Parks, Washington, D.C.

The Tidal Reservoir, an ornamental body of water between the Potomac River and Washington Channel, is an integral feature of the picturesque man-made Potomac Park representing the early-20th-century ideals of landscape design. It occupies the site of a silty marsh known as the Potomac "flats" during the 19th century, which was a problem at many levels: the navigation and commercial potential of this area was declining, its use as a sewage dump produced a stagnant and malodorous breeding ground for diseases such as malaria, and it was a serious eyesore. Besides correcting these failings, by the 1870s the city identified the complementary goal of filling in the flats and improving navigation. The river would be dredged and the captured material used as fill, a task that ultimately took many years and congressional appropriations to realize. Eventually 600 acres would be reclaimed, including what today is delineated as the 110-acre Tidal Reservoir (or Basin), the peninsular East Potomac Park, and West Potomac Park.

After a severe flood in 1881, when waters "lapped the foot of the Capitol Hill," Congress enacted a plan by Maj. Peter Hains of the U.S. Army Corps of Engineers. His design was based on an earlier proposal of 1879 by Maj. William Twining wherein ornamental and functional "flushing lakes" were proposed for the manmade park. As chief engineer for the project, Hains substituted a reservoir for the lakes and is credited with masterminding the overall improvement of the waterfront parks. The design called for closing in the north end of Washington Channel and creating a tidal reservoir that would provide an outlet to clean the channel of spilled sewage and other impurities. Water accumulated at high tide from the inlet gate on the Potomac River, and the area was "flushed" daily when 250,000 gallons of water flowed from the reservoir via the outlet gate during low tide.

In 1897 the area was established as federal parkland. No reclamation work had been completed by 1901 when the McMillan Commission planned an elaborate scheme for the National Mall area and beyond, including the Tidal Reservoir. The Corps of Engineers and McMillan Commission, among others, continued to improve the area through the early 20th century, transforming "Potomac Park from wilderness to beauty spot."

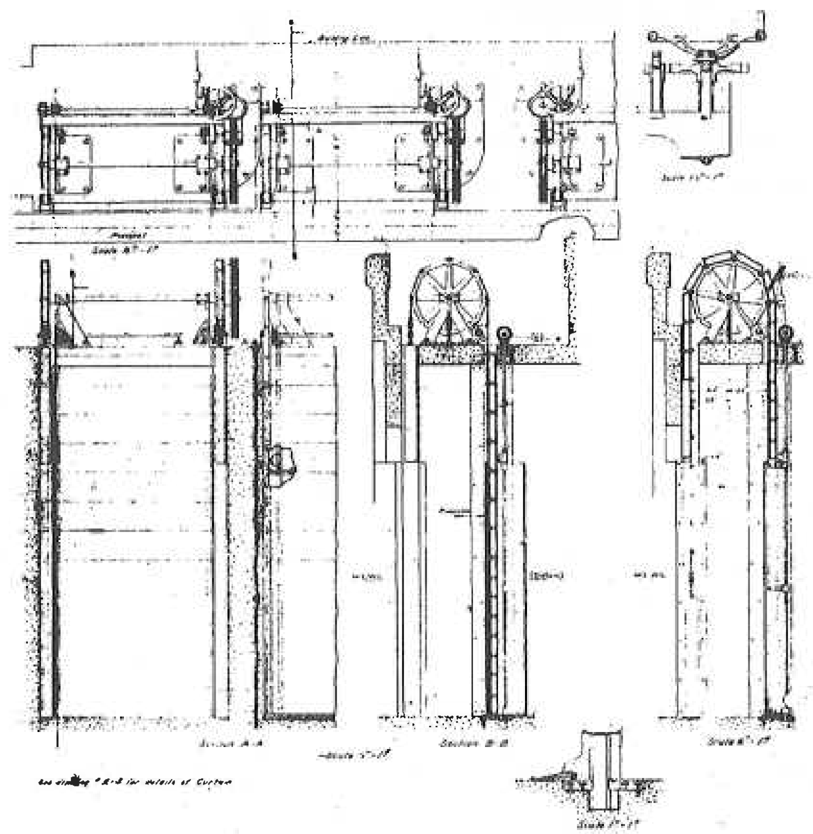


Tidal Basin, southeast elevation of Outlet Bridge. HAER photograph by Jet Lowe, 1989.

Tidal Reservoir Inlet Bridge

The Inlet Bridge carries an early motoring route, Ohio Drive, across the Tidal Basin inlet and connects East and West Potomac parks. Constructed in 1908-09, its Neoclassical design contributed to the formality of the design of the capital city ongoing during this era, thus it was "essential that it be an aesthetically pleasing design." As the "last engineering work of the [reclamation] project," the span was authorized with the River and Harbor act of 1907; the following year a roadway component was combined with the gates. The three-year project cost $120,000 including gates and operating mechanisms costing nearly $9,000.

Construction began in April 1908 with a cofferdam founded on 1,184 pilings and steel reinforcements. Engineer Col. Spencer Cosby, and later Maj. Jay Morrow, supervised the work done by day labor. The bridge measures 184 feet long with a 25-foot-wide roadway and 7-foot sidewalks (added in 1926). The bridge features a small vertical-lift drawbridge atop the central arch that contains the lock. A removable floor system, conceived to permit small craft to enter the basin, probably never was used, and a fixed span replaced it in 1985. The original stone and macadam deck has been replaced with reinforced concrete and steel I-beams to support the roadway; one sidewalk later was replaced with a bridle path. The lock mechanism consists of wood tidal gates and steel curtain gates.



Tidal Basin Inlet Bridge, detail from original drawing of curtain wall gates.

Architect Nathan C. Wyeth was engaged by the Corps of Engineers to assure the monumental Neoclassicism of the bridge. The architectural elements are comprehensive and refined: "ornamental" exposed aggregate clads the reinforced-concrete structure, made to look like masonry by scoring, and concrete piers at the center span feature niches with gargoyle-studded bronze fountains. A patterned concrete balustrade lines the walkways, and $2,130 bronze light standards with "alabasterine" glass globes were installed on the piers in 1912; they were removed when the road was widened. The Beaux-Arts-trained Wyeth, by this time a prominent local architect, also designed the Francis Scott Key Bridge (see Georgetown chapter).

Tidal Reservoir Outlet Bridge

The low-level Outlet Bridge is located in East Potomac Park at the Washington Channel and the foot of 14th Street, sandwiched between two larger, close-by spans. One of the earliest built features of the reservoir plan, it originally functioned without the regulating wood gates, which were added after 1894 to alleviate a silting problem. Although it was not intended as a thoroughfare, heavy pedestrian use resulted in the installation of hand- and guardrails and confirmation that it also served as a passageway.

Constructed in 1889 by Maj. Hains of the Corps of Engineers, the stone masonry bridge has six 6-foot-wide arched spans with a total length of 94 feet 2 inches, and its top sits 20 feet 7 inches from the floor of the reservoir. Staunch piers are protected from scouring by cutwaters, as are the abutments at each end of the span. A rough-faced gray granite is used on the headwall, voussoirs, and coping. Pilings were driven 74 feet below low-tide levels.

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U.S. National Museum

(Smithsonian Institution Arts & Industries Building)

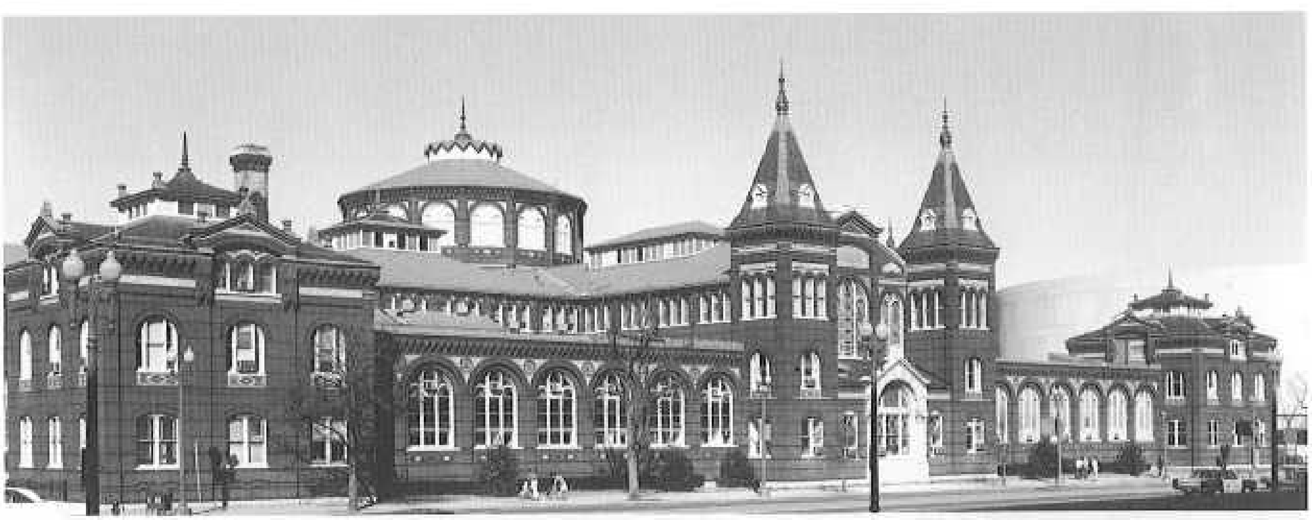
Washington, D.C.

The U.S. National Museum, 1879-81, is the first building created solely to house a Smithsonian collection. Built for the arts and manufactures exhibits donated from the 1876 Centennial Exposition in Philadelphia, the building itself was based on the U.S. Government Building erected for that event. It was the second of sixteen museum buildings—after the Castle—affiliated with James Smithson's legacy, and one of the oldest on the National Mall. It is significant, too, for its fireproof construction.

The architectural firm of Adolf Cluss (1825-1905) and Paul Schulze (ca. 1828-97) won the architectural competition for the new building, whose construction was overseen by the National Museum Building Commission. Civil engineer Gen. Montgomery C. Meigs, who had conducted a study of public museums in Europe and supervised the structural system, also submitted a design. The priority was to create inexpensive, open, and functional spaces that were fireproof. By the end of 1880 the roof was completed and parts of the building already were occupied by the Smithsonian; it opened to the public in October 1881.

The National Museum was designed with a symmetrical Greek cross plan with central octagonal rotunda 108 feet high set in a square with four radiating naves 117 feet long and 56 feet high; it is one of the few buildings in the world on a perfectly square plan. The four identical elevations feature projecting central pavilion entrances and boxy corner pavilions. The exterior is a geometric pattern of red, black, buff, and blue brick, and the last remaining example of architectural brick polychromy in Washington. The vivid coloration coupled with the jaunty roof line with its pediments and towers was a comfortable choice for a structure for the nation's premiere park. Caspar Buberl's "Columbia Protecting Science and Industry," 1881, above the north entrance was the only one of four intended sculptures installed.

The massive building, in an exuberant Victorian Romanesque style, is countered on the interior by a delicate skeletal metal structure. The building was divided into eight windowed "ranges" and "covered courts" with skylights and clerestory windows. The naves, courts, and ranges were divided by arcades of round arches resting on piers. In 1883, the walls were changed from a uniform gray to a more colorful scheme using maroon up to 12 feet with gray above and stencils on the walls of the central rotunda.



Arts & Industries Building, south elevation. Courtesy National Museum of American History, Smithsonian Institution.

During the last decades of the 19th century, numerous changes and modifications were made to the National Museum building. In 1884 storage and work rooms were carved out of the four corners; a low lean-to annex was erected on the east side; wood floors were replaced with marble; and a second floor was added to the south-east range. The cast-iron balconies were added by Hornblower & Marshall between 1894 and 1897. In 1901 a tunnel was constructed to the adjacent Smithsonian Castle. In 1902 the walls were repainted in red up to 15 feet with ivory above; the rotunda was painted olive and ivory; and new stencils were designed by Grace Lincoln Temple. It was renamed the Arts & Industries Building in 1910 when the natural history collections were moved to the new Museum of Natural History. Hugh Newell Jacobsen redesigned the stencils, etched glass, and encaustic tile floors in 1976, and although they replicate the ambiance of the building, they are not historically accurate. In 1964 the remaining Arts & Industries Collection was moved to what is now the National Museum of American History. It is a designated National Historic Landmark.

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Smithsonian Institution "Castle"

Washington, D.C.

The Smithsonian Institution Building, 1846-51, was designed by James Renwick, Jr. (1818-95), a self-taught architect and trained engineer. More familiarly known as the "Castle," it was described as the "première example of the picturesque movement in America." Its significance lies in the successful combination of flexible asymmetrical Norman styling with up-to-date structural knowledge.

Chartered by Congress in 1846, the Smithsonian was established thanks to a $500,000 bequest by English scientist James Smithson, who had never been to America. A board of regents was created, which proceeded to direct the construction of a "suitable building of plain and durable materials and structure, without unnecessary ornament, and of a sufficient size, and with suitable rooms or halls, for the reception and arrangement, upon a liberal scale of objects...." Artifacts to be exhibited were specifically confined to the fields of natural history, art, and objects of "foreign and curious research."

The Castle is a two-story mass except for its myriad towers, with interior spaces more symmetrical than its exterior form suggests. A library and lecture room originally occupied the first floor, with the level above used as a museum; smaller, miscellaneous rooms were used for scientific study, meetings, and offices, and functioned as gallery space. The red sandstone used for the structure came from a quarry near the Potomac River in Seneca, Md. It was chosen

Smithsonian Institution "Castle," ca. 1900, called the most picturesque building in America when completed in 1851. Courtesy Smithsonian Institution.

instead of the Aquia sandstone used on so many government buildings to that date, after twenty-five stone samples from more than fifteen quarries were tested for durability; attractiveness and low cost were other important factors. The qualities of the Seneca stone were unimpeachable:

> When first removed from the parent bed, it is comparatively soft, working freely before the chisel and hammer, and can even be cut with a knife; by exposure, it gradually indurates, and ultimately acquires a toughness and consistency that not only enables it to resist atmospheric vicissitudes but even the most severe mechanical wear and tear.

The cost estimate for completing the Castle with this stone, which was floated to the National Mall via the Chesapeake & Ohio Canal, was initially $205,250. Joseph Henry, the first secretary (director) of the Smithsonian Institution, lived in the east wing of the building with his family in 1849 during its initial construction. For many years the building housed all Smithsonian operations. Reconstructions over the years have included repairs following a fire in 1865 that destroyed the upper story of the main block and the north and south towers. In 1884 the east wing was fireproofed and enlarged.

Today, the Castle houses administrative offices and an information center. The Smithsonian is composed of sixteen museums and the National Zoo, collectively responsible for approximately 140 million artifacts and specimens, plus scientific research centers in Panama, Cambridge, Mass., and elsewhere. Nine Smithsonian museums are on the National Mall. Five other museums and the zoo are located elsewhere in the city, while the Cooper-Hewitt Museum and the National Museum of the American Indian are located in New York City; the latter soon to be in Washington. The Castle is a National Historic Landmark. The other local building to Renwick's credit is the Smithsonian's Renwick Gallery, 1859-61 (the original Corcoran Gallery of Art).

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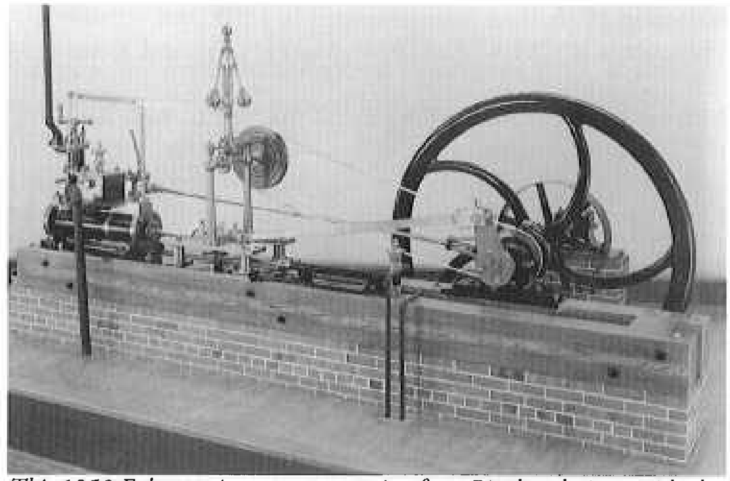
Exhibits at National Museum of American History
Smithsonian Institution
Washington, D.C.


This 1850 Faber stationary steam engine from Pittsburgh sits outside the 1850s machine shop in the "Engines of Change" exhibit. Courtesy National Museum of American History, Smithsonian Institution.

Much has changed since the Smithsonian's Museum of History and Technology opened its doors in 1964 with the mission "to present the history of science and engineering and the cultural development of the United States." Today the renamed and repositioned National Museum of American History, one of sixteen Smithsonian Institution museums, "dedicates its collections to a broader understanding of our nation and its many peoples."

Yet much remains on display from the museum's original dedication to the global history of industrial, scientific, and technological pursuits. Layers of museum exhibitions both historical and historic unfold as one enters from the Constitution Avenue (north) side. At the entrance, the late 1980s artifact emporium "A Material World" features a full-size test section of George Washington Bridge suspension cable and a Riehle Brothers materials-testing machine from the Chicago World's Fair of 1893. Nearby, the amazing 1831 steam locomotive, *John Bull,* which the museum acquired in the 1880s, heads toward the transitional and stylized "Engines of Change" exhibition, a mid-1980s revisionist industrial history that replaced the old Hall of Tools whose centerpiece, an 1855 steam-powered machine shop, remains in place.

Occupying the vast southeast corner of the first floor is the Hall of Power Machinery and the Hall of Bridges and Tunnels, opened in the mid-1960s. These two halls bespeak a time when the pure definition of objects as evidence of nothing more than themselves mattered most—rather than as symbols held aloft to embroider this or that theory of social history. The Power Hall traces water and steam power from the ancients to the mastery of the internal combustion engine, with a long pause amidst the glories of stationary steam. A formidable collection of exquisitely modeled suspension and truss bridges are evidence of another sort: the art of the modelmaker. The world's great bridges, tunnels, and many of their construction workers are fitted out in loving detail.

It was out of the rich stew of artifacts and histories of technologies exhibited in these halls that the Society for Industrial Archeology emerged in 1971, a quasi-institutional response to frustrated interests in endangered sites and processes too vast to be preserved within the halls of a museum. If entire bridges, tunnels, and factories cannot come to us, we must go to them! Complementing such field study, the Historic American Engineering Record (HAER) was established in 1969 to graphically document industrial structures of significance as a means of preserving knowledge of how they look and work. All of which has the power to remind us that this museum of history and technology remains one of SIA's sacred shrines and, fittingly, home to its organizational archives.

Bureau of Engraving and Printing
Washington, D.C.

The Bureau of Engraving and Printing, established in 1862, is most often recognized for producing currency. Although best known for its U.S. notes, as a Department of the Treasury function it began producing revenue stamps in 1876, then postage stamps in 1894, and occasionally has printed other nations' money: for the Philippines (1928), Cuba (1934), Siam (1945), and Korea (1947).

Making money is an intaglio process that begins with hand engraving a piece of soft steel to be used as a master die. Separate portions of the design—e.g., portrait, vignette, and lettering—are hand-cut by the engravers. Master dies are not used for direct printing, but their designs are transferred to make printing plates that will each print thirty-two notes. The original dies are stored and may be used again and again.

Currency is printed on high-speed, sheet-fed rotary presses capable of producing more than 8,000 sheets per hour, under pressure estimated at 20 tons. The backs of the notes are printed with green ink and allowed to dry for up to forty-eight hours before the faces are printed in black. After inspection they are overprinted with the Federal Reserve District seal and its number designation, then with the seal and serial numbers in green ink. Two

Hand-powered flatbed spider press in the original BEP building, ca. 1904; the pressmen are aided by female printers' assistants. Courtesy Bureau of Engraving and Printing.

guillotine cutters slice the 100-sheet stacks of notes before they are bundled into "bricks" of 40 units of 4,000 notes each.

The BEP initially operated in the basement of the Treasury building where six people hand-stamped notes that had been printed by private banks. The BEP commenced printing its own currency in late 1863, and by 1877 all U.S. currency in circulation had been printed by the government. Paper currency was first issued to help finance the Civil War, during which notes valued at 3, 5, 10, 25, and 50 cents were printed in lieu of coinage because of the tendency of the latter to be hoarded.

Two of the BEP's three active buildings are in Washington; the third was completed in Texas in 1991. In the 1880s it occupied its first independent home, a Romanesque structure of pressed brick and rolled iron girders designed by Supervising Architect of the Treasury James G. Hill, which is extant at the corner of 14th Street and Independence Avenue. In need of additional space, the bureau acquired acreage down the block and James Knox Taylor was commissioned to design a new building. Completed in 1914 at a cost of $2.88 million, the Neoclassical design utilizes steel framing, fireproof concrete, and Indiana limestone with granite trim. Nearly 10 acres of floor space is created in the vast rectangular plan that measures 505 feet long, 296 feet wide, and six stories high. Within a few years space was again needed and the plain Annex Building was constructed next door, designed by architect Louis M. Simon. Built of reinforced concrete with a limestone facade (due to a shortage of funds), this structure is 570 feet long and 285 feet wide. Upon completion in 1938 it was believed to be the second-largest reinforced-concrete building in the country, having consumed 7,740 tons of steel and 139,968 tons of concrete. Beneath it are two tunnels and a railroad spur.

In 1932 the BEP's 4,500-person labor force was 55 percent female. At that time it operated 240 four-plate power presses operated by three people each and produced about 1 million notes annually; this task required 1,125 tons of paper and 1,100 tons of ink. In contrast, BEP currently produces 37 million notes a day using 24 presses that consume 18 tons of ink daily. An estimated 95 percent of these notes will replace those already in circulation. The paper used to print currency is 75 percent cotton and 25 percent linen; in 1999 it cost 4.2 cents per note to produce currency.

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Bureau of Engraving and Printing web site at http://www.bep.treas.gov/historical.htm

U.S. Treasury Building
Washington, D.C.

After three fires damaged or destroyed the earliest U.S. Treasury buildings—the most severe being the loss of James Hoban's 1817 structure—it was determined that fireproof construction was a priority. The present Treasury Building was built in 1836-69, in four stages and by a series of architects, although this span of years and stable of designers is not apparent in the unified Neoclassical structure. It is the oldest departmental building in Washington and, located on the east side of the White House, it is balanced to the west by the State, War, and Navy Building (now the Dwight D. Eisenhower Executive Office Building), 1871-88. The remarkable feature of the Treasury Building is its fireproof construction, using brick vaulting carried by cast-iron beams.

Robert Mills (1781-1855), architect of the Washington National Monument and the U.S. Patent Office Building, designed the east and center wings between 1836 and 1842. He was responsible for the impressive 466-foot Ionic colonnade along the full length of the building. Each of the thirty monolithic granite columns is 36 feet tall. Later additions began with the construction of the south wing, 1855-60, and the west wing, 1855-64. The preliminary design of the wings was provided by Thomas U. Walter (1804-87), architect of the present Capitol dome, but architects Ammi B. Young (1800-74) and Isaiah Rogers (1800-69) refined the plans, designed interior details, and

Interior of U.S. Treasury Building, hall and ornate stairway. HABS photograph by Jack Boucher, 1974.

supervised construction. While the exterior of the building was executed along the lines of the original Mills wings, the interiors of the later wings reflect changes in both building technology and aesthetic taste. The final addition to the Treasury Building was the north wing, 1867-69, by Alfred B. Mullett (1834-90), architect of the State, War, and Navy Building. Similar in construction and decor to the south and west wings, the north wing contains the sole public space, the two-story marble Cash Room where the daily financial business of the U.S. government was transacted; it opened in 1869 as the site of President Grant's inaugural reception.

One of Mills' first duties at the Treasury was to inspect the remains of the building that burned in 1833. He discovered that a fireproof addition to George Hadfield's Treasury Building, which he built with Benjamin H. Latrobe in 1804, "received little or no injury from the fire" compared to other portions of the structure. Congress authorized $100,000 in 1836 to proceed with the re-building.

By the time Mills submitted plans for the proposed reconstruction, he was in private practice and an advocate of fireproof construction. He cited hydraulic cement as the key, for its waterproofing and quick-setting qualities, but lamented that he could not find sufficient bricklayers who knew how to erect a groin arch. His plans called for 114 offices with brick groin-vaulted rooms constructed using hydraulic cement rather than the usual lime mortar; this allowed a reduction of the wall thickness from 42 inches to 27 inches. The groin-vaulted spaces flank the central barrel-vaulted corridors, making Treasury the first large, modular office building. This first phase was completed in 1842 at a cost of $660,773. To accommodate the department's growth, Congress appropriated $300,000 for the next phase of the building, starting in 1855; at the start of the Civil War it served as temporary headquarters for Union troops and as President Andrew Johnson's office while Mrs. Lincoln vacated the White House. Before continuing with the construction of the north wing, it was necessary to remove the old State Department Building on the site, which occurred in 1867. To avoid the exterior thrust evidenced on the outer walls of the west wing, he used wrought-iron beams with segmental arches instead of brick groining in the ceilings of the cellar and basement. Other changes included the use of granite instead of painted cast-iron coffers on the north wing portico, and iron architraves instead of stucco around the windows.

One of the most heralded features of this and other buildings is Mills' signature fireproof, four-story, double flying staircase created by cantilevering each tread from the wall and corbeling the treads against each other. These and the staircases at Mills' Patent Office and General Post Office buildings are described as the "most magnificent monumental stone staircases in America surviving from this period." Walter's extensions of Mills' masonry bearing barrel- and groin-vault interiors utilized cast-iron columns and beams, with minor brick vaults and granite exterior walls; on the interior, rather than a plain plaster wall, Walter's bays are punctuated by cast-iron Corinthian pilasters carrying an ornate cast-iron frieze. Young, and Rogers after his retirement, proceeded with the west and south wings. Of the four burglar-proof vaults in the south wing designed and patented by Rogers in 1864, only one in the northwest corner survives; two layers of cast-iron balls sandwiched between the traditional layers of wrought-iron and steel plates rotate when struck by drills or other burglary tools, preventing penetration of the wall.

At the time of its completion, the Treasury Building was one of the largest office buildings in the world. In 1927 it was chosen as the image to appear on the $10 bill, and it was declared a National Historic Landmark in 1972. The 1864 Burglar-Proof Vault and Cash Room were restored several years ago, and the balance of the structure is currently undergoing a comprehensive interior and exterior restoration.

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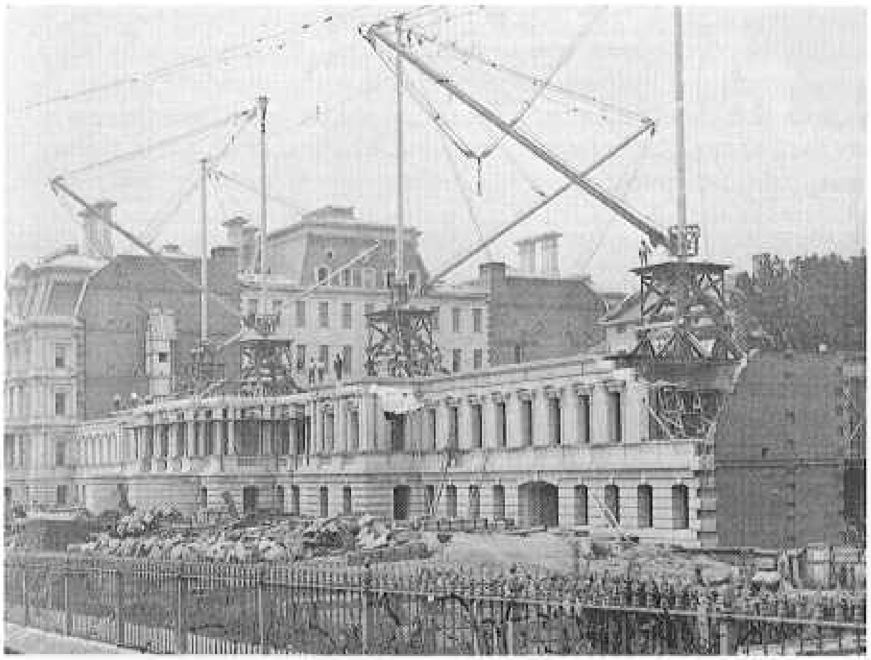
Three historic structure reports detailing the design and construction of the Treasury Building's five wings are available through the U.S. Treasury web site at http://www.ustreas.gov/curator/reports.htm

State, War, and Navy Building
(Old Executive Office Building; Dwight D. Eisenhower Executive Office Building)
Washington, D.C.

The State, War, and Navy Building, 1871-88, was designed by Alfred B. Mullett (1834-90) in the French Second Empire Style when he was Supervising Architect of the Treasury. It shares the same figure-eight plan as the Treasury Building at the northeast corner of the White House, forming the third component of the Pennsylvania Avenue triumvirate of monumental federal structures. The building was erected incrementally. The State Department occupied the south wing in 1875; the Navy Department the east wing in 1879; and the War Department the north, west, and center wings in 1888. The 650,000-square-foot home to the respective federal departments served as the model for a complex administrative office building but, ironically, by the time it was complete it was stylistically antiquated.

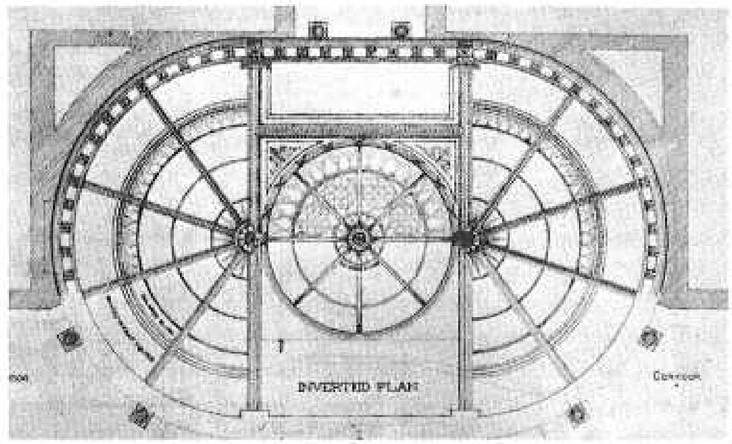


State, War, and Navy Building: Completed south wing with east wing under construction, 1875 (above); detail from drawings for the west wing stairway skylight and dome made of cast iron (opposite). From Lehman, Executive Office Building, GSA Historical Study No. 3.

These executive-branch agencies originally had been housed in separate structures built adjacent to the White House grounds as early as 1800. As mid-century approached, a number of architects familiar with government building submitted designs for a consolidated structure, but Mullett had designed a post office and treasury buiding in Boston that proved a popular prototype and resulted in the present building. The massive building is 480 feet long and 280 feet wide, successfully dispersed in five- and three-part elevations dominated by end and center pavilions that are joined by curtain walls. The thick application of features—paired columns, balustrades, window pediments, and mansard roof details—gives the building a three-dimensional quality and horizontal emphasis despite its six-story height. The walls are 54-inch-thick gray Virginia granite. When completed, the building contained more than 550 large rooms with 16-foot ceilings totaling 10 acres of floor space, making it the largest office building in the world at the time. Electricity and telephones, which came into use during its construction, were incorporated into the design.

Much of the interior is the work of Richard Von Ezdorf (1848-1926), an Austrian-trained engineer and interior designer. He used cast iron to create fireproof internal support trusses as well as superior ornamental elements on the interior. The hallways are articulated by cast-iron pilasters carrying transverse beams that support shallow brick arches. At each corner of the building a monumental curving staircase of granite is illuminated by a stained-glass sky dome; two double stairways connect the central wing to the perimeter wings. The door hardware is emblazoned with the insignia of the original offices in the building.

Restored spaces in the building include three libraries, among them the four-story cast-iron former State Department Library, now the Executive Office of the President Library; the Indian Treaty Room, originally the Navy Library and reception room, which cost more per square foot than any other room in the building because of its marble panels, bronze sconces, and gold-leaf highlights; and the War Department Library, now the Executive Office of the President Law Library. Other noteworthy spaces are the Diplomatic Reception Room, Secretary of State's office, and Secretary's suite.



Although Congress' first appropriation for a State, War, and Navy Building was $500,000, the cost of the project ultimately grew to about $10 million. It is a rare and exuberant example of the French Second Empire style in Washington, a city dominated by Classical forms. Mullett had altered several government buildings elsewhere in this style, but this is his finest work. In 1889 he sued the government for $158,441 in fees for work related to this building, alterations to the General Post Office, and the D.C. jail. He received nothing, and the following year shot himself because of "financial worries and despondence caused by ill health."

As years passed, the State, War, and Navy Building increasingly was seen as unfashionable and in the 1920s and 1930s it was slated for remodeling to remove "the very large number of small inartistic columns, more than 900 of them," and create something more akin to the Treasury Building. About this time, the departments began to relocate to other facilities and were replaced with those of the Executive Office of the President. Subsequently called inefficient and nearly demolished in 1957, what had been renamed the Old Executive Office Building has since been designated a National Historic Landmark. Since 1981, major renovations have been carried out, including the development of a comprehensive preservation program and the formulation of a master plan for the building's continued adaptive use. The building continues to house various agencies that comprise the Executive Office of the President, such as the Office of the Vice President, the Office of Management and Budget, and the National Security Council. It recently was renamed the Dwight D. Eisenhower Executive Office Building.

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Pension Building
(National Building Museum)
Washington, D.C.

The colossal red Pension Building, 1882-87, was designed by Quartermaster General Montgomery C. Meigs (1816-92) to house the U.S. Pension Bureau, a new federal agency created to award pensions to wounded and maimed Union veterans, as well as soldiers' widows and orphans, as a result of legislation passed during and after the Civil War. The Pension Building was Meigs' final accomplishment, and after many years housing government offices it was designated the National Building Museum in 1978. Because of its grand interior space, the building has become socially significant as the scene of presidential inaugural balls, beginning with Grover Cleveland's in 1893.

Meigs felt that the Pension Building was one of his finest accomplishments. The red brick Italian Renaissance Revival design was much criticized as an architectural anomaly in a city filled with white marble Classicism, however, and it was dubbed Meigs' "Old Red Barn." Built as a memorial to the Union soldiers, sailors, and marines of the Civil War, its architectural features are many, literal, and unique to Washington. This theme is carried out by the exterior terra-cotta frieze designed and sculpted by Bohemian-born Caspar Buberl, depicting a parade of Civil War military units. Measuring 3 feet tall and 1,200 feet long, in subject and scale it has been likened to the frieze on the Parthenon.

Inside, the Great Hall houses eight massive Corinthian columns of plastered brick with a faux-marble finish that are believed to be the tallest interior columns in the world. The 220-foot by 400-foot building is entirely fireproof because it lacks any structural wood. All floors are carried on brick barrel or dome vaults, or on iron beams; the roof is supported by iron trusses. The four stairways are made of brick, and only the window and door openings utilize timber. Technologically, the building was designed to provide natural air-conditioning and lighting for employees. Air vents in the exterior walls brought in cool, fresh air replacing hot air that escaped through the skylights in the roof. Although some of the offices are fitted with fireplaces, the entire building was steam-heated by several large, tubular boilers once located in a northwest corner cellar.

South and east elevations of the former Pension Building, architecturally atypical for Washington. HABS photograph by Jack E. Boucher, 1968.

U.S. General Post Office
(U.S. Tariff Commission Building)
Washington, D.C.

The U.S. General Post Office, Patent Office, and Treasury buildings all were initiated in the 1830s as part of a concerted effort to construct indestructible, fireproof structures in which to conduct essential government functions and store irreplaceable documents. In the wake of several disastrous fires since 1800 that destroyed the first generation of buildings, this was a priority for federal architects. In all of these structures Robert Mills (1781-1855), a proponent of fireproof construction, combined brick vaulting and the Greek Revival styling that would become the architectural language and symbol of the capital city.

The General Post Office, 1839-42, is located opposite the U.S. Patent Office (U.S. Civil Service Commission) Building. It replaced a former brick hotel that had been expanded and converted into a combined post office (on the first floor) and patent office (on the second floor); when the converted hotel burned in 1836, an estimated 7,000 models, plus patent records and library contents were lost in the blaze. The new building, smaller than either of Mills' other two projects in Washington, was designed on a U-shaped plan that was closed up with an addition by Thomas U. Walter in 1855. The three-story Renaissance Palazzo-inspired design has a rusticated basement, attic story, and Corinthian pilasters that define the elevation—the first use of Italianate style for an important public building in America. Louisa C. Tuthill, author of the first critical history of architecture in this country (1848), called it "one of the most splendid buildings in the United States."

> *I consider it appropriate, if not my duty, to direct the attention of Congress to the ... public buildings in this metropolis. Of these, the Treasury, General Post Office, and Patent Office buildings are comparatively of recent construction. They are fire-proof, and the only buildings of their class having any pretensions to architectural taste and proportion....*
>
> —Committee on Public Buildings and Grounds, *Annual Report for 1849*

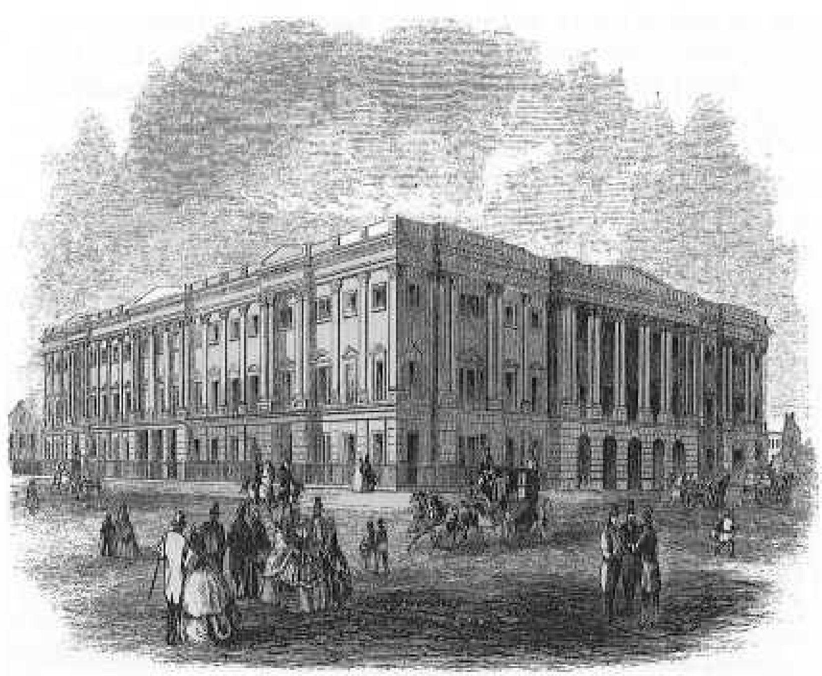
After the Aquia sandstone used to build the Capitol and White House showed problematic spalling and cracking, Mills convinced Congress that the new post office should be the first in Washington to be constructed of hardy marble. Marble from Westchester, N.Y., was of poor quality and did not hold up well, however, especially in decorative details and wall surfaces. The order of columns Mills selected was used by Palladio on the Temple of Jupiter Stator, the first marble building erected in Rome. The second-story interior is one of Mills' most elaborate, with a richly sculpted frieze, vault, and groin details.

Mills' design here is the same as for the other sites—a central barrel-vault corridor flanked by cubical groin-vaulted offices. The double-loaded corridor of offices facilitated ventilation and was a standard arrangement for federal office buildings during the 19th century. In 1839, advertisements for millions of the "best-quality hard bricks" to be delivered, 250,000 to 500,000 per month, appeared in newspapers; when one such contract was let, the bricks cost $7.50 per thousand. The hydraulic cement was to "be delivered in good tight barrels," 70 pounds to the bushel, costing 37.5 cents per bushel. "The powerful character of this cement has enabled us to give our vaulted ceilings, in the interior of the building, a degree of lightness unusual in vaulted or fire-proof buildings ...," it was explained in the Committee on Public Buildings and Grounds' Annual Report of 1840. Each floor contained twenty-five rooms except for the third floor, which was altered to accommodate a large space that later served as a library.

By the time Thomas U. Walter was selected to make the 1855 post office addition, Mills was aged; and when he died that year, his obituary put the slight in perspective. It read:

> He thought he had been promised the superintendency [of the extensions of the Post Office and Patent Office] but learned a few days since that they were to be placed under the supervision of Capt. Bowman and Capt. Meigs, of the engineers corps. The disappointment was too much for him. He became deranged and died.

Walter's design tripled the length of the east and west elevations and created a new northern wing. Access to the rectangular courtyard was through a sculpted archway occupied by the personifications of Fidelity flanked by Electricity and Steam. Like Walter's addition to Mills' Treasury, he used cast-iron girders and roof supports and wrought-iron I-beams to span the halls and offices with shallow segmental brick arches between masonry bearing walls. Still visible in some of the attic spaces, these early wrought-iron beams were made by the Phoenix Iron Company and patented in December 1857. Above the ground-floor post office was the mail-sorting facility in a two-story skylit room with a cast-iron balcony around the perimeter. In later years this space was divided into two separate floors, but renovations currently underway will return the original two-story height. The corrugated copper roof, since replaced, was also an unusual feature. Subsequent changes to the building include the lowering of the street grade, enlargement of some windows, installation of a gas-lighting system, and a heating system. It is a designated National Historic Landmark and is currently undergoing conversion into a hotel.



U.S. General Post Office, east and north elevations, ca. 1890. HABS Collection.

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U.S. Patent Office
(U.S. Civil Service Commission Building; Smithsonian American Art Museum and National Portrait Gallery)
Washington, D.C.

The site of the U.S. Patent Office was, according to Pierre L'Enfant's 1791 plan of the City of Washington, Federal Reservation No. 8, where a national church was to be erected. Substituting a temple to science and ingenuity for a religious shrine seemed appropriate. Although construction of the block-sized rectangular structure stretched over thirty years and drew on the talents of five architects, the result is a cohesive monument to Greek Revival styling that is matched across F Street by the U.S. General Post Office, built concurrently.

Although Robert Mills was put in charge of constructing the U.S. Patent Office in 1836, a design by Ithiel Town (1784-1844) and William Parker Elliott (1807-54) was selected over his own submissions. Mills later claimed credit for aspects of their plan, of which the south wing was constructed of sandstone during the first four years. The portico and flanking walls of this section is the only major example left in the city of the brownish color and texture of Aquia sandstone, an early mandated material for federal buildings.

The formal elevation has a rusticated *piano nobile* ground level, above which the four similar pilastered facades feature projecting Doric porticos. The entrance into each is unique, with variations on the placement of steps and doorways. Mills' modifications to the plan included the addition of a flying, double, semi-circular three-story staircase on the north wall of the south wing that is considered one of his most beautiful. Subsequently, from 1849

Interior view of groin vaults and cast-iron staircase of the U.S. Patent Office. HABS photograph by Jack E. Boucher, 1968.

to 1852, Mills served as architect of the U.S. Patent Office extension, which was completed as far as the 402-foot-long east wing constructed of marble up to the third floor, and the addition of square corner pavilions for the east and west wings. When Thomas U. Walter replaced Mills in 1852-57, he took direct responsibility for constructing the north wing, and gave the west wing to his assistant, Edward Clark, to oversee.

The interior of the U.S. Patent Office exemplifies the differences in construction principles and the manipulation of space. Within the south wing, office cells are located on the east end and open, colonnaded storage is on the west; the entire third floor was proportionately taller and used to display patent models. Barrel-vaulted bays face the windows, groin vaults down the center are carried by columns. The north and west wings also feature a series of cells, although they follow rectilinear trabeated rather than arcuated ceilings; shallow brick arches span between cast-iron beams. After a fire in 1877 when the iron girders of the west wing roof collapsed, the model rooms in the south and west wings were rebuilt in Victorian styling.

The streets surrounding the Patent Office were lowered in the 19th century and the F Street staircase was removed, so its harmony with the setting is lost. It is a designated National Historic Landmark.

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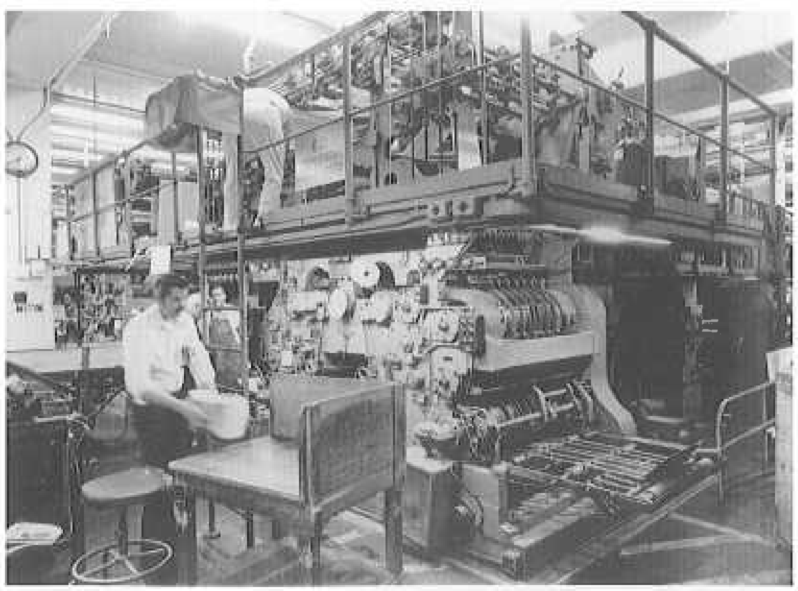
U.S. Government Printing Office
Washington, D.C.

Exterior of the U.S. Government Printing Office's two primary buildings, ca. 1940 (above); Congressional Record *letterpress, no longer in use, ca. 1979 (below). Both courtesy U.S. Government Printing Office.*

The U.S. Government Printing Office, one of the least understood federal agencies, grew out of the "publick printers" of the 18th century and, once the capital city was occupied after 1800, the various contractual congressional-reporting operations established during the first half of the 19th century. Formally established on the eve of the Civil War, today GPO occupies three buildings and boasts the largest in-plant printing business in the nation with 1999 sales at nearly $196 million and 163,200 jobs printed.

GPO handles congressional and executive branch printing, and distributes federal documents to the public. The *Congressional Record,* for instance, typically exceeds 200 pages—about the size of five metropolitan daily papers—and GPO must deliver 9,000 copies of it to Congress by 9 a.m. daily. It also produces the *Federal Register*—the government's official list of proposed rules and regulations—plus the *Code of Federal Regulations,* more than 6.7 million U.S. passports, and nearly 230 million postal cards annually.

Printer Cornelius Wendell moved from New York to Washington in the 1840s, and by 1852 he was a subcontractor for nearly all congressional printing needs, as he was "able to provide the largest and best-equipped printing establishment the city had ever seen." Within a few years he was elected House Printer and soon erected a building at North Capitol and H streets that would become the first home to GPO. Financial abuses that had long plagued the venue of government printing resulted in the formation of a government printing establishment in 1860. The first facility as built by Wendell included a printing office, bindery, paper warehouse, steam engine, boiler, and coal storage. The four-story red-brick building contained a composing room with 349 paired cases and 41,300 pounds of type, a proofreading room equipped with armchairs and desks, wetting and drying rooms, and a pressroom with twenty-three Adams presses and three cylinder presses.



To accommodate growing production demands, the building and equipment had grown to include seventeen standing presses, fourteen ruling machines, and seven paper-cutting machines by 1865. A number of additions were made to the original structure between 1871 and 1896 before it was demolished. Today GPO occupies nearly 35 acres of floor space in three buildings. The oldest dates from 1907, with two more built during the 1930s.

Beginning in the 1960s, GPO was one of the first printing organizations in the country to use electronic typesetting systems. Since then, successive generations of technology have been deployed to develop electronic databases of government information products from which publications in both print and electronic formats are produced. Fiber optics and lasers increasingly are employed at GPO. Up to half of the Senate portion of the *Congressional Record,* for instance, is transmitted from Capitol Hill via fiber-optic connections, and 80 percent of the *Federal Register* is transmitted by laser beam. GPO recently purchased two new Krause America LX170 computer-to-plate systems to make plates for the three 64-page, two-color, 35-inch by 50-inch Hantscho web presses used to print the *Congressional Record,* the *Federal Register,* the U.S. budget, and more. In one year GPO uses more than 55 million pounds of paper, and contractors performing GPO work use another 100,000 or so tons. GPO has also been a leading producer of CD-ROMs for more than a decade. In 1998-99 it was named the top in-plant operation in the country by *In-Plant Graphics* magazine; and in 1999, *PC Week* magazine called it one of the top U.S. technology innovators.

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U.S. Government Printing Office web site at http://www.gpo.gov

Union Station
Washington, D.C.

Washington's grand statement in railroad architecture is Union Station, a 1907 classical pile just north of the U.S. Capitol at the confluence of Louisiana Avenue, Delaware Avenue, Massachusetts Avenue, and all passenger rail lines entering the nation's capital. In one vast station, architect Daniel Burnham eliminated grade crossings and the random line-specific stations scattered throughout the city, including the Pennsylvania Railroad eyesore that had been an impediment to improving the National Mall. After a brush with oblivion in the 1970s, Union Station rose like a phoenix to become a shopping, dining, and entertainment mecca, while continuing to function as the city's train terminal. Besides Amtrak, Maryland Rail Commuter service, Virginia Railway Express, and the Metro subway system's red line stop here.

The main façade features three monumental granite archways that face the Capitol, which are flanked by sensuous allegorical figures representing six forces: Fire, Electricity, Freedom, Knowledge, Agriculture, and Mechanics. Inside the main waiting room, Burnham took as his model the Roman Baths of Diocletian, with a cavernous barrel vault guarded by three dozen Teutonic knights. Through terra cotta colonnades the 760-foot-wide concourse leads to thirty-two separate tracks, fanned out to receive the influx of government servants and dignitaries expected during the Golden Age of rail, when clerks and presidents alike traveled by train.

Principal elevation of Union Station, 1913, from a stereograph. Private collection.

Metrorail System (Metro)
Virginia, Maryland, and Washington, D.C.

Washington's Metrorail is a 103-mile rapid-transit system with 83 stations in two states and the District of Columbia. Along with San Francisco's Bay Area Rapid Transit (BART) and the Metropolitan Atlanta Rapid Transit Authority (MARTA), it is one of the first large-scale U.S. heavy-rail rapid-transit systems built since World War II, and it helped spur the resurgence of rail transit nationwide that continues today.

The first serious call for rapid transit in the nation's capital came in a 1959 report by the National Capital Planning Commission. In 1965, Congress authorized a 25-mile downtown subway, and the next year the three jurisdictions formed the Washington Metropolitan Area Transit Authority (WMATA) to build a downtown and regional subway system. Congress agreed to fund two-thirds of the cost. When ground was broken in December 1969, planners hoped the system would be complete within a decade, but funding delays, massive inflation in the 1970s, and other obstacles stretched construction over more than thirty years. Jackson Graham, a retired Army Corps of Engineers major general who managed Metro from 1967 to 1976, is credited with keeping the program on track. Rail operation began in 1976 on a 4.6-mile segment of track between the Rhode Island Avenue and Farragut North stations, and only in January 2001 would WMATA complete the system as planned in 1968.

Unlike counterparts designing the BART system, Metro engineers were conservative in their rapid-transit technology, relying on conventional standard-gauge track, married-pair cars, and other equipment. Usually, only after an innovation had been proven elsewhere did WMATA consider it. For example, zoned-fare collection using magnetic cards was rejected until it succeeded on the Illinois Central Railroad. On the other hand, Metro did help introduce several technologies to the U.S. transit industry, including automated train control, New Austrian Tunneling Method (NATM), plastic-membrane waterproofing, earth-pressure-balanced tunneling machines, and its long, modular escalators.

Roughly half of Metro is underground or under water, with the rest mostly at grade in highway medians or along railroad rights-of-way. Thanks to the region's varied geology and the evolution of technology during the system's construction, Metro tunnels have employed several construction techniques. In downtown Washington's flat bottomland, engineers specified cut-and-cover tangents along city streets. For curves between tangents, boring machines were used to tunnel under parks. The Potomac River crossing between Foggy Bottom and Rosslyn and the Connecticut Avenue route north of Dupont Circle avoided underground utility lines by deep tunneling through schistose gneiss on the edge of the Appalachian piedmont. The Silver Spring-to-Glenmont route, planned using traditional tunneling methods, was switched to NATM at a contractor's suggestion. The Anacostia River crossing between the Navy Yard and Anacostia used an earth-pressure-balanced machine to penetrate watery river soils. And to cross the Washington Channel between L'Enfant Plaza and the Pentagon, WMATA sank a prefabricated tube.

Metro Center Metrorail Station. Courtesy Washington Metropolitan Area Transit Authority.

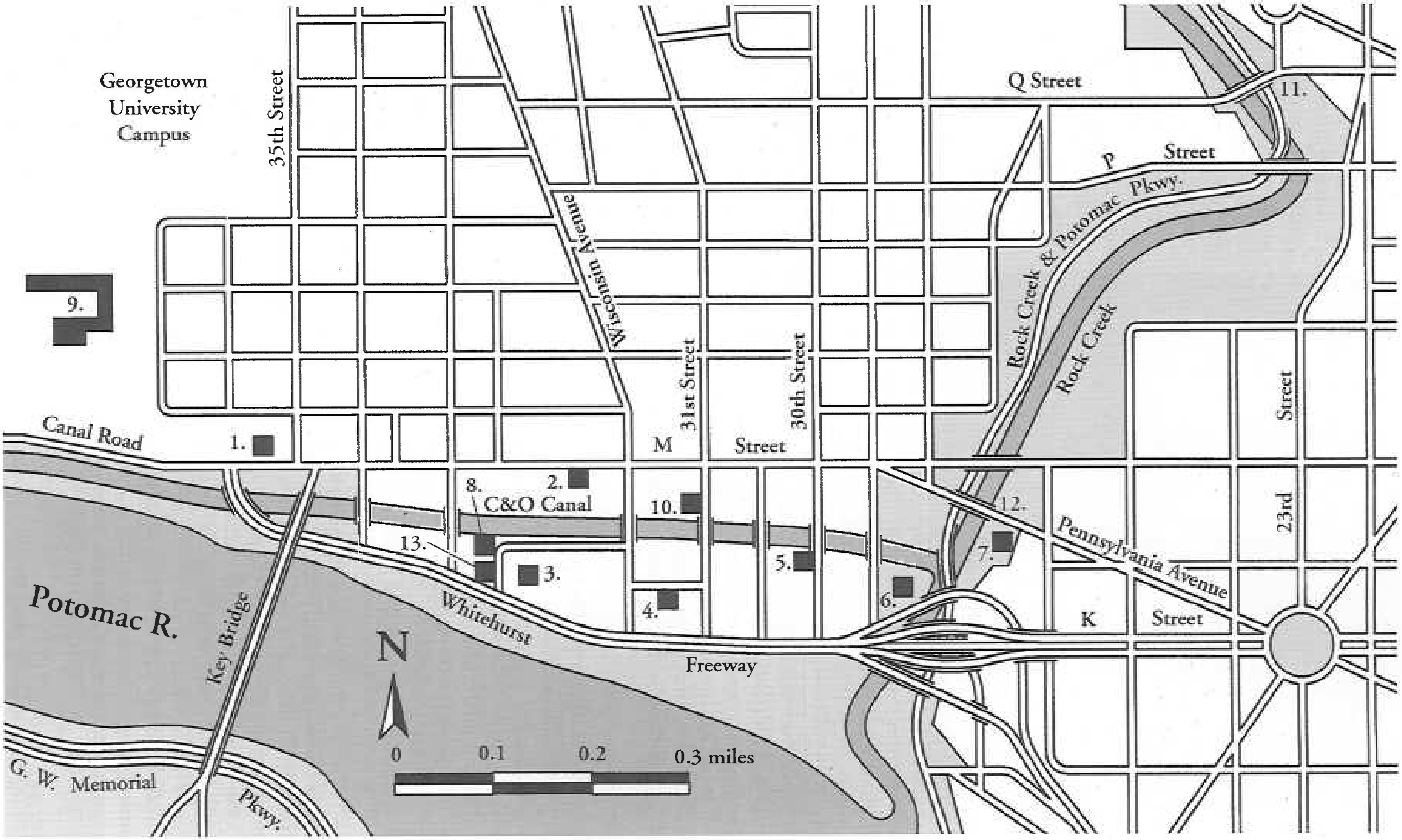
Above-ground portions also vary. Aerial structures near the Van Dorn Street station, for example, use an innovative post-tensioning system developed by Figg & Mueller.

Metro's underground stations were the product of a three-way negotiation among its consulting engineers (DeLeuw, Cather & Company) and architects (Harry Weese & Associates), and the Commission of Fine Arts, a federal body that must review major public buildings in Washington. The engineers wanted economic efficiency, the architects wanted spaciousness and simplicity, and the CFA wanted monumental grandeur. For the most part, monumentality and modernist aesthetics won out. Station construction varies with the manner of excavation. In the cut-and-cover stations downtown, cast-in-place concrete vaults support the earth above. Where stations were blasted out of rock, the vaults are thin, precast shells assembled within a larger horseshoe tunnel. Riders accustomed to the shriek of New York and Boston subways remark on the gentle whoosh of Metro trains. Credit for this quiet goes to a combination of technologies: gentle curves in the alignment, cushioned wheels, advanced brakes, and acoustical insulation in both the track bed and the station vaults.

Metro was built during a time of rapid change in the nature of public-works construction. During the peak years of construction, 1972-77, lawsuits forced WMATA to add elevators for handicapped access and hold public hearings on station design, while the D.C. government forced WMATA to make its contractors try to hire minority workers and subcontract with minority-owned firms. Most significant, the courts ruled that Metro must comply with the National Environmental Protection Act of 1969, forcing WMATA to prepare environmental impact statements—doubling the design phase from one year to two. These requirements and double-digit inflation in the 1970s drove up the system's cost from a $2.5 billion estimate to at least $10 billion. Moreover, rather than recovering operating expenses from fare revenue as planned, Metro recovers only about 70 percent, and relies largely on state and local taxes for the balance.

In recent years Metro has begun to show its age. Repeated escalator failures have led WMATA to plan for canopies over entrances to shield them from rain and snow. In 1999 and 2000, Metro had to temporarily abandon automated operation when key electronic components began to fail. And seeping groundwater has damaged equipment in some older rock tunnels, especially under Connecticut Avenue. Despite these problems, Metro remains enormously popular. Approximately 40 percent of downtown-bound rush-hour travelers use it, a high percentage for this country. Similarly, park-and-ride lots are filled and trains are crowded with weekday patronage that regularly exceeds 600,000.

The year 2001 marks two Metrorail milestones. In March it celebrated the 25th anniversary of the running of the first train. And in January, WMATA opened the Green Line from Anacostia to Branch Avenue, the last portion of the 103-mile system as adopted in 1968. But thanks to Metro's popularity and Congress, it will keep growing. Plans call for an extension of the Blue Line past Addison Road by two stations, and construction of a Red Line station between Union Station and Rhode Island Avenue. Meanwhile, WMATA is studying how best to serve Washington Dulles International Airport, a long-discussed goal.



Georgetown and Vicinity

1. Capital Traction Car Barn
2. Capital Transit Maintenance Shops
3. D.C. Paper Mill
4. D.C. Refuse Incinerator
5. Duvall Foundry
6. General Services Administration West Heating Plant
7. Godey Lime Kilns
8. Grace Street Power Station
9. Healy Building
10. Herman Hollerith Machine Shop
11. Pennsylvania Avenue Bridge
12. Q Street (Dumbarton) Bridge
13. Wilkins-Rogers Flour Mill

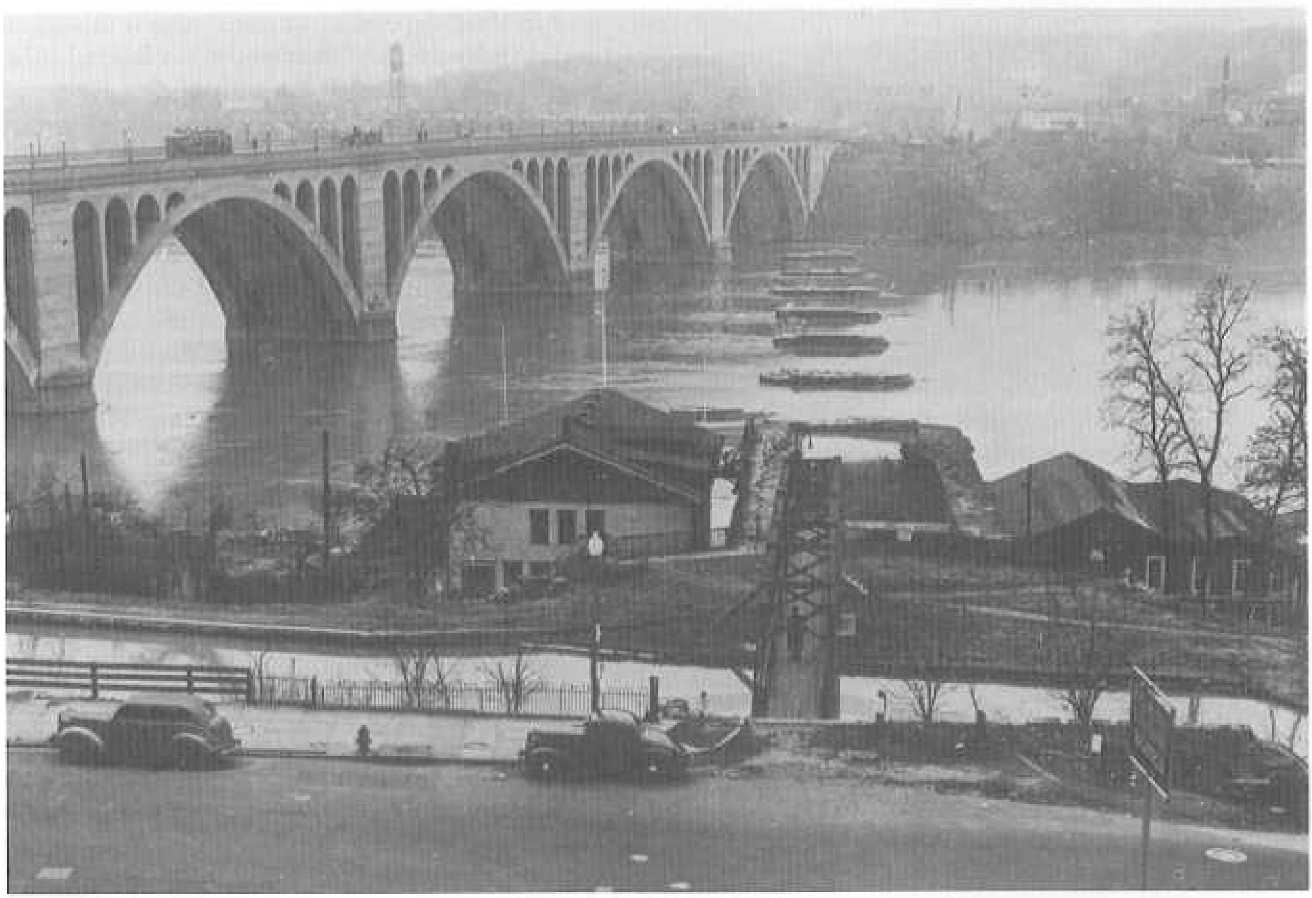
Francis Scott Key Bridge

Spanning Potomac River between Washington, D.C., and Arlington, Va.

The Francis Scott Key Bridge, constructed between 1917 and 1923, is an early reinforced-concrete-arch structure spanning the Potomac River between the communities of Georgetown in the District of Columbia and Rosslyn in Arlington County, Va. Although a long-time visual landmark and the last picturesque span west of the downtown core, it has little historic relationship to the overall design concepts applied to the monumental city during the early 20th century. Its unadorned appearance is a collaboration of the District Engineer Corps and the Commission of Fine Arts.

The bridge's original design by Nathan C. Wyeth featured a double-deck scheme, but due to the cost and limitations on domestic construction presented by World War I, it was changed to the single-deck version as built. U.S. Army Corps of Engineers Maj. Max C. Tyler oversaw the bridge's construction using day labor as opposed to outside contracting. Two concrete-mixing plants were built on site: one on shore and another founded on the riverbed, 25 feet beneath the low-water point. The open-spandrel arches were poured using huge floating steel-rib centers. The structure consumed approximately 68,000 cubic yards of concrete. The bridge is 1,791 feet 6 inches long, divided into six equal-length arch spans, and has a vertical channel clearance of 72 feet. It carries a 50-foot roadway with 8-foot sidewalks. Two trolley tracks, installed in 1923, completed work on the span.

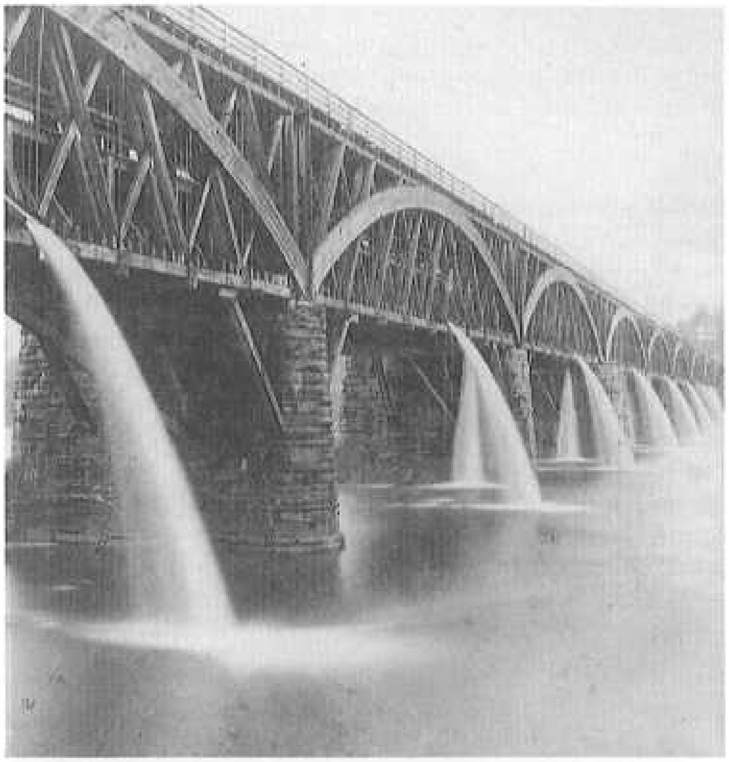
The completed bridge cost $2.5 million, double the original estimate. It is named for the composer of the Star-Spangled Banner who lived near the northern (Georgetown) terminus in a house that subsequently was demolished



Key Bridge, looking toward Virginia, ca. 1940; note piers of demolished Aqueduct Bridge on right. From HABS report on Potomac Aqueduct.

to build a portion of the Whitehurst Freeway. In 1939 an extra span was added to the south end of the bridge to provide an underpass for the then-new George Washington Memorial Parkway, which parallels the Virginia shoreline between Mount Vernon and Great Falls.

The forebear of Key Bridge, Aqueduct Bridge, was built in 1833-43 as an element of a 7-mile Chesapeake & Ohio Canal branch to the port city of Alexandria. It originally was an ungainly timber queen-post truss crossing that carried canal boats across the river on the upper deck, and other traffic below. This structure was later altered by the installation of Howe trusses and replacement of the boat channel with a roadway; then in 1888 it was reconstructed with entirely new iron trusses. The bridge was removed in 1933, well after Key Bridge was complete, and the U.S. Army Corps of Engineers dynamited most of the piers in 1962. A single pier is visible today upriver on the Virginia side.



Aqueduct Bridge, ca. 1870. From a stereograph. Private collection.

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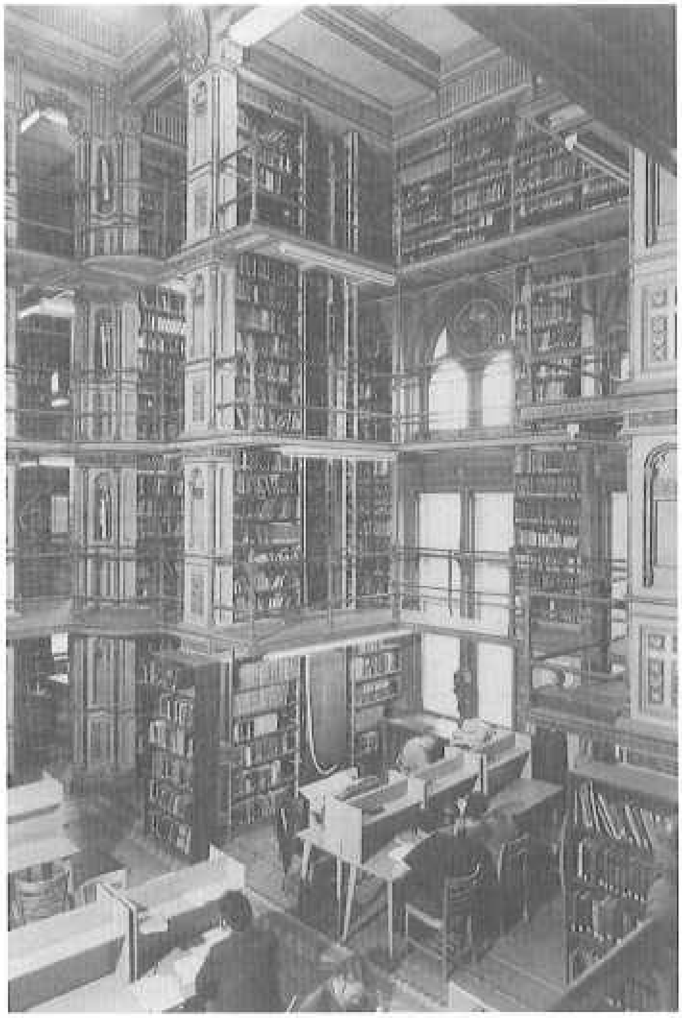
Healy Building
Georgetown University, Washington, D.C.

Georgetown University, founded in 1789, is the oldest Catholic university in America. The first buildings were constructed around the "old quadrangle," as part of Georgetown College. Healy Building was erected under the stewardship of the Rev. Patrick S. Healy, S.J. The north wing is attached to Old North and the south wing to the 1854 Maguire Building, forming a U-shaped complex with protected courtyard.



Interior of cast-iron library, Healy Building at Georgetown University. HABS photograph by J. Alexander and Jack E. Boucher, 1969.

Generally rectangular in plan, Healy Building is 310 feet long with a 200-foot central clock tower and end pavilions. A smaller, secondary spire is located above the stairs on the southwest corner. The width varies from 49 feet to 90 feet. It comprises four stories, plus basement and attic levels, constructed of Potomac blue gneiss with sandstone trim except for the rear (west) elevation in brick. Heating is provided by warm-water coils in the window recesses. Fresh outside air is drawn over them through the hollow cast-iron window sills by draft from the clock tower acting as a ventilating stack. The paired and single round-arched fenestration with ornamental features and shallow corbel course is derived from the Romanesque.

Although the exterior was completed in 1877-79, work on the interior spaces continued for nearly twenty more years. The building houses Gaston Hall, an elaborate auditorium on the third floor that was decorated and completed about 1897; Riggs Memorial Library, 1889; Hirst Reading Room, 1901; and a second-floor reading room, 1909. A number of parlors and offices remain in use, some in largely original condition. Riggs Library at the south end of the building is an outstanding internal space, with four levels (but two true stories) of cast-iron stacks in a foliate Gothic design with an open central atrium. In both design and detail, Riggs is suggestive of the contemporary departmental libraries in the State, War, and Navy Building west of the White House.

Healy Building was designated a National Historic Landmark in 1987. Its architects, John L. Smithmeyer (1832-1903) and Paul J. Peltz (1841-1918) are best known for their design of the Library of Congress's Jefferson Building (1897).

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Industrial Georgetown

Washington, D.C.

Community transformations are nowhere more astounding than in lower Georgetown, today a part of Washington's tony, white-collar business and residential sector but in decades past a steamy, greasy mix of foundries, slaughter houses, machine shops, canal workers' dives, concrete plants, lumber yards, and power plants.

C&O Canal lock into Potomac River, with industrial setting in background, ca. 1910. Courtesy National Museum of American History, Smithsonian Institution.

Georgetown's triangular industrial quarter is described by M (formerly Bridge) Street on the north, the Potomac River to the south, and Rock Creek to the east. Running through the pie slice is the Chesapeake & Ohio Canal. While the uses of Georgetown's smokestack district have changed, the industrial fabric of this dense 20-block area remains largely intact.

Chesapeake & Ohio Canal

Begun in 1824 and completed in 1850, the C&O Canal united the headwaters of the Potomac River with the treasures of the interior, principally coal. Of the 184 miles of canal, the five through Georgetown and immediately to the west remain fully watered today, spring through fall, with three sets of operable locks. Barge traffic ceased with the destructive forces of the Great Flood of 1924, but the canal's economy had been eclipsed from the outset by the simultaneous construction of nearby freight railroads, mainly the Baltimore & Ohio. Today the C&O Canal is a sleepy, mule-drawn reminder of the vagaries of almighty nature and of older industrial transport systems. The best route between the Ohio River valley and the Chesapeake Bay was not the straightest, but the quickest and the most reliable. Thus the railroads won. Yet the C&O Canal lives on as the National Park Service's narrowest park site, a favorite destination for hikers, kayakers, and canal sleuths.

Duvall Foundry

This 1850s brick foundry and machine shop produced fittings for the adjacent C&O Canal and its barges, made building stars for Georgetown houses and businesses, and during the Civil War manufactured arms for the Union forces. The structure became a veterinary hospital for canal mules, a chemical company, a paint manufactory, a coal and feed store, and an artist's studio before its Cinderella-like transformation back to foundry origins as the crown jewel of the Foundry complex of offices, theaters, and shops in 1974. Today, despite the unenlightened 1970s sandblasting of its brick exterior, the Duvall foundry is a pleasant canal-side restaurant and Georgetown meet market.

Duvall Foundry at 1050 30th Street. HABS photograph, 1967.

Godey Lime Kilns

Lime, that noxious but essential ingredient in Washington's monumental masonry architecture, was reduced by burning limestone at several 19th-century Georgetown lime kilns. Only William Godey's 1854 works survive, with ruins of two kilns sleeping beneath elevated freeway ramps at Rock Creek & Potomac Parkway and K Street. At its height, some twenty-five workers received Harpers Ferry limestone off canal and river barges and each week charged five "patent kilns" with enough crushed stone to yield 2,000 barrels of raw lime for local uses before the closure of the site in 1908. The National Park Commission purchased the kilns in the 1930s, yet allowed all but two of them to be demolished in the 1960s for on-ramps to the never-built Potomac Freeway. Foot access to the site is exceedingly hazardous between on-ramps and heavy traffic on the parkway.

Herman Hollerith Machine Shop

In 1897, mining engineer and railway-brake inventor Herman Hollerith developed statistical tabulating machines that used punched holes in cards to count things: people, vegetables, socks, votes. Hollerith cards and machines were used to tabulate the 1890 and 1900 U.S. censuses. From 1892 to 1940 Hollerith's punched-card tabulating machines were built at this factory in Georgetown on the C&O Canal at 31st Street. Today the structure's heavy flooring and thick masonry walls contain private offices. In 1911 Hollerith's Tabulating Machine Company merged with the Dayton Scale Company and the International Time Recording Company to form the Computing-Tabulating-Recording Company. The firm later simplified its name to International Business Machines Company, or IBM.

D.C. Refuse Incinerator

One of the most stately smokestacks still standing in Washington belongs to the D.C. Refuse Incinerator on K Street between 31st Street and Wisconsin Avenue. From 1932 to 1971 this structure burned Washington's rubbish on a steep hillside landscaped by the Olmsted Brothers firm. In Harrison P. Eddy's incinerator, stone ornaments and pointed corbeling in the brickwork tastefully portray up-shooting flames. With refuse burning abolished, this incinerator and its gantry crane reawaken to become the centerpiece of a new development: a Ritz-Carlton boutique hotel, thirty luxury residences, a thirteen-screen theater, and 10,000 square feet of retail space, all generating infinitely more garbage than ever was burned in this facility.

Grace Street Power Plant

Just across the canal from the Capital Transit Maintenance Shops (see below), a former 1850s stable found new life in 1897 as a power-generating plant for the shops; also for the D.C. Paper Mill further down Potomac Street. The increasingly high head available through the canal's elevation above the river at this stage served several water-power sites, with intakes still visible along the south bank of the canal. The Grace Street plant served only the paper mill until both closed in 1950. A 1970s office conversion retains the cathedral windows, the concrete smokestack, and a residue of plant equipment around the grounds, in a facility known as The Power House.

D.C. Paper Mill

One of the biggest industries in Washington employed hundreds in the D.C. Paper Mill at Potomac and K streets to produce high-grade cover stock, blotting paper, boxes, and other necessities for the massive D.C. paper market. Established in 1900, the mill expired by failing to keep pace with the competition's high-speed machinery, but the mill also was constricted by the site, caught between narrow streets, the canal, and the river. The papermaker's backwater became a blessing for others. Today, The Paper Mill condominiums and adjoining office complex tucked into these quiet streets keep the bulk of the mill's heavily built southwest building intact in one of the most sought-after corners of Washington.

Wilkins-Rogers Flour Mill

Access to the canal's water power and commercial markets drew industries to Georgetown's west end, none more so than the Bomford Mill, across Potomac Street from the D.C. Paper Mill. In 1832 Col. George Bomford was first in a string of flour and cotton millers to occupy these premises. The heavy masonry and timber construction of these multi-storied quarters expanded south to K Street with the Wilkins-Rogers Milling Company. Between

1916 and 1977, Wilkins-Rogers ground and bagged Indian Head corn meal, among other milled goods, for regional distribution. The complex remains the oldest mill in Washington. Water-power gearing remains in place in one basement, with the race now the watery centerpiece of a new courtyard around the complex of corporate offices that occupy the mill structures.

One resident recalled his 1850s boyhood and the Georgetown cotton mill "which we were allowed on rare occasions to visit, the intricate machinery of which inspired admiration and astonishment." Next door, at the Dent Ironworks, "the workmen, generally naked to the waist, moved about in the glare of the molten metal." The Dent building also survives intact, but the ironworkers, like their iron, are no more.

Capital Traction Union Station

One of Capital Traction's most ambitious streetcar undertakings sought in 1894 to unite D.C. and Virginia street railways at one union station, located near the Aqueduct Bridge at 36th and M Streets. Architect Waddy Wood designed a grand three-story masonry terminal in glazed brown brick, completed 1897, with a proper terminal tower visible from the opposite bank of the Potomac. Passengers would arrive from Virginia on ground level tracks, ascend to the roof on the tower's elevators, and board Washington streetcars for the completion of their journeys. Alas, the Virginia lines chose not to cross the Potomac. The structure became a car barn and later D.C. Transit's headquarters until the death of D.C. streetcars in the 1960s. Private offices occupy the edifice today, a proud reminder of the real-estate clout once enjoyed by the street railways.

Capital Transit Maintenance Shops

Entering the very swank, four-story Georgetown Park shopping mall at Wisconsin Avenue and M Street, one imagines with difficulty the true origins of this brick building in the very heart of Georgetown. This from 1862 to 1962 held the maintenance shops for Capital Transit vehicles, from the horse drawn to the electric streetcar. The walls of the old M Street Shops retain their original high-fired, iron-laced brick and wrought-iron tie rods with building stars to strengthen the four stories that front the C&O Canal. What once enclosed a full array of car works, from foundry, forge, and machine shops, to woodworking, upholstery, and paint shops, today encloses fashionable clothiers, sushi bars, and cyber toy stores. The existing glass-covered courtyard and hydraulic elevators recall identical features in the original shops.

Whitehurst Elevated Freeway

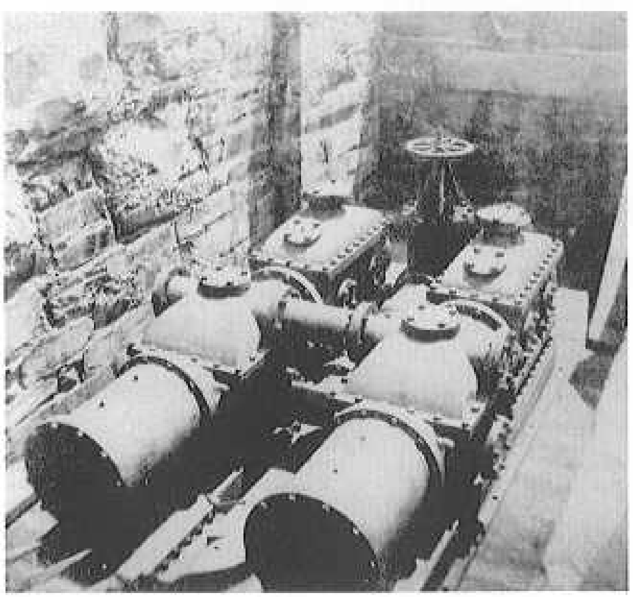
Slicing like a meat cleaver along the southern flank of industrial Georgetown is the riveted steel skyway named bureaucratically after H. C. Whitehurst, D.C. director of highways from 1929 to 1948, and thus one of the few things in the nation's capital not named for a soldier or politician. Several attempts have been made to demolish this Georgetown bypass, but like Chicago's El, the Whitehurst endures, creating its own industrial aura and a shadowy culture of moody restaurants, clubs, and off-beat music halls in the K Street gloom below.

Pennsylvania Avenue Bridge

Spanning Rock Creek and Rock Creek & Potomac Pkwy., Washington, D.C.

Pennsylvania Avenue Bridge, ca. 1870, looking northwest. In addition to Washington's water supply and street traffic, it carried a horse-car line. From a stereograph. Private collection.

After the Cabin John Bridge, this remarkable span of 1858-60 stands as the most interesting and exceptional structure of the Washington Aqueduct, the project to supply the city of Washington with a dependable supply of water. Some would say it is the most interesting. As with literally the entire undertaking, from conception to execution, it was the brainchild of the aqueduct's chief engineer Montgomery C. Meigs of the U.S. Army Corps of Engineers. The problem was to carry the aqueduct's conduit over Rock Creek, which formed the boundary between the newer city and pre-existing Georgetown to the west. Although an inverted siphon under the creek bed would have answered—as it would have at Cabin John—Meigs invariably favored structures that not only were visible, but also were visually and technologically spectacular. We may assume that at this site he chose not to employ a classical masonry arch—as at Cabin John—because of insufficient height between the creek and the surrounding topography, which would have required too flat an arch. His solution was, for the time, both conventional and innovative—a pair of arched, self-supporting, 48-inch cast-iron mains. Cast-iron arch bridges were, of course, nothing new, England's famed Iron Bridge of 1779 having spawned numerous others, mostly also in Britain. In the U.S. only one other iron arch had been built, in 1835, to carry the National Road over Dunlaps Creek in Brownsville, Pa. A modest 85 feet in span, it survives as America's oldest extant cast-iron arch. The Pennsylvania Avenue Bridge is the second oldest and by far the largest.



Worthington pumping engine in west abutment, just after installation in 1859. From a stereograph. Private collection.

Meigs' structure was remarkable for its span length—200 feet (with 20 feet rise)—and the fact that the two arch ribs formed the conduit of the aqueduct. To prevent freezing, these were lined with 3-inch pine staves, leaving a clear waterway of 42 inches. Shortly after completion the structure was turned into a vehicular bridge for Pennsylvania Avenue by supporting the roadway upon a web of cast-iron spandrel struts. The bridge was, surprisingly, not unique. The aqueduct was carried over College Pond near Georgetown University about a mile and a half to the west on a similar pair of arched mains, of 120-foot span, which bore no roadway. These later were buried when the pond was filled in.

The Rock Creek bridge holds further technological interest. In 1859, in the hollow west abutment, there was installed a unique pumping engine, built by the renowned Henry R. Worthington. This pumped water to a high-service reservoir (at the southeast corner of present-day Wisconsin Avenue and R Street) about 100 feet higher than the aqueduct's hydraulic gradient, for the supply of Georgetown. The motive power for the pump was the pressure of the aqueduct water itself, a small portion of which was drawn off for this purpose and then exhausted into the creek, another ration being pumped up the hill to the reservoir. The chamber remains—although not readily accessible—as does the pump itself, now in the collections of the Smithsonian Institution's National Museum of American History (but not on exhibit).

If the arch ribs survive, where are they? Still in place and still carrying water. By about 1910 it had become clear that the bridge—its width only about the 18-foot center-to-center distance of the ribs—was a serious traffic bottleneck. In 1915-16 there was built not exactly a replacement, but … an enhancement? The original roadway and its supporting struts were removed and the arched ribs literally surrounded by the present, wider, granite-sheathed, reinforced-concrete bridge, its span and rise matching those of the arched mains. Thus, the Meigs pipes do actually survive, entombed but partially visible through soffit slots in the new bridge.

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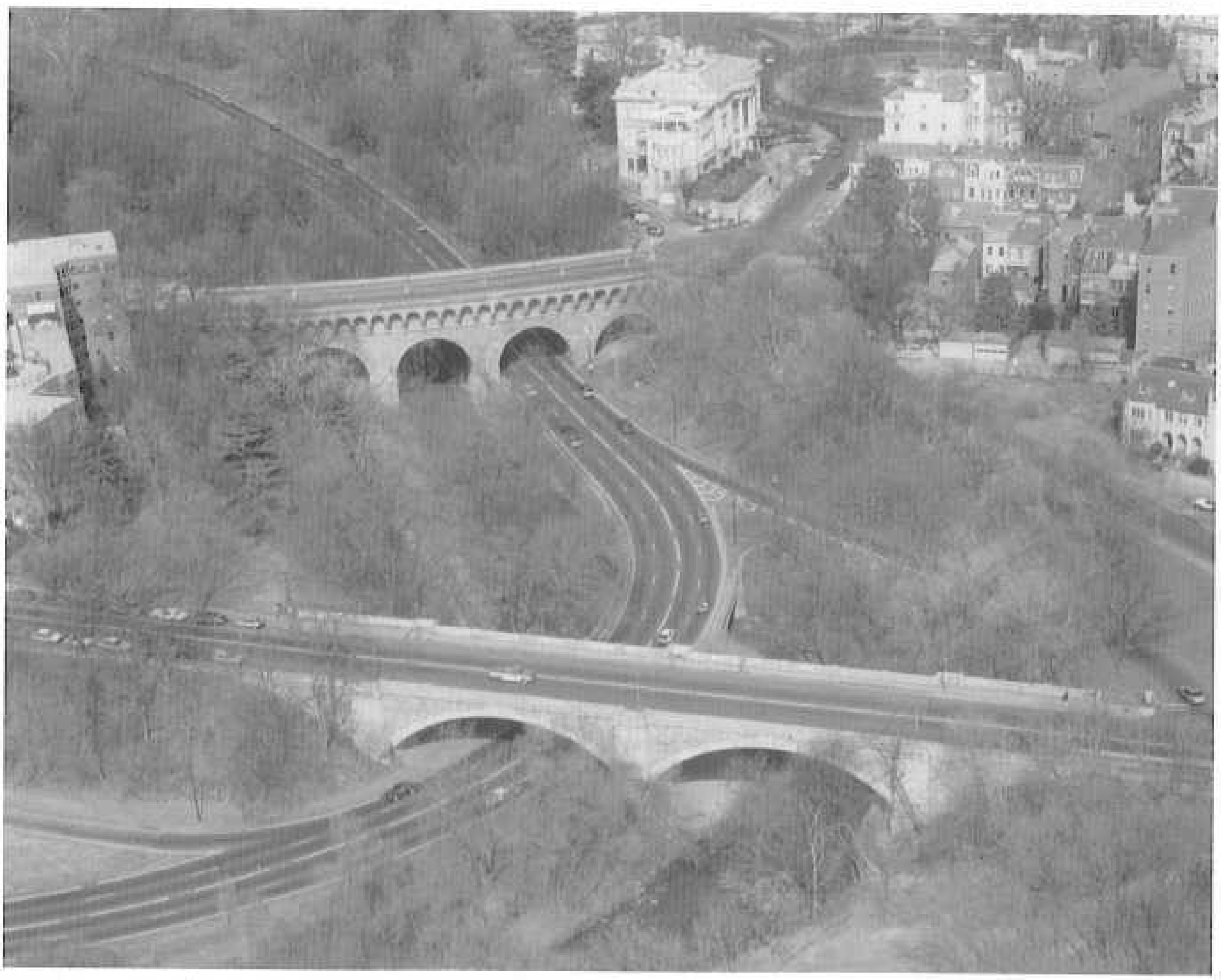
Q Street (Dumbarton) Bridge

Spanning Rock Creek and Rock Creek & Potomac Pkwy., Washington, D.C.

If the Connecticut Avenue Bridge is the longest, highest, and most dramatic span over the Rock Creek valley, the Q Street Bridge is the most evocative and personable—exemplifying the influence of the City Beautiful movement on the capital city. Built in 1915 midway between the Potomac River and the National Zoo, it is one of several east-west creek and valley crossings today. After the Rock Creek & Potomac Parkway Commission was created in 1913 to coordinate the construction of a scenic motor road between the river and Rock Creek Park (established 1890), all the new and rebuilt spans across the park valley were designed to harmonize with the natural setting and complement the driving experience.

The master architect on the project was Glenn Brown, a guiding force in the creation of the McMillan Commission, and prominent in local urban-planning efforts at the turn of the century. Although he designed three bridges for Rock Creek Park, only the Pebble Dash Bridge over Broad Branch was realized. The engineer for the Q Street Bridge was Daniel B. Luten, noted for the structural design of concrete bridges in the early 20th century.



Aerial view of Rock Creek & Potomac Parkway with Q Street Bridge (background) and P Street Bridge (foreground). HABS photograph by Jack E. Boucher, 1992.

Proposals for the Q Street Bridge site included relocating the Woodley Lane Bridge after the Connecticut Avenue Bridge was completed in 1907, or moving the Thompson steel bridge that was near the site of the present Massachusetts Avenue Bridge. This plan was abandoned, and despite the fact the city did not yet own the land west of the creek, plans for the bridge were prepared by 1911. Brown incorporated the ideals of civic art, the relationship of structures within large-scale urban plans, and classical architectural forms into his design. It was an early collaboration among architects, engineers, sculptors, and the newly formed Commission of Fine Arts.

By necessity Brown used a curved bridge form to accommodate different alignments of two sections of Q Street. He and his son Bedford reviewed images of hundreds of bridges around the world for inspiration—especially Roman aqueducts. Brown aimed at redirecting the appearance of future spans; he was impressed by the "possibilities that were presented for the designing of a structure that would perhaps dominate the proposed park improvements in the section of its location." The Connecticut Avenue Bridge set a quality precedent for new bridge construction, and after these two spans were complete, concrete arches became the standard for parkway crossings.

The Q Street structure contains five reinforced-concrete arches on a 12-degree curve. It is approximately 342 feet long and 36 feet wide. The arches rise 75 feet above the road. The multiple-arch elevation was one outcome of the curved plan, however the dominant 43-foot central arch is based on the Roman aqueduct model, with flanking arches and piers that decrease in size. Each arch is composed of stone ribs 12 feet wide, connected by reinforced-concrete walls; steel girders support the Q Street roadbed and the ornamental parapet carrying the sidewalk. The span's vertical highway clearance is 20 feet.

The quoins, abutment walls, balustrade wall, belt course, and carvings are designed to evoke the architecture of Spain and Italy. No pigment was added to the concrete, but a warm, reddish-buff Kingswood sandstone was specified for the ornamental features, and a mixture of different gravels and sands were used to achieve the hue elsewhere. Concrete was tooled to match the cut stone. The spandrels feature bas-relief panels. The most pronounced feature of the bridge is its projecting row of exaggerated concrete corbelling in which steel girders are encased. Along the base of the corbels there is a decorative belt course punctuated by sculpted Native American heads in full headdress that peer down upon passing motorists. The visage is based on a life mask of Sioux Chief Kicking Bear. Internationally known sculptor A. Phimister Proctor designed the bronze buffalos at the entrances to the bridge. At about 7 feet tall, they were the largest statues cast in a single piece at the time, and they gave rise to the popular moniker "Buffalo Bridge." A. L. Guidone & Company of New York City built the bridge under the direction of D. E. McComb, engineer of bridges for the District of Columbia. The cost of the span was approximately $223,500.

Changes include the removal of a concrete median with granite pedestals and street lamps. Six bronze posts were planned for this location, but it is unknown whether these ever were realized. The median was removed in 1938 for reasons of traffic safely, and the lights located on the parapet wall. The plaza at the intersection of Q and 23rd streets, which had been slated for a fountain, was modified as well. The bridge is designated a Category II City Landmark and it is included in the Sheridan-Kalorama Historic District.

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Washington Aqueduct and the City's Water-Distribution System

Washington, D.C., and Suburban Maryland

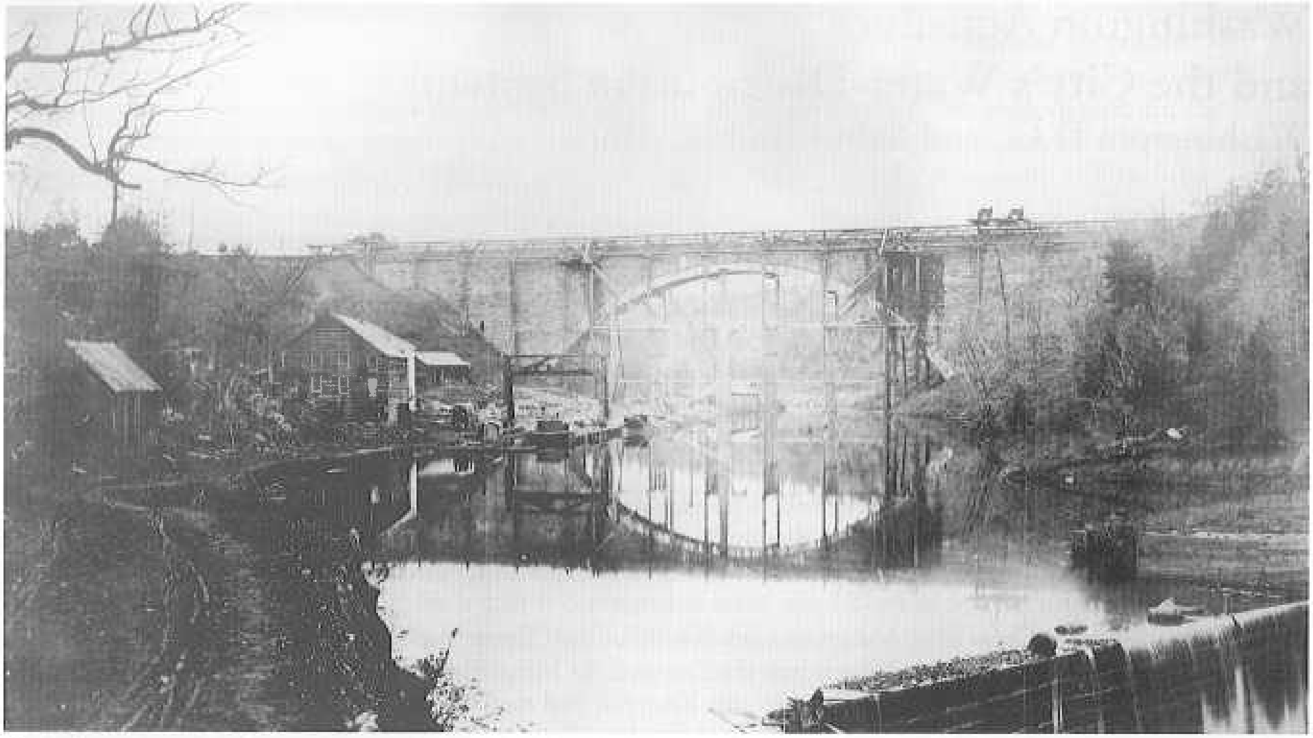
Whereas the first citizens of the District of Columbia were dependent upon springs scattered around the city for their water supply, by the mid-19th century an elaborate scheme composed of reservoirs, aqueducts, thousands of feet of piping, control structures, brick air vents, and a dam was under development. The architect of the new system, Montgomery C. Meigs of the U.S. Army Corps of Engineers, had been ordered in the early 1850s to prepare a report on a rational water-supply system for the city, and subsequently served as chief engineer for the resulting Washington Aqueduct, built predominantly between 1853 and 1863. Many modern components have been added to the system over the years, but a few key elements of the original system still are in active use today.

The collection, purification, and delivery of the water supply to the District remain the responsibility of the Corps of Engineers' supply division known as the Washington Aqueduct. Storing, pumping, and distributing the purified water is the responsibility of the District government's sanitary engineering division.

The aqueduct begins at Great Falls, Md., near Lock No. 20 of the Chesapeake & Ohio Canal, where the original cut-stone diversion dam stretches halfway across the Potomac. As Meigs built the system, water traveled a 9-foot-diameter conduit of brick and stone to the Dalecarlia Reservoir and then on to Georgetown Reservoir, the last point before distribution to the city. Of the six original bridges, three remain visible today—No. 3, Cabin John, and Rock Creek (now the Pennsylvania Avenue Bridge, described in the Georgetown chapter). MacArthur Boulevard, formerly called Conduit Road, covers portions of the pipeline. Bridges No. 1 and 2 were essentially culverts, and No. 5, over College Pond, has been buried. The construction was plagued by inadequate and interrupted congressional funding, difficulty acquiring right-of-way, sickness including malaria, and the outbreak of the Civil War with the resulting shortage of labor and fear of Confederate raids. The system was designed to meet the city's needs for an estimated 200 years, but capacity was reached in less than one-third that time.

C&O Canal just west of Georgetown, ca. 1920. At left is Washington Aqueduct Bridge No. 5, a cast-iron-pipe aqueduct of 120-foot span over College Pond, now buried.

The Dalecarlia and Bryant Street pumping stations disperse water to four major service areas west of the Anacostia River. On the eastern side, in Anacostia, two service areas are supplied by the Anacostia Pumping Station. A slow-sand water-filtration process was added to the system with the building in 1905 of the McMillan Reservoir. In 1928 water quality was further improved by the construction of a rapid-sand filter plant at Dalecarlia Reservoir, which helped eliminate muddy yellow coloration; additional filtration improvements followed. By 1942, concrete lining for cast-iron pipe was the adopted standard.



Cabin John (Aqueduct) Bridge, photographed on "the day when water was first turned on into the Aqueduct," 5 December 1863. Courtesy Washington Aqueduct, U.S. Army Corps of Engineers.

Cabin John Bridge

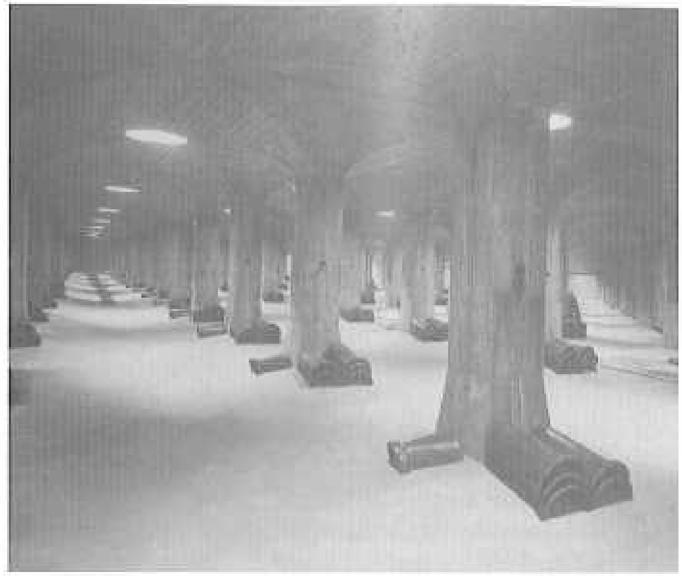
The bridge carrying the Washington Aqueduct across the valley of Cabin John Creek, some 9 miles from the intake at Great Falls, is the most monumental of the project's structures. It was conceived and largely designed by Meigs, with a considerable contribution by one of his assistant engineers, Alfred L. Rives, an American graduate of the Ecole des Ponts et Chaussées in Paris. From its completion in 1863 until 1903, the bridge's 220-foot span held the record as the longest masonry arch in the world. The rise of the arch is 57 feet. The main arch ring, 2 feet thick, is Quincy (Mass.) granite; a secondary ring is formed of radial sandstone voussoirs, added to increase the compressive strength of the main arch. The abutments are of gneiss and the spandrels—their interiors composed of nine arches to reduce the dead load on the arch—are of Seneca sandstone, quarried nearby (see the Smithsonian Institution "Castle" entry). The 9-foot-diameter brick-lined conduit passing above the arch crown leaked badly from nearly the beginning, in winter causing massive icicles to descend from the arch. The problem was solved in 1912 by insertion of a cast-iron lining. Seneca-stone parapets were added to the 20-foot deck in 1872 to accommodate road traffic. Historians have speculated as to why Meigs elected to cross the valley by this colossal and conspicuous construction rather than an inverted siphon, a then well-known technology for carrying an aqueduct down one side of a topographical depression and up the other. That is, in fact, the means by which a later, parallel, supplementary aqueduct traverses this valley. It generally has been concluded that it was the bridge's very visibility that drove Meigs' decision, his wish to erect a record-breaking and spectacular monument to the Washington Aqueduct and just possibly himself.

Dalecarlia Reservoir and Water Treatment Plant

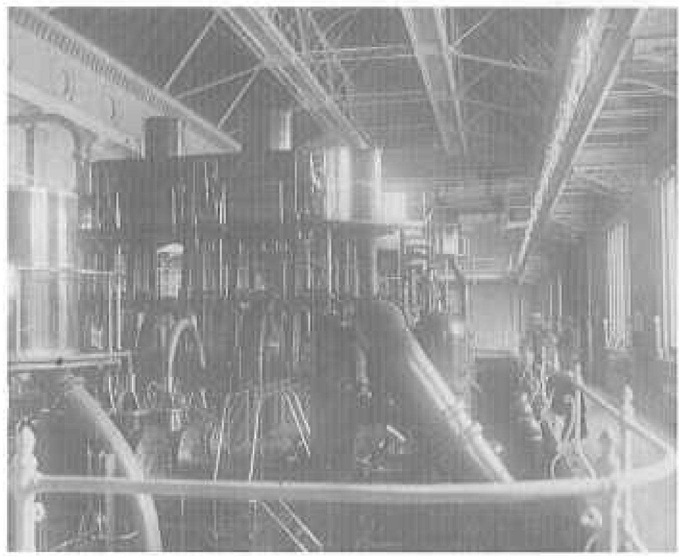
Dalecarlia Reservoir was the first reservoir built as part of the city's aqueduct system, and has a holding capacity of about 41 million gallons over 46 acres. In 1928, a rapid-sand filtration plant was added to treat the raw water from the reservoir. This plant contains thirty-six rapid-sand filter beds, with a capacity of 4 million to 6 million gallons of water per filter per day. Both sand and crushed anthracite coal are used as filter media. The Dalecarlia filter plant was designed in an "American Colonial" style of architecture, with different hues of red brick, a slate roof, and contrasting white woodwork. The Dalecarlia complex also contains a pumping station, in which fifteen vertical-shaft, electric centrifugal pumps supply filtered water to several high-service areas.

Georgetown Reservoir

Water from the Dalecarlia Reservoir flows to the Georgetown Reservoir, a sedimentation and storage reservoir with a capacity of 55 million gallons of water over 42 acres. The Georgetown Reservoir originally was the final treatment facility, but is now used as a sedimentation basin for water destined for the McMillan Filter Plant. The Georgetown Reservoir is also noted for a pipe vault that contains a circular staircase with the name "M. C. Meigs" cast in every riser, and a gatehouse constructed in the castle-shape of the Corps of Engineers' insignia.



Underground slow-sand filter at McMillan Reservoir (above); Bryant Street Pumping Station interior, ca. 1905 (below). Both courtesy National Museum of American History, Smithsonian Institution.



McMillan Reservoir

The reservoir in McMillan Park was completed in 1901, and with a capacity of 100 million gallons gave the Washington Aqueduct system a greatly enlarged storage capacity. A pumping station lifted water from the reservoir to an adjacent water treatment plant, completed in 1905. The McMillan Water Treatment Plant, no longer in use, was a product of the City Beautiful Movement and a Washington public-health milestone. Water passed through twenty-nine slow-sand filter beds, each one acre in size. The complex also includes concrete sand bins, regulator houses, and administration and maintenance buildings.

Bryant Street Pumping Station

Built in 1904, the Bryant Street Pumping Station moved water from the new McMillan Reservoir to high-service areas in the city. Located in the basement is an interesting collection of early pipes, valves, fountains, hydrants, and other artifacts connected with the city's water system that have been saved over the years by aqueduct personnel.

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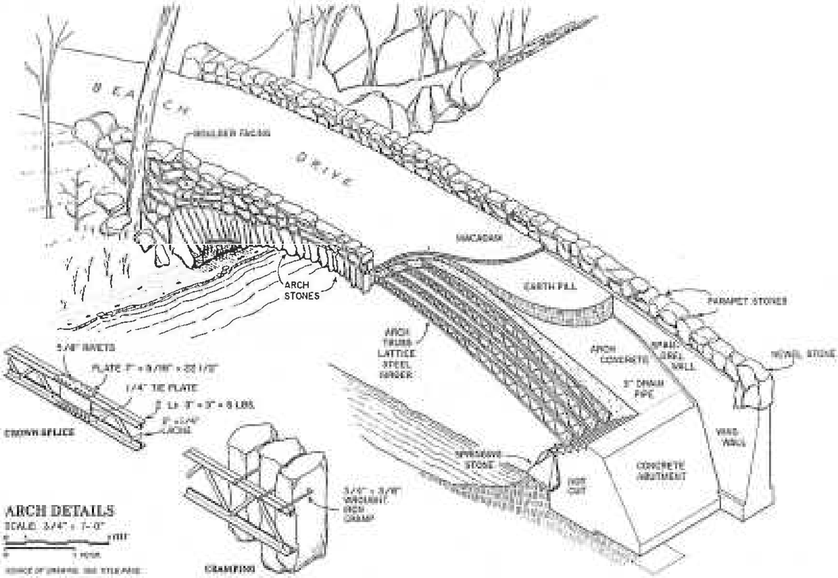
Boulder Bridge

Spanning Rock Creek at Beach Drive, Washington, D.C.



Boulder Bridge, cutaway. From HAER drawing by Elaine Pierce, 1995.

Boulder Bridge, built in 1901-02 and one of the earliest extant spans in Rock Creek Park (established 1890), exemplifies the rustic design common to early-20th-century parks—but a style rarely found in the national capital. It is located on what now is Beach Drive, the first road legislated to traverse the length of the park, which winds alongside and eventually crosses Rock Creek. It is the primary route through the park today.

The primitive, scenic drive required motorists to ford the creek at several locations because only four bridges were constructed in the park between 1898 and 1900. Boulder Bridge is one of two spans erected at the time. Col. Lansing H. Beach, Secretary of the Board of Control of Rock Creek Park, is credited with the design of the boulder-faced, Melan-arch bridge—one of the first in the park to be both functional and aesthetically pleasing. Engineer Walter J. Douglas, District Bridge Commissioner, approved the design. A royalty was paid for the use of Melan's patented system. Contractors Talty & Allen of Washington, D.C., constructed the bridge.

Although it was first conceived that the bridge could be constructed completely of boulders, the expense of this approach dictated that it would simply be clad with boulders resembling those in the nearby creek bed. Douglas specified the sought-after appearance and objective of the material:

> The term boulder stones here is meant to cover loose rock which shall be hard, sound, durable and of a quality to be approved by the Engineer, whose edges have become weathered or water-worn, or both and are more or less rounded. It is the intention to obtain a decidedly rustic effect on the facing, and to that end extreme care must be taken in the selection of the stones, and only mechanics who show an aptitude for this class of work shall be employed.

The cladding boulders were hauled in from four to six miles away, and particular care was taken in acquiring the spring and newel stones. The bridge measures 130 feet long overall. The single segmental arch spans 80 feet with a 12-foot rise. The distance between parapets is 23 feet. The poured-concrete abutments support arch-truss lattice steel girders embedded in concrete, with the parapet stones affixed to the outermost girders by wrought-iron clamps. To enhance the audible and visual effects of the picturesque setting, the project included the construction of a concrete dam that created a cascade of water over ornamental boulders between it and the bridge downstream.

Source

Marcia M. Miller, HAER No. DC-12, "Boulder Bridge," 1988.

Washington National Cathedral
(Cathedral Church of Saint Peter and Saint Paul)
Washington, D.C.

Although it took more than eighty years to build the Washington National Cathedral—a snap by medieval standards but downright sluggish for any other 20th-century structure—its conception dates to the 200-year-old plan for the city of Washington. Completed in 1990, the Neo-Gothic Episcopalian cathedral is modeled on 14th-century English and French examples, and was constructed using traditional building methods. Today it is the sixth-largest cathedral in the world, the second largest in the United States.

The Latin cross plan is 514 feet long and features a nine-bay nave with side aisles and five-bay chancel that is intersected by a six-bay, 215-foot transept. At the crossing is the *Gloria in Excelsis* tower, whose four pinnacles are the highest points in the city, reaching 301 feet. The primary building material is gray Indiana limestone, with some concrete and structural steel used sparingly. Flying buttresses brace the upper walls of the exterior. Like centuries-old European cathedrals, this one abounds in architectural sculpture, wood carving, leaded glass (more than two hundred stained-glass windows), mosaics, artistic metal work, and many other works of art. Most decorative elements have Christian symbolism or are memorials to famous persons or events. Sculptors designed most of the interior work, which then was carved by craftsmen; but on the exterior, the carvers have had more artistic license, as is the tradition. The result is many capitals, gargoyles, and smaller figures that are personalized, whimsical, and American in spirit.

The carillon is composed of fifty-three bells that weigh from 15 pounds to 12 tons (note G). It first rang in 1964; it also is the only church in the world with both peal bells (rung by pulling a rope) and a carillon (set of bells controlled by a keyboard and pedals) in the same tower. The John Taylor Company of Loughborough, England, cast the bells of the carillon, which has a four-octave range and is twice the size of most instruments of its kind. The largest, the Bourdon, is big enough to hold a table and chairs for four. A weighted wire connects each bell clapper to the corresponding key; clappers of the heavier bells are connected to foot pedals. The harder the key or pedal is struck, the louder the sound of the bell. The peal bells are by Mears & Stainbank Company of London, the firm that cast the original American Liberty Bell.


Aerial view of the cathedral under construction. Courtesy Washington National Cathedral.

The proposal for a national cathedral dates from 1792, when Pierre

L'Enfant's plan of the Federal City identified land for a "great church for national purposes," now the location of the U.S. Patent Office-turned-National Portrait Gallery. Plans to build the cathedral were renewed in 1891, and shortly thereafter Congress granted the Protestant Episcopal Cathedral Foundation of the District of Columbia a charter to erect the building on Mount Saint Albans in the northwest quadrant of the city. Frederick Bodley (d. 1907), England's leading Anglican church architect, headed the design team, with Henry Vaughan (d. 1917) as supervising architect. Construction began in 1907 and paused during World Wars I and II, the Depression years, and around 1976. American architect Philip Hubert Frohman (1887-1972) took over the design of the cathedral after the deaths of his predecessors, made some design modifications, and after fifty years in this position he is considered the cathedral's principal architect. He was succeeded in 1971 by Anthony J. Segreti and Robert C. Smith.

The 71,000-square-foot building can accommodate 27,000 standing, 7,500 seated. The building has functioned as a church since 1912. Other structures and functions within the cathedral complex include four schools for girls, boys, and clergy, but the cathedral has no affiliated congregation.

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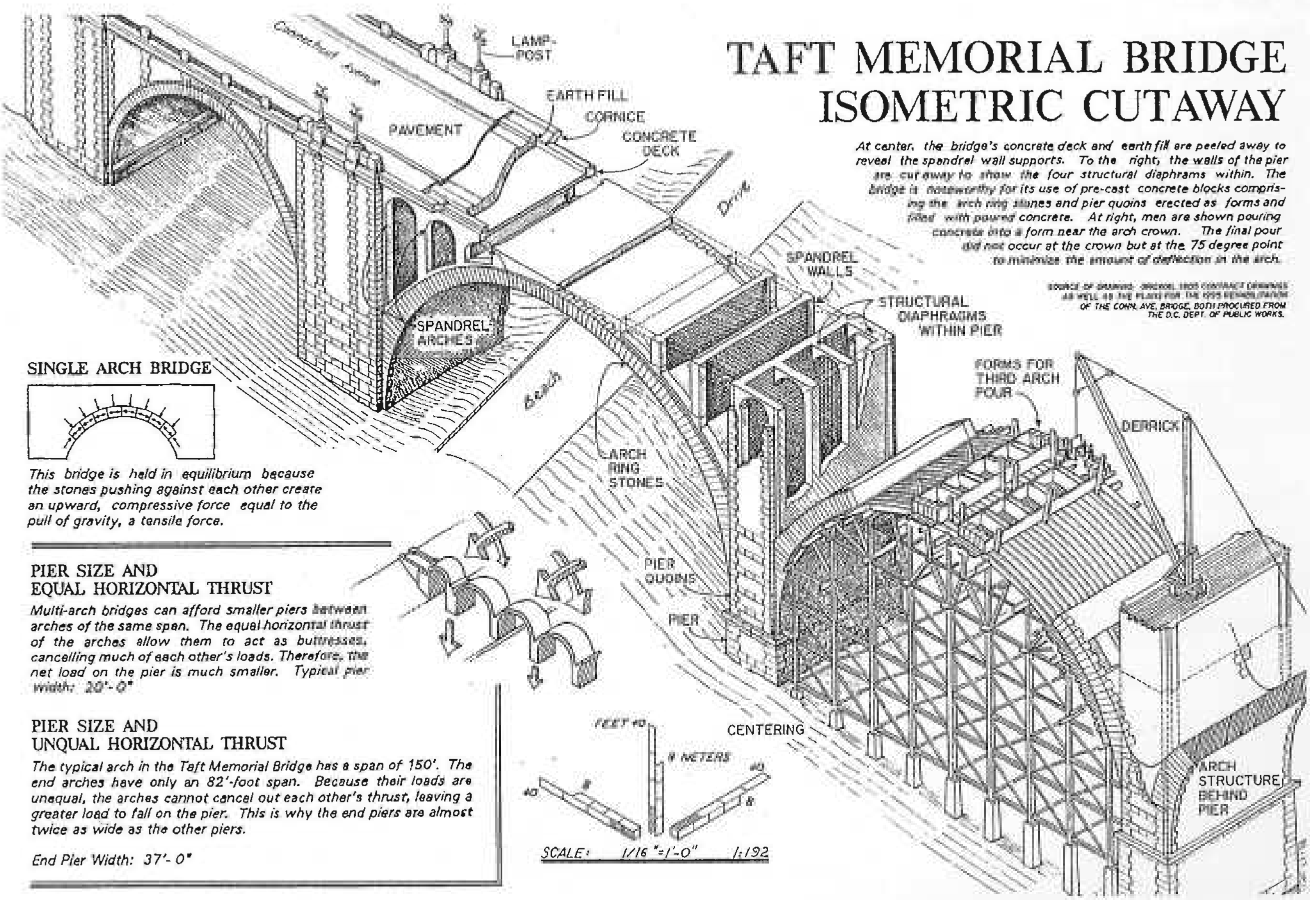
Connecticut Avenue Bridge
(William Howard Taft Memorial Bridge)
Spanning Rock Creek and Beach Drive, Washington, D.C.

The Connecticut Avenue Bridge carries one of the city's most important and elegant avenues across the deepest section of Rock Creek valley, and is the grandest of the unique spans that cross above Rock Creek. The 1,341-foot-long bridge crosses 125 feet above the creek, with a 50-foot highway clearance. Beach Drive and Cathedral Avenue, as well as the meandering creek for which the urban refuge is named, pass through its lofty arches. At the time the bridge was built, 1897-1907, it was considered the largest concrete-arch bridge in the world. Thanks to its soaring price tag of $846,331, it also was dubbed the "Million Dollar Bridge."

Engineer George S. Morison (1842-1903) designed the seven-arch bridge, composed entirely of monolithic concrete and molded concrete block. Morison already was a nationally recognized civil engineer by the time of the competition. He had designed several railroad truss bridges over the Missouri and Mississippi rivers and competed for the Arlington Memorial Bridge commission in 1900. Edward P. Casey (1864-1940), whose career centered on Washington and government architecture, was consulting architect on the project. The bridge fell under the auspices of the D.C. Bridge Division and engineer Walter J. Douglas.

When the Connecticut Avenue Bridge was first proposed, this area was served by the iron deck-truss Woodley Lane Bridge, a five-arch span less than 10 years old but increasingly inadequate to carry local traffic.
A competition was held to determine the span, as stipulated by Congress in its 1897 authorization for the



Connecticut Avenue Bridge, isometric cutaway showing construction procedure. HAER drawing by Ann Wheaton, 1995.

construction of a viaduct or bridge across the extension of Connecticut Avenue. Designs were solicited from Morison, best known as a railroad bridge designer, as well as L. L. Buck and W. H. Breithaupt. Morison was the only man to submit a design for an all-concrete bridge. Other entries included at least steel reinforcement and usually steel arches. Morison's concrete design, at $675,000, was not the least expensive, but he won the first prize of $600.

> The principal considerations leading to this decision were that the proposed bridge, being so conspicuously located on a fine residence avenue and in full view of a large area within which was the National Zoological Park, should be of a monumental character, and the masonry type above all others fulfilled this condition, as well as that of suitability.

An appropriation of $250,000 was proposed to commence construction of abutments, foundations, and piers, but subsequent lapses in funding and escalating costs contributed to the protracted period of construction. The foundations were undertaken by Cranford Paving Company; the arch pilings, constructed in 1904, were sunk to depths of 20 to 40 feet. Approximately 50,000 cubic feet of concrete was used to make the precast concrete blocks of the arches. Aggregate stone was quarried on site for the concrete quoins, moldings, balusters, and arch rings. Powdered gneiss was used to create the gray tones and sand helped produce the buff color of the elevations. Because no steel reinforcement was used, an immense amount of timber falsework was employed. The superstructure was completed in 1907. "Nowhere else has there been an attempt to build so great a number of arches, or arches of such size, entirely of concrete and without the provision of any steel framing as a support for the mass," reported the *American Exporter* in 1908.

The bridge has seven full-center arches: five 150 feet wide and two 82 feet wide. Six full-center 14-foot-wide spandrel openings are located above each main arch, supported by transverse piers 3 feet thick. The end piers are 37 feet thick. Sculptor Ernest C. Baristow designed the twenty-eight single and paired eagle-topped columnar light fixtures, which were cast at the J. L. Mott Iron Works in New York. The 25-foot-tall lights cost $1,000 each. The beloved cast-concrete lion sculptures at the termini are by Roland Hinton Perry (1870-1941).

Twice, in 1911 and 1934, it was proposed that a streetcar line cross the bridge, but both times it was opposed on aesthetic grounds to "prevent the mutilation of Taft Bridge." The span was rededicated as the William Howard Taft Bridge in 1931 because the former president lived nearby and frequently walked across it. The original roadway was 35 feet wide, but in 1936 it was widened to 40 feet with 5-foot 6-inch sidewalks. The lions were restored in 1965, and plans to install 8-foot suicide-prevention fences along the handrail in the 1980s were quashed after their appearance on the Calvert Street Bridge was so appalling.

This is Morison's only capital city bridge and it was his last anywhere. This structure is not to be confused with a second Connecticut Avenue Bridge, 1930-32, by architect Paul Cret, built further north across Klingle Valley in the western arm of Rock Creek Park.

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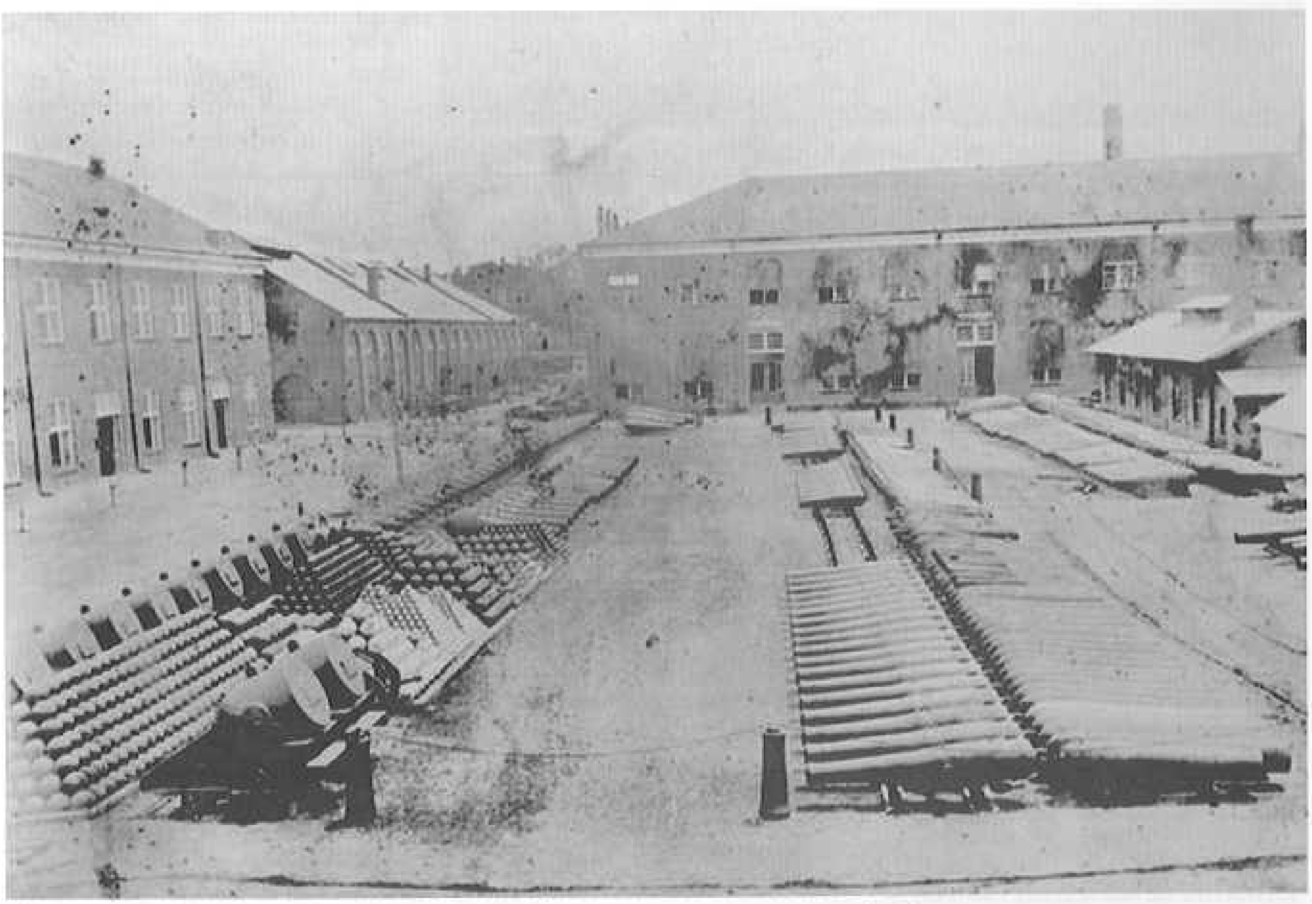
Amy Ross, HAER No. DC-27, "Connecticut Avenue [over Klingle Valley] Bridge," 1992.

U.S. Navy Yard
Washington, D.C.

The capital city's naval yard dates to 1799 when Secretary of the Navy Benjamin Stoddert appropriated $1.05 million for the construction of ships and dry docks a year after the formation of the Navy Department, amid the undeclared war with France. Over the next 150 years it was a hub of governmental ordnance research and development, a role that diminished only as the need for larger facilities and a deep-water port increased. Today the 42-acre historic district contains numerous industrial buildings and a museum.

During the early 19th century, important figures worked at this facility: Robert Fulton tested torpedoes here; Commodore John Rodgers built the first marine railway; John P. Holland demonstrated the practicality of the submarine; and John A. Dahlgren improved cannon technology. From 1805 to 1814, the yard produced ships and manufactured equipment that made it "the chief manufacturing establishment in the city" at the time. Damaged in the War of 1812 and rebuilt, the Navy Yard grew beyond its initial role to become an important ordnance center. Dahlgren, who headed rocket manufacturing, "built the Navy Yard from the primitive shop he found on his arrival in 1847 to a complete research and development center." During the Civil War it became all the more critical after the Confederates occupied the Norfolk Navy Yard.

In 1896 Congress appropriated $100,000 to build a "Model Tank for Experiments" at the Navy Yard, an undertaking that was lobbied for by naval architect and engineer David Watson Taylor (1864-1940). Taylor was responsible for designing and overseeing the construction of the state-of-the-art Experimental Model Basin (EMB) and for the next fifteen years was in charge of its operations. Its carriage, powered by four 450-horsepower motors,



Ordnance at the Washington Navy Yard, ca. 1866. Brady & Company photograph in HABS Collection.

towed ship models and carried photographic equipment. A brick building housed the basin, which was 14 feet deep, 42 feet wide, 470 feet long, and held 1 million gallons of water. By the early 20th century, the basin no longer could meet current technological requirements and it was superceded in 1940 by the David Taylor Model Basin in Carderock, Md. (see Suburban Maryland chapter). Among the achievements at the Navy Yard were improvements in propeller research, the bulbous bow design, ventilating fans, and naval aviation.

Specializing in large-gun production, by 1898 the facility was considered the "most modern ordnance plant in the world." The yard functioned at peak capacity during World War I and through the 1930s as the fleet was strengthened. The yard's role during World War II was largely as a research and repair center, when its name was changed to the U.S. Naval Gun Factory. In 1962 the factory closed, but the Navy Yard continues to serve as an administrative center.

Among the extant buildings and structures are the main gate by Benjamin Henry Latrobe (1764-1820), also architect of the master plan for the facility; the copper rolling mill (No. 46); the breech-mechanism shop and adjoining buildings (Nos. 40, 44, 76); the model basin (No. 70); the marine railway (structure No. 308) built in 1823, rebuilt in 1855; the optical tower, 1918-19; and multiple residences, offices, barracks, and other industrial buildings.

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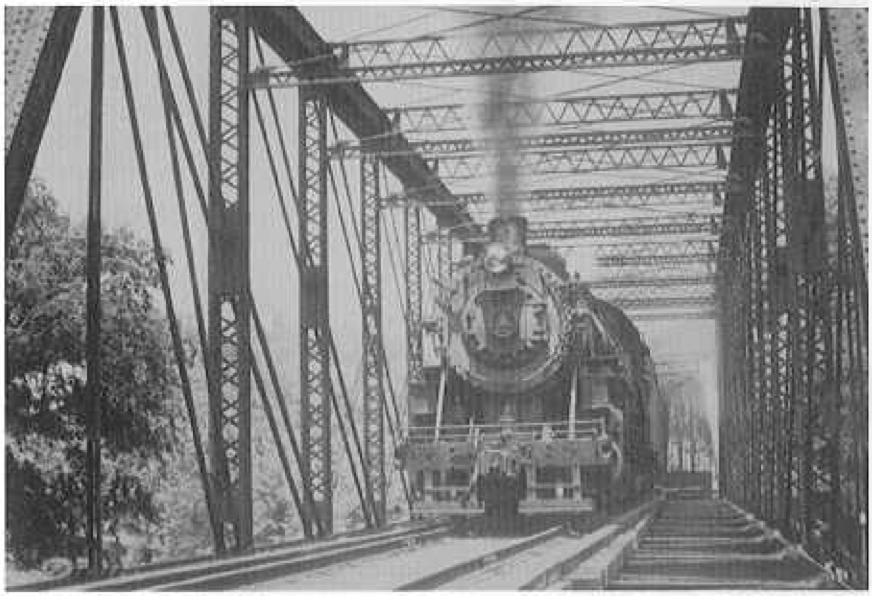
Georgetown Branch, Baltimore & Ohio Railroad
(Capital Crescent Trail)
Between Silver Spring, Md., and Washington, D.C.

The Georgetown Branch is the extant remains of a partially realized attempt by the Baltimore & Ohio Railroad to run a new line in competition with the Pennsylvania Railroad to connect North and South across the Potomac River in the 1890s. While the river crossing never was built, mainly due to the 1906 construction of the Potomac Yard in Alexandria, Va., the Georgetown Branch was completed in 1910. It operated until 1985 as a low-volume branch line connecting with the B&O's Metropolitan Branch at Silver Spring principally to serve coal-fired power plants in Georgetown. After decommissioning by B&O successor CSX in 1986, the right-of-way became a nationally known "rails-to-trails" project. After a decade-long fight by the Coalition for the Capital Crescent Trail, the National Park Service and Montgomery County joined together to build a state-of-the-art bike trail.



B&O locomotive crossing Bridge No. 18 over the C&O Canal near Arizona Avenue, ca. 1946. Courtesy William Duvall, Coalition for the Capital Crescent Trail.

The B&O began construction of the line in 1892, laying two miles from Silver Spring Junction to Chevy Chase, Md. This portion included the Rock Creek Trestle, originally 1,400 feet long. The timber trestle was rebuilt three times, but today remains in derelict condition due to vandalism by arson. Because of financial difficulties, work did not resume on the branch until 1909. The line continued through the nascent village of Bethesda through a cut beneath modern-day Wisconsin Avenue. When Bethesda real estate boomed in the postwar era, a deal allowed the commercial Air Rights Building to be constructed over the air rights of the railroad. Today, the trail runs uninterrupted through the Air Rights Tunnel, reopened in 1998.

From Bethesda, the line continued ten miles to Georgetown. Remaining obstacles to be surmounted included boring beneath the Washington Aqueduct pipelines under Conduit Road (now MacArthur Boulevard). A 341-foot brick-lined tunnel was dug, complete with handsome brick portals and "Dalecarlia, 1910" outlined in brick relief. The line then passed through the Dalecarlia Reservoir property, over the D.C. line, and crossed the C&O Canal near Arizona Avenue. Here the B&O erected Bridge No. 18, built of two dissimilar spans: the span over the canal is an eleven-panel double-intersection Pratt through truss 187 feet long and 30 feet deep, while the road span is a five-panel Pratt through truss 103 feet long by 21 feet deep. Both are 28 feet wide, forming a 321-foot-long crossing. While traditionally pin-connected, they are distinct as two of only three remaining through trusses inside the Beltway. After this bridge, the line then ran alongside the canal the remaining two miles to Georgetown. Here it served the Capital Traction Company's power house from 1912 to 1933. The last customer of the line remained the General Services Administration's Georgetown heating plant on 26th Street, which received its last rail-transported load of coal in 1985.

While a relatively minor line compared to the busy Northeast Corridor, the Georgetown Branch has an interesting history. In a curious twist of railroad management, the modest branch line was carried on the B&O books as two

A B&O diesel locomotive emerges from the brick portal of the Dalecarlia Tunnel under CSX ownership, ca. 1975. Photo courtesy William Duvall, Coalition for the Capital Crescent Trail.

separate and distinct railroads. The 6.7-mile section between Silver Spring and the south end of the Dalecarlia Tunnel at the District line was formally the Metropolitan Southern Railroad, while the 3.7-mile piece between Dalecarlia and Georgetown bore the imposing title the Washington & Western Maryland Railroad. The line was extended across lower Rock Creek in 1914 to haul limestone for the construction of the Lincoln Memorial. In 1981, the Smithsonian Institution fired up the historic *John Bull* steam locomotive of 1831 and ran it along the Georgetown Branch between Georgetown and Bridge No. 18. A video of this sesquicentennial venture can be viewed near the *John Bull* himself, at the National Museum of American History, in the "Engines of Change" exhibition.

Today all these engineering features are part of the popular Capital Crescent Trail, which was successfully developed following a ten-year struggle by trail activists. Dedicated in 1996 after completion of the River Road footbridge, the Trail was extended further east when the Air Rights Tunnel through Bethesda was reopened in 1998. Ironically, it is the debate over reusing the right-of-way as a commuter rail line that has halted the continuation of the trail to Silver Spring. But plans are on the drawing board to restore the Rock Creek Trestle and continue a rail trail along the Metropolitan Branch between Silver Spring and Union Station, completing D.C.'s own "Bicycle Beltway."

Sources

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David Taylor Model Basin
(Naval Surface Warfare Center at Carderock)
Carderock, Md.

The U.S. Navy Department's David Taylor Model Basin, 1937-40, is one of the largest such testing facilities in the world, and it has been instrumental in the development of naval architecture for the Navy, Coast Guard, and Maritime Administration. Designated a Historic Mechanical Engineering Landmark by the American Society of Mechanical Engineers, the facility represents the second generation of vessel-testing experimentation—after the earlier towing tank at the historic U.S. Navy Yard.

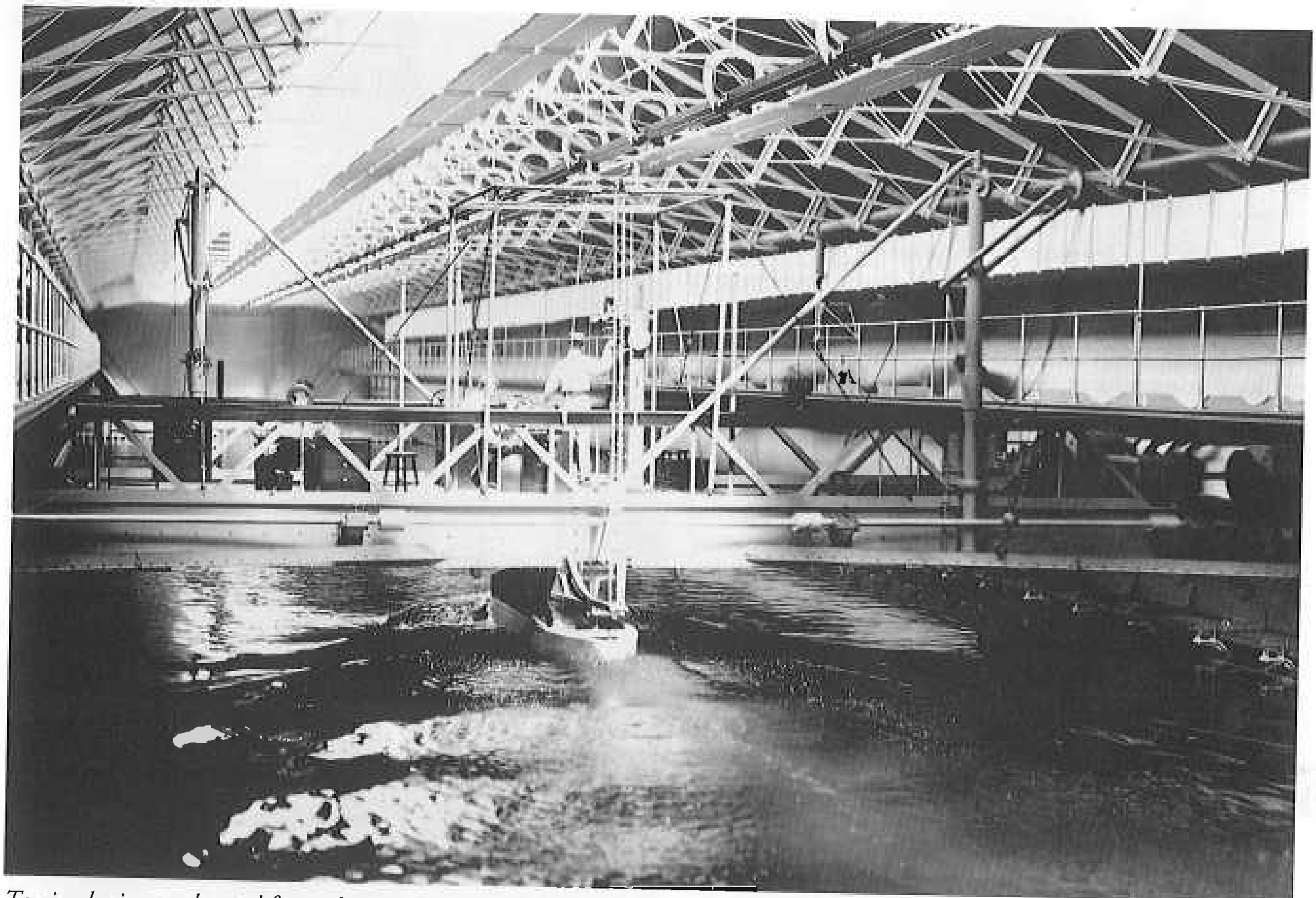
Before any naval or merchant vessels are developed, scale models are built and tested under conditions that measure their performance. The Navy's Bureau of Construction and Repair identified several specifications to be met by the design of the new facility, including: property large enough to double the work area, "a group of individual model basins, each designed to accomplish specific functions," and basins in which a model could be towed for 8 seconds at constant velocity. Of a practical nature, two other criteria were a supply of fresh water to fill the basins, and an unyielding foundation upon which to build them.

The basin walls are concrete set on bedrock for stability. The railroad rails mounted on their walls to carry the towing carriages follow the curvature of the earth rather than a true straight line. Towing Carriage No. 1, a triangular structure with fourteen wheels, serves the deep- and shallow-water basins as well as a J-shaped turning basin, which adjoin one another. The building that encloses the three primary basins is 3,200 feet long, covered with a reinforced-concrete-arch roof spanning 110 feet. The carriages are powered by electric or electro-hydraulic drive systems with regenerative braking.

Basin	Length (feet)	Width (feet)	Depth (feet)	Volume (cubic feet)	Wavemaking		Towing Carriage Speed (knots)
					Length (feet)	Height (feet)	
Shallow Water	303	51	0 - 10	—	—	—	18
Deep Water	1,886	51	22	15,820,000	5 - 40	4 - 24	20
High Speed	2,968	21	10 - 16	6,310,000	3 - 40	2.5 - 24	>50

The deep-water basin is used to test models of large vessels; the shallow-water basin is for tugboats, barges, and river craft; the high-speed basin for motor and patrol boats, and similar craft; and the small model basin is used to test unusual research problems and special models. Tests include hydrodynamic force, wake surveys, propeller characterizations, resistance, and self-propulsion. Among the feats of this facility have been the development of submarine hull forms that permitted higher underwater speeds than World War II-era machines, technical improvements that resulted in the nuclear-powered SSN 585 SKIPJACK class, highly skewed propellers, and the Small Waterplane Twin Hull (SWATH) ship concept. Also on the premises are the Circulating Water Channel, Rotating Arm, and Maneuvering and Seakeeping basins, the shop where scale models of all Navy ships and submarines (up to 40 feet long) are built for testing, the Ship Materials Technology Center, deep submergence pressure tanks, and wind and water tunnels.

The facility is named for David Watson Taylor (1864-1940), the naval architect and engineer who designed and oversaw the construction in 1896 of the first facility of its kind, the Washington Navy Yard's Experimental Model Basin. By the 1930s this facility had become antiquated, and after much lobbying the Carderock facility was built and dedicated to by-then Rear Admiral Taylor, who attended the ceremony. It is currently part of the Naval Ship Systems Engineering Station headquartered in Philadelphia.



Towing basins can be used for traditional Froude-scaled ship model resistance, self-propulsion, and flow-measurement experiments. The towing carriages may be used for a variety of unusual experiments, including towing of fishing nets, calibration of current meters, as a control station for remotely operated vehicles, and assessing stability of towed bodies. Courtesy David Taylor Model Basin.

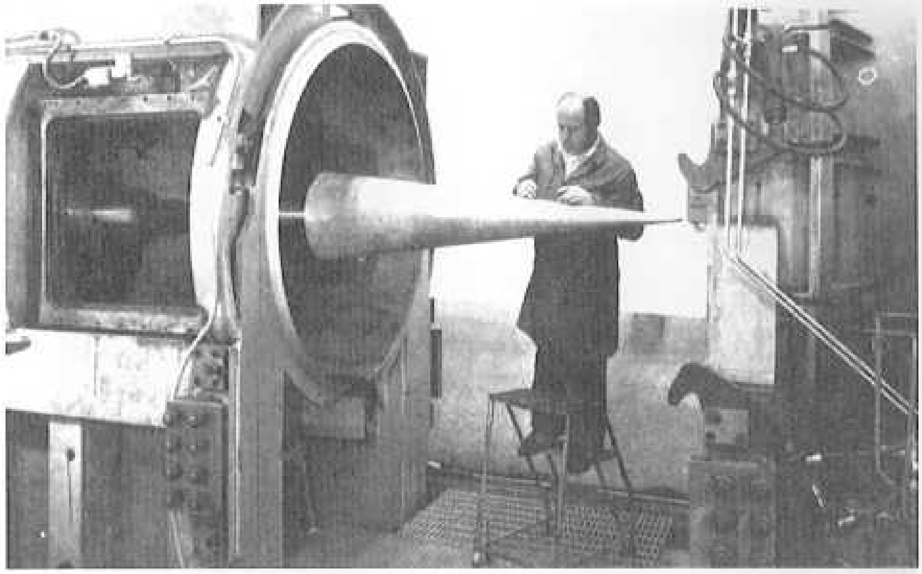
Sources

American Society of Mechanical Engineers, "The David Taylor Model Basin, a Historic Mechanical Engineering Landmark," 30 January 1998.

David Taylor Model Basin web site at http://www50.dt.navy.mil/facilities/Carriages.html

Naval Ordnance Laboratory
(White Oak Naval Weapons Center)
Silver Spring, Md.

The former Naval Ordnance Laboratory (NOL) was established in 1944 as the site of U.S. Navy research on guns and explosives, a mission later extended to torpedoes, mines, and projectiles until its mandated closure in 1997. Currently owned by the General Services Administration (GSA) and the U.S. Army, the approximately 700-acre property is considered a hazardous clean-up site slated for redevelopment. The research facility has also been recognized as historically significant for its association with the first generation of Cold War-era defense weapons.



Hypersonic Wind Tunnel No. 9, built 1967; seen here in operation, 1975. Courtesy Naval Surface Warfare Center, Dahlgren Division.

The facility housing the initial "Naval Ordnance Laboratory," so named in 1929, was located at Washington Navy Yard—the marriage of the 1919 Mine Building and the Experimental Ammunition Unit. In 1946 it moved to the Silver Spring-based White Oak facility. The mission of the new laboratory was to further the pursuit of a "vigorous and active policy in research and in the translation of knowledge gained in the fields of abstract science to that of practical application in the Naval profession," according Secretary of the Navy James Forrestal. "In other words, a new weapon of war can here be conceived, developed, tested, and refined to a point where it becomes susceptible to quantity production."

The NOL represented technical competence in mine design, underwater acoustics, nuclear weapon safety and effects, aerodynamics, hydroballistics, warhead design, ship-protection systems, and explosive materials research that reverberated through the military community and private sectors during the Cold War and active conflicts.

In 1974 the facility merged with the Naval Weapons Laboratory of Dahlgren, Va., into the Naval Surface Weapons Center. At this time the facility continued Naval research on surface warfare systems, ordnance technology and strategic systems, included metal plating, degreasing, solvent cleaning, sandblasting, printing, pest control, and deloading and demilitarization of ordnance. In 1997 the White Oak facility closed as a result of the 1995 Base Realignment and Closure (BRAC) decision.

As of 1998, about 662 acres were transferred to GSA, the balance to the Army. The site currently encompasses 212 structures, many of which are not cost-effective to rehabilitate and will be demolished. An environmental clean-up is targeting volatile and semi-volatile organic compounds, metals, PCBs, explosives, and radioactive material.

Source

William B. Anspacher et al., *The Legacy of White Oak Laboratory* (Dahlgren, Va.: Naval Surface Warfare Center, Dahlgren Division, 2000).

Paul E. Garber Preservation, Restoration, & Storage Facility
Smithsonian Institution National Air and Space Museum
Suitland, Md.

Interior of the Garber facility. Courtesy National Air and Space Museum, Smithsonian Institution.

The Paul E. Garber Preservation, Restoration, and Storage Facility is a utilitarian, multi-building complex occupied by the National Air and Space Museum. It is home to nearly 200 aircraft and spacecraft undergoing restoration or in storage. Currently the facility is preparing for its move to the new Steven F. Udvar-Hazy Center at Washington Dulles International Airport in 2003. The craft—in their entirety or represented by critical components—may be a prototype, the first or last of its kind, or associated with a new record or historic accomplishment.

Approximately seventy artifacts have been completely restored since 1959. Restoration—intended to last for 300 to 400 years—involves cleaning, the removal and neutralization of corrosion, and the application of coatings for protection. Replacement parts are clearly identified as such, and paint schemes duplicate as closely as possible original appearances. Multiple restorations are undertaken concurrently, beginning with photodocumentation of each step. It takes approximately 2,500 hours to restore a World War I-era fabric-covered aircraft as compared to, for example, a metal aircraft requiring 9,000 hours, or the Arado 234 that took 18,000 hours.

The Garber facility is named for a life-long flight enthusiast who became the museum's first curator and helped collect about half of the seventy some aircraft currently displayed at the museum on the Mall. The Garber complex has thirty-two buildings, nineteen filled with aeronautics artifacts. Until World War II, all the museum's aircraft were displayed in the Arts & Industries Building and a World War I "temporary" prefab nearby, or they were loaned to other institutions. After World War II, a large array of U.S. military aircraft, as well as captured enemy aircraft, was presented to the museum but stored off-site. With the Korean War, these sites were needed by the government, so the impetus for a museum-operated storage facility large enough to accommodate so many oversized artifacts was sought. The Garber facility has been open to the public since 1977.

The $238-million, 710,000-square-foot center coming to Dulles will allow the museum to exhibit many artifacts never before displayed—in excess of 180 aircraft and 100 spacecraft—including the Space Shuttle Enterprise and F-4 Phantom. It is scheduled to open on the 100th anniversary of the first manned, powered flight by the Wright Brothers.

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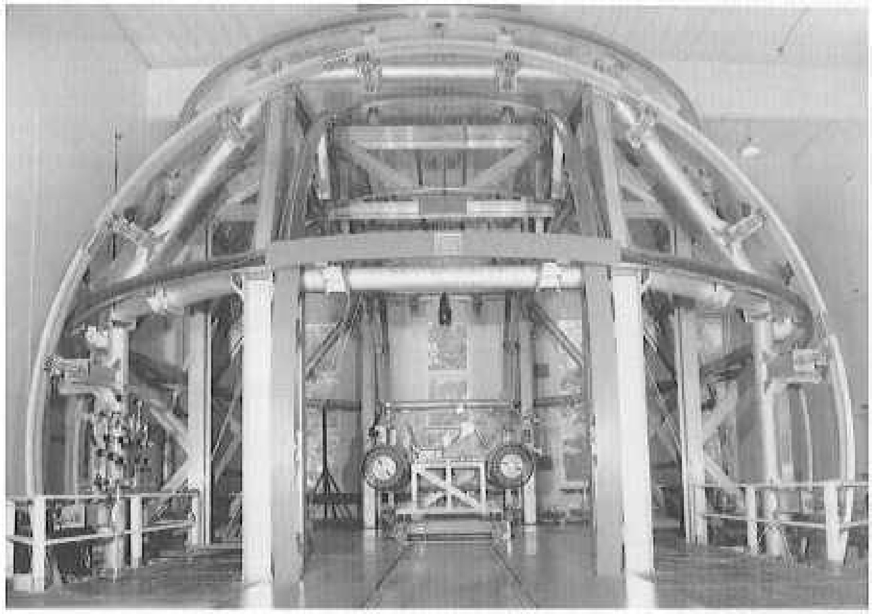
Goddard Space Flight Center
National Aeronautics and Space Administration
Greenbelt, Md.



Magnetic sphere in Attitude Control Test Facility. NASA photograph in National Historic Landmark nomination.

Goddard Space Flight Center was established in 1959 as the National Aeronautics and Space Administration's first center devoted to the exploration of space. As a science and technological research facility, its mission is to gain a better understanding of earth's systems—oceans, atmosphere, ice, and land—and study the applications of space technology to disciplines such as medical diagnostics.

During its history, Goddard has developed numerous satellites targeted at gathering data about many aspects of space, including interstellar dust and hot stars, black holes, comet composition, the Milky Way, solar flares, gamma rays, solar wind, and the Big Bang theory. The Hubble Space Telescope and Landsat mapping are two of its more publicly recognized credits. In 1998 it entered the realm of museum conservation with a three-year Acousto-optic Imaging Spectrometer (AImS) analysis of the American flag that flew over Fort McHenry in 1814 and inspired Francis Scott Key to pen the "Star-Spangled Banner," which is in the collection of the Smithsonian Institution's National Museum of American History. The project involved making seventy-two separate images of the 30-foot by 34-foot flag that are composed of 235 infrared wavelengths. Contaminants and damage to the flag caused by exposure to light, pollution, and temperature variation will be identified using reflected infrared light rather than thermal infrared cameras that report only radiated heat.

One of the most recognized devices at Goddard is its Attitude Control Test Facility, built in 1966, a unique NASA innovation that makes it possible to determine and to minimize the magnetic movement of even the largest unmanned spacecraft and observatories. This is critical to successfully orbit and maintain satellites. The Attitude Control Test Facility, located in Building No. 310-20, is designated a National Historic Landmark as part of the National Park Service's "Man in Space Theme Study."

The Greenbelt complex includes thirty-three major buildings and more than fifty minor structures; Goddard also operates another facility in Wallops Island, Va., and one in New York City. The buildings house a number of activities, including research and development, data management, building and testing spacecraft, and education. The facility is named for Dr. Robert Goddard, the father of modern rocketry.

Source

Harry A. Butowsky, "Attitude Control Test Facility," National Historic Landmark nomination, 1984.

Bollman Truss Bridge

Spanning Little Patuxent River, Savage, Md.

The Bollman Truss Bridge in Savage, Md., is the sole surviving example of the type of span that revolutionized the railroad industry—and helped ensure the success of the Baltimore & Ohio Railroad—with all its principal structural members made of iron. Built in 1869, it is considered the oldest remaining U.S. railroad bridge constructed of anything but masonry.

As the first commercially organized railroad, the B&O in the mid-19th century was still, in many ways, a pioneering enterprise. Chief engineer Benjamin H. Latrobe, Jr., about 1850 specified that iron would be used for bridges instead of timber. Wendel Bollman (1814-84), Master of Road and responsible for all railroad property that did not move, designed a new style of bridge that would be used consistently on the railroad; the main objective of this improvement was a bridge that was fire- and rot-proof.

Bollman Truss Bridge. Courtesy National Museum of American History, Smithsonian Institution.

The distinction of the Bollman system, which he called a "suspension" truss, was a series of diagonal wrought-iron tension links combined with a cast-iron compression chord called a "stretcher." The spacing between the chord and junction of each pair of links was maintained by cast-iron vertical posts or struts. The truss had no bottom chord. The members seen in the drawing that look like a bottom chord are not in tension. Instead, they are spacers that keep the transverse deck beams from swinging. A significant safety feature was the independence of the structural units, with each floor beam supported by separate pairs of diagonal ties.

A 76-foot-long prototype of the new truss was erected on the railroad's Washington Branch over the Little Patuxent River at Savage Station in 1850 and the design was patented in 1852. Of the hundred or so Bollman truss bridges produced for the B&O, the locations of only about twenty are known for sure. Perhaps the largest—and most complex—was built in stages, 1851-70, to carry both road and rail traffic across the Potomac River at Harpers Ferry (see Upper Potomac Valley chapter). The extant two-span bridge was erected at an unknown main-line location, and as it grew inadequate to carry increasingly heavy locomotives, was moved to an industrial spur at Savage in 1888.

Bollman left the B&O in 1858 and, with several former co-workers, founded his own bridge-building firm in Baltimore, eventually styled the Patapsco Bridge & Iron Works. Active at the same time as a handful of other such innovators such as Squire Whipple (1804-88), Albert Fink (1827-97), and John A. Roebling (1806-69) who were designing bridges of iron, the less well-known Bollman and his truss are equally significant.

Interesting testimony concerning Bollman's design was given by Montgomery C. Meigs when he toured the B&O west of Harpers Ferry in June 1857. He was not taken by the variety of the grand yet rugged scenery along the route to Fairmount, W.Va., was not as impressed with either the Bollman or Fink trusses as he expected to be, and remarked in his journal:

Fink's bridge I think I like better than Bollman, though there is not much difference in the plan. Both have the defects of such structures—namely that any flaw in the material seriously, perhaps dangerously, impairs the strength of the bridge. Both are rigid frames. Bollman makes the most noise passing over it, the iron rods rattling in a manner which is most alarming. Both are noisy enough. I stood upon the [Fink] bridge over the Monongahela, which is of three spans of 205 feet each, while the train passed. The bridge swayed to and fro perceptibly. The train brings it down, one of the carpenters informed me, about 1-1/2 inches. Both have a set of diagonal braces running in addition to the main braces with the intention of supporting the bridge during repair.

The Savage bridge is a National Historic Landmark and a National Historic Civil Engineering Landmark. It has been restored to serve as a pedestrian crossing in Little Patuxent Park. The distinctive wooden housings protecting the pinned connections at the upper-chord ends were replicated, based on measured drawings made in 1964. Instead of the original five-color paint scheme, the superstructure was painted entirely in iron-oxide red for economic reasons. Howard County, which owns and restored the bridge, has indicated that it may someday adopt a speculative polychrome paint scheme based on contemporary black-and-white photographs of other Bollman trusses.

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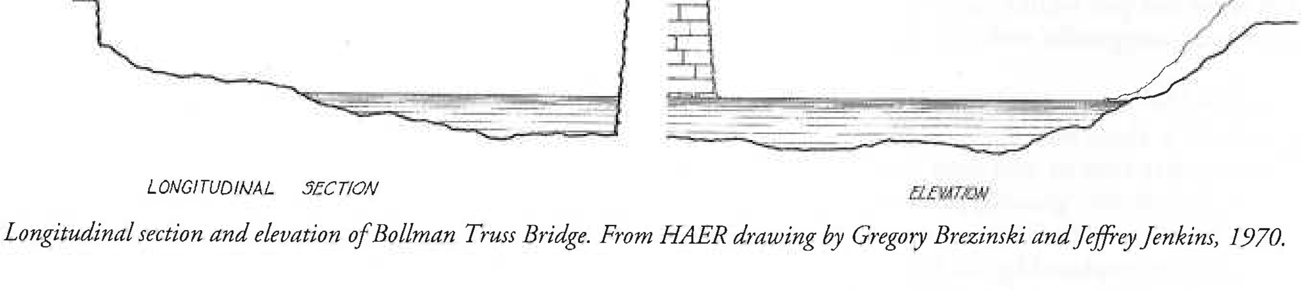

Longitudinal section and elevation of Bollman Truss Bridge. From HAER drawing by Gregory Brezinski and Jeffrey Jenkins, 1970.

Thomas Viaduct

Spanning Patapsco River between Relay and Elkridge, Md.

The Thomas Viaduct was built by the Baltimore & Ohio Railroad between 4 July 1833 and 4 July 1835, and named for Philip E. Thomas, its first president. The railroad, some five years after it had begun operation, struggling westward from Baltimore, determined that its chances for commercial success would be greatly improved if it had a direct connection with Washington, D.C. Thus the "Washington Branch" was undertaken, departing the main line at Relay about 9 miles southwest of the Baltimore terminal, which necessitated an immediate crossing of the Patapsco River valley at that point. Relay was the site of an inn at which the horses that drew the B&O's first cars the 14 miles between Baltimore and Ellicott's Mills (now Ellicott City) were changed—hence the name.

Thomas Viaduct, ca. 1930. Courtesy National Museum of American History, Smithsonian Institution.

At this early stage in the B&O's progress, when capital was reasonably abundant, the policy was that all ways and structures were to be as permanently constructed as possible, with all undergrade bridges to be built of stone--a policy that gradually gave way before the clear need for faster return on the initial investment. The Patapsco span was designed by the railroad's assistant chief engineer, Benjamin H. Latrobe, Jr. (1806-1878), son of the celebrated Greek Revival architect. Latrobe and Casper W. Wever supervised construction, which was carried out by contractor John McCartney. The result was a structure remarkable in every aspect. Like the Boston & Providence Railroad's Canton Viaduct, under construction concurrently, the Thomas Viaduct was designed on a massive scale for its day, dwarfing all contemporary masonry works and marking, at this very early period, the real beginning of the major railroad structure in America. Moreover, the exigencies of the route alignment required that the viaduct follow a 4-degree curve, giving rise to almost unprecedented problems of design and construction. The arch spans and pier widths varied between opposite sides of the structure, thus placing the lateral pier faces on radial lines, not parallel with one another.

The eight full-centered arches each span slightly under 60 feet. The total length is 612 feet and the height from rail to riverbed is about 60 feet. The arch rings, spandrel facing, and piers are rough-faced local granite. The structure's ability to carry even its own dead load was doubted by many at the time of construction, and its failure under the weight of the 6-ton "grasshopper" locomotives then in use was even more widely predicted by those who should have known better. In fact—with no alteration or major repairs—this splendid work has carried every type of motive power employed by the B&O and its successor lines for some 165 years, including the monster 300-ton articulated compounds of the 1920s. All main-line traffic between Baltimore and the west has passed over the Thomas Viaduct since about 1870, when the main line was rerouted over the Washington Branch. The handsome cast-iron railings are original.

According to the "Viaduct on the Baltimore and Washington Railroad" in *The United States Illustrated,* ca. 1860, edited by Charles A. Dana:

> The traveler may well discern in the viaduct of a railroad, a monumental atonement on the part of surveyors and engineers for the injuries their labors elsewhere inflict upon the picturesque beauty of the landscape....
>
> Our viaduct should be strong! Does it not every day sustain car-loads of the men of weight and substance throughout the land, hurrying to and from the Federal Capitol? Consider the assembled wisdom which, during Congressional sessions, presses upon its seven [sic] arches and eight abutments!

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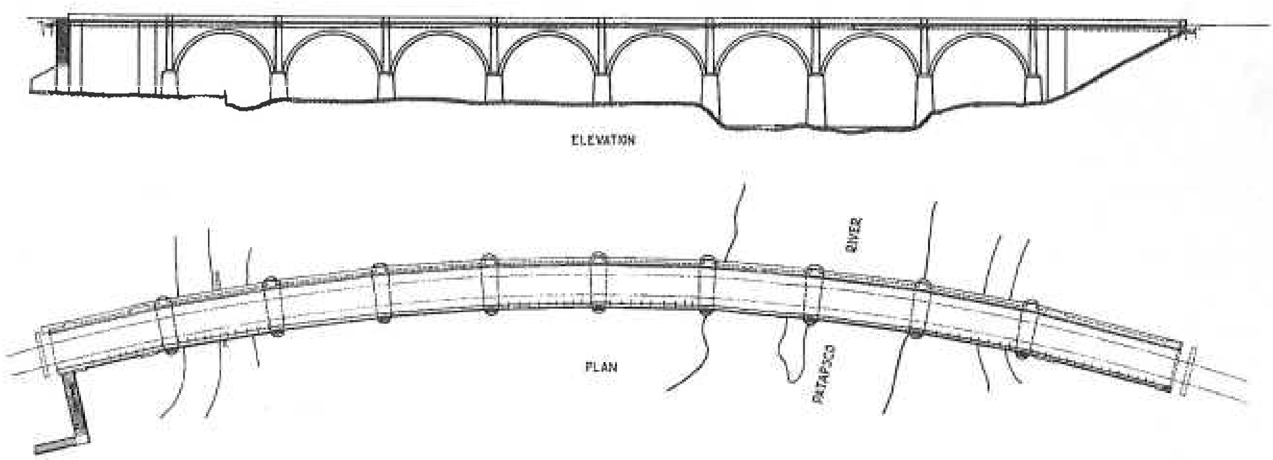
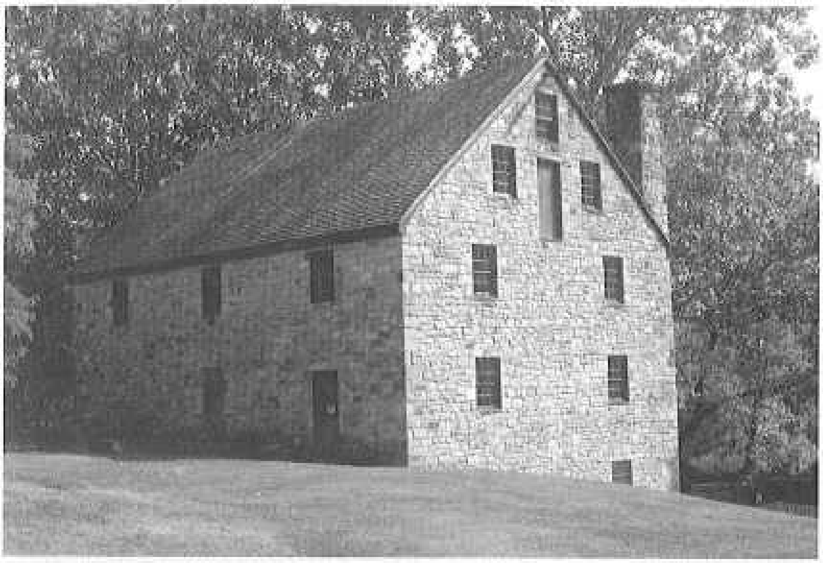


Elevation and plan of Thomas Viaduct. Redrawn from original in B&O Collection, Maryland Room, McKedlin Library, University of Maryland at College Park.

Industries at Mount Vernon

Fairfax County, Va.



Mount Vernon gristmill, originally built in 1770, reconstructed 1932. Courtesy Mount Vernon Ladies' Association.

As early as the 1760s, George Washington made the decision to replace tobacco with wheat as his staple crop at Mount Vernon, his Potomac River plantation in Virginia. This tour features three buildings: a reconstruction of a sixteen-sided treading barn, Washington's reconstructed gristmill, and archaeological excavations at the site of the 75-foot by 30-foot stone distillery, which exemplify his innovative and entrepreneurial character, and his desire to create a self-sufficient plantation.

In 1792 Washington designed a "round" two-story barn to move the treading of wheat inside, away from the outside farmyard. His goals, to produce a cleaner grain and be able to easily secure the wheat, were achieved by erecting the barn on outlying Dogue Run Farm. Horses entered the upper floor via an earthen ramp; this floor had spaces between the floorboards so grain, separated from the straw during the treading process, would fall down to the lower level. The barn survived into the 19th century before falling down. It was rebuilt in 1995 as the centerpiece of a new agricultural exhibit at Mount Vernon.

After treading, the grain was gathered and sent to the Mount Vernon gristmill, originally constructed in 1770. It was outfitted with two pairs of millstones: French buhr for producing the finest flour and local granite for grinding coarser cornmeal. According to an 1803 insurance document, the mill was built of stone and stood two and one-half stories high, 32 feet by 46 feet. In 1791 Washington paid to install in the mill a series of improvements recently patented by Oliver Evans, a Delaware inventor. Washington was one of the first to adopt Evans' labor-saving system. The mill proved to be a highly profitable venture and its flour was routinely sold to Europe and the West Indies.

In 1797 a large stone distillery with five stills and a boiler began operation next to the gristmill. Two years later the distillery produced more than 11,000 gallons of corn and rye whiskey that sold for more than $7,000. This distillery was one of the largest in early America and supported more than 150 hogs and cattle with the slop from the stills.

By the end of the 19th-century, this complex also had disappeared from the landscape. In 1932 the gristmill was reconstructed by the Commonwealth of Virginia and opened as a state park. Today the Mount Vernon Ladies' Association is restoring this reconstruction, creating a working gristmill. Ongoing archeological investigations have recently uncovered the footprint of the distillery and a series of brick and wooden drains that carried the water necessary for distillation into and then away from the still house.

Source

Alan and Donna Jean Fusonie, *George Washington: Pioneer Farmer* (Mount Vernon, Va.: Mount Vernon Ladies' Association, 1998).

Colvin Run Mill

Dranesville vicinity, Va.

Colvin Run Mill is a restored early 19th-century Oliver Evans-style gristmill. It is currently undergoing major maintenance, including replacement of the flume and restoration of the overshot waterwheel. The large log that will be used as the axle for the waterwheel was seasoning on site for a year, and has been planed. The site also includes a country store, blacksmith shop, and the miller's house with various exhibits.

Colvin Run Mill with buhr stone.

By the early 19th century Northern Virginia had moved from a tobacco economy to one based on growing wheat. The Shenandoah Valley was also a major wheat-producing area. Merchant mills were established at favorable sites on the way to Tidewater shipping points, as well as in the valley and port cities. Turnpikes were established largely to serve these mills. Colvin Run Mill is on Leesburg Pike just east of Dranesville, where it intersects with Georgetown Pike. Dranesville Tavern is now preserved as a unit of the Fairfax County Park Authority, representative of a typical stopover dating from the turnpike era. Leesburg Pike terminated in Alexandria. Other turnpikes, such as the Little River Turnpike leading from Aldie Mill, also served Alexandria. Both the communities of Aldie and Leesburg had additional turnpikes leading into the Shenandoah Valley.

Roller milling was first introduced to millers in the mid-Atlantic region in summer 1876, and it had been popularized by the 1880s. By 1895, the business letterhead read "Colvin Run Roller Mills." In the 1920s, the mill served not only the community for many miles around, but also some twenty stores in and around Washington, D.C., and Richmond. Flour and meal also were shipped by rail from Herndon, a few miles away, to Ohio, New York, Maine, Pennsylvania, and Kentucky.

Colvin Run Mill continued to use buhr stones for at least part of the grinding process into the 20th century. Sam and Alfred Millard operated the mill from 1883 to 1934; in 1930 they recalled in an interview for the journal *National Miller and American Miller* that one pair of buhr stones—probably the oldest—was reserved for grinding cornmeal. Other buhr stones were used for grinding whole wheat or "health" flour. Buhr stones were used to crack wheat and rollers were used to process this cracked wheat into finer flour. Using buhr stones in combination with rollers, the Millards produced about thirty-five barrels of white flour per day.

After the business closed, the roller mill equipment was donated to a World War II scrap drive. Some of the equipment in the mill today was taken from another 19th-century mill in Northern Virginia that was salvaged for the restoration.

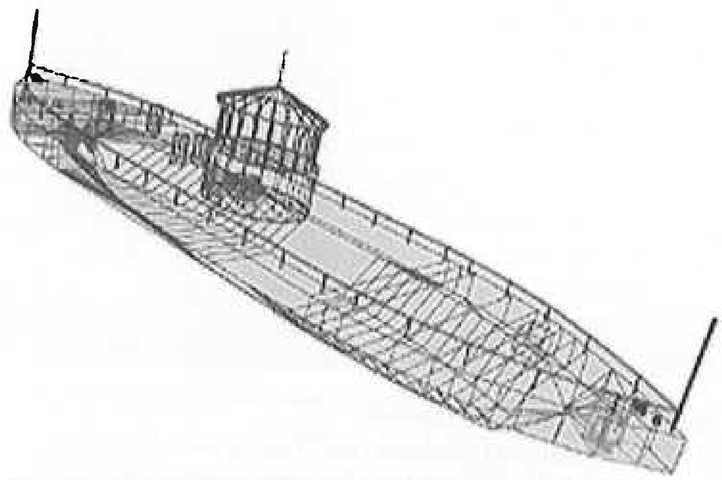
Source

Colvin Run Mill web site at http://www.io.com/~curucahm/COLVIN/colvinrun.html

Fairfax County Parks Authority web site at http://www.co.fairfax.va.us/parks/crm/

Advanced Marine Center at Computer Sciences Corporation
Arlington, Va.

Until recently, the development of naval weapons systems and vessels always began with design, modeling, and prototype testing—evidenced in the government's 19th-century experiments at the U.S. Navy Yard, and later the 20th-century David Taylor Model Basin (Naval Surface Warfare Center). While the latter technology remains current, the state-of-the-art generation of marine architectural design and testing is virtual, as represented by capabilities of the Advanced Marine Center, a unit of Computer Sciences Corporation. The Crystal City-based company has expanded its expertise beyond new design and also applied this virtual discipline to the documentation of historic cultural resources.



Wire-frame model of the Monitor. *Courtesy Advanced Marine Center at Computer Sciences Corporation.*

Beginning in the early 1990s, the U.S. Senate Armed Services Committee began studying the use of "modern simulation technology" by the Defense Department as an alternative to the long process of building and testing prototypes. This interactive simulation, Virtual Environment/Virtual Reality (VE/VR), allows advances in the tools of naval warfare without a protracted production schedule, which also avoids the likelihood that they would be obsolete by the time they are released.

The company uses Simulation-based Design (SBD) and Virtual Prototyping (VP) combined with Computer-Aided Engineering/Computer-Aided Design (CAE/CAD) to develop high-performance visualizations for all kinds of surface ships and submarines. This allows real-time and dynamic simulations with three-dimensional models used in the development of vessels and for subsequent interactive simulation-based training exercises. The company's ship-bridge simulator systems feature radar and navigation systems, bridge mock-ups with fully functional displays, and machinery control.

In addition, the Advanced Marine Center uses computer technology to document submerged vessels in their static condition, as well as to determine how the vessel would have operated based on its engineering capabilities and real physics, incorporating changes in speed and climate. It is also possible to develop photo-realistic rendering sequences through which one can virtually walk.

Source

Otto P. Johns et al., "Using Virtual Environments in the Design of Ships," *Naval Engineers Journal* (May 1994): 91-106.

Potomac River Generating Station

Alexandria, Va.

The Potomac River Generating Station in Alexandria, Va., was built in the 1940s as part of the Potomac Electric Power Company's regional electric-generating facilities. The plant, recently acquired by Mirant, formerly Southern Energy, is a coal-fired facility with a net capacity of 482 megawatts. The generating station, constructed by Stone & Webster, was first brought on line in October of 1949. The five units are composed of General Electric turbine-generators, and boilers designed by Combustion Engineering, Inc. At full load, the station consumes approximately 4,800 tons of coal per day, delivered by railroad. There are five stacks, one for each unit, each 161 feet high.

Unit No.	Net Summer Capacity (kilowatts)	On-Line	Contractor
1	88,000	1949	Stone & Webster
2	88,000	1950	Stone & Webster
3	102,000	1954	Stone & Webster
4	102,000	1956	Stone & Webster
5	102,000	1957	Stone & Webster

Boilers

Unit No.	1, 2	3, 4, 5
Type	Natural circulation, tangentially fired with superheater and economizer	Controlled circulation, tangentially fired with superheater, single reheater, and economizer
Height (feet)	127	127
Designed and Manufactured	Combustion Engineering, Inc.	Combustion Engineering, Inc
Steam Capacity (lb./hr.)	800,000	725,000
Operating Pressure (psig)	850	1,825
Operating Temperature (°F)	950	1050 (main steam), 1000 (reheat)

Turbine-Generators

Unit No.	Type	Speed (rpm)	Manufacturer	Rating (kilowatts)	Generator Voltage
1, 2	Straight flow - condensing	1800	General Electric	93,000	13,800
3, 4, 5	Tandem compound, two-flow, single reheat - condensing	3600	General Electric	108,000	13,800

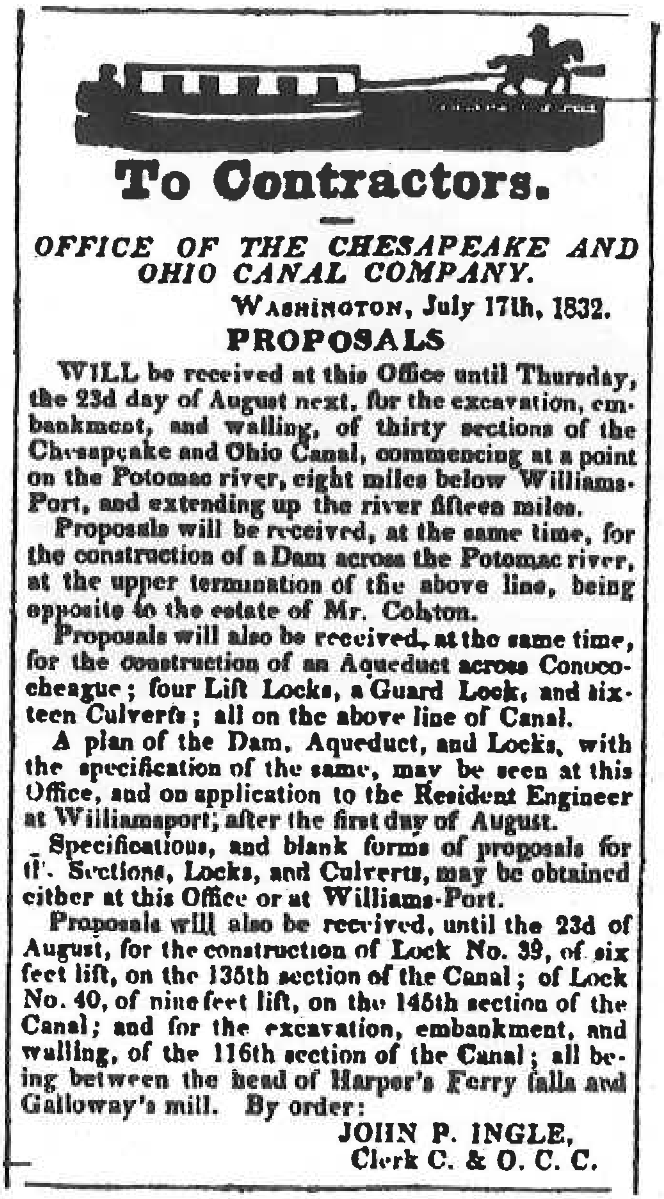
Source

Potomac Electric Power Company "Potomac River Generating Station," data sheet (1998).

Conococheague Creek Aqueduct (No. 5), C&O Canal

Williamsport vicinity, Md.

The Conococheague Creek Aqueduct, built in 1833-34, was the fifth of eleven multiple-arch stone aqueducts erected on the Chesapeake & Ohio Canal—and the last and most ornate. By the time the canal reached Williamsport, this Potomac River community was well established. Improvements made by the first canal effort, George Washington's Potowmack Company, facilitated the shipment of wheat westbound for milling, then barged back down river to Georgetown as flour. Grist and merchant mills, tanneries, lumberyards, and stores formed the community and promoted trade on the eve of the C&O Canal's arrival.



To Contractors.

OFFICE OF THE CHESAPEAKE AND OHIO CANAL COMPANY.

WASHINGTON, July 17th, 1832.

PROPOSALS

WILL be received at this Office until Thursday, the 23d day of August next, for the excavation, embankment, and walling, of thirty sections of the Chesapeake and Ohio Canal, commencing at a point on the Potomac river, eight miles below Williams-Port, and extending up the river fifteen miles.

Proposals will be received, at the same time, for the construction of a Dam across the Potomac river, at the upper termination of the above line, being opposite to the estate of Mr. Colston.

Proposals will also be received, at the same time, for the construction of an Aqueduct across Conococheague; four Lift Locks, a Guard Lock, and sixteen Culverts; all on the above line of Canal.

A plan of the Dam, Aqueduct, and Locks, with the specification of the same, may be seen at this Office, and on application to the Resident Engineer at Williamsport; after the first day of August.

Specifications, and blank forms of proposals for the Sections, Locks, and Culverts, may be obtained either at this Office or at Williams-Port.

Proposals will also be received, until the 23d of August, for the construction of Lock No. 39, of six feet lift, on the 135th section of the Canal; of Lock No. 40, of nine feet lift, on the 145th section of the Canal; and for the excavation, embankment, and walling, of the 116th section of the Canal; all being between the head of Harper's Ferry falls and Galloway's mill. By order:

JOHN P. INGLE,
Clerk C. & O. C. C.

C&O Canal call for contractor proposals for Conococheague Creek Aqueduct, 1832, in Williamsport Republican Banner.

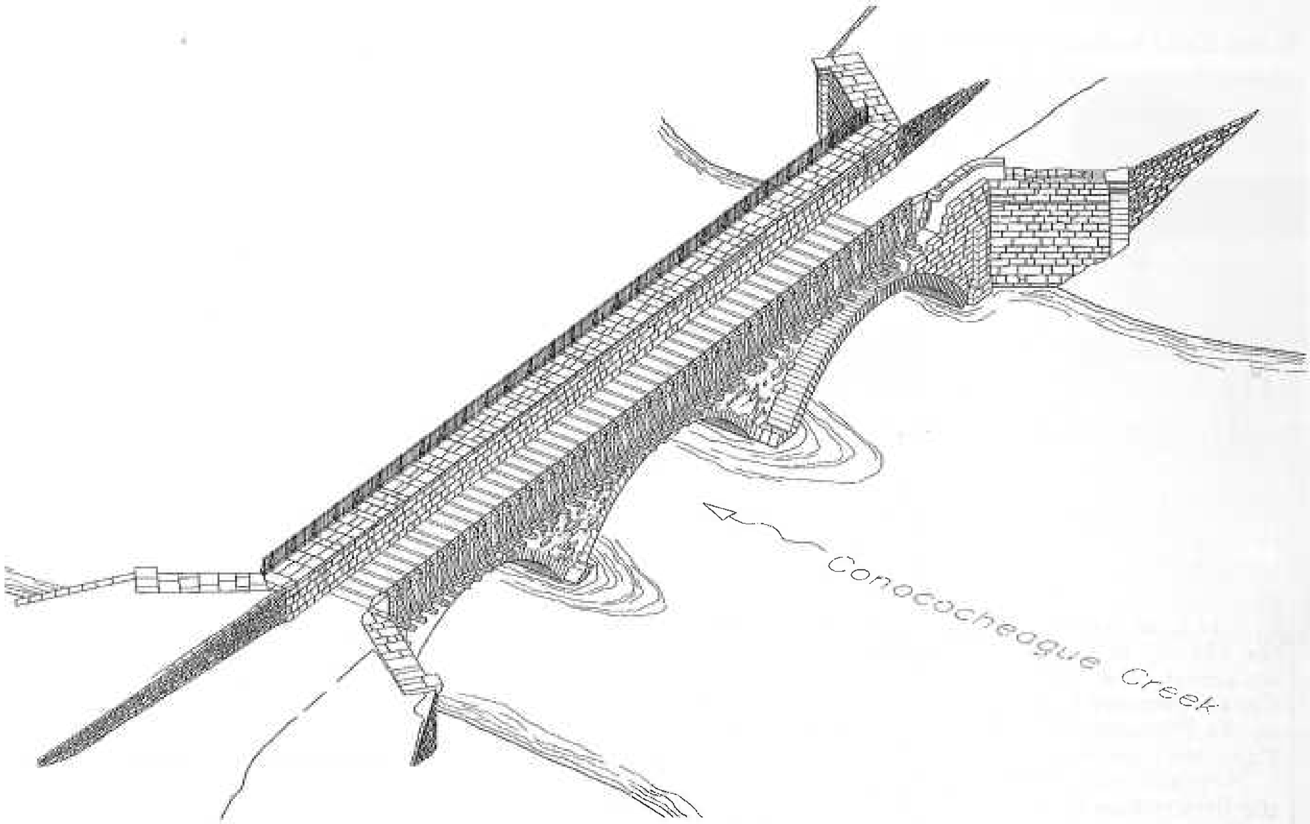
The aqueduct over Conococheague Creek was part of canal Sections 173-202, which included four lift locks, sixteen culverts, and a guard lock. Resident engineer Thomas F. Purcell designed the structure, which is 196 feet long with three 60-foot arch spans. The mammoth piers sit on bedrock, and the "rock work" structure was slated to have accents of cut-stone pilasters, ring stones, sheeting, water table, and parapet interiors, according to specifications. However, after 1832 the company also mandated that aqueducts built north of Point of Rocks, Md., should be of hammer-dressed rather than cut stone, except at the discretion of the engineer. Purcell called for the addition of engaged pilasters with capitals and bull-nose piers, as well as cut stone for the inside face of parapet walls.

Michael Byrne & Company of Frederick, Md., whose crews built the Monocacy Aqueduct, also built this one, several lift locks, and completed work on the Paw Paw Tunnel. The stone came from the High Rock Quarry (today Pinesburg Quarry) three miles away. Boteler & Reynolds, a regular canal supplier until 1837, provided hydraulic cement. The original railing for the aqueduct was to be cast iron, but a wrought-iron one was built instead, along with a mule curb and low wood rail to keep animals from falling into the water. Water was first admitted to the channel in April 1835. The structure cost approximately $66,760, far in excess of the original $26,500 estimate.

Civil War troops damaged the structure, but during the 1870s-80s a repaired and renovated aqueduct again served a prosperous C&O Canal. The Potomac flood of 1924 marked the abandonment of the canal and aqueduct. Protected after 1938, it was first stabilized during the 1960s, and most recently in the 1980s.

Source

Lee R. Maddex, HAER No. MD-123, "Conococheague Creek Aqueduct, Chesapeake & Ohio Canal," 1996.



Conococheague Creek Aqueduct, isometric view. From HAER drawing by Dana Lockett, 1997.

Salisbury Street Bridge

Spanning C&O Canal, Williamsport, Md.

The Salisbury Street Bridge in Williamsport, one of several spans across the Chesapeake & Ohio Canal, represents an early and unaltered standard metal truss bridge. Erected for the canal company in 1879 by the Baltimore-based Patapsco Bridge & Iron Works —the firm founded by a leader in metal bridge design and construction, Wendel Bollman (1814-84)—it is one of two surviving bridges of its kind in Maryland. Bollman in the 1850s was responsible for all stationary property on the Baltimore & Ohio Railroad. One of his most significant extant structures is the truss bridge in Savage, Md., built a decade earlier and the sole surviving example of the type of span, with its principal structural members made of iron, that revolutionized the railroad industry.

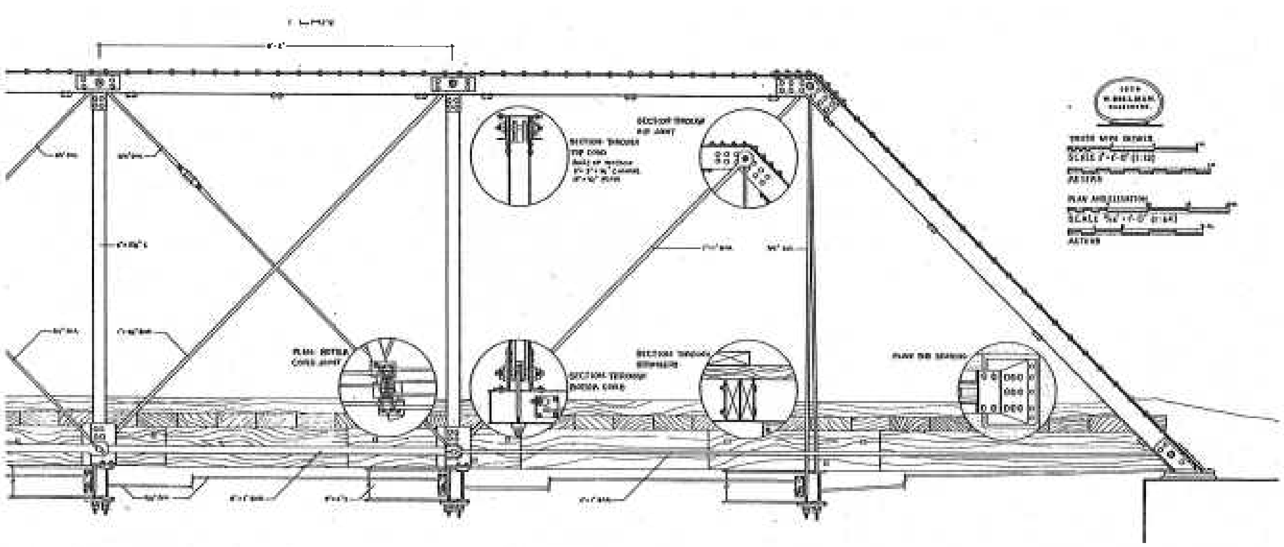
The single-span, skewed, wrought-iron pony Pratt truss at Williamsport spans 67 feet and is 13 feet 3 inches wide; the trusses are 9 feet deep. The top chord is built up of rolled iron channels and plate; the lower chord is made of iron eye-bars. The diagonals are round iron bars acting only in tension. The floor beams are rolled I-beams and the deck is timber. An oval identification plate is extant. The bridge's stone piers date to an older timber-bridge crossing that existed as early as 1867. These dimensions are slightly wider and longer than the span as it was realized, according to a letter from the canal president to Bollman. The structure cost $1,075 and required one month to erect.

Located at the confluence of the Conococheague Creek and Potomac River, Williamsport was a major loading and unloading point for boats traveling the latter, and after 1834 it was a hub of canal-boat activity. Just north of the Salisbury Street Bridge is the Conococheague Creek Aqueduct, which carries the C&O Canal north of Williamsport.

Sources

A. P. Gorman, B&O Railroad, letter to Wendall [sic] Bollman, 27 April 1879.

Jean Yearby, HAER No. MD-24, "Salisbury Street Bridge," 1984, including notes in HABS/HAER office files.



Salisbury Street Bridge: detail from HAER photograph by William E. Barrett, 1974 (above); elevation from HAER drawing by J. R. Frondorf, 1974 (below).

Williamsport Lift Bridge, Western Maryland Railway
Spanning C&O Canal, Williamsport, Md.

The Williamsport Lift Bridge, located on the Chesapeake & Ohio Canal approximately one-tenth of a mile east of the Conococheague Aqueduct in Williamsport, Md., may be the country's smallest vertical-lift bridge and its only asymmetrical lift bridge (an extra panel is present on the river side of the canal to allow for its towpath).

The bridge was constructed in 1923 by the Western Maryland Railway on its spur to provide access across the canal to the R. Paul Smith Generating Plant of Potomac Edison (today Allegheny Energy Supply), visible between the canal and the river. It was in operation only a short time, as the canal closed permanently in 1924. Reputedly the bridge was lifted only once; it subsequently has been used as a stationary rail bridge.

Williamsport Lift Bridge. HAER photograph by William E. Barrett, 1970.

In 1997 the Chesapeake & Ohio Canal National Historical Park contracted with Denis McMullan & Associates to determine if the bridge could be put back in operational status and, if so, at what cost. A long-range goal of the park is to develop canal-barge rides in this area, thus requiring that the bridge be lifted to provide vertical clearance. McMullan reported that the bridge was in very good condition and that it could be made fully operational for something less than $300,000—almost half of which would be spent to fully bag the structure and remove its lead paint in an environmentally sensitive manner. Since then no work has been undertaken on the structure, except to assure its safety in the stationary position. The Baltimore Museum of Industry furnished copies of the original fabrication drawings, which permitted analysis of the structure by McMullan.

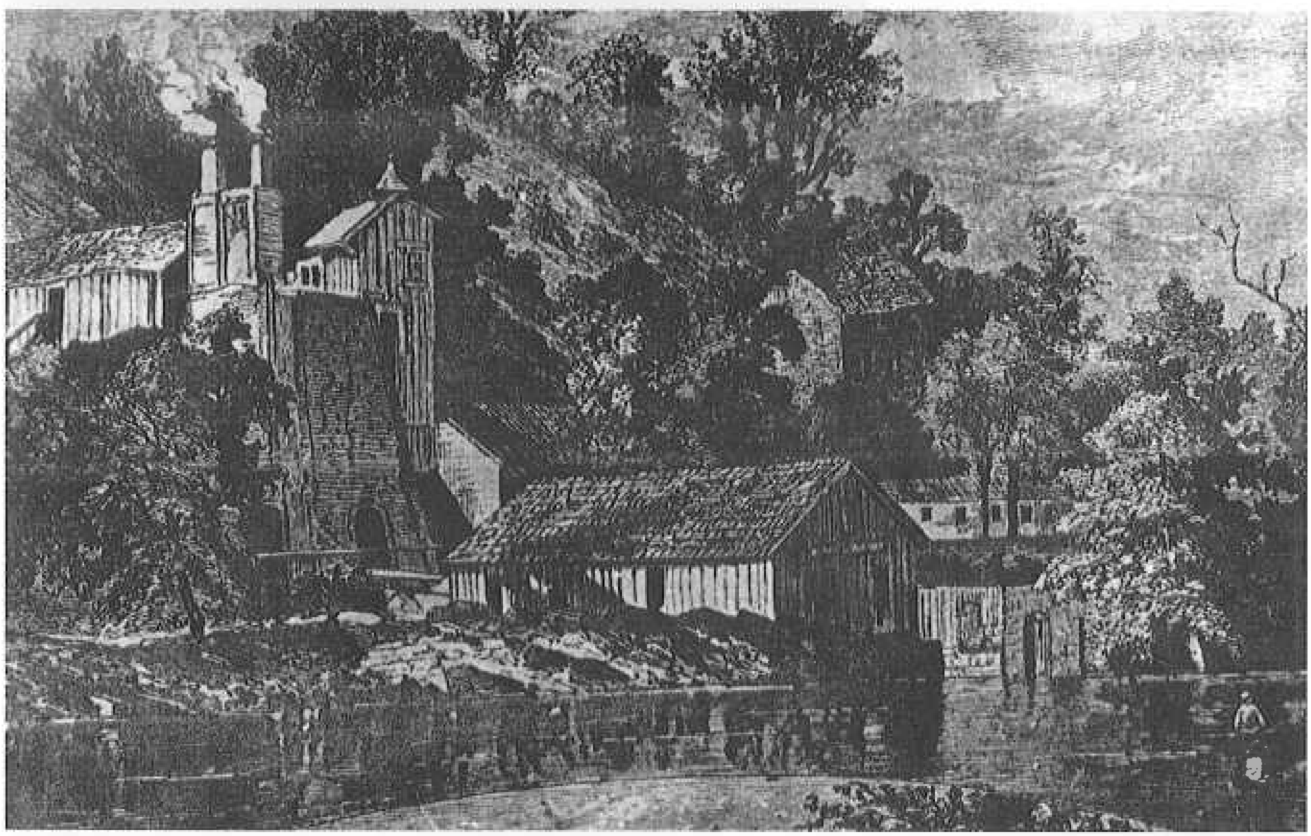
Source

HAER No. MD-23, "Potomac Edison Company, Chesapeake & Ohio Canal Bridge," 1970 (photographs only).

Antietam Iron Works
Antietam, Md.

The most visible remnant of the Antietam Iron Works is the triple stack built back into the cliff at a point a few hundred yards up Antietam Creek from the Potomac River. The structure resembles the lime kilns that dotted Frederick and Washington counties in western Maryland in the 19th century. These burned the limestone commonly underlying the area for agricultural use. In fact this triple stack may have been a limestone kiln. Its placement relative to the embankment and other surrounding archeological evidence, however, suggests that at least part of this structure was a blast furnace at the Antietam Iron Works.

The Antietam Iron Works' history of operation spans more than one hundred years. A charcoal blast furnace produced pig iron during the plantation era of colonial iron making. It continued to produce pigs and castings until the focus of this industrial complex was shifted to the production of cut nails around 1830. Puddling furnaces and trains of rollers were installed to produce nail plate that then was passed to on-site nail machines. The works was an integrated facility, smelting iron ore, refining it, and producing a consumer product. A hot-blast furnace built in the mid-1840s ended reliance on the surrounding thousands of acres of wooded land for charcoal and allowed the switch to coke fuel. Both of these changes were accomplished in the early to middle stages of similar industrial conversion in the United States. (The first nail works in Wheeling, Va., not yet nicknamed the Nail City, was put into operation in 1832.) After a hiatus during the Civil War, new owners recognized its location virtually at the crossroads of major road, canal, and railroad arterials and updated the works with a new furnace. Even during this stage, pig iron production seems to have been steady. The works' value continued to decrease, however, as measured by purchase prices. It probably was producing specialty pig iron at the end of operations in 1886 as iron rapidly was being superseded by steel.



Antietam Iron Works and Rolling Mill, ca. 1872, from Picturesque America.

The remaining evidence of the works represents various points in its history. Some walls supported structures that likely were used until the end, while others undoubtedly were abandoned much earlier. The location of the final and most modern furnace is not readily apparent.

Start a tour by the Antietam Aqueduct of the C&O Canal. A quick detour out to the Potomac River brings one to evidence of the works' history. Large slag stones formed many more than one hundred years ago are scattered about on the shore, having resisted the continuous flooding of the river. Back to the aqueduct and a few steps south on the towpath is the stone entrance to the boat basin, where a significant wharf was located solely to serve the works. On the walk up the creek, off to the right, when the field is free of crops, is revealed the roadbed of the tramway that carried coke to the top of the final furnace. The large areas of soil discoloration are the result of carbon staining the ground at the coke yard. Further on the right is the office, while the Antietam Creek bridge, a near mate to the infamous Burnside Bridge, appears on the left. Then on the right is the old store (now a private residence), a stable, and the furnaces. Ruins of the canal, sluiceway, and foundations of some of the buildings are on the left, culminating with the ends of the dam that spanned the creek, resulting in a 20-plus-foot deep impoundment. Returning to and crossing the bridge one enters the town of Antietam. Some of the houses were the tenements sold with the works on several occasions.

Sources

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Monocacy Aqueduct (No. 2), C&O Canal
Dickerson vicinity, Md.

The Chesapeake & Ohio Canal, extending 184 miles northwest from Washington, D.C., to Cumberland, Md., is America's best-preserved historic canal. The C&O Canal was made possible by eleven aqueducts, the longest being the Monocacy Aqueduct across the Monocacy River near Dickerson. Also designated Aqueduct No. 2, the structure is 516 feet long and consists of seven 54-foot arch spans. Designed by Benjamin Wright, the "Father of American Civil Engineering," it took 200 men five years to construct (1828-33). The aqueduct stood without major rehabilitation until sustaining damage from Hurricane Agnes in 1972. As part of the C&O Canal reconstruction, the aqueduct was strengthened with steel trusses banded around it and reinforcing rods inserted into the masonry. Following the floods of 1996, the C&O Canal National Historical Park undertook a comprehensive analysis of this structure. The adequacy of the external banding and reinforcing rods was assessed, as was the original structure. Structural analysis was supplemented by visual inspection by Bureau of Reclamation divers and the American Society of Civil Engineers (ASCE). Historical analyses were revisited. The result is the development of a comprehensive rehabilitation program for what the National Trust for Historic Preservation in 1998 designated one of the most threatened historic structures in the United States. In November 2001, Congress appropriated $7 million for its rehabilitation.

Wright was hired as chief engineer of the C&O Canal in June 1828. President John Quincy Adams turned the first spade of earth for the canal on 4 July 1828. Wright, assisted by Nathan Roberts, designed the Monocacy Aqueduct in October 1828, following the smaller aqueduct 20 miles to the south across Seneca Creek. Wright estimated that the structure contained 8,500 perches of stone at an estimated cost of $60,000—or eight times that of Seneca Aqueduct. The first 50 miles of the canal were divided into five residencies, beginning at Georgetown

South end of Monocacy Aqueduct prior to its stabilization. HABS photograph by Jack Boucher, 1959.

and extending to Point of Rocks, Md.; Monocacy Aqueduct was in the fifth residency. Each residency was assigned an engineer and assistant engineer to oversee the contractors. Danish engineer Herman Böye was appointed in 1828 to supervise the fifth residency, but he died less than two years later; Robert Leckie was the first superintendent of masonry. The C&O Canal initially contracted with Alfred Hovey to construct the aqueduct, but when he defaulted in December 1829, the contract was assigned to A. P. Osborne. The remote fifth residency was visited infrequently by the Georgetown-based Wright or his assistants.

The closest stone quarry to the construction site was Peters Quarry near Seneca Creek, some 20 miles down the river, but it would have necessitated hauling blocks up the Potomac against the current. Instead, the company attempted to use the gray stone located on Mrs. Nelson's farm about four miles away. Excavation started in spring 1829, but after three piers had been erected using the stone it was found to be deficient, and in July 1830 Wright ordered the work razed. Leckie resigned soon thereafter and the construction contract was assigned to the Pennsylvania Main Line Canal-building firm Byrne & LeBaron. The new contractor found a new source of stone on the farm of Joseph Johnson, about 2.5 miles from the construction site, and this white stone proved superior. A tramway was used to move it from quarry to canal. The C&O Canal also developed Boteler's Mill, south of Shepherdstown, as a source of hydraulic cement, but construction of the aqueduct was estimated to require at least 40,000 bushels. The shortage was aggravated because contractors closer to the mill would waylay the descending boats to get their cement. The Monocacy Aqueduct opened to traffic in 1833. That, and the settlement of its dispute with the Baltimore & Ohio Railroad, allowed the company to meet its charter requirement to have 100 miles of canal operational in the first five years. The structure was in use until 1924. Following Hurricane Agnes, the current "Erector set" was installed on the aqueduct in 1975.

> *...in point of beauty and perfection of workmanship, ... it is believed [to] compare with any work of the kind in this Country or in Europe...*
>
> —C&O Canal official

One goal of the current rehabilitation project is to remove this visually intrusive apparatus once a new system of primarily stainless-steel masonry anchors is operational. Inspection of the aqueduct can begin underneath the first arch. The white ring stones retain their compressive strength, based on coring and compressive testing. Using standards developed for assessing masonry-arch road bridges in Britain, structural engineer Denis McMullan determined that the aqueduct is structurally in relatively good shape. On the upstream side, under the arch, a lateral crack—probably as old as the structure—is visible that roughly corresponds with the berm wall above. The rehabilitation treatment calls for filling the voids under the piers with special concrete restrained by seabags, and the insertion of stainless-steel masonry anchors horizontally through the arches. (The Federal Highway Administration inserted some masonry anchors in 1975 and the ends of these are visible at the top of the arches.)

Under the arch, the leaching of hydraulic cement and lime from the structure is also visible. Tests indicate that little hydraulic cement or lime remains in the rubble fill above the ring stones. This will be corrected by the low-pressure pumping of grout into the structure and repointing cracks. This technique has been successfully tested at the Conococheague Aqueduct and can be accomplished without threat to the environment. Some sections will have to be torn down and rebuilt.

Alcoa Eastalco Works

Adamstown vicinity, Md.

The Alcoa Eastalco Works is an aluminum-reduction plant that began operation in 1970. The 400-acre plant, which employs more than 800 persons, casts aluminum into three shapes: (1) extrusion ingots or billets for structural materials such as architectural, transportation, and industrial machinery and equipment; (2) rolling ingots or slabs for structural materials such as window frames and automobile parts; and (3) remelt ingots or T-ingots, which are remelted and cast into a variety of shapes. Alumina, a compound containing aluminum and oxygen atoms, is obtained from bauxite ore mined in South America. The alumina is shipped to Baltimore, and then transported by rail to Frederick. At the Eastalco Works, electrical current is passed through the alumina in a chemical bath in special electrolytic cells called "pots" to separate the aluminum from the oxygen. Each cell draws 140,000 amperes of electric current. Eastalco is the largest consumer of electricity in Maryland.

Eastalco helped pioneer innovative techniques for feeding alumina into the cells. In the 1970s, this became one of only two plants in the world to adopt the semi-gantry crane to feed the cells and break the crust that forms on electrolytic pots. The pots at Eastalco today are continuously supplied with alumina through an automated process called "center feed," in which each pot has its own alumina feeders and crustbreakers. Molten aluminum is siphoned from the reduction pots and cast into billets, slabs or T-ingots. Eastalco also produces the carbon anode blocks used in the electrolytic cells. A 2,700-ton hydraulic press transforms a heated coke and liquid pitch mixture into sixty anode blocks per hour. All of these processes at Eastalco require an enormous amount of water, and the plant pumps nearly 1 million gallons of Potomac River water every day (filtered both before and after use in the plant).

The Eastalco Works is located on a historic property in Frederick County. The surrounding land originally was part of Carrollton Manor, a tract given to the Carroll family by King Charles of England in the 17th century. The company has preserved the summer home of Charles Carroll, a signer of the Declaration of Independence.

Sources

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Catoctin Iron Furnace

Thurmont, Md.

Three iron furnaces operated at this site between the Revolutionary War and 1903, spanning a range of technological advances from a primitive charcoal operation to a relatively sophisticated blast furnace. Only the remains of the second, ca. 1856, cut-stone charcoal furnace are extant, but well preserved.

The first, Catoctin Furnace stack No. 1, was also the last of Maryland's seventeen or so Colonial-era furnaces, built by brothers James and Thomas Johnson (the latter would become the first governor of Maryland). The 32-foot-tall and 8.5-foot-square structure was in blast by 1776, operating on water power from the nearby Little Hunting Creek, with an output of 600 to 900 tons of pig iron annually. The furnace was relined and enlarged slightly in the following decade, boosting capacity; it was enlarged again in 1831, which nearly doubled its production. By the end of the century it had been dismantled.

Remains of Catoctin Furnace. Courtesy National Museum of American History, Smithsonian Institution.

Surrounding it was a typical community of service and residential buildings including charcoal and casting houses, a forge, stables, and a sawmill. A compact operation, it used iron ore and limestone mined a half-mile from the furnace, and timber for fuel cut from nearby forests. The furnaces were truncated pyramids of stone built near a hill or bank; "fillers" carried iron ore, charcoal, and limestone across the "bridge," from which it was dumped into the stack. In the forge, the pig iron was refined and hammered into bars of wrought iron that were, in turn, shaped into tools and other products; the metal could also be remelted and cast into molds to make pots, etc.

The second charcoal furnace—its bellows steam-powered—stack No. 2 (Isabella), was constructed in 1856 by Fitzhugh & Kunkel. The 33-foot by 9-foot stack had an annual production capacity of 3,300 tons of pig iron. With this improvement came an engine house and related buildings. In 1873, the Catoctin anthracite coke furnace stack No. 3 (Deborah), was built. This relatively advanced, hot-blast operation also was powered by steam. The considerably larger, 50-foot by 11-foot structure could turn out approximately 9,000 tons of iron a year; by 1900, a minor enlargement of the site pushed production to 15,000 tons. Just a few years into the 20th century, No. 3 was closed and dismantled and No. 2 was partially dismantled, and so ended the pig-iron industry in Maryland.

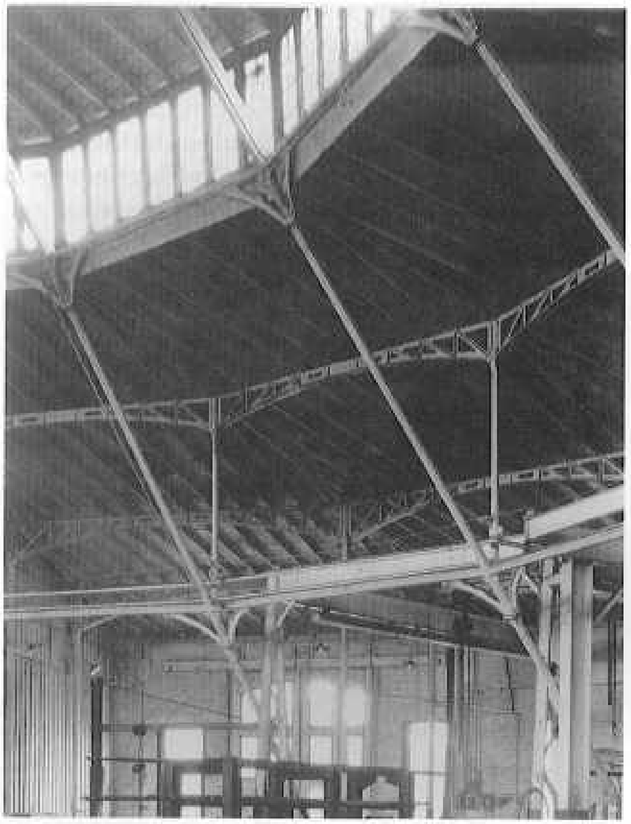
In 1936 Catoctin iron furnace was acquired by the federal government and stabilized by the National Park Service, after which it was transferred to the state of Maryland. Many of its affiliated archeological sites—roads and building foundations—are believed to be under nearby U.S. Route 15.

Source

Contract Archaeology Inc., for Maryland State Highway Administration, "A Historical and Archaeological Survey of Land Affected by the Dualization of U.S. Route 15 at the Catoctin Iron Furnace," 1971.

West Roundhouse, Baltimore & Ohio Railroad

Martinsburg, W.Va.



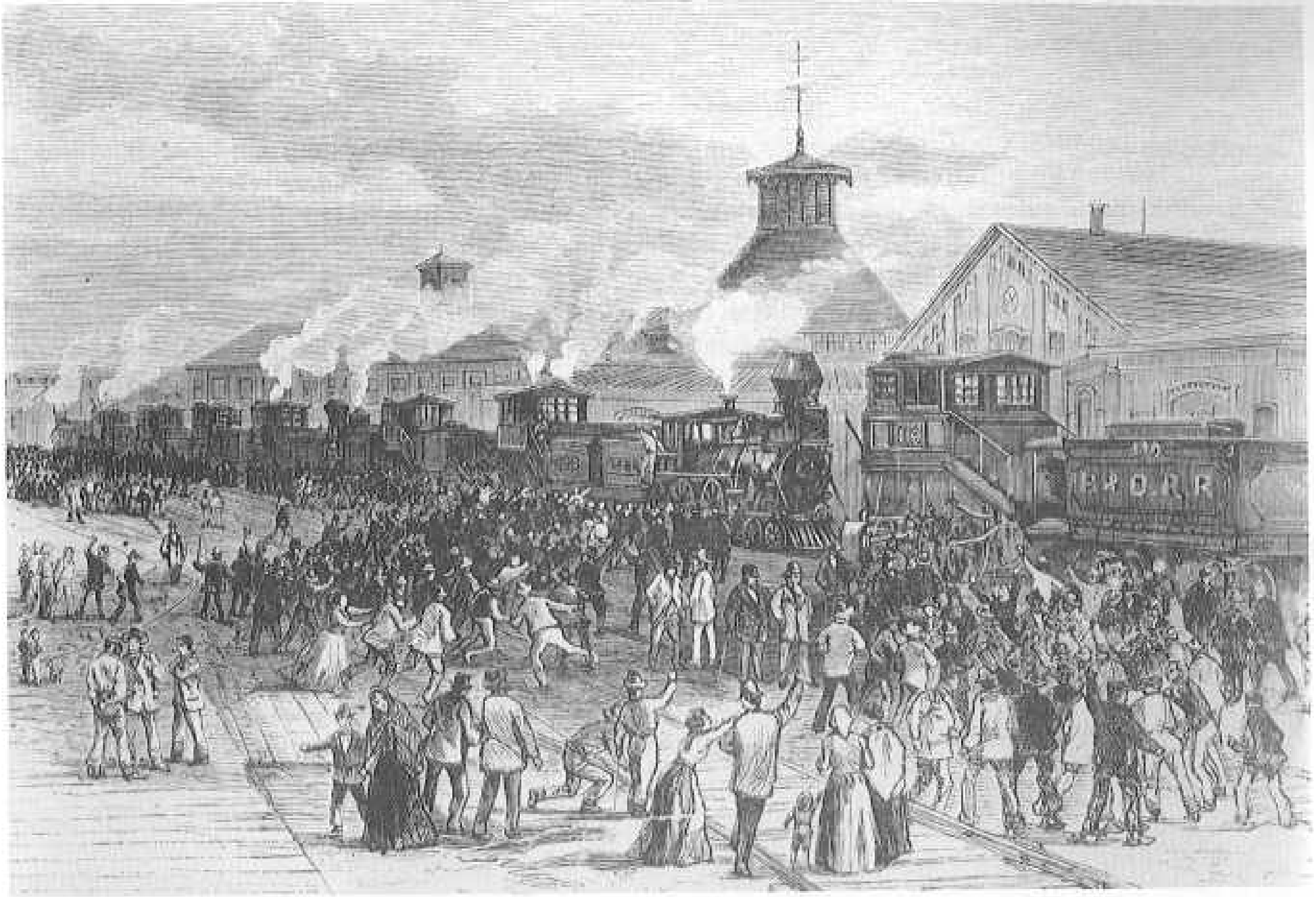
Interior of West Roundhouse, showing cast-iron frame. HAER photograph by William E. Barrett, 1970.

The West Roundhouse in Martinsburg, one remnant of the Baltimore & Ohio Railroad shop complex there, is architecturally noteworthy for its transitional cast-iron framing and culturally significant as the site of the first major confrontation of the Great Railroad Strike of 1877. Erected in 1866, it is one of two roundhouses where running repairs were made to locomotives in a community boasting one of the longest continuously operating railroad facilities in the nation.

The railroad officially arrived at Martinsburg in 1842, initially with only a few daily trains passing through at a sluggish 10 to 20 miles per hour. Travel time between Martinsburg and Baltimore fell from two days to six hours, however. The rail line expanded after mid century, building or improving facilities at Baltimore, Piedmont (then Va., now W.Va.), and Wheeling as well as Martinsburg, which served as a division point between the First and Second divisions. The first generation of shop buildings, including a twelve-sided Gothic Revival roundhouse, dated to 1848-54. These antebellum facilities were burned by Confederates who also absconded with fourteen locomotives and other equipment. Between 1851 and 1872 the B&O erected six Fink-style covered roundhouses, suggesting the level of company satisfaction with this technique.

The rebuilt roundhouse in Martinsburg is based on Albert Fink's (1828-97) structural system that had been employed at the B&O's Piedmont yard. Measuring 174 feet 4 inches from outside corner to outside corner, it is a sixteen-sided polygon with brick walls enclosing the interior iron framework of independent octagonal vertical and inclined cast-iron columns that support trusses and bracketed circumferential struts. There is a clear span between inclined iron columns of 120 feet. The bell-shaped roof, topped originally with a smoke cupola, is above the 50-foot-diameter turntable pit; it is set apart from the main roof by a band of clerestory windows. A newer, disproportionately small cupola is in place today atop the enormous timber roof; it is approximately 68 feet from the top of the cupola to the building floor. Sixteen wedge-shaped work bays radiate from the turntable, and tracks are extant in the concrete-slab floor in all but three of them. The turntable walls are a composite of concrete, brick, and stone. The table is balanced on a center tapered bearing anchored on a series of large, cut stones. An interstitial ledge 4 feet 6 inches below the floor supports the ring rail on which the turntable rolls. Remnants of an air-powered donkey engine are extant on the underside of the turntable.

The country's post-war prosperity began to ebb with the Panic of 1873. The Great Railroad Strike of 1877 was precipitated by railroads slashing wages by about 10 percent. In July, the trainmen and enginemen in Martinsburg initiated the first major railroad strike in the nation—which proved violent, brief, and unsuccessful. During the 1870s, changing technologies and corporate expansion took the hub status from Martinsburg; by the 1880s covered locomotive roundhouses were an anachronism. The company experienced a gradual decline until the Panic of 1893, which would be its death knell; the shops were virtually abandoned by 1897, but remained in limited use into the 1970s. The West Roundhouse site includes the rectilinear Machine and Frog shops.



"The Great Railroad Strike—Blockade of Engines at Martinsburg," Harpers Weekly, *11 August 1877.*

Documentation is underway for potential designation of the West Roundhouse as a National Historic Landmark, as well as consideration as a National Historic Civil Engineering Landmark. Located at the end of Race and Martin streets, the property currently is owned by a state-legislated redevelopment authority that anticipates a redevelopment and revitalization project.

Sources

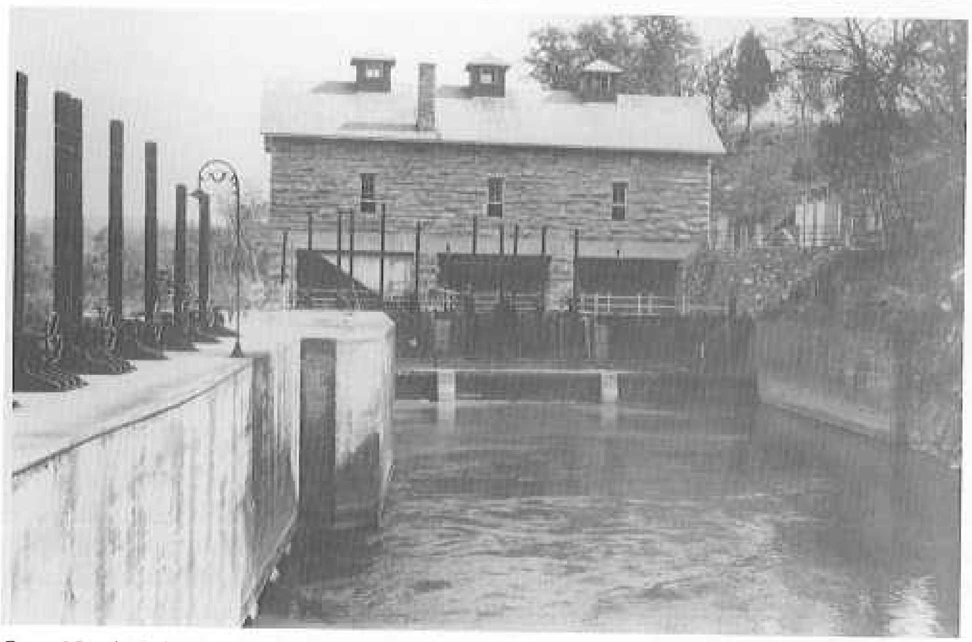
Jean Yearby, HAER No. WV-1-A, "Baltimore & Ohio Railroad, Martinsburg West Roundhouse," 1984.

John P. Hankey, draft of *The Baltimore and Ohio Railroad Martinsburg Shop Complex Historic Structure Report,* for the Berkeley County Roundhouse Authority (Grove & Dall'Olio Architects, August 2000).

Allegheny Energy Dam No. 4 Hydroelectric Plant
Shepherdstown vicinity, W.Va.

Potomac River Dam No. 4 is one of seven stone dams built by the Chesapeake & Ohio Canal Company to feed water to its 184-mile-long canal. It was completed in 1860, replacing a timber-crib dam built in 1835 on the same site, about four miles above Shepherdstown. The handsome Romanesque powerhouse, constructed of limestone excavated from the forebay, was completed in 1909.

The severity and frequency of Potomac River floods necessitated elevating the generators high above the river and prohibited directly connecting them to the submerged horizontal-shaft turbines found 36 feet 10 inches below. Turbines were installed in two of the three pits in 1909. These each contain a pair of Leffel 40-inch-diameter, dual-runner, horizontal turbines. Working under a 17-foot 4-inch head, each four-runner turbine set rotates at 168 rpm, generates 850 horsepower, and discharges 32,460 cubic feet per minute. On each turbine shaft is a 10-foot-diameter sheave, coupled to a 4-foot 5-1/2-inch-diameter upper sheave by a 1,250-foot-long, 1-5/8-inch-thick sisal rope (since replaced by synthetic rope) loop that winds back and forth between the two sheaves twenty-six times. A Warren Electric Company 500-kilowatt horizontal-shaft generator and an Electric Machinery Company 500-kilowatt generator (installed in 1922), each rotating at 360 rpm, produce 2,500 volts of three-phase, 60-cycle alternating current. Two exciters, belt-driven from the generator shafts, operate at 850 rpm to produce 25-kilowatt, 160-volt direct current. Lombard type "O" governors, equipped with electric speed controllers and exerting a maximum 12,000 pounds of hydraulic pressure, control water flow into the turbines.



Dam No. 4 Hydroelectric Plant, ca. 1936. Charles Morris photograph in HAER collection.

The Dam No. 4 power plant originally was operated by the Martinsburg Power Company, which also ran a 450-kilowatt power station at Dam No. 5 above Williamsport. Both facilities were absorbed by the Potomac Light & Power Company in 1916, which until the 1980s also controlled the Potomac Power Plant in Harpers Ferry. PL&PC became Potomac Edison in 1922. Today these two historic hydroelectric plants, as well as three more on the Shenandoah River, are a small but significant supplier of hydroelectricity for the energy network of Allegheny Power.

Source

Charles Scott, HAER No. WV-27, "Dam No. 4 Hydroelectric Plant," 1980.

Thomas Shepherd's Grist Mill

Shepherdstown, W.Va.

This privately owned grist mill, tucked in the center of the town of Shepherdstown, W.Va., most likely is the earliest grist mill in the Shenandoah Valley. It was constructed ca. 1739 by western Maryland native Thomas Shepherd along Falling Spring Branch (now Town Run) in the small village of Mecklenburg, upstream from the Pack Horse Ford, which would become a major crossing of the Potomac on the Philadelphia Wagon Road to the Valley of Virginia. Following Shepherd's death in 1776, the mill passed through different owners during the 19th century but maintained a prominent role in the economic development of Shepherdstown. It operated as a merchant mill, grinding grain from local farmers and selling flour to markets in Philadelphia and Alexandria, Va.

The mill began as a two-story stone building most likely powered by a wooden overshot water wheel. The wheel was replaced in the mid-19th century by a 40-foot Fitz overshot water wheel, originally located more than 100 feet downstream with an "endless wire" transmission to the buhr stones. The wheel was moved to its present location adjacent to the mill in 1905. The installation of the larger wheel greatly increased capacity, reaching thirty-five barrels per day in the 1890s. Roller equipment (removed in 1947) replaced the stone during this period, along with separators and pullers installed in a new third story to aid in the gradual reduction process.

Shepherd's Mill operated for two hundred years until it closed in 1939 when it could no longer compete with larger flour mills. However, it played an integral part in the development of Shepherdstown as an agricultural trading center for the bountiful Shenandoah Valley.

Source

Dennis Zembala, HAER No. WV-5, "Thomas Shepherd's Grist Mill," 1975.

Undated postcard view of "flour mill and wheel" at Shepherdstown. From HAER files.

Boteler's Cement Mill
Shepherdstown vicinity, W.Va.

Boteler's Cement Mill, 1829-30, is the oldest in the Potomac River Valley. In 1828 Dr. Henry Boteler first discovered the existence of natural cement rock on his property, one mile below Shepherdstown, while building a gristmill on the Potomac. This discovery interested the Chesapeake & Ohio Canal Company, which was in need of a strong "water cement" to construct its aqueducts, culverts, and lock walls. The canal's chief engineer, Benjamin Wright, reportedly called the Shepherdstown cement "the best quality in the world."

The first operating kiln at Boteler's site came on line in spring 1829. It is extant up the hill from the mill. The kiln was problematic from the start, however, with poor access for delivery of raw materials up a steep cliff to the top of the kiln, and poor control of the temperature in the kiln. Nonetheless, the end product showed favorable results. Boteler decided to try a set of smaller kilns, which would make it easier to control temperature and amounts of cement produced. Three kilns 7 feet in diameter were in full operation by November 1829, and another set of three was constructed by spring 1830. These six kilns combined to produce up to 1,000 bushels, or 300 to 350 barrels, of cement per day. Once burned, the cement stone was floated down a head race to an adapted water-powered grist mill. Originally, the three-story mill seemed to alternate between grinding grain and cement on the same millstones. Burnt cement stone was fed through "crackers"—two 2-foot corrugated iron disks—then into a hopper before being ground by buhr stones and packed in 300-pound barrels. The dimensions of the original structure are unknown, as the cement mill was burned by Union troops in 1861. The extant ruins are from the second mill, built ca. 1865.

Battery of six natural-cement kilns at Boteler's Cement Mill, built 1829-30. Photograph by Christopher H. Marston, 2001.

Transportation of cement was often hazardous due to floods, rapids, and low water. Cement was shipped down the Potomac River in barrels and bushel bags, typically to a site of canal construction. The C&O Canal was accessible after 1837 when a river lock was constructed at Antietam for boats crossing the river below Dam No. 4. Shepherdstown cement was used to build the Monocacy Aqueduct in 1832-33 and the Conococheague Aqueduct in 1833-34. The Shepherdstown Cement Mill was the main supplier to the C&O Canal until Round Top (near Hancock, Md.) went into production in 1837. Although the cement mill had competition from other mills for C&O Canal business, it continued to supply the construction industry in Washington, D.C. The mill also played a prominent role in the aftermath of the Battle of Antietam in September 1862. Lee's Confederate forces retreated across the Potomac at Pack Horse Ford just below the mill site following the battle. Confederates held the bluffs above the cement mill and laid down a brutal fire that decimated the Union forces. Those who survived took refuge in the cement kilns and cement mill ruins. This engagement is known as the "Battle of the Cement Mill."

The mill continued to operate in spite of periodic floods, droughts, and transportation difficulties into the 20th century. It ceased operating following the 1901 death of owner Col. Blount. Significant remains of the complex represent a remarkable industrial archaeology site along River Road below Shepherdstown, including the 1829 large kiln, 1829-30 battery of six kilns, remains of the 1865 cement mill, a two-story office, and the mill dam.

Source

Thomas F. Hahn and Emory Kemp, *Cement Mills Along the Potomac River,* Monograph Series 2, No. 1 (Morgantown: West Virginia University, Institute for the History of Technology and Industrial Archaeology, 1994).

Virginius Island

Harpers Ferry National Historical Park, Harpers Ferry, W.Va.

Virginius Island was once a busy industrial village complex, using the water power of the Shenandoah River to run a variety of concerns including a cotton factory, flour mill, sawmill, machine shop, iron foundry, blacksmith shop, and carriage factory. Succumbing to the ravages of floods in 1852, 1870, and finally 1889, much of Virginius Island has since been reclaimed by the river.

The National Park Service has established a walking trail over the island to help visitors inspect and imagine the establishments that once thrived here. Sites include the Cotton Mill, ruins of a four-story structure built in 1848. Four Leffel turbines were installed when it was converted to the Child & McCreight Flour Mill in 1868. Today the turbines remain, surrounded by the stone foundation walls and arches under restoration. The intake arches and headgates of Herr's Dam also survive, which formed a mill pond serving several mills on the island. The foundations for the six flumes of the Shenandoah Pulp Mill remain and can be seen from Shenandoah Street. In operation by 1888, Thomas Savery's pulp mill used six New American 36-inch turbines and two Improved Success turbines to drive Pusey & Jones three-pocket wood grinders. The pulp mill remained in business nearly fifty years, until closing due to the Flood of 1936.

The remains of the Shenandoah Canal and the still active Winchester & Western Railway add to this remarkable though easily overlooked feature of the park. Harpers Ferry National Historical Park continues to perform archeology and restoration initiatives to make Virginius Island a living museum of industrial archeology.

Sources

Jack Bergstresser, HAER No. WV-35, "Waterpower on Virginius Island," 1987.

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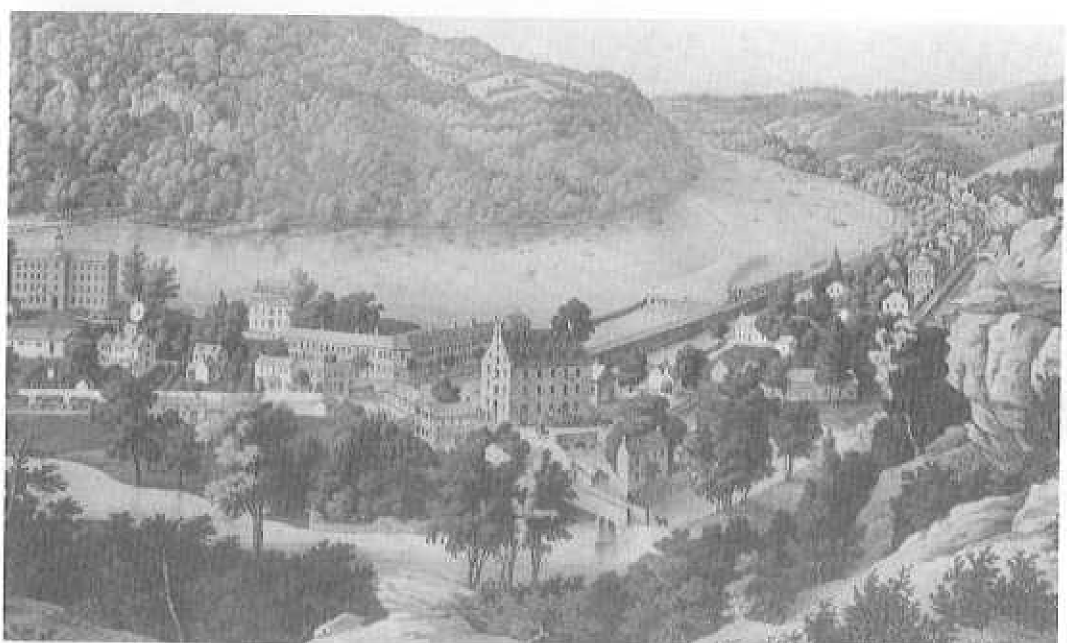
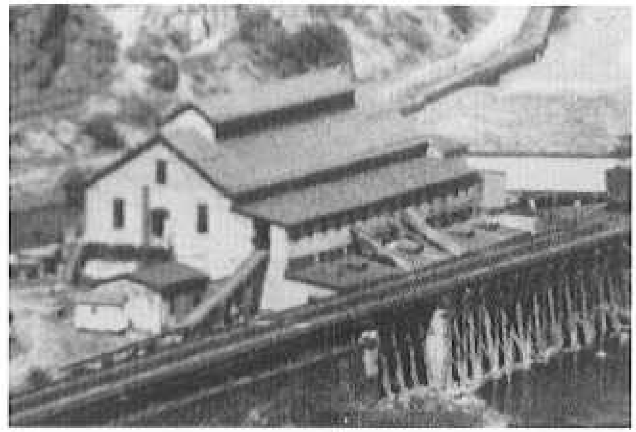


Virginius Island, from an 1857 lithograph. U.S. Rifle Factory sits at far right facing the Shenandoah Canal and Herr's Mill dominates the center. At left stands the four-story Cotton Factory, converted to the Child & McCreight Flour Mill in 1867. Courtesy National Park Service.

Potomac Power Plant

Harpers Ferry National Historical Park, Harpers Ferry, W.Va.

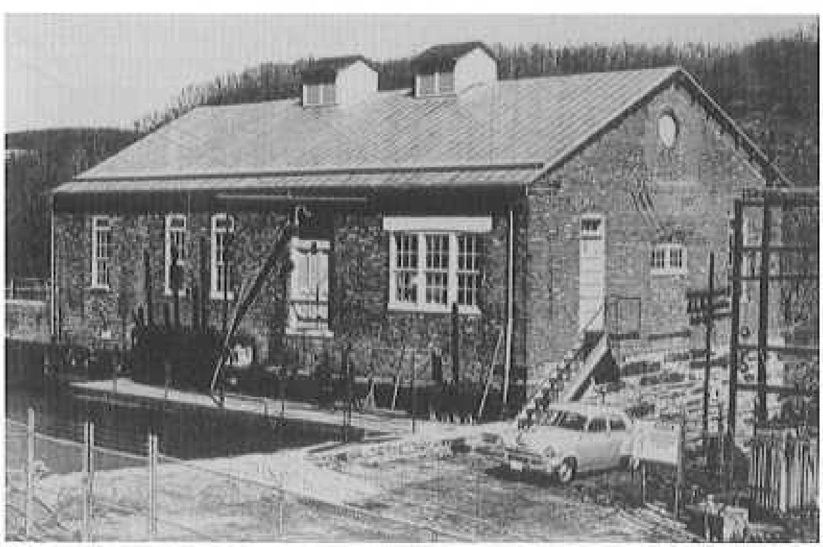
The Potomac Power Plant traces its roots back to 1834, when a tilt-hammer and barrel-welding shop was constructed for the musket factory of the U.S. Arsenal in Harpers Ferry. The shop was situated at the western end of the musket factory grounds, by the power canal that supplied the armory workshops with water power. Flumes were constructed underneath the shop floor to channel water through the water wheels that drove the shop's machinery. In 1853, this shop was torn down and replaced with a rolling mill, which was built on the foundations of the tilt-hammer shop.



Thomas Savery's Potomac Pulp Mill, ca. 1900, with the B&O Main Stem trestle in the foreground (above); the altered structure under ownership of the Harpers Ferry Electric Light & Power Company, ca. 1930 (below). Both courtesy Harpers Ferry National Historical Park.

Most of the arsenal buildings were destroyed during the Civil War, and all of the government property in Harpers Ferry, including the site of the rolling mill, was sold at auction in 1884 to Thomas Savery, an official of the Pusey & Jones shipbuilding and papermaking-machinery manufacturing company of Delaware. In Harpers Ferry, Savery built two paper pulp mills, the first on Virginius Island on the south side of the town by the Shenandoah River, and the other on the Potomac River, on the site of the old rolling mill that was now bordered by the tracks of the Baltimore & Ohio Railroad. Construction on the Potomac Pulp Mill began in 1888, and the first pulp was produced in spring 1889.

The mill made ground-wood pulp from then until 1925, when a fire destroyed part of the structure. The mill ground wood into a wet fibrous substance that paper mills used as an alternative to rags. The process remained fairly constant throughout the life of the mill. Water entered the mill's flumes from the power canal, and in the process of dropping approximately 25 feet, turned the runners of various water turbines. The turbines were directly connected to wood grinders. Workers placed short, debarked logs into the grinders, where a revolving stone ground the log into small fibers. The fibers then were mixed with water to become pulp, which was transported to the second floor of the mill, moved across screens to separate the fibers from larger wood slivers, and formed into sheets on wet machines. These sheets were loaded onto railroad cars for shipment.



The pulp mill did not use all of the water power available from its site on the Potomac River, so in 1898 Savery launched his company into a business that eventually proved more profitable than pulp-making. After initially leasing space to an entrepreneur who wanted to generate electricity for the town of Harpers Ferry using turbines in the pulp mill, Savery bought him out and constructed his own power plant within the mill building. Savery's electric company leased space and water power from the pulp company, and set up generators in the southwest corner of the mill. Two flumes were used to generate electricity. Electric lights were turned on in Harpers Ferry in 1899, and Savery eventually extended lines to several nearby communities.

The 1925 fire also destroyed most of the pulp-making machinery. Company officials decided to abandon the less-profitable pulp operation, and rebuild solely as a power plant. The plant continued to generate electricity as it changed hands in the 1930s, and Potomac Edison purchased it in 1944. One generator and turbine were taken off line in 1973, and the remaining generator and turbine, the last water-powered machinery in Harpers Ferry, were shut down in 1991.

Equipment remaining in the building includes a 1905 Dayton Globe water turbine, a 1925 General Electric generator, a ca.1925 Woodward turbine governor, and various electric switch boards. Structurally, the power plant embodies, literally, an interesting assortment of early Harpers Ferry industrial buildings. Parts of the foundation and flumes may date to either the 1834 tilt-hammer shop and/or the 1853 rolling mill; portions of the structure contain foundation stone and bricks reused from former armory workshops; and the north and west walls were reconstructed after the 1925 fire with bricks from an 1847 cotton factory and flour mill on Virginius Island.

Sources

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David T. Gilbert, *Waterpower: Mills, Factories, Machines & Floods at Harpers Ferry, West Virginia, 1762-1991* (Harpers Ferry, W.Va.: Harpers Ferry Historical Association, 1999).

Baltimore & Ohio Railroad Bridges

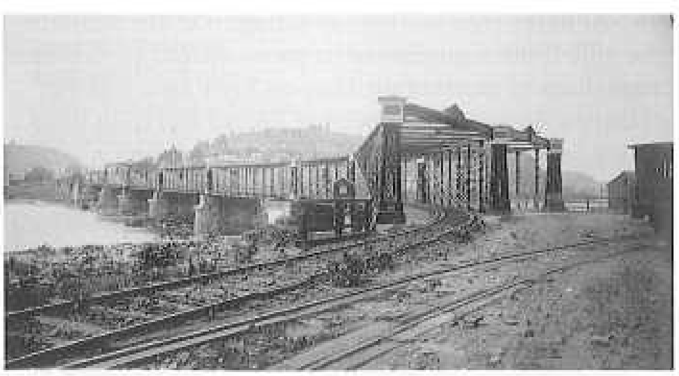
Spanning Potomac River at Harpers Ferry, W.Va.

In 1837 the Baltimore & Ohio Railroad departed from its home state of Maryland, crossing the Potomac River into Harpers Ferry, Va. (now W.Va.), on its way westward. The railroad—alas, no longer under its original, historic, style—operates over this crossing to the present day. In the ensuing 164 years it has produced one of the nation's most interesting sagas ever of bridge and railroad engineering, for the line has made this interstate transit on no fewer than four different bridges following three separate and distinct alignments, examined below in sequence:

The B&O's Potomac River crossing, with its three different alignments. HAER photograph by William E. Barrett, 1970.

I. Latrobe-Wernwag

The initial alignment as laid out by the railroad's surveyors left the Maryland shore of the river at the foot of a steep, rocky prominence known as Maryland Heights, made a sharp curve to the left over the C&O Canal, crossed the Potomac into the town just west of the confluence with the Shenandoah, then made an equally tight curve to the right, and continued westward along a trestle between the U.S. Arsenal and the river. The sharpness of these two dog-leg curves from the outset was hard on locomotive running gear and an operational nightmare, slowing train speeds. The first bridge here was a covered timber structure, designed by B&O assistant engineer Benjamin H. Latrobe, Jr., and erected by the famed German-American bridge builder Lewis Wernwag—who likely also played a role in the design. In 1839 the bridge was altered to incorporate the "wye" (also known as the "wide") span, enclosing a mid-river switch forming a junction with the Winchester & Potomac Railroad (later the Valley Branch of the B&O). A major event was replacement in 1851 of the single timber "Winchester" span between the wye and the shore. This was an event of high historical moment, for the 124-foot replacement span was nothing less than the third bridge erected by the railroad's Master of Road, Wendel Bollman, of his new iron truss design and the first of real consequence. Like its predecessor, it consisted of three lines of trussing, for the bridge carried not only the railroad, but a common road, each in its own passageway between two of the lines. The new span was to a large extent still experimental, the end towers being of granite rather than of cast iron as thereafter became the convention for Bollman trusses. So stood the bridge until its total destruction by Confederate troops in June 1861.



Bollman bridge, ca. 1870, looking from Maryland Heights toward Harpers Ferry. Courtesy National Museum of American History, Smithsonian Institution.

II. Bollman

The B&O maintained erratic wartime operations on temporary timber trestling, and as quickly as it was able, erected four permanent spans of Bollman trusses. Harpers Ferry, as one of the most strategic points in the war, changed hands frequently. This usually resulted in destruction of the trestling, although the frequent Potomac "freshets" (floods) carried it away even more often. Each time the long-suffering railroad erected replacements. By 1870 the B&O had been able to repair the wounds of war, and there stood an essentially new, all-iron, Bollman-truss structure, although still following the original tortuous alignment.

III. The 1894 Improvement

Toward century's end, with increasing locomotive weights and wheel bases, and as well a demand for higher running speeds, both the loading limitations of the Bollman trusses and the impossibly short radii of the alignment's two curves had become an insupportable burden for the B&O operating department. An "improvement" in 1894 solved both problems. The rock spur of Maryland Heights was pierced with an 812-ft tunnel, and a new, longer bridge, crossing the river at a considerable skew, was erected on piers directly in line with those of the old bridge to prevent further obstruction of the waterway. This resulted in greatly eased curves on both sides of the river. The bridge, a combination of steel Pratt through trusses and plate girders, permitted the heaviest loadings of the day. The west end of the new bridge was again "wyed" for the B&O's Valley Branch. Upon completion of this project, the railroad sections of the Bollman spans were removed, leaving it solely a highway bridge, which it remained until washed out in the disastrous flood of 1936.

Portal of highway section of Bollman bridge, 1933, with railroad section removed. Courtesy National Museum of American History, Smithsonian Institution.

IV. The 1930-31 Improvement

Even with the crossing's relieved curvature of the 1894 improvement, there remained moderately severe turns as the line left the Maryland shore and then entered West Virginia, a continued operational restriction. The B&O engineering department produced an ultimate solution in 1930-31 with a further improvement. By erecting yet another, longer bridge—a series of deck plate-girders—at an even greater skew to the river, and "bell-mouthing" the river end of the 1894 tunnel, the alignment from the Maryland side and across the river became essentially a tangent, eliminating one of the curves. On the West Virginia side the line was swung well inland, away from the river edge, on a sweeping curve of generous radius. The result was that non-stop trains could pass through this previously problematic point at nearly full speed. The 1894 bridge was retained to provide continued access to the Valley line, switching from the newly routed mainline just outside the tunnel portal.

The Crossing Today

The collective result of these projects is an apparently unique living exhibit of bridge and railroad engineering. The three alignments are readily visible on the ground: the two most recent bridges are right there, in service, on their respective alignments; the two iterations of the tunnel also evident. The 1894 bridge is fully accessible by a formal fenced footpath. The original Latrobe-Wernwag-Bollman alignment also is there to be seen, in the form of the surviving stone abutments and river piers, including the curiously wide pier at the west end of the wye span. There even survive a few bits of the Bollman bridge itself. After its loss to the river in 1936, its salvage was not rigorously pursued, for during a spell of uncommonly low water in the mid-1980s a number of its parts emerged to view near the West Virginia abutment. The National Park Service, custodians of much of the Harpers Ferry area, had the wisdom to recover these. They then were recorded by the Historic American Engineering Record and from them a representative portal of the West Virginia end of the bridge has been erected in one of the NPS's exhibition buildings on the town's main street. This remarkable, industrial-archeologically significant three-alignment, four-bridge river crossing has been recognized by its placement, in 1978, on the National Register of Historic Places, presumably the only such entry!

Sources

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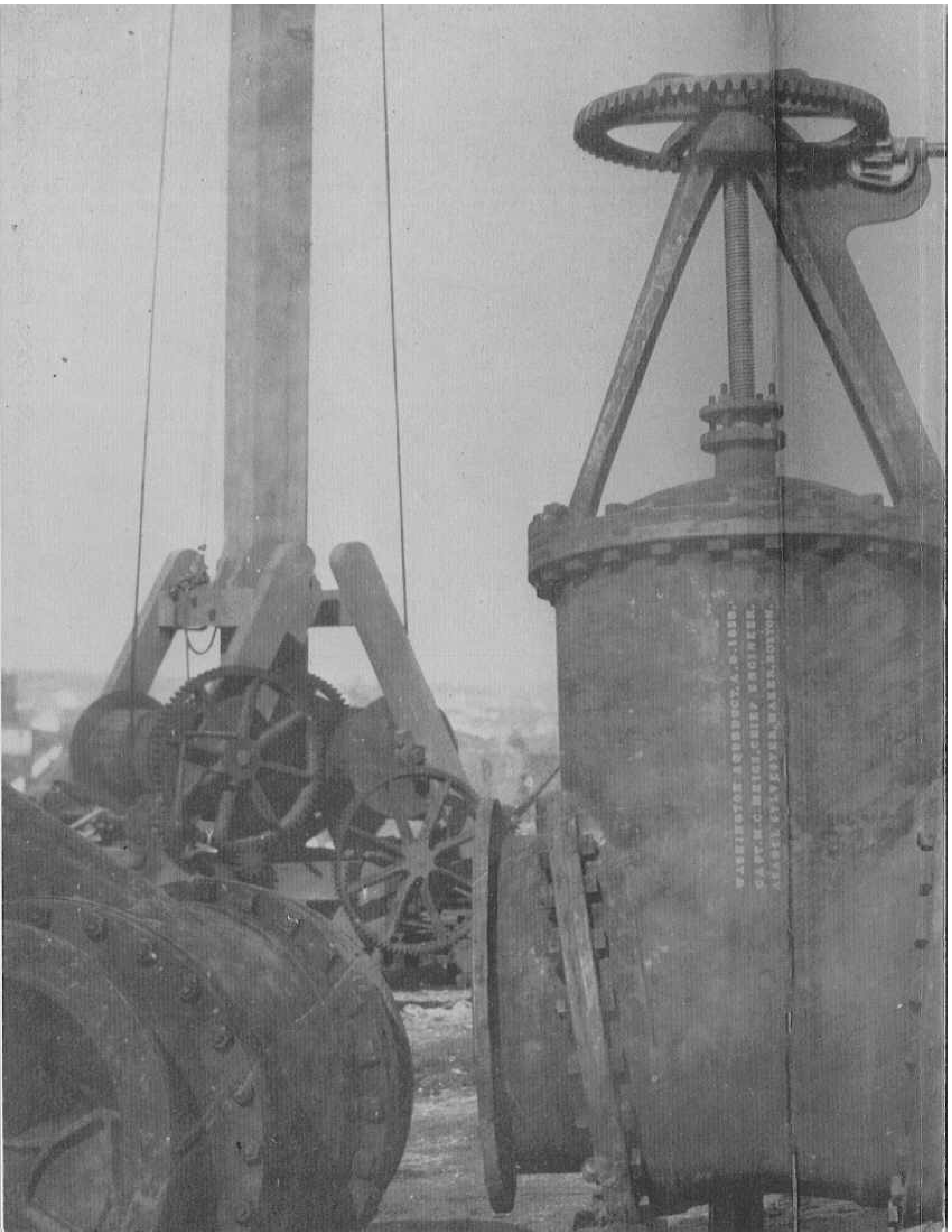
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CAPT. M.C. MEIGS, CHIEF ENGINEER.