

Wheeling Suspension Bridge
Spanning the Eastern Channel of
the Ohio River
Wheeling
Ohio County
West Virginia

HAER No. WV-2

HAER
WVA,
35-WHEEL,
35-

PHOTOGRAPHS

MEASURED DRAWINGS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C.
20013-7127

HAER
WVA,
35-WHEEL,
35-

HISTORIC AMERICAN ENGINEERING RECORD

INDEX TO PHOTOGRAPHS

Wheeling Suspension Bridge
U.S. Route 40, Spanning the Ohio River
Wheeling
Ohio County
West Virginia

HAER No. WV-2

William E. Barrett, Photographer for photos WV-2-1 to WV-2-38, 1976

- WV-2-1 OVERALL VIEW OF BRIDGE, WITH MADISON IN FOREGROUND, LOOKING NORTHEAST.
- WV-2-2 GENERAL VIEW OF BRIDGE WITH DOWNTOWN WHEELING IN FOREGROUND.
- WV-2-3 GENERAL VIEW OF MADISON HALF OF BRIDGE, LOOKING SOUTHWEST.
- WV-2-4 NORTH ELEVATION OF WHEELING HALF OF BRIDGE.
- WV-2-5 NORTH ELEVATION, CENTER PORTION OF BRIDGE.
- WV-2-6 NORTH ELEVATION, CENTER AND WEST-CENTER PORTION OF BRIDGE.
- WV-2-7 NORTH ELEVATION OF WHEELING (EAST) HALF OF BRIDGE.
- WV-2-8 NORTH ELEVATION OF MADISON (WEST) HALF OF BRIDGE.
- WV-2-9 NORTH ELEVATION OF MADISON HALF OF BRIDGE.
- WV-2-10 NORTH ELEVATION OF MADISON HALF OF BRIDGE.
- WV-2-11 CENTER PORTION OF WHEELING (EAST) ~~HALF~~ OF BRIDGE, LOOKING SOUTH.
- WV-2-12 THREE-QUARTER VIEW OF BRIDGE, LOOKING SOUTHWEST, TOWARDS MADISON.
- WV-2-13 THREE-QUARTER VIEW OF BRIDGE, LOOKING TOWARDS MADISON.
- WV-2-14 SOUTH ELEVATION VIEW OF MADISON HALF OF BRIDGE, WITH AUXILIARY SWAY BRACING ANCHOR IN FOREGROUND.
- WV-2-15 VIEW OF MADISON TOWER FROM MID-SPAN, SHOWING CAR AND PEDESTRIAN.
- WV-2-16 VIEW TOWARDS MADISON TOWER FROM MID-SPAN.
- WV-2-17 VIEW OF MADISON TOWER FROM NORTHERN SIDEWALK AT MID-SPAN.

- WV-2-18 VIEW OF MADISON TOWER FROM CENTER OF ROADWAY AT MID-SPAN.
- WV-2-19 VIEW TOWARDS MADISON TOWER FROM MID-SPAN.
- WV-2-20 VIEW TOWARDS MADISON TOWER FROM SIDEWALK AT MID-SPAN.
- WV-2-21 VIEW OF MADISON TOWER LOOKING TOWARDS WHEELING.
- WV-2-22 ELEVATION VIEW OF MADISON TOWER AND NORTH CABLE TOWER.
- WV-2-23 VIEW OF WHEELING TOWER FROM NORTHERN SIDEWALK AT MID-SPAN.
- WV-2-24 VIEW OF WHEELING TOWER FROM MID-SPAN.
- WV-2-25 VIEW OF WHEELING TOWER FROM CENTER OF ROADWAY AT MID-SPAN.
- WV-2-26 VIEW OF WHEELING TOWER FROM MID-SPAN.
- WV-2-27 VIEW LOOKING TOWARDS WHEELING TOWER FROM CENTER SPAN.
- WV-2-28 VIEW OF WHEELING TOWER FROM APPROACH ROAD.
- WV-2-29 GENERAL VIEW OF BRIDGE LOOKING TOWARDS MADISON, WITH WHEELING TOWER IN FOREGROUND.
- WV-2-30 DETAIL VIEW OF TOWER.
- WV-2-31 DETAIL VIEW OF NORTH SIDE OF TOWER IN WHEELING.
- WV-2-32 DETAIL VIEW OF SOUTH SIDE OF TOWER IN WHEELING.
- WV-2-33 DETAIL VIEW OF TOP OF WHEELING TOWER.
- WV-2-34 DETAIL VIEW OF DECK TRUSS.
- WV-2-35 DETAIL VIEW OF NORTH CABLE ANCHOR IN WHEELING.
- WV-2-36 DETAIL VIEW OF ANCHOR FOR AUXILIARY SWAY BRACING.
- WV-2-37 DETAIL VIEW OF DECK TRUSS.
- WV-2-38 DETAIL VIEW OF BASE OF TOWER.
- Jack E. Boucher, Photographer for photos WV-2-39 to WV-2-56, March, 1977
- WV-2-39 VIEW OF EAST TOWER, LOOKING WEST.
- WV-2-40 VIEW OF EAST TOWER, LOOKING SOUTHWEST.

WV-2-41 DETAIL OF TOP OF EAST TOWER.

WV-2-42 VIEW LOOKING WEST ACROSS BRIDGE FROM TOP OF EAST TOWER.

WV-2-43 DETAIL SHOWING EAST END CABLE HOUSING.

WV-2-44 VIEW THROUGH UPPER PORTION OF EAST TOWER ARCH, LOOKING WEST AT
ROADWAY AND SUSPENSION CABLES.

WV-2-45 VIEW THROUGH ARCH OF EAST TOWER, LOOKING WEST AT ROADWAY AND
SUSPENSION CABLES.

WV-2-46 VIEW THROUGH ARCH OF EAST TOWER, LOOKING WEST AT ROADWAY AND
SUSPENSION CABLES.

WV-2-47 VIEW FROM ROADWAY THROUGH ARCH OF EAST TOWER

WV-2-48 GENERAL VIEW OF BRIDGE, FROM NORTHEAST.

WV-2-49 PERSPECTIVE VIEW OF BRIDGE, FROM NORTHEAST.

WV-2-50 VIEW OF BRIDGE, FROM NORTHEAST.

WV-2-51 VIEW LOOKING ALONG NORTH SIDE OF BRIDGE.

WV-2-52 VIEW OF BRIDGE, FROM NORTHEAST.

WV-2-53 VIEW OF WEST TOWER FROM SHORE.

WV-2-54 VIEW OF WEST TOWER FROM WESTERN APPROACH ROAD.

WV-2-55 VIEW OF WEST TOWER FROM MID-SPAN.

WV-2-56 GENERAL VIEW OF BRIDGE FROM WEST SHORE.

HISTORIC AMERICAN ENGINEERING RECORD

HAER
WVA,
35-WHEEL,
35-

Wheeling Suspension Bridge

HAER No. WV-2

Location: Spanning the eastern channel of the Ohio River at Wheeling, Ohio County, West Virginia

Date of Construction: Original span completed October 20, 1849

Builder/Designer: Charles Ellet

Present Owner: State of West Virginia

Significance: Oldest vehicular suspension bridge still in operation in the world; span in excess of 1,000 feet. First bridge built crossing the Ohio River. Originally designed and built by Charles Ellet in 1849, it was often called the father of modern American suspension bridges. In 1969 it was designated an ASCE National Engineering Landmark, and a U.S. National Historic Landmark in 1976. The Wheeling Bridge is perhaps the most important extant antebellum civil engineering structure in North America.

Historian: Clifford M. Lewis, with technical assistance from Emory L. Kemp, A.S.C.E.

Transmitted by: Jean P. Yearby, HAER, 1987

Connecting West Virginia with Ohio, the Wheeling Suspension Bridge stands as a symbol of technological progress in the midst of the industrial revolution. It is the crowning achievement of a brilliant man whose reputation was late in emerging from the shadows of obscurity--Charles Ellet, Jr.¹ The decision to build the bridge occurred in the context of a rivalry between Pittsburgh, Pennsylvania, and Wheeling, West Virginia, in the days when Wheeling was still making a bid to become one of the transportation and industrial centers of the West.² The ensuing argument over its construction at Wheeling concluded with a landmark decision by the U.S. Supreme Court.

On June 21, 1969, the American Society of Civil Engineers designated the bridge a National Engineering Landmark, and on July 4, 1976 the National Park Service designated it a National Historic Landmark. It has been described as the oldest vehicular suspension bridge still in operation. With a span in excess of 1,000, it was the longest suspension bridge in the world at the time of its erection, surpassing the Fribourg, Switzerland, Gran Pont Bridge (completed in 1834) by 114 feet.³ The Wheeling Suspension Bridge was the first bridge to effect a crossing of the Ohio River, one of the world's busiest rivers. Its dramatic destruction by wind in 1854 provided engineers with the best object lesson in the aerodynamics of bridges until the collapse of the Tacoma Narrows Bridge in 1940.⁴

The history of the Wheeling Bridge, is the folk tale of a great local enterprise, when people in a small city of 13,000 resolutely mustered the capital to attract the pioneering B & O Railroad to Wheeling and dared to risk their own money in backing a venture so great and innovative as a suspension bridge more than a thousand feet long.⁵ Charles Ellet, as distinguished a designer of railroads as of bridges, was identified with every aspect of this local effort. He influenced the routing of the B & O along Grave Creek to the Ohio River and designing the bridge itself in almost every detail.⁶

The possibility of a bridge spanning the Ohio River had been the preoccupation of the people of Wheeling for decades. It was in the mind of Ebenezer Zane, founder of Wheeling, when he laid out Zane's Trace from Wheeling to Limestone, Kentucky, in 1797.⁷ Ellet was only a six-year-old farm boy in Bucks County, Pennsylvania, when in 1816, a charter was granted to the Wheeling & Belmont Bridge Company for the erection of the National Road from Cumberland to Wheeling. Virginia planters were loath to spend tax money on schemes as far distant as Wheeling, and although a start had been made on the western channel portion as late as 1836, no bridge had been completed over either channel between Wheeling (Zane's) Island and the eastern and western shores.⁸ But this was the year Charles Ellet turned his thoughts to the Ohio River. In communication with Henry Moore of Wheeling, he submitted a sketch of a suspension bridge across the east channel to the Ohio River at this city.⁹

CHARLES ELLET

Charles Ellet had no formal early education and, in his youth, learned what he knew from his mother and other members of the family.¹⁰ At the age of 17, he

had a desire to become a civil engineer. He became a "rod man" on the Susquehanna branch canal and later, for two years, was assistant engineer on the Chesapeake and Ohio Canal, during which time he also studied foreign languages. Encouraged by his mother, who recognized his facility in mathematics, he took passage for Europe in 1830. With the help of Marquis de Lafayette (no stranger to Wheeling) and American Ambassador Rives, he enrolled in the Ecole des Ponts et Chaussées, which served as a graduate school for engineers who had passed through the polytechnic school. During his year and a half in Europe, Ellet toured several countries, learning a great deal from observation, publications, and conversations about railroads, waterways and bridges. Ironically, it was in Europe that he fell in love with a type of bridge which had been developed in its modern form in Wheeling's backyard by a country justice-of-the-peace, James Finley.¹¹ Finley had built his first of some forty small chain suspension bridges in 1796, near Uniontown, Pennsylvania. As Ellet explained the principle, "The suspension bridge enables a light and weak structure to yield repeatedly to a heavy body passing over it, to acquire a new state of equilibrium and return to its former situation as soon as the disturbing force is withdrawn."¹²

THE BRIDGE PROPOSAL

Obviously, the inexpensive but durable characteristics of the suspension bridge, along with its freedom from pillars, would attract the attention of Wheeling capitalists working within the limitations of local funding. There were in America at that time only two engineers with enough experience in suspension bridge building, Charles Ellet and John Roebling.¹³ In 1841, Ellet took time off from his supervision of work on a 357-foot suspension bridge over the Schuylkill River at Fairmount, Philadelphia, and visited Wheeling. He proposed to build a suspension span for \$130,000.¹⁴ Roebling, a native of Germany but later of Saxonburg, north of Pittsburgh, came to Wheeling in 1845 and made a proposal of \$150,000, which he was able to reduce the following year to \$130,000 by leaving out certain ornamentation.¹⁵

As the prospect of a Wheeling terminus of the National Road promoted interest in the original charter of 1816, so the prospective arrival of the Baltimore and Ohio Railroad¹⁶ probably influenced the local leadership to prepare for it by reorganizing the bridge company and obtaining a new charter of March 19, 1847.¹⁷ The wooden bridge was finally completed across the western channel in 1837 by the Zanes and the road across the island were absorbed into the new stock company, capitalized at \$200,000, and in 1848 increased to \$210,000.¹⁸

The directors of the new organization were James Baker, Henry Moore, F. W. Stevens, W. T. Selby, John McGill, William Paxton, Thomas Hughes, and Daniel C. List, with Thomas Sweeney as president. The directors of the North Western Bank of Virginia and the Merchants' and Mechanics' Bank of Wheeling, with stockholders' consent, were permitted to acquire up to one thousand shares of stock for each bank. The company was granted the right of way across the island and ferry rights to the Virginia shore at Wheeling. Most importantly, the company was given the right to erect and keep a wire suspension toll bridge between Zane's Island and the Virginia shore or bank.

A significant provision of the charter pertained to height, a factor that was to enter into litigation reaching the Supreme Court with challenging questions involving constitutional law.¹⁹

If the said bridge mentioned in the eighth section of this act, shall be so erected as to obstruct the navigation of the Ohio River in the usual manner by such steamboats and other crafts as are now commonly accustomed to navigate the same when the River shall be as high as the highest floods therein heretofore known, then unless, upon such obstruction being found to exist, such obstruction shall be immediately removed or remedied, the said last mentioned bridge may be treated as a public nuisance and abated accordingly.

In May of 1847, the directors invited Ellet and Roebling to appear before the board and present plans and estimates of cost. Roebling appeared on May 29 and July 13, on the latter date presenting three different plans for the bridge, one involving a 600-foot span with two abutments placed in the river.²⁰ Ellet presented his plan on July 2. The plans were too dissimilar to permit adequate cost comparisons. The directors, therefore, asked Roebling to estimate a 24-foot bridge, in addition to the 26-foot structure he had already described. Ellet was also asked to estimate on 24- and 26-feet, in addition to the 22 feet he had recommended. After an exchange of telegrams, the board chose Ellet as engineer.²¹ The announcement brought a flurry of congratulatory notices in southern and eastern newspapers. On December 27, Ellet informed the board that he would accept 200 shares of stock in lieu of a \$5,000 salary for his services, a custom he followed in other negotiations. This already-known prospect may have influenced the board vote of 7-1 in his favor, not because of the amount of the investment but because it reflected his confidence in his own work.²²

Threats of suit against the bridge on the part of Pittsburgh interests must be the explanation for the speed with which the directors acted. On June 2, only four days after Roebling's first appearance and before any contract was signed, they ordered timber, based on his plan.

In September, the directors requested Louisville hydraulic cement, possibly never delivered, and purchased a steamship for service to the operation at \$2,400. They ordered stone delivered by a Mr. Cawley (also spelled Crolley) from quarries during the winter.²³ A spot on Zane's Island was reserved for the making of the cables, which were assembled on the ground before being lifted into place. This work was contracted to Richards and Bodley, who started to make their first cable in April.²⁴ Madison Street (now 10th Street), from the river to Main Street, was purchased from the city. Kelly & Miller originally received the contract for the erection of the stonework.²⁵

THE BRIDGE

Ellet assured the City Council of Wheeling that although no span of that length had been previously attempted, the laws governing its equilibrium were known and could be measured accurately. He described the span as 1,010 feet.

from center to center of the supporting towers and 97 feet (93 as built) above the low water surface of the Ohio River. He estimated the record-breaking flood of 1832 at 44.5 feet and claimed that the flooring of the bridge would be high enough to permit the passage of a steamboat having a stack 50 feet above flood water. He estimated the eastern tower to be 153.5 feet above the water, 60 feet above the abutment supporting it, and 21.75 feet above the summit of the western tower. The flooring was 24 feet wide, with a 17.5 foot roadway and foot-walks on either side. The flooring was supported by 12 cables of iron wire, each 4 inches in diameter and 1,380 feet long. The cables rested on iron rollers placed on the summits of the columns, moving back and forth slightly in response to the contraction and expansion of the metals and loads placed upon the flooring. The towers were inclined from the vertical to bring the resultants of all forces, including the moment of the towers themselves, to the center of the base.

Each cable was to be composed of 550 strands of No. 10 wire, and the cables were paired, with three pairs on each side. Ellet provided for 593,400 pounds of live load, or that represented by 1.6 six-horse loads wagons and 500 people occupying the bridge at one time.²⁶ Another representation was that of 700 head of cattle or an army of 4,000 men. The weight of the bridge itself (dead load) was calculated at 920 pounds per linear foot and the transitory load at 618 pounds per linear foot. He estimated that the cables would be three times as strong as the weight of the bridge itself and three times the additional tension produced by the load upon the flooring. The twelve cables were each 1,380 feet in length and contained 455,500 pounds of wire. The cables were to terminate in chambers in the fastening walls and were arranged to give easy access at the points of connection. From the chambers, heavy bars were continued 60 to 65 feet into the masonry of the wing-walls on the west and into Main Street walls (actually 26 feet deep) on the east and so secured that they could not be moved without collapsing the whole wall.

"The cables and all the iron work will be manufactured at Wheeling, of the best material that the country affords." The columns of stone were not equal in height, the western being 69.75 feet and the eastern 60 feet in height. The bridge that was built corresponds closely to Ellet's description.

In view of the fact that railroads on both sides of the Ohio River would soon be joined in Wheeling, Ellet set forth the facts concerning the serviceability of the Wheeling Bridge to carry railroad traffic. Although he believed suspension bridges were capable of supporting this type of traffic and asserted that for an additional \$30,000 the Wheeling structure would accommodate a railroad, he seemed to express caution by warning not to allow more than isolated railroad engines on the bridge.²⁷ Railway cars were to be horse drawn. The directors of the bridge undoubtedly wanted the rail traffic. On April 17, 1848, they voted additional anchor irons sufficient to bear a railroad train. Early in 1854, the Hempfield Railroad, which eventually under another name connected Wheeling with Greensburg, Pennsylvania, by way of Washington, Pennsylvania, petitioned to be allowed to cross the bridge, while a contract was signed with the Cleveland and Pittsburgh Railroad, which later had a passenger station in Bridgeport, West Virginia.²⁸ The object of the contract is not indicated in the minutes, but

the Citizen's Railway Company completed 1,866 operated horse-drawn street cars across the bridge to the station.²⁹ The plans to run trains across the bridge were given up when the B & O chose to build a better situated bridge across the Ohio River to Bellaire. It is not difficult to conceive that multiple uses would have caused multiple inconveniences. Another utility that took advantage of the existence of the bridge was a telegraph company which, however, had difficulty meeting its rental obligation.³⁰

During 1848, Ellet commuted back and forth between Niagara Falls and Wheeling, over exceedingly rough roads, for he had been granted a contract, in competition with Roebling, to erect a combined railroad and carriage bridge across the Niagara River Gorge.³¹ Wheelingites as well as others were thrilled to read about his exploits--how he solved the problem of getting his first line across the gorge by attracting boys into a kite-flying contest; how he was pulled across the chasm on a single wire, and how he drove a horse and carriage across his 7.5 foot wooden service bridge, even before most of the side rails had been installed. This period was marked by constant bickering and litigation with his Niagara backers, characteristic of such enterprises in that age. It is entirely to the credit of the Wheeling Bridge directors that they worked so harmoniously with each other and with others, not even censoring him, at least officially, when the Wheeling Bridge later fell. The Niagara directors dismissed Ellet with a settlement estimated at \$10,000. They then engaged John Roebling, who used Ellet's service bridge from which to build a two-deck suspension facility, the railroad running over the head of frightened carriage passengers.

Wheeling people were properly conscious of their bridge's place in history. As the day of temporary bridging of the river drew near, the Daily Gazette had this to say:³²

At the time of writing this, the foot bridge is nearly completed, and before this number of our paper goes to press, a crossing will be effected over and high above the broad expanse of the Ohio River; by means of the longest span (1,010) ever projected in the world!

The operation of stretching the cables, as well as all the previous operations upon this stupendous structure, are of the most ponderous and Herculean magnitude; but the skill and genius of the Superintendent Engineer, Chas. Ellet, Esq., as well as the skill and intrepidity of his workmen, have rendered them comparatively easy, and thus far entirely successful, and unattended by any accident.

On October 1, when the last cable had been brought over and anchored, the same paper gave forth with this prophetic paean:³³

Centuries will roll away, another and another chain will be thrown over the Ohio and the Father of Waters, yet this work will stand and throw a halo of glory around the names of those who executed it, and the people in whose midst it was constructed, as the pioneers on this species of improvement.

The Wheeling Suspension Bridge was officially completed on Saturday, October 20, 1849, and although the timing had not been completely verified, "the city was alive with strangers, and people from the surrounding country, thronging the shore on the other side of the river, anxious to behold the magnificent ceremony of joining Virginia and Ohio in perpetual union, by means of the longest and most beautiful span ever projected in the world."³⁴ With the Stars and Stripes fluttering from the eastern tower and the Ohio flag floating from the western tower, the workmen joined the last timber of the floor in the middle of the span, and at 10:30 a.m., Messrs. Charles Ellet and Joseph Dickinson, superintendent of stone and iron work, seated in a one-horse carriage, while the crowd watched with breathless anxiety, drove their carriage like a triumphal chariot at a dizzy height through the air. "The roar of cannon announced its safe arrival at the western shore, and a long and triumphant shout broke from the thousands of delighted spectators. This was followed by Gen. Tom Thumb's heavy two-horse vehicle drawn by Shetland ponies presented by Queen Victoria." Tom Thumb himself was late in arriving, but the Daily Wheeling Gazette pronounced the day beautiful, "a triumph of which the people of Wheeling, and indeed of which those in all parts of the United States may justly feel proud."³⁵

THE OPENING

The October 20 celebration was but a warmup for the formal opening and its festivities on November 15. This day was punctuated by the music of the Zanesville band and the firing of cannons. A continuous train of people moved over the bridge from 3 o'clock until dark.³⁶

At 6 o'clock, the thousand lamps, hung up on the wires, were lighted almost simulanteously and presented an elegant and graceful curve of fire, high above the river, that was never excelled in beauty. It forcibly reminded one of Mr. Clay's remarks, a few days since, when looking at the work from a distance, while his face flowed with pride and exultation--"Take that down! You might as well try to take down the rainbow."

Ohio and Indiana leaders were conspicuous in the crowd, and it was the Hon. R. W. Thompson of Indiana, dubbed by the Gazette as the "lion of the Pacific Railroad Convention," who in his address on the rostrum in front of the Monroe House "let the cat out of the bag" and revealed the dreams the railroad men were having concerning the bridge:³⁷

We have heard of your bridge in Indiana and we have not been ignorant of its progress and its purposes. Let me assure you that in that State a series of railroads are steadily tending towards one great thoroughfare, and pointing unerringly as the needle points to the poll, to the West end of that bridge.!

In the day of ecological awareness, the toast to Ellet has an ironic twist:³⁸

Charles Ellet, Jr.--The fame of his genius will be as enduring as the towers he has erected, and as pure as the beautiful river he has spanned.

One of the ditties sung on the occasion ended with the following verse aimed at Pittsburgh's threat to destroy the bridge, within or without the law.³⁹

You'll find in law your great mistake.
And this will be a pity,
Too late alas, a light will break
Upon your Smoky City.
Then don't hold out about the route,
Ere eighteen fifty-four,
You will see stars when you hear cars
Come in from Baltimore.
Then give us the track, the railroad track,
From here to the eastern shore;
O give us the track to carry us back
From Wheeling to Baltimore.

THE LEGAL BATTLE

Now that the bridge was up, Pittsburgh's strategy shifted from that of injunction to abatement.⁴⁰ Pennsylvania's original action had been a request for an injunction against the bridge company and its agents. The appeal was to Supreme Court Justice Grier, a native of Pittsburgh, filed in the United States Court of Philadelphia, August 16, 1849. On this occasion, Justice Grier ordered the controversy transferred to the United States Supreme Court, while Pennsylvania filed a bill in equity seeking an injunction, and after completion of the bridge a supplemental bill seeking its abatement. The chief arguments advanced by Pennsylvania, in and out of court, came down to the following:⁴¹

- 1) the 1000 miles of Ohio River constitute the main channel of inland commerce in the United States;
- 2) Pennsylvania has invested huge sums of money on a system of canals and railroads linking the Ohio with the Atlantic and bringing to the Ohio River the greater share of \$50,000,000 in revenue and 30,000 passengers;
- 3) contributing to its "wealth and honor" are steamboats that ply the Ohio as far as New Orleans;
- 4) most pertinent to the case in hand is the traffic between Cincinnati and Pittsburgh carrying 168,000 passengers and 80,000 tons of freight in 1849;
- 5) one-third of the above traffic is carried by seven large packets with stacks 75 to 85 feet above the water, essential to swift and efficient navigation;
- 6) Pittsburgh is the leading state on the river in boat-building--50 in 1849 alone--while two ocean-going vessels currently under construction could never get under the bridge, and thus the whole industry is threatened;
- 7) all the giant packets would have been halted during the 32-1/2-foot flood of January 15, 1849, far below the record flood of 45 feet. One stack was

ripped by a spike on the suspension bridge, two stacks were cut down and mutilated in order to get through and, in some cases, passengers have been transferred to other vessels in Wheeling, causing delays and inconveniences;

- 8) bridges over both channels are in violation of international, national,⁴² and state law, which has been constantly disregarded by the Wheeling and Belmont Bridge Company in building a low bridge without a draw over the western channel and then a bridge which is too low across the eastern channel. The bridge elevation slants sharply toward the island and the eastern side is so low that stacks would have to be hinged at great expense and some danger;
- 9) the rights of citizens to free navigation are rights which states have the ability and duty to protect; when a state becomes a party to a suit, the Supreme Court has original jurisdiction;
- 10) the bridge could have been built in such a way as to accommodate the steamships, which have a right not only to the water but the air above it, as is needed for navigation;⁴³
- 11) if the right to regulate stacks is granted, there is nothing to prevent governments from regulating width, type of propulsion, or any other aspect of propulsion;
- 12) while it is true that stacks are hinged to permit smaller Pittsburgh boats to go under the stone bridge connected with the Louisville canal and locks, this is tolerated because of the contribution made by Louisville interests in making navigation possible around the falls of the Ohio and because of private rather than public property involved there;
- 13) there is no proportion between the advantage to be gained from the bridge compared to free navigation. The river can be crossed more easily and less expansively by a ferry than by a bridge. The bridge employs only two toll keepers and a few persons occasionally for maintenance. It did not cost as much as the seven Pittsburgh giant packets, which must be replaced every five years and which give employment to five hundred persons. The packets travel five hundred miles compared to the thousand feet traversed by those using the bridge;
- 14) if the bridge is to accommodate a railroad, remember that the railroad is, by nature, a monopoly whose right-of-way depends upon government preferment, whereas free competition reigns on the river. Bridging would give a preferment to Baltimore with which Pennsylvania could not compete;⁴⁴
- 15) a dangerous precedent would be established, with other bridges flung across the Ohio River, and even now Cincinnati is planning its own bridge;⁴⁵
- 16) it is true that low bridges have been built across the Monongahela, but they were erected before progress created higher stacks and, after all, they only interfere with Pennsylvania business.⁴⁶

To overcome the impression that the suit really involved only a few citizens and to make sure that the Supreme Court would have jurisdiction over the case, both houses of the Pennsylvania legislature were asked to concur in a resolution directing the State's Attorney General to bring the action.

Wheeling people undoubtedly respected the right of free use of the river. They too had a stake in what transpired lower down the river and had their own

free navigation to worry about, both above and below the bridge.⁴⁷ They knew that the Monongahela bridges did affect interstate commerce. They were probably not aware that in a few years more dams would be built and a tremendous tonnage of coal would be shipped on that river from West Virginia mines.

Wheelingites believed that the practicality of hinging stacks had already been demonstrated, as at Louisville, and that it was reasonable to call a halt to "chimney" height at some point, else bridging anywhere would become impossible and the Ohio River would become an obstacle to national development. They questioned the sincerity and minimized the claims of Pittsburghers reporting inconveniences experienced at Wheeling, situated fifty miles from Pittsburgh and in another state.

Wheeling also believed that freedom of navigation was not without its limitations when it conflicted with equal or greater rights, including the right to deliver United States mail, impeded an average of more than 24 days a year by ice floes in the Ohio River, and the right of the government to transport troops and equipment. (How essential the latter right was, the Civil War demonstrated, when the B & O had to ferry Hooker's troops and supplies across the river at Bellaire when he was rushed to the relief of the Union Army in Tennessee.)

Wheeling strategy and approach was intensely practical and therefore political. The first move was to get the Virginia Assembly to declare the bridge of lawful height. Wheeling denied the corporate capacity of Pennsylvania to bring suit, partly because the bridge was located within the sovereign power of Virginia. Ellet, whose tongue and pen were always prolific, exercised both in behalf of the bridge and suggested the main lines of strategy.⁴⁸ He had vitriolic exchanges with Edwin M. Stanton, a native of Steubenville, who had taken up residence in Pittsburgh and was later Secretary of War. Stanton was chief counsel for the Pennsylvania interests. R. H. Walworth, former chancellor of the State of New York, was appointed commissioner to examine the evidence. He reported a great conflict in the testimony of witnesses but observed that a preponderance of testimony indicated danger to navigation. He suggested the possibility of a draw in the bridge to avoid obstruction, but an engineer consulted by the Court reported that no draw in a bridge over either channel would create a safe and convenient passage for the large steamers.⁴⁹

The majority opinion of the Court, given in May 1852, was written by Associate Justice McLean of Cincinnati, and was favorable to Pennsylvania. The majority held that the bridge was an obstruction to navigation; that it was in violation of acts of Congress and could not be authorized or protected by Virginia; that competition between railroads and waterways might have beneficial results, but that railroads would never supersede waterways.

The bridge was permitted to remain, if raised, to a height of 111 feet above low water for a distance of 300 feet across the main channel, or altered in some way so as not to interfere with navigation. But everyone knew that the height prescribed would prevent the bridge from being used by railroads, while

the alterations suggested for the western channel, if possible, would necessitate great additional expense.

Chief Justice Taney and Associate Justice Daniel wrote separate dissenting opinions. In fact, the Wheeling bridge cases occasioned 14 distinct opinions written by members of the Supreme Court. Daniel dealt with the case from the standpoint of state and local economic rivalry. He concluded from the majority decision that any new economic advantage might become the occasion for a suit by an aggrieved industry in another state. He gave a hypothetical example of the effect that might be created on Pennsylvania transportation if a railroad should finally link the eastern seaboard with the Ohio River at Point Pleasant, a prospect, in fact, even then being entertained by Ellet and many others.

Taney, basing his opinion on *Willson vs. Blackbird Creek Marsh Co.*, held that a bridge such as Wheeling's could not be regarded as a nuisance without specific legislation by Congress.⁵⁰ He believed that Congress was in a better position than the Supreme Court to determine details falling within its constitutional power.⁵¹

Undaunted by the adverse decision and backed by the legislatures of Virginia and Indiana, Wheeling appealed to the United States Congress to make the bridge part of a postal and military road.⁵² The request had considerable support among the states' rights advocates and a large minority of Ohioans who lived in sections favorable to a railroad crossing at Wheeling rather than Pittsburgh.

On August 31, 1852, the U. S. Congress, as a rider to the Post Office appropriations bill, approved the bridge as a post road and of legal height. Obviously, Congress had adopted the philosophy of the minority opinion. Almost equally surprising was the Supreme Court's seeming acquiescence in the same philosophy.

After the bridge fell in 1854, Pennsylvania again appealed to Justice Grier of the Supreme Court for an injunction enjoining the bridge company from rebuilding the structure. Justice Grier granted the injunction during the court's vacation, but Ellet and the directors ignored it. In a sharply divided vote, the court held that Congress had power to validate a structure previously declared unacceptable. The various points of legal disagreement remain applicable to modern problems facing the courts.⁵³

The minutes of the bridge company contain many references to payment for legal services and for travel in connection with the case, chiefly in collecting testimony. Along those receiving payments were Reverdy Johnson and Alexander H.H. Stuart, prominent Whigs, both supporters of the bridge.⁵⁴

Ellet complained that the opposition had called only one person who combined practical knowledge with scientific theory. He believed that this man, none other than John Roebling, had been called by Pittsburgh interests on the assumption that he had had some disagreement with the bridge company. Much to everyone's surprise, Roebling denounced the high chimneys as objectionable in

every way, and "if they could be forced from our rivers by some low bridge, it would be the greatest service which could be rendered to the navigation of the western waters."⁵⁵

By 1852, court costs and other expenses led the directors to seek a \$300,000 ceiling on bridge stock, in addition to \$100,000 borrowing power to meet expenses. What had started out to be a good investment became, instead, a financial drain. Tolls were raised on some classifications, lowered on others. The original charges had been as follows:⁵⁶

foot passengers to and from the island	5¢
man and horse	10¢
1-horse carriage or wagon	15¢
1-horse dray	25¢
2-horse dray	35¢
1-horse cart	15¢
2-horse cart	25¢
2-horse carriage or wagon	20¢
3-horse wagon	25¢
4-horse wagon	40¢
5-horse wagon	60¢
6-horse wagon	75¢

Droves

cattle per head.....	5¢
horse and mules per head each	8¢
hogs and sheep per head	2¢

Tickets

single island foot passenger	50¢ per month
single foot passenger working on the island	\$5.00 per year
family	\$10.00 per year

Stage Coaches

4-horse mail or passenger coach	\$1.25 per month
Western Stages	\$2000.00 per year

A fine of \$5.00 for horses exceeding a walk was established soon after the opening of the bridge.

Hugh Dillon was appointed toll keeper on the Wheeling side at a salary of \$500 plus a residence, and Walker Hunter, keeper at \$400 on the Ohio side.⁵⁷ During a relatively quiet period, Ellet supervised repairs on the west channel bridge and added wing walls to it.

1854 COLLAPSE

A two-year period of peace reigned until May 17, 1854, when a strong wind that had been blowing all day apparently rose in intensity about 3:00 p.m. and sent the bridge to oscillating. The inhabitants had experienced slight undulations

of the bridge before, and seemed to enjoy the sensation they felt from these vibrations. An Intelligencer reporter happened to be on the bridge that fateful afternoon, enjoying the experience. When the bridge began to sway violently, he thought it prudent to leave. Two minutes after leaving the bridge, he saw people running toward the river bank. Retracing his steps, he saw the bridge leaping and, in the next day's paper, gave this classic description of the bridge's death throes.⁵⁸

For a few moments we watched it with breathless anxiety, lunging, like a ship in the storm; at one time it rose to nearly the height of the towers, then fell, and twisted and writhed, and was dashed almost bottom upward. At last there seemed to be a determined twist along the entire span, about one half of the flooring being nearly reversed, and down went the immense structure from its dizzy height to the stream below, with an appalling crash and roar. Nearly the entire structure struck the water at the same instant, dashing up an unbroken column of foam across the river, to the height of at least forty feet!

The reporter observed that on the Wheeling side of the bridge, all except two cables on the north side and one small cable on the south side were torn from their anchorage in the heavy masonry on Main Street, one stone in this masonry weighing 1500 pounds being thrown several feet. The large iron gate at this end was "shivered to atoms," and the toll house completely demolished, the toll keeper making a narrow escape with his life. On the island side, but one cable broke from the anchorage. Only two of the cables snapped asunder, and that at the outside of the towers, the rest of their breakage being at their connection with the anchors.

We witnessed the terrific scene and saw that it was brought about by the violence of the gale. The great body of the flooring and the suspenders, forming something like a basket swung between the towers, was swayed to and fro, like the motion of a pendulum. The cables on the south side were finally blown off the apex of the eastern tower, retaining their position on the opposite side of the river. This destroyed the equilibrium of the swinging body; and each vibration giving it increased momentum, the cables, which sustained the whole structure, were unable to resist a force operating on them in so many different directions, and were literally twisted and wrenched from their fastenings.

First reports of other damage done by the wind were quite impressive, but one suspects that they were influenced by the emotional impact upon the reporter of the collapse of the bridge. Writing from the calmer vantage point of May 23, the Intelligencer reported that "The storm did other damage in the city, but nothing of a serious character." D. B. Steinman, famous bridge builder and Roebling biographer, likened the phenomena exhibited at Wheeling to the behavior of "Galloping Gertie," the Tacoma bridge destroyed by a wind of less than hurricane proportions.⁵⁹ Appearing in Wheeling on May 20, 1956, on the occasion of the reopening of the suspension bridge after renovation and repair, Steinman spoke of the importance of the field of aerodynamics, the

science of gases in motion which he introduced into civil engineering courses in 1918 for the first time in the history of the profession.⁶⁰ Steinman died in 1960 after completing the five-mile-long bridge over the Straits of Mackinac,⁶¹ whose main span is the third largest in the world. Steinman made the following comment on the Wheeling newspaper story:

The newspaper man who wrote the foregoing dramatic account unknowingly summarized the crux of the aero-dynamic phenomenon he had observed when he used the significant phrase: "Each vibration giving it increased momentum." And when he stated that the mechanical solution of the failure "must await further developments," he wrote better than he knew.

From what Steinman said and has written, it is logical to believe that he received his first inspiration to pursue this still mysterious subject of aerodynamics because of the collapse of the Wheeling bridge and John Roebling's astute reflections thereon. Steinman's proposal to help with the designing of Galloping Gertie was dismissed by the Russian-born Moisseff, but there is no bridge builder today who will ignore the Roebling and Steinman principles of stiffening trusses, and inclined and under-floor stays.⁶²

Upon hearing of the Wheeling disaster, Roebling ordered more wire from Trenton for the Niagara span, although he had introduced all of the aforementioned safety factors into the Niagara bridge.⁶³ After months of reflection on the fall of the Wheeling bridge, he wrote concerning its demise with considerable engineering insight, but his advice was forgotten or unheeded.⁶⁴

On the day following the gale, the steamer "Pennsylvania" lowered her stacks in derision as she passed over the wreckage of the bridge. The Intelligencer, cut to the quick by the action, reminded Pittsburghers how Wheelingites had organized a relief expedition when Pittsburgh residents had been prostrated by a disaster.⁶⁵

Reconstruction and Further Litigation

The bridge directors immediately appointed a five-man reconstruction committee who telegraphed Ellet the sad news and asked for two rebuilding plans, one for temporary repair and one for long-range construction.⁶⁶ Ellet came quickly, arriving May 21, and rejected the idea of an abutment in the middle of the river. It was undoubtedly a prick to his pride in the suspension principle, but also an invitation to the Pennsylvania interests to renew their legal attack on the bridge. As it turned out, Pennsylvania did not need any such blatant encouragement. On June 26, 1854, the Attorney General asked Justice Grier for an injunction to stay the reconstruction pending a hearing on whether the reconstruction should conform to the Court's decree at the 1851 term. Thus were bandages removed and old sores probed.

With the Supreme Court being in recess, Justice Grier, with Chief Justice Taney witnessing, granted the injunction on June 28. The action was completely ignored by Wheeling, where Captain William H. McComas was engaged,

under Ellet, to superintend the salvage of much of the bridge and its reconstruction on a one-way traffic basis, with bells at either end to signal all clear from the opposite side.⁶⁷

The steamships Thomas Swann and Courier dragged the wreckage from the river. A ferry was rented from Shively and Smith to fulfill the company's service obligations to the public.⁶⁸

On July 26, a 14-foot version of the bridge was again functioning. Ever ready for a ceremony, Charles Ellet and Captain McComas reinaugurated service by crossing the bridge in a carriage on the morning of July 25.⁶⁹ The temporary span continued to serve until 1859. The long tolerance of the makeshift arrangement is not surprising in view of renewed litigation, followed by the Panic of 1857. At the Supreme Court's December term of 1854, Pennsylvania filed a motion for sequestration against the bridge company for contempt of court and for an attachment against the bridge company officers for their contempt in disregarding the injunction.⁷⁰

The appeal was rejected, and from the decision as given by Justice Nelson, it would appear that Pennsylvania's only possibility of redress, in light of the Congressional action declaring the bridge to be of proper height, would have been an action at law based on damages suffered. The Wheeling officers were acquitted of contempt charges by a 5-4 vote.⁷¹ Justice McLean went back to the original case and asserted his belief that no preference should be given, by any regulation of commerce or revenue, to the ports of the State over those of another.⁷² Justice Daniel, on the other hand, criticized Justice Grier for his injunction on the ground that the Court must act collectively.

The court entitled Pennsylvania to collect certain costs from the bridge company, and rejected a request from Wheeling to review this order, concluding that "there must be an end to litigation."⁷³ Wheeling had won its long fight, but the issues remain to plague modern jurors.

After erecting the temporary bridge under Ellet's direction, Captain McComas departed from Wheeling with the warm praise of the directors ringing in his ears. It was natural that he be summoned to return following a resolution of the board on January 10, 1859, to create a two-lane span.⁷⁴ The directors selected the first of two plans prepared by McComas, at an estimated cost of \$35,752.⁷⁵ The final cost of the first bridge project was estimated at \$250,000 and that of the temporary structure at \$17,000. The unanticipated costs had devalued the stock of the company from \$25 per share to as low as \$7.50.⁷⁶

Roebblingization

With the second advent of McComas began the long process by which, over the years, the Wheeling Suspension Bride was "Roebblingized." As a first step in this direction, the board paid McComas \$50.00 to make a trip to look at the Roebbling bridge over the Niagara.⁷⁷ After McComas started work on the new structure, Washington Roebbling, son of John, came down from Pittsburgh to see

the activity. Writing to an inquirer more than sixty years later, he had these recollections of McComas' work:⁷⁸

One strand had been thrown entirely out of saddle and was made anew. He consolidated 5 or 6 separate strands into one cable, built his own little wrapping machine out of wood, very cute. The cable did not have the regulation 7 strands and was therefore awkward to compress. He made new cable bands and suspender--used the old floor and old wooden truss which acted as a railing and had no stiffness....Much of the truss had to be rebuilt. He double-tracked the floor which was only single track after the storm.

Washington Roebling, whose urbanity was in contrast with his father's serious mein, had the following kind words to say concerning his father's ancient competitor: "Ellet (sic) was a fine architect (i.e., engineer) - the Stone Towers are beautiful and stand above on high ground with a remarkable apron wall extending from the Towers down to the water's edge."⁷⁹

Additional information concerning McComas' reconstruction was supplied in 1933 by a Rensselaer Polytechnic Institute professor, T. R. Lawson, son of Joseph Lawson, suspension bridge superintendent.⁸⁰

The original cables were 12 in number, consisting of 6,600 number 10 gauge iron wires. Under the reconstruction of 1860 these wires were increased about one-third and the 12 cables reduced to four, each about 7-1/2 inches in diameter, and were wrapped with No. 14 wire. The sidewalks were placed outside of the suspenders but were so narrow that difficulty was experienced in using them, this being complicated by the rather large angle made by the suspenders to the vertical. Guy pliers above and below the river were also added at this time and wind guys placed at points along the platform.

On July 28, McComas crossed the bridge in a four-horse omnibus filled with invited guests, "refreshing the inner man" several times on the island and again with a larger crowd at the McLure House. The ferry was sold, traffic resumed as usual, and thoughts of major repairs were dismissed for another decade.⁸¹

Following the Civil War, in October of 1865, Joseph Lawson was appointed superintendent of the suspension bridge, a position he held for 58 years until his death in December 1923. For most of his later years, he was simultaneously superintendent, treasurer, clerk and secretary, and supervised the major reconstructions of 1871, 1886, and 1921-23 so efficiently that virtually no interruption to traffic resulted. In April 1871, he was authorized to purchase new wire rope guys and to go to New York to confer with Washington Roebling in relation to the general repairs of the bridge.⁸² When Lawson called Roebling's office, Roebling was at a critical point in the construction of the Brooklyn Bridge over the East River. His father had died of injuries in 1869, and only a few months before Lawson's call for help, one of Roebling's huge caissons was partially destroyed by fire. One may suppose that it was because of his generous enthusiasm for his profession rather than

a desire for "poetic justice" that he complied with the request and for only \$485.00 outlined not only one but two plans for strengthening and stiffening the bridge. On July 1, by motion of Michael Reilly, the second plan was unanimously adopted.⁸³ Repair bills amounting to nearly \$10,000 are reported in the minutes along with a sum of \$1,000 paid to Superintendent Lawson over and above his salary.⁸⁴

T.R. Lawson reports that the Roebling company plan provided for widening the floor by forcing the cables farther apart and placing the sidewalks inside the suspenders. A system of wire stays was also added at that time, in accordance with a plan invented by the Roeblings.

Washington Roebling's brief account, understandably inaccurate in some of its dates, reveals that "about 1887 or 1883 the people were afraid of its strength. I sent Hildenbrand (William Hildenbrand, a prominent engineer) there and he put in a set of stays to strengthen and stiffen it. He calculated the margin of safety at only two times under a load of 25 lbs. per square foot, and yet the bridge does its work all right--no stretching of cables perceptible." The actual year of this alteration was 1886.⁸⁵ Further stiffening of the bridge was accomplished by repairs of 1922 and 1930.⁸⁶

With the advent of automobile traffic, the bridge became a real money maker, though tolls were reduced to 5 cents and foot passengers were allowed free access. On January 1, 1927, the capital stock was increased to \$1,500,000 through a new charter obtained from the State of West Virginia.⁸⁷

As traffic increased, it seemed to be in the public interest to put the two Wheeling bridges and rights-of-way across the east and west channels into government ownership. As a first move, the bridge company accepted an offer of \$2,150,000 and conveyed its property, including the two bridges, to the city of Wheeling in 1941, and the following year, the city transferred the bridges to the State of West Virginia under the supervision of the State Road Commission.⁸⁸

From 1891 until about 1960, the suspension bridge had a competitor in a truss structure known as the "steel bridge," built between the island and the mainland of Wheeling one block south of the suspension bridge.⁸⁹ A new bridge over the Ohio River was fast becoming a necessity at the half century mark, and original plans called for the demolition of both bridges when the new bridge became a reality. Fortunately, the State Road Commission decided to maintain the suspension bridge. Engineering consultants up to and including the year 1971 have consistently given the bridge a clean bill of health. From the extensive 1953 report of Howard, Needles, Tammen and Bergendorf of Kansas City and New York, two items are of particular interest. The first is that the original cables--save one, the oldest remaining part of the bridge exclusive of the masonry--are still functioning well. Several years ago, at the northwest tower, several hundred badly-rusted wires were discovered, but these were cut out and new wires spliced in.⁹⁰

The second item of interest is the age of various parts of the bridge (for 1850, read 1849):

Masonry	1850
Main cables	part 1850 and part 1860
Lateral wind guys and piers	1860
Suspenders	1860
Auxiliary cable stays	1872
Stiffening trusses	1922
Floor beams	1922
Timber subfloor	1930
Timber top floor	1948

The engineers found the timber deck to be "quite badly deteriorated." Consequently, when the new Fort Henry bridge became serviceable, the old flooring was replaced with a steel grating floor, and sidewalks were supported on new steel floor beams. Howard and associates observed in 1966 that "the grating floor greatly reduces the chances of failure by wind. It is very unlikely that failure of the span in a wind would cause any loss of life."

Ellet's Epilogue

Before concluding the story of the Wheeling Suspension Bridge, it is fitting to summarize briefly the last few years of the life of its builder, Charles Ellet, Jr.

Regrettably, too many writers dealing with the history of the suspension bridge have dismissed Ellet as a flamboyant boaster with inadequate background in the science of engineering. Fortunately, the recent biography of Ellet by Gene D. Lewis is righting former judgements and exhibits Ellet as a genius, the scope of whose interests were nationwide and extending far beyond the field of bridge-building. His interest in the conservation and utilization of water resources was far in advance of belated modern efforts at conservation. His perennial competitor, John Roebling, became much better known in history, partly because he started construction of the Brooklyn Bridge before dying from the effects of an accident, and partly because his capable son, Washington Roebling, carried on the family tradition into the twentieth century before his death in 1925.

John Roebling, concentrating on bridge building and endowed with a real insight into the processes of aerodynamics, built safer bridges than Ellet, and it was Washington Roebling who brought his father's principles into play in the strengthening of the Wheeling Bridge, perhaps indirectly in 1860, but directly in 1871 and 1886. Following those operations, it could be said that the towers remained completely the handiwork of Ellet, while the suspension system represented an evolution in which almost all of the cables and probably some other elements dated back to the Ellet beginnings. One of the cables and other supports were those of McComas, while the majority of the remaining elements were those supplied under Roebling's direction between 1871 and 1886, under Lawson in 1921-23, by his successors in 1930, and finally a new floor supplied by the State of West Virginia in 1956.

Ellet's innovative contributions were mainly in the building of the suspension bridge, but a greater amount of time was actually spent on railroad engineering. In 1849-50, as a consultant to Wheeling interests, he wrote an analysis of proposed roadbeds that led the B & O officials to choose the hillier but shorter Grave Creek route in preference to one terminating at the mouth of Fish Creek, 23 linear miles below Wheeling. On that occasion, after somewhat tense exchanges between Baltimore and Wheeling, a former distinguished chief engineer of the B & O, Jonathan Knight, paid Ellet the highest of compliments. Writing to an acquaintance in Wheeling, he expressed gratitude that the survey and estimates of the different railroad routes had been subjected to "the acumen of that highly scientific, practical and able Civil Engineer, Charles Ellet, Jr., whose equal in his profession I know not."⁹¹

Soon after the opening of the Wheeling Bridge, Ellet was off to New Orleans to begin a half-year study of the flood control problem at the mouth of the Mississippi for the U. S. War Department. He published this report, along with another, on Ohio River navigation in 1853.

Until after the repair of the suspension bridge in 1854, Ellet managed to keep one foot in Wheeling. His principal engagement there was as chief engineer of the Hempfield Railroad from 1853 to 1855.⁹² Against Pittsburgh opposition, he completed the road as far as Washington, Pennsylvania, before resigning. In 1871, after its purchase by the B & O, it was completed to Greensburg, Pennsylvania. It is a tribute to Ellet's diligence that he was able to persuade Philadelphia interests to contribute \$600,000 towards the building of the Hempfield, despite opposition from Pittsburgh.

In April of 1853, Ellet became chief engineer of the western section of the Virginia Central Railroad and consulting engineer for the eastern section reaching the Atlantic. During the period in which the tunnel through the mountain was being built, Ellet engineered a sensational eight-mile temporary road over the summit. Furthermore, he made a third trip to Europe in 1854, this time to gain financial support.

In view of his desire for independent judgement, it is not surprising that Ellet at this period turned down an invitation to become chief engineer of the United States Navy. The invitation gives evidence of his high esteem and should be recalled when evaluating the critic's role adopted by Ellet during the period preceding and during the Civil War.

With the outbreak of this conflict, Ellet volunteered suggestions and aid many times but always unsuccessfully until the triumphs of the Virginia (earlier known as the Merrimac) led Secretary Stanton, in his desperation, to turn to Ellet for advice. By this time, it was not the Merrimac, which had bowed out of the fray, but the threat of iron clads on the Mississippi and Ohio that was causing consternation among northern military leaders. Working under a now amiable Stanton, Ellet acquired nine coal towboats of up to 175 feet in length and added to each vessel three thick wooden bulkheads so that the barges could be used as battering rams. Chief assembly points for the barges acquired here and there was Pittsburgh, where Ellet arrived on March 28, 1862.

Some of Ellet's ships finally participated in a naval engagement near Memphis on June 6. Reporting on the battle is confusing, but it seems likely that Ellet's presence helped make northern victory over the iron-clad southern vessels possible.

With characteristic flare, Ellet sent his son Charles to receive the surrender of the Memphis mayor. The elder Ellet had received a minor wound, but as in Roebling's case, infection set in and took his life. Ellet's family line soon died out, though his mother and daughter lived to the age of 90 to perpetuate his name and deeds with extensive memoranda.

There are many indications that Ellet is becoming better known to the American public. It may be concluded that the Wheeling Suspension Bridge will remain his chief accomplishment--a laboratory for engineers and a monument to millions of Americans, who have passed through and are still passing through Ellet's portals on their way across the mighty Ohio.

NOTES

1. Gene D. Lewis of the University of Cincinnati has written an excellent biography, Charles Ellet, Jr., (University of Illinois Press, Urbana, 1968). He acknowledges the assistance of Herbert P. Gambrell of Southern Methodist University, author of several articles on Ellet. Lewis demonstrates Ellet's right to be classified with Gallatin, Washington, and Marshall in their vision of national development. Like these men, who by their visits to the Kanawha Valley evidenced their personal interest in linking the James River to the Ohio at Point Pleasant, Ellet spent a great deal of his early energies trying to realize Richmond's dream of uniting the inland and ocean waterways. He deserves chief credit for the construction of a canal from Richmond to Lynchburg. Among many other activities, he became chief engineer for the Virginia Central Railroad in 1853 and distinguished himself by building a sensational eight-mile temporary track over the Blue Ridge Mountains while waiting for a tunnel to be dug. His fame extended to California, where John C. Fremont made an unsuccessful attempt to engage him to construct a mining canal in 1857. Ellet's role as advocate or consultant in many enterprises resulted in 46 printed pieces, not including his articles in newspapers and magazines.

2. As background for these early local rivalries, see C.H. Ambler, A History of Transportation in the Ohio Valley (Arthur H. Clark, Glendale, 1932) and James Weston Livingood, The Philadelphia-Baltimore Trade Rivarly, 1780-1860 (Harrisburg, 1947), which provides the setting for Ellet's early days in survey teams on Pennsylvania canals.

3. Herbert Hands, ASCE publicity release, January 13, 1969.

It should be noted that a small Roebling suspension bridge built across the Delaware, just south of the Lackawaxen, was completed a few months before the Wheeling Bridge. It had three piers in the river and was originally designed for canal boats. The Smithsonian in 1971 published a study of this bridge by Robert M. Vogel, under the title "Roebling's Delaware & Hudson Canal Aqueducts."

4. The similarity of the two collapses is well brought out by David Jacobs and Anthony E. Neville in their book, Bridges, Canals, and Tunnels, cosponsored by American Heritage and the Smithsonian Institute, 1968. See pages 76f, 112f, and 119f. This book, quite understandably, perpetuates the widespread belief that it was the elder Roebling who rebuilt the Wheeling Suspension Bridge. That the bridge today embodies his theories is due largely to plans drawn by his son, Washington Roebling and William Hildenbrand, his family engineer, for the renovation of the structure in 1872 and 1886.

5. Earl Chapin May, in Principio to Wheeling (New York, 1945) pp. 113f reports Wheeling stock subscriptions of \$500,000 in 1835 and again in 1838. This outpouring of capital was calculated to help Wheeling, instead of Pittsburgh or Parkersburg, become the terminus of the B & O.

6. Ellet was chosen by the City of Wheeling to give counsel in arguments against a proposed routing of the B & O bringing the railroad to Wheeling by way of Fish Creek, which would have induced creation of a terminal and a bridge at the mouth of that stream. Ellet's route was shorter, but it necessitated the cutting of two tunnels, including the Board Tree.

Ellet's interest in Wheeling is reflected in his property purchases: lots in South Wheeling in squares 11, 29, 30, 36, and 37 (Deed Book 36, p. 260) and joint ownership of property on Virginia Street, Zane's Island (Deed Book 36, p. 146).

7. Zane was empowered to build the path by an Act of Congress in May, 1796, but did not start work until the following year. See J.H. Newton, History of the Pan-Handle (Wheeling, 1879), p. 132. Zane had a passion for river crossings and reserved land for himself where he thought future bridges would be built.

8. The movement to bridge the Ohio at Wheeling had taken definite shape as early as 1816, when a charter from the State of Virginia was granted to Noah Zane and ten associates, incorporating a company to erect a toll bridge under the name of Wheeling and Belmont Bridge Company. From the wording of the charter, it is clear that the intention of the managers was to build bridges across both channels, and if only one was completed, they were allowed to charge half fare.

Of importance to later events was the provision that "the arches of the said bridges shall be erected so high above the usual high floods, heretofore known in the said river, as at all times during such high floods, to admit the safe passage under them of all flat bottomed boats and rafts; and there shall be made, from the abutment next to the Virginia shore, a draw bridge at least forty feet wide, which the said company at all times attend by their agents or servants, and raise the same free from expense to navigators to permit the safe passage of all craft or vessels as at any time cannot otherwise safely pass." The act further provided for its abatement as a public nuisance should it injure navigation.

The Wheeling Daily Times for March 30, 1847, gives the "aparseneaa and poverty of the population" as the reason for delay in building the western bridge before 1836. The Times gives \$78,000 as the cost of the covered bridge, describing two carriage tracks and two foot passages. In the following year, on request of Wheeling citizens, Lt. Dutton and Saunders of the National Engineer Corps made a survey for the bridge proposed across the eastern, or main, channel. They acknowledged the practicability of a wire suspension bridge 94 feet above low water, but their provision for a higharched pile of masonry connecting an abutment to the second bank, or elevation, of the Island would have brought the total project cost to an estimated \$400,000. This made Ellet's offer of \$130,000 more than attractive.

In 1836, since most of the original directors were dead, the amendment was sought by Noah Zane and granted in that year permitting reorganization of the board. Ohio's assembly concurred in the action the following year. With capital supplied by Noah and Daniel Zane, work had already been started in 1833 on a three-span wooden covered bridge with no draw. This was completed

in 1837, at a cost of about \$65,000, and sold to the reorganized company in 1847. (Wheeling Intelligencer, September 14, 1886.)

9. Lewis, Charles Ellet, Jr., p. 117.
10. Ibid., p. 7. Ellet was a direct descendant from an early governor of Pennsylvania, Samuel Carpenter, but Ellet's father was hopeful only for a farming career for Charles. His name for a time was kept before the public through the efforts of his mother and sister, both of whom lived to be ninety.
11. Jacobs and Neville, Bridges, Canals, and Tunnels, p. 73f.
12. Lewis, Charles Ellet, Jr., p. 27.
13. Among the many biographies of Roebling two stand out because their authors had access to abundant source materials: David B. Steinman, The Builders of the Bridges: the Story of John Roebling and His Son (New York, 1945) and Hamilton Schuyler, The Roebling: A Century of Engineers, Bridge-Builders and Industrialists, 1831-1931 (Princeton, N.J., 1931). These works describe in some detail the techniques invented by Roebling: his contribution to wire rope making in 1841, his method of wrapping cylindrical cables to prevent rust; his invention of wire spinning wheels and the aerial spinning process. Among the bridges built by the Roeblings' or their company were the Monongahela, Cincinnati, Brooklyn, and Delaware spans.
14. See the Wheeling Daily Times, March 30, 1847, which has a history of events leading up to the formation of the new bridge.
15. Ibid.
16. The railroad, once it reached Cumberland, Md., had several alternative routes to the Ohio. It is interesting to note that three of these were activated, leading to terminals at Wheeling, Pittsburgh, and Parkersburg.
17. The West Virginia Collection has kindly contributed a duplicate copy of the printed Charter of the Wheeling and Belmont Bridge Company (Wheeling, 1854). This booklet of 18 pages also contains the actions of the Virginia Legislature and United States Congress pertaining to the bridge.
18. The City of Wheeling was asked to subscribe \$50,000 to the stock of the Company (Wheeling Daily Times, March 30, 1847). Ellet looked to tolls to cover more than half the cost. In advertising for buyers of stock, the company predicted increased real estate sales on the Island (in fresh air away from coal smoke), concentration of wagon trains at the ferry crossing, more trade from across the Ohio for Wheeling, and more droves of livestock. For this reference and many others from the press, the writer is indebted to the research of Mrs. William A. Fluty of Wheeling.

19. Charter, p. 11, section 14.
20. Original Minutes of the Wheeling and Belmont Bridge Company, Vol. A., p. 15, unpublished. Mrs. William McDonald and Mrs. Willism A. Fluty made transcripts from the two volumes comprising the minutes. Their existence, revealed through the courtesy of a descendant of an early director, made possible the clarification of the role of Ellet, rather than Roebling, as the rebuilder of the bridge immediately after its collapse. Volume A, May 14, 1847, to February 13, 1884, contains 440 pages. Volume B, February 18, 1884, to October 23, 1944, has 542 pages.
21. Bridge company Minutes of July 17, 1847.
22. Lewis, Charles Ellet, Jr., p. 110, reveals that Ellet in May of 1847 had agreed to subscribe to the Niagara Bridge Company stock in the amount of \$30,000 in the expectation that he would realize this much in profit from the investment.
23. Whseling Daily Times, August 4, 1847.
24. Ibid, February 9, 1848, and April 19, 1848.
25. Newton, History of the Pan-Handle, p. 193, reveals that "In the matter of contracts, the company were (sic) particularly unfortunate in their selections, for we find both the firm contracting to supply the stone and that entrusted with the masonry, were alike compelled to resign their obligations soon after getting the work underway." William Otterson was then selected as superintendent of the stone work. This must have been a challenging task, for the stons abutments were 8' x 4' x 2' and fitted to a tolerance of 1/4 inch, while the stones on the approaches were tooled besutifully, with exact borders that still elicite the admiration of passersby.
26. Some confusion arises from comparing the present cables with Ellet's. The observer today sees four large cables, each composed of three small cables which fan out as they enter their anchorages. Originally they were apparently so closely stationed that each three appeared as one. The full title of Ellet's summary is Report on the Wheeling and Belmont Suspension Bridge to the City Council of Wheeling (Philadelphia, 1847). We are indebted to Mr. E. Douglas McKay of Wheeling for this source. Mr. McCay reports that the National Archives has a vast file of documentation related to the Wheeling Bridge. Reference should also be made to descriptions and drawings of the Wheeling Bridge in Bon R. Culmann, Der Bau der eisernen Brucken in England und Amerika, an 1852 publication apparently based on Ellet's descriptions, so far as the Wheeling bridge is concerned, perhaps taken from the 1849 Supreme Court case.
27. The alterations needed would have been a wider floor and the addition of four cables. See Minutes of April 17, 1848.

28. Minutes, Vol. 1, p. 53.
29. For the history of the Citizene Railway Company, see Newton, op. cit., p. 203.
30. The minutes of the bridge company for April 18, 1850, contain a warning to the telegraph company to remove its wires from the towers or meet its obligations. There were two telegraph companies, the Pittsburgh, Cincinnati and St. Louis Telegraph Company founded in 1847 and merged with the Western Union in 1853. A second company was started in 1848, known simply as the Western. These two companies ultimately merged with the Western Union. Further information concerning the telegraph companies may be found in Newton, History of the Pan-handle, p. 203.
31. Lewis, in Charles Ellet, Jr., p. 110f, believes that correspondence indicates that Roebling claimed to have won the Wheeling contract in an effort to impress the Niagara directors, who finally awarded Ellet a contract on November 9, 1847. In fairness to Roebling, it must be stated that a Resolution favoring Roebling's Plan C was approved on July 13, but amended in Ellet's favor. We do not know the board reported to Roebling, but he could not help being impressed, even misled, by the fact that the board had already ordered bridge timbers in accordance with Roebling's specifications.
32. Wheeling Daily Gazette, August 13, 1849.
33. On that day the last cable was brought across and anchored, leaving yet to be done the wrapping of the cables, suspension of the timbers, and laying of the floors. These tasks were accomplished in only three weeks.
34. Wheeling Daily Gazette, October 22, 1849.
35. Ibid., November 17, 1849.
36. Ibid., Clay's remark became a battle cry in the litigation that followed.
37. Ibid., Thompson was president of the Union Pacific Railway and a leading promoter of the Wheeling bridge and its possibilities for rail travel.
38. Ibid.
39. Charlee H. Ambler, A History of Transportation in the Ohio Valley Glendale, California, 1932, p. 221f.
40. Charles Grove Haines and Foster H. Sherwood, in The Role of the Supreme Court in American Government and Politics, 1835-1864, Berkeley, 1957, provide an extensive coverage of the issues growing out of the battle over the bridge between Pennsylvania and Virginia over a seven-year period. The conflict over this issue led to a total of 14 U.S. Supreme Court decisions or opinions. U.S. Supreme Court decisions on the bridge litigation are found in Pennsylvania

v. Wheeling and Belmont Bridge Co., 13 How. 518 (1852); 18 How. 421 (1856); 9 How. 647 (1850); 11 How. 528 (1850). The first two opinions are considered the most important.

41. The Pennsylvania legal case is summarized in the Report of the Select Committee of the Senate of Pennsylvania in Relation to the Bridge Across the Ohio River at Wheeling, Virginia (Harrisburg, 1850), 10 p.

42. The United States Congress in July of 1787 issued the famous Northwest Ordinance declaring "the navigable waters leading into the Mississippi and St. Lawrence, and the carrying places between the same, shall be common waterways, and forever free."

43. Raising the bridge 18 feet certainly would have eliminated the possibility of a railroad. The steep grades ascending to the structure would have made it difficult even for loaded wagons to navigate the span.

44. The mention of Baltimore gives some idea of the complexity of the economic competition the bridge involved.

45. Ellet and Roebling both appeared before the Cincinnati entrepreneurs. This time Roebling won, but the Civil War prevented his completing the magnificent structure of 1,053 feet before 1868.

46. One of those low bridges was that erected by Roebling in Pittsburgh--a 1500 foot suspension with eight spans. See Jacobs and Neville, Bridges, Canals, and Tunnels, p. 77.

47. Parkersburg was already a competitor, and both cities had their boat-building industries.

48. Ellet was charged by the company with responsibility of fighting the injunction (Minutes, July 23, 1847). Ellet's approach is illustrated by a six-page pamphlet addressed to Congress after the decision: The Wheeling Bridge (Philadelphia, July 8, 1852)--original in the possession of the Historical Society of Pennsylvania, Philadelphia. Ellet placed the blame for the controversy on the Ohio and Pittsburgh Railway Company, which owned a railway line running west through Salem, Massilon, and Wooster, Ohio. He charged that this company was trying to prevent the B & O from making its connection with the western roads any place south of Pittsburgh. He cited a protest entered into the suit of the Pennsylvania Railroad Company implying that the company should consider that railway traffic to Wheeling from east or west is a poor investment since no bridge "will again ever be attempted" there in the face of the Supreme Court decision. He accused the railroad and steamboat companies of collusion.

49. This was William J. McAlpins. (See Haines and Sherwood, The Role of the Supreme Court in American Government and Politics, 1835-1864, p. 181.)

50. McLean rejected the application of the Blackbird Creek case on the grounds the it dealt with a stream made navigable by the flow of the tide. Ibid., p. 179.

51. Ibid., p. 179f.

52. Ibid., p. 183. Ellet addressed a printed six-page document to Congress outlining the issues and attacking the Pittsburgh strategy (The Wheeling Bridge, July 8, 1852, Philadelphia).

53. One area certainly is that of desegregation of schools in relation to the power of the three branches of government.

54. Johnson was successively U.S. Senator from Maryland, Attorney-General of the United States, and successor to Charles Francis Adams as minister to England, where he negotiated the "Alabama claims." He prepared a defense for Mary E. Surrat, indicted in the Lincoln assassination. Stuart was appointed Secretary of the Interior in 1850. Although a Virginian, he opposed secession and after the Civil War was identified with movements behind Negro education and internal improvements.

55. Lewis, Charles Ellet, Jr., p. 123.

56. Minutes of the bridge company, November 14, 1849.

57. An early engraving of the bridge shows a round toll house with pointed roof.

58. The Intelligencer of May 22 describes the tremendous force demonstrated by a cable on the Island which had been broken asunder. "When it broke it gyrated around in almost every direction, and the huge thing is now coiled and twisted, and looks much like a serpent grown stiff in the act of striking a mortal blow." The description is reminiscent of the fright engendered among spectators when a partly constructed cable broke from the Brooklyn Bridge while it was under construction. It flew through the air with the rushing sound of a tornado. Plunging into the river, it created a 50-foot screen of water stretching from shore to shore. (Brooklyn Daily Eagle, June 14, 1878). During Fair time in 1862 another storm resulted in a panic on the bridge in which one small boy was killed (The Intelligencer, September 14, 1886).

59. Steiman, manuscript of May 20, 1956, speech at Wheeling Suspension Bridge rededication, 9 pp., p. 6f. The occasion for the speech was the reopening of the bridge after extensive repairs, but the celebration was made the occasion for a tribute and plaque honoring John Roebling following a 25-year-old mistaken belief that Roebling had been the rebuilder of the bridge immediately after its collapse. F.W. Roebling III, present also on that occasion, was advised of this understandable error in a 1969 letter from Blair Birdsall, chief engineer and general manager of the Roebling Bridge Division following C.C. Sunderland. Birdsall wrote the letter after learning of the sequence of rebuilding reflected in the Minutes.

60. Jacobs and Neville, Bridges, Canals, and Tunnels, p. 119f.
61. Ibid., p. 121. The Mackinac bridge had more than one span. Therefore, the Verrazano Narrows Bridge in New York built by Ammann in 1965 has the largest single span: 4520 feet.
62. Ibid., p. 119 and passim.
63. Roebling in October of 1849 had transferred his wire rope manufacturing operation from Saxon to Trenton, New Jersey. Transportation of the heavy products from Saxonburg to the Allegheny River had met too many obstacles from snow and mud. His home and little wood manufacturing buildings still stand in Saxonburg. The making of the wheeling bridge cables often has been erroneously attributed to Roebling.
64. His comments are said to have been publicized chiefly to allay the fears of Niagara bridge stockholders.
65. May 19, 1854.
66. Minutes of May 18, 1854. Ellet arrived in Wheeling on the 21st.
67. We have not acquired such background on McComas. He was known to Benjamin H. Latrobe, chief engineer of the B & O, who recommended him highly but unsuccessfully for the building of the Wheeling Custom House, completed early in 1859. Under date of December 8, 1955, Latrobe cited favorably McComas' work as superintendent on all of the B & O passenger stations construction.
68. The Minutes for July 5, 1854, p. 162, reflect a \$500 ferry rental charge.
69. On July 26, 1854, the day of the crossing, the Intelligencer carried the story of another suit by Pittsburgh interests. In the same newspaper for July 27 the width given for the suspension bridge is somewhat confusing: "The width of this new structure is 10 feet, and is divided into a single carriage way of 6 feet, and two footways, each 2 feet in width."
70. Haines and Sherwood, The Role of the Supreme Court in American Government and Politics, 1835-1864, p. 183.
71. Ibid., p. 184. Justice Nelson's opinion was based on the ruling of the court that since Congressional authorization had been given for the building of the bridge, the decree for abatement could not be carried out properly.
72. Ibid., p. 185. McClean believed Congress had violated the principle of separation of powers.
73. Ibid., p. 186.

74. Minutes of April 14, 1859. McComas requested the role of both manager of the works and engineer at \$2500 for one year of \$2000 per year if the rebuilding required more time.

75. Minutes of May 9, 1959. McComas' cost estimate was \$35,753.31.

76. It is ironic that the bridge brought economic hardships on its originators but was a bonanza to later owners, who finally sold it at almost ten times its original cost.

77. Minutes for May 17, 1859.

78. Washington Roebling's reflections were supplied by Blair Birdsall, engineer for the Roebling company for many years.

79. Ibid.

80. Thomas Laweon, a professor at Rennselaer Polytechnic Institute, was the son of Wheeling Bridge at a meeting of the American Toll Bridge Association, at Camden, New Jersey, January 26, 1933 (11 pp.). One of his informants was C.C. Sunderland, Roebling chief engineer. Local residents were again proud of their bridge, quoting dubious statistics such as the following from the Intelligencer of September 30, 1859: "The wire in one of the new cables, if stretched out, would measure 1,740."

81. Intelligencer, July 30, 1860.

82. Minutes of April 8, 1871. The same meeting gave him authority to purchase new rope guys.

83. The plan was for "strengthening, stiffening, and repairing," a typical Roebling approach. Minutes, p. 346.

84. In response to an inquiry in 1897 by J. Elfreth Watkins, of the Smithsonian, who was doing a history of the Pennsylvania Railroad, Joseph Lawson, still at that time Wheeling Suspension Bridge superintendent wrote a brief history of the bridge on June 12 of that year. He reveals that the bridge was twice "rebuilt," using all but one of the original cables. He states that Hildenbrand, Roebling's assistant, had been the chief engineer for any repair or material changes in the bridge since first making plans under Mr. Roebling's direction in 1871. He said that the bridge had never been closed for repairs or reconstruction since his assumption of duty in 1865. (Letter supplied in fasimile by Robert M. Vogel of the Smithsonian).

85. Hildenbrand stayed but a few days in 1886, receiving but \$150 for his contribution to the plans (Minutes, October 23, 1885). On June 12 the Intelligencer reported that "The excavation to reach the anchors is down 26 feet below Main Street. All scales of rust are scraped off the iron anchors very carefully. Additional anchors will be put in with a view to the possible

addition of new cables in the future. The present cables are being freed from rust and will then be painted. When all four of the anchor-piers have been opened, the anchors repaired and renewed and the cables painted, the repairs to the bridge proper will be begun. Steel beams will be substituted for the wooden ones, and a foot-walk on each side six feet wide and elevated above the roadways will take the place of the old narrow ones. The bridge will be practically a new one when the alterations are completed. A September 28 article in the same newspaper revealed much yet to be done: the anchors on Tenth Street were enclosed in a huge board fence while stone retaining walls were being constructed. The huge iron beams on which the bridge structure was to rest were still being forged.

86. T.R. Lawson address, p. 11.

87. It is interesting to note that the Bridge increased in value by \$650,000 in only 14 years. These were years of the Great Depression.

88. Of. Ohio County Deed Book 262, p. 381, and Belmont County Book, vol. 324, p. 442. The final approval by Governor Matthew M. Neely is dated June 3, 1943.

89. The year 1891 is the conjectured date given by Howard, Needles, Tammen and Bergendorff, April 2, 1953, in their report on "Ohio River Highway Bridge at Wheeling, West Virginia," p. 10.

90. Op. cit., p. 3.

91. Lewis, Charles Ellet, Jr., p. 138.

92. Ibid., pp. 152-59. Ellet was similarly engaged in southern Virginia, supervised rebuilding of the Wheeling Bridge, and made a third trip to Europe to raise funds during these busy years.