Harvard University Archives

Who was

T.C. Clarke, C.E.

Thomas Curtis Clarke, who began his career in the 1840s and remained active for sixty years, was a skilled civil engineer, railway builder, contractor, draughtsman, and author. But above all, Clarke was an innovative bridge designer who planned and built railway bridges – usually on a grand scale – throughout the world. In 1883 he helped form the Union Bridge Company, one of the world's largest bridge building firms. At his death in 1901, it was estimated that Clarke had constructed more than 125 miles of bridges and viaducts, a feat much touted at the time.[1]

Clarke worked on projects throughout the world (as most noteworthy engineers did), but he was also quite active in Canada. Throughout most of his life he had a close association with the town of Port Hope, Ontario, where he lived from 1853 to the mid 1860s and where he was buried. In 1859, he and two other Port Hope men won the contract to build the East and West Blocks of the Parliament Buildings in Ottawa.

Over time, the accomplishments of this distinguished engineer have been almost completely overlooked and forgotten – particularly in Canada. The objective in this paper is to shed some light on T.C. Clarke's remarkable career in Canada and around the world.

By Jim Leonard

EARLY LIFE

Thomas Curtis Clarke was born in Springfield, Massachusetts, on 5 September 1827,[2] the youngest of six children born to Samuel Clarke and Rebecca Hull. From 1841 to 1844 he was enroled at the prestigious Boston Latin School. He went on to Harvard University, graduating in 1848. With his university education complete, Clarke chose a career in law, "but being in delicate health at that time, he decided to adopt the profession of civil engineering."[3] In the late 1840s and 1850s, training for a career in engineering, architecture, and other related trades was usually accomplished by formal apprenticeship with practising professionals. Clarke must have shown great promise, since he worked for some of the most respected civil engineers and architects practising in the United States. His first apprenticeship was to Captain John Childe, a Massachusetts civil engineer considered by some to be the foremost railway builder of the 1840s. In 1848 Clarke joined Childe's corps of engineers for the construction of a 500 mile railway line running from Mobile, Alabama, to the mouth of the Ohio River. The project was financed by the Mobile and Ohio Railway. This was the longest railway operating on the continent at the time.[4]

In June 1849 Clarke fell ill, and was forced to leave the project. He returned to Boston, where by the fall he was studying architecture in the firm of Edward Clarke Cabot. Cabot is remembered for designing the Boston Theatre (1852) and Johns Hopkins Hospital. Clarke received extensive training in mechanical drafting with the firm. In 1850 he became a draughtsman under Walter Shanly, chief engineer of the Ogdensburg and Lake Champlain Railway and future manager of the Grand Trunk Railway. Later, Clarke returned to Childe's Mobile and Ohio Railway project as chief engineer. Some time after the fall of 1851, Clarke was in Chicago working with architect Edward Burling.[5] Burling was one of the first professional architects to practice in the city and the designer of many of its most important structures prior to the Great Fire of 1871.

Thomas Clarke's first project in Canada was with the Great Western Railway. Starting in October 1852, he accepted a position as resident engineer on the line that extended from St. Catharines, Ontario, to Dundas and Hamilton. Clarke worked with three other civil engineers on the venture: Amory Dexter of Boston, Augustus Bacon, and a young Toronto engineer and architect named Thomas Ridout Jr.[6] In 1853, Clarke left the Great Western Railway for a job on an ambitious railway scheme being prepared for Port Hope, Ontario. Rosewell G. Benedict, chief engineer of the Great Western Railway, joined Clarke on the Port Hope project.[7]

PORT HOPE, ONTARIO

In the early 1850s, Port Hope and Cobourg, its larger neighbour and longtime rival[8] to the east, were experiencing a boom. Railway development was a driving force of the economy. Cobourg established the Cobourg & Peterborough Railway Company in 1853. Plans for a Port Hope railway, left dormant since 1846, were reassessed, apparently in light of Cobourg's new initiative. It was hoped that the Port Hope rail line, intended to bypass Rice Lake at Bewdley, would be perceived as a shorter and more sensible line to Peterborough and the northern hinterland, thus undercutting the much longer and more troublesome route over Rice Lake already chosen by Cobourg.[9]

In the summer of 1852 a survey of the proposed northern route was undertaken by J.W. Tate, CE. In January 1853 Tate's plan was formally approved and the Port Hope, Lindsay & Beaverton Railway Company was born. In September 1853 R.G. Benedict was appointed chief engineer for the construction of the railway, T.C. Clarke resident engineer, and Edward Browne assistant engineer. Later, Clarke was also named secretary for the railway company.[10] Contracts to build the 42 miles of track between Port Hope and Lindsay were won by J.W. Tate and John Fowler of Port Hope. There are surprisingly few references in Port Hope newspapers to Clarke's work for the railway company. One article in an 1855 issue of the local newspaper does refer to bridge construction being supervised by Clarke and Benedict at "Galway's in Cavan ... one thousand feet long and forty feet high." The paper observed that the bridge was a "splendid piece of workmanship."[11] The Port Hope, Lindsay & Beaverton Railway was officially opened on 30 December 1857. By May 1858 a line had been extended into Peterborough, called "the reliable route to Peterboro" by those hoping to take business away from the now faltering Cobourg line.[12]

In April 1855 Clarke submitted a lengthy dissertation to the Canadian Institute entitled "On the Action of the Ice Upon the Bridge at Rice Lake."[13] The paper dealt with the chronic problems the Cobourg and Peterborough Railway Company was having with large ice flows crippling their bridge works over Rice Lake. Early in 1855 Clarke was hired for another Port Hope project. He was appointed company engineer overseeing the develop-

1 Obituary in *Harvard University Bulletin,* 3 July 1901.

2 *Ibid.*

3 John F. Rourke, Adolphus Bonzano, and Eliot C. Clarke, "Memoirs of Deceased Memebers," *Proceedings of the American Society of Civil Engineers* 29 (1903): 399. One wonders how civil engineering could be less strenuous than law?

4 American Society of Civil Engineers, *A Biographical Dictionary of American Civil Engineers* (New York: ASCE Committee on History and Heritage of American Civil Engineering, 1972), 25.

5 *Proceedings of the American Society of Civil Engineers* 29 (1903): 400.

6 Harvard University Archives, Newspaper Clippings File (#B 852 CLARKE, Thomas Curtis).

7 *The Port Hope Directory,* 1856-7 (Port Hope, C.W.: Book and Job Print, 1856).

8 George R. Stevens, *Canadian National Railways* (New York: Clarke, Irwin and Company, 1960), 1:434.

9 *Ibid.*

10 *The Port Hope Directory,* 1856-7.

11 *The Port Hope Guide,* 3 February 1855.

12 Charles H. Heels, *Railroad Recollections,* ed. Alan R. Capon (Bloomfield, Ont.: Museum Restoration Service, 1980).

13 See Clarke's paper in *The Canadian Journal; a repertory of industry, science and art; and a record of the proceedings of the Canadian Institute,* June 1855.

Figure 1 (above). "The Cone," Port Hope, Ontario, 1858, residence of T.C. Carke. (Jim Leonard, 1992)

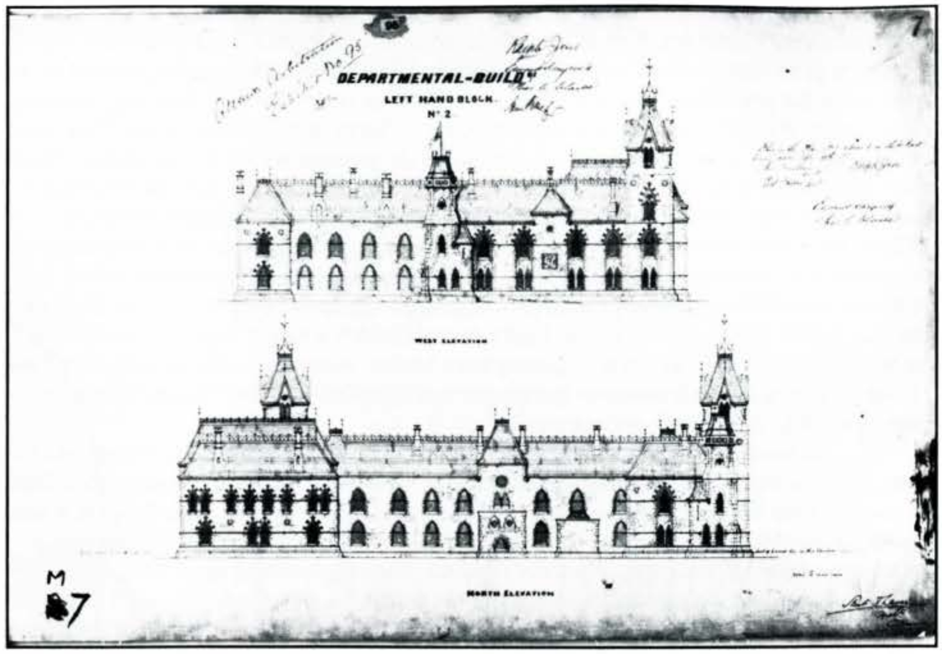


Figure 2 (right). The contract drawing for the West Block of the Parliament Buildings, Ottawa, 1963 (Augustus Laver and Frederick Warburton Stent, architects). Note the signatures of Ralph Jones, Edward Haycock, and Thos. C. Clarke on the top centre of the drawing. (National Archives, NMC 18066)

ment of Port Hope's harbour. The work involved the construction of a 96-foot-high wooden lighthouse, crib work, and large scale excavation and dredging for a harbour basin.[14] Although the project was supposed to be completed by 31 December 1856, work was still in progress as late as the fall of 1858. At that point, the western pier was being extended several hundred feet into Lake Ontario and troublesome sand bars were being dredged.

Thomas Curtis Clarke became closely acquainted with the J.D. Smith family during his stay in Port Hope. Smith was one of the town's most prominent and wealthy citizens. On 7 May 1857 Clarke married Smith's 20-year-old daughter, Susan Harriet Smith.[15] The Clarkes had six children (three sons and three daughters). In 1858 Clarke and his new wife moved into a beautiful board-and-batten cottage designed in the Gothic Revival style, known then and today as "The Cone" (**figure 1**). The Port Hope Guide cited Clarke as being both "the proprietor and we presume, likewise the architect," and that the house had been "erected upon the model of the Swiss Cottage, which promises to be when completed, a perfect Gem."[16]

In November 1858, Clarke was put in charge of one of three government surveys attempting to find a suitable means to improve navigation on the Ottawa River. The surveys were also designed to assess the practicality of building a canal system between Montreal and Lake Huron via the Ottawa River. Initially, Clarke managed only the French River, Lake Nipissing, and Mattawa River portion of the survey. He spent the harsh winter of 1858-59 on the project. Apparently impressed by the quality and promptness of his work, the government appointed him chief surveyor of the entire effort.[17] In 1860, Clarke submitted an extensive report on the work to the Legislative Assembly in Quebec. He recommended the construction of a canal system, and proposed building locks 250 feet by 45 feet and a series of dams. Clarke estimated the cost of the project at $12,000.

THE CONSTRUCTION OF THE PARLIAMENT BUILDINGS IN OTTAWA

In 1859, Thomas Curtis Clarke ventured into what certainly must have been his most ambitious project to date, the construction of the Parliament Buildings for the new capital. In May, the Department of Public Works in Quebec invited the nation's architects to enter a design competition for a legislative building and two departmental buildings on a 29-acre site on "Barrack Hill" in Ottawa. The winning architects were the Toronto firm of Thomas Fuller and Chilion Jones for the Centre Block and Augustus Laver and Frederick Warburton Stent for the two departmental buildings.

The Department of Public Works administered a competition for construction tenders. Thomas Clarke and two other Port Hope men, Ralph Jones and Edward Haycock, established the building firm of Jones, Haycock & Company[18] (Ralph Jones was architect Chilion Jones' first cousin),[19] and submitted tenders to erect the centre block for $434,500 and the east and west departmental buildings for $251,000.[20] Although out-bid on the centre block, Jones, Haycock, and Clarke did win the contract to build the departmental buildings, today known as the East and West Blocks (**figure 2**).

14 *The Port Hope Guide*, 27 January 1855.

15 Harvard University Archives, Newspaper Clippings File, 1901.

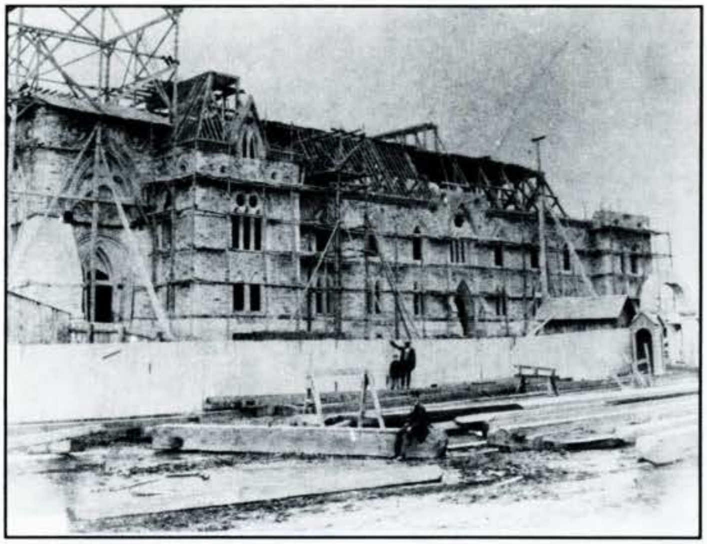
16 *The Port Hope Guide*, 2 October 1858.

17 "Early Presidents of the Society," *Civil Engineering* (American Society of Civil Engineers) 8, no.5 (May 1938): 360 [hereafter *Civil Engineering*].

18 See National Archives of Canada [hereafter NA], RG 11, Department of Public Works [DPW], Register of Correspondence, vol. 419, subject 1026, and vol. 424, subject 1027.

19 *The Prescott Telegraph*, 14 March 1884.

20 "Exhibit Letters," *Report of the Commission appointed to Inquire into Matters Connected with the Public Buildings at Ottawa* (Quebec: J. Blackburn, 1863).



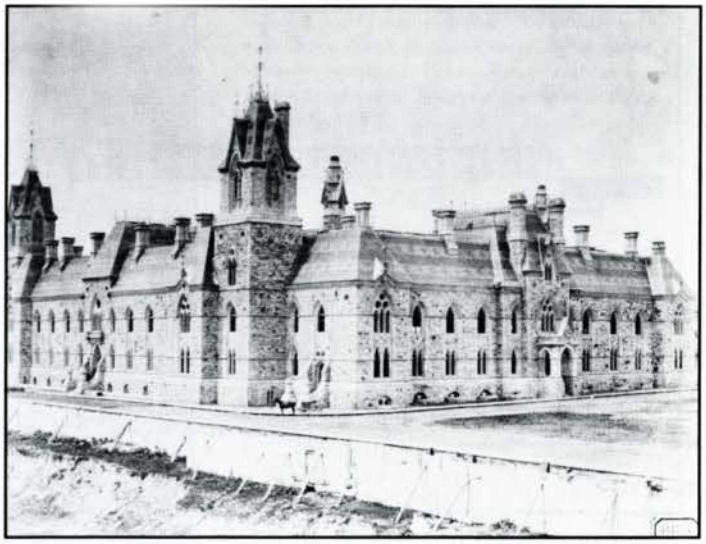


Figure 3 (left). The West Block, Parliament Buildings, under construction, c. 1863. (Canadian Inventory of Historic Building, STORRS 994151)

Figure 4 (right). The West Block, Parliament Buildings, near completion, c. 1867. (CIHB, STORRS 994159)

Clarke had become acquainted with his partners on the Port Hope railway and harbour works. Edward Haycock had been the draughtsman for the Port Hope railway company.[21] He was also a civil engineer, architect, and surveyor. Haycock shared an office on Walton Street in Port Hope with his son Samuel, also a practising civil engineer. Little else seems to be known about him. Ralph Jones was a successful building contractor living on Mill Street in the mid 1850s. Jones and another contractor, John Morton, were the sub-contractors for the excavation of the Port Hope harbour basin. Jones was born in Prescott, Grenville County, in 1818, the eldest son of Alpheus Jones. Ralph Jones "entered upon the business of railway contracting and built part of the Grand Trunk," and "constructed many railways in the United States,"[22] eventually settling in Port Hope.

Jones, Haycock, and Clarke recruited able clerks of works for the project from the Cobourg-Port Hope area. From about 1857 to the fall of 1859 some rather grandiose buildings projects were under construction in Cobourg, including a grand town hall and a bank. These two projects attracted exceptionally skilled contractors to the area. The company's new chief superintendent of works was a Welsh-born master stonemason named Charles Thomas. Thomas had been working in Cobourg since 1857 as contractor for the stone work on Victoria Hall, a monumental town hall designed by Toronto architect Kivas Tully.[23]

The second vast project under way in Cobourg at the time was the construction of an Italianate-style Bank of Montreal building (designed by James Springle, a Montreal architect). William Hutchison, a master-builder from Montreal, was the clerk of works.[24] Hutchison's 19-year-old son Alexander Cowper Hutchison, apprenticing as an architect in Springle's office, was also employed on the project.[25] Both William and Alexander Hutchison joined Jones, Haycock, and Clarke in Ottawa. William Hutchison was appointed clerk of works on the construction of the East Block and Alexander was hired as foreman of stonecutters for the same building.

Jones, Haycock, and Clarke started work on the Parliament Buildings site almost as soon as the contracts were signed. Excavation at the construction site began on 20 December 1859. The official laying of the cornerstone on the East Block occurred at about 11 o'clock, 2 April 1860, and was attended by a large number of people. The honour of actually laying the cornerstone went to Edward Haycock's young daughter, Mary Emily. After the ceremony, invited guests met at the offices of Jones, Haycock, and Clarke, "where a plentiful supply of champagne gave additional zest to the proceedings." Several toasts to the contractors and their wives were then offered.

By the early summer of 1860, Jones, Haycock, and Clarke had 601 men working for them on both buildings, divided into 43 work teams and practising a variety of building trades (**figure 3**). As for wages, stonecutters were paid $1.25 per day, while the more skilled stone carvers were paid an average of $2.50 per day. Clerks of works such as William Hutchison were paid nearly $1,000 per annum.[26]

Throughout the 1861 construction season it became increasingly apparent to the Department of Public Works, and to the government, that construction costs on the Parliament Buildings were growing enormously high, far exceeding all estimates. In February 1861 Thomas Clarke personally informed Samuel Keefer, Public Works Deputy Commissioner, that their firm would begin laying off workers unless more funds were advanced to them. All

21 *The Port Hope Directory*, 1856-7.

22 *The Prescott Telegraph*, 14 March 1884.

23 Jim Leonard, "Charles Thomas: A Stonemason's Legacy Restored," SSAC *Bulletin* 14, no. 3 (September 1989): 60-64. The research into the career of Thomas Curtis Clarke extended from earlier investigations of stonemason Charles Thomas, the author's distant uncle. Clarke's importance as an engineer was only stumbled upon after the associations between the two men were confirmed and later pursued.

24 *The Star* [Cobourg], 18 November 1857.

25 J. Russell Harper, *Early Painters and Engravers in Canada* (Toronto: University of Toronto Press, 1970), 168.

26 NA, RG 11, DPW, letter, 28 May 1860.

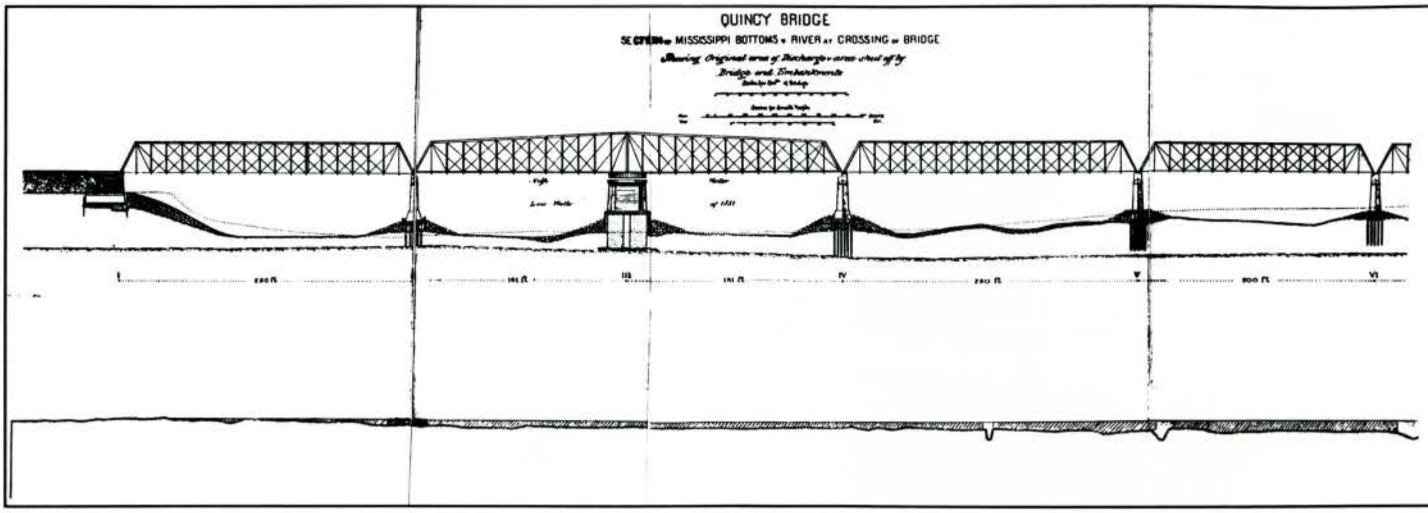


Figure 5. T.C. Clarke's design for a metal truss railway bridge over the Mississippi River at Quincy, Illinois (1866-67). (T.C. Clarke, An Account of the Iron Bridge Across the Mississippi at Quincy, Illinois *[New York: Van Nostrand, 1869])*

works stopped indefinitely in September 1861. It wasn't until April 1863, after a lengthy government probe, that construction finally resumed.

On 1 November 1864 Ralph Jones, Edward Haycock, Thomas C. Clarke, and Thomas McGreevy, contractor of the Centre Block, hosted a gala luncheon for the delegates of the Quebec Conference, the men who would later be known as Canada's Fathers of Confederation. The delegates were on their way to Toronto, but made a stop in Ottawa, in part to inspect the buildings they soon would occupy. This historic affair was held in the Centre Block. The Ottawa *Citizen* reported that

> in the Picture Gallery, a large room in the Centre Block, with panelled glass ceiling ... [the delegates] were entertained by the Contractors of the Buildings to a most sumptuous repast. The room was gaily decorated with flags, flowers and evergreens....[27]

The first toast of the afternoon came from John A. Macdonald. After a few more words, the *Citizen* recorded that MacDonald became overcome by emotion or was struck ill, and after several attempts at continuing his speech he sat down.[28] Thomas Clarke then stood and proposed a toast "to their guests the delegates from our sister Provinces, and their fair wives and daughters (cheers)." Clarke, on behalf of his fellow contractors and the people of Ottawa, then "tendered them a cordial and sincere welcome" and announced his regrets that they would be in town only for a short time.[29]

On 29 March 1867, Jones, Haycock, and Clarke submitted their final work estimates in the amount of $21,225.99 to the Department of Public Works, "being in full payment, and in final settlement for all works."[30] With the final bill settled and all work completed (**figure 4**), the contracting firm established by Jones, Haycock, and Clarke was formally dissolved.

Ralph Jones took a position in the Department of Public Work's Government Railway Division, and died of "paralysis" in Ottawa on 9 March 1884.[31] Edward Haycock's activities after 1867 are as yet unknown to the author. William Hutchison, clerk of works on the East Block, also took a job with the Department of Public Works, and worked for the department until his death on 6 August 1875.[32] He is buried in Montreal's Mount Royal Cemetery. Alexander Cowper Hutchison, foreman of stonecutters on the East Block, quickly established himself as a leading Montreal architect. Charles Thomas, chief superintendent of works, joined Clarke on his next construction project, the Quincy Bridge in Illinois. He was killed in a construction accident on the project in 1867.

CLARKE'S CAREER AFTER 1866

In November 1866, Clarke won a contract with the Chicago, Burlington and Quincy Railroad to design and build a metal truss railway bridge over the Mississippi River at Quincy, Illinois. Clarke designed the bridge as a low-level crossing with a pivot draw and 18 spans from 157 to 250 feet in length (**figure 5**).[33] Its superstructure was made of cast and wrought iron, making this the first iron bridge to span the Mississippi River. Clarke also elected to use heavy concrete to form the foundations and piers. He was one of the first engineers to use concrete on a large scale in bridge construction.[34]

Clarke's greatest problem on this project involved the building of stable foundation piers for the bridge. The river bottom in the area was very sandy. The bridge foundations therefore had to be set in the solid bedrock beneath, to ensure their stability. This meant

27 *The Citizen* [Ottawa], 4 November 1864.

28 *Ibid.*

29 *Ibid.*

30 NA, RG 11, DPW, letter, 29 March 1867.

31 *The Prescott Telegraph*, 10 March 1884.

32 *The Times* [Ottawa], 6 August 1875.

33 "Early Presidents of the Society," *Civil Engineering* 8, no. 5 (May 1938): 361.

34 *Civil Engineering* 8, no. 5 (May 1938): 360. See also T.C. Clarke, *An Account of the Iron Bridge Across the Mississippi at Quincy, Illinois* (New York: Van Nostrand, 1869).

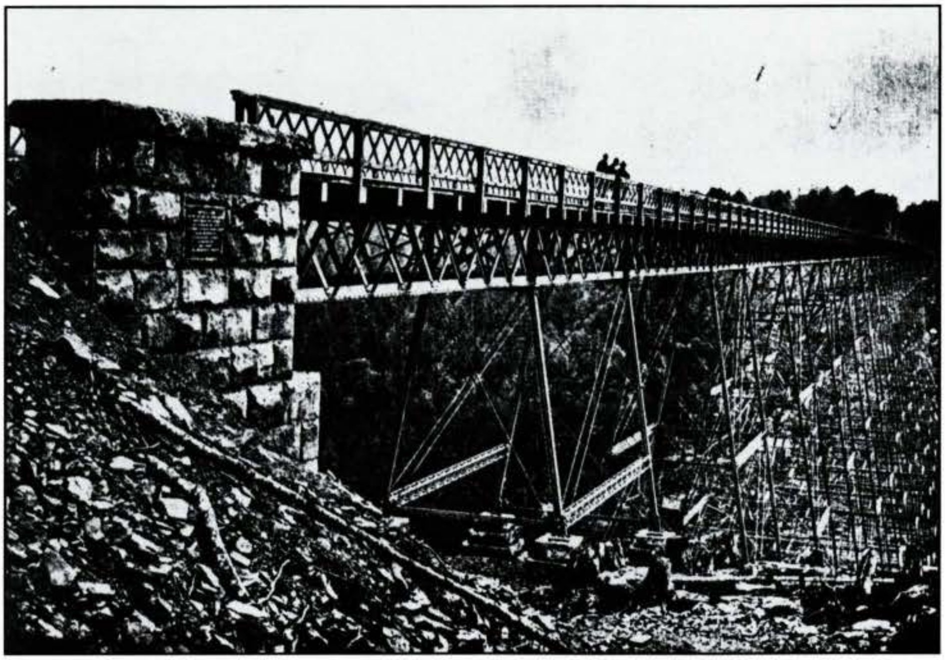


Figure 6. The Kinzua Viaduct, a 330-foot-high span over Kinzua Creek, McKean County, Pennsylvania, designed and built by Clarke, Reeves and Company in 1882-85. (Album of Designs of the Phoenix Bridge Company, *1885)*

dredging and excavating to a depth of 42 feet below the river bed for every pier. Clarke designed all machinery and plants necessary to build the bridge's foundation piers. He used wooden cribs filled with stone and masonry to build the piers in the deep waters of the Mississippi. Construction of the iron superstructure was contracted by tender; the entire bridge was completed in just 15 months. It was not long before Clarke was noted for being able to execute challenging projects like this, using "his own men and machines deep and difficult submarine foundations."[35]

In 1868 Clarke moved to Philadelphia, Pennsylvania, and formed the bridge building firm Clarke, Reeves and Company. Clarke was senior partner. He and his associates Samuel Reeves, John Griffen, and Adolphus Bonzano specialized in the construction of iron bridges, viaducts, and roofs. Their offices were located at 410 Walnut Street, Philadelphia.[36] The firm also managed a bridge and iron works operation located at Phoenixville, Pennsylvania.

Clarke, Reeves and Company won numerous building contracts in the 1870s and 1880s. In 1882 it was estimated that they had built over 54 miles of railroad bridges and were employing a work force of more than 500 men.[37] By 1884, the capital stock of the company was estimated at $100,000. Their projects included a bridge over the Androscoggin River in Maine (1872); the 1,000-foot-high Girard Avenue Bridge, Philadelphia (1873); a 1,300-foot-long bridge over the Tennessee River near Chattanooga for the Cincinnati Southern Railroad (1876); two small bridges over the Wabash River (1877); a 300-foot-long draw span over the Harlem River, New York(1880); a 108 foot skew span bridge over the Pennsylvania Canal at Harrisburg (1881); one of "the heaviest bridges in the World" over the Hudson River at Albany (1882); Gay Street Bridge, Phoenixville, Pennsylvania (1883); and a 330-foot-long draw bridge over the Snake River in Oregon (1883). They also constructed bridges in Peru, including a four span iron viaduct 187 feet high at Chipachuca. According to an 1896 issue of *Engineering News,* the company also built half the elevated railways in New York City.[38]

Clarke, Reeves and Company was also quite active in Canada. In 1873 they erected the iron spire for St. James Anglican Cathedral in Toronto.[39] It stood 150 feet tall on the church tower—the tower and spire together stood 306 feet[40]—and was designed by Toronto architect Henry Langley. The church itself was built in the early 1850s, but funds had been exhausted before a spire could be erected. In 1872 a public subscription raised sufficient money to finally build one. The completion of the spire apparently made St. James the tallest church in Canada, and second tallest in North America after St. Patrick's Cathedral in New York City.

In 1874 they tendered a bid to erect an iron bridge over the Grand River at Galt, Ontario. In 1877-78 they built all the iron bridges on the Quebec, Montreal, Ottawa and Occidental Railway line (a total of more than 6,000 lineal feet). In 1880 they constructed large viaducts for the Great Western Railway, and the same year the Quebec provincial govern-

35 *Engineering News and American Railway Journal* 35, no. 3 (16 January 1896): 34.

36 Clarke, Reeves & Company letterhead, in the J.C. Bailey Papers (MU 20), Archives of Ontario.

37 Newspaper Clippings File, Chester County, Pennsylvania, Historical Society [hereafter CCPHS], 12 June 1882.

38 *Engineering News and American Railway Journal* 35, no. 3 (16 January 1896): 34.

39 Newspaper Clippings File, CCPHS, 1872.

40 Patricia McHugh, *Toronto Architecture: A City Guide* (Toronto: Mercury Books, 1985), 30.

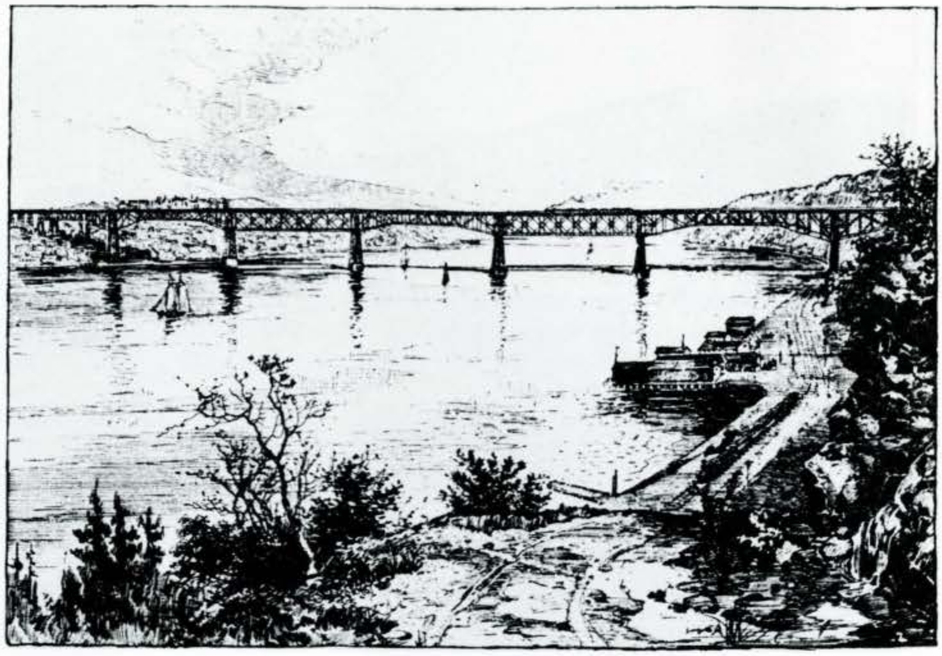


Figure 7. The Poughkeepsie Bridge over the Hudson River at Poughkeepsie, New York, designed and built by T.C. Clarke and the Union Bridge Company, 1886-88. (T.C. Clarke et al, The American Railway; Its Construction, Development, Management, and Appliances *[New York: Charles Scribner's Sons, 1897])*

ment contracted Clarke, Reeves and Company to build the Chaudière Railway Bridge over the Ottawa River. More than two million pounds of iron were produced at the Phoenix Bridge Works and shipped to Canada through the summer and fall of 1880.

Perhaps Clarke, Reeves and Company's most notable achievement was the Kinzua Viaduct built for the Erie Railway Company over the deep valley of the Kinzua Creek, McKean County, Pennsylvania (**figure 6**). Clarke, Reeves and Company designed and constructed the bridge, beginning in May 1882. The viaduct was built entirely without scaffolding or ladders. When completed, the Kinzua Viaduct was the tallest bridge in the world,[41] a breathtaking 300 feet high, and more than 2,000 feet long between abutments. The bridge was constructed of continuous lateral iron girders supported by 20 iron towers. Six of the towers were taller than those of the recently-completed Brooklyn Bridge in New York. More than four million pounds of iron were used in construction.

According to the American Society of Civil Engineers, the journal *Engineering News,* and other sources, Thomas Clarke was the inventor of the modern metal (iron or steel) viaduct that used towers and connecting spans.[42] The first such structure ever built spanned Blackwell's Island in New York City; Clarke designed it in 1869. Clarke stated that he hoped to avoid using perishable materials such as wood, and found metal to be less resistant to changes in shape caused by temperature and stresses.

In September 1878, the British Institute of Civil Engineers awarded Thomas Clarke the prestigious Telford Gold Medal and a cash award for his paper entitled "Design Generally of Iron Bridges of Very Large Spans for Railway Traffic." It was based largely on his work with Clarke, Reeves and Company. Even by the turn of the century, no other American civil engineer had been awarded this prize.[43]

THOMAS CLARKE SEVERED HIS CONNECTION with Clarke, Reeves and Company in 1883 and moved to New York City to become one of the founding members of the Union Bridge Company. In 1885 he tendered a design in competition for the Washington Bridge over New York's Harlem River. It would be of three arches, with spans of 280 feet. Clarke's creative energies were just as strong as ever: he shocked the engineering profession by proposing that the bridge be constructed of reinforced concrete, faced with granite (Clarke had been one of the first American civil engineers to use concrete on a large scale in bridge construction, on the Quincy Bridge project in 1866-67). His competition bid was rejected because his design "was neither stone, steel nor iron."[44] Clarke submitted modified plans which substituted steel rib arches for concrete, but it, too, was rejected. Today, concrete is one of the most common materials used in bridge construction.[45]

One of Clarke's major projects with the Union Bridge Company was the design and construction of the Poughkeepsie Bridge over the Hudson River at Poughkeepsie, New York (**figure 7**). Work began in 1886. The bridge was built as a viable shortcut to the New England and Pennsylvania coal fields. The bridge cut 305 miles off the old commercial route. The

41 *Civil Engineering* 8, no. 5 (May 1938): 361.

42 *Ibid.: Engineering News,* 1901, was cited in support this claim, as was "J.E. Greiner, M. Am. Soc. C.E., in Transactions, 1891 [i.e., *Transactions (American Society of Civil Engineers)* (Baltimore: J.E. Greiner Co., 1891)?]." See also *Engineering News and American Railway Journal* 24, no. 27 (5 July 1890): 8.

43 *Proceedings of the American Society of Civil Engineers* 29 (1903): 402.

44 *Engineering News and American Railway Journal* 24, no. 52 (20 December 1890): 564.

45 David Plowden, *Bridges: The Spans of North America* (New York: Viking Press, 1974), 298.

Figure 8. The Hawkesbury Bridge, New South Wales, Australia, designed by T.C. Clarke and the Union Bridge Company and built in 1887-89. (Martin Hayden, The Book of Bridges [New York: M. Cavendish, 1976])

Poughkeepsie Bridge consisted of three cantilever spans of 548 feet and connecting spans of 525 feet.[46] Its total length was almost 3,100 feet from end to end. It stood a towering 212 feet above the Hudson River. When completed in 1888, the Poughkeepsie Bridge was by far the largest railway bridge in North America.[47] It was also one of the first to combine both truss and cantilever design principles in the same structure. The grand Poughkeepsie Bridge was opened on 31 December 1888 and is still in use today.

In 1884 the Union Bridge Company entered into an international tendering competition with some of the world's leading engineering firms to build an immense bridge over the Hawkesbury River in New South Wales, Australia. The bridge would help link Sydney to Newcastle. Union Bridge estimated the cost of construction at £327,000.[48] Thomas Clarke and Theodore Cooper, also with the Union Bridge Company, designed the structure as a double-track steel railway bridge 2,896 feet long, divided into seven spans.[49] With this design they won one of the most highly-sought after and lucrative engineering contracts of the decade.

Construction began in the spring of 1887. Heavy equipment, hoist engines, and erecting machinery had to be shipped from New York to Sydney. The massive amount of steel necessary for such a project was prepared at the Union Bridge Company shops in Athens, Pennsylvania, and was shipped via Glasgow. Clarke and Cooper's plan called for laying six caisson pier foundations through very deep shark-invested water, then through 40 to 60 feet of soft mud at the river bottom. Some of the piers had to extend to a depth of 185 feet (high water mark) before even touching the bottom, which was deeper than any previous bridge excavation.[50] The area immediately surrounding the chosen site of the bridge proved inappropriate for constructing the complex steel superstructure. However, a mile down river lay a small island. The Union Bridge Company leased it and established a building site where the bridge's superstructure was built.

The 1,000-pound spans somehow had to be transported from the island to the site of the bridge. The only solution with any hope of success was to float each span, when finished, on a large make-shift pontoon. But, as E.K. Morse, one of the contractors on the project, recalled years later, "Such a thing had never been done and there we were, thousands of miles from home, with the problem on our hands and no marine experience."[51] A pontoon, with a span on top, was to be floated upstream, pulled by cables, and set into place at its intended location along the length of the bridge. The pontoon was then to be removed and sent back down river. Never before in civil engineering had such a procedure been tried. Although severe tropical storms, strong river currents, and severe flooding played havoc with the pontoons, the technique proved enormously successful. The last span was floated into place on 1 March 1889 amidst the cheers and whistles of the builders. The Hawkesbury Bridge, officially opened in May 1889, was the largest bridge built in Australia at the time, and the first to be built outside the United States by American civil engineers (**figure 8**).[52]

LATER YEARS

Thomas Clarke retired from the Union Bridge Company late in 1887. Age may have played a factor in his decision to leave the firm, since he did turn 60 that year. But his career as an engineer was far from over. Clarke became a consulting engineer for the City of New York in

46 *Civil Engineering* 8, no. 5 (May 1938): 363.

47 Plowden, *Bridges*, 165.

48 E.K. Morse, "Erecting the Hawkesbury Bridge, 1887-1889," *Civil Engineering* 8, no. 10 (October 1938): 682.

49 *Civil Engineering* 8, no. 5 (May 1938): 361.

50 *Civil Engineering* 8, no. 10 (October 1938): 682.

51 *Civil Engineering* 8, no. 10 (October 1938): 682.

52 *Civil Engineering* 8, no. 5 (May 1938): 361.

the 1890s. He also designed and built the Third Avenue and Willis Avenue bridges over the Harlem River in New York City. Clarke and his family also made frequent summer trips to Port Hope during these years. In January 1896 he was elected the 26th president of the American Society of Civil Engineers. Clarke was also an active member of the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and was one of the first Americans to be named to the British Institute of Civil Engineers.

THOMAS CURTIS CLARKE DIED AT HIS HOME at 146 East 38th Street in New York on 15 June 1901. After a short service at his home in New York, his body was transported by train to Port Hope. He was buried in St. John's Cemetery on 19 June.[53] A *New York Times* obituary called Clarke one of the most widely known civil engineers of his day.[54] The *Boston Herald* declared him "one of the greatest bridge building engineers in the World."[55] An obituary in the *Proceedings of the American Society of Civil Engineers* stated:

Mr Clarke's life and works illustrated the highest form of engineering ability.... His death removed one of the brilliant lights of the engineering profession.[56]

The second half of the 19th century was the great railway building era, spurred by the industrial revolution and an optimistic spirit of nation building. It was a time when talented and ambitious civil engineers such as Sandford Fleming, Samuel Keefer, and Washington Roebling could forge world-wide reputations. T.C. Clarke easily stands with these more celebrated figures in the engineering profession. He was a true bridge-building pioneer in the best tradition of the era, and although he worked around the world—as most great engineers did—his professional contributions to this country are undeniable, and his personal associations strong.

53 *The Daily Examiner* [Peterborough], 19 June 1901, stated the location of burial: "Mr Clark was well known by many in Peterborough. He was at one time chief engineer of the old Midland Railway. He will be buried to-day in Port Hope." Susan Harriet Smith-Clarke died in New York on 17 October 1909. She is buried in Port Hope beside her husband.

54 *The New York Times*, 17 June 1901.

55 *Herald* [Boston], 18 June 1901.

56 *Proceedings of the American Society of Civil Engineers* 29 (1903): 403.

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